Arsenic Exposure and Risk Assessment in Allama Iqbal Town, Lahore Pakistan

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Abstract

Naturally occurring arsenic in ground water has been a recognised serious hazard in many parts of the world in general and in some south Asian countries in particular. Recently, ground water arsenic contamination has been documented from various parts of Pakistan. In this study arsenic exposures and arsenic attributable health risks are estimated for two potentially impacted areas in Pakistan. The use of early stage biomarkers as proxies for exposure has also been tested from a well characterised field area in West Bengal and their utility to studies in northern Pakistan indicated.

In this thesis, an arsenic exposure and risk assessment study was carried out in Allama Iqbal Town Lahore, Pakistan and a preliminary exposure survey carried out in the Peshawar basin, Khyber Pukhtoon Khwa, Pakistan. The major identified exposure routes in both areas was found to be ground water, used for drinking/cooking purposes, and to a lesser extent raw rice. In Allama Iqbal town a median arsenic contamination of 24 µg/L (with maximum value 960 µg/L) in drinking water/cooking water (n=132) derived from ground water sources was found and which is well above the 10 µg/L arsenic WHO provisional guideline value. Rice arsenic concentration (n=86) had a median value of 0.08 mg/kg (range 0 .03 - 0.25 mg/kg), of this 40% - 93% (median 69%) was inorganic. The calculated excess lifetime cancer risk value from drinking/cooking As contaminated water (3.30×10^{-3}) and also from both water and rice together for volunteers of Allama Iqbal town Lahore, Pakistan is (3.52×10^{-3}) higher than the (10^{-4}-10^{-6}) range typically used as a threshold value by USEPA. Factors such as variations in water and rice supply, diet, dietary pattern, genetics, age are in combination also important in determining human exposure and arsenic attributable health risks in this area.

The maximum ground water arsenic contamination value (8 µg/L) found during the study of arsenic contamination in the Peshawar basin was lower than the WHO provisional guide v

Biomarkers of arsenic exposure, viz. human hair (n=115), nails (n=144) (toe and finger nails), and urine (n=23) collected from Allama Iqbal town Lahore have a median value of As in hair 0.33 mg/kg (0.03 -14.7 mg/kg), As in nails 0.84 mg/kg (0.53 - 64 mg/kg) (mean 0.94) and for urine median 118 µg/g creatinine (19 - 350 µg/g creatinine) (mean 137 µg/g) for urine. Hair As has a significant correlation (r^2=0.63 & p=0.01) with arsenic contents of drinking water as does to some extent nail As (r^2=0.24 & p=0.05). Similarly chronic daily intake of water is positively correlated with As content of hair (r^2=0.42 & p=0.01). This is also helpful in confirming ground water used for drinking /cooking as the major arsenic exposure route in this area.

The biomarkers of arsenic exposure study when applied in West Bengal India gives highly significant association values (r^2=0.70 & p=0.01) for cooked rice and chronic daily intake from cooked rice. With the frequent use of rice and being used as a staple food in West Bengal, ingestion of arsenic contaminated rice is being confirmed as a major exposure route in the West Bengal by the biomarkers of exposure: this is in contrast to Allama Iqbal town Lahore where drinking As contaminated water is being confirmed the major exposure route.

ICP-MS was used for quantifying the total concentration of arsenic in hair, nails, water, rice and urine. IC- ICP-MS was used for arsenic speciation analysis of urine as well as raw rice. An informed consent based questionnaire survey was used for collection of relevant information.

Declaration

No part of this work which is referred in this thesis has been submitted in support of an application for another qualification of degree of this or any other University Institute of learning.

Copyright Statement

Dedication

I dedicate my PhD thesis to my loving parents, who supported me at every step of my life.

Acknowledgements

I am really thankful to my supervisor, Dr. Dave Polya for his consistent guidance, moral support, and encouragement during all my research work and in all difficult times. I really appreciate his willingness to discuss any aspects of the project and helping me in how to cope with difficult situations not only in research but also in my role as a working mother. I also appreciate the role of my advisor Dr. Kate Brodie, my examiner Dr. Ray Burgess who examined and viva-ed my first year and second year reports and my Professor Dr. M. Tahir Shah whose kindness, useful advice and moral support helped me a lot during my study.

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I am especially thankful to my sweet mother, husband Liaqat, my brothers and sisters who really supported me and helped me all the time. I want to extend my special thanks to my dear brother the late M.Salman Khan who took charge of my house and baby during the last stages of my lab work and M. Majid Khan who helped me during my field work.

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I am here in UK due to my sponsor National Centre of Excellence in Geology University of Peshawar (NCEG), Higher Education Commission of Pakistan (HEC) and University of Manchester providing the financial support to carry out this project.

The Author

The Author graduated from the Department of Environmental Sciences University of Peshawar in 1998 and has a faculty position/research associateship in the National Centre of Excellence in Geology University of Peshawar, Pakistan. Since September 2006 she has been engaged in the research reported in this thesis with the exception of her maternity leave from September 2007 to August 2008.

Abbreviations

AAS	Atomic Absorption Spectrometry
ADD	Average Daily Dose
AES	Atomic Emission Spectrometry
AFS	Atomic Fluorescence Spectrometry
AR	Aggregate Risk Index
As (III)	Arsenite
As (V)	Arsenate
As	Arsenic
ASE	Accelerated Solvent Extraction
CDI	Chronic daily Intake
CEM	Conceptual Exposure Model
CH_3OH	Methanol
CRM	Certified Reference Material
DMA (III)	Dimethylarsinous Acid
DMA (V)	Dimethylarsinic Acid
DMAA	Dimethylarsinoyl Acetic Acid
DMAB	Dimethylarsenobutanoic Acid
DMAE	Dimethylarsinoylethanol
DMAP	Dimethylarsenopropionic Acid
DMAS	Dimethylarsinothioic Acid
DMA-Sugar	Dimethylated Arsenosugars
EFSA	European Food Safety Authority
FAAS	Flame Atomic Fluorescence Spectrometry
FAO	Food and Agriculture Organization
GC	Gas Chromatography
GF	Graphite Furnace
GHAA	Atomic Absorption via gaseous hydride formation
GIS	Geographic Information System

GPS	Global Positioning System
H_3PO_4	Phosphoric Acid
HCl	Hydrochloric Acid
HG	Hydride Generation
HI	Hazardous Index
HNO_3	Nitric Acid
HPLC	High Performance Liquid Chromatography
IARC	International Agency for Research on Cancer
ICP-MS	Inductively Coupled Plasma Mass Spectrometer
KPK	Khyber Pukhtoon Khwa
LOD	Limit of Detection
MA (V)	Monomethylarsonic Acid
MAE	Microwave Assisted Extraction
MCL	Maximum Contamination Limit
MCM	Monte Carlo Method
MDL	Maximum Detection Limit
MOE	Margin of Exposure
NAA	Neutron Activation Analysis
NAS	National Academy of Sciences
NEQS	National Environmental Quality Standards of Pakistan
NIST	National Institute of Standards and Technology
NRC	National Research Council
NWQMP	National Water Quality Monitoring Program
OD	Optical Density
PBA	Probability Bounds Analysis
PBPK	Physiologically Based Pharmacokinetic Models
PCRWR	Pakistan Council for research in water Resources
PRA	Probabilistic Risk Assessment
PRAMA	Probabilistic Risk Assessment and Arsenic Mitigation
PTDI	Provisional Tolerable Daily Intake

PTWI	Provisional Tolerable Weekly Intake
QSAR	Quantitative Structure Activity Relationship
Rf D	Reference Dose
RPF	Relative Potency Factor
SF	Slope Factor
STP-GFAA	Stabilized temperature Plat form Graphite Furnace Atomic Absorption
TFA	Trifluoroacetic Acid
TMA+	Tetramethylarsonium Ion
TMAO	Trimethylarsine Oxide
UE	Ultrasonic Extraction
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

Chapter 1 Introduction

Project relevance, goals, approach, and thesis structure

Inorganic arsenic has been declared as a group 1 and type A carcinogen by IARC (IARC 2004a) and USEPA (1984) respectively. Around the globe arsenic contamination of ground water from natural geochemical sources is presently the most serious challenge in the planning of large-scale use of ground water for drinking and other purposes (Smedley and Kinniburgh 2002). Arsenic in drinking water is a global issue because it has been recognised as a problem in all continents. More than 100 million people have been affected worldwide as a result of naturally occurring arsenic in drinking water supplies (WHO 2001). According to (Mazumder 1998), 57 million people are drinking water having >50 µg/L arsenic while 137 million are drinking >10 µg/L.

Four major regions of exposure to elevated levels of arsenic via drinking water are in Asia. In order of severity, they are in Bangladesh, West Bengal (India), Inner Mongolia (PR China) and Taiwan. In Bangladesh 27 million people are exposed to >50 µg/L at the same time as 50 million people are exposed to >10 µg/L. In India (especially in West Bengal) 11 million are exposed to >50 µg/L whereas 30 million are exposed to >10 µg/L arsenic due to using the arsenic contaminated water from shallow reducing ground water sources for drinking, cooking and irrigation purposes which constitute the major health hazard problem (Polya and Charlet 2009; von Ehrenstein et al. 2005, 2006a). In addition an alarming number of toxicity cases linked to drinking arsenic enriched water have been reported (Mazumder et al. 2000; Mukherjee et al. 2005; von Ehrenstein et al. 2006b). Likewise in China 5.6 million people are exposed to >50 µg/L and 15 million are exposed to >10 µg/L (Mazumder 1998; von Ehrenstein et al. 2005).

In addition to ground water arsenic contamination, food specially rice and rice derived food products like cereals and baby food have been recently reported as important source of arsenic intake in some parts of the world (Burló et al. 2012; Cascio et al. 2011; Meharg et al. 2008a; Stone 2008a; Viñas 2003; Watanabe et al. 2002; Williams et al. 2007a;) and have raised concerns about impacts on human health (Mondal and Polya 2008; Rahman et al. 2009). Other food products like vegetables, fish, poultry and other sea derived food have been reported to have inorganic and organic species of arsenic (Baeyens et al. 2009; Khan 2010; Navas-Acien et al. 2011).

Arsenic is present in different forms (Maitani 1987) and species can be transformed from one form into another form (Berg et al. 2001; Cascio et al. 2011; Thomas 2004;). Inorganic As has been documented as a toxicant and carcinogen (IARC 2004a) and is bioavailable (Mazumder 2003) and when consumed can be the reason for different health problems (Mazumder et al. 1998, 2000; Tseng 1989).

The absorbed arsenate (AsV) due to reduction transforms to Arsenite (AsIII) in the blood and it takes the methyl group from S adenosylemethionine to produces (MMAIII) and (DMAIII) and is the prominent specie in terms of its interaction with the tissues (Vahter et al. 1995). While organic species like arsenobetaine, arsenoslipids and arsenosugars are mainly found in sea based diet and rapidly excreted in urine (Vahter et al. 1995; Vahter 2002). They are comparatively less toxic than the inorganic arsenic species, thus making speciation studies important for risk assessment (Francesconi and Kuehnelt 2004).

Methylation of arsenic mainly occurs in liver along with other organs but the rate and extant is variable not only in different population groups and mammalian species but it is also different even in individuals. It has been indicated that subjects who excrete low MMA in urine can get rid of ingested inorganic arsenic faster than those having more MMA in urine (Vahter 2002, 1994, 2008; Vahter et al. 2006).

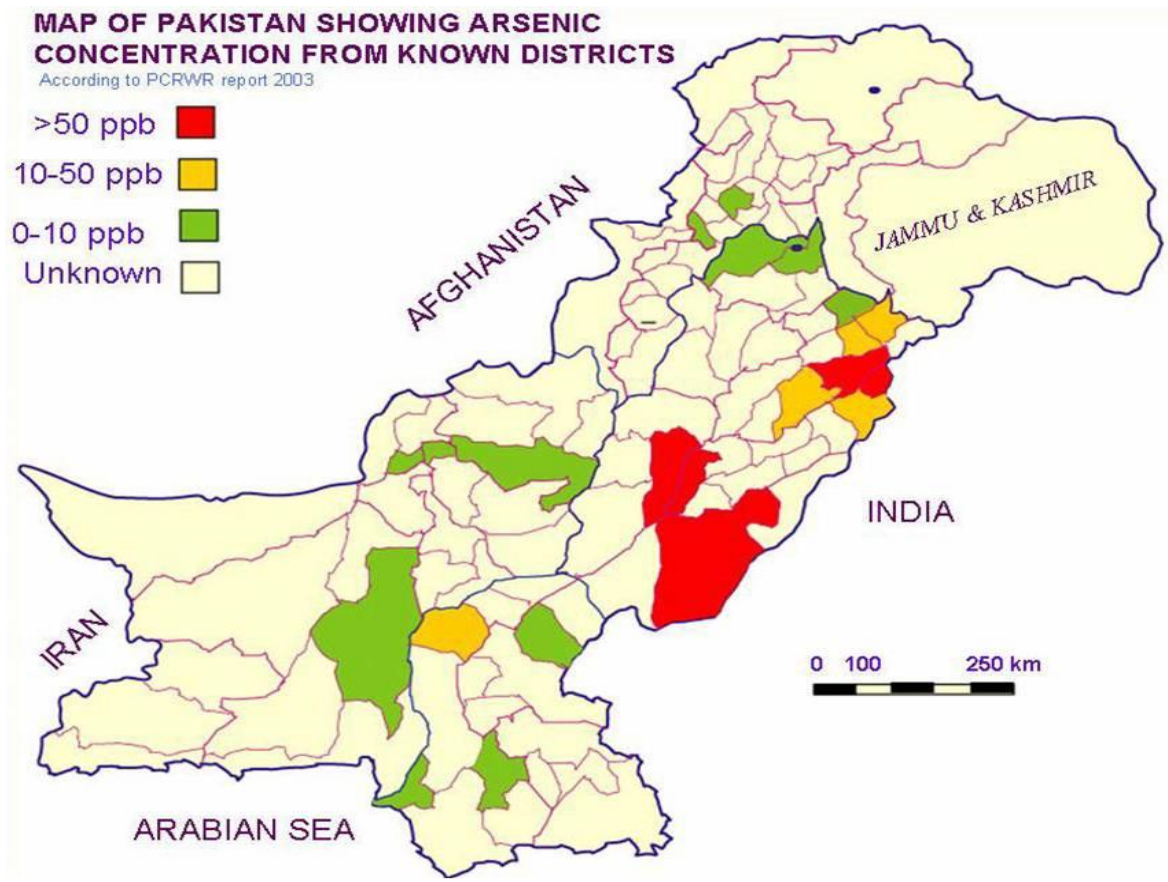
Arsenic exposure may also cause skin lesions, vascular diseases, liver and neuro-toxicity and diabetes mellitus (WHO 2001). There is a lot of reported literature, based on past and on-going experience in various countries in Asia and South America concerning the higher risk of skin, lung, bladder, kidney and liver cancer along with other non-cancerous health effects that result from continuous consumption of elevated levels of As in drinking water (Cantor 2001; Celik et al. 2008; Chen et al. 1988; Chowdhury et al. 2000; Ferreccio et al. 2000; Guo 2007; Mazumder et al. 1998; Mazumdar and Gupta 1991).

Arsenic contamination in groundwater is also a seriously emerging problem in Pakistan, especially in the Punjab (Ahmad 2004; Anwar 2005; Farooqi et al. 2003, 2007; Nickson et al. 2005; PCRWR 2003a, 2003b, 2004, 2008a) and the Sind province (Arain et al. 2007, 2009; PCRWR 2004, 2008a) (Figure1.1).

A nationwide ground water survey program for arsenic by mutual cooperation of the Pakistan Council for Research in Water Resource (PCRWR) and the United Nation International Children and Emergency Fund (UNICEF) in 1999-2000 has reported >50 μg/L arsenic in ground water of some districts of Pakistan.

Figure 1.1 Mean arsenic concentrations in ground water in different districts of Pakistan

(compiled from data from Ahmed et al., 2004; Farooqi et al., 2007; Kahlown 2002; Nickson et al., 1998; PCRWR 2003).



In order to determine the magnitude of the problem and the potential for adverse health effects from arsenic hazard in Pakistan, quantitative risk assessment is a necessary tool. Quantification of a problem through risk assessment needs accurate exposure assessment data. The identification and comparison of different exposure media and various exposure routes is important for quantifying the risk. The probabilistic method is useful because it involves a characterization of variability (natural variation) and uncertainty (lack of knowledge) to obtain a better basis for arsenic risk management decisions (Tseng 2007; Vahter 2008).

Exposure assessment can be done either directly (for drinking water and food) or through biomarkers of exposure (urine, hair, nail & skin etc.) (Sedman et al. 2006). The biomarker response can confirm the predicted degree of human exposure and is helpful in the identification of population subgroups that are at particular risk (e.g. children and the pregnant women). Socio demographic factors such as life style, life stage, health status, nutrition, and genetic variability have an important role in various health problems.

Nature and duration of the project

This thesis describes different experiments and techniques for measurement of arsenic exposure and risk assessment in human beings. The study addresses the geogenic and anthropogenic sources of ground water arsenic pollution in Pakistan with main focus on previously reported As contaminated areas. Allama Iqbal town, Lahore and its suburbs, located in the capital city of Punjab Pakistan which is an arsenic impacted area and a limited number of samples from Peshawar basin for a preliminary study about As exposure in parts of Khyber Pukhtoon Khwa Pakistan are the subjects of our study here.

In addition to this due to participation in and contribution in the PRAMA project, data of one chapter was collected from low, high and medium As impacted areas of west Bengal, India which is one of the highly impacted areas of South Asia.

Ethical approval for these study areas in Pakistan was obtained from the University of Peshawar and for the study areas in West Bengal from CSIR-Indian Institute of Chemical and University of Manchester.

Ground water samples used for drinking and cooking purpose, raw rice, hair, both toe and hand nails samples and first morning voids/ urine samples have been collected from the volunteers after obtaining appropriate informed consent. The urine samples were lyesd before submission for analysis in order to ensure compliance with the Human Tissues Act 2004.

An informed consent based house-hold questionnaire survey was carried out in study areas for collection of relevant information, such as water sources used, consumption of water and rice, demographic information, age, gender, weight of the participants, consumption pattern, education, health and economic status of the consumers and their smoking status.

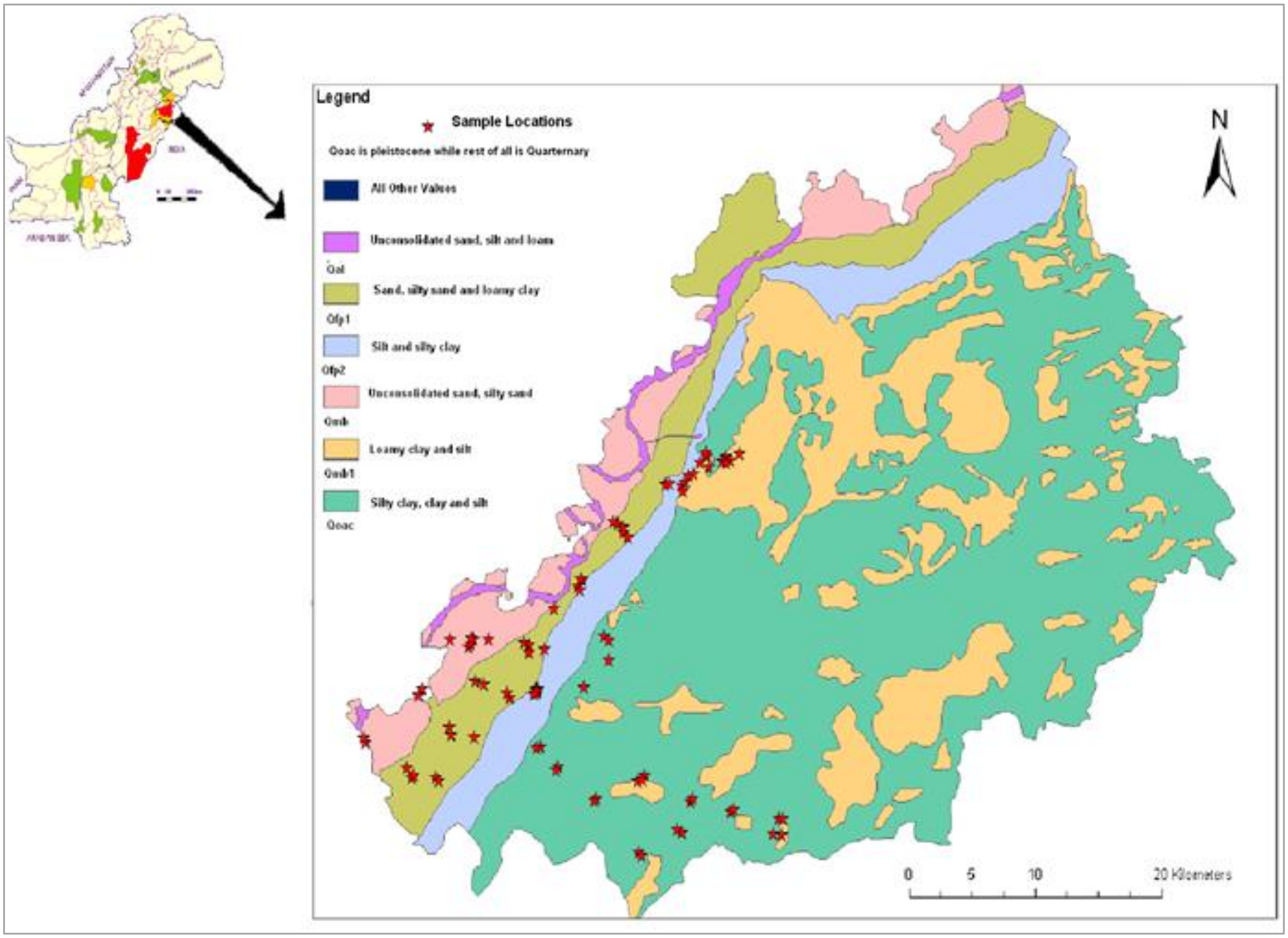
ICP-MS and IC-ICP-MS have been used as the principle analytical instruments for elemental analysis and speciation analysis.

Daily dietary intake has been calculated for both male and female populations of the study area with the help of both questionnaire derived data and laboratory based data. The USEPA (1989) one hit model was used for estimation of excess life time cancer risk from arsenic intake from water and rice.

Moreover, the use of biomarkers (human hair, nail and urine) has been confirmed whether or not the study populations have been exposed to arsenic polluted media.

Global Positioning System (GPS) have been used to record the location of each sampling point along with the collection of all samples which was used in mapping the sampling areas shown in Figure 1.2.

Figure 1.2 Geological map of Lahore (modified from Geological Survey of Pakistan, Lahore 2008) showing the sample collection points



Aims and objectives

Aims:

The purpose of this study:

1. To identify and evaluate various sources of arsenic exposure in Lahore and Peshawar basin of KPK, Pakistan.
2. To assess any risk posed from arsenic contamination of any type in the subjected population of Allama Iqbal town Lahore and Peshawar basin of KPK.

Objectives:

1. Direct measurement of exposure by quantifying the distribution of arsenic in ground water and raw rice in Allama Iqbal town Lahore and Peshawar basin of KPK, Pakistan.
2. Measure arsenic concentration in biomarkers, thereby testing its utility as a proxy for exposure
3. Determination of the relative importance of water and food to the arsenic exposure in population of Allama Iqbal town Lahore and Peshawar basin of Pakistan.
4. Obtaining values for the input parameters into the model by collecting field based and laboratory based data. The model will be used to quantitatively assess risks to human health and determine if any readily definable groups are particularly at risk.

Project out puts

The results of the project have already been presented in different workshops and conferences and abstracts have been published. The detailed abstracts are given in appendix A3.

Four papers are in preparation for submission so far from this project.

1. Ground water arsenic exposure in Allama Iqbal town Lahore, Punjab, Pakistan.

   By Khattak, S.A and Polya, D.A.

   (Target journal: Journal of Hazardous Material)

2. The role of biomarkers in arsenic exposure assessment from drinking as contaminated water and eating rice in Allama Iqbal Town Lahore, Pakistan.

   By Khattak, S.A and Polya, D.A.

   (Target journal: Journal of Environmental Monitoring)

3. Relationship of Drinking/Cooking water and cooked/raw rice arsenic contents to Biomarkers of arsenic exposure in West Bengal India

   By Khattak, S.A., Polya, D.A., Mondal, D., Banerjee, M., Banerjee, N., Bhattacharya, U., Kundu, M and Giri, A. K.)

   (Target journal: Journal of Environmental Monitoring)

4. Preliminary study for arsenic exposure and risk assessment in Peshawar basin of Khyber Pukhtoon Khwa (KPK) province, Pakistan

   By Khattak, S.A., Shah, M.T. and Polya, D.A.

   (Target journal: Journal of Environmental Monitoring)

Author’s and co-author’s Contributions to each paper

Paper 1- Author is the lead investigator, carried out field surveys, collected the samples and field based data, analysed them in the laboratory of the University of Manchester, carried out the data analysis and writing up the manuscript. David A Polya gave overall conceptual guidance and reviewed the manuscript.

Paper 2- Author is the lead investigator, did the field surveys, collected the samples, analysed them, carried out the data analysis and writing up the manuscript. David.A.Polya provided overall conceptual guidance and reviewed manuscript.

Paper 3- Author – analysed a major portion of nails, hair, urine and some rice samples, carried out data analysis and writing up of the manuscript. D. Mondal collected samples and data from one area (Chakdha) also coordinated and arranged the data set. M. Banerjee and M. Kundu both collected samples from one area (Bhawangola-I Block) and analysis of rice and water samples. N. Banerjee carried out analysis of a major part of rice samples and its data reduction. U. Bhattacharya carried out the analysis of most of the hair samples and some nails samples and its data reduction. A. K. Giri provided guidance and organised field surveys in India along with providing overall supervision of India-based field and laboratory activities as well providing infrastructural support. David.A.Polya provided overall conceptual guidance, along with infrastructural support in Manchester and also reviewed the manuscript.

Paper 4- Author the lead investigator, conducted field surveys, collected the samples and data, analysed all samples in laboratory, carried out the data analysis and writing up the manuscript, Tahir Shah provided conceptual guidance and logistical support in the field David.A.Polya gave conceptual guidance and reviewed the manuscript.

Thesis Overview

This thesis consists of a general introduction chapter (1) followed by two review chapters (2 & 3) which provide support to the rest of four chapters (4, 5, 6&7) written in the form of independent scientific papers. The last chapter (8) summarises the conclusions and suggests future work.

There is a list of appendices which gives the details of samples analytical data, detailed analytical protocols, field and laboratory (CoSHH) risk assessments, ethical approvals, questionnaires and informed consent forms used during fields work, field photographs, abstracts submitted to various conferences, Conferences and Workshops attended training attended and course work done during my PhD.

Chapter 1: Introduction

This gives an idea about the nature, duration, goals and overall approach to the project. It also enlists project output in the form of different manuscripts with the contribution of author and each co-author. It briefly explains the structure of the thesis by giving an overview of each chapter.

The subsequent chapters are in the form of papers which has the advantage that each chapter is a self-contained unit.

Chapter 2: Review of Analytical methods for total arsenic and arsenic speciation in rice and urine

The purpose of this review chapter is to report different techniques/ methods used and discuss the recent developments in the analytical methods for total arsenic and arsenic speciation in various media. It also gives a detail discussion about different solvents and solvents mixtures used, some of the available techniques applied in the field of sample extraction, preparation, detection methods of As and its metabolites in rice and rice products along with their respective pros and cones. It describes methods which are in common practice and also emphasise the need for some new analytical techniques especially for the analysis of rice and other food components.

Chapter 3: Risk Assessment Methods – A Review

This chapter first describes various concepts and terminology commonly used in the different steps of a risk assessment process. In the next step it give an insight into the risk assessment process by addressing various commonly practiced methods and techniques and the inherent issues in the risk assessment process. Issues such as variability and uncertainty involved in the modelling methods are also the subject of this review.

Chapter 4: Ground water arsenic exposure in Allama Iqbal town Lahore, Punjab, Pakistan.

This chapter is about arsenic exposure and risk assessment in Allama Iqbal Town, Lahore Punjab which has been previously reported as an arsenic impacted area. It explains the gravity of the arsenic contamination problem in drinking water in the world and the existing situation of this problem in Pakistan. It briefly describes the geology, hydrogeology of the field area. The aim of the chapter is to identify and evaluate different arsenic exposure media by analysing drinking/cooking water and raw rice with the speciation of inorganic arsenic in rice, ultimately focusing on the importance of different exposure routes and establishing the distributions of the exposure factor values and life time cancer risk assessment from all possible routs of exposure. Different analytical techniques like ICP-MS, IC-ICP-MS and standard methods of analysis were used.

Chapter 5: The role of biomarkers in arsenic exposure assessment from drinking arsenic contaminated water and eating rice in Allama Iqbal Town Lahore, Pakistan

This chapter focuses on biomarker of arsenic (As) exposure response and determination of arsenic in hair, nail and urine, validating the predicted degree of human exposure taking into account the influence of the socio demographical controls. The statistical analysis of the results in the form of Pearson correlation values have been used to get better idea about different associations of biomarkers with the As contents of drinking/cooking water and rice and also with the chronic daily intake (CDI) from drinking water, rice and total CDI (µg/kg/day).

Chapter 6: Relationship of drinking /cooking water and cooked/raw rice arsenic contents to biomarkers of arsenic exposure in West Bengal India

This chapter focuses on biomarkers of arsenic exposure and determination of total arsenic in hair, nail and urine as well as metabolites of arsenic in urine samples along with As in drinking and cooking water and both raw and cooked rice. Arsenic speciation analysis for both cooked and raw rice was also carried out. ICP-MS was used for analysing total arsenic and IC-ICP-MS was used for As metabolites analysis. Different statistical tools were applied for data analysis and very significant correlation of biomarkers of As exposure with drinking/cooking water and cooked rice were identified by performing Pearson correlation calculation in (SPSS 16.0).

Chapter 7: Preliminary study for arsenic exposure and risk assessment in the Peshawar Basin

This chapter comprises a preliminary study of arsenic exposure and risk assessment in the Peshawar basin. Drinking water, rice, human hair and nails, samples have been collected along with an informed consent based questionnaire survey for collection of relevant information from the volunteers of different districts of Peshawar basin. All drinking water samples were analysed for arsenic, some other trace elements and some major elements. Biomarkers of arsenic exposure was analysed for total arsenic only. Rice samples collected from market were analysed for total as well as metabolites of As.

Chapter 8: Conclusion and Future work

This is the last chapter depicting the various conclusions drawn from my work and also describes a range of possible future work.

References

Ahmad T K, Tahir MA, and Rashid, H. 2004. Arsenic an Emerging Issue: Experiences from Pakistan In: Proceedings of the 30th WEDC international conference, Vientiane, Lao PDR.
Alava P, Tack F, Du Laing G, Van de Wiele T. 2012. HPLC-ICP-MS method development to monitor arsenic speciation changes by human gut microbiota. Biomedical Chromatography 26(4): 524-533.
Anwar M. 2005. Arsenic, cadmium and lead levels in hair and toenail samples in pakistan. Environ Sci 12(2): 71-86.
Arain GM, Aslam M, Majidano SA, Khuhawar MY. 2007. A Preliminary Study on the Arsenic Contamination of Underground Water of Matiari and Khairpur Districts, Sindh, Pakistan. Journal of the Chemical Society of Pakistan 29(5): 463-467.
Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Jalbani N, Sarfraz RA, Shah AQ, Kandhro GA. 2009. Respiratory effects in people exposed to arsenic via the drinking water and tobacco smoking in southern part of Pakistan. Science of The Total Environment 407(21): 5524-5530.
Baeyens W, Gao Y, De Galan S, Bilau M, Van Larebeke N, Leermakers M. 2009. Dietary exposure to total and toxic arsenic in Belgium: Importance of arsenic speciation in North Sea fish. Mol Nutr Food Res 53(5): 558-565.
Burló F, Ramírez-Gandolfo A, Signes-Pastor AJ, Haris PI, Carbonell-Barrachina ÁA. 2012. Arsenic Contents in Spanish Infant Rice, Pureed Infant Foods, and Rice. Journal of Food Science 77(1): T15-T19.
Cantor KP. 2001. Invited commentary: arsenic and cancer of the urinary tract. American Journal of Epidemiology 153(5): 422-423.
Cascio C, Raab A, Jenkins RO, Feldmann J, Meharg AA, Haris PI. 2011. The impact of a rice based diet on urinary arsenic. Journal of Environmental Monitoring 13(2): 257-265.
Celik I, Gallicchio L, Boyd K, Lam TK, Matanoski G, Tao X, Shiels M, Hammond E, Chen L, Robinson KA, Caulfield LE, Herman JG, Guallar E, Alberg AJ. 2008. Arsenic in drinking water and lung cancer: A systematic review. Environmental Research 108(1): 48-55.
Charlet L, Polya, DA 2006. Arsenic hazard in shallow reducing ground waters in southern Asia. Elements 2: 91–96.
Chen C-J, Tsung-Li K, Wu M-M. 1988. Arsenic and Cancers. The Lancet 331(8582): 414-415.
Chowdhury UK, Biswas BK, Chowdhury TR, Samanta G, Mandal BK, Basu GC, Chanda CR, Lodh D, Saha KC, Mukherjee SK, Roy S, Kabir S, Quamruzzaman Q, Chakraborti D. 2000. Groundwater Arsenic Contamination in Bangladesh and West Bengal, India. Environ Health Perspect 108(5).
Farooqi A, Firdous N, Masuda H, Haider N. 2003. Fluoride and arsenic poisoning in ground water of Kalalanwala area, near Lahore, Pakistan. Geochimica et Cosmochimica Acta 67(18): A90-A90.
Farooqi A, Masuda H, Firdous N. 2007. Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. Environmental Pollution 145(3): 839-849.
Fatmi Z, Azam I, Ahmed F, Kazi A, Gill AB, Kadir MM, Ahmed M, Ara N, Janjua NZ. 2009. Health burden of skin lesions at low arsenic exposure through groundwater in Pakistan. Is river the source? Environmental Research 109(5): 575-581.
Ferreccio C, GonzÃ¡lez C, Milosavjlevic V, Marshall G, Sancha AM, Smith AH. 2000. Lung Cancer and Arsenic Concentrations in Drinking Water in Chile. Epidemiology 11(6): 673-679.
Finley BPD. 1994. The benefits of probabilistic exposure assessment: three case studies involving contaminated air, water, and soil Risk Analysis 14(1): 53–73.
Francesconi KA, Kuehnelt D. 2004. Determination of arsenic species: A critical review of methods and applications, 2000-2003. Analyst 129(5): 373-395.
Guo HR. 2007. Cancer risks associated with arsenic in drinking water. Environmental Health Perspectives 115(7): A339-340; author reply A340-331.

IARC. 2004. Some Drinking-water Disinfectants and Contaminants, including Arsenic. Monographs on the Evaluation of Carcinogenic Risks to Humans.
Khan SIA, Yunus AK, Rahman M, Hore M, Vahter SK, Wahed M A. 2010. Arsenic and Cadmium in food-chain in Bangladesh-An exploratory study. Jour Health Popul Nutr 28(6): 578-584.
Maitani TS, N. Abe, M. Uchiyama, S. Saito, Y. . 1987. Chemical formdependent induction of hepatic zinc-thionein by arsenic administration and effect of co-administered selenium in mice. Toxicol Lett 39: 63-70.
Mazumdar DNG, Gupta DJ. 1991. Arsenic and non-cirrhotic portal hypertension. J Hepatol 13(3): 376.
Mazumder DNG, Ghoshal UC, Saha J, Santra A, De BK, Chatterjee A, Dutta S, Angle CR, Centeno JA. 1998. Randomized placebo-controlled trial of 2,3-dimercaptosuccinic acid in therapy of chronic arsenicosis due to drinking arsenic-contaminated subsoil water. J Toxicol Clin Toxicol 36(7): 683-690.
Mazumder DN, Gupta DJ, Santra A, Pal A, Ghose A, Sarkar S. 1998. Chronic arsenic toxicity in west Bengal--the worst calamity in the world. J Indian Med Assoc 96(1): 4-7.
Mazumder DNG, Haque R, Ghosh N, De BK, Santra A, Chakraborti D, Smith AH. 2000. Arsenic in drinking water and the prevalence of respiratory effects in West Bengal, India. International Journal of Epidemiology 29(6): 1047-1052.
Mazumder DNG, Steinmaus C, Bhattacharya P, von Ehrenstein OS, Ghosh N, Gotway M, Sil A, Balmes JR, Haque R, Hira-Smith MM, Smith AH. 2003. Bronchiectasis in Persons With Skin Lesions Resulting From Arsenic in Drinking Water. Epidemiology 16(6): 760-765.
Meharg AA, Sun G, Williams PN, Adomako E, Deacon C, Zhu Y-G, Feldmann J, Raab A. 2008. Inorganic arsenic levels in baby rice are of concern. Environmental Pollution 152(3): 746-749.
Mondal D, Polya DA. 2008. Rice is a major exposure route for arsenic in Chakdaha block, Nadia district, West Bengal, India: A probabilistic risk assessment. Applied Geochemistry 23(11): 2987-2998.
Mukherjee A, Sengupta MK, Hossain MA, Ahamed S, Lodh D, Das B, Nayak B, Saha KC, Mukherjee SC, Pati S, Dutta RN, Chatterjee G, Chakraborti D. 2005. Are some animals more equal than others? Toxicology 208(1): 165-169.
Navas-Acien A, Francesconi KA, Silbergeld EK, Guallar E. 2011. Seafood intake and urine concentrations of total arsenic, dimethylarsinate and arsenobetaine in the US population. Environmental Research 111(1): 110-118.
Nickson RT, McArthur JM, Shrestha B, Kyaw-Myint TO, Lowry D. 2005. Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan. Applied Geochemistry 20(1): 55-68.
Nieuwenhuijsen M, Paustenbach D, Duarte-Davidson R. 2006. New developments in exposure assessment: The impact on the practice of health risk assessment and epidemiological studies. Environment International 32(8): 996-1009.
Nieuwenhuijsen MJ. 2003. Exposure assessment in occupational and environmental epidemiology. . Oxford, UK: Oxford University Press.
PCRWR. 2003a. Arsenic contamination in ground water of Southern Punjab.PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).
PCRWR. 2003b. Innovative Low Cost Arsenic Removal Technologies for Developing Countries. PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).
PCRWR. 2004 Arsenic Contamination in Groundwater of Central Sindh. .PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).
PCRWR. 2008. Pakistan drinking water quality report.Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF, Pakistan).
Polya DA, Charlet L. 2009. Environmental science: Rising arsenic risk? Nature Geosci 2(6): 383-384.
Rahman MM, Owens G, Naidu R. 2009. Arsenic levels in rice grain and assessment of daily dietary intake of arsenic from rice in arsenic-contaminated regions of Bangladesh-implications to groundwater irrigation. Environmental Geochemistry and Health 31: 179-187.

Ravenscroft P, Brammer H, Richards KS. 2009. Arsenic Pollution: global synthesis. 1st ed: Willy-Blackwell`s.
Ravenscroft P. 2011. Arsenic Pollution of Groundwater in Bangladesh. In: Encyclopedia of Environmental Health, (Editor-in-Chief: Jerome ON, ed). Burlington:Elsevier, 181-192.
Smedley PL, Kinniburgh DG. 2002. A review of the source, behaviour and distribution of arsenic in natural waters. Appl Geochem 17: 517-568.
Stone R. 2008. Food safety. Arsenic and paddy rice: a neglected cancer risk? Science 321(5886):184-5.(5886): 184-185.
Styblo M, Del Razo LM, Vega L, Germolec DR, LeCluyse EL, Hamilton GA, Reed W, Wang C, Cullen WR, Thomas DJ. 2000. Comparative toxicity of trivalent and pentavalent inorganic and methylated arsenicals in rat and human cells. Archives of Toxicology 74(6): 289-299.
Thomas DJ WS, Styblo M. . 2004. Elucidating the pathway for arsenic methylation. . Toxicol Appl Pharmacol 198: 319-326.
Viñas P, López-García, I., Merino-Meroño, B., Campillo, N., Hernández-Córdoba, M. 2003. Speciation of arsenic in baby foods and the raw fish ingredients using liquid chromatography-hydride generation-atomic absorption spectrometry. Chromatographia 57(9): 611-616.
von Ehrenstein OS, Mazumder DNG, Hira-Smith M, Ghosh N, Yuan Y. 2006. Am J Epidemiol 163: 662.
Watanabe C, Bae M, Inaoka T, Sekiyama M, Sudo N, Bokul MH, Ohtsuka R. 2002. Arsenic in cooked rice in Bangladesh. Lancet 360(9348): 1839-1840.
WHO. 2001. Environmental Health Criteria 224. Arsenic and Arsenic Compounds. . International Programme on Chemical Safety, World Health Organization: Geneva.
Williams PN, Raab A, Feldmann J, Meharg AA. 2007. Market Basket Survey Shows Elevated Levels of As in South Central U.S. Processed Rice Compared to California: Consequences for Human Dietary Exposure. Environmental Science & Technology 41(7): 2178-218.

Chapter 2 Review of Analytical methods for Arsenic / Arsenic Speciation

Introduction

The availability of arsenic (As) and its metabolites from geogenic as well as anthropogenic activities and a steady increase in the identified cases of arsenic poisoning, recently identified chronic episodes of arsenicosis, the bio accumulation , bioavailability, carcinogenic and other noncarcinogenic deleterious effect of As and its metabolites is very well known. There are four major occurrences in Asia (Bangladesh, West Bengal India, Inner Mongolia and Taiwan) with new case still being new identified in countries such as Cambodia, Nepal and Pakistan. Recently the importance of foods as one major source of As intake, have been recognized and studies on total As as well as speciation of As in food substances especially rice obtained from arsenic endemic areas have become important (Meharg 2004; Meharg et al. 2008; Mondal and Polya 2008; Ohno et al. 2007; Rahman et al. 2009; Roychowdhury et al. 2003; Sanz et al. 2007a; Schoof et al. 1999; Sengupta et al. 2006; Signes et al. 2008; Smith et al. 2006; Stone 2008b; Sun et al. 2008, 2009; Williams et al. 2007a; Yamily et al. 2008; Zavala and Duxbury 2008).

Total As and speciation analysis of As in rice facilitates accurate risk assessment in terms of food safety because it is a staple food for a large number of people in different parts of the world (Narukawa et al. 2008; Zavala et al. 2008). The PRC government leds the world in regulation of arsenic in rice – they have set a limit of 150 μg inorganic As/kg in rice for human consumption however, The WHO/FAO, however, have recommended a Provisional tolerable weekly intake of 15 μg inorganic As/kg body weight (Kohlmeyer 2003).

There is therefore a clear requirement for analytical techniques and methods for analysis of As and its metabolites. Such methods are well developed for groundwater but less so for more complex biological media, including food as highlighted by (De la Calle, et al 2012)

The purpose of this review chapter discuss and identify different available techniques applied in the field of sample extraction/ preparation, detection methods of As and As metabolites which are in common practice, especially for rice and rice derived food products (Figure 2.1, Table 2.1) – it also outlines the techniques selected for this study.

Sampling and analytical technique

Sample collection

The groundwater samples were collected in already labelled pre-cleaned plastic bottles (HDPE). Raw rice samples once collected and sealed in labelled zip locked plastic bags. Hair, nails and urine samples were collected from volunteers along with their drinking water samples (tube well, dug wells and tapes).

Analytical techniques for Total arsenic

Drinking water analysis

Some of the field parameters, e.g., pH, Eh, electrical conductivity and temperature were measured on spot with the help of different calibrated portable probes (Hanna Water Test Meter, What man Conductivity m-Sensor). After shifting all the samples to the Environmental Geochemistry lab in NCE in Geology University of Peshawar, these samples were acidified with 2% nitric acid (doubled distilled from Aristar Grade, MERCK).

All these samples were transported to Geochemistry lab of SEAES University of Manchester UK for analysis. An Inductively Coupled Plasma Mass Spectrometer (ICP-MS Agilent Technologies 7500 Inc.) was used for total As analysis without any filtration of samples. A commercially available certified reference material for drinking water (Stream water 1640 from National Institute of Standards and Technology (NIST), USA) was used to QA purposes.

Hair and nail analysis

Both hair and nails was cleaned for any external contamination by following the methods of (Chen et al. 1999).

Doubled distilled Nitric acid (made from Aristar Grade, MERCK) was used for digestion of hair and nails samples. When completely digested the digest was diluted (with 18 MΩ from Elga

Pure lab Deioniser system) and filtered, finally submitted to ICP-MS analysis for total As previously applied by (Gault et al. 2008).

For hair and nails samples human hair reference material (NCS DC 73347 from China National Analysis Centre for Iron and Steel Beijing, China) was used for QA purposes.

Urine samples analysis

Creatinine in urine samples was tested by using a Metra Creatinine Assay Kit (Quidel Corporation, USA) and Micro plate Reader (EL x 800 TM from Biotek supplied by North Star Scientific Ltd) recorded the OD (Optical Density). All urine samples already lysed and centrifuged were filtered and diluted with deionized water (5 times dilution) before being subjected to analysis. NIES No. 18 human urine CRM (from National Institute for Environmental Studies ONOGAWA 16-2, TSUKUBA, IBARAK, 305-0053 Japan) was used for QA purposes.

Raw rice analysis

Initially, rice samples have been washed with de-ionized water (18 MΩ from Elga Pure lab Deioniser system) and oven dried at 65 °C for 48 h. Dried rice samples have been grinded manually using a porcelain pestle and a mortar to homogenize the material.

The ground rice sample (0.2-0.5 g) was then used in open (on hot plate at 120 °C) as well as closed (Microwave, CEM Mars Express 2000) digestion following protocols of Williams et al 2006 (Williams et al. 2006). The conditions for closed digestion were: 10 minutes to reach the desired temperature (170°C) then 20 minutes heating time at 170°C for the digestion. Power was 1600W (100%). The total run time was 30 minutes and the cooling time was 40-45 minutes. Rice speciation analysis were performed with the help of High pressure liquid chromatography-Inductively Coupled Plasma Mass Spectrometer (ICP-MS Agilent Technologies 7500 Inc.).

Rice flour CRM 1568a (National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA) was also used to ascertain analytical accuracy, for quality control.

All of the filtration (for digests of rice, hair, nails and urine samples) was performed by using 0.45 µm (PTFE filters and Poly propylene syringes from VWR international) while for weighing an analytical balance (Fisher brand PS-100) was used

ICP-MS and IC-ICP-MS were used for total As and speciation of As respectively as per requirement of the study.

A GPS (geographical positioning system) reading (latitudes and longitudes) was taken at each water sample collecting site for recording the sample location and for future mapping.

Exposure and risk calculation

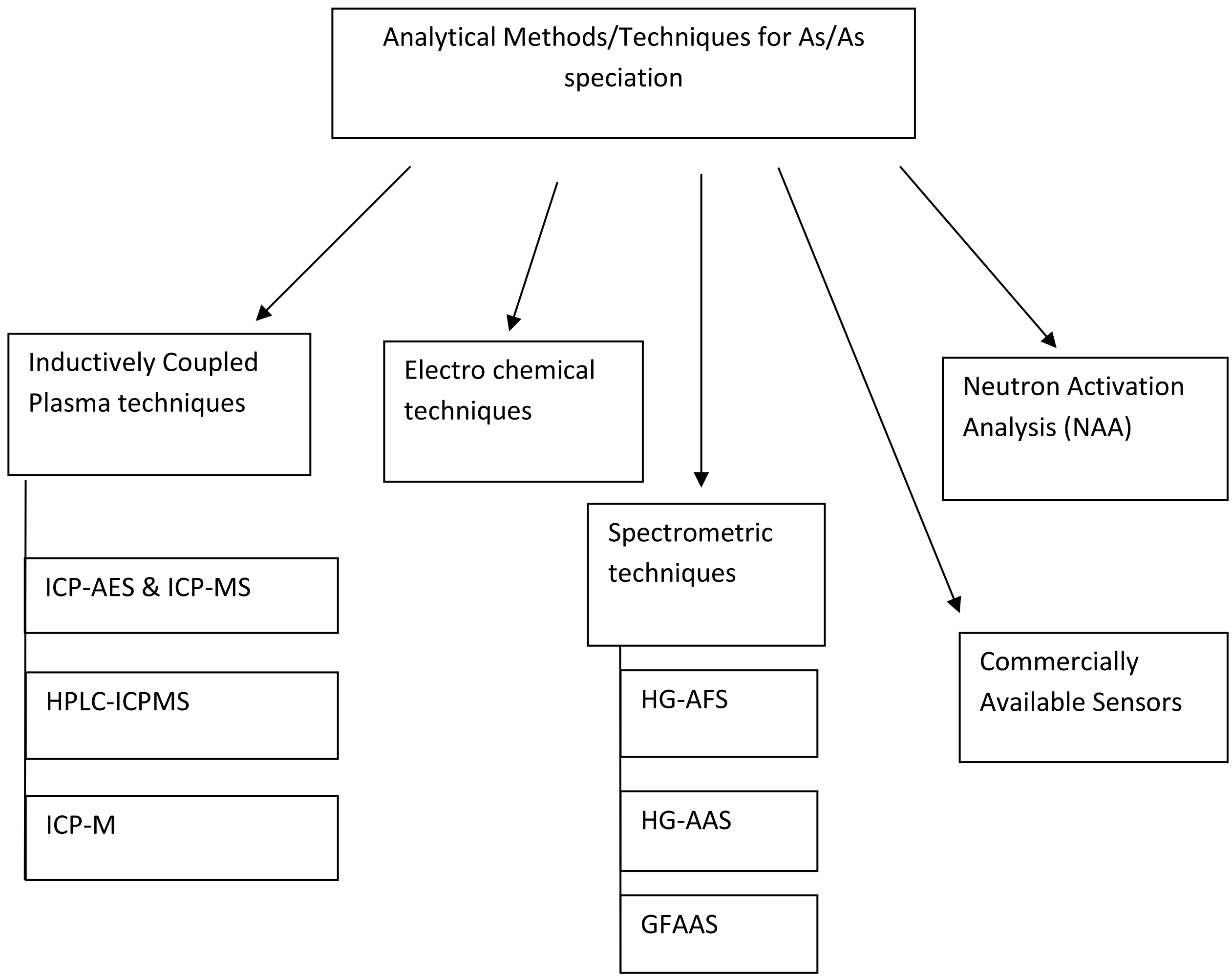
Drinking water was not filtered for arsenic analysis because it is consumed by the people as it is. Daily intake of water and rice by volunteers was determined with the help of information collected by questionnaires survey along with other relevant information regarding the socio economic set up, health, dietary habits, and sources of water used (age and gender distribution, education, occupation, dietary habits, presence of any specific skin symptoms, amount of water used for drinking and cooking etc. A standardized questionnaire (derived from one used in Cambodia by (Gault et al. 2008a) has been used.

During each field survey at least one principal user of each water source was interviewed in national language Urdu, commonly understood. Body mass index (BMI, kg/m^2) was also calculated for each participant. Chronic daily intake for each individual has been calculated on the base of this provided information.

Statistical analysis

Statistical analysis was performed by using SPSS 16.0 version and Ms-Excel 2007 and 2010.

Figure 2.1 Schematic for Different Analytical Techniques available for As/As-Speciation Analysis after (Hung et al 2004)



Cleaning/Washing of Rice: Cleaning and washing of rice is an essential part in every digestion process.

Grinding/Milling:

Almost all rice preparation process for extraction involve grinding of rice grains either manually by using pestle and mortar or mechanically by ball mills, stainless steel grinders, blenders and rotors. The milling time can elevate temperature which may affect the sample matrix and change the species of interest - thus care must be taken to keep the milling temperature <40C° for the stability of species (Huang et al. 2010). Some studies used sieved samples of rice once ground (Heitkemper et al. 2001a; Sanz et al. 2007b).

The size of the ground material does not matter for the total As extraction as mostly the sample is extracted with concentrated acids (60-69% HNO_3, or double distilled HNO_3, H_2O_2 and concentrated HCl) and are almost completely dissolved. However, for speciation analysis the extraction is made with mild conditions i.e., comparatively low strength acids (0.2M HNO_3 or 1% HNO_3 etc) and temperature >100C° (90-95 C°) and the digestion is mostly incomplete one, thus a fine powder sample is desirable as it is relatively easy to be extracted.

Extraction methods:

The most important and somewhat difficult step in the As speciation analysis is its extraction from sample material/rice in a way without changing the original species composition present in the samples which is now the topic of some recent studies (Jiang et al. 2005). There are many studies which focused on different solvent systems for extraction of As species from different materials including rice (Huang et al. 2010; Narukawa et al. 2008; Pizarro et al. 2003).

Use of Solvent/Solvent mixture

Water and Methanol

Methanol and methanol-water mixtures in different proportions have been used in many studies as an extraction medium for As in different types of samples and especially for marine based sample like fish, seafood and Hijiki, most of them having predominantly organic As species such as arsenobetaine (Kohlmeyer 2003; Pizarro et al. 2003; Suner et al. 2000; Viñas 2003). Water – ethanol when used as extraction medium gave good recovery without species inter conversion in terrestrial plant materials such as rice and straw (Yuan 2005).

Pizarro et al (2003) have successfully used it for speciation of As in chicken, fish as well as rice and have recovered 80% of As in rice samples and also found that species of As have been stable in the extract for about three months (Pizarro et al. 2003), however, there are some cases where very low recoveries for As speciation in rice have been documented when this solvent mixture was used for As speciation in rice samples. Extractions with 50% CH_3OH of As in rice grains have often been reported (D`Amato et al 2004; Pizarro et al 2003) however, the low extraction efficiency in some rice samples is a reported problem. Similarly only 10 % recoveries were reported by (Kohlmeyer 2003), 24-36% by (Heitkemper et al. 2001b), 30% by (Sanz et al. 2007b) and 7-18% by (Abedin et al. 2002).

Microwave assisted water as extraction medium have been documented for the highest recovery of As in rice by (Narukawa et al. 2008). The possibility of water as a better extraction medium for naturally occurring As species which are polar in nature and some, such as arsenosugar, which are hygroscopic in nature, have also been documented (Francesconi and Kuehnelt 2004).

Trifluoroacetic Acid (TFA)

TFA hydrolyzes starch during the rice digestion process and has been preferred due to its better extraction quality over water – methanol mixtures (Abedin et al. 2002). The use of TFA has been documented not only to eliminate ICP-MS background problem usually faced when HCl is used as an extractant and have been used for quantitative extraction of As from rice with a very good recovery of 92 % and 112 % for rice sample and rice standard reference material (SRM 11568a) respectively (Heitkemper et al. 2001a). 2M TFA has also been used for As species extraction by (Mondal and Polya 2008; Smith et al. 2006; Williams et al. 2005, 2006). There is one limitation to the use of TFA as an extraction medium for As speciation in that it cannot clearly distinguish between As (III) and As (V) due to partial reduction of As (V) to As (III) (Heitkemper et al.

2001a) – however in the present study the oxidation state of the inorganic arsenic is not material to risk calculations.

Enzymatic extraction

The enzymatic extraction of As is of interest due to the usage of moderate conditions of temperature and pH which prevents elemental losses by volatilization and minimizes organo metallic species degradation. α-amylase has been used with addition of Milli-Q water at moderate temperature by (Kohlmeyer 2003). Enzymatic extraction for As speciation analysis with α-amylase only by Ackerman et al (2005) and α-amylase with addition of methanol and sonication was used by Heitkemper et al (Ackerman et al. 2005; Heitkemper et al. 2001). α-amylase alone recovered only 36% of As species but the addition of protease enhanced recovery to 80 % with ultrasound sonication for the arsenic speciation study in rice reported by (Sanz et al. 2007). The main drawback of enzymatic hydrolysis is the large time required to complete the hydrolysis process and the cost of enzymes.

Acid base extraction

Acids (HCL, HNO_3, $HCLO_4$ and H_3PO_4) has been in use for extraction of total As from different verities of environmental and food samples (Watanabe et al. 2002). H_3PO_4, $HCLO_4$ and hydroxyl ammonium chloride have been mostly used for soil and sediments extraction (Zeng et al. 2008; Zhao et al. 2010) while HCl and HNO_3 for As and As speciation analysis (Baba et al. 2008; Raab et al. 2009).

HCl has been used for extracting the arsenic species from rice which good recoveries of As in some studies but the main problem in As extraction with HCl is that of the large amount of chloride produced and which interferes with As (V) retention thereby affecting the chromatographic separation as well as producing an elevated background signal due to formation of ^{40}Ar ^{35}Cl an isobaric interference m/z 75 (Heitkemper et al. 2001a; Huang et al. 2010). One more problem associated with HCl extraction was the partial reduction of As(V) although this can be overcome by the addition of H_2O_2 which leads to complete oxidation of As(III) (Huang et al. 2010).

Tetramethyl ammonium hydroxide and H_3PO_4 when used as an extraction medium for As in rice cause swelling of the resulting rice matrix, make it difficult to be filtered. Thus, after testing different acids and bases, HNO_3 have been declared as a most suitable extraction medium for As/speciation analysis by (Huang et al. 2010). He recommended it as a basis for simple, economic and reliable methods and very much suitable method for large number of sample analysis because 0.28M HNO_3 not only recovers As quantitatively but is independent of sample type and preserve the As species completely.

There are hundreds of studies using nitric acid in concentrated form for extraction of total As in different types of rice and rice products and other food materials either supported by heating on heating blocks or Microwave (Meharg et al. 2008, 2008b; Williams et al. 2005, 2006,2007, 2007b; Zavala et al. 2008).

As species were stable with microwave assisted 2% HNO_3 extraction in marine samples (Foster et al. 2007). A somewhat similar method of extraction with 1% HNO3 was applied on rice samples and got good recoveries of species and with little inter conversion of species (Sun et al. 2009; Zhu et al. 2008a; 2008b).

Recently Huang presented a novel extraction method of As and As speciation with 0.28 M HNO_3 (Huang et al. 2010). Huang et al (2011) investigated the use of their novel method on different types of rice- they found 115/121 samples had arsenic dominantly as Arsenite while 6/121 had DMA as the dominant species. They also predicted that there are some other trace element which influence the As speciation in rice grains. The amount of inorganic As present in rice can be as high as 90 % without any influence of rice origin, rice type, grain size, cultural practice and polish treatment (Huang et al. 2011).

Use of Analytical technique for extraction

There are different extraction systems commonly used for As speciation extraction such as shaking/mixing, sonication and pressurised extraction/microwave assisted or accelerated solvent extraction system (ASE).

Microwave extraction

Microwave-assisted extraction (MAEE) has been favoured and is now the established standard methods for elemental extraction for practical reasons. It is uses a closed vessel system which allows the automation of the extraction process with significant reduction in the extraction time, diminution of the solvent consumption, and simplicity and increase of sample throughput (Mar et al. 2009).

Microwave extraction resulted in very good extraction without any species alteration when water was used as an extraction medium at 80 °C and the sum of the amount of extracted species was 100% of the total As in sample (Narukawa et al. 2008). It is a very popular extraction technique nowadays (Smith et al. 2006)

Sonication/ Ultrasonic extraction

One of the techniques that could be used for speeding up and simplifying sample treatment is ultrasonic extraction. Enzymatic treatment based on the use of protease and α-amylase in aqueous media, applied with a focused ultrasound probe has been found to be an exceptionally fast, simple and novel extraction method for the determination of total arsenic and species in rice, with 80 % recovery (Sanz et al. 2007b). (Mihucz et al. 2007) used microprobe focused sonication in combination with enzymatic extraction of rice successfully. However, D`Amato et al reported that shaking and ultra-sonication for 1-2 hours at room temperature with the use of Methanol- water mixture gave no satisfactory results. The technique is very time consuming and recovery is typically less than 100% (D'Amato et al. 2004; Narukawa et al. 2008).

Accelerated Solvent Extraction

Narakua et al 2004 found that at high temperature and pressure when water was used as solvent for extraction, the rice material extraction efficiency reduced to 20% due to the gelatinous state of rice in water under these conditions; a 75% methanol to water mixture was found to have the highest extraction efficiency (130%) but it is difficult to control the extraction volume of the solvent and poor precision results

Detection methods:

The analytical process of arsenic and its speciation involves sample preparation, digestion and sample separation and detection steps. There are several methods for the quantification of total arsenic or the various forms of As species in a variety of samples (Figure 2.4).

There are several spectroscopy-based analytical methods approved by USEPA for the analysis of total As in drinking water. In these methods As is oxidised and analysed without considering its chemical form or oxidation state.

Routinely chromatography is used to separate different sample fractions and most commonly high-performance liquid chromatography (HPLC) is used. Furthermore, for detection purposes, atomic spectrometry such as flame atomic absorption spectrometry (FAAS), flame atomic fluorescence spectrometry (FAAS) or inductively coupled plasma atomic emission spectrometry (ICP-AES) (Ebdon 1988) are widely used.

Spectrometric techniques/Detection methods

Atomic detection techniques

Arsenic speciation in environmental media was determined by Braman and Foreback for the first time in 1973 when they introduced the hydride generation technique which separated the different arsenic species. Atomic Absorption was used as the detector and this method become very popular for determining the speciation of arsenic in water and urine samples.

Hydride generation Atomic Absorption Spectroscopy has been used successfully for analysis of As species extracted from rice samples (Viñas 2003; Watanabe et al. 2002; Yuan 2005; Zhao et al. 2006). HPLC-HG-AFS for As speciation of rice has also been used by Smith et al 2006 and for As speciation in rice straw by Jiang et al 2005 (Gomez-Ariza 1998; Jiang et al. 2005; Smith et al. 2006). The As species can be separated without derivatisation by HPLC but the usefulness of HG is that when hydride generation is used after HPLC , it increases the sensitivity for FAAS, FAFS and ICPAES (Ebdon 1988). Similarly, (Jiang et al. 2005) also investigated extraction of rice and rice plant material by applying different solvents and solvents mixtures (e.g. water, methanol, water: methanol, ethanol: water, water and acetonitrile) and different techniques, for example, shaking , ultrasonic, Soxhlet, microwave extraction). He found that arsenic species extraction can be efficiently and effectively done with microwave assisted digestion by using a nontoxic solvent mixture of water –ethanol mixture, without any change to the species. The high performance liquid chromatography-hydride generation-atomic fluorescence spectrometry (HPLC-HG-AFS) was used as a method of detection once extraction of arsenic from the rice straw was successfully done.

Schoof et al.1998 analysed several rice and yam samples obtained from Taiwan for total arsenic, inorganic arsenic, MMA and DMA. He used HG-AAS for detection and his method for Speciation analysis resulted in total recoveries of 73–139 %. He attributed the greater than 100 % recovery to the difference in the sensitivities of the methods for total and speciation of As (Schoof et al. 1998).

HPLC–thermo-oxidation–HG-AFS was used for the speciation of As in sea food and the recovery percentage was greater than 97 % for all species (Arsenobetaine, Arsenocholine, Trimethylearsine oxide and tetramethylearsonium ion) (Suner et al. 2000).

Cryogenic trapping-GC-AFS has the best detection limit of all but has difficulties in fully resolving As (III) and As (V), although this can be improved when pH control of the reduction conditions is used. HPLC-HG-FAAS can be used for routine studies while HPLC-HG-ICP is very useful for multi-element studies (Ebdon 1988; Ebdon et al. 1985; Yamamoto 1985).

The Atomic detection techniques described above are very useful due to their simplicity, reliability and cost effectiveness. One further advantage is that these techniques are available in many laboratories.

Inductively Coupled Plasma techniques

HPLC-ICP-MS was used to determine the concentration of iAs selectively (Narukawa et al. 2008). The ICP-MS method and addition of some modification to it has the advantage of multi-analyte low method detection limit and short analysis time but it has a high capital cost and requires a high level of operator skill. When the samples have high chloride, the problem of isobaric interferences of $^{75}As^+$ from, $^{40}Ar^{35}Cl^+$ occurs (Ackerman et al. 2005; Smith et al. 2006; Sun et al. 2008, 2009; USEPA 1999; Zhu et al. 2009, 2011).

Heitkemper et al (2001) investigated different procedures for extracting arsenic from rice and in each case, extracts were analysed for total extracted As by ICPMS using the method of standard additions. The use of TFA eliminates the ICP-MS background problem. IC-ICP-MS provided excellent sensitivity and selectivity for arsenic speciation analysis. Although there was partial reduction of As (V) to As (III) the overall method is very good for total inorganic As extraction (Heitkemper et al. 2001a).

Atomic Absorption via gaseous hydride formation (GHAA) is considered to be the most common method, with a detection limit of about 0.001 mg/L, for quantification of As in water. For example, EPA method 1632 is a GHAA method for direct analysis of drinking water and As speciation with MDL of 0.002 µg/L but it also requires a high level of skill (EPA, 1999). The most common methods for As speciation are HPLC or GHAA followed by detection with Atomic Absorption, Atomic Fluorescence spectroscopy, or ICP-MS.

In addition to the above mentioned methods, there are some other methods such as Neutron Activation Analysis (NAA) and some commercially available sensors have also been used for As analysis. The use of bio receptor cells which are actually genetically modified cells of bacteria have been used to detect inorganic arsenic species, having highest affinity with Arsenite, followed by arsenate and trimethyl arsine oxide -this technique could be potentially applied as a supportive detection method along with the chemical analysis for speciation (van der Meer and Baumann 2007).

Table 2.1 Standard analytical methods for As by USEPA

Methodology	Reference method	MD (µg/L)	Advantages	Disadvantages
ICP-MS	200.8 (EPA)	1.4	Multi-analyte Low MDL	High capital cost, high level of operator skill required, interferences from Argon Chloride in high chloride samples
ICP-MS with selective –ion monitoring	(Modification)	0.1	Multi-analyte Low MDL and short analysis time	
Stabilized temperature platform graphite furnace atomic absorption(STP-GFAA)	200.9 (EPA)	0.5	Widely used MDL	Single analyte
Graphite furnace Atomic Absorption (GFAA)	3113B (SM)	1	Widely used	Single analyte
	D-2972-93C (ASTM)	5	Low MDL	
Gaseous hydride atomic absorption(GHAA)	3114b (SM)	0.5	Low MDL	Single analyte
	D-2972-93B (ASTM)	1		

MD (µg/L); Method detection limit

References

Abedin MJ, Cotter-Howells J, Meharg AA. 2002. Arsenic uptake and accumulation in rice (Oryza sativa L.) irrigated with contaminated water. Plant and Soil 240(2): 311-319.
Abedin MJ, Cresser MS, Meharg AA, Feldmann Jr, Cotter-Howells J. 2002. Arsenic Accumulation and Metabolism in Rice (Oryza sativa L.). Environmental Science & Technology 36(5): 962-968.
Ackerman AH, Creed PA, Parks AN, Fricke MW, Schwegel CA, Creed JT, Heitkemper DT, Vela NP. 2005. Comparison of a chemical and enzymatic extraction of arsenic from rice and an assessment of the arsenic absorption from contaminated water by cooked rice. Environmental Science & Technology 39(14): 5241-5246.
Angeles Suner M, Devesa V, Rivas I, Velez D, Montoro R. 2000. Speciation of cationic arsenic species in seafood by coupling liquid chromatography with hydride generation atomic fluorescence detection. Journal of Analytical Atomic Spectrometry 15(11): 1501-1507.
Baba K, Arao T, Maejima Y, Watanabe E, Eun H, Ishizaka M. 2008. Arsenic speciation in rice and soil containing related compounds of chemical warfare agents. Analytical Chemistry 80(15): 5768-5775.
Chen KL, Amarasiriwardena CJ, Christiani DC. 1999. Determination of total arsenic concentrations in nails by inductively coupled plasma mass spectrometry. Biological trace element research 67(2): 109-125.
D'Amato M, Forte G, Caroli S. 2004. Identification and quantification of major species of arsenic in rice. Journal of Aoac International 87(1): 238-243.
Ebdon L, Hil, S., Walton, A. P., and Ward, R. W. . 1988. Coupled Chromatography-Atomic Spectrometry for Arsenic Speciation- a Comparative Study. Analyst 113: 1159-1165.
Ebdon L, Hill SJ, Jones P. 1985. Speciation of tin in natural waters using coupled high-performance liquid chromatography-flame atomic-absorption spectrometry. Analyst 110(5): 515-517.
Extraction Method and Mass Sample Survey. Food Chemistry.
Foster S, Maher W, Krikowa F, Apte S. 2007. A microwave-assisted sequential extraction of water and dilute acid soluble arsenic species from marine plant and animal tissues. Talanta 71(2): 537-549.
Francesconi KA, Kuehnelt D. 2004. Determination of arsenic species: A critical review of methods and applications, 2000-2003. Analyst 129(5): 373-395.
Gault AG, Rowland HA, Charnock JM, Wogelius RA, Gomez-Morilla I, Vong S, Leng M, Samreth S, Sampson M, Polya DA. 2008. Arsenic in hair and nails of individuals exposed to arsenic-rich groundwaters in Kandal province, Cambodia. The Science of The Total Environment 393(1): 168-176.
Gomez-Ariza JL S-RD, Beltran R, Corns W, Stockwel P. 1998. Evaluation of atomic fluorescence spectrometry as a sensitive detection technique for arsenic speciation. . Appl Organomet Chem 12(439-447).
Heitkemper DT, Vela NP, Stewart KR, Westphal CS. 2001a. Determination of total and speciated arsenic in rice by ion chromatographyand inductively coupled plasma mass spctrometry. J Anal At Spectrom 16: 299-306.
Heitkemper DT, Vela NP, Stewart KR, Westphal CS. 2001b. Determination of total and speciated arsenic in rice by ion chromatography and inductively coupled plasma mass spectrometry. Journal of Analytical Atomic Spectrometry 16(4): 299-306.
Huang JH, Fecher P, Ilgen G, Hu KN, Yang J. 2012. Speciation of Arsenite and arsenate in rice grain – Verification of nitric acid based extraction method and mass sample survey. Food Chemistry 130(2): 453-459.
Huang JH, Ilgen G, Fecher P. 2010. Quantitative chemical extraction for arsenic speciation in rice grains. Journal of Analytical Atomic Spectrometry 25(6): 800-802.

Jiang GB, Yuan CG, He B. 2005. Evaluation of the extraction methods for arsenic speciation in rice straw, Oryza sativa L., and analysis by HPLC-HG-AFS. Journal of Analytical Atomic Spectrometry 20(2): 103-110.
Kohlmeyer U, Jantzer, E., Kuballa, J. and Jakubik, S. 2003. Benefits of high resolution IC–ICP–MS for the routine analysis of inorganic and organic arsenic species in food products of marine and terrestrial origin. Analytical and Bioanalytical Chemistry 377: 6-13.
Liao CM, Lin TL, Hsieh NH, Chen WY. 2010. Assessing the arsenic-contaminated rice (Oryza sativa) associated children skin lesions. Journal of Hazardous Materials 176(1-3): 239-251.
Mar JL, Reyes LH, Rahman GM, Kingston HM. 2009. Simultaneous extraction of arsenic and selenium species from rice products by microwave-assisted enzymatic extraction and analysis by ion chromatography-inductively coupled plasma-mass spectrometry. J Agric Food Chem 57(8): 3005-3013.
Meharg AA, Deacon C, Campbell RCJ, Carey AM, Williams PN, Feldmann J, Raab A. 2008a. Inorganic arsenic levels in rice milk exceed EU and US drinking water standards. Journal of Environmental Monitoring 10(4): 428-431.
Meharg AA, Lombi E, Williams PN, Scheckel KG, Feldmann J, Raab A, Zhu Y, Islam R. 2008b. Speciation and Localization of Arsenic in White and Brown Rice Grains. Environmental Science & Technology 42(4): 1051-1057.
Meharg AA, Raab A, Baskaran C, Feldmann J. 2009. Cooking rice in a high water to rice ratio reduces inorganic arsenic content. Journal of Environmental Monitoring 11(1): 41-44.
Meharg AA. 2004. Arsenic in rice - understanding a new disaster for South-East Asia. Trends Plant Sci 9(9): 415-417.
Mihucz VG, Tatar E, Virag I, Zang C, Jao Y, Zaray G. 2007. Arsenic removal from rice by washing and cooking with water. Food Chemistry 105(4): 1718-1725.
Mondal D, Polya DA. 2008. Rice is a major exposure route for arsenic in Chakdaha block, Nadia district, West Bengal, India: A probabilistic risk assessment. Applied Geochemistry 23(11): 2987-2998.
Narukawa T, Inagaki K, Kuroiwa T, Chiba K. 2008. The extraction and speciation of arsenic in rice flour by HPLC-ICP-MS. Talanta 77(1): 427-432.
Ohno K, Matsuo Y, Kimura T, Yanase T, Rahman MH, Magara Y, Matsushita T, Matsui Y. 2009. Effect of rice-cooking water to the daily arsenic intake in Bangladesh: results of field surveys and rice-cooking experiments. Water Sci Technol 59(2): 195-201.
Ohno K, Yanase T, Matsuo Y, Kimura T, Hamidur Rahman M, Magara Y, Matsui Y. 2007. Arsenic intake via water and food by a population living in an arsenic-affected area of Bangladesh. Science of The Total Environment 381(1-3): 68-76.
Pizarro I, Gómez M, Cámara C, Palacios MA. 2003. Arsenic speciation in environmental and biological samples: Extraction and stability studies. Analytica Chimica Acta 495(1-2): 85-98.
Raab A, Baskaran C, Feldmann J, Meharg AA. 2009. Cooking rice in a high water to rice ratio reduces inorganic arsenic content. Journal of Environmental Monitoring 11(1): 41-44.
Rahman MM, Owens G, Naidu R. 2009. Arsenic levels in rice grain and assessment of daily dietary intake of arsenic from rice in arsenic-contaminated regions of Bangladesh-implications to groundwater irrigation. Environmental Geochemistry and Health 31: 179-187.
Roychowdhury T, Tokunaga H, Ando M. 2003. Survey of arsenic and other heavy metals in food composites and drinking water and estimation of dietary intake by the villagers from an arsenic-affected area of West Bengal, India. The Science of The Total Environment 308(1-3): 15-35.
Sanz E, Munoz-Olivas R, Camara C, Sengupta MK, Ahamed S. 2007. Arsenic speciation in rice, straw, soil, hair and nails samples from the arsenic-affected areas of Middle and Lower Ganga plain. J Environ Sci Heal A 42(12): 1695-1705.
Schoof RA, Yost LJ, Crecelius E, Irgolic K, Goessler W, Guo HR, Greene H. 1998. Dietary Arsenic Intake in Taiwanese Districts with Elevated Arsenic in Drinking Water. Hum Ecol Risk Assess 4: 117-135.

Schoof RA, Yost LJ, Eickhoff J, Crecelius EA, Cragin DW, Meacher DM, Menzel DB. 1999. A Market Basket Survey of Inorganic Arsenic in Food. Food and Chemical Toxicology 37(8): 839-846.
Sengupta MK, Hossain MA, Mukherjee A, Ahamed S, Das B, Nayak B, Pal A, Chakraborti D. 2006. Arsenic burden of cooked rice: Traditional and modern methods. Food and Chemical Toxicology 44(11): 1823-1829.
Signes A, Mitra K, Burlo F, Carbonell-Barrachina AA. 2008. Contribution of water and cooked rice to an estimation of the dietary intake of inorganic arsenic in a rural village of West Bengal, India. Food Additives and Contaminants 25(1): 41-50.
Smith NM, Lee R, Heitkemper DT, Cafferky KD, Haque A, Henderson AK. 2006. Inorganic arsenic in cooked rice and vegetables from Bangladeshi households. Science of The Total Environment 370(2-3): 294-301.
Stone R. 2008. Food safety - Arsenic and paddy rice: A neglected cancer risk? Science 321(5886): 184-185.
Sun G-X, Williams PN, Carey AM, Zhu YG, Deacon C, Raab A, Feldmann J, Islam RM, Meharg AA. 2008. Inorganic arsenic in rice bran and its products are an order of magnitude higher than in bulk grain. Environmental Science & Technology 42(19): 7542-7546.
Sun G-X, Williams PN, Zhu Y-G, Deacon C, Carey A-M, Raab A, Feldmann J , Meharg AA. 2009. Survey of arsenic and its speciation in rice products such as breakfast cereals, rice crackers and Japanese rice condiments. Environment International 35(3): 473-475.
USEPA. 1999. Analytical methods support document for arsenic in drinking water. EPA-815-R-00-010, Office of Ground Water and Drinking Water, U.S. . Washington, DC.
van der Meer JR, Baumann B. 2007. Analysis of bioavailable arsenic in rice with whole cell living bioreporter bacteria. Journal of Agricultural and Food Chemistry 55(6): 2115-2120.
Viñas P, López-García, I., Merino-Meroño, B., Campillo, N., Hernández-Córdoba, M. 2003. Speciation of arsenic in baby foods and the raw fish ingredients using liquid chromatography-hydride generation-atomic absorption spectrometry. Chromatographia 57(9): 611-616.
Watanabe C, Bae M, Inaoka T, Sekiyama M, Sudo N, Bokul MH, Ohtsuka R. 2002. Arsenic in cooked rice in Bangladesh. Lancet 360(9348): 1839-1840.
Williams PN, Islam MR, Adomako EE, Raab A, Hossain SA, Zhu YG, Feldmann J, Meharg AA. 2006. Increase in Rice Grain Arsenic for Regions of Bangladesh Irrigating Paddies with Elevated Arsenic in Groundwaters. Environmental Science & Technology 40(16): 4903-4908.
Williams PN, Price AH, Raab A, Hossain SA, Feldmann J, Meharg AA. 2005. Variation in Arsenic Speciation and Concentration in Paddy Rice Related to Dietary Exposure. Environmental Science & Technology 39(15): 5531-5540.
Williams PN, Raab A, Feldmann J, Meharg AA. 2007a. Market Basket Survey Shows Elevated Levels of As in South Central U.S. Processed Rice Compared to California: Consequences for Human Dietary Exposure. Environmental Science & Technology 41(7): 2178-2183.
Williams PN, Villada A, Deacon C, Raab A, Figuerola J, Green AJ, Feldmann J, Meharg AA. 2007b. Greatly Enhanced Arsenic Shoot Assimilation in Rice Leads to Elevated Grain Levels Compared to Wheat and Barley. Environmental Science & Technology 41(19): 6854-6859.
Yamamoto M, Ysuda, M., and Yamamoto, Y. 1985. Hydride-Generation Atomic Absorption Spectrometry Coupled with Flow Injection Analysis. Anal Chem 57: 1382-1385.
Yuan C, Jiang, B. and He, B. . 2005. Evaluation of the extraction methods for arsenic speciation in rice straw, Oryza sativa L., and analysis by HPLC-HG-AFS. J Anal At Spectrom 20: 103-110.
Zavala YJ, Duxbury JM. 2008. Arsenic in rice: I. Estimating normal levels of total arsenic in rice grain. Environmental Science & Technology 42(10): 3856-3860.
Zavala YJ, Gerads R, Gurleyuk H, Duxbury JM. 2008. Arsenic in rice: II. Arsenic speciation in USA grain and implications for human health. Environmental Science & Technology 42(10): 3861-3866.

Zeng M, Liao B, Lei M, Zhang Y, Zeng Q, Ouyang B. 2008. Arsenic removal from contaminated soil using phosphoric acid and phosphate. Journal of Environmental Sciences 20(1): 75-79.
Zhao FJ, Khan MA, Stroud JL, Zhu YG, McGrath SP. 2010. Arsenic Bioavailability to Rice Is Elevated in Bangladeshi Paddy Soils. Environmental Science & Technology 44(22): 8515-8521.
Zhao R, Zhao M, Wang H, Taneike Y, Zhang X. 2006. Arsenic speciation in moso bamboo shoot -- A terrestrial plant that contains organoarsenic species. Science of The Total Environment 371(1-3): 293-303.
Zhu YG, Sun GX, Lei M, Teng M, Liu YX, Chen NC, Wang LH, Carey AM, Deacon C, Raab A, Meharg AA, Williams PN. 2008. High Percentage Inorganic Arsenic Content of Mining Impacted and Nonimpacted Chinese Rice. Environmental Science & Technology 42(13): 5008-5013.
Zhu YG, Sun GX, Williams PN, Deacon C, Carey AM, Raab A, Feldmann J, Meharg AA. 2009. Survey of arsenic and its speciation in rice products such as breakfast cereals, rice crackers and Japanese rice condiments. Environment International 35(3): 473-475.
Zhu YG, Williams PN, Meharg AA. 2008a. Exposure to inorganic arsenic from rice: A global health issue? Environmental Pollution 154(2): 169-171.
Zhu YG, Zheng MZ, Cai C, Hu Y, Sun GX, Williams PN, Cui HJ, Li G, Zhao FJ. 2011. Spatial distribution of arsenic and temporal variation of its concentration in rice. New Phytologist 189(1): 200-209.

Chapter 3 Risk Assessment Methods – A Review

Introduction

Health risk assessment is an important tool to evaluate the potential health impacts of any chemical or any contaminated site and also to help in decision making process. The concept of risk assessment process was first introduced by the USEPA in 1976 (Anderson 2010; Ma et al. 2002; Maxwell 1999).

There are different types of risk assessments and several methods have been used for human health risk assessment. Initially the deterministic method has been in common practice but result in conservative estimates of risk except for highly exposed populations. The concept of probabilistic risk assessment (PRA) has become popular and now is common practice for health risk assessment studies. It has an edge over the previous deterministic methods by introducing the values for input parameters as probability distributions estimate and outputs more complete estimates for maximum exposure. PRA involves many new techniques such as simulation modelling, the most popular of which is Monte Carlo simulation.

The scope of this review is to describe different terms and concepts of common interest to all types of risk assessment process, some familiar types of risk assessments models and techniques in practice for quantification of risk and the more important issues of uncertainty and variability of the risk assessment process. In addition, how the present practice of quantitative risk assessment can be supported by a probabilistic approach and how it is different from other risk assessment methods which are in practice. The probabilistic method involves a characterization of variability (natural variation) and uncertainty (lack of knowledge) to obtain a better basis for arsenic risk management decisions thus it will be more useful when applied in different affected regions. Risk assessment has become a commonly used approach in examining environmental problems and is used to examine risks of different nature.

The NRC defines risk assessment as a formalized and structured process that estimates the magnitude, likelihood and uncertainty of environmentally induced health effects (NRC 1983).

Nearly all formal assessment methods, including those at the U.S. Environmental Protection Agency (EPA), assume that risk can be estimated, measured or expressed in numerical terms. Today, a quantitative, or at least semi quantitative, description of severity and likelihood of harm is the dominant paradigm for expressing risk from environmental hazards (NRC 1983, 1996, 1994).

Basic concepts of Environmental risk assessment

The basic concepts of environmental risk assessment including, hazard, exposure, risk, risk assessment, risk management, risk perception and risk communication.

Hazard is commonly defined as “the potential or particular situation which could leads to cause harm” (Royal Society 1992; U.S.EPA. 1998a).

Exposure: concentration or amount of a particular agent that reaches a target organism, system or a population in a specific frequency for a defined duration.

Risk commonly means Chances of disaster or the possibility of an unwanted outcome. Risk has specific definition when used in the risk assessment process and one of the most commonly accepted being “The combination of probability or frequency of the occurrence of a defined hazard and the magnitude of the consequences of occurrence” (RoyalSociety 1992).

A more precise and technical definition might be “risk is the probability that a particular circumstance will cause an unwanted event or effect during a defined period of time” (Rowe 1979).

Risk Assessment

Risk assessment is a process to calculate or estimate the risk to given target organism, system, or (sub) population, including the identification of attendant uncertainties, following exposure to a particular agent, taking into account the inherent characteristics of the agent of concern as well as the characteristics of the specific target system (IPCS 2004).

Risk assessment basically supports a risk management decision to be made.

The determination of this "acceptable" level of risk may have been prescribed before the risk assessment process starts for example, the legislative environmental quality standards (U.S.EPA 2000b).

Aggregate risk assessment addresses the issue of exposure to multiple routes; it considers only one chemical while the cumulative risk assessment incorporates risks from both multiple routes and multiple chemicals (U.S.EPA 2000a).

The margin of exposure (MOE), aggregate risk index (ARI), hazardous index (HI), relative potency factor (RPF) and toxicity equivalency factor (TEF) methods are among the several metrics that help estimate cumulative risk (U.S.EPA. 1999, 2000b).

Risk management is a decision-making process that uses the quantitative values obtained from risk assessment models by professional. These three components, risk assessment, risk management, and risk communication make the process of risk Analysis (IPCS 2004).

Risk assessment Methods/Models

The conceptual model is a descriptive model which uses available information to define all sources, types, and concentrations of contaminants, potentially contaminated media, potential exposure pathways, and final receptors (U.S.EPA. 1989).

An exposure model is "a logical or empirical construct which allows estimation of individual or population exposure parameters from available input data" (WHO 2000).

The first and also an important step for implementation of risk assessment are to develop a conceptual model (Regan 2002). The conceptual exposure model provides the basis for a comprehensive evaluation of the potential risks to human health. It also identifies the mechanisms through which receptors may be exposed to pollutants of potential concern at a particular location. In a conceptual model, the exposure pathways can be selected to correspond to the practical scenario. The contaminated media includes domestic water, indoor air, irrigation water, irrigation soil, agricultural products including vegetables, fruit, crops, and farm animals and their products like dairy and poultry etc. The exposure pathways include ingestion of drinking water and beverages, shower water, various types of foods like beef, meat, poultry, fish, milk and dairy products, vegetables and fruits, ingestion of soil, dermal contact of soil, shower water, inhalation of shower air, and inhalation of indoor air. Figure 3.1 depicts the conceptual site model for arsenic that illustrates the environmental transfer processes between media and exposure pathways linking exposure media and exposure routes involved.

Environmental multimedia modelling has been evolved in response to the transfer rate of a contaminant through different environmental media and process for example water/soil/air and food (McKone and MacLeod 2003).

There are three types of risk assessment models, ecological, environmental and chemical risk assessment.

The NAS Model

"The National Research Council (NRC 1983, 1996, 1994), of the National Academy of Sciences (NAS), described four phases to the human health risk assessment paradigm (hazard identification, dose-response assessment, exposure assessment, and risk characterization) and identified risk communication as a fifth area of study" (U.S.EPA. 2000c; Dearfield 2000)

Hazard identification:

Hazard identification/hazard characterization involves the determination of whether a chemical is or is not causally linked to particular health effects. A hazard is a source of risk but not a risk itself.

Dose response Assessment

Dose-response comprises the determination of the relationship between the magnitude of exposure and the probability of occurrence of the health effects under consideration.

Dose response is used as a qualitative yard stick to estimate risk from certain chemical/ toxicant under observation. The two principal toxicity indices are the slope factor (SF) and reference dose (RfD). The SF is a conservative estimate of the incremental probability of an individual developing cancer as a result of exposure over a lifetime, and RfD is the estimated amount of the daily exposure level for the population that is likely to be without an appreciable risk of deleterious effects during a lifetime (US EPA 2000a).

Exposure Assessment

The aims of exposure assessment are identification of potential receptors, evaluation of exposure routes and pathways, and quantification of exposure (Figure 3.1). The estimation of intake (dose) in the human body through contaminant contact is supposed by average daily dose (ADD). The ADD value means quantity of chemical substance ingested, inhaled, or absorbed through the skin per kilogram of body weight per day (mg/kg/day). The value of ADD could be used to assess the possible entry of arsenic and heavy metals in to the body.

Risk Characterization

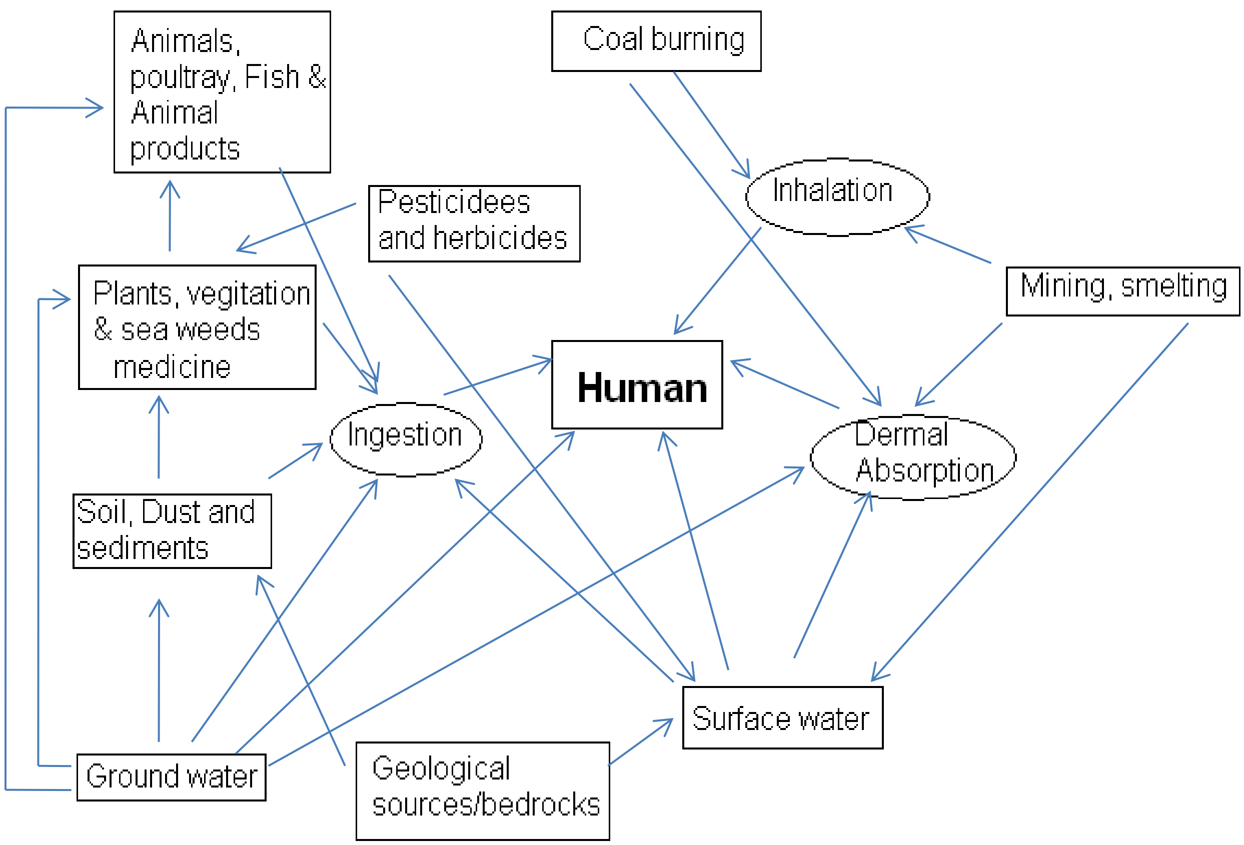
Risk characterization is the final phase of the health risk assessment process and has Risk estimation and Risk description as the two major components. It integrates these three phases of hazard identification, dose response assessment as well as the exposure assessment. It describes, uncertainties, assumptions, strengths and weaknesses involved in each step which is then integrated for risk estimation and decision making process. This phase determines the probability of an adverse effect to a human population by a toxic substance and outlines permissible exposure levels from which standards of exposure are set (Dearfield 2000).

An adverse effect is defined by the US Environmental Protection Agency as "Any biochemical, physiological, anatomical, pathological, and/or behavioural change that results in functional impairment that may affect the performance of the whole organism or reduce the ability of the organism to respond to an additional challenge"(U.S.EPA. 2002a).

Any good risk characterisation useful to the risk managers should have transparency, clarity, consistency and reasonable care. Once the risk characterisation is finalized, may be used as the basis for making different kinds of communication products like, press releases, fact sheet, technical briefing etc. (U.S.EPA. 2002a).

The importance of risk communication in an easily understandable and useful way is also very important because it is the only way to give a risk perspective to the concern communities, scientists, government agencies etc.

Figure 3.1 Arsenic Exposure Pathways



The NAS model does not include some of the processes which are relevant to certain other environmental risk assessment cases, such as problem formulation and release assessment Lipton et al (1993) identified that the NAS model for Human Health Risk Assessment can't be uniformly applied to Ecological risk assessment because of the basic differences in the two systems. He included preliminary step "Receptor identification"; in which chemical partitioning is combined with a conceptual model of the ecosystem to identify appropriate risk targets (Lipton 1993). According to the USEPA, (1998) any Environmental risk assessment possibly involves a number of process.

USEPA (2003) Cumulative Risk Assessment Model

Cumulative risk assessment is a tool for organizing and analysing information to assess, and possibly quantify, the overall detrimental effects on human health or ecologic resources caused by either simultaneous and/or sequential exposure to multiple environmental stressors. Simply we can say that the Cumulative exposure assessments estimate exposure to multiple chemicals via multiple pathways, for example, all of the potential routes for a single pesticide or all of the routes for a group of pesticides (Callahan 2007). It shifts the focus from a single, stressor to a broader approach comprised of combine effects of cumulative exposure to multiple stressors.

The U.S. Environmental Protection Agency (EPA) framework divides the process of cumulative risk assessment into three interrelated phases:

Planning, scoping, and problem formulation:

A team of experts, like risk assessors, risk managers and other relevant stakeholders set the main goals. The products of this phase are:

a) A conceptual model that identify the stressors to be evaluated, the health or environmental effects to be evaluated, and the relationships among various exposures and effects.

b) An analysis plan that specifies the data needed, the approach to be taken, and the types of results expected during the succeeding phase (U.S.EPA 2003e).

Analysis

The second phase estimates the combined risks of exposure due to multiple stressors for the population at risk, including an estimate of the uncertainty and variability associated with these risk estimates (U.S.EPA 2003e).

There are some difficult technical issues in this phase that needs to be addressed and resolved like, description of interactions among stressors and their effects on mixture toxicity, estimation of cumulative exposure to the stressors of interest, and the identification of vulnerable groups among the study population.

Interpretation and risk characterization

In the last phase the risk estimates are explained and prioritized according to their significance, reliability, and the overall confidence placed in them. In addition, the effects of key assumptions on final risk estimates are described, the uncertainties involved are delineated, and an assurance is made whether the assessment met already set criteria (U.S.EPA 2003a).

The U.S. EPA guidance states that use of mixture-specific toxicity data is the preferred method for characterizing cumulative risks and is most appropriate for fairly consistent mixtures such as environmental tobacco smoke, diesel exhaust, commercial pesticide formulations, and coke oven emissions. However, usually toxicity data on the mixtures of regulatory interest are not available, in such cases, where data is unavailable, the U.S.EPA recommends combining toxicity information for each individual chemical in an additive fashion (U.S.EPA. 2000d).

Assessment of potential health risk from combined exposures

There is a rapid development in the field of chemical mixture toxicology recently which encouraged the concept of multimedia risk assessment frame work for assessing potential health risk from combined exposure (Feron and Groten 2002).

One such type of study is about the multiple-pathway exposure models used for exposure assessment to estimate DDT and HCH exposure doses. This framework included an exposure model, physiologically based pharmacokinetic (PBPK) models and a tissue dose hazard index (Zhao and Shiyu 2009). The study presents a multimedia risk assessment framework with the integration of multi-pathway exposure models used for exposure assessment to estimate DDT and HCH exposure dose, physiologically based pharmacokinetic (PBPK) models are developed and used for consequence assessment to analyse the pollutant distribution and accumulation process in human tissues and tissue dose hazard index (HI), based on tissue doses, is used to estimate the health risks attributable to the mixture of pesticides. Like all other risk assessment models, the framework also involved issues of uncertainty and variability because the input parameters for the DDT and HCH PBK models were mainly estimated using relevant empirical equations based upon Quantitative Structure Activity Relationships (QSAR).

Currently, many risk assessment models, including simple and many multimedia risk assessment models for implementing site-specific risk assessment, have been developed: these include: MEPAS, MMSOILS (U.S.EPA 1996), CalTOX (McKone 1994), 3MRA (U.S.EPA. 2003e), and TRIM (U.S.EPA. 2002a, 2002b).

Tiered Approach

A tiered approach to cumulative risk assessment is encouraged by the USEPA, because it gives more transparency and less uncertainty. The initial tier of the risk assessment is a deterministic point estimate. If the first tier provides conclusive results, then the risk assessment is supplemented by probabilistic methods (e.g. a one-dimensional Monte Carlo simulation). The last step is an advanced probabilistic risk assessment (e.g. a two-dimensional Monte Carlo simulation). Thus a simple qualitative screening assessment should be undertaken in the first instance to identify the most important sources, pathways and receptors so that the most detailed exposure assessments can be focussed on the most important of these (IGHRC 2004).

An Ecological risk assessment framework for the contaminated soil currently adopted by the UK Environment Agency is a tiered approach. This framework is based on a review of schemes used in other countries, including the USA, Australia, Canada and the Netherlands.

Deterministic point approach

The deterministic approach predicts an event in a simple, linear system. It gives a distinct estimate of the maximum exposure, which can then be compared with reference values for health and environmental effects. Nevertheless, it is not possible to obtain an indication of the uncertainty in this value or the margin of safety. This may give a false picture of the situation and exaggerate the risk involved (NRC 1994; Oberg 2005; U.S.EPA 1997a).

Deterministic and GIS based models

The use of geographical information system (GIS) and geostatistical techniques provide strength to modelling methods (Nuckols 2004). These techniques have been used to model local pollution patterns on the basis of monitored data.

Air dispersion modelling techniques can be used to improve exposure estimates when undertaking risk assessments or when conducting epidemiological studies to establish associations between exposure and adverse effects (Nieuwenhuijsen et al. 2006). One interesting example is provided by the study of air pollution and lung cancer in Stockholm, where emission data, dispersion models and GIS was used to assess historical exposure to several components of ambient air pollution and compared estimates with actual measurements (Bellander 2001). Another example is the use of dispersion modelling and bio monitoring to estimate long-term exposures in which air dispersion modelling was applied to estimate ground-level concentrations of arsenic within 20 km of the Nováky Power station in the Nitra Valley in Slovakia as a function of distance and direction from the source and year of operation since the 1950s (Colvile et al. 2001).

The deterministic approach is the fundamental estimation approach that is appropriate for the application of the ‘‘individual-by-individual’’ concept of the aggregate and cumulative risk assessment. In this approach, each subject’s data are used with appropriate models to estimate pollutant- and route-specific dose, and then the risk metric. Therefore, each risk metric is calculated using the dose estimates that belong to one and the same subject. However, this approach has two major limitations.

(i) It cannot provide as much information about the variation, i.e., uncertainty, of the estimated results as the probabilistic approach.

(ii) The estimation can be performed only on those subjects having a complete set of data and have exposure estimates for all media (e.g., indoor air, drinking, washing and cooking water, food, floor dust, sill wipe and yard soil) pollutants and all routes.

But this is not generally the case for all subjects and all media for most databases that are medium specific. The world is full of complicated systems where the complex interactions of many variables or inherent probabilistic nature of certain phenomenon rules out the definitive prediction where a probabilistic estimation approach can be used to overcome these limitations.

Probabilistic methods

Instead of specifying input parameters as single values, these consider the probability distributions. The full range of possible values and their likelihood of occurrence are included into the analysis to produce the range and probability of expected exposure levels (Burmaster 1994; Finley 1994; Ma 2002; Smith 1994).

The primary purpose of probabilistic risk estimation is to analyse uncertainty and its sources as they are associated with risk estimates. Based on the deterministic dose and risk estimation models, the first step in a probabilistic analysis is the formulation of a probability distribution for each model variable. The Monte Carlo and Bayesian models are popularly used in probabilistic risk assessment and they explain the uncertainty in select parameters by evaluating the range and probability of possible exposure levels.

Probabilistic risk assessment have been popular for both exposure assessment (Boyce and Garry 2002; Caldas et al. 2006; Fryer et al. 2006; Kroes et al. 2002) and hazard characterization (Baird et al. 1996; Renwick et al. 2004). But PRA can only focus in one of these two areas at a time: that is, either at exposure assessment or hazard characterization, and can address only a part of the variation and uncertainty involved in the problem (Boon et al. 2005; Evans 2002).

Recently introduced concept of integrated probabilistic risk assessment, where variation and uncertainties in both exposure assessment and hazard characterization are included. The method is illustrated with a worked-out example on dietary exposure to a pesticide (Voet and Slob 2007).

Simulation method (Monte Carlo Analysis)

A probabilistic risk assessment is usually performed by simulating the outcomes from a large selection of possible choices for input variables and model parameters. Today, these calculations can be made on any PC. The choice of the probability distribution for the input variable is a very important factor because it can determine the outcome of a probabilistic risk assessment. The simulation work can start when the model is fully specified and the input distributions have been chosen. Monte Carlo analysis is the most frequently used simulation method (Oberg 2005).

The Monte Carlo method (MCM) is a statistical sampling method for obtaining the probability distribution of the possible outcomes of a model commonly used for classical PRA (U.S.EPA 1997b). MCM statistically combine the individual parameter distributions to produce a single, overall distribution which is often interpreted as the overall variation of the predicted risk. These individual distributions must be accurate, precise, and representative in order to have a good risk assessment. MCM can be described as a process where N sets of values are obtained from a joint distribution of all of the input variables, and N corresponding model outputs are calculated (Cullen 1999).

The uncertainty of the output can be examined using several statistics, including the standard error (S.E) of the mean and the confidence interval (CI) of the mean or a specific percentile. An advanced technique called the two-dimensional (2-D) Monte Carlo simulation (also known as "double looping" or "nesting") is used with an uncertainty analysis that requires variability to be distinguished from other types of uncertainty (Burmaster 1996; Cullen 1999; Oberg 2005).

Monte Carlo techniques have been incorporated into some of the most important risk assessments studies, such as the quantification of exposure and evaluation of the risk to population located near the facilities which manufactured components for nuclear weapons in the United States (Widner 2002). In addition, this technique have also been applied to many exposure assessments involving sites with contaminated fish (Wilson 2001), contaminated soils and aerial emissions and is particularly useful when a large number of algorithms are required to address various multiple pathways of exposure to humans (Paustenbach 2006,1991). In the United Kingdom, probabilistic risk assessment is used to derive soil guideline values. The major environmental application of PRA is in the management of contaminated land and this method is now well established as a significant number of studies have been published especially in the United States, Europe and Asia (Oberg 2005).

Several reports, have demonstrated the possibility of integrating GIS based information, such as spatial data to probabilistic risk assessment (PRA) for making valuable risk maps (Kone et al. 2002; Kooistra et al. 2001).

Uncertainty and variability

Since the risk assessment paradigm was established in 1983 (NRC 1983), the methodology of risk assessment has been much developed. However, despite of the significant improvement of the method, uncertainty remains a primary threat to the reliability in the model-based risks assessments. Currently there are no available standard procedures which can address the uncertainty and variability altogether (Wu and Tsang 2004) however; the probabilistic method involves a characterization of uncertainty and variability.

Risk assessment is an iterative process involving sequential evaluation of all site data and if any type of uncertainty is introduced into the early stages of the process, it spreads further as calculations proceed. In its guidance for human health risk assessments, the USEPA states that, "it is more important to identify the key site-related variables and assumptions that contribute most to the uncertainty than to precisely quantify the degree of uncertainty in the health risk assessment" (USEPA 1989).

The EPA (U.S.EPA 1992a) has classified uncertainty in exposure assessments in three categories: scenario uncertainty, parameter uncertainty, and model uncertainty.

Scenario uncertainty

The sources of scenario uncertainty include descriptive errors, aggregation errors, errors in professional judgment, and incomplete analysis. Scenario uncertainty arises from differences between the situation that is to be modelled and the real world situation. Sources of scenario uncertainty in exposure modelling include failures to identify: key receptor populations, significant sources pathways of exposure: Assumptions were made about several exposure parameters, for each pathway including the following: the activity patterns for an individual that may result in exposure; the frequency for occurrence of each activity; the routes of exposure by which an individual could be exposed; and the amount of impacted media an individual may contact during the activity, selecting inappropriate spatial and temporal scales for the exposure situation, for instance, for residues on imported crops, scenario uncertainty may result from incorrect information regarding the regions in which the product is used and how it is used (Huijbregts et al. 2003). Scenario and model uncertainty could be only exploratory and difficult to analyse quantitatively (Hertwich 2000).

Parameter Uncertainty

The uncertainty in the estimates of variables used in the final exposure model is called "parameter uncertainty" which can be further categorized into random errors, systematic errors and the use of generic data (Morgan and Henrion 1990). For example, the incorrect information provided by some survey respondents to underestimate their body weights may result in potential overestimation of the exposures, or to under-report food consumption may result in potential underestimation of exposures is due to parameter uncertainty or measurement bias in the data. Parameter uncertainty also exists in the distribution describing variability in different input variables, e.g. the concentration of soil contaminants (McKenna 1998) or describing indirect human exposure routes and may also significantly contribute to output error (Huijbregts et al. 2000).

Sampling errors may result from sampling too few observations or non-representative sampling. Parameter uncertainty needs a large set of data to be accurately quantified and due to the availability of large sets of data basis and information on activity, food habits and ingestion for human models, facilitate the quantification of parameter uncertainty.

The parameter uncertainty associated with various models may affect the selection of better models (Chen 2006). Partition constants and bio concentration factors are two examples of model parameters that contribute significantly to the uncertainty in health and environmental risk assessments (Kostka-Rick 2003; McKone 1994) Parameter uncertainty can also be quantified by representing parameters as distributions as in Monte Carlo Simulation technique but this requires some knowledge of the degree of uncertainty associated with a parameter estimate. Parameter uncertainty can be reduced by a more extensive collection of data and critical re-evaluation of information already available (Chen 2006; Cullen 1999).

Model uncertainty

Model uncertainty is due to differences between how the model simulates environmental processes and how these processes occur in reality. Models of environmental systems represent simplifications of real systems so they are never 100% accurate. Inaccuracies arise due to model assumptions, relationship errors, or from the selection of an inappropriate model. The differences in model design, environmental mechanism, mathematical formulations, and assumptions can result in difference of risk predictions by orders of magnitude (Mills 1997; Regan 2002). The quantification of model uncertainty is generally conducted by way of calculating the range of outputs of different models (Moschandreas 2002).

Some researchers have tried to quantify scenario and model uncertainty, and the outcome revealed was that the total uncertainty, including scenario, model and parameter uncertainty, was three times greater than that considering only parameter uncertainty (Moschandreas 2002). Although the contribution of scenario and model uncertainty to overall uncertainty is usually assumed to be negligible or is ignored, both types of uncertainty may significantly affect the outcome of risk assessment processes (Moschandreas 2002).

Fuzzy methods were introduced as tools for highlighting variability and uncertainty in risk assessment models (Kentel and Aral 2004). This method represents variability and uncertainty as an interval function (Regan and Ginzburg 2003). One of the most popular fuzzy methods in use is Probability Bounds Analysis (PBA). PBA has been introduced as a method of investigating the full extent of uncertainty (Ferson 1996, 2002; Williamson 1990). It describes model inputs as probability boxes (p-boxes) instead of probability distributions and each p-box include all possible distributions (minimum, maximum, and a medium) that meet certain constraints. PBA has already been practiced as a useful tool in the risk assessment process of contaminated land (Sander 2006).

Inter individual variability:

Inter individual variability (natural variation between individuals) and in a population is of major importance in all types of risk assessments. The differences between children and adults, perhaps is the most noticeable factor to be considered. Different lifestyles, food consumption, physiological characteristics, gender, diseases and occupation are some of the other factors that will have an influence on most health and environmental risks (Cullen 1999).Genetic variations, age, sex and nutritional status has been identified as the most important variability sources in a human arsenic metabolism model in a recent study (Kenyon et al. 2008).

Spatial variability

Spatial variability is another important aspect in risk assessment of contaminated land. The spatial distribution of soil pollutants is an obvious factor to evaluate, but soil properties may also vary (van Alphen, 1999). Risk may vary over a geographical area, for example, when uniform remedial measures applied, it becomes more important for the risk assessment process to be performed for environmentally persistent chemicals which are not easily treated (Labieniec 1996; van Alphen 2002).

Temporal variability

Temporal variability has rarely been given equal importance to the other two types of variability. The reason behind this is the lack of data, the complex dynamic nature of the models and the problems in finding suitable input parameter values. There are many processes in the environment which are time dependent, for example, leaching of soil pollutants by desorption,. the overall weather conditions changing significantly from one year to another and having impact on both water flow and pollutant transport. Occasionally it is important to characterize this temporal variability in weather especially in dispersion models where even slow changes in climatic conditions may become a challenge (van Alphen 2002).

Conclusion

The use of probabilistic risk assessment methods and techniques has become popular due to their advantages of more holistic and mechanistic approaches as compared to deterministic point estimate assessment approaches. The use of simulation modelling and more sophisticated techniques, such as MCS tools, have made the risk assessment process comparatively more transparent, and efficient. Uncertainty, validity and data availability are issues common to all the models, a constant effort is being made to address these issues by (i) avoiding erroneous estimation of exposure; (ii) producing accurate and precise estimates. And (iii) continuous introduction new methods to quantify complex spatial and temporal issues involved.

References

Anderson EL. 2010. The Evolution of Risk Assessment and Management at the USEPA: A 40th Anniversary Reflection. Human and Ecological Risk Assessment: An International Journal 16(6): 1215-1220.

Baird SJS, Cohen JT, Graham JD, Shlyakhter AI, Evans JS. 1996. Noncancer risk assessment: A probabilistic alternative to current practice. Hum Ecol Risk Assess 2(1): 79-102.

Bellander T, Berglind N, Gustavsson P, Jonson T, Nyberg F, Pershagen G, Jarup L. 2001. Using geographic information systems to assess individual historical exposure to air pollution from traffic and house heating in Stockholm. Environ Health Perspect. 109(6):633-639.

Boon PE, de Mul A, van der Voet H, van Donkersgoed G, Brette M, van Klaveren JD. 2005. Calculations of dietary exposure to acrylamide. Mutat Res Genet Toxicol Environ Mutagen 580(1-2): 143-155.

Boyce CP, Garry MR. 2002. Review of Information Resources to Support Human Exposure Assessment Models. Human and Ecological Risk Assessment 8(6): 1445 - 1487.

Burmaster DEaA, D.P 1994. Principles of Good Practice for the Use of Monte Carlo Techniques in Human Health and Ecological Risk Assessments. Risk Analysis 14: 477-481.

Burmaster DEaW, A.M. . 1996. An Introduction to Second-Order Random Variables in Human Health Risk Assessments.

Caldas ED, Boon PE, Tressou J. 2006. Probabilistic assessment of the cumulative acute exposure to organophosphorus and carbamate insecticides in the Brazilian diet. Toxicology 222(1-2): 132-142.

Callahan MA SK. 2007. If Cumulative Risk Assessment Is the Answer, What Is the Question? . Environ Health Prospect 115(5).

Chen YaM, H. . 2006. Model comparison for risk assessment: A case study of contaminated groundwater. Chemosphere 63(751-761).

Colvile RN, Stevens EC, Nieuwenhuijsen MJ, Keegan TJ. 2001. Atmospheric dispersion modeling for assessment of exposure to arsenic for epidemiological studies in the Nitra Valley, Slovakia. J Geophys Res 106(D15): 17421-17431.

Cullen A.C. FHC. 1999. Probabilistic techniques in exposure assessment: A handbook for dealing with variability and uncertainty in models and inputs. . New York, USA: Plenum Press, .

Cullen ACaF, H.C. 1999. Probabilistic techniques in exposure assessment: A handbook for dealing with variability and uncertainty in models and inputs. . New York, USA: Plenum Press, .

Dearfield KL FA. 2000. Peer review handbook. Washington DC.

Evans JS, Williams PL, Wilson AM, Baird SJS. 2002. Reproductive and Developmental Risks from Ethylene Oxide: A Probabilistic Characterization of Possible Regulatory Thresholds. Risk Analysis 21: 697–718.

Feron VJ, Groten JP. 2002. Food Chemical Toxicol 40: 825.

Ferson S, & Ginzburg, L. R. 1996. Different methods areneeded to propagate ignorance and variability. Reliability Engineering and System Safety 54: 133–144.

Ferson S. 2002. RAMASRisk Calc 4.0 Software: Risk Assessmentwith Uncertain Numbers. : Boca Raton, FL: Lewis Publishers.

Finley BP, D. 1994. The Benefits of Probabilistic Exposure Assessment: Three Case Studies Involving Contaminated Air, Water, and Soil. Risk Analysis 14(1): 53-73.

Fryer M, Collins CD, Ferrier H, Colvile RN, Nieuwenhuijsen MJ. 2006. Human exposure modelling for chemical risk assessment: a review of current approaches and research and policy implications. Environ Sci Policy 9(3): 261-274.

Hertwich EG MT, Pease WS (2000): . 2000. A systematic uncertainty analysis of an evaluative fate and exposure model. Risk Anal 20: 439-454.

Huijbregts MAJ, Lundi S, McKone TE, van de Meent D. 2003. Geographical scenario uncertainty in generic fate and exposure factors of toxic pollutants for life-cycle impact assessment. Chemosphere 51(6): 501-508.
Huijbregts MAJ, Thissen U, Jager T, van de Meent D, Ragas AMJ. 2000. Priority assessment of toxic substances in life cycle assessment. Part II: assessing parameter uncertainty and human variability in the calculation of toxicity potentials. Chemosphere 41(4): 575-588.
IGHRC 2004. Guidelines for good exposure assessment practice for human health effects of chemicals. Leicester: Institute for Environment and Health;.pages 81.
IPCS. year. IPCS risk assessment terminology. Available:
http://www.who.int/ipcs/methods/harmonization/areas/en/ipcsterminologyparts1and2.pdf.
Kentel E, Aral MM. 2004. Probabilistic-fuzzy health risk modeling. Stochastic Environmental Research and Risk Assessment 18(5): 324-338.
Kenyon EM, Klimecki WT, El-Masri H, Conolly RB, Clewell HJ, Beck BD. 2008. How can biologically-based modeling of arsenic kinetics and dynamics inform the risk assessment process? -- A workshop review. Toxicology and Applied Pharmacology 232(3): 359-368.
Kostka-Rick R MO. 2003. Selecting bioconcentration factors for minimizing uncertainty in probabilistic exposure assessment for cadmium. Fresenius Environ Bull 12: 581–583.
Kroes R, Muller D, Lambe J, Lowik MRH, van Klaveren J, Kleiner J, Massey, R.Mayer, S.Urieta, I. Verger, P.Visconti, A. 2002. Assessment of intake from the diet. Food Chem Toxicol 40(2-3): 327-385.
Labieniec PA DD, Siegrist RL 1996. Risk variability due to uniform soil remediation goals. J Environ Eng – ASCE 122: 612-621.
Lipton JG, H. 1993. A paradigm for ecological risk assessment Environmental Management 17(1): 1-5.
M. G. Morgan and M. Henrion. 1990. "Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis" New York Cambridge University Press, .
Ma H-w, Wu K-Y, Ton C-D. 2002. Setting information priorities for remediation decisions at a contaminated-groundwater site. Chemosphere 46(1): 75-81.
Ma H-w. 2002. Using stochastic risk assessment in setting information priorities for managing dioxin impact from a municipal waste incinerator. Chemosphere 48(10): 1035-1040.
Maxwell RM, Kastenberg, W.E. 1999. Stochastic environmental risk analysis: an integrated methodology for predicting cancer risk from contaminated groundwater. Stochastic Environ. Res. . Risk Assess 13(27-47).
McKenna SA. 1998. Geostatistical approach for managing uncertainty in environmental remediation of contaminated soils:Case study. Environ Eng Geosci 4: 175–184.
McKone TE. 1994. Uncertainty and Variability in Human Exposures to Soil Contaminants Through Home-Grown Food: A Monte Carlo Assessment. 14(4): 449-463.
Mills WB, Cheng, J.J., Droppo, J.G., Faillance, E.R., Gnanapragasam, E.K., Johns, R.A., Laniak, G.F., Lew, C.S., Strenge, D.L., Sutherland, J.F., Whelan, G., Yu, C. 1997. Multimedia benchmarking analysis for three risk assessment models: RESRAD, MMSOILS, and MEPAS. Risk Anal 17(187-201).
Moschandreas DJ, Karuchit, S. 2002. Scenarion-modelparameter: a new method of cumulative risk uncertainty analysis. . Environ Int 28: 247–261.
Nieuwenhuijsen M, Paustenbach D, Duarte-Davidson R. 2006. New developments in exposure assessment: The impact on the practice of health risk assessment and epidemiological studies. Environment International 32(8): 996-1009.
NRC. 1983. Risk assessment in the federal government: managing the process. Committee on the Institutional Means of Assessment of Risks to Public Health, Commission on Life Sciences, . NRC Washington, DC.
NRC. 1994. Science and judgment in risk assessment Washington DC, USA.
NRC. 1996. Understanding risk: Informing decisions in a democratic society. Stern, P.C., and H.V. Fineberg, eds. . Washington, DC.

Nuckols J R WM, Jarup L. . 2004. Using geographic information systems for exposure assessment in environmental epidemiological studies. Environ Health Perspect 112: 1007-1015.
Oberg TB, B 2005. A review of probabilistic risk assessment of contaminated land. Journal of Soil and Sediment 5(4): 213-224.
Paustenbach DJ GD. 2006. Biomonitoring: is body burden relevant to public health? . Regul Toxicol Pharmacol 44(3): 249-261.
Paustenbach DJ MD, Sheehan PJ, Lau V. 1991. An assessment and quantitative uncertainty analysis of the health risks to workers exposed to chromium contaminated soils . . Toxicology and industrial health, 7(3): 159-196.
Regan HM, Ak¸cakaya, H. R.,Ferson, S., Root, K.V., Carroll, S.,&, Ginzburg LR. 2003. Treatments of uncertainty and variability in ecological risk assessment of single-species populations. Human and Ecological Risk Assessment 9(4): 889-906.
Regan HM, Sample, B. E.,&Ferson, S. 2002 Comparison of deterministic and probabilistic calculation of ecological soil screening levels. . Environmental Toxicology and Chemistry 21: 882-890.
Renwick AG, Flynn A, Fletcher RJ, Muller DJG, Tuijtelaars S, Verhagen H. 2004. Risk-benefit analysis of micronutrients. Food Chem Toxicol 42(12): 1903-1922.
RL S. 1994. Use of a Monte-Carlo simulation for human exposure assessment at a Superfund site. Risk Anal 14: 433–439.
Rowe W. 1979. Introduction to risk assessment. In: Goodman GT, Rowe WD (eds) London Academic Press.
RoyalSociety. 1992. Risk: Analysis, Perception and Management. London.
Sander P, & O¨ berg, T. 2006. Comparing deterministic and probabilistic risk assessments. A case study at a closed steel mill in southern Sweden Journal of Soils and Sediments 6: 55-61.
Smith RL. 1994. Use of a Monte-Carlo simulation for human exposure assessment at a Superfund site. Risk Anal 14: 433–439.
U.S.EPA. 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A) Interim Final.Office of Emergency and Remedial Response (EPA/540/1-89/002). Washington, DC.
U.S.EPA. 1992a Guidelines for exposure assessment. . Washington, DC.
U.S.EPA. 1996. Guidelines for Reproductive Toxicity Risk Assessment. Washington, DC.
U.S.EPA. 1997a. Policy for Use of Probabilistic Analysis in Risk Assessment at the U.S. Environmental Protection Agency. Fred Hansen, Deputy Administrator. Science Policy Council,. Washington , DC. Available at http://www.epa.gov/osp/spc/probpol.htm.
U.S.EPA. 1997b. Guiding Principles for Monte Carlo Analysis. Risk Assessment Forum, Office of Research and Development,. (EPA/630/R-97/001). Washington , DC.
U.S.EPA. 1998a. Report of the Workshop on Selecting Input Distributions for Probabilistic Assessments. Risk Assessment Forum, . (EPA/630/R-98/004). Washington , DC.
U.S.EPA. 2000a. Strategy for Research on Environmental Risks to Children. Office of Research and Development,. (EPA/600/R-00/068). Washington , DC.
U.S.EPA. 2000b. Further Site Characterization and Analysis, Revised Baseline Modeling Report, Hudson River PCBs Reassessment RI/FS Volume 2D. Prepared for U.S. EPA Region 2 and USACE, Kansas City District by Limno-Tech, Inc., and Menzie-Cura & Associates, Inc., by Von Stackelberg, Burmistrov and Linkov.
U.S.EPA. 2000c. Further Site Characterization and Analysis, Baseline Ecological Risk Assessment for Future Risks in the Lower Hudson River, Hudson River PCBs Reassessment RI/FS Volume 2F. Prepared for U.S. EPA Region 2 and USACE, Kansas City District by Limno-Tech, Inc., and Menzie-Cura & Associates, Inc., by Von Stackelberg, Kane-Driscol, Menzie and Linkov.
U.S.EPA. 2000d. Phase 2 Report Further Site Characterization and Analysis Volume 2F—Revised Human Health Risk Assessment Hudson River PCBs Reassessment RI/FS.

U.S.EPA. 2002a. Framework for Cumulative Risk Assessment. . Washington , DC
U.S.EPA. 2002b. A Review of the Reference Dose and Reference Concentration Process. Washington , DC
U.S.EPA. 2003a. Technical Background Document for the Sewage Sludge Exposure and Hazard Screening Assessment. Office of Water,. (EPA 822-B-03-001). Washington , DC.
U.S.EPA. 2003e Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. Office of Research and Development, . (EPA/600/P-00/001Cb). Washington , DC
U.S.EPA. 2003e. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds. Washington , DC
U.S.EPA. USEPA. 1999. Exposure Factors Handbook, US EPA. Washington, DC.
van Alphen BJ SJ. 2002. Effects of soil variability and weather conditions on pesticide leaching — A farm-level evaluation. J Environ Qual 31: 797–805.
Van Der Voet H, Slob W. 2007. Integration of Probabilistic Exposure Assessment and Probabilistic Hazard Characterization. Risk Analysis 27(2): 351-371.
WHO. 2000. Methods of Assessing Risk to Health from Exposure to Hazards Released from Landfills, . Copenhagen.
Widner TE FS. 2002. Dose reconstructions for radionuclides and chemicals: case study involving federal facilities at Oak Ridge, Tennessee. . New York, USA: John Wiley and Sons Inc.
Williamson RC, & Downs, T. 1990. Probabilistic arithmetic I: Numerical methods for calculating convolutions and dependency bounds International Journal of Approximate Reasoning 4: 89–158.
Wilson ND PP, Paustenbach DJ. . 2001. An event-by-event probabilistic methodology for assessing the health risks of persistent chemicals in fish: a case study at the Palos Verdes Shelf. . J Toxicol Environ Health 62(8): 595–642.
Wu F-C, Tsang Y-P. 2004. Second-order Monte Carlo uncertainty/variability analysis using correlated model parameters: application to salmonid embryo survival risk assessment. Ecological Modelling 177(3-4): 393-414.
Zhao X, Shiyu LI. 2009. Health Risk Assessment of Chemical Mixtures Exposure to Residents in the Lake Taihu Region, China. Human and Ecological Risk Assessment: An International Journal 15(6): 1317-1334.

Chapter 4 Ground water arsenic exposure in Allama Iqbal town Lahore, Punjab, Pakistan

Abstract

Naturally occurring arsenic in ground water is a global issue but of particular importance in Asia (Ravenscroft et al. 2009; Smedley and Kinniburgh 2002; Smith et al. 2000, 2006) including in Pakistan. High groundwater arsenic has been found in the Punjab (Ahmad 2004; Farooqi et al. 2007a, 2009; Kahlown et al 2002; Nickson 1998; PCRWR 2008a, 2003a &b) and Sind (Ahmad 2004; Arain et al. 2009, 2008; Jakhrani 2009; PCRWR 2004, 2008a) where high arsenic has been found in water used for drinking, cooking & irrigation (Ahmad 2004; Nickson 1998).

Present study aimed to determine the relative importance of rice and water to human exposure in Allama Iqbal town, an arsenic-impacted peri-urban part of Lahore, Punjab. Groundwater utilized as drinking water from 105 households, raw rice, hair, nails and urine samples from volunteers of that area were collected and analysed by ICP-MS for total arsenic. All urine samples were lysed to destroy any human cells prior to analysis. IC-ICP-MS was used for arsenic speciation. Throughout the study standard methods were followed and for quality assurance measures, standard reference materials, duplicate samples and procedural blanks were included in every set of analysis. Daily intake of water and rice by volunteers along with their food habits, demographic, health information and location of sampling was determined through questionnaires. The model of (Mondal and Polya 2008) was used to calculate chronic daily intake (CDIs) and excess life time cancer risks.

Groundwater arsenic concentration as high as 960 µg/L were found (median value of 24 µg/L). Rice arsenic concentrations ranged from 0.03 - 0.25 mg/kg (median 0.08 mg/kg), of this 40 % - 93% (median 69 %) was inorganic. CDI ranged from 0.16 to 36 µg/kg/day and median 1.5 (µg/kg/day). The median CDI is broadly comparable to values previously published (Kile et al. 2007; Mondal et al. 2008; Polya et al., 2010a; Williams et al. 2007b) for other seriously arsenic impacted areas and this is reflected in elevated concentrations of arsenic in hair, nails and urine. Water was the dominant route of exposure for 90 % of the volunteers. The calculated excess lifetime cancer risk value from drinking/cooking As contaminated water (3.30×10^{-3}) and also

from both water and rice together for volunteers of Allama Iqbal town Lahore, Pakistan is (3.52×10^{-3}) higher than the USEPA (10^{-4}-10^{-6}) range typically used threshold value.

Introduction

Arsenic and its inorganic compounds have been documented by USEPA and IARC (IARC 2004a, 1987; USEPA 2001) as carcinogens on the basis of their deleterious effects to humans (IARC 2004a, 1987; USEPA 2001). Long term exposure to inorganic arsenic (iAs) from drinking water which has been considered as the predominant exposure route is generally associated with increased incidences of diabetes, chronic cough as well as some of cardiovascular diseases, adverse reproductive outcomes, skin diseases like keratosis, hyper keratosis, melanosis and leucomelanosis, skin, lung, bladder, kidney and other internal organ cancers (ATSDR 2007; Chen et al. 2004, 2009; Chiou et al. 2001; Hopenhayn-Rich et al. 1998; IARC 2004a; Kapaj et al. 2006; Mazumder 2003; NRC 1999a, 2001; Smith et al. 1998; Steinmaus et al. 2000; Vahter et al. 2006; WHO 1996, 2001).

Naturally occurring arsenic in ground water is a global issue, impacting many parts of America, Europe, Asia, and Australia (Bundschuh et al. 2010; Chakraborti et al. 2004; Kapaj et al. 2006; Nriagu et al. 2007; Ravenscroft et al. 2009; Smedley and Kinniburgh 2002; Smith et al. 2006, 2000). However, the situation in Southeast Asia (Bangladesh, India, Cambodia, Vietnam, Taiwan, Thailand, Nepal) particularly in Bangladesh, West Bengal India is critical, because arsenic contaminated groundwater is mainly used for drinking as well as cooking and irrigation purpose which poses a serious threat to human health and is the eventual cause of prevailing mortality for some population groups (Argos et al. 2010; Bhattacharya et al. 2007; Chatterjee et al. 2010a; Mondal and Polya 2008; Rahman et al. 2009; Smedley and Kinniburgh 2002).Only in Bangladesh 35-77million people are chronically exposed while in different districts of India 6 million are consuming arsenic contaminated water and among them 30,000 are threatened with visible symptoms of arsenic poisoning (Chakraborti et al. 2002; Smedley and Kinniburgh 2002).

The toxicity of ingested As not only depends upon the amount of the subjected material but also on the duration of the exposure (Caussy et al. 2003) once ingested enter in the circulatory system and metabolized into different methylated species which can produced a lethal damage even to the genetic material (Chen et al. 2009; Chiou et al. 1997). There are also some other important factors like age, gender, diet status, food habits, smoking status and genetic makeup of individuals which can play an important role in gravity of the situation (Mitra et al. 2004; Steinmaus 2006; Tseng 2009; Tsuda et al. 1995; Uchino et al. 2006).

Although drinking water is considered as the most significant contributor to chronic arsenic-related health problems, due to the dependency of epidemiological data collected during last couple of years has mainly on the concentration of As in the drinking water as the substitute for exposure (Chen et al. 1988; Smith et al. 2000, 2006). But the chronic symptoms recorded in Bangladesh and West Bengal India may reflect pathways other than just drinking water (Huq 2003). In addition to water ingestion of As contaminated food, like vegetables and cereals especially rice and rice products like rice milk, rice bran and malt etc. has been considered as other major pathway of As exposure (Meharg and Rahman 2003; Meharg et al. 2008a; Mondal and Polya 2008; Rahman et al. 2009; Smith et al. 2006; Stone 2008; Su et al. 2009; Sun et al. 2009; Torres-Escribano et al. 2008; Uchino et al. 2006; Williams et al. 2006, 2007a; Zhu et al. 2008a).

In those countries where arsenic in drinking water is not the main problem many scientists consider rice as the main source of inorganic arsenic in diet (Meliker et al. 2006; Mondal and Polya 2008; Williams et al. 2007a). The cooking methods of rice also influences the exposure from cooked rice (Carbonell et al. 2009; Mondal and Polya 2008; Rahman et al. 2006, 2011; Senguptaa 2006).

Rice could be the major As exposure route for many of the Asian communities where rice is eaten three times daily (Carbonell et al. 2009; Mondal and Polya 2008; Rahman et al. 2009; Williams et al. 2006) and also for the infants and toddlers feeding either on rice milk and other rice products (Meharg et al. 2008a) .

WHO provisional guideline vale for drinking water As concentration is 10 µg /L (WHO 2003) while the USEPA maximum limit for inorganic arsenic (iAs) is 10 µg/L (USEPA 2004). Recently China has established their maximum contamination limit of 150 µg/ kg rice for (iAs) but unfortunately there is no such limit imposed by the USEPA, EU or WHO (EFSA 2009; Francesconi 2007).

Arsenic contamination in groundwater is also a seriously emerging problem in Pakistan, especially in the Punjab province (Ahmad 2004 ; Kahlown et al. 2002; Nickson et al. 2005; PCRWR 2008b) and the Sind province (Ahmad 2004; Arain et al. 2007, 2009; Farooqi et al. 2003, 2007a; PCRWR 2003a-b, 2008a) where high arsenic has been found in water used for drinking, cooking and irrigation (Ahmad 2004 ; Nickson et al. 2005; PCRWR 2008b). Arsenic concentrations as high as 2400 µg/L has been reported in parts of Punjab (Farooqi et al. 2007a). There is a reliance on groundwater as opposed to surface water sources for drinking-water supplies in most areas of Pakistan (Chilton 2001). Around 70% of drinking-water supplies come from aquifers (Tahir 1998).

Arsenic problem in ground water in Pakistan has been surfaced as a result of field testing, in Rawalpindi and Attock districts by a joint study of the Pakistan Council of Research in Water resources (PCRWR) and the United Nations Children Fund (Ahmad 2004) and secondly from the National Water Quality Monitoring Program (NWQMP). High risk (mean As > 50 µg/L) districts currently identified include Lahore, Kasur, Bahawalpur, Muzaffarghar, Multan in the Punjab (Ahmad 2004; Farooqi et al. 2007a; Nickson et al. 2005; PCRWR 2008b) and Larkana and Mirpure Khas, Dadu in the Sind province (>200µg/L in some places) (Asghar 2006; PCRWR 2004) . Kazi et al., 2009 have reported the presence of As in the range of 35-152 µg/L in surface water from, Mancher lake in Sind (Kazi et al. 2009). The Punjab and the Sind provinces are the first and second highly populated provinces according to 1998 census report and thus presence of arsenic in drinking water in densely populated districts could be more problematic in the long run.

The relative importance of water and rice as exposure route for arsenic has been the subject of recent studies in West Bengal (Mondal and Polya 2008) and Bangladesh (Kile et al. 2007) amongst other places (Polya et al., 2010a), but there is a dearth of such data for Pakistan.

Here is a study of exposure to arsenic through drinking water and eating rice in Allama Iqbal Town, a peri-urban area in Lahore district, Punjab, Pakistan, which has previously been documented as an arsenic impacted district (Farooqi et al. 2007b; PCRWR 2008a, 2003a-b). A questionnaire based survey was carried out in the field for collection of information about water sources, consumption of water and rice, individual ingestion rates, health and socioeconomic status, smoking habits etc. It also report the output from a simple model (Mondal and Polya 2008) of arsenic attributable cancer risks, based on measured arsenic concentrations in water and rice and consumption data for water and rice. Lastly, the measurement of arsenic in hair and nails as proxies for arsenic exposure is evaluated.

Materials and methods

The study area

The area selected for study was an arsenic-impacted town, the Allama Iqbal town, district Lahore, located around 31.56°N 74.35°E. The Lahore district is located on a flat alluvial plain mainly on the left bank and a small apart on the right bank of the Ravi River (Figure 4.2). Lahore is the capital of Punjab covering an area of 2,306 km^2. It is the second largest city of Pakistan having 7.2 million populations (1998 census report). The district of Lahore is divided into 9 towns and further subdivided into 150 union councils. Allama Iqbal Town is one of the largest towns and comprises both urban as well as rural populations (Figure 4.1 and 4.2).

The climate of Lahore is semi-arid to sub-humid. The coldest month is January and the hottest is June having mean maximum temperatures of 40.8ºC respectively. The average rain fall in the area is 580 millimetres occurring during monsoon season, heaviest rain fall takes place during July, August and early September (65% of the total). The driest months are October and November.

Figure 4.1 Administrative boundary map of District Lahore showing different districts (Local Government, 2001)

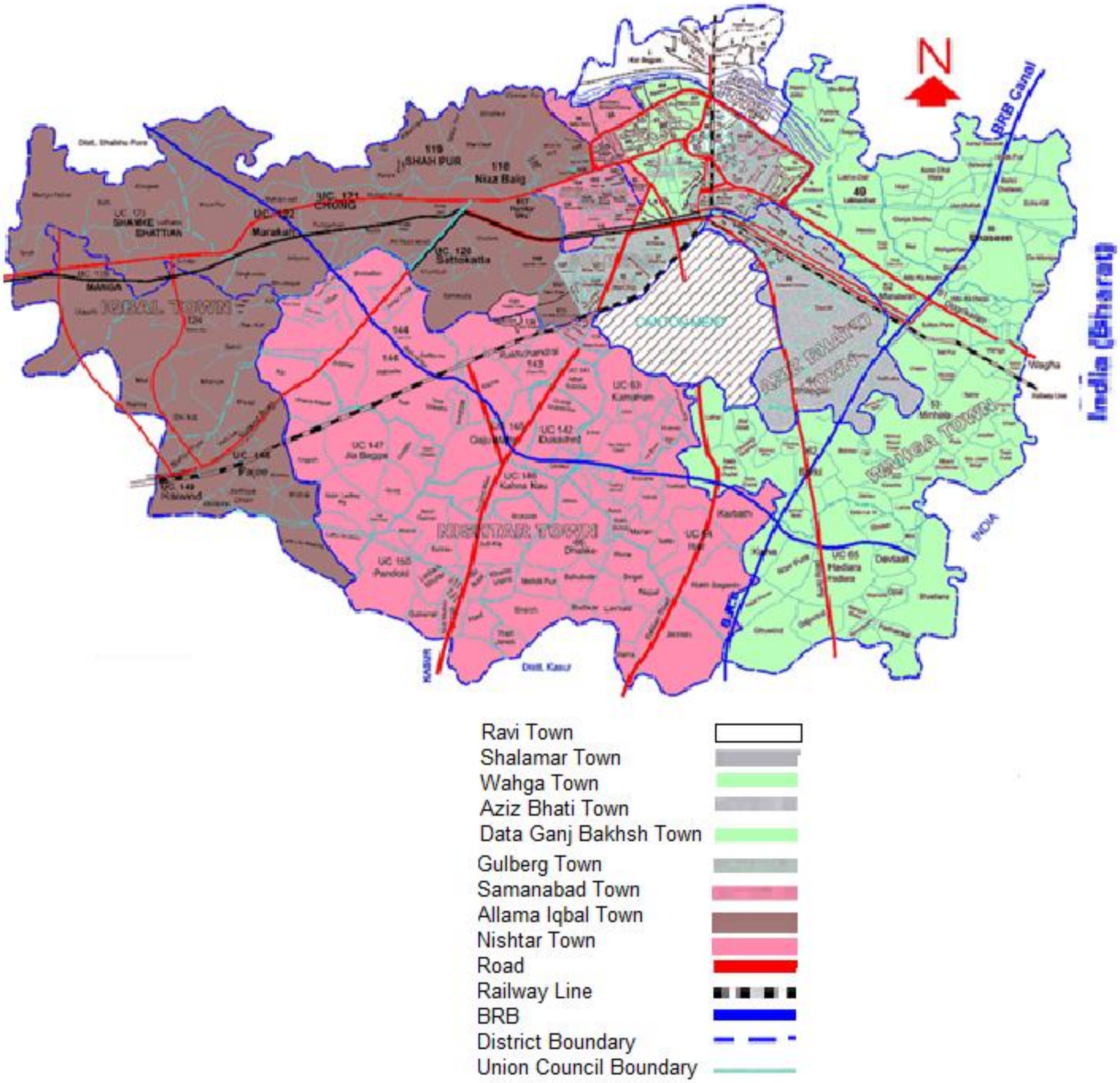
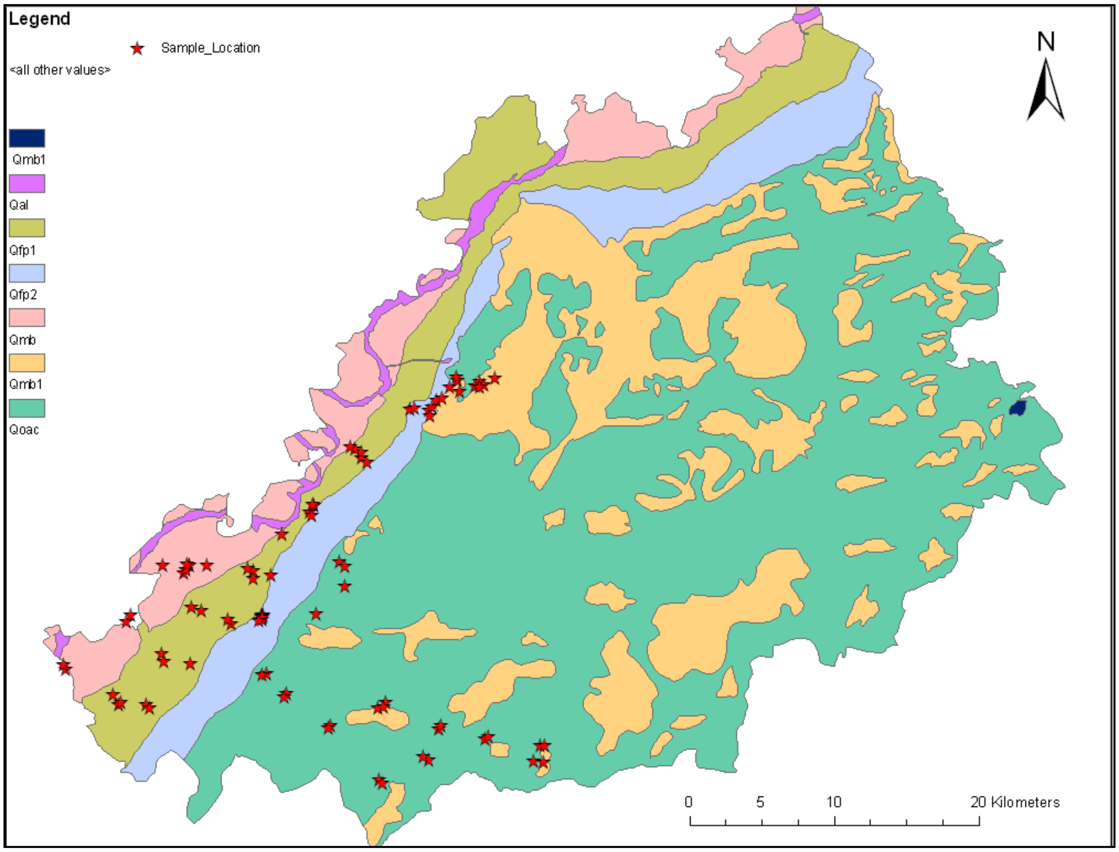


Figure 4.2 Geological map of District Lahore showing Sampling locations (GSP, 2009)



Qal- Unconsolidated sand, silt and loam; Qmb - Unconsolidated sand, silty sand;

Qfp1- Sand, silty sand and loamy clay; Qfp2- Silt and silty clay; Qmb1- Loamy clay and silt;

Qoac- Silty clay, clay and silt

Sampling and analytical technique

An informed consent was obtained from the individuals and guardians (in the case of children and females) before making a request of the samples. As such an activity is unusual in the field area, it was necessary to brief the people and in some cases the elders of the family about the purpose of sample collection. As human hair, nails and urine samples were collected prior to the field work an ethical approval was obtained from the Ethical committee of National Centre of Excellence in Geology, University of Peshawar for this study (see appendices for copy of ethical approval). All participants took part by their free will (for adults) and with the consent of their parents/guardians for children. An informed consent based questionnaire survey was carried out, and assurances were made to the participants about the confidentiality of their data which would be used for research purpose only.

A GPS (geographical positioning system) reading (latitudes and longitudes etc) was taken at each water sample collecting site for recording the sample location and future mapping.

The groundwater samples (n = 104) were collected in duplicate from kitchen taps, hand pumps, dug wells and tube wells of different house hold as well as some of the community tube wells in already labelled pre-cleaned plastic bottles (HDPE). Some of the field parameters, e.g., pH, Eh, electrical conductivity and temperature were measured on the spot with the help of different calibrated portable probes (Hanna Water Test Meter, What man Conductivity m-Sensor). After shifting all the samples to the Environmental Geochemistry lab, these samples were acidified with 2% nitric acid (doubled distilled from Aristar Grade, MERCK). An Inductively Coupled Plasma Mass Spectrometer (ICP-MS Agilent Technologies 7500 Inc) was used for total As analysis without any filtration of samples. A commercially available certified reference material for drinking water (Stream water 1640 from National Institute of Standards and Technology (NIST), USA) was used for QA purposes

Raw rice samples (n = 80) were collected from each household along with groundwater samples. Initially, rice samples were washed with de-ionized water (18 MΩ from Elga Pure lab Deioniser system) and oven dried at 65 °C for 48 h. Dried rice samples were ground manually using a porcelain pestle and a mortar to homogenize the material. The ground rice sample (0.2-0.5 g) was then used in open (on hot plat at 120 °C) as well as closed (Microwave, CEM Mars Express

2000) digestion following protocols of (Williams et al. 2006). The conditions for closed digestion were, 10 minutes to reach the temperature (170°C) then 20 minutes heating time at 170°C for the digestion. Power was 1600W (100%). The total run time was 30 minutes and the cooling time was 40-45 minutes. Rice speciation analysis was performed with the help of High pressure liquid chromatography Inductively Coupled Plasma Mass Spectrometer (ICP-MS Agilent Technologies 7500 Inc). Rice flour CRM 1568a (National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA) was also used to ascertain analytical accuracy, for quality control.

Hair, nail and urine samples were collected from volunteers along with their drinking water samples (tube well, dug wells and taps). Nails (both toe and finger nail) and hair (around 5 cm) sample cut from the nape of the neck from each individual using a clean pair of nail clippers/ scissors were collected in labelled, zip lock plastic bags. Any use by the volunteer of dye, gel or cosmetics was recorded. Both hair and nails were cleaned for any external contamination by following the methods of (Chen et al. 1999). Doubled distilled nitric acid (made from Aristar Grade, MERCK) was used for digestion of hair and nails samples. The digests were filtered, diluted with 18 MΩ water from Elga Pure lab Deionizer system and finally submitted to ICP-MS analysis for total As by the method described by Gault et al. (2008). For hair and nails samples, human hair reference material (NCS DC 73347 from China National Analysis Centre for Iron and Steel Beijing, China) was used fir QA purposes.

First morning voids were collected in cleaned, labelled polypropylene bottles. Creatinine in urine samples was tested by using Metra Creatinine Assay Kit (Quidel Corporation, USA) and a micro plate Reader (EL x 800 TM from Biotek supplied by North Star Scientific Ltd) used to record the OD(Optical Density). All urine samples already lysed and centrifuged were filtered and diluted 5 times with deionized water before being subjected to analysis. NIES no. 18 human urine CRM (from National Institute for Environmental Studies ONOGAWA 16-2, TSUKUBA, IBARAK, 305-0053 Japan) was used to check the accuracy of the method.

ICP-MS and IC-ICP-MS were used for total As and speciation of As respectively as per requirement of the experiment. All of the filtration for rice, hair, nails and urine samples was performed by using 0.45 µm (PTFE filters and Poly propylene syringes from VWR international) while for weighing all samples an analytical balance (Fisher brand PS-100) was used.

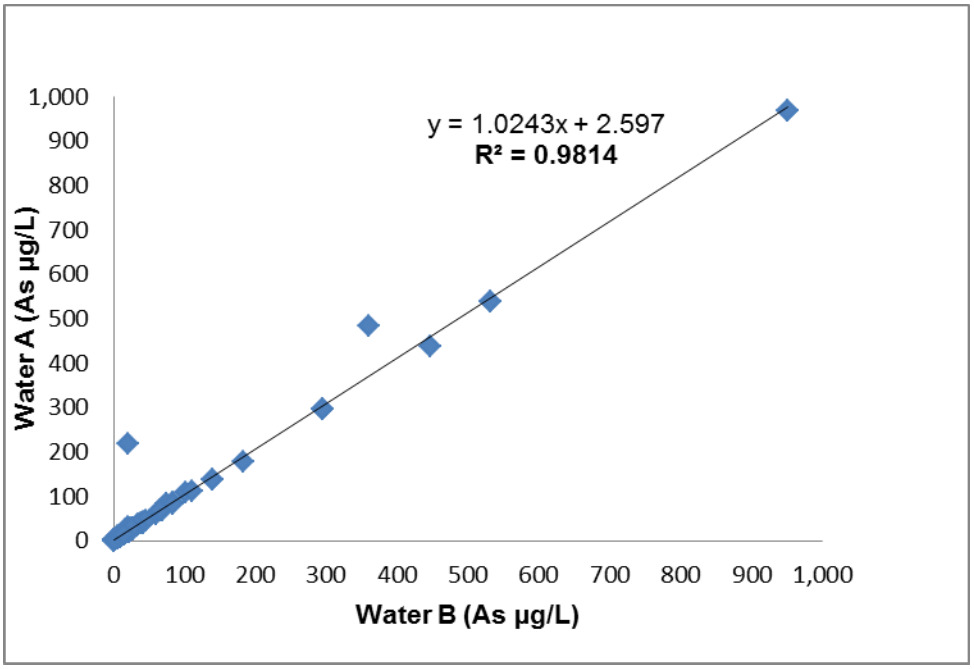
Quality control

Quality control measures (Table 4.1) were strictly followed during the analytical work. Certified reference material, duplicate samples and procedural blanks were used in each analytical run. For drinking/cooking water analysis on ICP-MS for total As a set of calibration standards (0, 5, 10, 50, 100, 500, 740 µg/L) were used to calibrate the instrument. Calibration standards were analysed at the start, end and after every 10 or so water samples to check for analytical drift during each session. There is a very significant agreement between the duplicate samples analysed with r = 0.98 (Fig 4.3). Analysis of the NIST (National Institute of Standards and Technology) SRM1640 for Trace Elements in Natural Water gave a result of 27.20 ± 0.9 µg/L (n=3) which is in close agreement with the certified value of 26.71 ± 0.41 µg/L. LOD (Limit of detection) for the analyses, calculated from value for blank plus two times the standard deviation of the blank were typically around 0.1 µg/L.

Table 4.1 Quality Control: results of ICP-MS analysis of CRMs

Media	No. of session	Calibration Standards	CRM literature value	CRM found value
Water	4	1, 5,10,50,100,700 µg/L	26.67±0.41 µg/L	25.49 ± 0.42 µg/L
Raw rice	5	1,5,10,50 µg/L	0.29±0.03 mg/kg	0.28 ± 0.03 mg/kg
Urine	1	5,10,20,50,100,500 µg/L	137±11 µg/L	151 ±17 µg/L
Hair	3	1, 5, 10, 50, 100 µg/L	0.28±0.04 mg/kg	0.28 ±0.03 mg/kg
Nail	2	1, 5, 10, 50, 100 µg/L	0.28±0.04 mg/kg	0.29 ±0.015 mg/kg

Figure 4.3 Comparison of analysis of duplicate water samples (A and B) for total arsenic (µg/L)



Raw rice samples analysis was also accompanied by procedural blanks, CRM and 20% duplicate sample analysis for assurance of experimental quality. Calibration standards (0, 1, 5, 10, 20, 50 µg/L) were used to calibrate the instrument before as well as during the analytical run.

The certified reference material used for rice was NIST rice flour 1568a gives a value of 0.28±0.03 (n=12) which is very near to its certified value of 0.29 ± 0.03. Each analytical session was accompanied by 20% duplicate as well procedural blanks analysis for QC measurement.

There is positive correlation (r^2= 0.46) (p < 0.01) between the amount of total As analysed by ICP-MS and the species sum found by IC-ICP-MS (Figure 4.7) which show us the quality of our results for raw rice.

Exposure and risk calculation

Drinking water was not filtered for arsenic analysis because it is consumed by the people as it is. Daily intake of water and rice by volunteers was determined with the help of information collected by questionnaires survey along with information regarding the socio economic set up, health, dietary habits, age and gender distribution, education, amount of water used for drinking and cooking and sources of water used. A standardized questionnaire (derived from one used in Cambodia by (Gault et al. 2008a) has been used.

During the field survey at least one principal user of each water source was interviewed in the national language, Urdu, and body mass index (BMI, kg/m^2) was also calculated for him/her. Chronic daily intake (CDI µg/kg/body wt.) for each individual was calculated on the basis of this provided information. USEPA (1989) one hit model was used to estimate excess life time cancer risk due to arsenic intake from ground water and rice.

Results and discussion

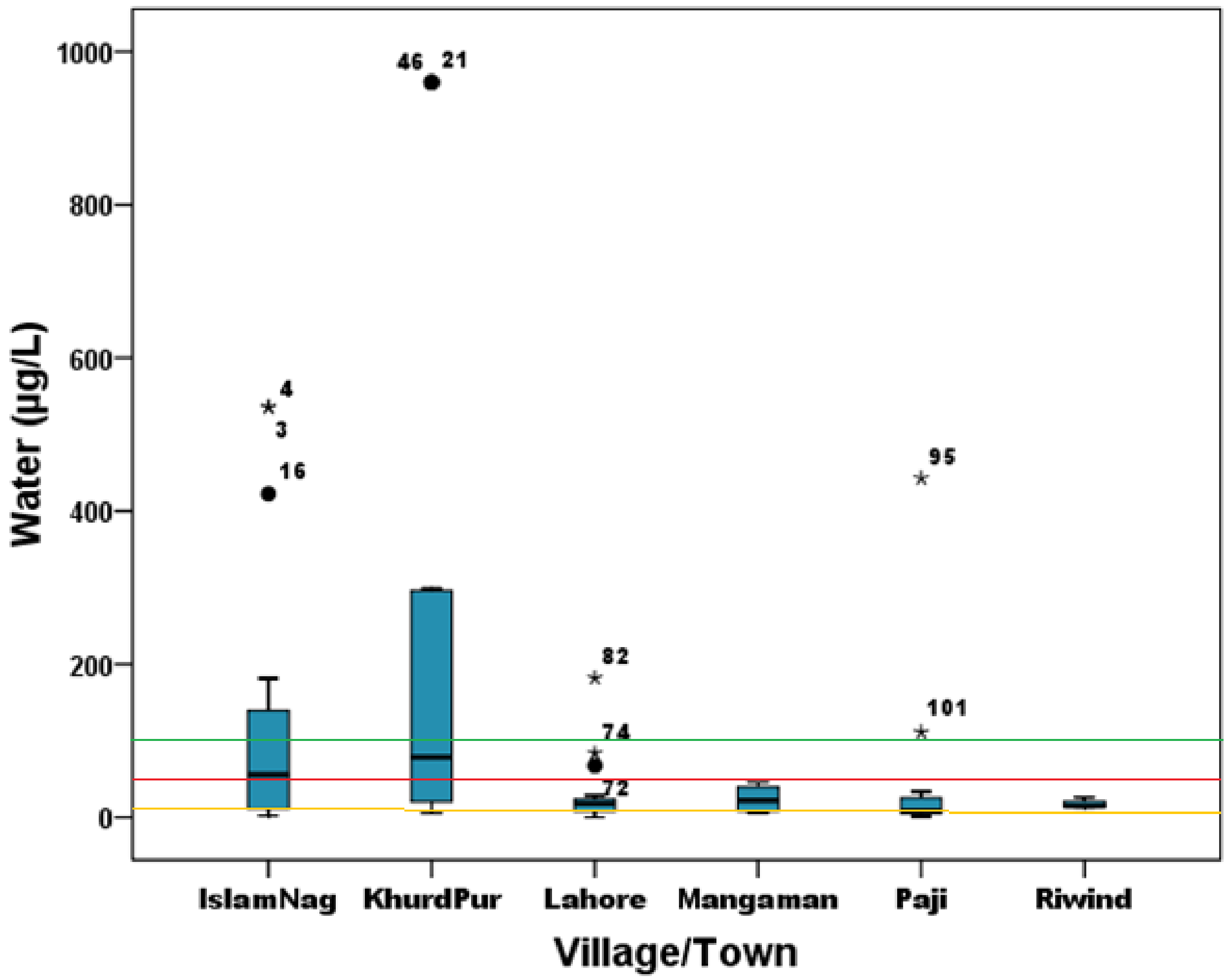
The household survey for collecting drinking and cooking water samples from various sources (tube wells, hand pumps and dug well) existed in the field area was conducted during March-April 2009 in Allama Iqbal Town a peri-urban area of district Lahore, Punjab, Pakistan to have an idea about the arsenic exposure of the local population. The summary of the physico-chemical parameters and As concentration of ground water used for drinking and cooking purpose originated from different sources of the surveyed village /colony is presented in (table 4.4) (Supplementary Information).

The pH of the groundwater is slightly basic (mean 8; range 7.2–9.4) the electrical conductivity ranged (88–3100 µS/cm) with mean (1046 µS/cm). The Eh values range from −109 to 160 mV; mean: 80- mV (see Table 1) in supplementary information.

Arsenic concentration in the drinking and cooking water in Allama Iqbal town was found to be as high as 960 µg/L with a mean of 91 µg/L. As concentrations of the drinking water sources derived from ground water and used by volunteers mostly had a higher value than the WHO provisional guideline value of 10 µg/L. The median As concentration value was 24 µg/L which was more than double the 10 µg/L WHO provisional guideline value for arsenic in drinking water (Figure 4.4) (Table 4.3). 81 % (*n* = 83) of drinking water sources were above the WHO recommended values of 10 µg/L while for 29 % of the values (*n* = 30) were above 50/ µg/L which is the national environmental quality standard for Pakistan (NEQS).

This high value of 960 µg/L found here from Allama Iqbal town Lahore is near to the value (906 µg/L) reported by Nickson et al., 2005 in Muzaffar Ghar which is another arsenic impacted district from Punjab Pakistan (Nickson et al. 2005).

Figure 4.4 Distribution of As in drinking water (µg/L) from households of Allama Iqbal Town, Lahore. Box and whisker plot shows inter-quartile range as a box, total range as whisker, with outliers indicated by dots or stars which are included in calculation.



Discussion about various steps involved during raw rice cleaning, extraction and analysis

Washing with water having less than 10 µg/L As can reduce the As content of rice by up to 28 % (Sengupta et al. 2006). The traditional washing and cooking practiced in most of the Indian subcontinent - includes washing until clear and then cooking rice with lots of water (rice:

water ratio of 1:6) and discarding the excess water after cooking - could reduce the amount of As in rice (Ackerman et al. 2005; Raab et al. 2009; Sengupta et al. 2006).

Arsenic concentration in cooking water is also very important as it can increase total arsenic in cooked rice when rice is being cooked in contaminated water (Mondal and Polya 2008). Cooking method has been considered very important in the As risk estimation from cooked rice and different studies have recommended the traditional method of rice cooking in order to reduce risk especially in the As endemic areas (Ackerman et al. 2005; Liao et al. 2010; Meharg et al. 2009; Mihucz et al. 2007; Ohno et al. 2009; Raab et al. 2009; Watanabe et al. 2002). Conversely washing rice with water having 50 µg/L As can increase the amount of As in cooked rice (Sengupta et al. 2006; Signes et al. 2008; Watanabe et al. 2002).

Raw rice arsenic concentration ranged from 0.03 mg/kg to 0.25 mg/kg with a median value of 0.095 mg/kg (green line in Figure 4.5) and only few samples has a value above 0.15 mg/kg (Chinese MCL for rice) The mean rice arsenic concentration is not as high as reported in the other regions of south East Asian countries.

Nearly 70% of the arsenic found in rice is inorganic As, while the rest is organic As (29% DMA and 1% MMA) (Fig 4.6). The results for inorganic contents of rice is similar to values found in west Bengal (74±13% iAs (Mondal and Polya 2008) and reported by (Williams et al. 2005). for Bangladeshi and Indian rice (80-81%).

Figure 4.5 Distribution of total As (mg/L) in raw rice samples collected from Allama Iqbal Town, Lahore. . Box and whisker plot shows inter-quartile range as a box, total range as whisker, with outliers indicated by dots or stars which are included in calculation.

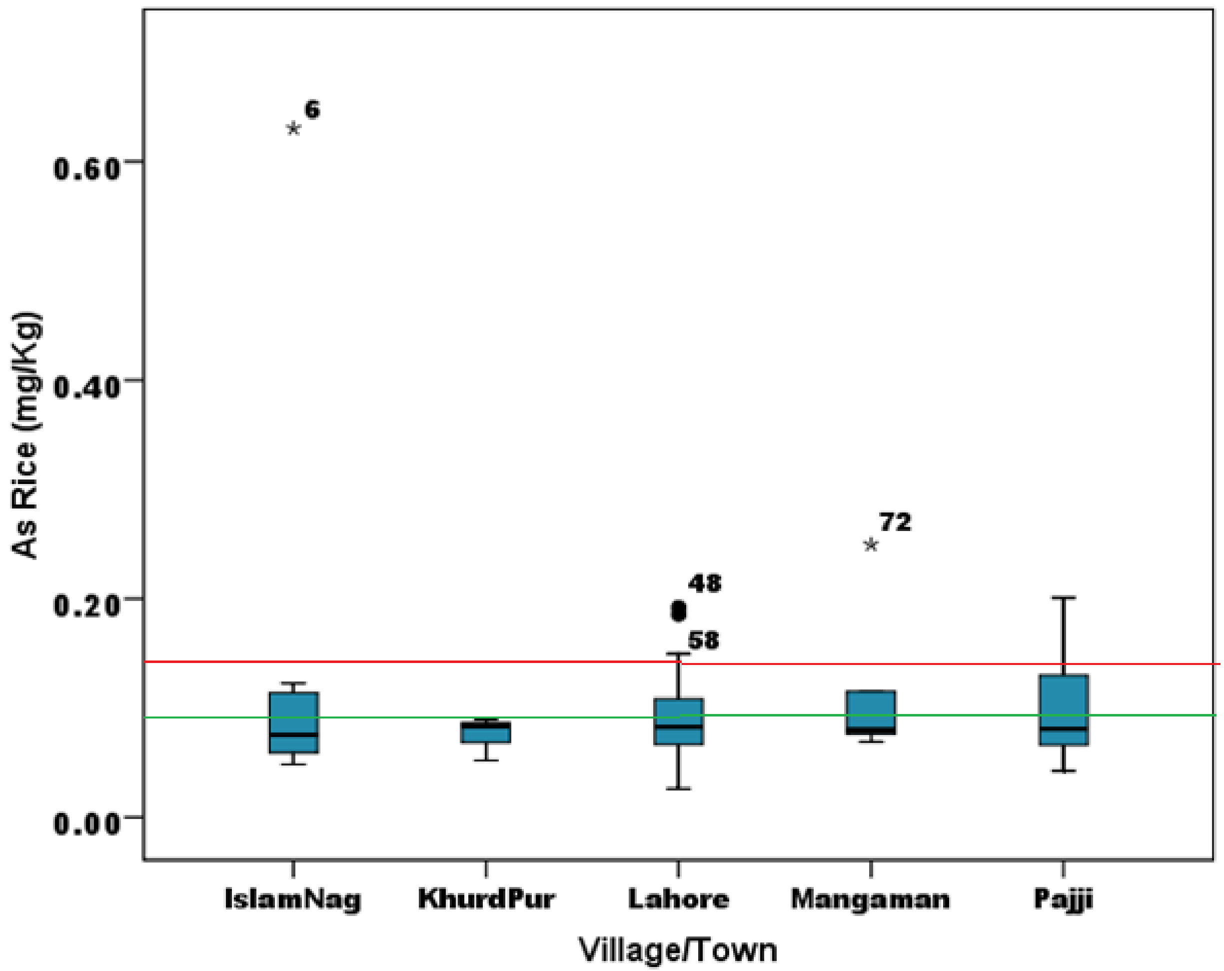


Figure 4.6 Organic (DMA, MMA & As-B) and inorganic species distribution in raw rice from different households units of Allama Iqbal Town, Lahore. .

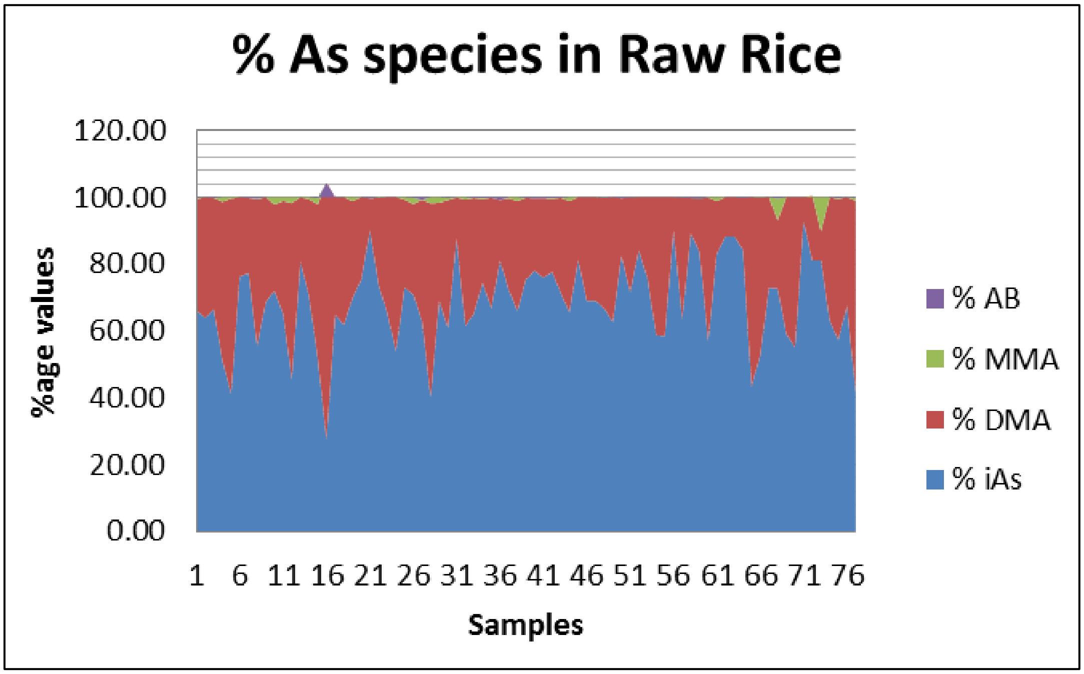
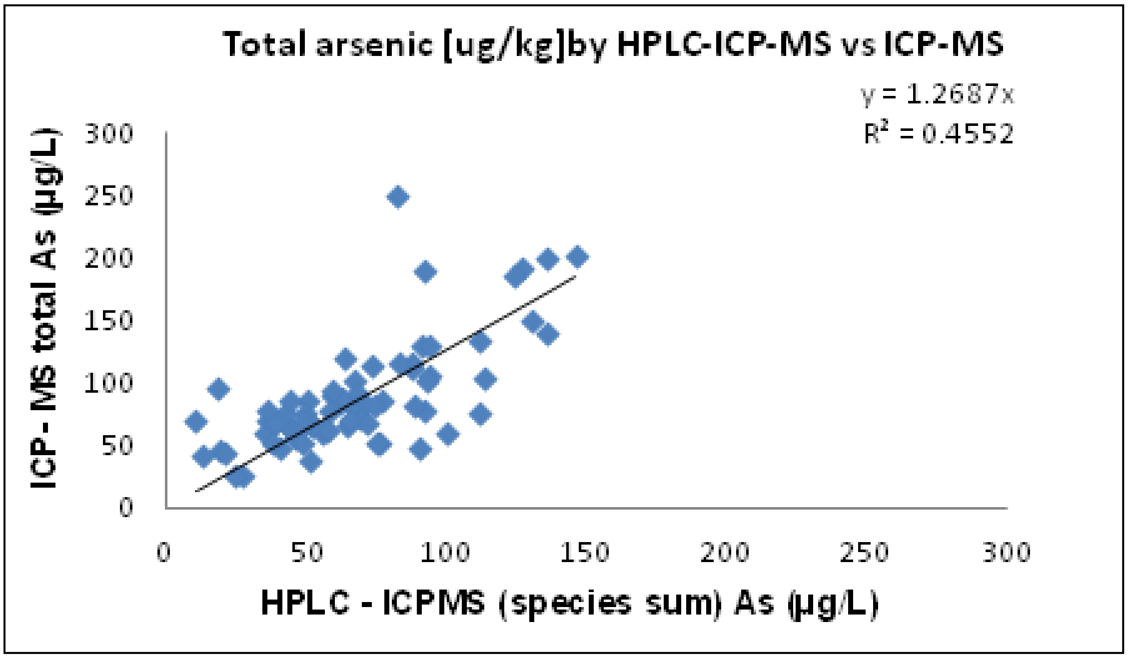


Figure 4.7 Comparison of the results (total As in µg/L) by ICP-MS and HPLC-ICPMS (species sum)



Although majority of residents use wheat, and rice is only consumed 2-3 times a week, nevertheless chronic daily intake values (0.04- 1.43 mg/kg/day) median = 0.27 mg/kg/day (Table 4.3) can be problematic for a fraction of residents who eat rice two times daily.

Basmati rice, which is locally cultivated and very popular all over the world is used in 99% of the area, rice variety is important because variation in As content of rice depends on its variety (Meharg and Rahman 2003).

Different environmental exposures, for example drinking, cooking with As contaminated water or eating As contaminated food and also the cooking methods of food are mainly responsible for As contamination (Carbonell et al. 2009; Chakraborti et al. 2009a; Del Razo et al. 2002).

Arsenic contamination in rice has been documented to be incorporated by As contaminated irrigation water and paddy field soils (Bhattacharya et al. 2010a; Bi et al. 2011; Brammer 2009; Brammer and Ravenscroft 2009; Chen et al. 2006; Chon et al. 2008; Das et al. 2007; Duxbury et al. 2009) in rice irrigated areas. Cooking method is also very important (Rahman et al. 2006) because cooking of rice with water saturated with arsenic increases the cooked rice arsenic content (Bae et al. 2003; Laparra et al. 2005; Ohno et al. 2007) thus the use of cooked rice has been recommended for risk assessment purpose (Bae et al. 2003) but here I have collected raw rice only. The impact on risk assessment is likely to be small, however, because compared to rice, water was the dominant route of exposure for 90 % of the volunteers. Total calculated daily intakes (CDI) ranged from 0.04 µg/kg/day to 87 µg/kg/day with a mean value of 4 µg/kg/day and a median value of 1 µg/kg/day (Table 3). The median CDI is broadly comparable to values previously published for other arsenic impacted areas (Kile et al. 2007; Mondal and Polya 2008). The mean value of total arsenic exposure study exceeds the World Health Organization's provisional tolerable daily intake (PTDI) of 2.1 µg As/kg-day.

Hair and nails samples have been proved as useful biomarkers for chronic arsenic exposure assessment, although external contamination is a concern (Orloff et al. 2009; Torres et al. 2009). There are only a small number of studies who proved the exposure assessment from medium like food and water ingestion by using biological markers to check the human dose response relationship (Ollson et al. 2009). Here we found, elevated concentrations of arsenic in hair (range 0.03 mg/kg to 14.6 mg/kg median 0.99 mg/kg) and nails (range 0.53 mg/kg to 65 mg/kg median 0.94 mg/kg) (Table 4.3). Both hair and nail arsenic has a positive correlation with drinking water As concentration (Figures 4.8).

Values of arsenic concentration in hair from the volunteers of Allama Iqbal town is higher than reported by (Agusa et al. 2006) for a study in Vietnam (0.09-2.77 µg/g with median 0.04 µg/g), Gault et al., (2008) in Cambodia (0.10-7.95 µg/g have median 0.54 µg/g), and Mosaferi et al., 2005 in Iran (0.02-3.42 mg/kg) (Gault et al. 2008b; Mosaferi 2003; Torres et al. 2009). Anwar et al., 2005 have reported mean values of As contents in hair (0.31 mg/kg) and nails (0.7 mg/kg) for residents of Lahore and suburban areas which is less than our reported results (Anwar 2005).Arsenic concentration values in this study are comparable to those of Kiel et al., 2007, to

Monroy-Torres et al., 2009 in children from rural areas of Mexico (0.006-5.9 µg/g with a mean value of 1.3 µg/g) and Kubota et al., 2006 (0.05-16 µg/g and a median 0.79 µg/g) (Kile 2007; Kubota et al. 2006).

The linear correlation value calculated for As content of hair and total CDI for males population is ($r^2 = 0.46$) and ($p < 0.01$) and female ($r^2 = 0.56$) ($p < 0.01$) is significant (Fig 4.9). Comparatively better associations have been found in females then males. It may be due to females spend more time at home, common for this sect of society in the prevailing culture of the area.

An average daily total arsenic intake of 174 µg/day has been reported by Kiel et al., 2007 while a comparatively higher value of 515 µg/day is documented by another study of Watanabe et al 2004 but they have used different methods of the food samples collection in Bangladesh (Watanabe et al. 2004).

Figure 4.8 Association of As concentration in drinking water with amount of As concentration in human hair samples from the volunteers of AI Town Lahore (marked by Gender)

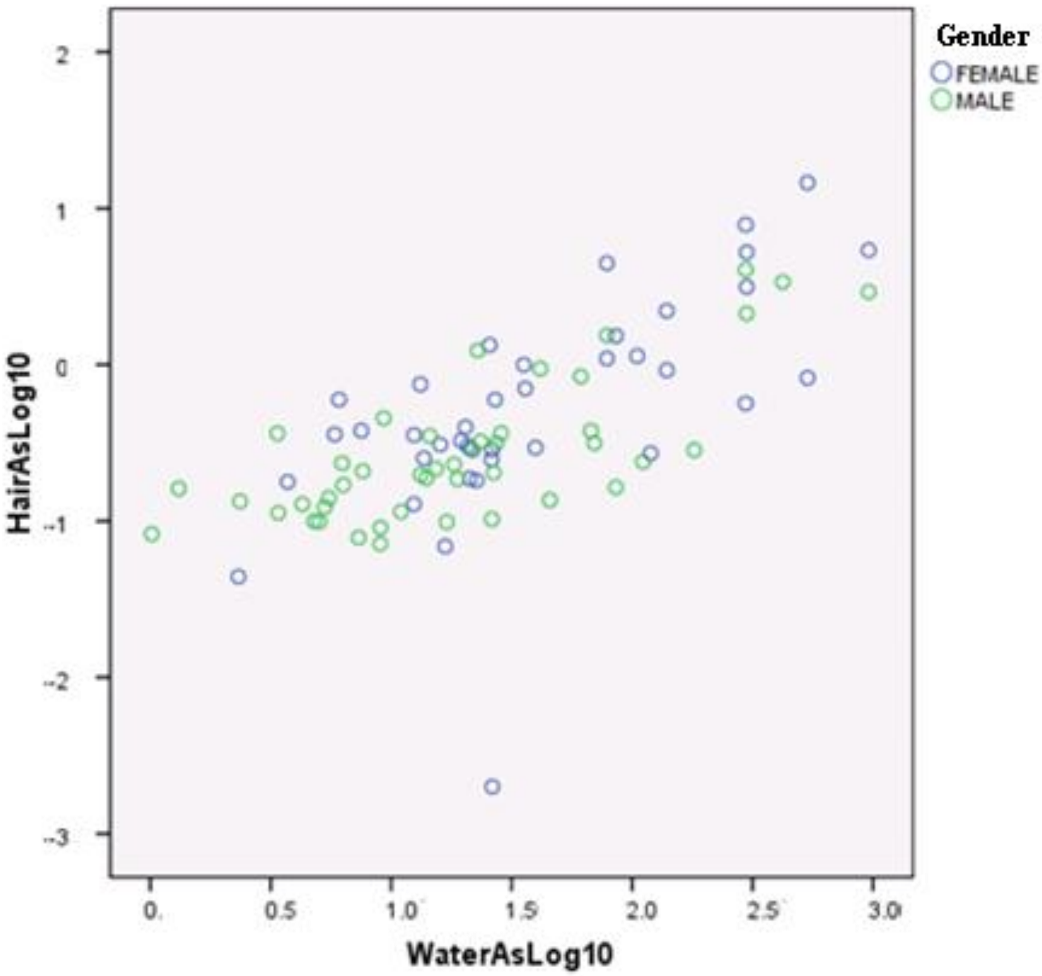
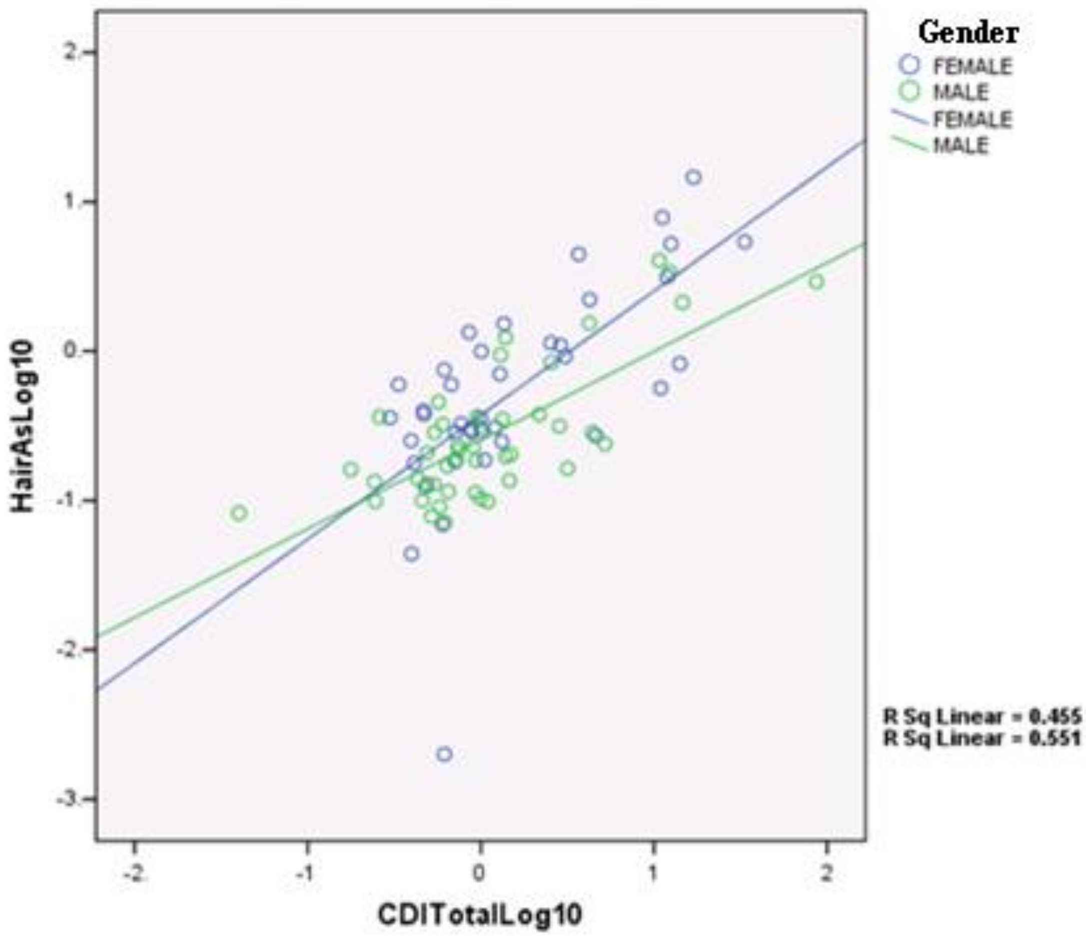


Figure 4.9 Association of total daily intake with amount of As concentration in human Hair samples from the volunteers of AI Town Lahore (marked by Gender)



The pearson correlation (sig. 2 tailed) values of drinking water arsenic with hair As concentration is (r^2= 0.63) (p < 0.01) (n=84) is significant and arsenic concentration in nails (r^2= 0.24) (p < 0.01) are both positive and significant, particularly for hair. . The association of As concentration in drinking water with CDI from Water (r^2= 0.99) (p < 0.01) and water and rice

(r^2= 0.91) (p < 0.01) is highly significant.. These associations point to ingesting arsenic contaminated water is the major exposure route in Allama Iqbal town, Lahore.

Life time risk values in both male and female population of Allama Iqbal Town Lahore

The calculated median increased life time cancer risk due to drinking water ($3.30E^{-03}$) is much higher than the 10^{-4}–10^{-6} threshold range typically used by USEPA. The median excess life time cancer risk from rice ($2.27E^{-03}$) and both from rice and drinking water together ($3.52E^{-01}$) is also higher than the USEPA thresh hold value (Table 4.2). The median life time cancer risk from both drinking/cooking water and rice value among female population is higher and are more voluenerable to cancer risk due to their low body mass value and mostly has no other outside drinking water source.

The questioner based interview survey of the area gave us an indication about some other confounding factors like dietary approach, lifestyle habits, gender, age, health status, socioeconomic status, demographic variable, education and awareness level of the residents of the area. All these factors also play a very important role in addition to the amount of arsenic in drinking water and rice as well as the exposure duration.

Table 4.2 Arsenic life time risk values for both male and female population of Allama Iqbal Town Lahore, Pakistan

	Risk water	Risk rice	Risk total	% risk from water	% risk from rice
Male	$1.64E^{-01}$	$9.45E^{-03}$	$1.73E^{-01}$	9454.51%	545.49 %
Female	$1.66E^{-01}$	$1.33E^{-02}$	$1.79E^{-01}$	9259.89%	740.11 %

Table 4.3 Descriptive Statistics for arsenic concentration in different media collected from Allama Iqbal town, Lahore Population

	N	Mean	Median	Std. Deviation	Minimum	Maximum	95th Percentile	99th Percentile
BMI	103	24.24	22.82	6.42	13.50	52.69	36.43	52.25
Water intake (L)	103	1.94	1.70	0.69	1.05	4.50	3.45	4.49
Age (y)	103	32.83	28.00	16.16	11.00	85.00	65.00	85.00
Nail (mg/kg)	86	2.76	0.85	7.47	0.17	64.57	13.00	64.57
Hair (mg/kg)	83	1.00	0.30	2.05	0.04	14.61	5.08	14.61
Urine (µg/g creatinine)	23	134.13	117.90	95.48	18.74	349.55	345.19	349.55
Rice (mg/kg)	88	0.10	0.08	0.09	0.03	0.63	0.20	0.63
Water (µg/L)	106	91.27	22.68	186.34	0.06	959.85	503.11	959.85
CDI Rice (µg/kg/day)	88	0.34	0.30	0.26	0.08	1.88	0.83	1.88
CDI water (µg/kg/day)	103	3.78	0.60	10.62	0.00	86.39	16.40	84.85
CDI Total (µg/kg/day)	103	4.07	0.94	10.64	0.00	86.65	16.94	85.11

Smoking Status

39 out of 104 (37 percent) of the respondents have reported different kinds of health problems.14 percent (15/104 respondents) are smokers and rest of them (89) are non –smokers, out of these 15 smokers 9 people have health problems. 6 respondents has recorded skin problems of which 3 has rain drops on skin and nodules in palm and sole while 2 has black patches on skin and one has rough skin of hands and palm.

There are reported cases of increased risk of lung and bladder cancer in smokers who consume high concentration of arsenic in drinking water (Adonis et al. 2005; Bates et al. 2004; Ferreccio et al. 2000; Kurttio et al. 1999) for example recently a study by Mostafa et al 2008 in Bangladeshi population who are smokers and taking more than 100 µg/l As in drinking water are reported at high risk of lung cancer (Kurttio et al. 1999).

In addition there are 17/104 other respondents who has recorded skin problems having roughness of skin with nodules on palm and soles and rain drops on their body skin but they reported themselves as non-smokers. All the respondents who reported as smokers were males.

There is possibility of biasness on the part of respondents while reporting their smoking status, as smoking is not being considered as good habit especially in Pakistani society and smoker's ratio could be actually much higher in the study area. Other commonly reported health problems were mostly coughs, high blood pressure, headaches and weakness..

Conclusion

Water is the most important and a serious arsenic exposure route in Allama Iqbal Town, Lahore Pakistan. The excess life time cancer risk from water both for male and female population in Allama Iqbal Town, Lahore is much higher than10^{-4}–10^{-6} threshold range typically used by USEPA. Hair arsenic exhibited a good positive correlation with drinking water arsenic concentration suggesting that water was the dominant route of exposure in the volunteers studied; and (ii) hair is a useful proxy for exposure. Rice cannot be eliminated a potential significant route for some people in the area with high rice diets. Other factors, e.g. variations in water and rice supply, diet, dietary pattern, genetic, age may also, in combination, are important in determining human exposure in this area. Water is a more important arsenic exposure route than rice in Allama Iqbal Town, Lahore, Pakistan.

The arsenic exposures through various pathways (drinking groundwater, food and dietary habits) show an urgent need for regulatory measures and effective policy making for quality health.

References

Adonis M, Martínez V, Marín P, Berrios D, Gil L. 2005. Smoking habit and genetic factors associated with lung cancer in a population highly exposed to arsenic. Toxicology Letters 159(1): 32-37.

Agusa T, Kunito T, Fujihara J, Kubota R, Minh TB, Kim Trang PT, Iwata H, Subramanian A, Viet PH, Tanabe S. 2006. Contamination by arsenic and other trace elements in tube-well water and its risk assessment to humans in Hanoi, Vietnam. Environmental pollution (Barking, Essex 139(1): 95-106.

Ahlborn GJ, Nelson GM, Grindstaff RD, Waalkes MP, Diwan BA, Allen JW, Kitchin KT, Preston RJ, Hernandez-Zavala A, Adair B, Thomas DJ, Delker DA. 2009. Impact of life stage and duration of exposure on arsenic-induced proliferative lesions and neoplasia in C3H mice. Toxicology 262(2): 106-113.

Ahmad T K, M.A.,Tahir, A. and Rashid, H. 2004. Arsenic an Emerging Issue: Experiences from Pakistan In: Proceedings of the 30th WEDC international conference. Vientiane, Lao PDR.

Anwar M. 2005. Arsenic, cadmium and lead levels in hair and toenail samples in pakistan. Environ Sci 12(2): 71-86.

Arain GM, Aslam M, Majidano SA, Khuhawar MY. 2007. A Preliminary Study on the Arsenic Contamination of Underground Water of Matiari and Khairpur Districts, Sindh, Pakistan. Journal of the Chemical Society of Pakistan 29(5): 463-467.

Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Jalbani N, Sarfraz RA, Shah AQ, Kandhro GA. 2009. Respiratory effects in people exposed to arsenic via the drinking water and tobacco smoking in southern part of Pakistan. Science of The Total Environment 407(21): 5524-5530.

Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Shah AQ, Jalbani N, Sarfraz RA. 2009. Determination of arsenic levels in lake water, sediment, and foodstuff from selected area of Sindh, Pakistan: Estimation of daily dietary intake. Food and Chemical Toxicology 47(1): 242-248.

Arain MB, Kazi TG, Jamali MK, Jalbani N, Afridi HI, Shah A. 2008. Total dissolved and bioavallable elements in water and sediment samples and their accumulation in Oreochromis mossambieus of polluted Manchar Lake. Chemosphere 70(10): 1845-1856.

Argos M, Kalra T, Rathouz PJ, Chen Y, Pierce B, Parvez F, Islam T, Ahmed A, Rakibuz-Zaman M, Hasan R, Sarwar G, Slavkovch V, va Green A, Graziano J, Ahsan H. 2010. Arsenic exposure from drinking water, and all-cause and chronic-disease mortalities in Bangladesh (HEALS): a prospective cohort study. The Lancet 376(9737): 252-258.

Asghar U, Perveen F, Siddiqui I, Usmani TH. 2006. Contamination of arsenic in public water supply schemes of Larkana and Mirpurkhas districts of Sind. Journal of chemical society of Pakistan 28: 130-135.

ATSDR. 2007. Toxicological Profile for Arsenic (Update). United States Department of Health and Human Services: Atlanta, GA, USA.

Bae M, Watanabe C, Inaoka T. 2003. Arsenic in cooked rice in Bangladesh (vol 360, pg 1839, 2002). Lancet 361(9362): 1060-1060. Publisher, LANCET LTD, 84 THEOBALDS RD, LONDON WC1X 8RR, ENGLAND

Bates MN, Rey OA, Biggs ML, Hopenhayn C, Moore LE, Kalman D, Steinmaus C, Smith AH. 2004. Case-Control Study of Bladder Cancer and Exposure to Arsenic in Argentina. American Journal of Epidemiology 159(4): 381-389.
Bhattacharya P, Samal AC, Majumdar J, Santra SC. 2010. Arsenic Contamination in Rice, Wheat, Pulses, and Vegetables: A Study in an Arsenic Affected Area of West Bengal, India. Water Air Soil Poll 213(1-4): 3-13.
Bhattacharya P, Welch AH, Stollenwerk KG, McLaughlin MJ, Bundschuh J, Panaullah G. 2007. Arsenic in the environment: Biology and Chemistry. Science of The Total Environment 379(2-3): 109-120.
Bi XY, Fu YR, Chen ML, He YS, Ren LM, Xiang W, Qiao SY, Yan S, Li ZG, Ma ZD. 2011. Occurrence of arsenic in brown rice and its relationship to soil properties from Hainan Island, China. Environmental Pollution 159(7): 1757-1762.
Brammer H, Ravenscroft P. 2009. Arsenic in groundwater: A threat to sustainable agriculture in South and South-east Asia. Environment International 35(3): 647-654.
Brammer H. 2009. Mitigation of arsenic contamination in irrigated paddy soils in South and South-east Asia. Environment International 35(6): 856-863.
Bundschuh J, Litter M, Ciminelli VST, Morgada ME, Cornejo L, Hoyos SG, Hoinkis J, Alarcon-Herrera MT, Armienta MA, Bhattacharya P. 2010. Emerging mitigation needs and sustainable options for solving the arsenic problems of rural and isolated urban areas in Latin America - A critical analysis. Water Research 44(19): 5828.
Carbonell-Barrachina AA, Signes-Pastor AJ, Vazquez-Araujo L, Burio F, Sengupta B. 2009. Presence of arsenic in agricultural products from arsenic-endemic areas and strategies to reduce arsenic intake in rural villages. Mol Nutr Food Res 53(5): 531-541.
Caussy D, Gochfeld M, Gurzau E, Neagu C, Ruedel H. 2003. Lessons from case studies of metals: investigating exposure, bioavailability, and risk. Ecotoxicology and Environmental Safety 56(1): 45-51.
Chakraborti D, Pal A, Chowdhury UK, Mondal D, Das B, Nayak B, Ghosh A, Maity S. 2009. Arsenic Burden from Cooked Rice in the Populations of Arsenic Affected and Nonaffected Areas and Kolkata City in West-Bengal, India. Environmental Science & Technology 43(9): 3349-3355.
Chakraborti D, Rahman MM, Paul K, Chowdhury UK, Sengupta MK, Lodh D, Chanda CR, Saha KC, Mukherjee SC. 2002. Arsenic calamity in the Indian subcontinent What lessons have been learned? Talanta 58(1): 3-22.
Chakraborti D, Sengupta MK, Rahman MM, Ahamed S, Chowdhury UK, Hossain MA, Mukherjee SC, Pati S, Saha KC, Dutta RN, Zaman QQ. 2004. Ground water arsenic contamination and its health effects in the Ganga-meghna-Brahmaputra plain. J Environ Monitor 6 (6): 72-83.
Chatterjee D, Haider D, Majumder S, Biswas A, Nath B, Bhattacharya P, Bhowmick S, Mukherjee-Goswami A, Saha D, Hazra R, Maity PB, Chatterjee D, Mukherjee A, Bundschuh J. 2010. Assessment of arsenic exposure from groundwater and rice in Bengal Delta Region, West Bengal, India. Water Research 44(19): 5803-5812.
Chen BW, Hua N, Lu ML, Le XC. 2009. Metabolism, Toxicity, and Biomonitoring of Arsenic Species. Progress in Chemistry 21(2-3): 474-482.
Chen CH, Chiou HY, Hsueh YM, Chen CJ, Yu HJ, Pu YS. 2009. Clinicopathological characteristics and survival outcome of arsenic related bladder cancer in taiwan. The Journal of Urology 181(2): 547-552; discussion 553.
Chen C-J, Tsung-Li K, Wu M-M. 1988. ARSENIC AND CANCERS. The Lancet 331(8582): 414-415.

Chen C-L, Hsu L-I, Chiou H-Y, Hsueh Y-M, Chen S-Y, Wu M-M, Chen C-J. 2004. Ingested arsenic, cigarette smoking, and lung cancer risk: A follow-up study in arseniasis-endemic areas in taiwan. JAMA: The Journal of the American Medical Association 292(24): 2984-2990.
Chen KL, Amarasiriwardena CJ, Christiani DC. 1999. Determination of total arsenic concentrations in nails by inductively coupled plasma mass spectrometry. Biological trace element research 67(2): 109-125.
Chen ZL, Wang FM, Zhang L, Gao YL, Sun YX. 2006. Arsenic uptake and accumulation in rice (Oryza sativa l.) at different growth stages following soil incorporation of roxarsone and arsanilic acid. Plant and Soil 285(1-2): 359-367.
Chilton PJ. 2001. Pakistan water quality mapping and management project. Scoping study – draft final report Loughborough, UK:Water Engineering and Development Centre, Loughborough University & London School of Hygiene & Tropical Medicine, (WELL Task 568).
Chiou HY, Chiou ST, Hsu YH, Chou YL, Tseng CH, Wei ML, Chen C-J. 2001. Incidence of transitional cell carcinoma and arsenic in drinking water: a follow-up study of 8,102 residents in an arseniasis-endemic area in northeastern Taiwan. American Journal of Epidemiology 153(5): 411-418.
Chiou HY, Hsueh YM, Hsieh LL, Hsu LI, Hsu YH, Hsieh FI, Wei ML, Chen HC, Yang HT, Leu LC, Chu TH, Chen-Wu C, Yang MH, Chen CJ. 1997. Arsenic methylation capacity, body retention, and null genotypes of glutathione S-transferase M1 and T1 among current arsenic-exposed residents in Taiwan. Mutat Res 386(3): 197-207.
Chon HT, Lee JS, Lee SW, Kim KW. 2008. Evaluation of human exposure to arsenic due to rice ingestion in the vicinity of abandoned Myungbong Au-Ag mine site, Korea. Journal of Geochemical Exploration 96(2-3): 231-235.
Das DK, Prosun Bhattacharya ABMJBRZ, Richard HL. 2007. Effects of arsenic-contaminated irrigation water, zinc and organic matter on the mobilization of arsenic in soils in relation to rice (Oryza sativa L.). In: Trace Metals and other Contaminants in the Environment, Vol. Volume 9:Elsevier, 339-362.
Del Razo LM, Garcia-Vargas GG, Garcia-Salcedo J, Sanmiguel MF, Rivera M, Hernandez MC, Cebrian ME. 2002. Arsenic levels in cooked food and assessment of adult dietary intake of arsenic in the Region Lagunera, Mexico. Food and Chemical Toxicology 40(10): 1423-1431.
Duxbury JM, Panaullah GM, Alam T, Hossain MB, Loeppert RH, Lauren JG, Meisner CA, Ahmed ZU. 2009. Arsenic toxicity to rice (Oryza sativa L.) in Bangladesh. Plant and Soil 317(1-2): 31-39.
EFSA. 2009. Scientific Opinion on Arsenic in Food, EFSA Panel on Contaminants in the Food Chain (CONTAM)2, 3. In: EFSA Journal 1351.
Farooqi A, Firdous N, Masuda H, Haider N. 2003. Fluoride and arsenic poisoning in ground water of Kalalanwala area, near Lahore, Pakistan. Geochimica et Cosmochimica Acta 67(18): A90-A90.
Farooqi A, Masuda H, Firdous N. 2007a. Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. Environmental Pollution 145(3): 839-849.
Farooqi A, Masuda H, Kusakabe M, Naseem M, Firdous N. 2007b. Distribution of highly arsenic and fluoride contaminated groundwater from east Punjab, Pakistan, and the controlling role of anthropogenic pollutants in the natural hydrological cycle. Geochemical Journal 41(4): 213-234.
Farooqi A, Masuda H, Siddiqui R, Naseem M. 2009. Sources of Arsenic and Fluoride in Highly Contaminated Soils Causing Groundwater Contamination in Punjab, Pakistan. Archives of Environmental Contamination and Toxicology 56(4): 693-706.

Ferreccio C, GonzÃlez C, Milosavjlevic V, Marshall G, Sancha AM, Smith AH. 2000. Lung Cancer and Arsenic Concentrations in Drinking Water in Chile. Epidemiology 11(6): 673-679.

Francesconi KA. 2007. Toxic metal species and food regulations-making a healthy choice. Analyst 132(1): 17-20.

Gault AG, Rowland HA, Charnock JM, Wogelius RA, Gomez-Morilla I, Vong S, Leng M, Sarnreth S, Sampson ML, Polya DA. 2008. Arsenic in hair and nails of individuals exposed to arsenic-rich groundwaters in Kandal province, Cambodia. The Science of The Total Environment 393(1): 168-176.

Hopenhayn-Rich C, Biggs ML, Smith AH. 1998. Lung and kidney cancer mortality associated with arsenic in drinking water in Cardoba, Argentina. International Journal of Epidemiology 27(4): 561-569.

Huq SMI, Naidu, R., 2003. Arsenic in groundwater of Bangladesh: Contamination in the food chain. (Arsenic Contamination: Bangladesh Perspective): ITN-Bangladesh, Centre for Water Supply and Waste Management BUET, Dhaka, Bangladesh. pp. 203-226.

IARC. 2004. Some Drinking-water Disinfectants and Contaminants, including Arsenic. IARC Monographs on the Evaluation of the Carcinogenic Risks to Humans, Suppl. 7, Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs. Volumes 1 to 42, Lyon, France.

Kahlown MA, Tahir, M.A. and Asraf, M. Water quality Issues and status in Pakistan. In: Proceedings of the Seminar on Strategies to address the present and future water quality Issues, 2002. Pakistan Council of research in water resources. Islamabad.

Kapaj S, Peterson H, Liber K, Bhattacharya P. 2006. Human Health Effects From Chronic Arsenic Poisoning : A Review. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering 41(10): 2399-2428.

Kazi TG, Arain MB, Baig JA, Jamali MK, Afridi HI, Jalbani N, Sarfraz RA, Shah AQ, Niaz A. 2009. The correlation of arsenic levels in drinking water with the biological samples of skin disorders. The Science of The Total Environment 407(3): 1019-1026.

Kile M. 2007. Biomarkers of prenatal exposure to arsenic. Epidemiology 18(5): S47-S47.

Kile ML, Houseman EA, Breton CV, Smith T, Quamruzzaman Q, Rahman M, Mahiuddin G, Christiani DC. 2007. Dietary Arsenic Exposure in Bangladesh. Environ Health Perspect 115(6).

Kubota R, Kunito T, Agusa T, Fujihara J, Monirith I, Iwata H, Subramanian A, Tana TS, Tanabe S. 2006. Urinary 8-hydroxy-2'-deoxyguanosine in inhabitants chronically exposed to arsenic in groundwater in Cambodia. Journal of Environmental Monitoring 8(2): 293-299.

Laparra JM, Velez D, Barbera R, Farre R, Montoro R. 2005. Bioavailability of Inorganic Arsenic in Cooked Rice: Practical Aspects for Human Health Risk Assessments. J Agric Food Chem 53(22): 8829-8833.

Rahman MA, Hasegawa H, Rahman MM, Miah MAM. 2006. Influence of cooking method on arsenic retention in cooked rice related to dietary exposure. Science of the Total Environment 370(1): 51-60.

Sengupta MK, Mukherjee A, Ahamed S, Das B, Nayaka B, Pala A, Chakraborti D. 2006. Arsenic burden of cooked rice: Traditional and modern methods. Food and Chemical Toxicology 44(11): 1823-1829.

Mazumder DNG, Steinmaus C, Bhattacharya P, von Ehrenstein OS, Ghosh N, Gotway M, Sil A, Balmes JR, Haque R, Hira-Smith MM, Smith AH. 2003. Bronchiectasis in Persons With Skin Lesions Resulting From Arsenic in Drinking Water. Epidemiology 16(6): 760-765.

Meharg AA, Deacon C, Campbell RCJ, Carey AM, Williams PN, Feldmann J, Raab A. 2008b. Inorganic arsenic levels in rice milk exceed EU and US drinking water standards. Journal of Environmental Monitoring 10(4): 428-431.

Meharg AA, Rahman M. 2003. Arsenic contamination of Bangladesh paddy field soils: Implications for rice contribution to arsenic consumption. Environmental Science & Technology 37(2): 229-234.

Meharg AA, Sun G, Williams PN, Adomako E, Deacon C, Zhu Y-G, Feldmann J, Raab A. 2008a. Inorganic arsenic levels in baby rice are of concern. Environmental Pollution 152(3): 746-749.

Meliker JR, Franzblau A, Slotnick MJ, Nriagu JO. 2006. Major contributors to inorganic arsenic intake in southeastern Michigan. International Journal of Hygiene and Environmental Health 209(5): 399-411.

Mitra SR, Mazumder DN, Basu A, Block G, Haque R, Samanta S, Ghosh N, Smith MM, von Ehrenstein OS, Smith AH. 2004. Nutritional factors and susceptibility to arsenic-caused skin lesions in West Bengal, India. Environmental Health Perspectives 112(10): 1104-1109.

Mondal D, Adamson GCD, Nickson R, Polya DA. 2008. A comparison of two techniques for calculating groundwater arsenic-related lung, bladder and liver cancer disease burden using data from Chakdha block, West Bengal. Applied Geochemistry 23(11): 2999-3009.

Mondal D, Polya DA. 2008. Rice is a major exposure route for arsenic in Chakdaha block, Nadia district, West Bengal, India: A probabilistic risk assessment. Applied Geochemistry 23(11): 2987-2998.

Monroy-Torres R, Macias AE, Gallaga-Solorzano JC, Santiago-Garcia EJ, Hernandez I. 2009. Arsenic in Mexican Children Exposed to Contaminated Well Water. Ecology of Food and Nutrition 48(1): 59-75.

Mosaferi M YM, Mesdaghinia A, Naidu A, Nasseri S & Mahvi AH. 2003. Arsenic occurrence in drinking water of IR of iron: the case of Kurdistan province. . In: Proceedings of the In Fate of arsenic in the Environ BUET-UNU International Symposium, , 2003. Dhaka, Bangladesh. 1–6.

Jakhrani MA, Malik KM, Mazari MQ, Jakhrani AA, Hassan M. 2009. Determination of Arsenic and Other Heavy Metals in Hand Pump and Tube-Well Ground Water of Khairpur, Sindh, Pakistan. In: Proceedings of the Second International Conference on Environmental and Computer Science. Dubai, UAE IEEE Computer Society, Los Alamitos, CA, USA, 271-276.

Nickson RT. 1998. Arsenic poisoning of Bangladesh groundwater. Nature 395: 338-338.

Nickson RT, McArthur JM, Shrestha B, Kyaw-Myint TO, Lowry D. 2005. Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan. Applied Geochemistry 20(1): 55-68.

NRC. 1999. Arsenic in Drinking Water.National Academy Press: Washington, DC.

NRC. 2001. Arsenic in Drinking Water (2001 update). National Academy Press: Washington, DC.

Nriagu JO, Bhattacharya P, Mukherjee AB, Bundschuh J, Zevenhoven R, Loeppert RH. 2007. Arsenic in soil and groundwater: an overview. In: Trace Metals and other Contaminants in the Environment, Vol. 9:Elsevier, 3-60.

Ohno K, Yanase T, Matsuo Y, Kimura T, Hamidur Rahman M, Magara Y, Matsui Y. 2007. Arsenic intake via water and food by a population living in an arsenic-affected area of Bangladesh. Science of The Total Environment 381(1-3): 68-76.

Ollson CA, Koch I, Smith P, Knopper LD, Hough C, Reimer KJ. 2009. Addressing arsenic bioaccessibility in ecological risk assessment: a novel approach to avoid overestimating risk. Environ Toxicol Chem 28(3): 668-675.

Orloff K, Mistry K, Metcalf S. 2009. Biomonitoring for Environmental Exposures to Arsenic. J Toxicol Env Heal B 12(7): 509-524.

PCRWR. 2003a. Arsenic Contamination in Groundwater of Southern Punjab.PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).

PCRWR. 2004 Arsenic Contamination in Groundwater of Central Sindh. .PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).

PCRWR. 2008. Pakistan drinking water quality report.Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF, Pakistan).

PCRWR. 2008a. Water Quality Status of Pakistan (5th Technical Report 2005-2006). Islamabad: PCRWR.

PCRWR. 2008b. Pakistan drinking water quality report.Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF, Pakistan).

Rahman MA, Hasegawa H, Rahman MA, Rahman MM, Miah MAM. 2006. Influence of cooking method on arsenic retention in cooked rice related to dietary exposure. Science of The Total Environment 370(1): 51-60.

Rahman MM, Owens G, Naidu R. 2009. Arsenic levels in rice grain and assessment of daily dietary intake of arsenic from rice in arsenic-contaminated regions of Bangladesh-implications to groundwater irrigation. Environmental Geochemistry and Health 31: 179-187.

Ravenscroft P, Brammer H, Richards KS. 2009. Arsenic Pollution: global synthesis. 1st ed: Willy-Blackwell`s.

Smedley PL, Kinniburgh DG. 2002. A review of the source, behaviour and distribution of arsenic in natural waters. Appl Geochem 17: 517-568.

Smith AH, Goycolea M, Haque R, Biggs ML. 1998. Marked Increase in Bladder and Lung Cancer Mortality in a Region of Northern Chile Due to Arsenic in Drinking Water. American Journal of Epidemiology 147(7): 660-669.

Smith AH, Lingas EO, Rahman M. 2000. Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. Bull WHO 78: 1093-1103.

Smith AH, Marshall G, Yuan Y, Ferreccio C, Liaw J, von Ehrenstein O, Steinmaus C, Bates MN, Selvin, S. 2006. Increased Mortality from Lung Cancer and Bronchiectasis in Young Adults after Exposure to Arsenic in Utero and in Early Childhood. Environ Health Perspect 114: 1293-1296.

Smith NM, Lee R, Heitkemper DT, Cafferky KD, Haque A, Henderson AK. 2006. Inorganic arsenic in cooked rice and vegetables from Bangladeshi households. Science of The Total Environment 370(2-3): 294-301.

Steinmaus C BM, Yuan Y, Kalman D, Atallah R, Rey OA, Biggs ML, Hopenhayn C, Moore LE, Hoang BK, Smith AH. 2006. Arsenic methylation and bladder cancer risk in case-control studies in Argentina and the United States. Journal of occupational and Environmental medicine 48(5): 478-488.

Steinmaus C, Moore L, Hopenhayn-Rich C, Biggs ML, Smith AH. 2000. Arsenic in drinking water and bladder cancer. Cancer Invest 18(2): 174-182.

Stone R. 2008. FOOD SAFETY: Arsenic and Paddy Rice: A Neglected Cancer Risk? Science 321(5886): 184-185.

Su Y-H, McGrath S, Zhao F-J. 2009. Rice is more efficient in arsenite uptake and translocation than wheat and barley. Plant and Soil 328(1): 27-34.

Sun GX, Williams PN, Zhu YG, Deacon C, Carey AM, Raab A, Feldmann J, Meharg AA. 2009. Survey of arsenic and its speciation in rice products such as breakfast cereals, rice crackers and Japanese rice condiments. Environment International 35(3): 473-475.

Tahir MA. Drinking water quality monitoring in the rural areas of Rawalpindi. In: Proceedings of the national workshop on quality of drinking water, 1998. Islamabad, Pakistan Pakistan Council of Research in Water Resource, 35–39.

Torres-Escribano S, Leal M, VÃlez D, Montoro R. 2008. Total and Inorganic Arsenic Concentrations in Rice Sold in Spain, Effect of Cooking, and Risk Assessments. Environmental Science & Technology 42(10): 3867-3872.
Tseng CH. 2009. A review on environmental factors regulating arsenic methylation in humans. Toxicology and Applied Pharmacology 235(3): 338-350.
Tsuda T, Babazono A, Yamamoto E, Kurumatani N, Mino Y, Ogawa T, Kishi Y, Aoyama H. 1995. Ingested Arsenic and Internal Cancer: A Historical Cohort Study Followed for 33 Years. American Journal of Epidemiology 141(3): 198-209.
Uchino T, Roychowdhury T, Ando M, Tokunaga H. 2006. Intake of arsenic from water, food composites and excretion through urine, hair from a studied population in West Bengal, India. Food and Chemical Toxicology 44(4): 455-461.
USEPA. 2001 Arsenic in drinking water.Final Rule. Federal Register (66 FR 6976) 22 January.
USEPA. 2004. Risk assessment guidance for Superfund Vol. 1 Human Health Evaluation Manual. (Human Health Evaluation Manual (Part E, Supplemental guidance for dermal risk assessment),). Washington, DC.:United States Environmental Protection Agency.
Vahter M, Li L, Rahman A, Nermell B, Fängström B, Ekström E-C, Arifeen SE, Persson L-A. 2006. Does metabolism of arsenic affect the toxicity during early human development? Toxicology Letters 164(Supplement 1): S201-S202.
Watanabe C, Kawata A, Sudo N, Sekiyama M, Inaoka T, Bae M, Ohtsuka R. 2004. Water intake in an Asian population living in arsenic-contaminated area. Toxicology and Applied Pharmacology 198(3): 272-282.
WHO. 1996. Drinking Water Guideline,Health Criteria and Other Supporting Information. . World Health Organization: Geneva.
WHO. 2001. Environmental Health Criteria 224. Arsenic and Arsenic Compounds. . International Programme on Chemical Safety, World Health Organization: Geneva.
WHO. 2003. Arsenic in Drinking Water. Background document for development of WHO guidelines for drinking-water quality. Geneva:World Health Organization.
Williams PN, Islam MR, Adomako EE, Raab A, Hossain SA, Zhu YG, Feldmann J, Meharg AA. 2006. Increase in Rice Grain Arsenic for Regions of Bangladesh Irrigating Paddies with Elevated Arsenic in Groundwaters. Environmental Science & Technology 40(16): 4903-4908.
Williams PN, Price AH, Raab A, Hossain SA, Feldmann J, Meharg AA. 2005. Variation in Arsenic Speciation and Concentration in Paddy Rice Related to Dietary Exposure. Environmental Science & Technology 39(15): 5531-5540.
Williams PN, Raab A, Feldmann J, Meharg AA. 2007a. Market Basket Survey Shows Elevated Levels of As in South Central U.S. Processed Rice Compared to California:â€‰ Consequences for Human Dietary Exposure. Environmental Science & Technology 41(7): 2178-2183.
Williams PN, Raab A, Feldmann J, Meharg AA. 2007b. Market Basket Survey Shows Elevated Levels of As in South Central U.S. Processed Rice Compared to California: Consequences for Human Dietary Exposure. Environmental Science & Technology 41(7): 2178-2183.
Zhu YG, Williams PN, Meharg AA. 2008. Exposure to inorganic arsenic from rice: A global health issue? Environmental Pollution 154(2): 169-171.

Supplementary information

Table 4.4 Summary of the salient features, including arsenic concentration (µg/L), of groundwater sources of drinking/cooking water, Allama Iqbal town Lahore, Pakistan

Note: na ; Not available, Tube Well;1, Hand pump;2, Bore hole;3 and well;4, Cond; conductivity, T ;temperature; 10 µg/L); WHO provisional guide value; 50 (µg/L) NEQS of Pakistan; for arsenic

Code	Village/ Colony	Water source	Age (yr)	Depth (ft approx)	pH	Cond mS/cm	Eh mV	T°C	Water As (µg/L)	>10 (µg/L)	>50 (µg/L)
IN01	Islam Nagar	1	2	180	7.93	0.91	64	19.1	28	y	
IN02	Islam Nagar	3	1	200	8.94	0.61	108	17.4	139	y	y
IN03	Islam Nagar	2	22	90	9.22	1.4	28	23.5	535	y	y
IN04	Islam Nagar	2	22	90	9.22	1.4	28	23.5	536	y	y
IN05	Islam Nagar	4	4	70	8.78	0.9	42	23.3	139	y	y
IN06	Islam Nagar	4	18	300	8.36	1.21	90	16.7	181	y	y
IN07	Islam Nagar	4	15	100	9.41	0.83	60	24.1	42	y	y
IN08	Islam Nagar	4	15	120	8.5	0.44	108	17.9	86	y	y
IN09	Islam Nagar	1	18	85	8.45	0.44	110	20.6	2		
IN10	Islam Nagar	3	3	160	7.96	2.11	-67	24.7	35	y	
IN11	Islam Nagar	1	1	100	7.93	0.99	77	21.7	11	y	
IN12	Islam Nagar	4	6	150	8.04	1.93	160	17.4	2		
IN13	Islam Nagar	1	9	na	7.79	2.34	126	20.1	17	y	
IN14	Islam Nagar	4	20	120	7.82	2.79	159	17.6	2		
IN15	Islam Nagar	2	30	130	8.23	1.72	119	26	5		
IN16	Islam Nagar	4	4	80	8.5	0.44	108	17.9	422	y	y
IN17	Islam Nagar	4	5	150	7.93	0.91	64	19.1	70	y	y
IN18	Islam Nagar	4	3	180	8.5	0.44	108	17.9	86	y	y
KP1	KhurdPur	3	10	100	7.15	1.11	111	19.6	41	y	y
KP2	KhurdPur	3	10	100	7.15	1.11	111	19.6	296	y	y

KP3	KhurdPur	3	10	90	8.53	1.51	-27	19	296	y	y
KP4	KhurdPur	4	14	170	7.72	0.52	110	21.1	960	y	
KP5	KhurdPur	4	23	90	7.86	0.37	-3	19	27	y	y
KP6	KhurdPur	4	1	100	7.53	0.87	83	22.7	61	y	
KP7	KhurdPur	4	23	80	7.98	0.61	53	22.6	23	y	
KP8	KhurdPur	3	20	80	8.12	0.26	68	24.6	26		
KP9	KhurdPur	3	12	105	8.2	0.69	118	17.2	6		
KP10	KhurdPur	1 &3	12	90	8.04	0.36	140	20	6	y	
KP11	KhurdPur	1	16	400	7.54	0.27	-15	20.2	13	y	y
KP12	KhurdPur	4	20	100	8.01	0.45	134	17.3	105		
KP13	KhurdPur	4	10	100	7.77	1.44	117	25	6	y	
KP14	KhurdPur	1	23	na	7.82	0.93	140	17.2	18	y	y
KP15	KhurdPur	4	25	150	7.77	1.56	140	17.4	119	y	
KP16	KhurdPur	4	23	110	7.44	0.99	-17	19.9	36		
KP17	KhurdPur	2	7	100	7.64	1.59	132	23.6	9		
KP18	KhurdPur	4	12	100	7.17	1.36	-109	24.9	1	y	y
KP19	KhurdPur	4	12	100	7.17	1.36	-109	24.9	78	y	y
KP20	KhurdPur	4	12	100	7.17	1.36	-109	24.9	78	y	y
KP21	KhurdPur	4	12	100	7.17	1.36	-109	24.9	299	y	y
KP22	KhurdPur	4	12	100	7.17	1.36	-109	24.9	299	y	y
KP23	KhurdPur	4	12	100	7.17	1.36	-109	24.9	299	y	y
KP24	KhurdPur	4	18	110	8.53	1.51	-27	19	78	y	y
KP25	KhurdPur	4	14	100	7.15	1.11	111	19.6	960	y	y
KP26	KhurdPur	4	23	90	7.86	0.37	-3	19	296	y	y
KP27	KhurdPur	3	10	100	7.15	1.11	111	19.6	61	y	y
KP28	KhurdPur	3	10	90	8.53	1.51	-27	19	296	y	y
LH01	Lahore	1	15	na	7.62	0.42	76	27.7	960	y	
LH02	Lahore	1	8	725	8.47	0.32	69	19.5	23	y	
LH03	Lahore	1	23	na	8.4	0.35	73	19.5	23	y	
LH04	Lahore	4	24	150	7.66	0.28	75	21.2	23	y	

LH05	Lahore	1	23	700	7.7	0.32	73	24	19	y	
LH06	Lahore	3	5	na	7.55	0.49	114	18	20	y	
LH07	Lahore	1	12	200	7.93	0.28	88	19.2	23	y	
LH08	Lahore	1	5	200	7.95	0.45	102	19.8	12	y	
LH09	Lahore	2	4	na	7.93	0.76	118	20.3	21	y	
LH10	Lahore	4	7	190	8.26	0.23	99	23	13	y	
LH11	Lahore	2	4	140	7.96	0.35	106	19.7	20	y	
LH12	Lahore	1	1	na	7.6	0.27	83	20.6	15	y	
LH13	Lahore	1	16	na	8.19	0.29	112	27	26	y	
LH14	Lahore	1	20	na	8.45	0.31	132	17.5	27		
LH15	Lahore	1	20	700	8.41	0.35	108	19.1	7		
LH16	Lahore	1	15	90	7.5	0.76	139	19.9	3		
LH17	Lahore	1	10	140	8	0.51	-53	17	0		
LH18	Lahore	3	6	85	7.92	2.48	105	19.6	1	y	
LH19	Lahore	4	15	na	7.6	2.42	-5	23.5	26		
LH20	Lahore	4	6	150	7.82	1.041	102	23.4	4		
LH21	Lahore	4	15	120	7.3	0.99	120	22.5	3	y	
LH22	Lahore	3	23	350	8.26	1.2	69	19.5	12	y	
LH23	Lahore	2	3	90	8.03	0.66	73	19.3	19	y	
LH24	Lahore	1	25	150	7.64	0.7	123	22.4	16	y	
LH25	Lahore	1	15	115	8.63	2.94	97	18.1	10		
LH26	Lahore	1	3	80	7.64	1.01	-57	19.3	7	y	y
LH27	Lahore	1	1	na	8.45	0.94	77	15.3	67		
LH28	Lahore	1	20	na	8.7	0.29	100	10	6	y	y
LH29	Lahore	1	43	na	8.42	0.57	106	18.1	83	y	
LH30	Lahore	3	8	120	7.34	3.1	137	25.5	28	y	
LH31	Lahore	3	na	90					21	y	
LH32	Lahore	1	13	60	7.74	1.03	155	19.3	15		
LH33	Lahore	4	2	180	8.08	0.8	150	19.2	1	y	
LH34	Lahore	1	na	100	7.71	1.37	144	19.7	26	y	

LH35	Lahore	4	9	90	7.72	0.77	143	19.5	14	y	
M01	M.mandi	1	3	700	8.04	0.86	137	17.3	0	y	
M02	M.mandi	1	40	100	8.15	1.02	100	15.5	39		
M03	M.mandi	3	8	90	7.64	1.76	150	17.3	9	y	
M04	M.mandi	1	8	100	8.12	1.66	130	15.6	39	y	
M05	M.mandi	4	30	120	7.94	1.11	145	18.3	45		
M06	M.mandi	2	5	na	7.86	0.57	150	17.5	5	y	
M07	M.mandi	1	20	50	7.5	0.7	-40	20.7	25	y	
P01	Pajji	3	16	100	7.71	1.72	137	20.3	19	y	
P02	Pajji	4	6	250	7.61	1.59	137	24.8	6	y	
P03	Pajji	4	4	200	7.91	1.39	125	26.1	33		
P04	Pajji	2	4	n	7.94	2.64	138	20.4	7		
P05	Pajji	2	6	70	8.88	1.21	95	20.7	6	y	
P06	Pajji	3	8	90	7.97	2.03	150	20	25	y	y
P07	Pajji	2	1	70	7.5	1.9	-60	24.6	443	y	
P08	Pajji	2, 4	4	70	8.18	0.53	139	19.6	21		
P09	Pajji	2	6	80	7.22	1.52	48	24.1	1	y	
P10	Pajji	2	23	175	7.9	1.95	158	19.6	15		
P11	Pajji	2	15	120	8.62	1.17	1.5	22.3	3		
P12	Pajji	2,3	4	100	7.95	2.02	152	20	5	y	y
P13	Pajji	2	12	60	8.25	1.87	126	24.1	111		
R01	Riwind	1	40	na	8.02	0.81	135	17.4	2	y	
R02	Riwind	1	7	100	8.23	0.88	115	16	9	y	
R03	Riwind	1	5	na	8.33	0.61	127	19.1	13	y	
Minimum			1	50	7.15	0.23	-109	10	0		
Maximum			43	725	9.41	3.1	160	27.7	960		
Mean			12.73	149.66	7.96	1.08	78.12	20.47	92		
Median			12	100	7.93	0.99	106	19.7	23		

Table 4.5 Excess Life time cancer risk from arsenic intake in Allama Iqbal Town Lahore, Pakistan

A (Male volunteers)

No	Age (yrs)	Wt (kg)	Water IR(l)	Water As (µg/l) Average	Life expectancy (y)	CDI water (µg/kg/d)	ED	Risk from water intake	Risk from water (male)	As rice(mg/kg)	Life expectancy (y)	CDIrice (µg/kg/d)	ED	Risk from rice intake	Risk from rice (male)	Risk total (male)	%risk from water	%risk from rice
1	21	65	1.70	28.32	62	0.74	21	3.76E-04	1.64E-01	0.05	62	0.15	21	7.55E-05	9.45E-03	1.73E-01	9454.51%	545.49%
2	35	88	1.45	181.18	62	2.99	35	2.53E-03		0.63	62	1.43	35	1.21E-03				
3	56	60	1.30	41.57	62	0.90	56	1.22E-03		0.12	62	0.40	56	5.43E-04				
4	29	65	1.70	2.36	62	0.06	29	4.33E-05		0.06	62	0.18	29	1.27E-04				
5	28	62	2.70	11.00	62	0.48	28	3.24E-04		0.05	62	0.17	28	1.15E-04				
6	23	70	3.70	17.02	62	0.90	23	5.00E-04		0.07	62	0.20	23	1.09E-04				
7	25	75	4.30	4.78	62	0.27	25	1.66E-04		0.07	62	0.19	25	1.12E-04				
8	65	78	2.25	422.37	62	12.18	65	1.92E-02		0.07	62	0.18	65	2.85E-04				
9	40	70	2.85	69.75	62	2.84	40	2.75E-03		0.00	62	0.00	40	0.00E+00				
10	52	88	3.25	85.67	62	3.16	52	3.98E-03		0.00	62	0.00	52	0.00E+00				
11	40	69	2.45	296.23	62	10.52	40	1.02E-02		0.07	62	0.20	40	1.97E-04				
12	27	50	4.50	959.85	62	86.39	27	5.64E-02		0.06	62	0.26	27	1.69E-04				
13	45	70	2.70	61.23	62	2.36	45	2.57E-03		0.06	62	0.19	45	2.02E-04				
14	14	50	2.30	22.86	62	1.05	14	3.56E-04		0.08	62	0.34	14	1.14E-04				
15	16	40	1.70	26.65	62	1.13	16	4.38E-04		0.07	62	0.35	16	1.36E-04				
16	14	42	2.20	6.26	62	0.33	14	1.11E-04		0.09	62	0.41	14	1.38E-04				
17	18	50	1.65	18.24	62	0.60	18	2.62E-04		0.08	62	0.31	18	1.33E-04				
18	24	70	2.85	9.32	62	0.38	24	2.20E-04		0.07	62	0.19	24	1.10E-04				
19	23	45	1.45	0.93	62	0.03	23	1.67E-05		0.07	62	0.30	23	1.69E-04				
20	48	60	3.00	78.62	62	3.93	48	4.56E-03		0.09	62	0.29	48	3.35E-04				
21	15	34	1.60	298.93	62	14.07	15	5.10E-03		0.09	62	0.51	15	1.85E-04				
22	17	54	2.70	959.85	62	47.99	17	1.97E-02		0.09	62	0.33	17	1.37E-04				
23	34	80	2.05	22.74	62	0.58	34	4.79E-04		0.00	62	0.00	34	0.00E+00				
24	38	82	2.10	23.51	62	0.60	38	5.53E-04		0.00	62	0.00	38	0.00E+00				
25	40	60	2.70	18.86	62	0.85	40	8.21E-04		0.03	62	0.09	40	8.43E-05				
26	59	82	3.95	15.38	62	0.74	59	1.06E-03		0.00	62	0.00	59	0.00E+00				
27	15	65	1.85	27.36	62	0.78	15	2.83E-04		0.07	62	0.20	15	7.39E-05				
28	20	65	1.05	3.37	62	0.05	20	2.64E-05		0.07	62	0.21	20	9.95E-05				
29	18	62	2.45	1.02	62	0.04	18	1.75E-05		0.00	62	0.00	18	0.00E+00				
30	16	55	2.70	4.28	62	0.21	16	8.13E-05		0.09	62	0.33	16	1.26E-04				
31	18	60	1.45	10.59	62	0.26	18	1.11E-04		0.06	62	0.21	18	9.17E-05				
32	17	56	2.45	7.63	62	0.33	17	1.37E-04		0.04	62	0.15	17	6.32E-05				
33	28	65	1.65	67.44	62	1.71	28	1.16E-03		0.15	62	0.46	28	3.12E-04				
34	50	75	2.05	83.67	62	2.29	50	2.77E-03		0.00	62	0.00	50	0.00E+00				
35	52	82	2.30	28.59	62	0.80	52	1.01E-03		0.06	62	0.15	52	1.84E-04				
36	20	58	2.70	1.09	62	0.05	20	2.45E-05		0.00	62	0.00	20	0.00E+00				
37	28	56	1.90	14.00	62	0.47	28	3.22E-04		0.07	62	0.25	28	1.70E-04				
38	25	56	1.30	9.00	62	0.21	25	1.26E-04		0.12	62	0.41	25	2.49E-04				
39	45	75	2.10	45.56	62	1.28	45	1.39E-03		0.07	62	0.18	45	2.00E-04				
40	22	70	2.70	5.52	62	0.21	22	1.13E-04		0.08	62	0.22	22	1.16E-04				
41	40	75	1.45	25.15	62	0.49	40	4.70E-04		0.25	62	0.67	40	6.44E-04				
42	17	47	1.05	19.08	62	0.43	17	1.75E-04		0.08	62	0.35	17	1.44E-04				
43	14	50	1.30	7.33	62	0.19	14	6.45E-05		0.08	62	0.33	14	1.12E-04				
44	20	57	1.65	6.33	62	0.18	20	8.87E-05		0.13	62	0.46	20	2.20E-04				
45	32	62	2.85	443.01	62	20.36	32	1.58E-02		0.07	62	0.21	32	1.65E-04				
46	58	78	1.50	21.84	62	0.42	58	5.89E-04		0.05	62	0.12	58	1.69E-04				
47	18	65	2.30	1.31	62	0.05	18	2.02E-05		0.04	62	0.13	18	5.71E-05				
48	15	50	1.85	3.40	62	0.13	15	4.56E-05		0.20	62	0.80	15	2.92E-04				
49	35	50	2.45	5.02	62	0.25	35	2.08E-04		0.00	62	0.00	35	0.00E+00				
50	29	56	2.45	111.07	62	4.86	29	3.41E-03		0.09	62	0.34	29	2.35E-04				
51	20	59	1.65	9.02	62	0.25	20	1.22E-04		0.10	62	0.33	20	1.58E-04				
52	17	45	1.85	13.25	62	0.54	17	2.24E-04		0.19	62	0.84	17	3.46E-04				
53	25	60	1.50	26.20	62	0.66	25	3.96E-04		0.10	62	0.34	25	2.07E-04				
54	33	55	3.50	14.46	62	0.92	33	7.35E-04		0.11	62	0.41	33	3.28E-04				

(B Female volunteers)

No	Age (yrs)	Weight (Kg)	Water IR(l)	Water As (µg/l) Average	Life expectancy (y)	CDIwater (µg/kg/d)	ED	Risk from water intake	Total water risk(female)	RiceAs(mg/kg)	Life expectancy (y)	CDIrice (µg/kg/d)	ED	Risk from rice intake	Risk from rice (female)	Risk total	%risk from water	%risk from rice
1	30	62	1.25	139.29	63	2.81	30	2.01E-03	1.66E-01	0.58	63	1.88	30	1.34E-03	1.33E-02	1.79E-01	9259.89%	740.11%
2	41	41	1.30	535.48	63	16.98	41	1.66E-02		0.11	63	0.56	41	5.43E-04				
3	65	51	1.30	536.48	63	13.67	65	2.12E-02		0.11	63	0.45	65	6.92E-04				
4	70	55	1.50	139.29	63	3.80	70	6.33E-03		0.12	63	0.45	70	7.44E-04				
5	22	75	1.05	85.67	63	1.20	22	6.28E-04		0.06	63	0.16	22	8.24E-05				
6	24	64	1.50	35.53	63	0.83	24	4.76E-04		0.06	63	0.17	24	9.84E-05				
7	16	56	1.60	2.33	63	0.07	16	2.53E-05		0.09	63	0.33	16	1.26E-04				
8	45	68	1.70	2.29	63	0.06	45	6.13E-05		0.09	63	0.25	45	2.68E-04				
9	37	45	1.65	296.23	63	10.86	37	9.57E-03		0.07	63	0.32	37	2.79E-04				
10	45	85	1.50	27.01	63	0.48	45	5.11E-04		0.08	63	0.20	45	2.12E-04				
11	25	67	1.65	5.83	63	0.14	25	8.55E-05		0.05	63	0.16	25	9.24E-05				
12	24	68	1.90	13.22	63	0.37	24	2.11E-04		0.08	63	0.24	24	1.40E-04				
13	20	65	1.40	105.03	63	2.26	20	1.08E-03		0.09	63	0.27	20	1.29E-04				
14	48	58	1.70	6.23	63	0.18	48	2.09E-04		0.07	63	0.24	48	2.69E-04				
15	22	56	2.05	119.57	63	4.38	22	2.29E-03		0.07	63	0.24	22	1.24E-04				
16	52	78	2.45	36.05	63	1.13	52	1.40E-03		0.06	63	0.15	52	1.92E-04				
17	47	53	2.25	78.62	63	3.34	47	3.73E-03		0.09	63	0.33	47	3.66E-04				
18	13	42	1.70	298.93	63	12.10	13	3.75E-03		0.09	63	0.41	13	1.28E-04				
19	11	38	1.45	298.93	63	11.41	11	2.99E-03		0.09	63	0.46	11	1.19E-04				
20	85	47	1.50	78.62	63	2.51	85	5.08E-03		0.09	63	0.37	85	7.46E-04				
21	65	48	1.65	959.85	63	32.99	65	5.11E-02		0.09	63	0.36	65	5.58E-04				
22	25	45	1.60	296.23	63	10.53	25	6.27E-03		0.08	63	0.37	25	2.23E-04				
23	45	76	2.10	61.23	63	1.69	45	1.81E-03		0.08	63	0.21	45	2.26E-04				
24	85	51	1.65	296.23	63	9.58	85	1.94E-02		0.09	63	0.35	85	7.14E-04				
25	20	75	1.65	22.63	63	0.50	20	2.37E-04		0.08	63	0.21	20	1.00E-04				
26	65	60	1.45	20.78	63	0.50	65	7.77E-04		0.11	63	0.37	65	5.73E-04				
27	37	48	2.05	23.78	63	1.02	37	8.95E-04		0.00	63	0.00	37	0.00E+00				
28	25	62	1.90	12.43	63	0.38	25	2.27E-04		0.19	63	0.62	25	3.69E-04				
29	18	65	1.90	21.40	63	0.63	18	2.68E-04		0.08	63	0.26	18	1.10E-04				
30	35	64	1.85	13.67	63	0.40	35	3.29E-04		0.00	63	0.00	35	0.00E+00				
31	12	46	1.05	20.35	63	0.46	12	1.33E-04		0.00	63	0.00	12	0.00E+00				
32	25	62	1.45	26.28	63	0.61	25	3.66E-04		0.00	63	0.00	25	0.00E+00				
33	40	80	1.70	7.52	63	0.16	40	1.52E-04		0.12	63	0.31	40	2.94E-04				
34	29	68	1.45	0.06	63	0.00	29	8.61E-07		0.10	63	0.31	29	2.11E-04				
35	26	67	1.25	26.23	63	0.49	26	3.03E-04		0.08	63	0.22	26	1.39E-04				
36	35	65	1.50	3.72	63	0.09	35	7.15E-05		0.11	63	0.33	35	2.72E-04				
37	35	75	1.45	12.43	63	0.24	35	2.00E-04		0.09	63	0.25	35	2.07E-04				
38	34	80	1.25	19.49	63	0.30	34	2.47E-04		0.19	63	0.46	34	3.76E-04				
39	22	68	1.45	16.77	63	0.36	22	1.87E-04		0.08	63	0.24	22	1.27E-04				
40	40	50	1.50	6.08	63	0.18	40	1.74E-04		0.04	63	0.15	40	1.45E-04				
41	45	53	1.30	21.19	63	0.52	45	5.57E-04		0.14	63	0.53	45	5.69E-04				
42	22	60	2.45	26.08	63	1.07	22	5.58E-04		0.08	63	0.26	22	1.35E-04				
43	50	85	1.45	0.20	63	0.00	50	4.13E-06		0.00	63	0.00	50	0.00E+00				
44	60	65	1.65	39.74	63	1.01	60	1.44E-03		0.00	63	0.00	60	0.00E+00				
45	20	58	1.45	39.40	63	0.99	20	4.69E-04		0.08	63	0.27	20	1.27E-04				
46	35	75	2.25	33.64	63	1.01	35	8.41E-04		0.07	63	0.18	35	1.53E-04				
47	22	50	1.05	25.63	63	0.54	22	2.82E-04		0.08	63	0.32	22	1.65E-04				
48	34	47	1.05	15.99	63	0.36	34	2.89E-04		0.20	63	0.85	34	6.90E-04				
49	40	76	2.05	2.53	63	0.07	40	6.49E-05		0.03	63	0.08	40	7.49E-05				

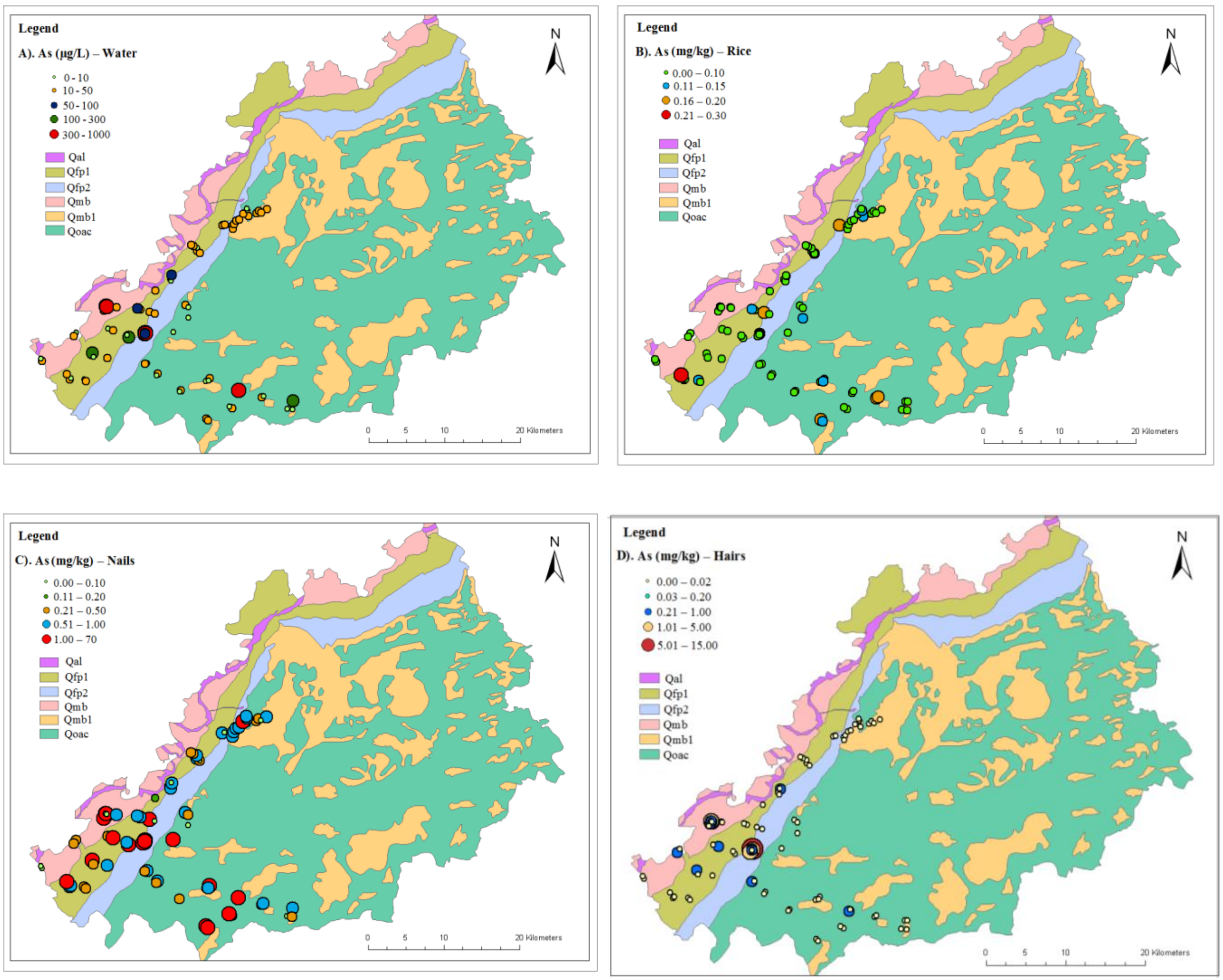
Figure 4.10 Spatial variation of arsenic in drinking water, raw rice, human nails and hair in Allama Iqbal town Lahore

A. Drinking/cooking water arsenic concentration (µg/L)

B. Total arsenic (mg/kg) in raw rice

C. Arsenic concentration (mg/kg) human nails

D. Arsenic concentration (mg/kg) human hair



Chapter 5 Role of biomarkers in arsenic exposure assessment due to drinking arsenic contaminated water and eating rice in Allama Iqbal Town Lahore, Pakistan

Abstract

Drinking arsenic contaminated ground water has been accepted as a worldwide problem and is a well-known documented cause of chronic arsenicism in south Asian countries such as India and Bangladesh where millions of people are victims (Kapaj et al. 2006; Smedley and Kinniburgh 2002; Smith et al. 2002). Like other south Asian countries ground water arsenic contamination have been recently reported in southern Punjab and northern Sind provinces of Pakistan (Ahmad 2004. ; Anwar 2005; Arain et al. 2009; Farooqi et al. 2007, 2009; Fatmi et al. 2009a; Jakhrani et al. 2009; Nickson et al. 2005). Biomarkers of exposure have become very popular human exposure assessment tool for studies evaluating the chronic body burden of arsenic (As). Samples of human urine, blood, hair and nails were collected from the potentially exposed groups and analysed for total arsenic as well as its metabolites which have different toxicity levels.

Hair (n=115), nails (n=144) (toe and finger nails), and urine (n=23) samples were collected in April - May of 2009 along with drinking water (n=132) and raw rice samples (n=86) from Allama Iqbal town of district Lahore a previously reported As impacted area and Peshawar basin having no known reported exposure . All hair and nails samples were washed and analysed by using the standard methods by (Chen et al. 1999; Gault et al. 2008a). Urine samples were lysd and subsequently tested for creatinine. ICP-MS was used for quantifying the total concentration of As in hair, nails, water, rice and urine. IC- ICP-MS was used for arsenic speciation analysis of urine as well as raw rice. The median value of As hair is 0.30 (0.04-14.6 mg/kg), median value of As in nail is 0.85 (ranged from 0.17- 65 mg/kg) and median value for urine is118 µg/g creatinine (ranged from 19-350 µg/g creatinine).

Association of drinking water As with hair As is significant with ($r^{2} = 0.63$) ($p < 0.01$) and comparatively much better than with nails As ($r^{2} = 0.24$) ($p < 0.01$) for the total population. Chronic daily intake from water also has a good positive ($r^{2} = 0.42$) ($p < 0.01$) value with hair arsenic contents which gives an idea that hair is a good biomarker for the exposed population of Allama Iqbal town Lahore (Supplementary Table 5.4). The proper correlation between As in hair/As nails and As in drinking water for male compared to females is suggestive that male may be more likely to drink from more than one source (Supplementary Table 5.5 and 5.6).

Introduction

Chronic exposure to drinking as contaminated ground water is a public health hazard in many countries of the world like Bangladesh, India, Vietnam, Cambodia, Argentina, Mexico, China, Chile, and some parts of America (Smith et al. 2000; Tseng et al. 2005).

Bangladesh and West Bengal have been documented as the two worst victims of mass arsenic poisoning having 35 and 6 million people are exposed to more than 50 µg/L As (Smith et al. 2000; Tseng et al. 2005).

Arsenic in drinking and cooking water mainly derived from ground water sources has recently been reported from different parts of Punjab and Sind provinces in Pakistan(Ahmad 2004. ; Anwar 2005; Arain et al. 2009; Farooqi et al. 2003, 2007; Fatmi et al. 2009a; Jakhrani et al. 2009; Nickson et al. 2005). According to PCRWR Lahore, Kasur, Multan , Bahawalpur and Muzaffer ghar in Punjab province while Mirpur Khas , dadu and Larkana in Sind , Pakistan has mean arsenic level > 50 µg/L (Ahmad 2004; Arain et al. 2007, 2009; Farooqi et al. 2003, 2007a; Fatmi et al. 2009b; Nickson et al. 2005; PCRWR 2003a-b, 2008a).

Nickson, McArthur et al. 2005 reported ground water As contamination of up to maximum 945 µg/L from Muzaffer Ababd district of Punjab (Nickson et al. 2005) furthermore Farooqi et al 2004, 2007 reported up to 2400 µg/L from Khaalanwala village of Punjab (Farooqi et al. 2003, 2007a).

The use of drinking water As concentration as an estimate of actual intake of As is not very accurate because the intake of water varies from individual to individual and some time the drinking water source also varies for the same individual for example those people who used to work in different place or children or teachers going to schools use more than one source of water (Calderon et al. 1999).

The biomarkers of arsenic exposure like urine, hair and nail analysis for absorbed dose of As is now considered as very important tool for identifying at risk groups. Biomarkers exposure data are more superior to the one collected by the use of questionnaire survey as it gives the exact picture of the absorbed dose in the biological system from all sources of exposure (Karagas et al. 2001a).

The most frequently used biomarkers for recent exposure assessment is urine because major portion of absorbed As is excreted in urine by the kidneys within 3-4 days of exposure used in many studies (Hughes 2006; Tseng et al. 2005; Wang et al. 2001). In chronically exposed population, residing in Bangladesh who were subjected to highly level of arsenic concentration have shown high correlations between drinking water arsenic level and arsenic concentrations in urine and blood (Smith 2006). Urinary As concentration thus gives the idea about on-going exposure.

The use of human hair as an important biological material has been recommended by WHO, USEPA and IAEA to be used for environmental monitoring throughout the world (Morton et al. 2002). Toenail is an integrated measure of As exposure and a biomarker of internal dose which could reflect exposure occurred up to a maximum of one year before the nails sample collection (Kile et al. 2005). Arsenic in scalp hair, finger and toenails is being considered useful biomarkers for measurement of chronic arsenic exposure. Due to the binding of As to keratin of hair and nails they give an idea about long term exposure to arsenic contamination (Garland et al. 1993; Slotnick and Nriagu 2006; Slotnick et al. 2007).

The rapid elimination of iAs and its metabolites from urine make it useful to assess only recent exposures studies. The same is true for blood arsenic which tends to be cleared instantly from blood, except at high exposure levels.

Only one problem with hair and nails when used as biomarkers is its external contamination.

There is a list of factors affecting the arsenic toxicity in any exposed population for example, age, sex, diet, amount of intake, nutritional status consumption period, smoking habit, ethnicity, and genetic variability and age was a significant effect modifier of drinking water exposure on toenails (Kapaj et al. 2006; Kile et al. 2005). Allama Iqbal town Lahore is a peri urban area of district Lahore where most of the sampled population is abstained from a balance diet. Malnutrition has been considered as one factor commonly found in the As affected populations in most studies (Airas et al. 2004; Brima et al. 2006; Kapaj et al. 2006). However, there are some studies which has identified As patients in small populations who daily take good nutritious food but consume As contaminated water like Chiu village in Chile and Eruani village of Laksam, Chandipur village of Nawabganj (Bangladesh) (Airas et al. 2004; Anawar et al. 2002).

The aim of this study is to correlate the arsenic content in scalp hair, nails (both finger and toe nails) and urine with arsenic concentration in ground water and raw rice , individual chronic daily intake of arsenic, and to identify any exposure group severely at risk.

Material and Methods

Sample collection

The ethical approval for this study was obtained from the Ethical Committee of NCE in Geology, University of Peshawar before starting any field work and all the procedures were ethically approved. A copy of the ethical approval is attached in the Annexes.

An informed consent was obtained from the individuals and guardians (in case of children and female) before making a request of the samples. As such of activity is unusual in the field area so it was necessary to brief the people and in some cases the elders of the family about the purpose of sample collection.

Hair, nails, urine, raw rice and drinking/cooking water samples (household taps and water storage/ container) were collected from volunteers of Allama Iqbal town Lahore. Stratified random sampling was considered as ideal method for the evaluation of exposure from arsenic because it increases the representativeness of the samples without increasing the cost and as probability sampling also decreases the subjectivity.

Sample collection was accompanied by an informed consent, questionnaire based survey for collection of information regarding demographic, health status, food habits, drinking water source etc. and this study was ethically approved by University of Peshawar.

Both toe and finger nail samples, cut with the help of new clean nail clippers and collected and stored in labelled, zip lock plastic bag. A small amount of hair (around 5cm) from the nap of the neck was cut with the help of a clean pair of scissors. A cello tape (Velcro PVC) was used to wrap up the end of hair farthest from the scalp for the identification of scalp end (un wrapped end). Labelled zip lock bags were used to place hair just like nails samples. Any use of dye, gel or cosmetics was recorded. Hair and nail samples were collected from the same volunteer. First morning voids were collected in cleaned, labelled polypropylene bottles.

A GPS reading (latitudes and longitudes) was taken at each water sample collecting site for recording the sample location and future mapping.

Washing and cleaning procedure

Standard methods of washing for nails (Chen et al. 1999) and hair (IAEA 1978) were followed. Nails sample were first washed with 18.5 MΩ deionized water and any visible dirt was removed with a nylon wire brush. Samples were kept in clean glass beakers, submerged in 25 ml of 1% Triton-X100 solution and sonicated for 20 minutes by using (electric sonicator from Biotek). The wash solution was discarded and the nails were rinsed at least 3 times with 18.5 MΩ deionized water before being dried at 60°C.

Hair samples from the scalp end, taken in a clean glass beaker was added with 25ml acetone (analytical grade) and kept in ultrasonic bath for 10 minutes. This wash acetone was discarded and 25 ml of 18.5MΩ deionized water was added and again sonicated for 10 minutes. The process was repeated two more times with water and finally with acetone. After the last wash with acetone, hair samples were allowed to dry overnight at room temperature.

Digestion and analysis

Hair/nail samples were accurately weighed by analytical balance (Fisher brand PS-100) into acid cleaned and properly labelled 10 ml polypropylene test tubes. 1 ml of concentrated nitric acid (double distilled from Aristar grade) was added to each tube, capped with clean stoppers and left to digest for 48 hours. These samples were intermittently shaken to be uniformly digested. After 48 hours, 9 ml of deionized water was added and the mixture was well shaken prior to filtration through a 0.45 µm polypropylene syringe filter (VWR International Ltd). These hair and nail digested and diluted solution was filtered into new ICP-MS polystyrene test tube and stored at 4°C before analysis. All the equipment used is cleaned in 5% HNO_3 solution in a plastic bath tub and then washed with 18.5 MΩ deionized water to avoid any external contamination.

Urine samples already lysd, centrifuged and temperature treated for polio virus were filtered with 0.45 µm polypropylene syringe filter (VWR International Ltd) and 1 to 5 times diluted with 18.5 MΩ deionized water for As speciation while with 2% HNO_3 solution for total As in urine. Creatinine adjustment was done for urine samples by using Metra Creatinine Assay Kit (Quidel Corporation, USA) and optical density was read at 490 nm within 10 minutes of the completion of the incubation by Absorbance Micro plate Reader (EL x 800 ™ from Biotek supplied by North Star Scientific Ltd).

Every batch of hair, nails and urine samples was accompanied by a set of 10-20 % duplicate procedural blanks, (acid blanks and distilled water) and certified reference material (CRM) in triplicate for quality assurance purpose. There is good association between the duplicate samples.

Procedural blanks (both distil water as well as acid blanks) were also used in each run of sample analysed just to get an idea about the quality of the reagents used. The blanks value for hair samples is 0.07 µg/L and for nails 0.037 µg/L. limit of detection LOD was measured (concentration of As in blanks plus three times the standard deviation of blank) for hair is 0.074 µg/L and for nails sample analysis is 0.067 µg/L .

For hair and nails samples human hair reference material (NCS DC 73347 from China National Analysis Centre for Iron and Steel Beijing, China) while for urine samples NIES no. 18 human urine CRM (from National institute for environmental Studies ONOGAWA 16-2, TSUKUBA, IBARAK, 305-0053 Japan) was used. No known reference material has been documented for human nails and in studies by (Adair et al. 2006; Freeman et al. 2004) the same human hair CRM is also used for nails.

The value of total As in the reference material (A+B+C/3) is 0.28 ± 0.03 mg/kg for hair samples which and for nails samples analytical run the value of CRM was (A+B+C/3) 0.286 ± 0.015 mg/kg is near to the reported certified value of 0.28 ± 0.4 mg/kg.

Total arsenic in hair, nails, water and rice samples were analysed at by Inductively Coupled Plasma Mass Spectrometer (ICP-MS) by Agilent Technologies 7500 Inc.) While As speciation analysis was performed by High Pressure Liquid Inductively Coupled Plasma Mass Spectrometer (ICP-MS by Agilent Technologies 7500 Inc.).

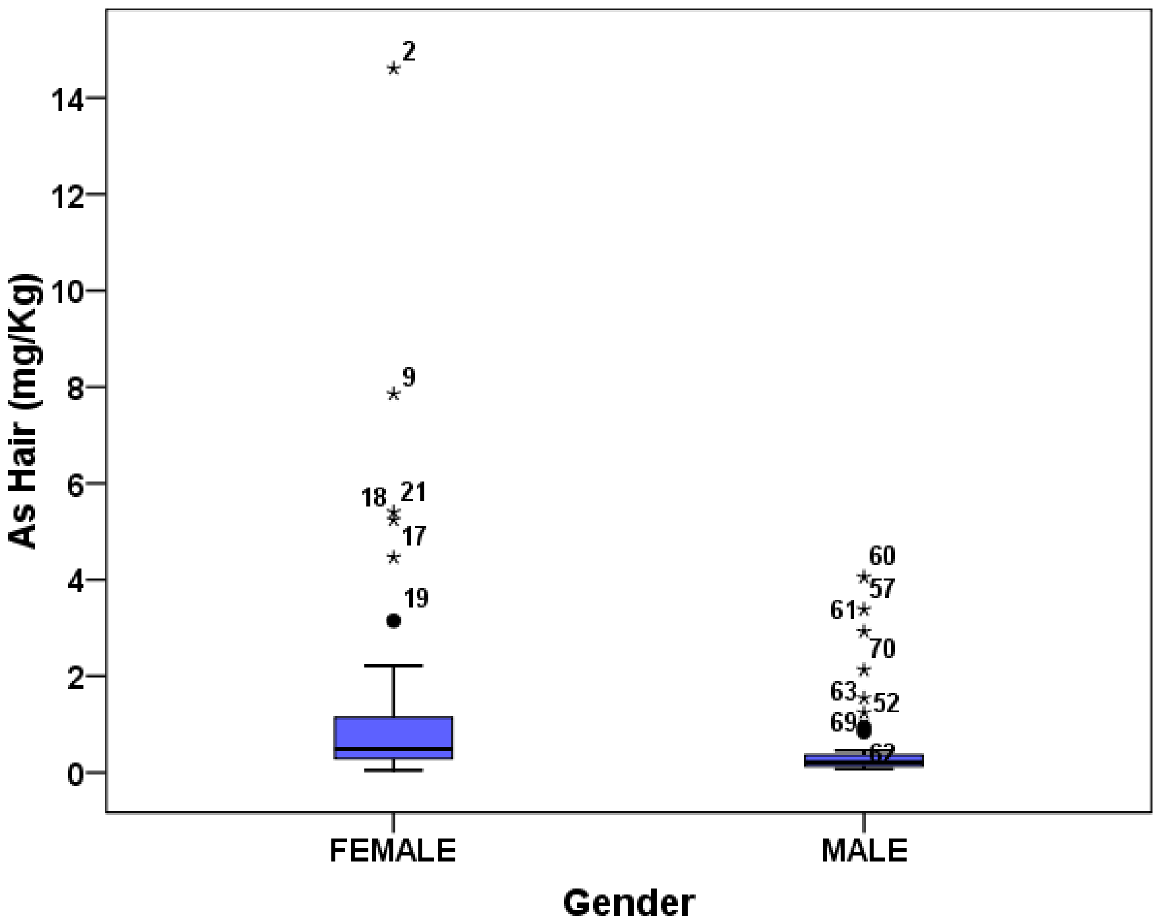
Results and discussions

Human hair (n=84), nails (n=88) (both toe and fingernails together) and urine (n=23) samples collected from an arsenic impacted area Allama Iqbal town Lahore have been analyzed by ICP-MS for total arsenic.

The volunteers of Allama Iqbal Town Lahore have a mean Body Mass Index (BMI) value of 24 ± 7 in the range of (13.5 - 53).

Figure 5.1 Arsenic contents in hair samples (µg/g) from male and female population of Allama Iqbal town, Lahore

Box and whisker plot shows inter-quartile range as a box, total range as whisker, with outliers indicated by dots or stars which are included in calculation.

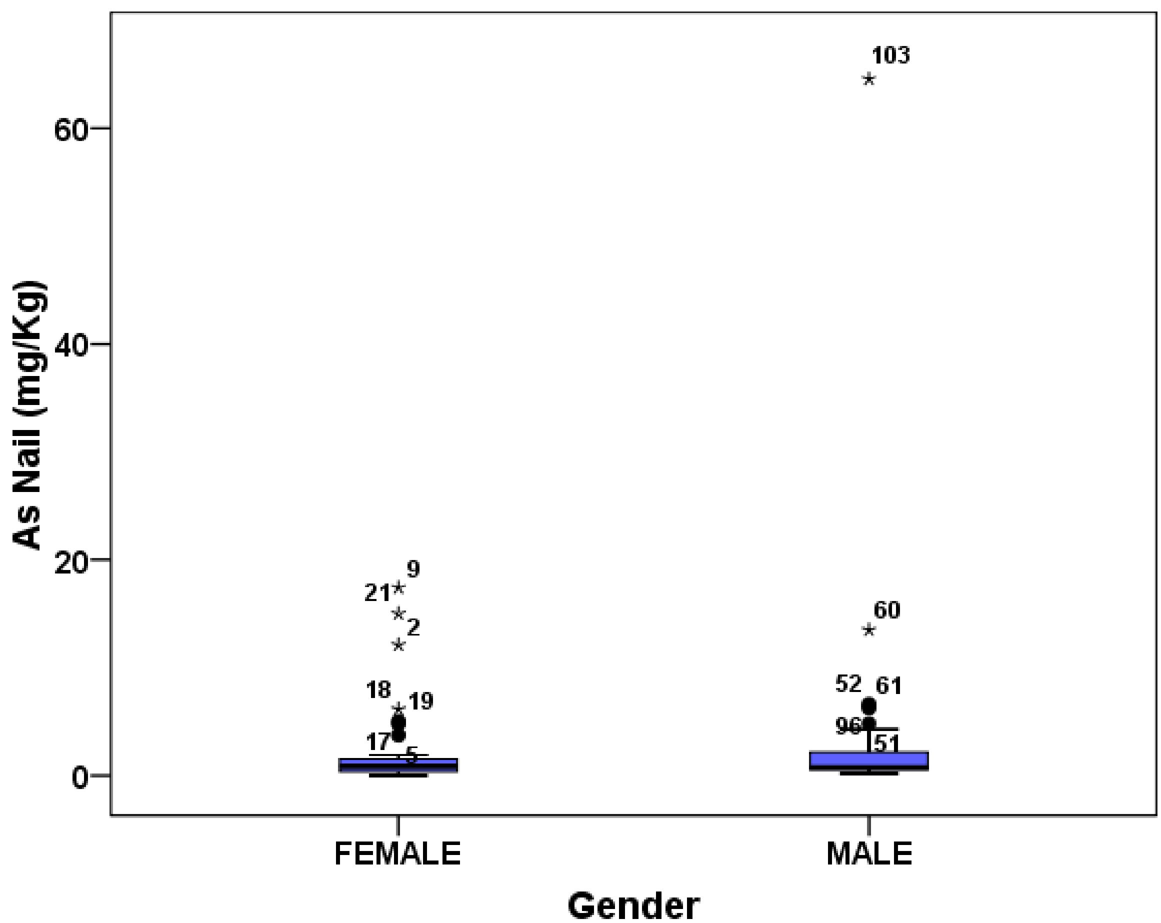


ICP-Ms analysis of As contents in hair samples collected has a median concentration of 0.30 mg/kg and mean 1.00 (± 2) mg/L (0.04 to 14.61 mg/L)(Fig 5.1) which is higher than NRC, 1999 reported normal value of (0.02-0.2 mg/kg) As content in hair (NRC 1999b). The mean reported value is also higher than the one reported in India (0.61mg/kg), Japan (0.05 mg/kg), Canada (0.016 mg/kg), Poland (0.02 mg/kg) by Takagi et al 1986, in Italy (0.09 mg/kg) by Caroli et al 1992, and in Malaysia (0.28 mg/kg) and Nigeria (0.09 mg/kg) by Oluwole et al 1994 where drinking arsenic contamination water is the main As exposure media in all the cases (Caroli et al. 1992; Oluwole et al. 1994; Takagi et al. 1986).

This study has hair arsenic concentration less than the reported value of (Sthiannopkao et al. 2010) median (0.6 mg/kg) and a mean value of (3.2 mg/kg) (n=68) from Kandal Province of Cambodia.

Figure 5.2 Arsenic contents in nails samples (mg/kg) from male and female population of Allama Iqbal town, Lahore

Box and whisker plot shows inter-quartile range as a box, total range as whisker, with outliers indicated by dots or stars which are included in calculation.



While arsenic concentration of nails both toe and finger nails samples has a median value of 0.76 mg/kg, mean value of 2.8 (±7) mg/kg and ranged (0.17- 65 mg/kg) (Fig 5.2) is also higher than the normal reported As content (0.02-0.5 mg/kg) reported by NRC (NRC 1999a). This value of As in biomarkers like hair and nails may provide reliable estimates of internal dose of absorbed As for a long period from low level exposure (Karagas et al. 2001b).

As contents of human urine samples is (18.74 – 349.55 µg/L) (n= 23) for population of AI Town, Lahore have a mean value of 134 .13 (± 95) µg/g creatinine (Fig 5.3).

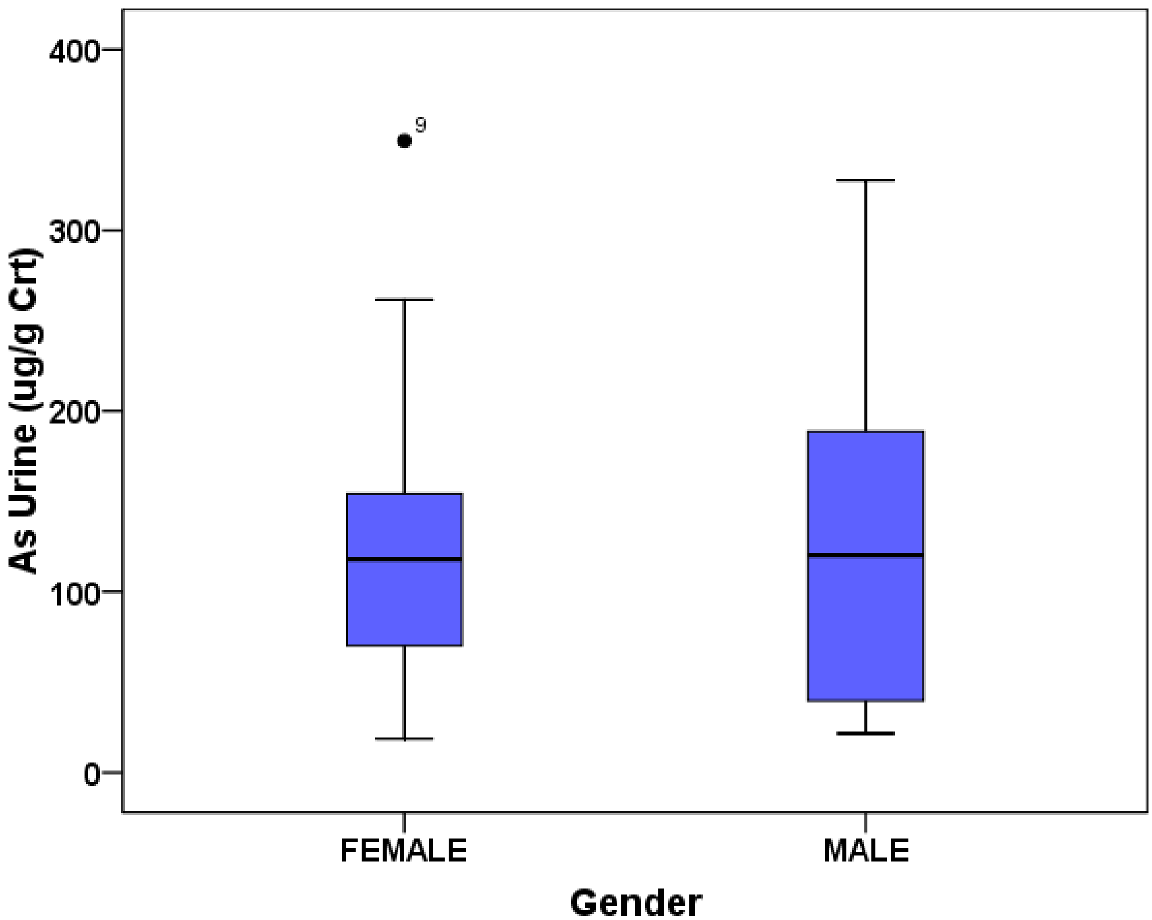
The total As analysed by ICP-MS for drinking water As has a median value of 24 and a mean of 91 (± 185) µg/L , (0.06 - 960 µg/L). Mean value for As concentration is higher than WHO guideline value (10 µg/L) for As in drinking water.

The As concentration in raw rice analysed by ICP-MS has a mean value of 0.1 (± 0.07) mg/kg and range (0.03-0.63 mg/kg) and only few samples which exceeded the Chinese MCL of 0.15 mg/kg (Table 5.1). Details of both As in drinking water and rice along with their respective figures can be seen in chapter 4.

The Pearson correlation Sig. (2 tailed) values gives us an idea about the association of As content of hair, nails and urine value with water, rice arsenic and also with CDIs (µg/kg/day) calculated for rice, water and total CDI (rice and drinking water) (µg/kg/day). The As contents in hair and nails has a positive association with the drinking water As contents and hair show comparatively higher value (r^2=0.63) ($p < 0.01$) then nails (r^2=0.24) ($p < 0.01$) while As content of urine has (r^2= 0.043) ($p < 0.01$) no such trend for the overall population of Allama Iqbal town Lahore. However, total number of urine samples (n=23) collected were very small comparatively which may be one reason.

Figure 5.3 Total urinary arsenic (µg/L) in urine samples of volunteers (male and female) from Allama Iqbal town Lahore

Box and whisker plot shows inter-quartile range as a box, total range as whisker, with outliers indicated by dots or stars which are included in calculation.



Furthermore the association between As in hair with both calculated daily intake CDI (µg/kg/day) values for As contaminated drinking water and total CDI (rice + water) (µg/kg/day) (Fig 5.4) has a positive value ($r^2=0.42$, $p < 0.01$) which is comparable to the correlations between arsenic concentrations in hair vs. daily dietary intake ($r^2 = 0.452$, $p < 0.001$) reported by Uchino et al 2006 in West Bengal India (Uchino et al. 2006).

This association act as additional evidences for arsenic exposure from drinking water sources in Allama Iqbal town Lahore. The scatter plot for log transformed values of arsenic contents in hair , nails, urine, rice and drinking water along with CDIs from rice, water, and CDI total further clarify the picture of different associations (Fig 5.4 and 5.5).

Figure 5.4 Correlation of hair arsenic (mg/kg) and calculated total daily intake CDI (µg/kg/day) for male and female volunteers from Allama Iqbal town Lahore

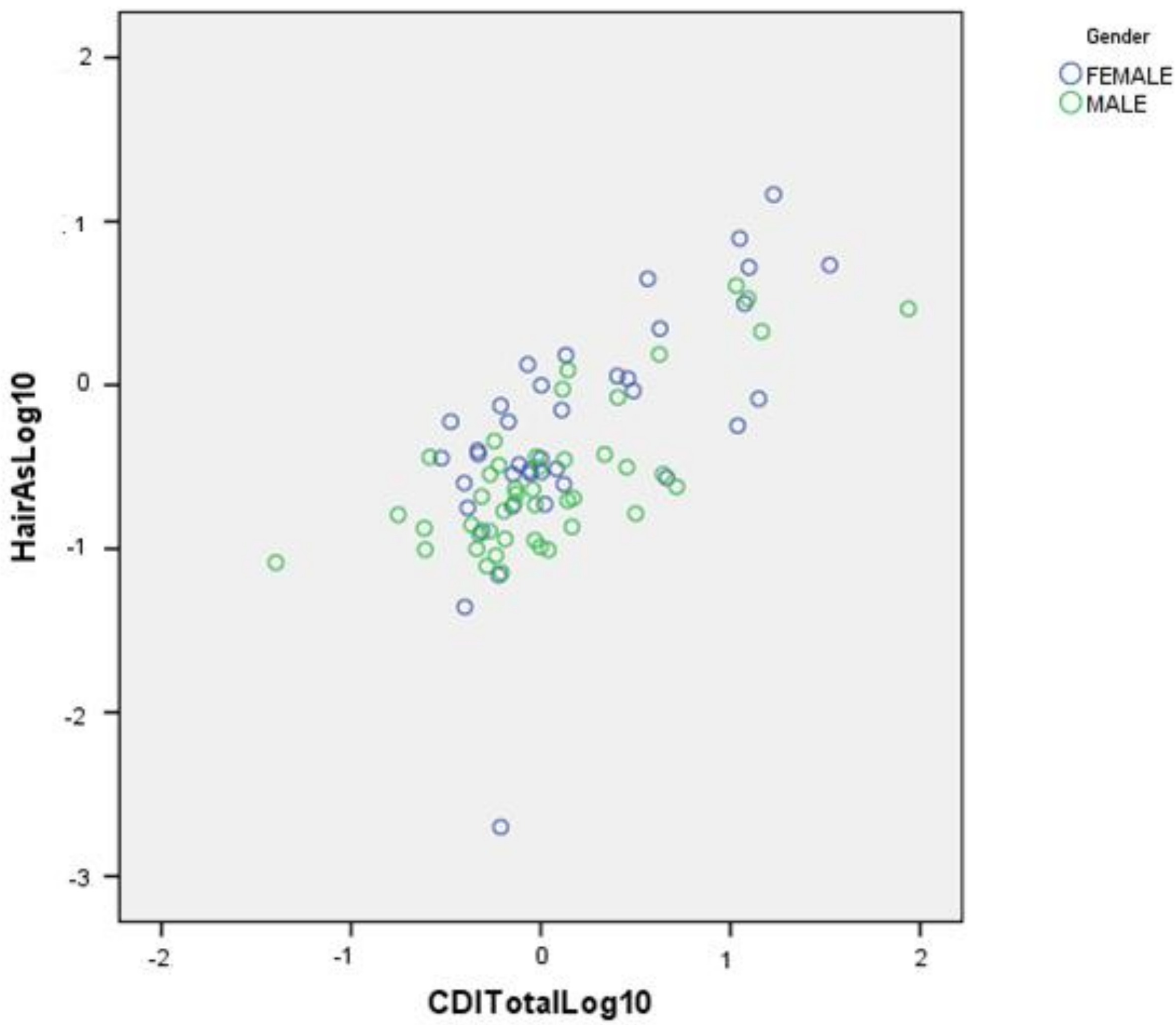
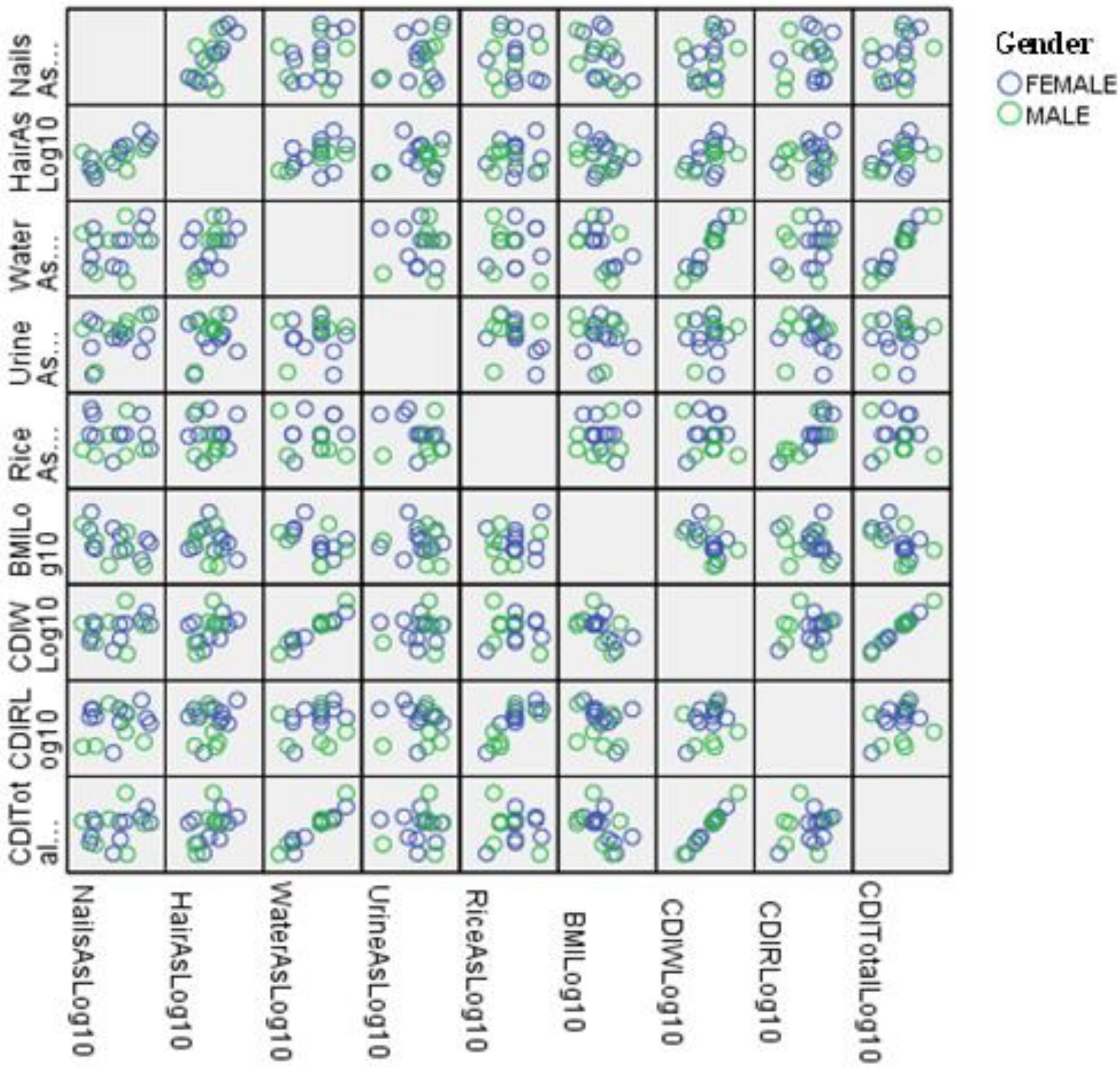


Table 5.1 Descriptive statistics of volunteers from Allama Iqbal town, Lahore

	N	Mean	Median	Std. Deviation	Minimum	Maximum	95th Percentile	99th Percentile
BMI	103	24.2	22.8	6.42	13.5	52.6	36.4	52.2
Water intake (L/day)	103	1.94	1.70	0.69	1.05	4.50	3.45	4.49
Age (y)	103	32.8	28.0	16.2	11.0	85.0	65.0	85.0
Nail As (mg/kg)	86	2.76	0.85	7.47	0.17	64.6	13.0	64.6
Hair As (mg/kg)	83	1.00	0.30	2.05	0.04	14.6	5.08	14.6
Urine As (µg/g cret)	23	134.1	117.9	95.5	18.7	349.5	345.2	349.5
Rice As (mg/kg)	88	0.10	0.08	0.09	0.03	0.63	0.20	0.63
Water As (µg/L)	106	91.3	22.7	186.3	0.06	959.8	503.1	959.8
CDI Rice (µg/kg/day)	88	0.34	0.30	0.26	0.08	1.88	0.83	1.88
CDI water (µg/kg/day)	103	3.78	0.60	10.6	0.00	86.4	16.4	84.8
CDI Total (µg/kg/day)	103	4.07	0.94	10.6	0.00	86.6	16.9	85.1

Figure 5.5 Associations for As contents in hair, nails, urine, rice, water samples (µg/L) from male and female volunteers from Allama Iqbal town Lahore



Female population biomarkers data and associations

Female population overall has a mean and median BMI value of 27 ± 7 (15 - 52) has arsenic contents of hair (n=39) median 0.5 mg/kg, mean value of 1.5 ± 3 (0.04 - 14.6 mg/kg) and their nails (n=39) (both toe and finger nails) has a median value of 0.85 mg/kg, mean value of 2.3 ± 4 mg/kg (0.18 - 17.40 mg/kg) while arsenic content of urine for female has a mean value of 136 ± 92 µg/kg-creatinine (ranging from 19- 350 µg/kg - creatinine) (Table 5.2).

The Pearson correlation Sig. (2 tailed) values for the association of As content of hair and drinking water As is (r^2=0.64, $p < 0.01$) nails and drinking water is (r^2=0.77, $p < 0.01$) is significant (Table 5.6) and is comparable to the one found in Cambodia by Gault et al 2008 (Gault et al. 2008a).

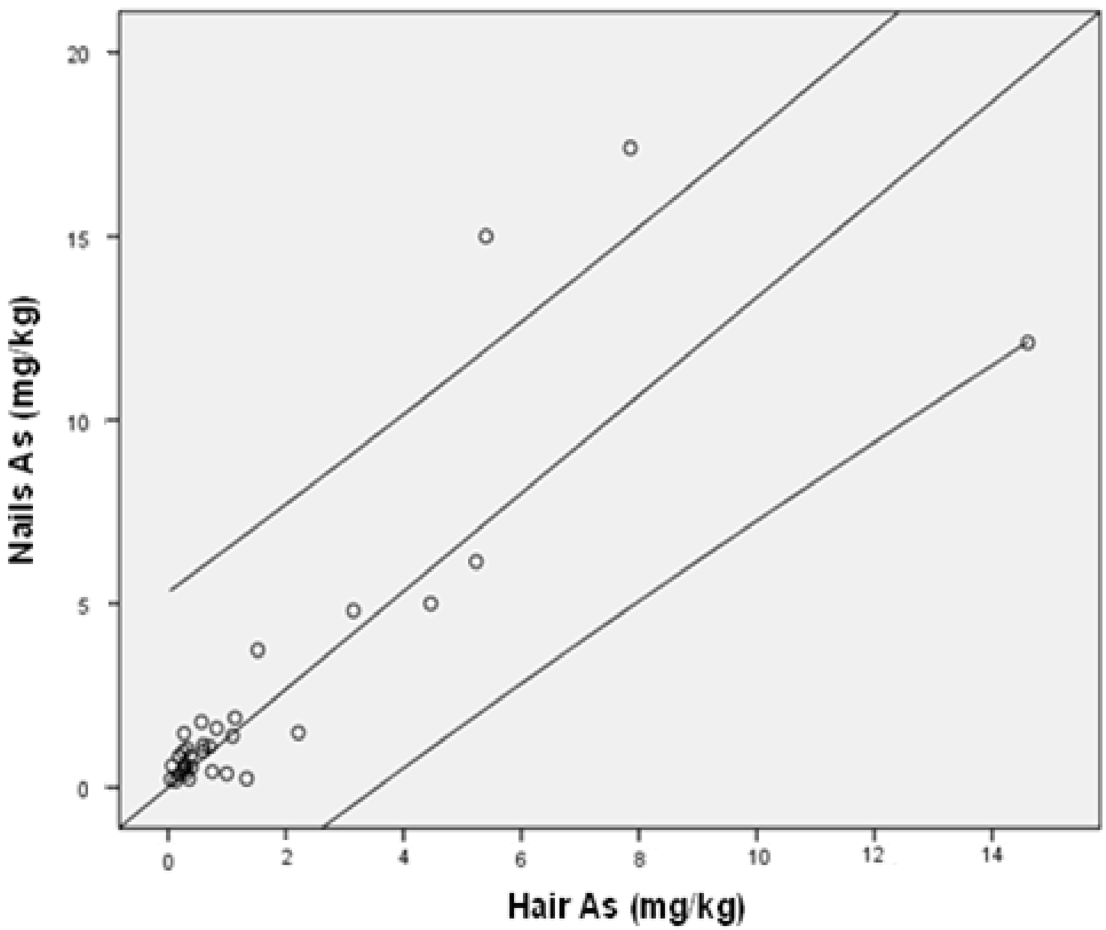
Likewise the association of hair As with CDI Drinking water (r^2=0.65, $p < 0.01$) as well as total CDI (r^2=0.66, $p < 0.01$) and also of nails with CDI drinking water (r^2=0.79, $p < 0.01$) as well as total CDI (r^2=0.79, $p < 0.01$) is also very significant then both male as well as overall population of Allama Iqbal town Lahore. These significantly positive associations indicates that for all the female population drinking water derived from groundwater is the major source of As exposure like the one reported in Cambodia (Phan et al. 2010).

In contrast to our results there are some studies which reported no considerable differences for males and females during the assessment of As in hair and children and adolescents proved to be more susceptible as compared to the adults (Saad and Hassanien 2001).

The As contents of urine has a negative correlation value with drinking water As (r^2= - 0.14, $p \geq$ 0.65) for female population of Allama Iqbal Town Lahore.

The association of As contents in hair and nails in female population is also (r^2=0.84, $p < 0.01$) highly significant (Figure 5.6) and is comparable to the reported values of Gault et al., 2008 in Cambodia.

Figure 5.6 Correlation of arsenic in hair with arsenic in nails (mg/Kg) for female volunteers of Allama Iqbal town, Lahore



The associations for BMI with , water As ,CDI water, rice As, CDI rice, total CDI, hair, nails, and urine has overall negative trend.

Table 5.2 Descriptive statistics for female volunteers of Allama Iqbal town, Lahore

	N	Mean	Median	S. D	Minimum	Maximum	Percentile	
							95th	99 th
BMI	49	27.3	27.0	7.12	15.0	52.7	39.9	52.7
Age (y)	49	36.5	35.0	17.8	11.0	85.0	77.5	85.0
Water intake (L)	49	1.61	1.50	0.34	1.05	2.45	2.35	2.45
Nail As (mg/kg)	39	2.29	0.85	3.97	0.18	17.4	15.0	17.4
Hair As (mg/kg)	38	1.55	0.48	2.79	0.04	14.6	8.19	14.6
Urine As (µg/g cret)	13	136.4	117.9	91.9	18.7	349.5	349.5	349.5
Rice As (mg/kg)	43	0.10	0.09	0.08	0.03	0.58	0.20	0.58
Water As (µg/L)	49	100.2	26.1	179.6	0.06	959.8	535.9	959.8
CDI Rice (µg/kg/day)	43	0.35	0.31	0.28	0.08	1.88	0.81	1.88
CDI water (µg/kg/day)	49	3.17	0.61	6.04	0.00	32.9	15.3	32.9
CDI Total (µg/kg/day)	49	3.48	1.01	6.09	0.00	33.4	15.8	33.4

Male population biomarkers data and associations

Arsenic concentration in different biomarkers for the male population with mean BMI 21.4 ± 4 ranged (13.5 – 32.3) have comparatively higher value for nails As having a median As (0.74 mg/kg) and mean value of 3 ± 9 mg/kg, ranged (0.17-64.6 mg/kg) but has lower values for both hair As median (0.2 mg/kg), mean 0.54 (± 0.9) mg/kg ranged (0.07-4.05 mg/kg) and urine As values median 120 µg/g creatinine and mean value of 131 ± 104 µg/g creatinine, ranged (21.5 – 328 µg/g creatinine) (Table 5.3). The Pearson correlation values for As in hair, nail, urine, water, raw rice and CDIs calculated from water intake, rice intake and both water and rice together is given in Supplementary information (Table 5.5).

Table 5.3 Descriptive Statistics for male population of Allama Iqbal Town Lahore

	N	Mean	Median	S. D	Minimum	Maximum	Percentiles	
							95	99
BMI	54	21.4	20.9	4.05	13.5	32.3	27.9	32.3
Age (y)	54	29.5	25.0	13.8	14.0	65.0	58.2	65.0
Water intake (L)	54	2.24	2.15	0.79	1.05	4.50	4.04	4.50
Nail (mg/kg)	47	3.15	0.74	9.47	0.17	64.6	10.7	64.6
Hair (mg/kg)	45	0.54	0.21	0.89	0.07	4.05	3.24	4.05
Urine (µg/g cret)	10	131.2	120.1	104.9	21.5	327.7	327.7	327.7
Rice (mg/kg)	45	0.10	0.07	0.09	0.03	0.63	0.24	0.63
Water (µg/L)	54	87.0	18.9	197.9	0.93	959.8	572.2	959.8
CDI Rice (µg/kg/day)	45	0.33	0.29	0.23	0.09	1.43	0.83	1.43
CDI water (µg/kg/day)	54	4.34	0.60	13.5	0.03	86.4	27.3	86.4
CDI Total (µg/kg/day)	54	4.62	0.92	13.5	0.04	86.6	27.5	86.6

Conclusion

Hair and nails have been confirmed as good biomarkers of As exposure assessment for the volunteers of Allama Iqbal Town Lahore who consume As contaminated drinking and cooking water above the WHO guideline value of 10 µg/L As. On the basis of gender the values of As content of hair and nail have a better association for female population of the area than their male counterparts perhaps suggests that males more likely to be taking water from various other sources in addition to household if they work away from home.

References

Adair BM, Hudgens EE, Schmitt MT, Calderon RL, Thomas DJ. 2006. Total arsenic concentrations in toenails quantified by two techniques provide a useful biomarker of chronic arsenic exposure in drinking water. Environmental Research 101(2): 213-220.

Ahmad T K, Tahir MA, and Rashid, H. 2004. Arsenic an Emerging Issue: Experiences from Pakistan In: Proceedings of the 30th WEDC international conference, Vientiane, Lao PDR.

Ahmed K. 2007. Toxic Elements in the Drinking Waters of Pakistan. Journal of the Chemical Society of Pakistan 29(6): 591-597.

Airas S, Duinker A, Julshamn K. 2004. Copper, zinc, arsenic, cadmium, mercury, and lead in blue mussels (Mytilus edulis) in the Bergen harbor area, Western Norway. Bull Environ Contam Toxicol 73(2): 276-284.

Anawar HM, Akai J, Mostofa KM, Safiullah S, Tareq SM. 2002. Arsenic poisoning in groundwater: health risk and geochemical sources in Bangladesh. Environment International 27(7): 597-604.

Anwar M. 2005. Arsenic, cadmium and lead levels in hair and toenail samples in Pakistan. Environ Sci 12(2): 71-86.

Arain GM, Aslam M, Majidano SA, Khuhawar MY. 2007. A Preliminary Study on the Arsenic Contamination of Underground Water of Matiari and Khairpur Districts, Sindh, Pakistan. Journal of the Chemical Society of Pakistan 29(5): 463-467.

Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Jalbani N, Sarfraz RA, Shah AQ, Kandhro GA. 2009. Respiratory effects in people exposed to arsenic via the drinking water and tobacco smoking in southern part of Pakistan. Science of The Total Environment 407(21): 5524-5530.

Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Shah AQ, Jalbani N, Sarfraz RA. 2009. Determination of arsenic levels in lake water, sediment, and foodstuff from selected area of Sindh, Pakistan: Estimation of daily dietary intake. Food and Chemical Toxicology 47(1): 242-248.

August; 114(8): 1293–1296 114(8): 1293–1296.

Brima EI, Haris PI, Jenkins RO, Polya DA, Gault AG, Harrington CF. 2006. Understanding arsenic metabolism through a comparative study of arsenic levels in the urine, hair and fingernails of healthy volunteers from three unexposed ethnic groups in the United Kingdom. Toxicology and Applied Pharmacology 216(1): 122-130.

Calderon RL, Hudgens E, Chris X, Schreinemachers D, Thomas DJ. 1999. Excretion of arsenic in urine as a function of exposure to arsenic in drinking water. Environmental Health Perspectives 107(8): 663-667.

Caroli S, Senofonte O, Violante N, Fornarelli L, Powar A. 1992. Assessment of reference values for elements in hair of urban normal subjects. Microchemical Journal 46(2): 174-183.

Chen KL, Amarasiriwardena CJ, Christiani DC. 1999. Determination of total arsenic concentrations in nails by inductively coupled plasma mass spectrometry. Biological trace element research 67(2): 109-125.

Farooqi A, Firdous N, Masuda H, Haider N. 2003. Fluoride and arsenic poisoning in ground water of Kalalanwala area, near Lahore, Pakistan. Geochimica et Cosmochimica Acta 67(18): A90-A90.

Farooqi A, Masuda H, Firdous N. 2007. Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. Environmental Pollution 145(3): 839-849.
Farooqi A, Masuda H, Siddiqui R, Naseem M. 2009. Sources of Arsenic and Fluoride in Highly Contaminated Soils Causing Groundwater Contamination in Punjab, Pakistan. Archives of Environmental Contamination and Toxicology 56(4): 693-706.
Fatmi Z, Azam I, Ahmed F, Kazi A, Gill AB, Kadir MM, Ahmed M, Ara N, Janjua NZ. 2009a. Health burden of skin lesions at low arsenic exposure through groundwater in Pakistan. Is river the source? Environmental research 109(5): 575-581.
Freeman BLE, Dennis LK, Lynch CF, Thorne PS, Just CL. 2004. Toenail Arsenic Content and Cutaneous Melanoma in Iowa. Am J Epidemiol 160(7): 679-687.
Garland M, Morris JS, Rosner BA, Stampfer MJ, Spate VL, Baskett CJ, Willett WC, Hunter DJ. 1993. Toenail trace element levels as biomarkers: reproducibility over a 6-year period. Cancer epidemiology, biomarkers & prevention 2(5): 493-497.
Gault AG, Rowland HA, Charnock JM, Wogelius RA, Gomez-Morilla I, Vong S, Leng M, Samreth S, Sampson ML, Polya DA. 2008. Arsenic in hair and nails of individuals exposed to arsenic-rich groundwaters in Kandal province, Cambodia. The Science of The Total Environment 393(1): 168-176.
Hughes MF. 2006. Biomarkers of exposure: a case study with inorganic arsenic. Environmental Health Perspectives 114(11): 1790-1796.
IAEA. 1978. Activation analysis of hair as an indicator of contamination of man by environmental trace element pollutants,. (IAEA/RL/50,). Vienna, Austria. International Atomic Energy Agency
Jakhrani MA, Chaudhray AJ, Hassan M, Malik KM, Jakhrani AA, Mazari MQ. 2009. Determination of Arsenic and Other Heavy Metals in Hand Pump and Tube-Well Ground Water of Khairpur, Sindh, Pakistan. Proceedings of the Second International Conference on Environmental and Computer Science: 271-276.
Kapaj S, Peterson H, Liber K, Bhattacharya P. 2006. Human Health Effects From Chronic Arsenic Poisoning- A Review. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering 41(10): 2399-2428.
Karagas MR, Stukel TA, Morris JS, Tosteson TD, Weiss JE, Spencer SK, Greenberg ER. 2001a. Skin Cancer Risk in Relation to Toenail Arsenic Concentrations in a US Population-based Case-Control Study. American Journal of Epidemiology 153(6): 559-565.
Kile ML, Houseman EA, Rodrigues E, Smith TJ, Quamruzzaman Q, Rahman M, Mahiuddin G, Su L, Christiani DC. 2005. Toenail arsenic concentrations, GSTT1 gene polymorphisms, and arsenic exposure from drinking water. Cancer Epidemiol Biomarkers Prev 14(10): 2419-2426.
Morton J, Carolan VA, Gardiner PHE. 2002. Removal of exogenously bound elements from human hair by various washing procedures and determination by inductively coupled plasma mass spectrometry. Analytica Chimica Acta 455(1): 23-34.
Nickson RT, McArthur JM, Shrestha B, Kyaw-Myint TO, Lowry D. 2005. Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan. Applied Geochemistry 20(1): 55-68.
NRC. 1999a. Arsenic in Drinking Water.Nat. Academy Press, Washington, DC.
NRC. 1999b. Arsenic in Drinking Water.National Academy Press: Washington, DC.

Oluwole A, Ojo J, Durosinmi M, Asubiojo O, Akanle O, Spyrou N, Filby RH. 1994. Elemental composition of head hair and fingernails of some Nigerian subjects. Biological trace element research 43-45(1): 443-452.

PCRWR. 2003a. Arsenic Contamination in Groundwater of Southern Punjab.PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).

PCRWR. 2003b. Innovative Low Cost Arsenic Removal Technologies for Developing Countries.PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).

PCRWR. 2008. Pakistan drinking water quality report. Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF, Pakistan).

Phan K, Sthiannopkao S, Kim KW, Wong MH, Sao V, Hashim JH, Yasin MSM, Aljunid SM. 2010. Health risk assessment of inorganic arsenic intake of Cambodia residents through groundwater drinking pathway. Water Research 44(19): 5777-5788.

Saad A, Hassanien MA. 2001. Assessment of arsenic level in the hair of the nonoccupational Egyptian population: pilot study. Environment International 27(6): 471-478.

Slotnick MJ, Meliker JR, AvRuskin GA, Ghosh D, Nriagu JO. 2007. Toenails as a biomarker of inorganic arsenic intake from drinking water and foods. J Toxicol Environ Health 70(2): 148-158.

Slotnick MJ, Nriagu JO. 2006. Validity of human nails as a biomarker of arsenic and selenium exposure: A review. Environmental Research 102(1): 125-139.

Smedley PL, Kinniburgh DG. 2002. A review of the source, behavior and distribution of arsenic in natural waters. Appl Geochem 17: 517-568.

Smith AH, Lingas EO, Rahman M. 2000. Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. Bull WHO 78: 1093-1103.

Smith AH, Lopipero PA, Bates MN, Steinmaus CM. 2002. Arsenic Epidemiology and Drinking Water Standards. Science 296(5576): 2145-2146.

Smith AH, Marshall G, Yuan Y, Ferreccio C, Liaw J, von Ehrenstein O, Steinmaus C, Bates MN, Selvin S. 2006. Increased mortality from lung cancer and bronchiectasis in young adults after exposure to arsenic in utero and in early childhood. Environ Health Perspect 114: 1293-1296.

Sthiannopkao S, Kim K-W, Cho KH, Wantala K, Sotham S, Sokuntheara C, Kim JH. 2010. Arsenic levels in human hair, Kandal Province, Cambodia: The influences of groundwater arsenic, consumption period, age and gender. Applied Geochemistry 25(1): 81-90.

Takagi Y, Ohkubo Y, Asada T, Matsuda S. 1986. An International Comparison of Trace Amounts of Fluoride Contained in Human Hair. In: Studies in Environmental Science, Vol. Volume 27, (Humio T, Ming-Ho Y, eds):Elsevier, 423-429.

Tseng CH, Huang YK, Huang YL, Chung CJ, Yang MH, Chen CJ, Hsueh YM. 2005. Arsenic exposure, urinary arsenic speciation, and peripheral vascular disease in Blackfoot disease-hyperendemic villages in Taiwan. Toxicology and Applied Pharmacology 206(3): 299-308.

Uchino T, Roychowdhury T, Ando M, Tokunaga H. 2006. Intake of arsenic from water, food composites and excretion through urine, hair from a studied population in West Bengal, India. Food and Chemical Toxicology 44(4): 455-461.

Wang JP, Zheng BS, Qi L, Liu F, Moore MR, Ng JC. 2001. Early warning biomarkers for chronic arsenic exposure in humans. Toxicology 164(1-3): 59-59.

Supplementary Information

Table 5.4 Pearson correlation values for arsenic in biomarkers, drinking/cooking water, rice and calculated daily intake CDI in volunteers from Allama Iqbal Town, Lahore

As Nails	Pearson Correlation	1								
mg/kg	Sig. (2-tailed)									
	N	88								
As Hair	Pearson Correlation	.301**	1							
mg/kg	Sig. (2-tailed)	0.007								
	N	79	84							
Water	Pearson Correlation	.241*	.627**	####						
µg/L	Sig. (2-tailed)	0.023	0							
	N	88	84	108						
Urine	Pearson Correlation	.479*	0.103	0.043	1					
µg/L	Sig. (2-tailed)	0.038	0.674	0.846						
	N	19	19	23	23					
As Rice	Pearson Correlation	0.055	-0.044	0.012	-0.131	1				
mg/kg	Sig. (2-tailed)	0.637	0.712	0.915	0.572					
	N	77	74	88	21	88				
BMI	Pearson Correlation	-0.163	-.227*	-.211*	-0.268	0.151	1			
	Sig. (2-tailed)	0.13	0.038	0.031	0.217	0.16				
	N	88	84	104	23	88	104			
CDI water	Pearson Correlation	0.179	.420**	.899**	0.096	-0.048	-.203*	1		
(µg/kg-day)	Sig. (2-tailed)	0.096	0	0	0.662	0.659	0.039			
	N	88	84	104	23	88	104	104		
CDI rice	Pearson Correlation	0.14	0.148	0.162	0.188	.904**	-0.07	0.084	1	
(µg/kg-day)	Sig. (2-tailed)	0.193	0.18	0.099	0.391	0	0.481	0.395		
	N	88	84	104	23	88	104	104	104	
Total CDI	Pearson Correlation	0.181	.423**	.901**	0.098	-0.032	-.204*	1.000**	0.104	1
(µg/kg-day)	Sig. (2-tailed)	0.091	0	0	0.657	0.766	0.038	0	0.292	
	N	88	84	104	23	88	104	104	104	104

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 5.5 Correlations values for arsenic in biomarkers, water and rice and calculated daily intake CDI for male volunteers from Allama Iqbal Town, Lahore

As Nail mg/Kg	Pearson Correlation	1.000								
	Sig. (2-tailed)									
	N	47								
As Hair mg/Kg	Pearson Correlation	.133	1.000							
	Sig. (2-tailed)	.400								
	N	42	45							
As Water µg/L	Pearson Correlation	.074	.766**	1.000						
	Sig. (2-tailed)	.619	.000							
	N	47	45	54						
As urine µg/g creatinine	Pearson Correlation	.836**	.756*	.195	1.000					
	Sig. (2-tailed)	.010	.030	.588						
	N	8	8	10	10					
As Rice mg/Kg	Pearson Correlation	.063	-.089	.015	.390	1.000				
	Sig. (2-tailed)	.694	.590	.922	.339					
	N	41	39	45	8	45				
CDI Water µg/Kg/day	Pearson Correlation	.068	.580**	.935**	.171	-.058	1.000			
	Sig. (2-tailed)	.649	.000	.000	.637	.704				
	N	47	45	54	10	45	54			
CDI rice µg/Kg/day	Pearson Correlation	.079	-.097	.012	.233	.929**	-.040	1.000		
	Sig. (2-tailed)	.621	.559	.939	.579	.000	.796			
	N	41	39	45	8	45	45	45		
CDI total µg/Kg/day	Pearson Correlation	.070	.580**	.936**	.173	-.043	1.000**	-.024	1.000	
	Sig. (2-tailed)	.638	.000	.000	.632	.777	.000	.877		
	N	47	45	54	10	45	54	45	54	
BMI	Pearson Correlation	-.070	-.189	-.108	-.476	.373*	-.167	.106	-.168	1.000
	Sig. (2-tailed)	.638	.215	.437	.165	.012	.228	.490	.224	
	N	47	45	54	10	45	54	45	54	54

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 5.6 Correlations values for As in biomarkers, water and rice and calculated daily intake CDI for female volunteers from Allama Iqbal Town, Lahore

As Nails mg/Kg	Pearson Correlation	1.000								
	Sig. (2-tailed)									
	N	40								
As Hair mg/Kg	Pearson Correlation	.843**	1.000							
	Sig. (2-tailed)	.000								
	N	36	39							
As Water µg/L	Pearson Correlation	.768**	.642**	1.000						
	Sig. (2-tailed)	.000	.000							
	N	40	39	49						
As urine µg/g-crt	Pearson Correlation	.319	-.045	-.141	1.000					
	Sig. (2-tailed)	.339	.895	.647						
	N	11	11	13	13					
As Rice mg/Kg	Pearson Correlation	-.057	-.026	.012	-.517	1.000				
	Sig. (2-tailed)	.740	.882	.941	.071					
	N	36	36	43	13	43				
BMI	Pearson Correlation	-.384*	-.428**	-.443**	-.099	.100	1.000			
	Sig. (2-tailed)	.014	.007	.001	.748	.525				
	N	40	39	49	13	43	49			
CDI water µg/Kg/day	Pearson Correlation	.798**	.652**	.989**	-.035	-.006	-.454**	1.000		
	Sig. (2-tailed)	.000	.000	.000	.909	.970	.001			
	N	40	39	49	13	43	49	49		
CDI Rice µg/Kg/day	Pearson Correlation	.238	.284	.318*	-.159	.869**	-.225	.312*	1.000	
	Sig. (2-tailed)	.138	.080	.026	.605	.000	.121	.029		
	N	40	39	49	13	43	49	49	49	
CDI Total µg/Kg/day	Pearson Correlation	.797**	.655**	.989**	-.037	.014	-.456**	1.000**	.337*	1.000
	Sig. (2-tailed)	.000	.000	.000	.904	.930	.001	.000	.018	
	N	40	39	49	13	43	49	49	49	49

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Chapter 6 Relationship of Drinking /Cooking water and rice Arsenic contents to Biomarkers of Arsenic exposure in West Bengal India

Abstract

Drinking arsenic contaminated ground water has been a documented worldwide problem and is a responsible for chronic arsenic exposure in south Asian countries like India and Bangladesh where millions of people are affected (Argos et al. 2010; Kapaj et al. 2006; Smith et al. 2002; Smedley and Kinniburgh 2002). In addition, As in different dietary material and especially rice and rice products has been recently recognized as an additional source of As exposure (Das et al. 2004; Meharg et al. 2005, 2006, 2008a; Mondal and Polya 2008; Meharg and Rahman 2003) which is of utmost importance for those communities where it is used as a daily diet (Brahic 2008; Chatterjee et al. 2010b).

Samples of drinking and cooking water, cooked ,uncooked rice, human urine, hair and nails were collected from the highly, medium and relatively less exposed groups in west Bengal and analysed for total arsenic as well as its metabolites. All these samples were processed by using standard methods for cleaning, digestion and were analysed for total arsenic by ICP-MS and for arsenic metabolites by HPLC-ICP-MS. The mean value of hair arsenic is 1.59 (range 0.08-19.44 mg/kg), mean value of nail as is 2.40 mg/kg (range 0.13 -36.13 mg/kg). Mean value of urine As is 139.38 µg/g creatinine (range <DL – 2763.5 µg/g creatinine). The arsenic speciation results for rice have i-As > DMA > MMA > AB and is broadly comparable with published arsenic speciation in rice data. The mean i-As content was 75 ± 8 %.

Association of arsenic in drinking water (which is mostly used as cooking water too) with nails As is ($r^{2\,=}$ 0.76) and hair As ($r^{2\,=}$ 0.68) is highly significant and positively correlated value with urine creatinine adjusted As ($r^{2\,=}$ 0.38) for the total population. CDI water (µg/kg/day) also has a significant correlation with arsenic hair ($r^{2\,=}$ 0.64) and nails values ($r^{2\,=}$ 0.67) which indicates water as the major source of As for the exposed population. Likewise, CDI cooked rice (µg/kg/day) value has also significant Pearson correlation values

with As contents of nail ($r^{2 =}$ 0.69), hair ($r^{2 =}$ 0.64) and urine ($r^{2 =}$ 0.22) which is comparable to the values of drinking water association values for biomarkers, furthermore somewhat less significant association values for uncooked rice proved cooked rice as the next significant source of As exposure after drinking/cooking water. In this study both arsenic in hair and nails has been proved as good biomarkers for As exposure in the exposed volunteers of West Bengal India.

Introduction

Inorganic arsenic (iAs) has been characterized as a group one carcinogen and is responsible for chronic As problems in many parts of the world (IARC 2004b; WHO 2001, 2004). The problem is highly common in the many Asian countries like Bangladesh, West Bengal India, Cambodia, Vietnam in some parts of China and also in Inner Mongolia (Argos et al. 2010; Smedley and Kinniburgh 2002; Smith et al. 2000). The situation is highly alarming especially in lower Ganga plain (Bangladesh and West Bengal India) in terms of increasing number of affected villages from drinking highly As contaminated water (Acharyya 1999; Chakraborti et al. 2002,2003, 2009b; Haque et al. 2003; Mazumder et al. 1998; Rahman et al. 2001; Sanz 2006; Smith et al. 2000) and upper and middle Ganga plain where according to a recent study of Vickey sing et al 2010 40% of the deep tube well sources have above 10 µg/L As (Acharyya 1999; Ahamed et al. 2006; Singh et al. 2010). Only in Bangladesh 35-77 million people are chronically exposed while in different districts of India 6 million are consuming arsenic contaminated water and among them 30,000 are threatened with visible symptoms of arsenic poisoning (Chakraborti et al. 2002; Smedley and Kinniburgh 2002).

The rice of West Bengal and Bangladesh contains high iAs, which is generally considered as comparatively more toxic then its organic counterparts (Chakraborti et al. 2009a; D'Amato et al. 2004; Meharg et al. 2005; Mondal and Polya 2008). Recent studies have identified As contaminated drinking/cooking water and As contaminated rice as important media of As exposure (Chatterjee et al. 2010a) and especially in Bangladesh and West Bengal India (Bhattacharya et al. 2010a, b; Carbonell et al. 2008a; Chakraborti et al. 2009a).

Different environmental exposures for example drinking, cooking with As contaminated water or eating As contaminated food and also the cooking methods of food, dust inhalation from any As contaminated soil site are mainly responsible for As contamination (Carbonell et al. 2009; Chakraborti et al. 2009a; Del Razo et al. 2002).

Arsenic contamination in rice has been documented to be incorporated from As contaminated irrigation water and paddy field soils (Bhattacharya et al. 2010a; Bi et al. 2011; Brammer 2009; Brammer and Ravenscroft 2009; Chen et al. 2006; Chon et al. 2008; Das et al. 2007; Duxbury et al. 2009) in rice irrigated areas. Further to this the cooking of rice with arsenic contaminated water and the cooking method of rice can also increase the amount of As in rice (Chakraborti et al. 2009a).

The relative importance of water and rice as exposure route for arsenic has been the subject of recent studies in West Bengal India (Mondal and Polya 2008) and Bangladesh (Kile et al. 2007) amongst other places (Polya et al., 2010a).

Inorganic arsenic is bio accumulative and it has the ability to produce different systematic diseases, it even can produce chromosomal aberrations and ultimately causes cancer of urinary bladder, kidney and lungs (Mazumder et al. 1998). In order to understand arsenic toxicity and metabolism, quantification of individual arsenic species is required and thus as speciation analysis is very important for evaluation of As exposure and quantification of risk from arsenic.

Recent arsenic body intake can be easily detected in urine samples as the body can get rid of most of the methylated As in urinary excretion, thus urine As concentration is being used as a biomarker of As exposure for short term exposure (Agusa et al. 2009). Hair (Agusa et al. 2006; Kurttio et al. 1998) and nails (Karagas et al. 2000; Schmitt et al. 2005) have been considered as useful biomarkers of As exposure for evaluation of chronic As exposure in many exposed populations (Adair et al. 2006; Brima et al. 2006; Button et al. 2009; Freeman et al. 2004; Gault et al. 2008; Ghosh et al. 2007; Hindmarsh 2002; Hinwood et al. 2003; Karagas et al. 2000; Sanz et al. 2007c; Schmitt et al. 2005). Biomarkers of As exposure could be used for better insight for As body burden when compared to environmental exposure and can be used as a proxy for As exposure assessment.

The aim of this study is to determine the relationship for As contents of raw rice, cooked rice and drinking/cooking water with the body burden/ contents of As in biomarkers of As exposure i.e. hair, nails and urine samples in West Bengal India.

Material and Methods

Sample collection and cleaning

Hair, nails, urine, raw and cooked rice and drinking/cooking water samples were collected from volunteers in West Bengal India. Ethical approval of the study was obtained from the Indian Institute of Chemical Biology, Jadavpur Calcutta. Sample collection was accompanied by an informed consent, questionnaire based survey for collection of information regarding demographic, health status, food habits, drinking water source etc.

Both toe and finger nail samples (0.1-0.5 g) and around 5 cm hair from the nap of the neck, cut with the help of new clean nail clippers or scissors, collected and stored in labelled, zip lock plastic bags. Any use of dye, gel or cosmetics was recorded. Hair and nail samples were collected from the same volunteer. First morning voids were collected in cleaned, labelled polypropylene bottles. A GPS reading (Latitudes and Longitudes etc) was taken at each water sample collecting site for recording the sample location and future mapping.

The standard method of washing for nails (Chen et al. 1999) and hair (IAEA 1978) was followed. Nail samples were first washed with 18.5 MΩ deionized water and any visible dirt was removed with a nylon wire brush. The samples were kept in clean glass beakers, submerged in 25 ml of 1% Triton-X100 solution and sonicated for 20 minutes. The wash solution was discarded and the nails were rinsed at least 3 times with 18.5 MΩ deionized water before being dried at 60°C.

Hair samples taken from the scalp end were placed in a clean glass beaker to which was added 25ml acetone (analytical grade) and then kept in an ultrasonic bath for 10 minutes. This wash acetone was discarded and 25 ml of 18.5MΩ deionized water was added and again sonicated for 10 minutes. The process was repeated two more times with water and finally with acetone. After the last wash with acetone, hair samples were allowed to dry overnight at room temperature.

Digestion and analysis

Hair/nail samples were accurately weighed by analytical balance (Fisher brand PS-100) into acid cleaned and properly labelled 10 ml polypropylene test tubes. 1 ml of concentrated nitric acid (double distilled from Aristar grade) was added to each tube, capped with clean stoppers and left to digest for 48 hours. These samples were intermittently shaken to be uniformly digested. After 48 hours, 9 ml of deionized water was added and the mixture was well shaken prior to filtration through a 0.45 μm polypropylene syringe filter (VWR International Ltd). These hair and nail digested and diluted solutions were filtered into new ICP-MS polystyrene test tubes and stored at 4°C before analysis. All the equipment used was cleaned in 5 % HNO_3 solution in a plastic bath tub and then washed with 18 MΩ deionized water to avoid any external contamination.

Urine samples, already lysd, were filtered with 0.45 µm polypropylene syringe filter (VWR International Ltd) and up to 5 times diluted with 18 MΩ deionized water for As speciation or made up to 2% HNO_3 for total As in urine. Creatinine adjustment was done for urine samples by using a Metra Creatinine Assay Kit (Quidel Corporation, USA) and optical density was read at 490 nm within 10 minutes of the completion of the incubation by means of an Absorbance Micro plate Reader (EL x 800 ™ from Biotek supplied by North Star Scientific Ltd).

Every batch of hair, nails and urine samples was accompanied by a set of 10-20 % duplicates, procedural blanks and certified reference material (CRM) and analysed in triplicate for quality assurance purpose.

Total arsenic in hair, nails, water and rice samples were analysed by Inductively Coupled Plasma Mass Spectrometer (ICP-MS) (Agilent Technologies 7500) while As speciation analysis was performed by High Pressure Liquid Inductively Coupled Plasma Mass Spectrometer (HPLC-ICP-MS) by (Agilent Technologies 7500).

For quality control purpose different calibration standards were used for calibrating the instruments (ICP-MS or IC-ICP-MS) at the start , end and during the sample runs, normally after every 10 samples or where any abnormally high concentration were observed (Table 6.1).

Certified reference materials NIST (National Institute of Standards and Technology) SRM1640 for Trace Elements in Natural Water, NIST Rice flour1568a for As analysis in cooked and uncooked rice, Human hair CRM (NCS DC 73347 from China National Analysis Centre for Iron and Steel Beijing, China) for both hair and nail sample analysis and CRM (NIES No.18) for human urine analysis were used for assurance of analytical quality of the analysis. All these CRMs were analysed in triplicate. As there is no known reference material documented for human nails and in almost all studies the CRM of human hair is used for nails likewise no separate CRM is known for speciation of As in rice and urine, thus we also used the CRM NIST Rice flour1568a for speciation of As in rice and NIES No.18 human urine for As speciation of human urine samples which are normally used for total As determination in rice and urine analysis in literature. The certified values of each CRM and the values obtained during our analysis have been tabulated (Table 6.1). The value of total As found in the reference material (NCS DC 73347) for runs for hair samples was near to the reported certified value of 0.28 ± 0.4 mg/kg and for nail sample analytical runs the analysed value of CRM was found to be 0.29 ± 0.015 mg/kg. The mean arsenic concentration determined by the same method for the CRM (NIST 1568a rice flour) was 0.27 ± 0.03 mg/kg (n=6). These are all in good agreement with the certified value of 0.29 ±0.03 mg/kg.

Results for arsenic speciation (AsB, MMA, DMA and Inorganic arsenic) of NIST CRM rice floor 1568a has recovery of 82% for the analysis of As speciation in rice which is in good agreement with the literature. Recovery of inorganic contents of the NIST CRM 1568a was 33 ±7 % for this analysis which is broadly comparable with previously published values of 30-35%. Procedural blanks were typically found to be < 1µg/l (Table 6.4).

In order to check the precision of the analytical run 10-20% duplicate samples were analysed in each run (for drinking water, raw and cooked rice as well as for urine, hair and nails samples) - see figure 1 for the results of duplicate sample analysis of rice. Duplicate analyses for total As in rice samples typically agreed to within ± 0.001 mg/kg As in rice equivalent (Table 6.6) and figure 6.1.

Procedural blanks (both acid blanks as well as deionized water), were included during analysis of drinking/cooking water, rice, hair, nails and urine samples. The results of procedural blanks for total As in rice (both deionized water blank and nitric acid blanks) rice is given (Tables 6.3 & 6.4) and for As speciation is given in table 6.5. Procedural blanks (n=6) as well as deionized water blanks (n=3) both were found below detection limit (0.01 mg/kg As in rice equivalent) respectively.

Table 6.1 Quality Control used during different analytical sessions of ICP-MS for West Bengal Indian samples

Media	No. Calib standard	Calibration Standards	CRM Reported value	CRM found value
Water	4	10,50,100,500 µg/L	26.67±0.41 µg/L	
Raw rice	4	1,5,10,20 µg/L	0.29±0.03 mg/kg	0.29±0.04 mg/kg
Cooked rice	3	5,10,20 µg/L	0.29±0.03 mg/kg	0.263±0.02 mg/kg
Urine	6	5,10,20,50,100,500 µg/L	137±11µg/L	112±8 µg/L
Hair	5	1, 5, 10, 50, 100 µg/L	0.28±0.04 mg/kg	0.27±0.02 mg/kg
Nail	5	1, 5, 10, 50, 100 µg/L	0.28±0.04 mg/kg	0.29±0.015 mg/kg

CRM; Certified Reference Material

Table 6.2 Analysis of Certified Reference Material NIST Rice flour CRM 1658a

No	Sample No	As (mg/Kg)	Error (mg/Kg)
1	CRM1	0.28	0.01
2	CRM2	0.26	
3	CRM3	0.28	
4	CRM4	0.25	0.01
5	CRM5	0.27	
6	CRM6	0.26	

CRM; Certified Reference Material

Table 6.3 Analysis of demonized water blank (diw) s for rice

Sample No	Sample Name	Conc. [µg/l]	RSD
1	diw2	<0.004	250.0887
2	diw3	<0.004	N/A
3	diw4	<0.004	N/A

Table 6.4 Analysis of procedural blanks for rice

Sample No	Sample Name	Conc. [µg/l]	RSD
1	blank1	<0.016	N/A
2	blank 2	<0.016	N/A
3	blank 3	<0.016	N/A
4	blank 4	<0.016	N/A
5	blank 5	<0.016	N/A
6	blank 6	<0.016	N/A

blank; procedural blanks

Table 6.5 Analysis of procedural blanks for QA of arsenic speciation in rice, by HPLC-ICP-MS

Name	AB	DMA	MMA	T iAs	AsB-As	DMA-As	MMA-As	iAs	Sum of species
	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]	[µg/l]
blank1	0.00	0.04	0.01	-0.01	0.00	0.02	0.01	-0.01	0.02
blank2	0.03	0.14	0.01	0.02	0.01	0.08	0.01	0.02	0.12
blank3	0.00	0.02	0.00	-0.11	0.00	0.01	0.00	-0.11	-0.10
blank4	0.27	0.05	0.00	0.01	0.11	0.03	0.00	0.01	0.15

Figure 6.1 Standard deviation of duplicate samples of rice analysed by ICP-MS for total As (mg/kg)

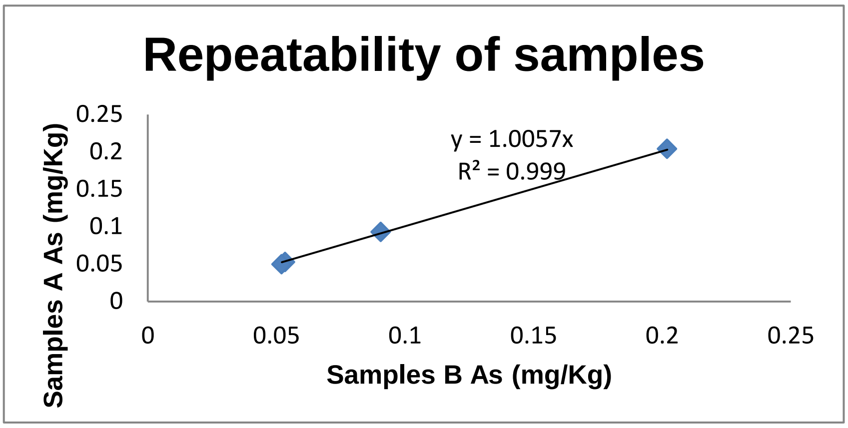
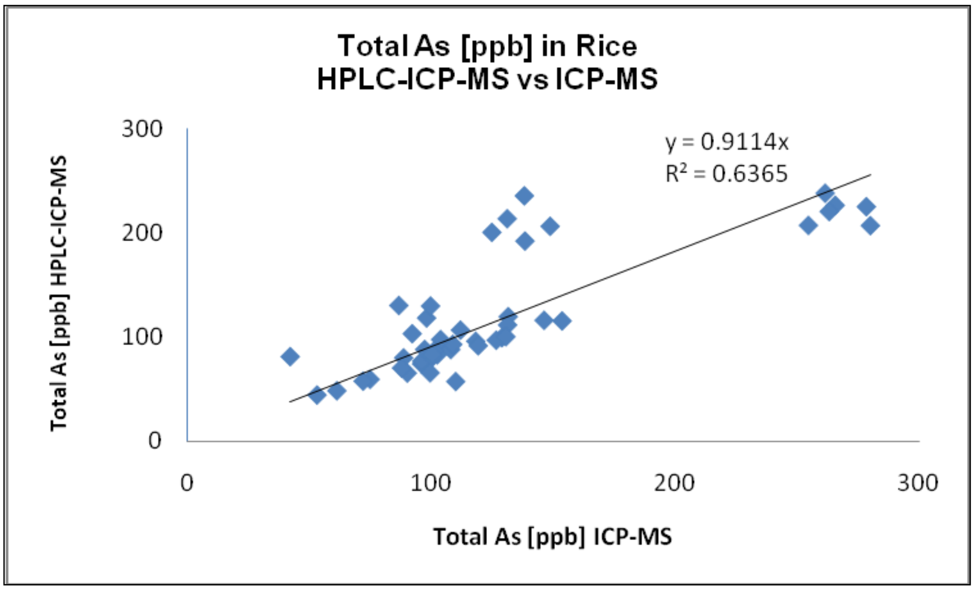


Table 6.6 Results for rice quality control (precision) duplicate samples

Duplicate samples		SD
Name	As (mg/kg)	Error (mg/kg)
1A	0.20	0.001
1B	0.20	
2A	0.09	0.001
2B	0.09	
3A	0.05	0.001
3B	0.05	
4A	0.05	0.002
4B	0.04	

Figure 6.2 Total arsenic in rice samples, IC-ICP-MS vs. ICP-MS



Results and Discussion

Samples of drinking and cooking water, cooked, uncooked rice, human urine, hair and nails were collected from (highly, medium and relatively less exposed) groups from West Bengal and analysed for total arsenic as well as arsenic species.

The mean value of As hair was 1.59 mg/kg (range 0.08-19.44 mg/kg), mean value for nail As was 2.40 mg/kg (range 0.13 -36.13 mg/kg) and a mean value of 139.38 µg/g creatinine (range <DL -– 2763.5 µg/g creatinine) for urine (Table 6.7). Mean values for As content of hair and nail for female population is higher than their male counterparts while the mean value for urinary creatinine adjusted and non-adjusted values are much higher in the male population in this study.

All these mean values of As in hair, nails and urine samples are much higher than the reported background/normal levels of (Mandal et al. 2004; Samanta et al. 2004; Uchino et al. 2006) for As in hair vs. drinking water and As in urine and drinking water.

The recommended Provisional tolerable weekly intake (PTWI) value of arsenic is (2.1 µg/kg body weight/day) by Food and Agriculture Organization/World Health Organization (FAO/WHO).

Our mean chronic daily intake calculated from all media is 6.32 (0.72 - 7715 µg/kg/day) which is higher than the provisional tolerable weekly intake (PTWI) values of arsenic. In a study by Uchino et al 2006 in West Bengal India these values were 3.32, 5.75 and 12.9 µg/kg body weight/day from mild, moderate and high arsenic-affected families, respectively.

Concentration of As in urine did not vary by sex (Calderon et al. 1999) but a recent study by (Kile et al. 2009) suggested that arsenic metabolism was significantly associated with sex, exposure, age, smoking, chewing betel nut, urinary creatinine, and season.

The results of total As in rice analysed by ICP-MS is given in (Table 6.10) and that of arsenic speciation is given in (Table 6.11) of Supplementary Information. All of these rice samples were found to have arsenic concentrations (0.04-0.16 mg/kg) with a median value of 0.1 mg/kg. There is only one sample (A-43) above the PR China regulatory limit of 0.15 mg/kg of arsenic. Y778 and Y791 could not be analysed for total arsenic due to non-availability of the samples.

The observed relative importance of arsenic speciation in the groups of rice samples analysed was i-As>DMA>MMA>AB, which is broadly comparable with published arsenic speciation in rice data. There is a very good correlation (r^2=0.6) for total As (sum of all species) in rice samples by HPLC-ICP-MS vs. ICP-MS .The mean i-As content was 75 ± 8 %. Sample Y847 had only 4.92 µg/kg -abnormally less than other samples, it could be either due to incomplete neutralization that is by missing any reagent or spillage of sample during handling. Y778 and Y791 were only analysed for As speciation and not for total arsenic due to non-availability of sample so the data analysis is incomplete for these two samples.

Association of arsenic in drinking/cooking water and rice (raw & cooked rice) with biomarkers (hair, nail, and urine arsenic)

Arsenic in drinking water (which is mostly used as cooking water too) has a highly significant Pearson correlation value ($r^2 =$ 0.76) with As contents of the nails samples and also with As contents of hair that is ($r^2 =$ 0.68) while the correlation is, though positive, relatively less significant with urine creatinine adjusted As values ($r^2 =$ 0.38) for the total study population from West Bengal India (Table 6.9 & Figure 6.3). A positive correlation value for As in drinking water, with hair, nails and urine sample As from the exposed population in West Bengal India have been recorded by Mandal et al 2004 who also performed the speciation of As in all these biomarkers. Somewhat similar highly significant association of drinking water As with as contents of hair, nails and urine were also reported by (Samanta et al. 2007) in West Bengal and for hair and nails by (Gault et al. 2008a) in Cambodia.

Some studies considered toe nail/nail As concentration as comparatively better biomarkers than hair (Hinwood et al. 2003; Karagas et al. 2000; Mandal et al. 2004; Schmitt et al. 2005; Wilhelm et al. 2005). (Mandal et al. 2004) consider the total As content of nails as a better biomarker of As exposure due to its significant association with its inorganic contents in their study in West Bengal India.

The chronic daily intake (CDI) µg/kg/day calculated from drinking water also has a significant correlation with As contents of nails ($r^2 =$ 0.67) and As contents of hair values ($r^2 =$ 0.64) which suggests water as the major source of As exposure for the exposed study population (Table 6.9 & Figure 6.3)

Likewise, CDI µg/kg/day cooked rice value has also significant Pearson correlation values with As contents of nail ($r^2 =$ 0.69), hair ($r^2 =$ 0.64) and urine ($r^2 =$ 0.22) which is comparable to the values of drinking water association values for hair ($r^2 =$ 0.76), nails ($r^2 =$ 0.68) and urine ($r^2 =$ 0.38) biomarkers. However, the Pearson correlation values of As contents of the biomarkers and uncooked rice are much less significant than the association with cooked rice and drinking/cooking water (Figure 6.3).

These results indicate cooked rice as a major source of As exposure like drinking/cooking water which has already been reported by Mondal and Polya 2008 and others previously. The highly significant association values of As contents of human nails and hair with drinking /cooking water and cooked rice in this study also suggest that both hair and nails can be used as useful biomarkers of As exposure for the As exposed population.

If we look at the association of drinking/cooking water As and cooked rice with biomarkers of As exposure in terms of gender then we observe comparatively high Pearson correlation value of drinking water with As contents of nails ($r^{2} = 0.86$) and As contents of hair ($r^{2} = 0.73$) in females while drinking water with As contents of nails ($r^{2} = 0.699$) and As contents of hair ($r^{2} = 0.65$) in male of this study population. But this trend is different for the association of As drinking/cooking water and urinary As for males it is relatively high then females (Table 6.12 & 6.13 of Supplementary Information).

Table 6.7 Descriptive statistics for As concentration in drinking/cooking water, rice and biomarkers of As exposure and calculated daily intake values for West Bengal India

Media	N	Minimum	Maximum	Mean	Std. Deviation
Water As (µg/L)	231	0.00	680	38.4	84.6
Un cooked rice As (mg/kg)	220	0.00	2.8	0.16	0.20
Cooked Rice As (mg/kg)	218	0.05	2.36	0.2	0.26
Urine µg/L (µg/L)	219	<DL	1980	73.4	171.3
Urine creatinine (µg/g)	221	<DL	2763	139.3	352.4
Hair (mg/kg)	139	0.08	19.4	1.5	2.32
Nails (mg/kg)	127	0.13	36.1	2.4	3.97
CDI water (µg/kg/day)	228	0.00	49.9	2.4	6.17
CDI raw rice (µg/kg/day)	228	0.00	29.8	1.6	2.15
CDI cooked rice (µg/kg/day)	228	0.00	25.1	2.2	2.76
CD total (µg/kg/day)	228	0.72	77.1	6.3	8.85
Valid N (list wise)	96				

Table 6.8 Descriptive statistics for As concentration in drinking/cooking water, raw and cooked rice, biomarkers of As exposure and calculated daily intake values for total, female and male population of West Bengal India

	Valid N		Water As (µg/L)	UC rice As (mg/kg)	C Rice As(mg/kg)	As Urine (µg/L)	Urine creatinine (µg/g)	Nails (mg/kg)	Hair (mg/kg)	CDI water (µg/kg/day)	CDI raw rice (µg/kg/day)	CDI cooked rice (µg/kg/day)	CDI total (µg/kg/day)
Total population	96	N	231	220	218	219	221	127	139	228	228	228	228
		Min	0.00	0.00	0.05	-40.00	-253	0.13	0.08	0.00	0.00	0.00	0.72
		Max	680.00	2.80	2.36	1980	2763	36.13	19.44	49.96	29.82	25.13	77.15
		Mean	38.40	0.16	0.22	73.44	139	2.40	1.59	2.46	1.67	2.20	6.32
		SD	84.69	0.20	0.26	171.33	352	3.97	2.32	6.17	2.15	2.76	8.85
Female population	47	N	112	106	107	105	106	65	64	110	110	110	110
		Min	0.00	0.00	0.05	<DL	<DL	0.28	0.10	0.00	0.00	0.00	0.73
		Max	680.00	0.49	2.36	902.00	21.34	36.13	19.44	40.80	5.20	25.13	67.99
		Mean	36.19	0.15	0.21	62.88	5.93	2.77	1.69	2.22	1.46	2.18	5.87
		SD	81.32	0.07	0.26	122.10	4.75	4.96	2.83	5.63	0.82	2.77	7.88
Male population	48	N	119	114	111	114	115	62	75	118	118	118	118
		Min	0.00	0.00	0.05	-40.00	-252.58	0.13	0.08	0.00	0.00	0.00	0.72
		Max	680.00	2.80	2.36	1980.00	1936.57	14.18	9.29	49.96	29.82	25.13	77.15
		Mean	40.47	0.18	0.22	83.52	135.63	2.01	1.50	2.68	1.86	2.21	6.75
		SD	88.04	0.27	0.26	206.56	286.16	2.53	1.80	6.66	2.87	2.77	9.67

Table 6.9 Pearson correlation values for association among various media, biomarkers of As exposure and calculated daily intake for all volunteers of West Bengal India

Water As µg/L	Pearson Correlation	1										
	Sig. (2-tailed)											
	N	231										
Raw rice mg/Kg	Pearson Correlation	.284**	1									
	Sig. (2-tailed)	0										
	N	220	220									
Cooked Rice As mg/Kg	Pearson Correlation	.706**	0.064	1								
	Sig. (2-tailed)	0	0.359									
	N	218	208	218								
Urine µg/L	Pearson Correlation	.513**	.691**	.282**	1							
	Sig. (2-tailed)	0	0	0								
	N	219	208	208	219							
Urine Creatinine µg/g	Pearson Correlation	.379**	.274**	.214**	.616**	1						
	Sig. (2-tailed)	0	0	0.002	0							
	N	221	210	210	218	221						
Nail As mg/kg	Pearson Correlation	.761**	-0.018	.685**	.384**	.369**	1					
	Sig. (2-tailed)	0	0.843	0	0	0						
	N	127	122	125	119	118	127					
Hair As mg/kg	Pearson Correlation	.681**	-0.016	.632**	.188*	.272**	.837**	1				
	Sig. (2-tailed)	0	0.856	0	0.031	0.002	0					
	N	139	135	137	131	130	109	139				
CDI Water µg/kg/day	Pearson Correlation	.964**	.192**	.649**	.413**	.310**	.667**	.643**	1			
	Sig. (2-tailed)	0	0.004	0	0	0	0	0				
	N	228	217	215	217	219	126	137	228			
CDI Raw rice µg/kg/day	Pearson Correlation	.280**	1.000**	0.043	.679**	.277**	-0.015	-0.015	.193**	1		
	Sig. (2-tailed)	0	0	0.528	0	0	0.869	0.866	0.004			
	N	228	217	215	217	219	126	137	228	228		
CDI Cooked rice µg/kg/day	Pearson Correlation	.710**	0.069	1.000**	.288**	.222**	.686**	.638**	.649**	0.049	1	
	Sig. (2-tailed)	0	0.314	0	0	0.001	0	0	0	0.462		
	N	228	217	215	217	219	126	137	228	228	228	
CDI total µg/kg/day	Pearson Correlation	.963**	.396**	.775**	.544**	.353**	.720**	.635**	.948**	.392**	.778**	1
	Sig. (2-tailed)	0	0	0	0	0	0	0	0	0	0	
	N	228	217	215	217	219	126	137	228	228	228	228

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 6.3 Graphical representation of correlation values for different parameters (with 95%CI) for all volunteers of West Bengal India

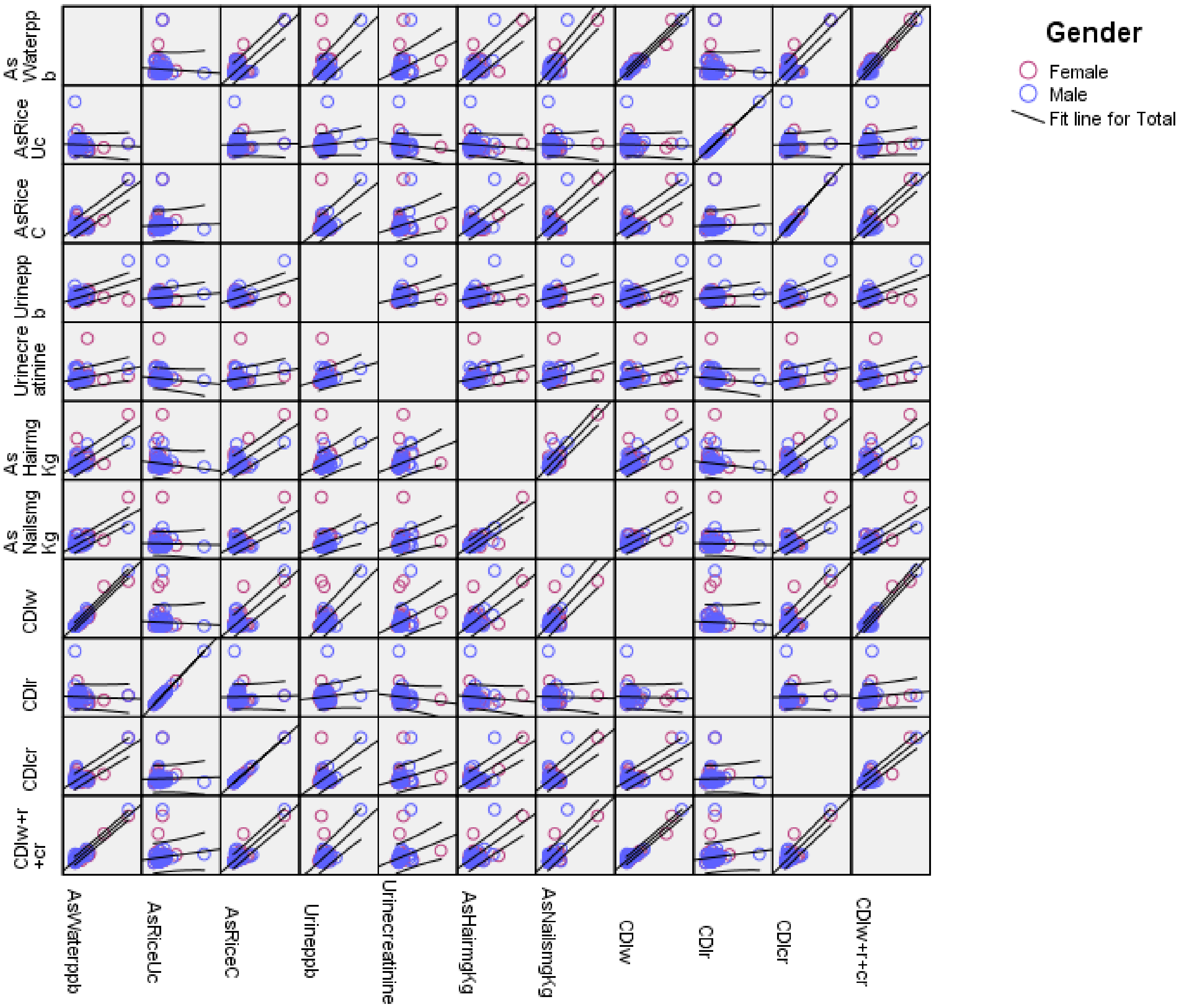


Figure 6.4 Graphical representation of the correlation between As contents of nails (mg/kg) vs. As contents of drinking/cooking water (µg/L) for both male and female population of West Bengal India

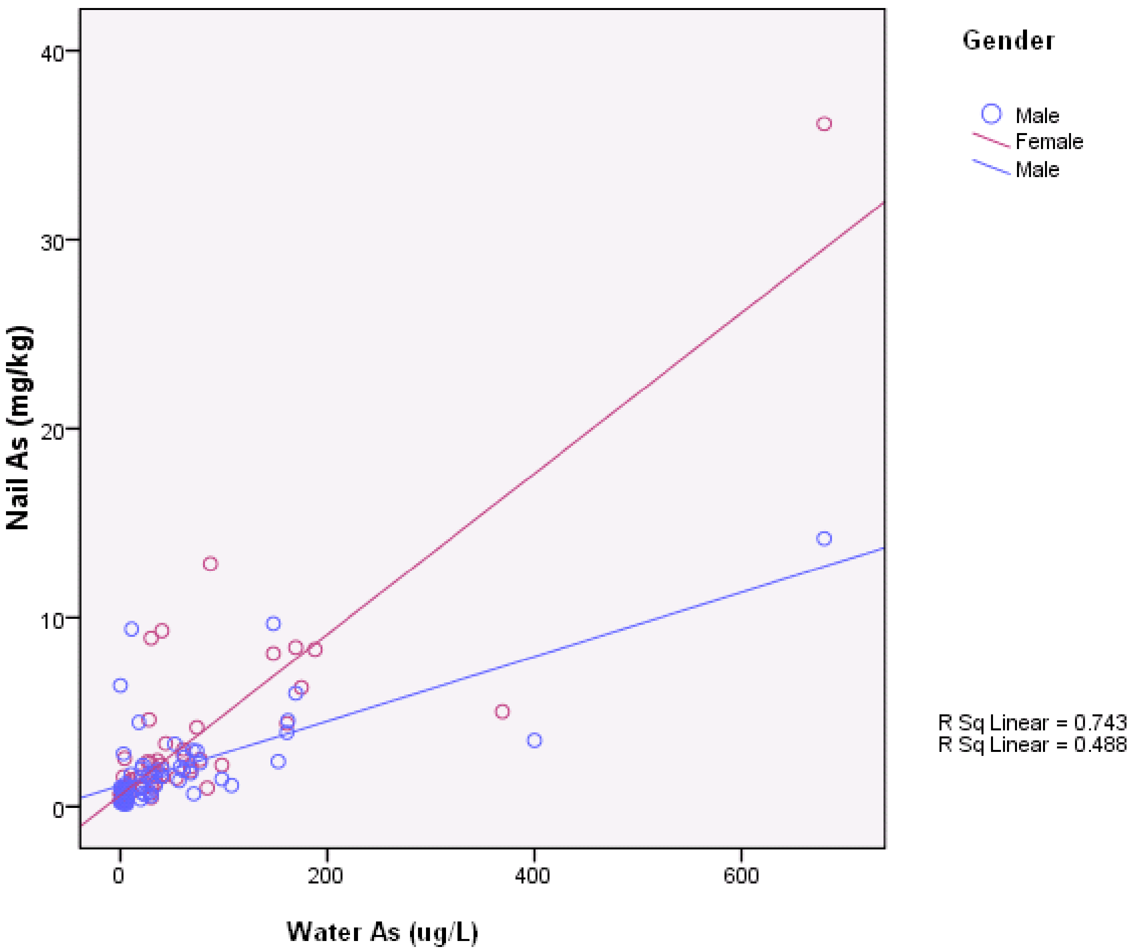


Figure 6.5 Graphical representation of the correlation between As contents of hair (mg/kg) vs. As contents of drinking/cooking water (µg/L) for both male and female population of West Bengal India

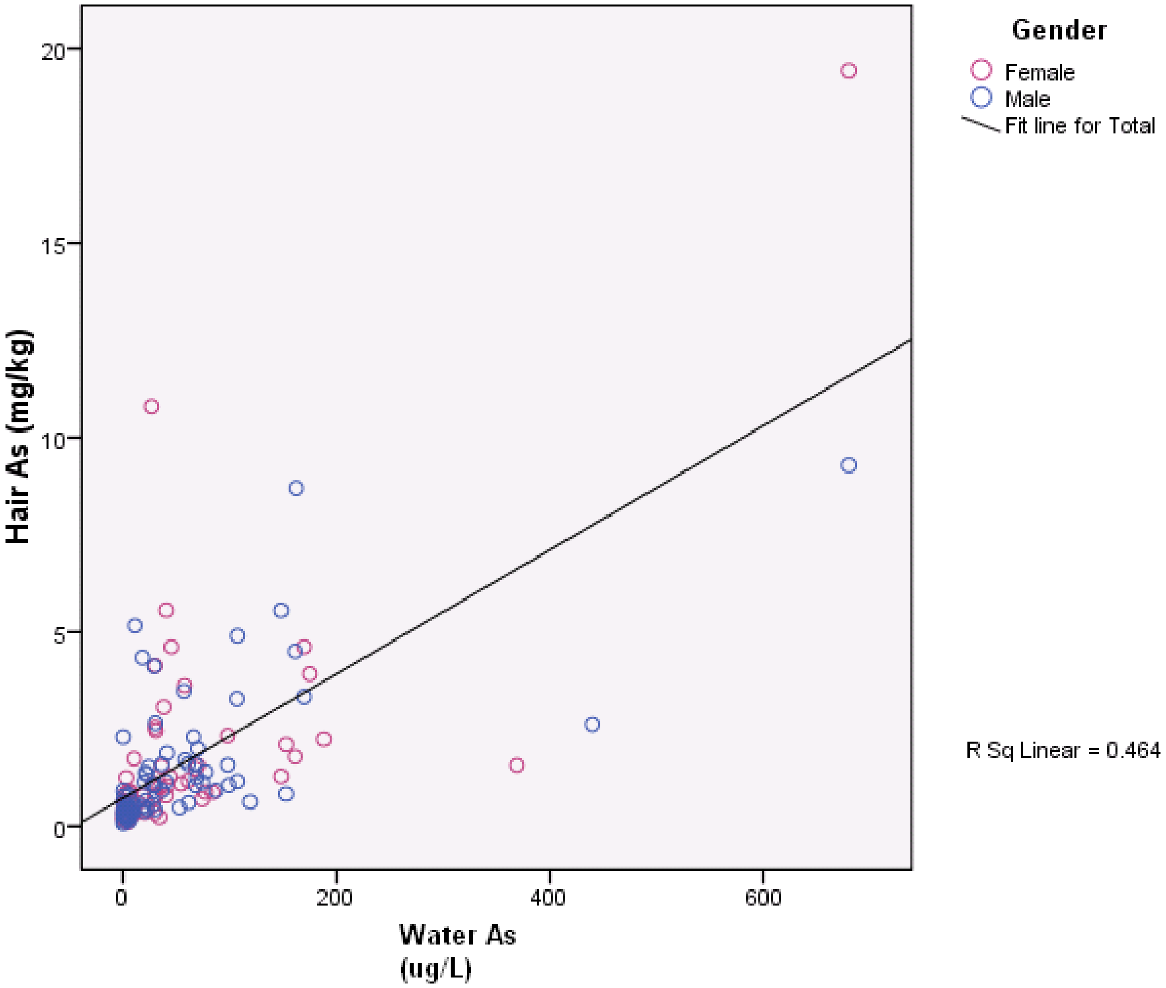


Figure 6.6 graphical representation of the correlation between As contents of nails (mg/kg) vs. As contents of hair (mg/kg) for both male and female population of West Bengal India

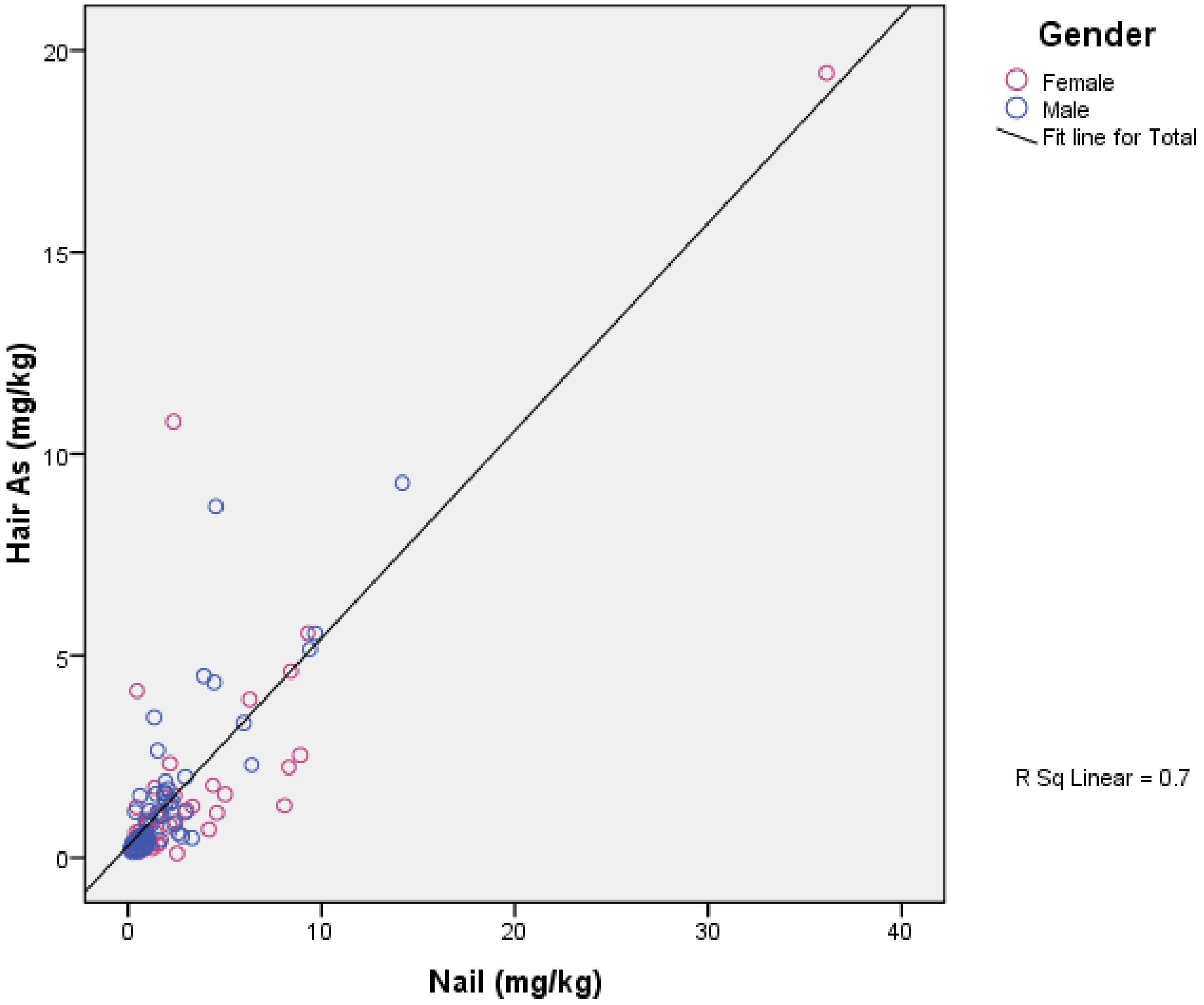


Figure 6.7 Graphical representation of the correlation between As contents of hair (mg/kg) vs As contents of cooked rice (mg/kg) for both male and female population of West Bengal India

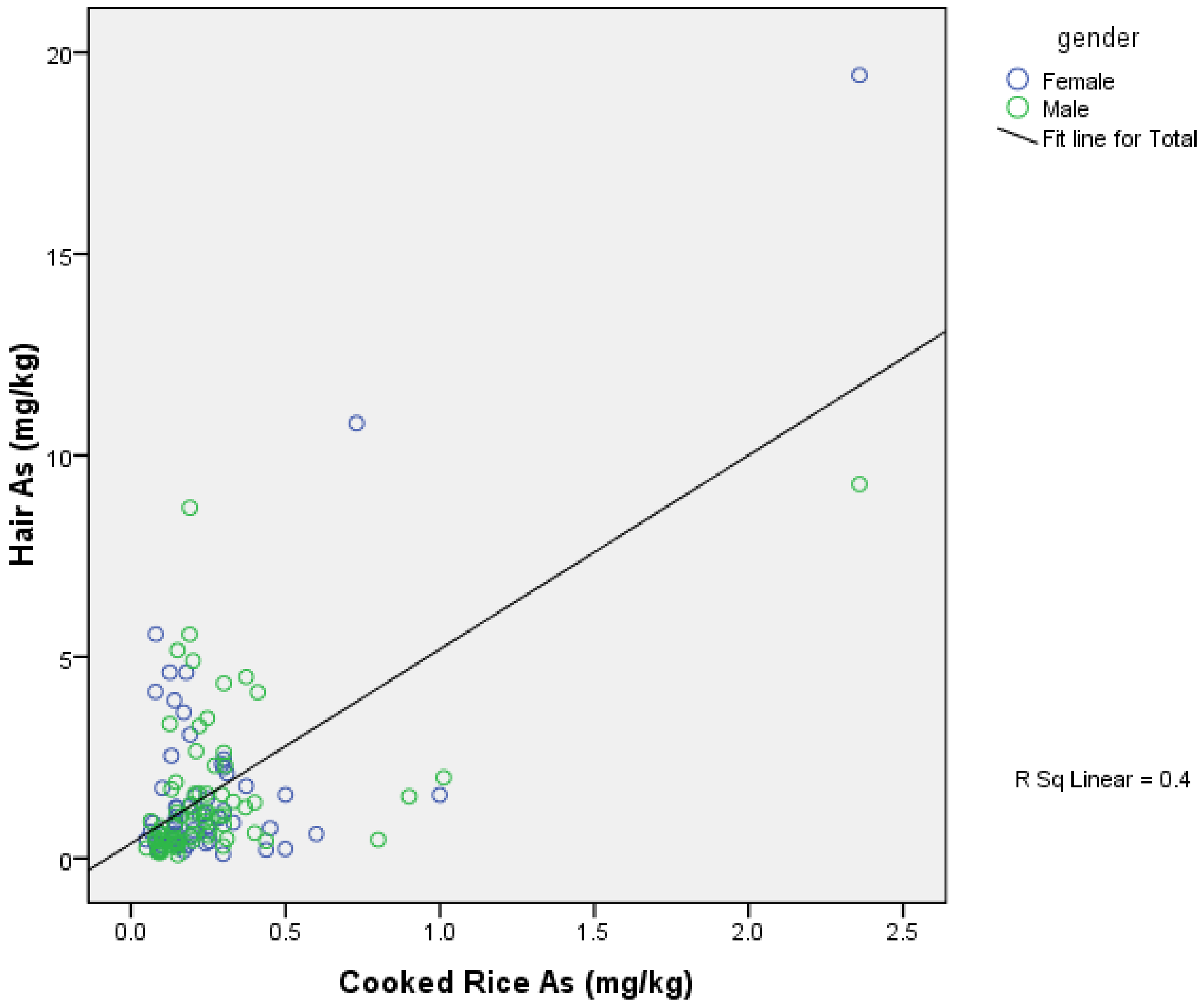
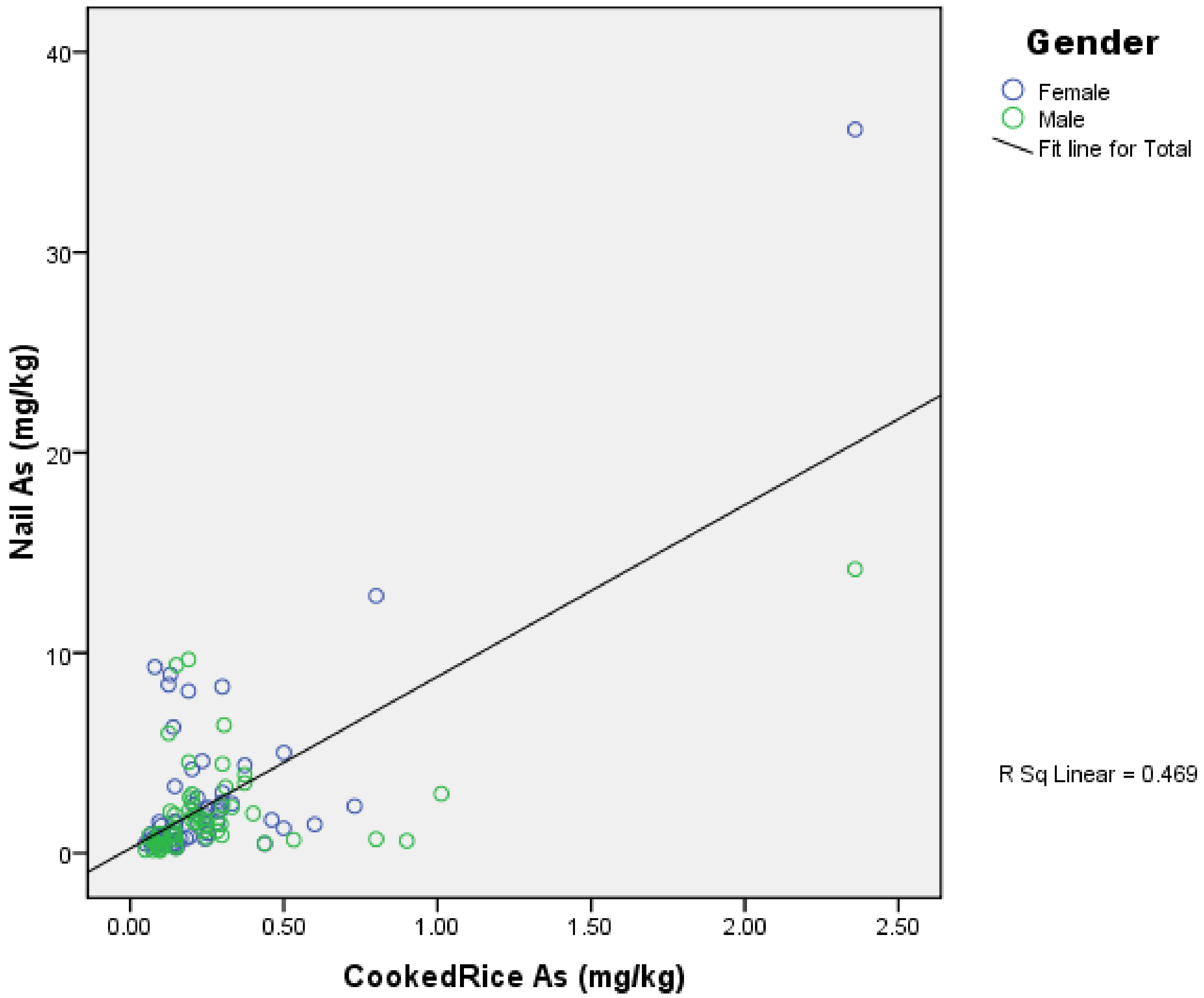


Figure 6.8 Graphical representation of the correlation between As contents of nails (mg/kg) vs As contents of cooked rice (mg/kg) for both male and female population of West Bengal India



Conclusion

Arsenic in cooked rice and drinking/cooking water are the two main exposure media for the population in the study area. The highly significant association values of arsenic contents of human nails and hair with drinking /cooking water and cooked rice and a positive correlation value of human urine in this study also proved that both hair and nails can be used as useful biomarkers of As exposure for the exposed population.

References

Acharyya SK. 1999. Arsenic poisoning in the Ganges delta. Nature 401: 545-545.
Adair BM, Hudgens EE, Schmitt MT, Calderon RL, Thomas DJ. 2006. Total arsenic concentrations in toenails quantified by two techniques provide a useful biomarker of chronic arsenic exposure in drinking water. Environmental Research 101(2): 213-220.
Agusa T, Kunito T, Fujihara J, Kubota R, Minh TB, Kim Trang PT, Iwata H, Subramanian A, Viet PH, Tanabe S. 2006. Contamination by arsenic and other trace elements in tube-well water and its risk assessment to humans in Hanoi, Vietnam. Environmental pollution (Barking, Essex 139(1): 95-106.
Agusa T, Kunito T, Minh TB, Kim Trang PT, Iwata H, Viet PH, Tanabe S. 2009. Relationship of urinary arsenic metabolites to intake estimates in residents of the Red River Delta, Vietnam. Environmental Pollution 157(2): 396-403.
Ahamed S, Kumar Sengupta M, Mukherjee A, Amir Hossain M, Das B, Nayak B, Pal A, Chandra Mukherjee S, Pati S, Nath Dutta R, Chatterjee G, Mukherjee A, Srivastava R, Chakraborti D. 2006. Arsenic groundwater contamination and its health effects in the state of Uttar Pradesh (UP) in upper and middle Ganga plain, India: a severe danger. The Science of The Total Environment 370(2-3): 310-322.
Argos M, Kalra T, Rathouz PJ, Chen Y, Pierce B, Parvez F, Islam T, Ahmed A, Rakibuz-Zaman M, Hasan R, Sarwar G, Slavkovich V, van Geen A, Graziano J, Ahsan H. Arsenic exposure from drinking water, and all-cause and chronic-disease mortalities in Bangladesh (HEALS): a prospective cohort study. The Lancet 376(9737): 252-258.
Beane Freeman LE, Dennis LK, Lynch CF, Thorne PS, Just CL. 2004. Toenail Arsenic Content and Cutaneous Melanoma in Iowa. Am J Epidemiol 160(7): 679-687.
Bhattacharya P, Samal AC, Majumdar J, Santra SC. 2010a. Arsenic Contamination in Rice, Wheat, Pulses, and Vegetables: A Study in an Arsenic Affected Area of West Bengal, India. Water Air Soil Poll 213(1-4): 3-13.
Bhattacharya P, Samal AC, Majumdar J, Santra SC. 2010b. Accumulation of arsenic and its distribution in rice plant (Oryza sativa L.) in Gangetic West Bengal, India. Paddy Water Environ 8(1): 63-70.
Bi XY, Fu YR, Chen ML, He YS, Ren LM, Xiang W, et al. 2011. Occurrence of arsenic in brown rice and its relationship to soil properties from Hainan Island, China. Environmental Pollution 159(7): 1757-1762.
Brahic C. 2008. High levels of arsenic in food-aid rice drinks. New Scientist 199(2671): 7-7.
Brammer H, Ravenscroft P. 2009. Arsenic in groundwater: A threat to sustainable agriculture in South and South-east Asia. Environment International 35(3): 647-654.
Brammer H. 2009. Mitigation of arsenic contamination in irrigated paddy soils in South and South-east Asia. Environment International 35(6): 856-863.
Brima EI, Haris PI, Jenkins RO, Polya DA, Gault AG, Harrington CF. 2006. Understanding arsenic metabolism through a comparative study of arsenic levels in the urine, hair and fingernails of healthy volunteers from three unexposed ethnic groups in the United Kingdom. Toxicology and Applied Pharmacology 216(1): 122-130.
Button M, Jenkin GR, Harrington CF, Watts MJ. 2009. Human toenails as a biomarker of exposure to elevated environmental arsenic. Journal of Environmental Monitoring 11(3): 610-617.

Calderon RL, Hudgens E, Chris X, Schreinemachers D, Thomas DJ. 1999. Excretion of arsenic in urine as a function of exposure to arsenic in drinking water. Environmental Health Perspectives 107(8): 663-667.

Carbonell-Barrachina AA, Signes A, Mitra K, Burlo F. 2008a. Effect of cooking method and rice type on arsenic concentration in cooked rice and the estimation of arsenic dietary intake in a rural village in West Bengal, India. Food Additives and Contaminants Part a-Chemistry Analysis Control Exposure & Risk Assessment 25(11): 1345-1352.

Carbonell-Barrachina AA, Signes A, Mitra K, Burlo F. 2008b. Contribution of water and cooked rice to an estimation of the dietary intake of inorganic arsenic in a rural village of West Bengal, India. Food Additives and Contaminants 25(1): 41-50.

Carbonell-Barrachina AA, Signes-Pastor AJ, Vazquez-Araujo L, Burio F, Sengupta B. 2009. Presence of arsenic in agricultural products from arsenic-endemic areas and strategies to reduce arsenic intake in rural villages. Mol Nutr Food Res 53(5): 531-541.

Chakraborti D, Das B, Rahman MM, Chowdhury UK, Biswas B, Goswami AB, Nayak B,Pal A, Sengupta MK, Ahamed S, Hossain A, Basu G, Roychowdhury T, Das D. 2009a. Status of groundwater arsenic contamination in the state of West Bengal, India: A 20-year study report. Mol Nutr Food Res 53(5): 542-551.

Chakraborti D, Mukherjee SC, Pati S, Sengupta MK, Rahman MM, Chowdhury UK, Lodh D, Chanda CR, Chakraborti AK, Basu GK. 2003. Arsenic groundwater contamination in Middle Ganga Plain, Bihar, India: a future danger? Environmental Health Perspectives 111(9): 1194-1201.

Chakraborti D, Pal A, Chowdhury UK, Mondal D, Das B, Nayak B, Gosh A, Maity S. 2009b. Arsenic Burden from Cooked Rice in the Populations of Arsenic Affected and Nonaffected Areas and Kolkata City in West-Bengal, India. Environmental Science & Technology 43(9): 3349-3355.

Chakraborti D, Rahman MM, Paul K, Chowdhury UK, Sengupta MK, Lodh D, Chanda CR, Saha KC, Mukherjee SC. 2002. Arsenic calamity in the Indian subcontinent What lessons have been learned? Talanta 58(1): 3-22.

Chatterjee D, Haider D, Majumder S, Biswas A, Nath B, Bhattacharya P, Bhowmick S, Goswami MA, Saha D, Hazra R, Maity PB, Chatterjee D, Mukherjee A, Bundschuh J. 2010b. Assessment of arsenic exposure from groundwater and rice in Bengal Delta Region, West Bengal, India. Water Research 44(19): 5803-5812.

Chen KL, Amarasiriwardena CJ, Christiani DC. 1999. Determination of total arsenic concentrations in nails by inductively coupled plasma mass spectrometry. Biological trace element research 67(2): 109-125.

Chen ZL, Wang FM, Zhang L, Gao YL, Sun YX. 2006. Arsenic uptake and accumulation in rice (Oryza sativa l.) at different growth stages following soil incorporation of roxarsone and arsanilic acid. Plant and Soil 285(1-2): 359-367.

Chon HT, Lee JS, Lee SW, Kim KW. 2008. Evaluation of human exposure to arsenic due to rice ingestion in the vicinity of abandoned Myungbong Au-Ag mine site, Korea. Journal of Geochemical Exploration 96(2-3): 231-235.

D'Amato M, Forte G, Caroli S. 2004. Identification and quantification of major species of arsenic in rice. Journal of Aoac International 87(1): 238-243.

Das DK, Prosun Bhattacharya ABMJBRZ, Richard HL. 2007. Effects of arsenic-contaminated irrigation water, zinc and organic matter on the mobilization of arsenic in soils in relation to rice (Oryza sativa L.). In: Trace Metals and other Contaminants in the Environment, Vol. Volume 9:Elsevier, 339-362.

Das HK, Mitra AK, Sengupta PK, Hossain A, Islam F, Rabbani GH. 2004. Arsenic concentrations in rice, vegetables, and fish in Bangladesh: a preliminary study. Environment International 30(3): 383-387.

Del Razo LM, Garcia-Vargas GG, Garcia-Salcedo J, Sanmiguel MF, Rivera M, Hernandez MC, Cebrian ME. 2002. Arsenic levels in cooked food and assessment of adult dietary intake of arsenic in the Region Lagunera, Mexico. Food and Chemical Toxicology 40(10): 1423-1431.

Duxbury JM, Panaullah GM, Alam T, Hossain MB, Loeppert RH, Lauren JG, Meisner CA, Ahmed ZU. 2009. Arsenic toxicity to rice (Oryza sativa L.) in Bangladesh. Plant and Soil 317(1-2): 31-39.

Gault AG, Rowland HA, Charnock JM, Wogelius RA, Gomez-Morilla I, Vong S, Leng M, Samreth S, Sampson ML, Polya DA. 2008. Arsenic in hair and nails of individuals exposed to arsenic-rich groundwaters in Kandal province, Cambodia. The Science of The Total Environment 393(1): 168-176.

Ghosh P, Banerjee M, De Chaudhuri S, Chowdhury R, Das JK, Mukherjee A, Sarkar AK, Mondal L, Baidya K, Sau TJ, Banerjee A, Basu A, Chaudhuri K, Ray K, Giri AK. 2007. Comparison of health effects between individuals with and without skin lesions in the population exposed to arsenic through drinking water in West Bengal, India. J Expo Sci Environ Epidemiol 17(3): 215-223.

Haque R, Mazumder DN, Samanta S, Ghosh N, Kalman D, Smith MM, Mitra S, Santra A, Lahiri S, Das S, De BK, Smith AH. 2003. Arsenic in drinking water and skin lesions: dose-response data from West Bengal, India. Epidemiology (Cambridge, Mass 14(2): 174-182.

Hindmarsh JT. 2002. Caveats in hair analysis in chronic arsenic poisoning. Clin Biochem 35(1): 1-11.

Hinwood AL, Sim MR, Jolley D, de Klerk N, Bastone EB, Gerostamoulos J, et al. 2003. Hair and toenail arsenic concentrations of residents living in areas with high environmental arsenic concentrations. Environmental Health Perspectives 111(2): 187-193.

IAEA. 1978. Activation analysis of hair as an indicator of contamination of man by environmental trace element pollutants,. (IAEA/RL/50,). Vienna, Austria.:International Atomic Energy Agency

IARC. 2004. Monographs on the Evaluations of Carcinogenic Risks to Humans.

Kapaj S, Peterson H, Liber K, Bhattacharya P. 2006. Human Health Effects From Chronic Arsenic Poisoningâ€"A Review. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering 41(10): 2399-2428.

Karagas MR, Tosteson TD, Blum J, Klaue B, Weiss JE, Stannard V, Spate V, Morris JS. 2000. Measurement of low levels of arsenic exposure: a comparison of water and toenail concentrations. American Journal of Epidemiology 152(1): 84-90.

Kile ML, Hoffman E, Hsueh YM, Afroz S, Quamruzzaman Q, Rahman M, Mahiuddin G, Ryan L, Christiani DC. 2009. Variability in biomarkers of arsenic exposure and metabolism in adults over time. Environmental Health Perspectives 117(3): 455-460.

Kile ML, Houseman EA, Breton CV, Smith T, Quamruzzaman Q, Rahman M, Mahiuddin G, Christiani DC. 2007. Dietary Arsenic Exposure in Bangladesh. Environ Health Perspect 115(6).

Kurttio P, Komulainen H, Hakala E, Kahelin H, Pekkanen J. 1998. Urinary excretion of arsenic species after exposure to arsenic present in drinking water. Archives of Environmental Contamination and Toxicology 34(3): 297-305.

Mandal BK, Ogra Y, Anzai K, Suzuki KT. 2004. Speciation of arsenic in biological samples. Toxicology and Applied Pharmacology 198(3): 307-318.

Mazumder DN, Das Gupta J, Santra A, Pal A, Ghose A, Sarkar S. 1998. Chronic arsenic toxicity in west Bengal--the worst calamity in the world. J Indian Med Assoc 96(1): 4-7, 18.

Meharg AA, Rahman M. 2003. Arsenic contamination of Bangladesh paddy field soils: Implications for rice contribution to arsenic consumption. Environmental Science & Technology 37(2): 229-234.

Meharg AA, Sun G, Williams PN, Adomako E, Deacon C, Zhu Y-G, Feldmann J, Raab A. 2008a. Inorganic arsenic levels in baby rice are of concern. Environmental Pollution 152(3): 746-749.

Meharg AA, Williams PN, Islam MR, Adomako EE, Raab A, Hossain SA, Zhu YG, Feldmann J. 2006. Increase in rice grain arsenic for regions of Bangladesh irrigating paddies with elevated arsenic in groundwaters. Environmental Science & Technology 40(16): 4903-4908.

Meharg AA, Williams PN, Price AH, Raab A, Hossain SA, Feldmann J. 2005. Variation in arsenic speciation and concentration in paddy rice related to dietary exposure. Environmental Science & Technology 39(15): 5531-5540.

Mondal D, Polya DA. 2008. Rice is a major exposure route for arsenic in Chakdaha block, Nadia district, West Bengal, India: A probabilistic risk assessment. Applied Geochemistry 23(11): 2987-2998.

Rahman MM, Chowdhury UK, Mukherjee SC, Mondal BK, Paul K, Lodh D, Biswas BK, Chanda CR, Basu GK, SahaKC, Roy S, Das R, Palit SK, Quamruzzaman Q, Chakraborti D. 2001. Chronic arsenic toxicity in Bangladesh and West Bengal, India--a review and commentary. J Toxicol Clin Toxicol 39(7): 683-700.

Samanta G, Das D, Mandal BK, Chowdhury TR, Chakraborti D, Pal A, Ahmad s. 2007. Arsenic in the breast milk of lactating women in arsenic-affected areas of West Bengal, India and its effect on infants. J Environ Sci Health A Tox Hazard Subst Environ Eng 42(12): 1815-1825.

Samanta G, Sharma R, Roychowdhury T, Chakraborti D. 2004. Arsenic and other elements in hair, nails, and skin-scales of arsenic victims in West Bengal, India. Science of The Total Environment 326(1-3): 33-47.

Sanz E, MuÃ±oz-Olivas R, CÃ¡mara C, Sengupta MK, Ahamed S. 2007. Arsenic speciation in rice, straw, soil, hair and nails samples from the arsenic-affected areas of Middle and Lower Ganga plain. Journal of Environmental Science and Health, Part A: Toxic/Hazardous Substances and Environmental Engineering 42(12): 1695-1705.

Sanz MA. 2006. Treatment of acute promyelocytic leukemia. Hematology Am Soc Hematol Educ Program: 147-155.

Schmitt MT, Schreinemachers D, Wu K, Ning Z, Zhao B, Le XC, Mumford JL. 2005. Human nails as a biomarker of arsenic exposure from well water in Inner Mongolia: comparing atomic fluorescence spectrometry and neutron activation analysis. Biomarkers 10(2-3): 95-104.

Smedley PL, Kinniburgh DG. 2002. A review of the source, behaviour and distribution of arsenic in natural waters. Appl Geochem 17: 517-568.

Smith AH, Lingas EO, Rahman M. 2000. Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. Bull WHO 78: 1093-1103.

Smith AH, Lopipero PA, Bates MN, Steinmaus CM. 2002. Arsenic Epidemiology and Drinking Water Standards. Science 296(5576): 2145-2146.

Uchino T, Roychowdhury T, Ando M, Tokunaga H. 2006. Intake of arsenic from water, food composites and excretion through urine, hair from a studied population in West Bengal, India. Food and Chemical Toxicology 44(4): 455-461.

Vicky-Singh, Brar MS, Preeti-Sharma, Malhi SS. 2010. Arsenic in Water, Soil, and Rice Plants in the Indo-Gangetic Plains of Northwestern India. Communications in Soil Science and Plant Analysis 41(11): 1350-1360.

WHO. 2001. Environmental Health Criteria 224. Arsenic and Arsenic Compounds. . International Programme on Chemical Safety, World Health Organization: Geneva.

Wilhelm M, Pesch B, Wittsiepe J, Jakubis P, Miskovic P, Keegan T, Nieuwenhuijsen MJ, Ranft U. 2005. Comparison of arsenic levels in fingernails with urinary As species as biomarkers of arsenic exposure in residents living close to a coal-burning power plant in Prievidza District, Slovakia. J Expo Anal Env Epid 15(1): 89-98.

Supplementary information

Table 6.10 Total arsenic determined by ICP-MS, in ground rice samples

No	Code	As (mg/kg)	Error (mg/kg)
1	Y799	0.04	0.01
2	Y423	0.05	0.01
3	Y835	0.06	0.01
4	Y885	0.07	0.02
5	Y772	0.07	0.02
6	Y768	0.09	0.02
7	Y842	0.09	0.01
8	Y834	0.09	0.01
9	Y822	0.09	0.02
10	Y187	0.09	0.02
11	Y350	0.10	0.02
12	Y746	0.10	0.02
13	Y200	0.10	0.00
14	Y333	0.10	0.01
15	Y503	0.10	0.03
16	Y413	0.10	0.02
17	Y237	0.10	0.02
18	Y763	0.10	0.03
19	Y861	0.10	0.01
20	Y616	0.10	0.03
21	Y194	0.10	0.03
22	Y870	0.10	0.01
23	Y810	0.11	0.03
24	Y478	0.11	0.01
25	Y620	0.11	0.04
26	Y646	0.11	0.04
27	Y776	0.12	0.01
28	Y868	0.12	0.01
29	Y302	0.12	0.04
30	Y826	0.13	0.05
31	Y718	0.13	0.03
32	A-43	0.13	0.02

33	Y748	0.13	0.03
34	Y881	0.13	0.02
35	Y798	0.13	0.01
36	Y795	0.14	0.02
37	Y271	0.14	0.02
38	Y469	0.15	0.04
39	Y738	0.15	0.02
40	Y619	0.15	0.02
41	Y847	0.16	0.03

Table 6.11 Arsenic speciation, determination by HPLC-ICP-MS, in ground rice samples from India

No	Code	Total-As (µg/L) from ICP-MS	Total-As (µg/L) [iAs+AsB+DMA+MMA] [by HPLC-ICP-MS]	%Apparent Recovery	% iAs	% DMA	% MMA	% AB
1	Y271	138	192	139	62	32	5	1
2	Y302	125	200	161	64	28	8	1
3	Y799	42	82	194	80	15	5	1
4	Y748	131	213	163	53	41	6	0
5	Y333	98	119	121	79	20	1	0
6	Y413	100	130	131	82	18	0	0
7	Y187	92	103	112	70	28	2	1
8	Y768	87	130	151	74	24	2	0
9	Y738	149	206	139	76	21	2	1
10	Y776	118	96	82	79	20	0	0
11	Y718	129	100	77	68	32	0	0
12	Y194	103	90	87	70	29	1	0
13	Y616	102	83	81	72	24	2	1
14	Y798	131	120	91	71	25	3	0
15	Y810	108	88	82	71	28	0	1
16	Y478	109	93	86	69	30	0	1
17	Y350	96	75	78	68	26	2	4
18	Y746	96	77	81	80	18	1	1
19	Y619	154	116	75	83	17	0	0
20	Y646	112	107	96	75	23	2	1
21	Y763	100	81	81	79	16	5	0
22	Y200	97	88	91	73	22	5	0
23	Y469	146	116	80	87	13	0	0
24	Y795	138	235	170	84	14	2	0
25	Y881	131	112	85	79	19	2	0
26	Y503	99	66	66	60	20	19	0
27	Y870	104	98	94	80	16	4	0
28	Y822	90	66	73	84	15	0	1

29	Y772	75	60	80	76	22	2	0
30	Y861	101	87	86	73	25	1	1
31	Y835	61	49	80	82	16	0	1
32	Y620	110	58	52	82	17	0	0
33	Y868	119	92	77	76	24	0	0
34	Y237	100	84	84	81	19	0	0
35	Y885	72	58	81	78	21	0	1
36	Y834	89	80	91	77	23	0	0
37	Y826	126	97	77	81	18	1	0
38	A-43	130	101	77	80	17	2	1
39	Y842	88	71	81	69	29	2	0
40	Y423	53	45	85	82	16	0	2
41	CRM1	278	225	33	84	16	0	0
42	CRM2	261	238	33	33	64	3	0
43	CRM3	280	207	32	33	64	4	0
44	CRM4	255	207	33	32	64	4	0
45	CRM5	266	226	33	33	62	5	0
46	CRM6	263	220	34	33	64	4	0

Table 6.12 Pearson correlation values among various media, biomarkers of As exposure and calculated daily intake for female population of West Bengal India

Water As (µg/L)	Pearson Correlation	1										
	Sig. (2-tailed)											
	N	112										
Un cooked rice As (mg/kg)	Pearson Correlation	0.042	1									
	Sig. (2-tailed)	0.666										
	N	106	106									
Cooked Rice As(mg/kg)	Pearson Correlation	.750**	0.167	1								
	Sig. (2-tailed)	0	0.095									
	N	107	101	107								
As Urine (µg/L)	Pearson Correlation	.225*	-0.094	0.15	1							
	Sig. (2-tailed)	0.021	0.355	0.135								
	N	105	99	101	105							
Urine creatinine (µg/g)	Pearson Correlation	.315**	-0.137	0.16	.711**	1						
	Sig. (2-tailed)	0.001	0.173	0.108	0							
	N	106	100	102	104	106						
Hair (mg/kg)	Pearson Correlation	.726**	-0.127	.754**	0.078	0.158	1					
	Sig. (2-tailed)	0	0.326	0	0.552	0.232						
	N	64	62	63	60	59	64					
Nails (mg/kg)	Pearson Correlation	.862**	-0.028	.825**	.299*	.316*	.848**	1				
	Sig. (2-tailed)	0	0.826	0	0.019	0.014	0					
	N	65	62	64	61	60	54	65				
CDI water (µg/kg/day)	Pearson Correlation	.965**	0.031	.682**	0.17	.273**	.630**	.765**	1			
	Sig. (2-tailed)	0	0.757	0	0.084	0.005	0	0				
	N	110	104	105	104	105	63	64	110			
CDI raw rice (µg/kg/day)	Pearson Correlation	0.034	1.000**	0.102	-0.08	-0.105	-0.11	-0.013	0.035	1		
	Sig. (2-tailed)	0.726	0	0.302	0.422	0.288	0.391	0.917	0.719			
	N	110	104	105	104	105	63	64	110	110		
CDI cooked rice (µg/kg/day)	Pearson Correlation	.751**	0.168	1.000**	0.151	0.164	.755**	.825**	.684**	0.099	1	
	Sig. (2-tailed)	0	0.088	0	0.125	0.095	0	0	0	0.306		
	N	110	104	105	104	105	63	64	110	110	110	
CD total (µg/kg/day)	Pearson Correlation	.957**	0.174	.848**	0.166	.241*	.708**	.831**	.958**	0.164	.850**	1
	Sig. (2-tailed)	0	0.078	0	0.091	0.013	0	0	0	0.088	0	
	N	110	104	105	104	105	63	64	110	110	110	110

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 6.9 Graphical representation of correlation values for different parameters for female population of West Bengal India

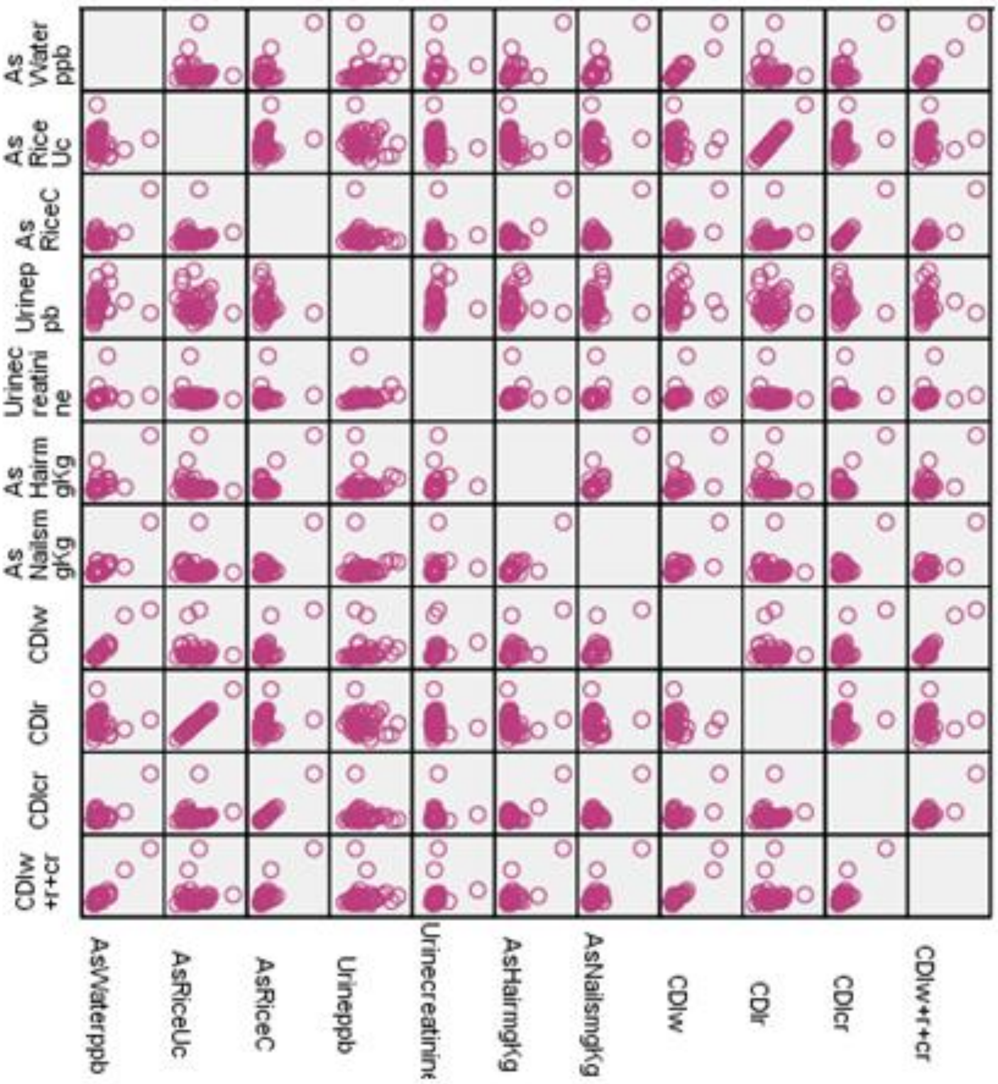


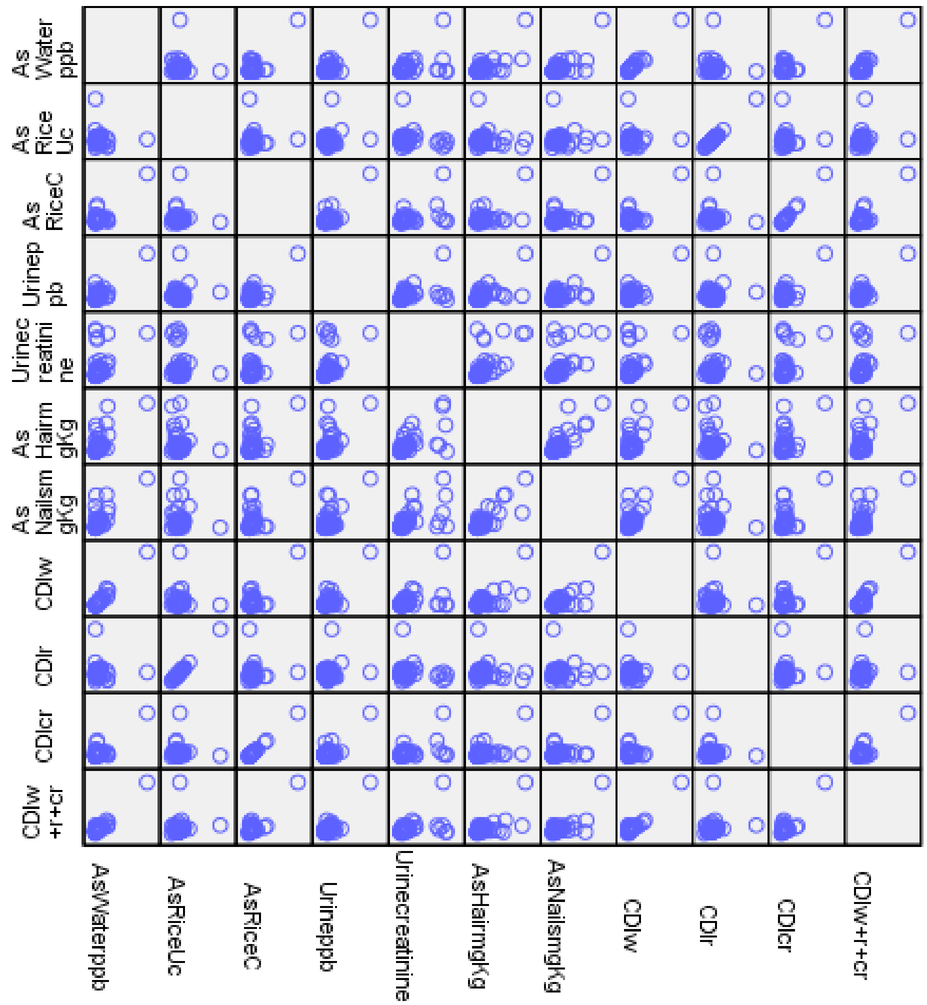
Table 6.13 Pearson correlation values for association between various media, biomarkers of arsenic exposure and calculated daily intake for male population of West Bengal India

Water As (µg/L)	Pearson Correlation	1										
	Sig. (2-tailed)											
	N	119										
Rice As Raw rice (mg/kg)	Pearson Correlation	.382**	1									
	Sig. (2-tailed)	0										
	N	114	114									
Rice As cooked (mg/kg)	Pearson Correlation	.668**	0.049	1								
	Sig. (2-tailed)	0	0.613									
	N	111	107	111								
Urine (µg/L)	Pearson Correlation	.676**	.831**	.370**	1							
	Sig. (2-tailed)	0	0	0								
	N	114	109	107	114							
Urine Creatinine (µg/g)	Pearson Correlation	.467**	.531**	.281**	.648**	1						
	Sig. (2-tailed)	0	0	0.003	0							
	N	115	110	108	114	115						
Hair As (mg/kg)	Pearson Correlation	.653**	0.021	.492**	.340**	.475**	1					
	Sig. (2-tailed)	0	0.862	0	0.004	0						
	N	75	73	74	71	71	75					
Nail As (mg/kg)	Pearson Correlation	.699**	0.008	.560**	.654**	.560**	.830**	1				
	Sig. (2-tailed)	0	0.955	0	0	0	0					
	N	62	60	61	58	58	55	62				
CDI Water (µg/kg/day)	Pearson Correlation	.966**	.247**	.628**	.532**	.366**	.695**	.682**	1			
	Sig. (2-tailed)	0	0.008	0	0	0	0	0				
	N	118	113	110	113	114	74	62	118			
CDI Raw rice (µg/kg/day)	Pearson Correlation	.380**	1.000**	0.034	.819**	.532**	0.019	0.002	.247**	1		
	Sig. (2-tailed)	0	0	0.722	0	0	0.869	0.991	0.007			
	N	118	113	110	113	114	74	62	118	118		
CDI Cooked rice (µg/kg/day)	Pearson Correlation	.676**	0.057	1.000**	.379**	.296**	.504**	.564**	.627**	0.044	1	
	Sig. (2-tailed)	0	0.548	0	0	0.001	0	0	0	0.636		
	N	118	113	110	113	114	74	62	118	118	118	
CDI total (µg/kg/day)	Pearson Correlation	.972**	.481**	.727**	.719**	.495**	.603**	.701**	.941**	.479**	.731**	1
	Sig. (2-tailed)	0	0	0	0	0	0	0	0	0	0	
	N	118	113	110	113	114	74	62	118	118	118	118

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 6.10 Graphical representation of correlation values for different parameters for male population of West Bengal India



Chapter 7 Preliminary study for arsenic exposure and risk assessment in Peshawar Basin of Khyber Pukhtoon Khwa (KPK) province, Pakistan

Abstract

Arsenic contaminated groundwater in some south Asian countries like Bangladesh and West Bengal India is one of the largest environmental health hazards in the world. PCRWR with the help of UNICEF have carried out a nationwide survey for drinking water As contamination in different parts of Pakistan which also included 12-13 samples from Mardan, Peshawar and Mingora in KPK province. In order to know the existence of arsenic contamination in ground water of the Peshawar basin, about 30 drinking water/cooking water from household water taps, human hair, nails and raw rice samples (market) from different parts of the Peshawar basin in 2006 have been collected. Drinking/cooking water, raw rice, hair and nails samples were analyzed for total As by ICP-MS. HPLC-ICP-MS was used to determine the speciation of As in rice samples. All drinking/cooking water samples were found to be below the 10 μg/L arsenic concentration (WHO provisional guideline values). No samples of rice grain (Oryza sativa L.) had arsenic concentrations more than the Chinese maximum contamination limit (0.15 mg/kg).

Introduction

Ground water arsenic problem is newly identified in Pakistan as a result of a national level survey program. At some places in Punjab and Sind provinces it is well above the maximum permissible limit of WHO (10µg/L) (Ahmad 2004; PCRWR 2003a, 2004).

The maximum reported level of As in ground water from Kalalanwala, Punjab province is about 1900 µg/L (Farooqi et al. 2007a) and 906 µg/L in Muzaffar Ghar district (Nickson et al. 2005). On the other hand up to 352 µg/L of inorganic As in ground water (n=240) has been reported recently in Sind province (Baig et al. 2010) with a maximum of 250 µg/L from southern parts of Sind (Arain et al. 2007, 2009).

According to the latest survey of PCRWR (2002-2008) the major identified problems of drinking water are due to arsenic, fluoride, nitrates and bacterial contamination which needs to be addressed immediately (Farooqi et al. 2003, 2007b, 2009; PCRWR 2008a).

Ground water arsenic situation in different parts of the world and its hazardous impacts has already been discussed in the previous chapters in detail. In order to have an idea about the ground water arsenic situation in NWFP province, five districts were selected and random sampling strategy was applied.

Ethical approval of the study was obtained from the Ethics Committee of NCEG University of Peshawar, Pakistan. An informed consent based questionnaire survey was performed along with the sample collection in the field and a GPS was used for recording the exact sample location. Samples of ground water used for drinking as well as cooking purpose were collected along with hair and nail samples from volunteers. The samples were collected and analyzed by using standard methods of analyses accompanied by strict quality control measures. Some physical parameter was measured in the field while the chemical analysis was performed on ICP MS and ICP AES in the SEAES chemistry laboratory.

The data obtained was analyzed and presented, by using Microsoft Excel 2003, 2007, SPSS 16 and Arc GIS 9, in the form of correlation tables, graphs and concentration maps (Supplementary information).

Peshawar Basin

The Peshawar basin is an intra-mountain basin (>5500 km^2) situated at the southern margin of the Himalayas and northwest of the Indus plain between the longitude 71° 15’ and 72° 45’ E and latitude 33° 45’ and 34° 30’ N in the North West Frontier Province (NWFP) of Pakistan. It is bounded by the mountain ranges of Khyber in the west and northwest, Attock Cherat in the south and Swat in the north and northeast while the Indus River borders its south eastern side where it is open for discharge of water. The west east flowing river Kabul and its tributaries irrigate the basin and join the Indus at eastern exit (Figure 7.1) (Tariq 2001).

The Peshawar basin is fairly flat with average elevation of 300 m above mean sea level. The central part of the basin is generally covered with fluvial micaceous sand, gravels and lacustrine deposits while quaternary flanglomerates are lying along the margins of the basin. On the basis of varying lithologies, the quaternary sediments, covered soils and hosting aquifers of the Peshawar basin are classified as Peshawar piedmont, Peshawar floodplain and Peshawar lacustrine sediments, soils and aquifers respectively.

Both surface water and ground water irrigation is practiced in Peshawar basin.

A number of dug wells are used for irrigation in Mardan and Charsadda areas. Irrigation department operated about 190 tub wells within Peshawar basin. These tube wells are used for irrigation purposes. Domestic water supply is served by the 609 wells drilled and operated by Public Health Engineering Department (PHED) whereas in rural areas there are also domestic wells in most of the houses (WAPDA 1994). There are four main rivers draining the Peshawar basin that is the Kabul River, the Swat River, the Bara river and the Kalpani Nala. Besides these rivers there are several perennial and non- perennial Nala that contribute to the Peshawar basin drainage system and ultimately discharge into the Kabul river. The Kabul river is the main river which drains almost the whole basin and enters the plain near Warsak and falls in the Indus river near Jehangira.

Climatic Condition

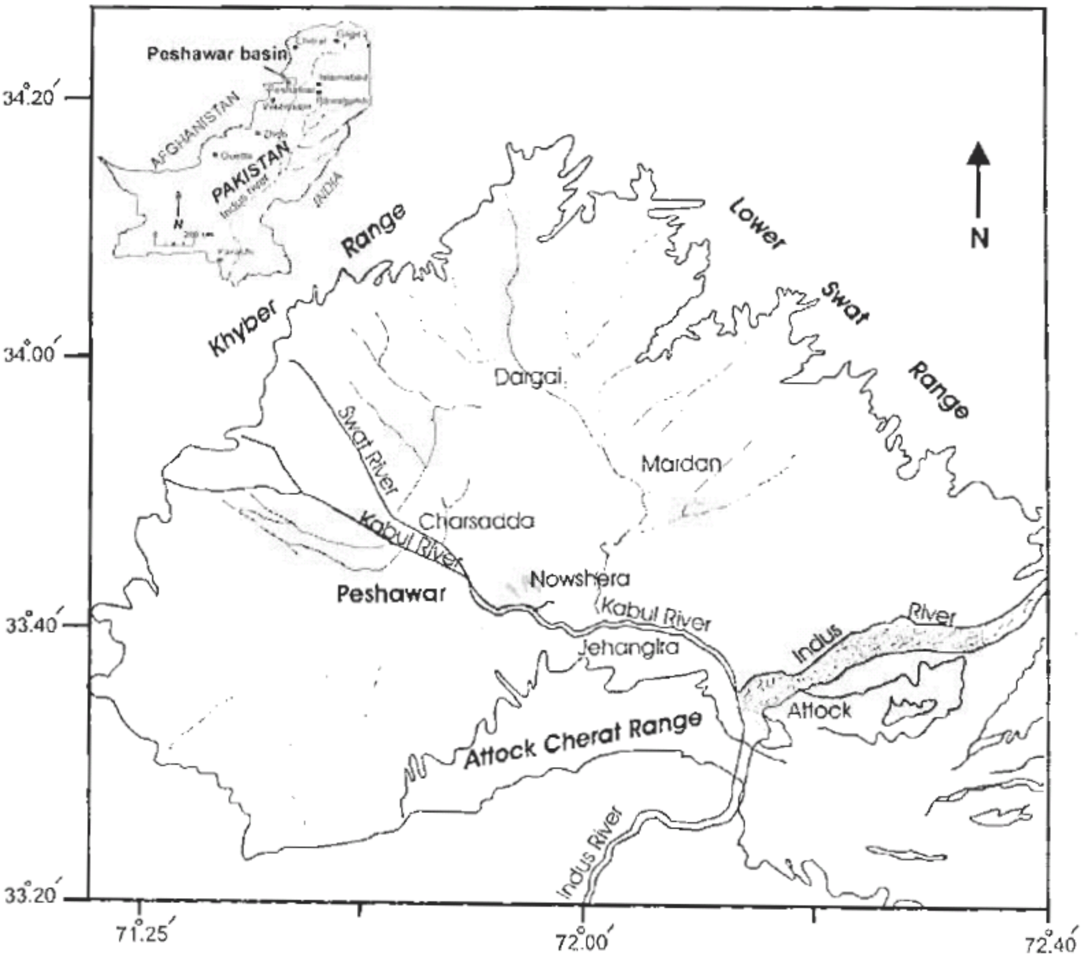
The climate of the area ranges from semiarid subtropical continental lowland type in the western parts to sub humid to subtropical continental lowland type in the eastern parts of the basin. The rain fall ranges from 340 mm to 630 mm. The hottest months are June and July with an average daily temperature of 40°-48° C. January is the coldest month with an average daily temperature of -2° C. The mean annual potential evaporation is approximately 1200 mm in Mardan and Nowshera, 1100 mm in Charsadda and 1500 mm in Peshawar (WAPDA 1994).

Population of the field Area

The Peshawar district has a population of 1,650,941 with a growth rate of 4.1 %/annum (Population Census, 1999). The selected districts are the highly populated area of NWFP with the population density ranges from 500-1000 persons per sq. kilometer.

Figure 7.1 Map of Peshawar Basin (including Peshawar, Mardan, Nowshera, Charsadda and Swabi) and the drainage system

Source: Map of Peshawar basin adapted from the work of Burbank and Thahirkheli (Burbank 1985)



Methodology

Sampling and Field Survey

All the procedures of the study were ethically approved by the Ethics Committee of NCEG, University of Peshawar prior to the commencement of the study. The volunteers were briefed about the purpose of the study as such type of activity is unusual in the area. They were also assured that their provided samples will be used for research purposes only. An informed consent was obtained from the individuals and guardians (in the case of children and females) before making a request of the samples.

The water hair and nail samples were collected in September and October 2006. Stratified random sampling method for the evaluation of different subgroups of population subjected to arsenic exposure for the risk assessment process have been applied as it has less subjectivity and more representativeness of the sample without increasing the cost and As probability. Samples (n= 27) were collected from five districts (Peshawar, Mardan, Nowshera, Charsadda and Swabi) of Peshawar basin areas including urban as well as rural residents (Figure 7.2). These samples were taken from both male and female including different age groups (12-75 years).

Questionnaire survey

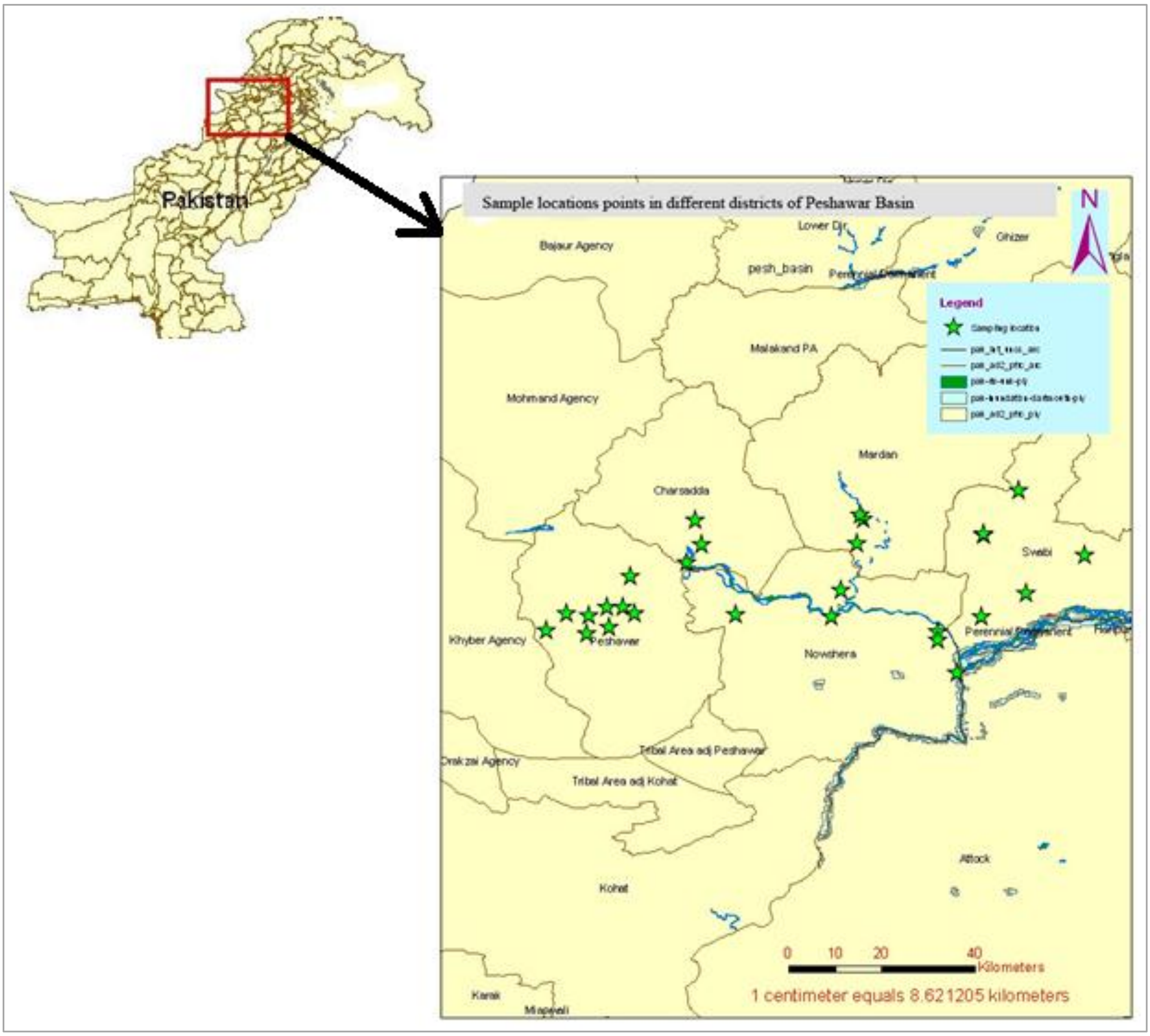
Each participant was interviewed to complete a questionnaire, which asked for demographic characteristics such as age, sex, weight, height and diet and information on potential exposure sources, such as source of drinking water, water consumption patterns, consumption of home-grown produce, smoking patterns, location of residence, education and occupation. Participants were also asked about their present health status and any health problem especially skin problems, such as keratosis and melanosis.

Sample collection:

Drinking water samples (unfiltered) were collected in acid-washed 500-mL polyethylene bottles from the kitchen tap, tube well (or other designated drinking water source, excluding bottled water). Precautions were made before taking the samples by allowing the water to run through the pipes for a maximum time of 5 minutes in order to purge the source. A labelled clean plastic bottle was filled to the top, and the lid replaced. Replicates samples were also collected. The water samples was transported to the geochemistry laboratory of NCEG, stored in the dark at 4 degree C and later transported on to the SEAES University of Manchester.

Human hair and nails samples were collected and stored by adopting the same procedure as previously described in chapter 4.

Figure 7.2 Field areas and sample location map for Peshawar Basin KPK, Pakistan



Washing and cleaning procedure

Visible dirt was removed from the nail samples using a nylon wire brush and deionized water. Then the samples were placed in clean glass beakers, submerged in 25 ml of 1% Triton-X100 (prepared by dilution of 10 ml of Triton-X100 with 990 ml of 18.5 M deionized water) and sonicated for 20 minutes. The wash solution was discarded and the nails were rinsed at least 3 times with 18.5 MΩ deionized water before being dried at 60 °C.

Hair samples were taken in a clean glass beaker and 25 ml acetone (analytical grade from Fisher brand) was added to it. Then it was kept in an ultrasonic bath for 10 minutes. This solution was discarded and 25 ml of 18.5MΩ deionized water was added and again sonicated for 10 minutes. The wash solution was discarded and the process was repeated two more times with water and then finally with acetone. After the last wash step, the hair samples were allowed to dry overnight at room temperature. Proper risk assessment of the procedure was adopted before the lab work and CoSHH risk assessment forms were submitted.

Field analysis

Calibrated portable probes (Hanna Water Test Meter, Whatman Conductivity m-Sensor) were used to measure the *in situ* pH, temperature and electrical conductivity of the drinking water samples in field.

Chemical analysis

Water samples were analyzed for total As by ICP-MS (Plasma Quad II (Fissions). Operating conditions for the instrument were the same as described by Gault et al. (2005). Arsenic was detected at m/z = 75 with mass interference from $^{40}Ar^{35}Cl^{+}$ corrected through monitoring of m/z = 77 and 82 using TJA Solutions' Plasma Lab software. All the samples were run in duplicate and the standards were run after every set of 10 samples. Concentrations were determined using a 5 point calibration curve.

Human hair and nails collected from volunteers and rice samples collected from markets were also analyzed with ICP-MS for total arsenic while rice speciation analysis was performed by HPLC-ICP-MS in SEAES.

ICP-MS is useful for those samples having very low arsenic as its detection limit for most of the elements is typically below 0.01ng/ml. It is also preferred for its rapid analysis i.e., 60 seconds per samples and multi element analysis capability in a single run. In addition to its high sensitivity detection, it has the ability to measure a large range of concentration (Gill 1997).

Quality control measures

Standards reference material (SRM), SRM NIST1640 for drinking and cooking water, Rice flour NIST CRM 1568a for rice samples and human hair CRM NCS DC 73347 was used during analysis. External standards and reagent blanks (acid blanks and Milli Q water blanks) were analyzed after every ten samples analyzed and duplicate samples were run in order to check the preparative steps applied during sample preparation. All the SRMs were analyzed for checking the method as a quality control measure. The average recovery of the CRM NIST CRM 1568a used during rice samples analysis was 0.23 mg/kg, about 20 % lower than the certified value of (0.29±0.03 mg/kg) (Table 7.7 of Supplementary information).

A set of calibration standards i.e. a blank and 3-5 different dilutions of a calibration standard of known composition were used for calibrating the instrument for each analyte of interest in order to insure the quality control measures. For example, for rice total As analysis, external calibration was accomplished using standards with concentrations of 5, 10, 50, 100 and 200 µg/L. Calibration standards were prepared immediately prior to analysis by dilution of concentrated multi element stock solutions (Alfa Asser, UK) with 2% sub distilled HNO_3 in 18 MΩ deionized water. Sometimes field controls are also used but they were not used in this study.

Reagents blanks were analyzed along with the samples for correcting the contamination, because the reagents used for diluting, digesting or preparing the sample might contain the analyte of interest. These reagents or procedural blanks included blanks of deionized water or acids used in the digestion or dilution steps. The results for the procedural blank is given in (Table 7.6)

Blanks were also used at uniform intervals and also immediately after those sample having greater concentration then the highest standard to address the problem of carryover from one sample to the other.

An in house Turbo Pascal program, used for the drift correction of the raw instrumental data obtained from the ICP-MS, DBSCORR program was used for the correction of raw instrumental arsenic analysis and were corrected for blanks, drift and analytical sensitivity using a least square fitting of a linear calibration of replicate analysis of five calibration standards (Polya 2002a).

For IC- ICP-MS analysis, peak areas for individual arsenic species, were integrated by using TRPEAK software (Polya 2002b).

Data analysis and data presentation

Different statistical techniques were applied for the data analysis and data presentation. SPSS, Microsoft Excel 2003, 2007 and Arc GIS9 were used for data analysis and data presentation.

Results and discussions

Locations of the five districts of Peshawar basin from where the samples were collected are plotted on a geo referenced map from the website of the Humanitarian Information Centre (HIC) Pakistan (http://www.humanitarianinfo.org/).

The green stars in the above figure 7.1 represent each sampling point.

All the physical parameters , such as, pH, temperature, conductivity etc. were analyzed on the spot at sources of drinking/cooking water (Table 7.1) .The pH range is 7.6 to 9.1 with mean (7) and median (9) in the test samples suggest a slightly alkaline nature of water sources. There is a normal variation in the pH and EC. Previously (Shahida 2007) also reported the alkaline nature of ground water.

Table 7.1 results for physical parameters for ground water used for drinking/cooking in KPK

	Min	Max	mean	Median	SD
pH	6.94	7.20	7.01	7.00	0.05
Temp (C°)	25.90	27.4	26.9	27.0	0.30
Cond (µS/cm)	-6.80	970	666	722	174
Eh (mV)	-6.80	3.90	0.34	0.60	2.09

The arsenic concentration ranged from 0.1-8 µg/L with a mean value of 0.9 µg/L and an average value 1.56 µg/L (SD=1.7) in this study (Table 7.2). This result for arsenic concentration in the drinking and cooking water of different parts of Peshawar basin i.e. Charsadda, Nowshera, Peshawar, Mardan and Swabi is in agreement with the already reported values of PCRWR, 2006-2008 for other KPK areas, viz. Peshawar, Mardan and Mingora and is also less than the WHO (10 µg/L) recommended guideline value for arsenic concentration for drinking water.

Table 7.2 Trace elements Results for Drinking/cooking water from KPK

Element (m/z)	Min (µg/L)	Max (µg/L)	Mean (µg/L)	Median (µg/L)	SD
As (75)	0.1	8	1.58	0.9	1.65
Cd (111)	-1.20	0.03	-0.5	-0.5	0.19
Cu (65)	0.3	13	4.7	4.4	2.72
Mn (55)	-0.11	36.0	0.78	0.00	4.81
Ni (60)	-0.10	4.0	0.53	0.4	0.65
Pb (208)	-0.09	1.5	0.16	0.06	0.28
Se (78)	-0.10	3	0.65	0.4	0.71
Zn (66)	-6.90	113	11.3	3	20.6

Possible reason for the low concentration of arsenic can be the depth and geology of water source (wells and bore holes). The majority of the samples are collected from PHED tube wells which are very deep. The average depth of a bore hole in Pakistan is 115 ft according to the International Water Management Institute.

Table 7.3 Descriptive statistics for volunteers of Peshawar basin, KPK

	N	Minimum	Maximum	Mean	Std. Deviation
Age-Yrs	27	18.00	65.00	28.33	13.14
Weight-kg	27	46.00	85.00	60.52	9.21
BMI-Lbs/Inch^2	27	15.40	39.05	23.08	5.34
Water As (µg/L)	30	0.20	8.00	1.79	1.88
Hair As (mg/L)	27	0.02	0.37	0.12	0.09
Nails As (mg/L)	26	0.02	0.75	0.19	0.17
Rice As (mg/L)	20	0.02	0.201	0.10	0.06
CDI water (µg/kg-BW)	27	0.01	0.29	0.06	0.07
CDI raw rice (µg/kg-BW)	27	0.00	0.92	0.26	0.25
CDI total (µg/kg-BW)	27	0.01	0.95	0.32	0.23
Valid N (list wise)	19				

The As contents in the raw rice samples which are mostly consumed in these localities obtained from markets have also been analyzed both for total as well as species of As. The details of results obtained for rice analysis along with quality control measures have been documented in detail in the (supplementary information) of this chapter. Total As contents of raw rice analyzed ranges from 0.02-0.20 mg/kg with a mean value of 0.1 mg/kg (SD=0.06) and more than 60% As found was inorganic which is similar to the values obtained for As contents of rice from Lahore. The only problem is that the number of samples collected from KPK is very small and these rice samples were collected from markets instead of different households as we did in Lahore.

The contents of As in hair (mean value of (0.12 mg/L) and both hand and toe nails (mean value of (0.19 mg/L) are very much less than the values obtained for the exposed population of Lahore where drinking/cooking water As contents are very high (Table 7.4).

Similarly, the calculated mean values for chronic daily intake from drinking water (0.06 µg/Kg-BW), raw rice (0.26 µg/kg-BW) and total CDI (water +raw rice) (0.32 µg/kg-BW) for Peshawar basin areas (Table 7.4) is far less than the same values calculated for arsenic exposed area of Allama Iqbal town Lahore, Pakistan where the calculated mean values for chronic daily intake from drinking water (3.8 µg/kg-BW), raw rice (0.34 µg/kg-BW) and total CDI (water + raw rice) was (4.07 µg/kg-BW).

The overall results were within the maximum contamination level values for arsenic contents of drinking water, raw rice, and human hair and nails samples is actually beneficial for the residents of Peshawar, Mardan, Nowshera Charsadda and Swabi. Previously PCRWR (2003-2004) also reported no anomalous values for arsenic from Peshawar and Mardan which is in accordance with our results.

Limitations of the study

The sample size was very small which is the main short coming of the study and an increase in the sample size could help make the data more representative.

Use of raw market rice instead of household based collected raw and cooked rice samples could be another problem area and could be improved.

Conclusion

The results show that the ICP MS analysis for the drinking ground water collected from the major districts of Peshawar basin were within the permissible limits for As below the WHO (10 µg/L) recommended guideline value for arsenic concentration for drinking water. In addition, the values of arsenic concentration in human hair and nail samples are also much lower than those for the arsenic exposed population of Allama Iqbal town Lahore.

References

Ahmad T, Kalown MA, Tahir A and Rashid H. 2004. Arsenic an Emerging Issue: Experiences from Pakistan. 30th WEDC International Conference, 2004, Vientiane, Laos.

Baig JA, Kazi TG, Shah AQ, Afridi HJ, Arian MB, Jamali MK, Jalbani N. 2010. Speciation and evaluation of Arsenic in surface water and groundwater samples: a multivariate case study. Ecotoxicol Environ Saf 73(5): 914-923.

Arain GM, Aslam M, Majidano SA, Khuhawar MY. 2007. A Preliminary Study on the Arsenic Contamination of Underground Water of Matiari and Khairpur Districts, Sindh, Pakistan. Journal of the Chemical Society of Pakistan 29(5): 463-467.

Arain MB, Kazi TG, Baig JA, Jamali MK, Afridi HI, Jalbani N, Sarfaraz RA, Shah AQ, Khandro GA. 2009. Respiratory effects in people exposed to arsenic via the drinking water and tobacco smoking in southern part of Pakistan. Science of The Total Environment 407(21): 5524-5530.

Burbank DW, Tahirkheli RA. 1985. The magnetostratigraphy fission-track dating and stratigraphic evolution of the Peshawar Basin, northern Pakistan. Geological Society of America Bulletin 96: 539-552.

Ebdon L, Hil S, Walton AP and Ward RW. 1988. Coupled Chromatography-Atomic Spectrometry for Arsenic Speciation- a Comparative Study. Analyst 113: 1159-1165.

Farooqi A, Firdous N, Masuda H, Haider N. 2003. Fluoride and arsenic poisoning in ground water of Kalalanwala area, near Lahore, Pakistan. Geochimica et Cosmochimica Acta 67(18): A90-A90.

Farooqi A, Masuda H, Firdous N. 2007a. Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. Environmental Pollution 145(3): 839-849.

Farooqi A, Masuda H, Kusakabe M, Naseem M, Firdous N. 2007b. Distribution of highly arsenic and fluoride contaminated groundwater from east Punjab, Pakistan, and the controlling role of anthropogenic pollutants in the natural hydrological cycle. Geochemical Journal 41(4): 213-234.

Farooqi A, Masuda H, Siddiqui R, Naseem M. 2009. Sources of Arsenic and Fluoride in highly contaminated Soils causing groundwater contamination in Punjab, Pakistan. Archives of Environmental Contamination and Toxicology 56(4): 693-706.

Gill R. 1997. Modern Analytical geochemistry: Longman Singapore Publishers Ltd.

Nickson RT, McArthur JM, Shrestha B, Kyaw-Myint TO, Lowry D. 2005. Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan. Applied Geochemistry 20(1): 55-68.

PCRWR. 2003a. Arsenic contamination in ground water of southern Punjab. PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).

PCRWR. 2004 Arsenic Contamination in groundwater of central Sindh. PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).

PCRWR. 2008. Pakistan drinking water quality report. Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF, Pakistan).

Polya DA. 2002a. DBSCORR version 8. Unpublished Turbo Pascal Programme, . Department of Earth Sciences (now SEAES), University of Manchester,UK.

Polya DA. TRPEAK version 10. Unpublished Turbo Pascal Programme. In: Proceedings of the International Conference on Arsenic in the Asia–Pacific region, 2002b.

Shahida N. 2007. Monitoring Of Surface Water Ground Water Air And Soil In Peshawar Basin Against Time The 3rd Dimension. PhD thesis, NCEG, University of Peshawar. http://eprints.hec.gov.pk/2138/1/2055.htm

Tariq S. 2001. Environmental geochemistry of surface water and soil in Peshawar basin, N.W.F.P., Pakistan. PhD thesis, NCEG, University of Peshawar. PhD thesis. http://eprints.hec.gov.pk/7065/1/3016H.htm

WAPDA. 1994. Hydrogeology and ground water of the North West Frontier Province, Pakistan. .Hydro geology Directorate, Pakistan and TNO-DGV institute of Applied Geosciences, the Netherlands.

Supplementary Information

Table 7.4 Major elements Results analysed by ICP-AES for Drinking/cooking water from KPK. Negative values indicate

Element (Wavelength/nm)	Min	Max	mean	Median	SD
As 188.979 (µg/L)	-14.4	-2.82	-8.16	-8.05	2.31
Ba 230.425 (µg/L)	-14.5	123	38.02	35.01	28.4
Ba 455.403 (µg/L)	4.58	118	45.68	44.40	25.5
Ca 317.933 (µg/L)	5084	76370	33471.08	26970	15318
Cu 324.752 (µg/L)	-14.8	33.06	-5.86	-6.75	6.51
Fe 238.204 (µg/L)	-0.96	21.98	3.55	1.71	4.94
K 766.490 (µg/L)	144	3850	1390	1299	1015
Mg 279.077 (µg/L)	1813	37330	12818	10500	8666
Mg 280.271 (µg/L)	1900	18070	9313	8875	4363
Mn 257.610 (µg/L)	-0.63	70.18	2.18	-0.20	10.0
Na 589.592 (µg/L)	2274	106200	21302	18440	17381
P 213.617 (µg/L)	-12.2	30.38	-1.32	-4.02	7.85
Pb 220.353 (µg/L)	-6.81	-2.91	-5.19	-5.30	0.88
S 181.975 (µg/L)	1466	27690	9036	7506.00	6684
Sr 407.771 (µg/L)	115.9	332	255	268.90	57.2
Sr 460.733 (µg/L)	121	90	418	368.20	182

Figure 7.3 Graphical presentation of association among the log transformed As concentration data for drinking/cooking water, raw rice, biomarkers of As exposure and CDI for Peshawar basin KPK

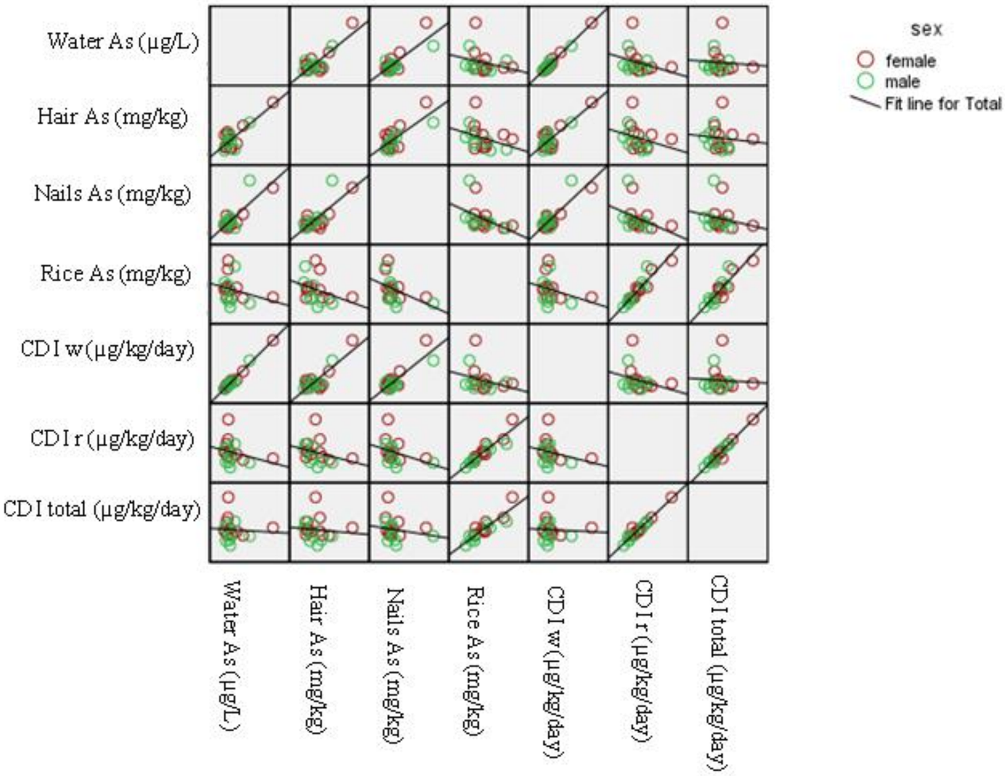


Table 7.5 Results of total arsenic concentration (mg/kg) for the raw rice samples (obtained from markets) in Peshawar basin, KPK and Allama Iqbal town Lahore.

	Peshawar Rice As (mg/kg)	Lahore Rice As (mg/kg)
Min	0.06	0.03
Max	0.21	0.25
Median	0.08	0.08
Mean	0.10	0.09

Figure 7.4 Reproducibility of rice results (sample A vs B) for Peshawar basin, KPK

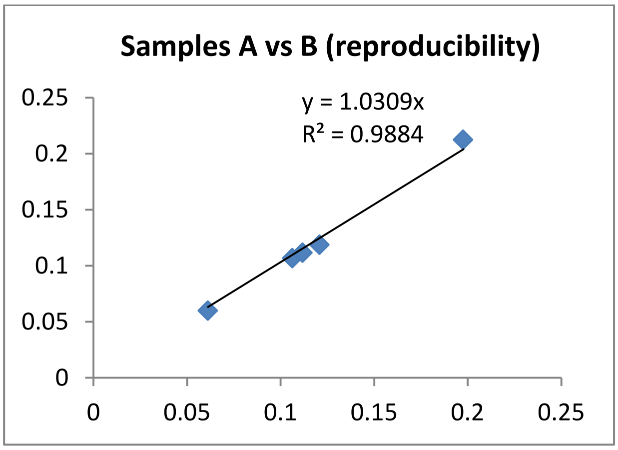


Table 7.6 Quality of procedural blanks used during analysis of raw rice samples from Peshawar basin, KPK

Procedural blanks	As (µg/L)
Blank HNO_3 1	0.006
Blank HNO_3 2	0.003
DW Blank 1	<0.000
DW Blank 2	<0.000

Table 7.7 Quality of CRM used during analysis of raw rice samples from Peshawar basin, KPK

Name	As (mg/kg)
CRM 1	0.23
CRM 2	0.22
CRM 3	0.23
Average	0.23

Table 7.8 Correlation values for As concentration in exposure media, biomarkers and CDI for KPK population

Age (y)	Pearson Correlation	1.000								
	Sig. (2-tailed)									
	N	27								
BMI-Lbs/Inch²	Pearson Correlation	.133	1.000							
	Sig. (2-tailed)	.509								
	N	27	27							
Water As (µg/L)	Pearson Correlation	.155	.082	1.000						
	Sig. (2-tailed)	.440	.683							
	N	27	27	30						
Hair As (mg/kg)	Pearson Correlation	.414*	-.022	.433*	1.000					
	Sig. (2-tailed)	.032	.913	.024						
	N	27	27	27	27					
Nails As (mg/kg)	Pearson Correlation	-.092	.237	.343	.556**	1.000				
	Sig. (2-tailed)	.656	.244	.086	.003					
	N	26	26	26	26	26				
Rice As (mg/kg)	Pearson Correlation	.059	.087	-.266	-.171	-.448	1.000			
	Sig. (2-tailed)	.804	.715	.258	.470	.054				
	N	20	20	20	20	19	20			
CDI w (µg/kg/day)	Pearson Correlation	.149	.060	.995**	.437*	.341	-.282	1.000		
	Sig. (2-tailed)	.459	.767	.000	.023	.089	.228			
	N	27	27	27	27	26	20	27		
CDI r (µg/kg/day)	Pearson Correlation	-.031	.034	-.432*	-.115	-.186	.935**	-.416*	1.000	
	Sig. (2-tailed)	.880	.864	.024	.568	.362	.000	.031		
	N	27	27	27	27	26	20	27	27	
CDI total (µg/kg/day)	Pearson Correlation	.012	.055	-.170	.006	-.089	.911**	-.151	.962**	1.000
	Sig. (2-tailed)	.954	.783	.396	.975	.666	.000	.452	.000	
	N	27	27	27	27	26	20	27	27	27

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7.9 Pearson Correlation values for As concentration in exposure media, biomarkers CDI for Male KPK population

Age (y)	Pearson Correlation	1.000								
	Sig. (2-tailed)									
	N	13								
BMI-Lbs/Inch²	Pearson Correlation	-.119	1.000							
	Sig. (2-tailed)	.700								
	N	13	17							
Water As (µg/L)	Pearson Correlation	.150	.214	1.000						
	Sig. (2-tailed)	.624	.482							
	N	13	13	13						
Hair As (mg/kg)	Pearson Correlation	.424	-.228	.351	1.000					
	Sig. (2-tailed)	.149	.454	.240						
	N	13	13	13	13					
Nails As (mg/kg)	Pearson Correlation	-.343	.474	.096	.333	1.000				
	Sig. (2-tailed)	.275	.120	.766	.290					
	N	12	12	12	12	12				
Rice As (mg/kg)	Pearson Correlation	-.111	.116	.008	-.610	-.465	1.000			
	Sig. (2-tailed)	.777	.766	.983	.081	.246				
	N	9	9	9	9	8	9			
CDI w (µg/kg/day)	Pearson Correlation	.135	.193	.997**	.374	.115	-.098	1.000		
	Sig. (2-tailed)	.660	.527	.000	.208	.722	.801			
	N	13	13	13	13	12	9	13		
CDI r (µg/kg/day)	Pearson Correlation	-.338	-.091	-.514	-.428	-.205	.954**	-.514	1.000	
	Sig. (2-tailed)	.258	.767	.073	.145	.522	.000	.073		
	N	13	13	13	13	12	9	13	13	
CDI total (µg/kg/day)	Pearson Correlation	-.430	-.076	-.178	-.371	-.188	.923**	-.170	.878**	1.000
	Sig. (2-tailed)	.163	.813	.579	.235	.559	.001	.598	.000	
	N	12	12	12	12	12	8	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

Table 7.10 Pearson Correlation values for As concentration in exposure media, biomarkers CDI for Female KPK population

Age (y)	Pearson Correlation	1.000								
	Sig. (2-tailed)									
	N	14								
BMI-Lbs/Inch²	Pearson Correlation	.403	1.000							
	Sig. (2-tailed)	.153								
	N	14	14							
Water As (µg/L)	Pearson Correlation	.072	-.045	1.000						
	Sig. (2-tailed)	.806	.879							
	N	14	14	17						
Hair As (mg/kg)	Pearson Correlation	.453	.141	.684**	1.000					
	Sig. (2-tailed)	.104	.631	.007						
	N	14	14	14	14					
Nails As (mg/kg)	Pearson Correlation	.366	-.009	.719**	.795**	1.000				
	Sig. (2-tailed)	.218	.977	.006	.001					
	N	13	13	13	13	13				
Rice As (mg/kg)	Pearson Correlation	.236	.060	-.363	-.038	-.421	1.000			
	Sig. (2-tailed)	.461	.853	.246	.906	.197				
	N	12	12	12	12	11	12			
CDI w (µg/kg/day)	Pearson Correlation	.083	-.089	.995**	.696**	.738**	-.351	1.000		
	Sig. (2-tailed)	.778	.762	.000	.006	.004	.264			
	N	14	14	14	14	13	12	14		
CDI r (µg/kg/day)	Pearson Correlation	.308	.062	-.310	-.028	-.232	.959**	-.277	1.000	
	Sig. (2-tailed)	.284	.834	.281	.924	.446	.000	.337		
	N	14	14	14	14	13	12	14	14	
CDI total (µg/kg/day)	Pearson Correlation	.333	.048	-.145	.093	-.090	.934**	-.111	.986**	1.000
	Sig. (2-tailed)	.244	.870	.620	.751	.769	.000	.706	.000	
	N	14	14	14	14	13	12	14	14	14

**. Correlation is significant at the 0.01 level (2-tailed).

Chapter 8 Conclusions and future work

Conclusions

Arsenic risk assessment and hazard evaluation studies have been carried out in Allama Iqbal town Lahore and, on a preliminary basis, in the Peshawar basin (Khyber Pukhtoon Khwa) KPK, Pakistan. This study mainly focused on identification of major exposure routes, their relative importance and contributions to the total exposure, calculated excess life time cancer risks and also the use of biomarkers of exposure as a more objective measure of recent exposure.

The problem of identification of various routes of arsenic exposure was addressed by direct measurement of exposure by quantifying the distribution of arsenic in drinking/cooking water sources and raw rice and their calculated daily intake of arsenic from water, rice and total from water and rice for the volunteers of Allama Iqbal town Lahore and Peshawar basin KPK, Pakistan.

The aim of determining the relative importance of drinking /cooking water derived from ground water and rice as exposure pathways has been achieved by estimating the overall excess lifetime cancer risk due to drinking arsenic contaminated ground water and ingestion of rice. The entire field based, laboratory, risk assessment methods have been combined for the cancer risk estimation of Allama Iqbal town Lahore, Pakistan. The results indicates that drinking water is the major arsenic exposure pathway for subjected population of Allama Iqbal town Lahore and rice could be another major route of exposure after drinking water for those groups of population who consume rice two to three times daily (rice is not normally the staple food for most of the volunteers). Water is a more important arsenic exposure route than rice in Allama Iqbal Town, Lahore, Pakistan.

The calculated excess lifetime cancer risk value from drinking/cooking (3.30×10^{-3}) As contaminated water and also from both water and rice together (3.52×10^{-3}) for volunteers of Allama Iqbal town Lahore, Pakistan is higher than the USEPA (10^{-4}-10^{-6}) range typically used threshold value.

The biomarkers of arsenic exposure (human hair, nails, and urine samples) study in Allama Iqbal town Lahore showed that hair and nails have been confirmed as good biomarkers of As exposure assessment for the volunteers of Allama Iqbal Town Lahore who consume As contaminated drinking and cooking water above the WHO provisional guideline value of 10 µg/L As. This is because the arsenic concentrations of nails and hair have a very good Pearson correlation of ($r^{2 =}$ 0.76) & ($r^{2 =}$ 0.68) respectively with arsenic contents of drinking water. As well as with chronic daily intake arsenic from water with ($r^{2 =}$ 0.67)for nails and ($r^{2 =}$ 0.64) for hair. Arsenic content of hair ($r^{2 =}$ 0.73) and nails ($r^{2 =}$ 0.86) have a better association with As concentration in drinking water for the female population of the area compared to male counterparts – this raises the possibility that the male population of Allama Iqbal town Lahore has also other sources of drinking water in addition to their household source, perhaps due to their employment.

The biomarkers of arsenic exposure study in West Bengal India supported the hypothesis that hair, nails and urine could be used as a proxy for exposure. There are highly significant association values of As contents of human nails ($r^{2 =}$ 0.76) and hair As ($r^{2 =}$ 0.68) with drinking /cooking water and cooked rice. The chronic daily intake (CDI) µg/kg body weight calculated from drinking water and cooked rice gives the idea that water and cooked rice could have more contribution to the body burden of arsenic in volunteers from West Bengal India.

The preliminary study of arsenic exposure in Peshawar basin KPK, though have suggested that drinking /cooking water derived from ground water are within the permissible limits of WHO for As concentration in that area – in agreement with values reported by PCRWR (2003-2004) for the Peshawar and Mardan areas..

In contrast arsenic contaminated ground water which is used for drinking, cooking, cleaning and bathing is a health hazard for the volunteers of Allama Iqbal town Lahore, Pakistan and needs to be addressed urgently through further regulatory policy and other remediation measures.

Future work

One of the most important tasks in relation to arsenic exposure, is identification of alternative sources of water with appropriate consideration of risk substitution for the exposed population of Allama Iqbal town Lahore.

Evaluation of the impacts of confounding factors like genetics, diet/ nutrition, dietary habits, age, gender and smoking habits on the arsenic exposure and risk assessment needs to be addressed in future studies in this exposed area of Allama Iqbal town Lahore and any other areas.

Population subgroups who could be relatively more susceptible to the exposed dose of arsenic for example infants, children, pregnant women and elderly people needs to be identified in order to decrease the negative consequences of arsenic exposure. For the risk estimation for these susceptible groups simple risk calculation methods based on a probabilistic approach needs to be developed.

The arsenic risk assessment and evaluation study which has been done in Allama Iqbal town Lahore needs to be further improved and replicated in other town and districts of southern Punjab and northern Sind provinces where high ground water arsenic has been reported.

Appendices

A1.Trainings / Courses**:**

1. EPS Graduate School: Introduction to the research (workshop) (2 days)
2. EPS Graduate School: Academic Writing (2 days)
3. University Course: End Note (4 hours)
4. University: First Aid (1 day)
5. EART30151 Analytical Techniques [attendance only]
6. Graduate Teaching Assistant / Demonstrator Training (GTA) 17 Sep, 2009 (lab based)
7. Effective Presentations
8. EPS Graduate School: Publishing Academic Paper (workshop)
9. The raw data obtained from the ICP-MS have been further processed by Different statistical software like Turbo Pascal program “DBSCORR” and “R” a program for statistical computing and graphics.
10. Demonstration for 1st year practical classes Eart10350 “Environment Problems” from Sept (2009).
11. Research Paper Review Exercise Aug 2009.
12. Lay summary writing Exercise 16 Oct 2009.
13. A Distance Learning short course on “Social Capacity Building For Arsenic Mitigation Measures Understanding The Health Risk Of Drinking Arsenic Contaminated Water”
14. Electronic thesis submission work shop-15 September 2010
15. Elsevier Author Workshop 5th November 2010, Mansfield Copper building University of Manchester.

A2.Workshops/ Conferences/ Presentations

16. Attended and deliver a power point presentation on "Relative Importance of Rice and Water as Arsenic exposure route in Pakistan (Punjab, district Lahore) PRAMA workshop Manchester, 2-4 September, 2009
17. Attended and participated in the Poster presentation in William Smith Meeting 2009, London (Date: 21-23/09/2009)

    Conference name: William Smith Meeting 2009, London

    Name of poster: Human exposure to groundwater arsenic in Allama Iqbal Town, Lahore, Punjab, Pakistan

    Place: Burlington House, Geological Society of London
18. Abstract published for the poster presented with the title, Arsenic in Geosphere and Human Diseases in As 2010 Tainan, Taiwan Conference proceedings (17-21 May 2010). Relative importance of arsenic exposure from water and rice in Allama Iqbal Town, a peri-urban area of Lahore, Pakistan
19. Poster presentation at Mineralogical Society Annual meeting in Aberystwyth 21- 23 June 2011
20. Poster presentation in PRAMA Workshop University of Manchester 21-23Sep 2011

A 3. Submitted/Published Abstracts

Graduate research conference in the University of Manchester Jun 2007

Arsenic in Groundwater of Pakistan

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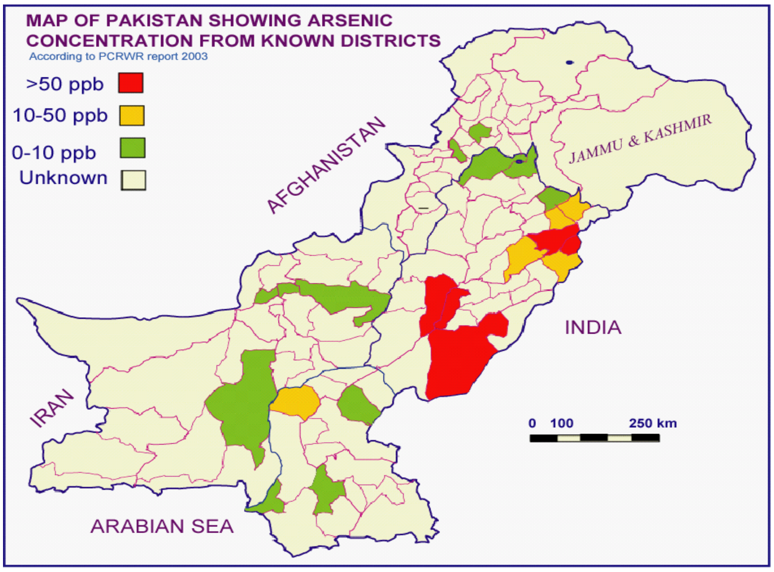
Arsenic in groundwater has been widely recognized as a massive human health hazard in many countries in southern Asia, notably Bangladesh, India and Nepal (Islam, Gault et al. 2004). More recently, high arsenic in ground waters has been found in Pakistan in water used for drinking, cooking and irrigation (Nickson, McArthur et al. 1998; PCRWR 2000; Ahmed et al. 2004). High risk (mean As > 50 µg/L) districts currently identified include Lahore, Kasur, Muzaffarghar, Multan in Punjab (Nickson, McArthur et al. 1998; PCRWR 2000; Kahlown 2002; Ahmed et al. 2004; Farooqi, Masuda et al. 2007) and Larkana and Mirpure Khas in Sindh province (Asghar 2000) (see Figure 1).

Fig.1.



Map of Pakistan Showing mean Arsenic concentration by district (from data compiled from (Nickson, McArthur et al. 1998; Asghar 2000; PCRWR 2000; Kahlown 2002; Ahmed et al. 2004; Farooqi, Masuda et al. 2007).

The purpose of this study (commenced September 2006) is to create and parameterize a suitable model to estimate risks to human health in Pakistan from arsenic-bearing groundwater's. This work will entail (i) quantifying the distribution of arsenic in groundwaters in Pakistan, (ii) developing a risk assessment model, and (iii) obtaining values for the input parameters into the model. The model will be used to quantitatively assess risks to human health and determine if any readily definable groups (e.g. women, children, certain districts, thesil, union councils) are particularly at risk.

William Smith Meeting 2009

Human exposure to groundwater arsenic in Allama Iqbal Town , Lahore, Punjab, Pakistan

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Groundwater arsenic is recognised as a threat to human health in many areas of the Punjab, Pakistan (Ahmad et al. 2004, Farooqi et al.2006, Nickson et al 2005, PCRWR 2003 & 2008).In this study, we aimed to determine the relative importance of rice and water to human exposure in Allama Iqbal Town, an arsenic-impacted part of Lahore, Punjab. Raw rice and ground waters utilised as drinking water were collected from 102 households and analysed for total arsenic by ICP-MS. Hair samples were taken from volunteers and also analysed for arsenic by ICP-MS after digestion following the methods of Gault et al. (2008). In addition to standard quality assurance measures, overall method quality was checked through participation in an Interlaboratory Quality Exercise (IQE). Daily intake of water and rice by volunteers was determined through questionnaires.

Groundwater arsenic concentration as high as 900 µg/L were found with a median value of 49 µg/L. Rice arsenic concentrations ranged from 0 .02 mg/kg to 0.24 mg/kg with a median value of 0.06 mg/kg. Total calculated daily intakes (CDIs) ranged from 0.16 µg/kg/day to 36 µg/kg/day with a median value of 1.5 µg/kg/day. Water was the dominant route of exposure for 90 % of the volunteers. The median CDI is broadly comparable to values previously published for other seriously arsenic impacted areas and this is reflected in elevated concentrations of arsenic in hair (range 0.03 mg/kg to 14.7mg/kg median 0.64 mg/kg).

Hair arsenic exhibited a significant positive correlation with CDI suggesting that (i) water and rice were the dominant routes of exposure in the volunteers studied; and that (ii) other factors, e.g. variations in water and rice supply, dietary, genetic, age are, in combination, also important in determining human exposure in this area.

References

Ahmad et al. (2004) http://wed.lboro.ac.uk/conferences/pdf/30/Ahmad.pdf
Arain et al. (2009) Food and Chemical Toxicology, 47 242-248.
Farooqi et al. (2006) Environmental Pollution, 145 839-849.
Gault, et al. (2008) Science of the Total Environment, 393 168-176.
Nickson et al (2005) Applied.Geochemistry, 20 55-68.
Ohno et al. (2007) Science of the total Environment, 381, 68-76
PCRWR (2003a) PCRWR, Ministry of Science and Technology government of Pakistan, PCRWR, UNICEF Joint Venture.

PCRWR (2008) PCRWR, Ministry of Science and Technology government of Pakistan.

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As 2010 Conference in Tainan Taiwan

Relative importance of arsenic exposure from water and rice in Allama Iqbal Town, a peri-urban area of Lahore, Pakistan

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Introduction

Arsenic has been documented as class 1 carcinogen on the basis of its deleterious effects to humans (USEPA, 2001). Naturally occurring arsenic in ground water is a global issue, impacting most continents of the world and in southern Asian countries in particular (Smith et al., 2000, 2006; Smedley and Kinniburgh, 2002, Ravenscroft et al., 2009). Arsenic contamination in groundwater is also a seriously emerging problem in Pakistan, especially in the Punjab province (Nickson et al. 1998; Kahlown, 2002; PCRWR, 2003, 2008; Ahmed et al. 2004; Farooqi et al. 2007) and the Sind province (PCRWR, 2003, 2008; Ahmed et al. 2004; Arian et al 2008) where high arsenic has been found in water used for drinking, cooking and irrigation (Nickson et al. 1998; PCRWR 2000; Ahmed et al. 2004). Arsenic concentrations as high as 2400 µg/L has been reported in parts of Punjab (Farooqi et al. 2007).

The relative importance of water and rice as exposure route for arsenic has been the subject of recent studies in West Bengal (Mondal and Polya, 2008) and Bangladesh (Kile et al., 2007) amongst other places (Polya et al., 2010a), but there is a dearth of such data for Pakistan.

We report here a study of exposure to arsenic through drinking water and eating rice in Allama Iqbal Town , a peri-urban area in Lahore district, Punjab, Pakistan, which has previously been documented as an arsenic impacted district (PCRWR, 2003, 2008; Farooqi et al., 2007). We also report the output from a simple model (Mondal and Polya, 2008) of arsenic attributable cancer risks, based on measured arsenic concentrations in water and rice and consumption data for water and rice. Lastly, we evaluate the measurement of arsenic in hair and nails as proxies for arsenic exposure.

Methodology

Drinking water (n=104), raw rice (n=78), fingernail (n=88) and hair (n=87) samples were collected in March – April 2009 from volunteers living in Allama Iqbal Town. Inductively coupled plasma-mass spectrometry (ICP-MS) was used for analysis, after digestion, where appropriate, following the methods of Gault et al. (2008). In addition to standard quality assurance measures, overall method quality was checked through participation in an Interlaboratory Quality Exercise (IQE). Daily intake of water and rice by volunteers was determined through food frequency questionnaires. The model of Mondal and Polya (2008) was used to calculate median increased life time cancer risk and chronic daily intake (CDIs).

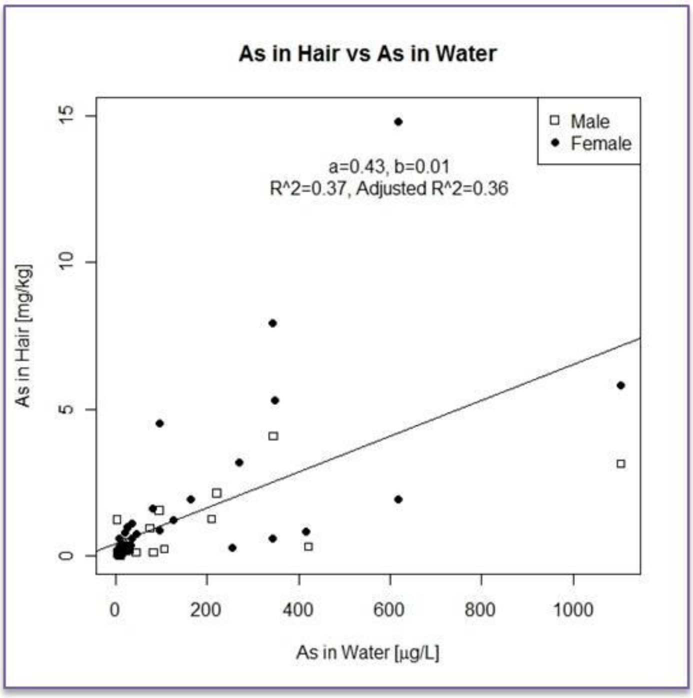
Results

Groundwater arsenic concentration as high as 1100 µg/L were found with a median value of 25 µg/L. Rice arsenic concentration ranged from 0.014 mg/kg to 0.24 mg/kg with a median value of 0.06 mg/kg.

Compared to rice, water was the dominant route of exposure for 90 % of the volunteers. Total calculated daily intakes (CDIs) ranged from 0.13 µg/kg/day to 90 µg/kg/day with a median value of 0.89µg/kg/day. While CDI calculated with rice ranged from 0.037 mg/kg/day to 1.06 mg/kg/day with a median value of 0.22 mg/kg.

The median CDI is broadly comparable to values previously published for other seriously arsenic impacted areas (Williams et al., 2007; Kile et al., 2007; Mondal and Polya, 2008; Polya et al., 2010a) and this is reflected in elevated concentrations of arsenic in hair (range 0.03 mg/kg to 14.8 mg/kg median 0.33 mg/kg) and nail (range 0.53 mg/kg to 64 mg/kg median 0.94 mg/kg).
The calculated median increased life time cancer risk due to drinking water is higher than the 10^{-4}–10^{-6} threshold range typically used by USEPA.
Hair and, to a lesser extent, toenail arsenic exhibited a significant positive correlation with CDI suggesting that (i) water and rice were together the dominant routes of exposure in the volunteers studied; but nevertheless that (ii) other factors, e.g. variations in water and rice supply and consumption, diet, genetics and age may also be important in determining human exposure in this area.

Figure 1. Correlation of arsenic in hair and arsenic in drinking water for 68 volunteers from Allam Iqbal Town, Pakistan



Conclusion
Water is a more important arsenic exposure route than rice in Allama Iqbal Town, Lahore, Pakistan.

Acknowledgement

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References

Ahmad, T., Kahlown, M.A., Tahir, A. and Rashid, H., 2004. Arsenic an emerging issue: Experiences from Pakistan. 30th WEDC International Conference. http://wedc.lboro.ac.uk/conferences/pdfs/30/Ahmad.pdf

Arain, M.B., Kazi, T.G. and Baig, J., 2009. Determination of arsenic levels in lake water, sediment, and foodstuff from selected area of Sindh, Pakistan: Estimation of daily dietary intake. Food and Chemical Toxicology, 47(1), 242-248.

Farooqi, A., Masuda, H. and Firdous, N., 2006. Toxic fluoride and arsenic contaminated groundwater in the Lahore and Kasur districts, Punjab, Pakistan and possible contaminant sources. Environmental Pollution, 145(3), 839-849.

Kahlown, M.A., Tahir, M.A., Rasheed, H. and Anwar, I., 2003. Arsenic Contamination of Groundwater in Southern Punjab PCRWR,-UNICEF Joint Venture.

Kile, M.L., Houseman, E.A., Breton, C.V., Smith, T., Quamruzzaman, O., Rahman, M., Mahiuddin, G. and Christiani, D.C.2007. Dietary arsenic exposure in Bangladesh, Environ. Health Perspect. **115,** 889–893.

Mondal, D., Polya, D.A. 2008. Rice is a major exposure rout for arsenic in Chahkdha block, Nadia district , West Bengal, India. A probablistic risk assessment. Applied Geochemistry 23(11): 2987-2998

Nickson, R.T., McArthur, J.M. and Shrestha, B., 2005. Arsenic and other drinking water quality issues, Muzaffargarh district, Pakistan. Applied Geochemistry, 20 (1), 55-68.

PCRWR 2003, Arsenic Contamination in Groundwater of Southern Punjab. PCRWR, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).

PCRWR, 2008 PCRWR, Ministry of Science and Technology government of Pakistan

Polya, D.A., Mondal, D. And Giri, A.K. 2010a. Quantification of deaths and DALYs arising from chronic exposure to arsenic in ground waters utilized for drinking, cooking and irrigation of food crops in Preedy, V. and Watson (Eds) Handbook of Disease Burdens and Quality of Life Measures, Springer-Verlag, ISBN: 978-0-387-78665-0

Ravenscroft, P., Brammer, H., Richards, K.S. 2009. Arsenic pollution: a global synthesis. Wiley-Blackwell, U.K;

Smedley, P.L. and Kinniburgh, D.G., 2002. A review of the source, behaviour and distribution of arsenic in natural waters. Applied Geochemistry, 17, 517-568.

Smith, A.H., Lingas, E.C. and Rahman, M. 2000. Contamination of drinking water by arsenic in Bangladesh: a public health emergency, Bull. World Health Org. 78, 1093–1103.

Smith, A.H., Marshall, G. Yuan, Y. Ferreccio, C. Liaw, J. von Ehrenstein, O. Steinmaus, C. Bates, M.N. and Selvin, S. 2006. Increased mortality from lung cancer and bronchiectasis in young adults after exposure to arsenic in utero and in early childhood, Environ. Health Perspect. 114, 1293–1296.

USEPA, 2001, Risk Assessment Guidance for Superfund, vol. III – Part A, Process for Conducting Probabilistic Risk Assessment. US Environmental Protection Agency, Washington, DC. Report EPA/630/R-97/001.

Williams, P.N. ; Raab, A. ; Feldmann, J. and Meharg, A.A. 2007 Market basket survey shows elevated levels of As in south central U.S. processed rice compared to California: consequences for human dietary exposure, Environ Sci Technol. 41, 2178–2183.

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Geogenic Arsenic in Groundwaters and Soils – Re_evaluating Exposure Routes & Risk Assessment

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Abstract

We present here data from the AquaTRAIN, CALIBRE and PRAMA networks and also from recent work from other groups that demonstrate that: (i) the 10 μg/L guideline for arsenic in drinking water may not be as conservative a value as for other chemicals; (ii) rice is a major exposure route for many individuals, including in the European Union, and that re-assessment of the arsenic-in-food regulations within the European Union is required; and (iii) exposure to arsenic through drinking water and rice may result in genetic and other damage in individuals, that are otherwise externally asymptomatic, at least in the earlier stages of the development of cancers and other detrimental sequela, some of which have latency periods of decades. There is a clear and present need for more critically determining the human health and socio-economic impacts of current levels of human exposure to arsenic within the European Union and elsewhere. The relative merits of regulatory/remediatory strategies need to explicitly take into account substitution of risks.

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1. Introduction

Regulation and remediation of hazardous chemicals in drinking waters (including groundwaters used for that purpose) and soils has been very largely, though not exclusively, driven by studies (speciation, biogeochemistry, hydrology/hydrogeology, exposure, remediation, human health impacts) of anthropogenic chemicals and the application of conservative safety factors. Uncertainties and mis-perceptions regarding exposure routes, dose-response relationships and consequent human health risks associated with geogenic chemicals, notably arsenic, have contributed to drinking water and food regulations in both the European Union and elsewhere they are not as demonstrably protective of public health as those for many chemicals of known anthropogenic origin [1, 2, 3]. Both EFSA [4] and FAO/WHO [5] have recently raised similar concerns. Interestingly just a decade ago, reviews by the NRC [6,7] raised similar concerns over the previous WHO guide value of 50 µg/L for drinking water, leading to the tightening to the current WHO provisional guide value of 10 µg/L [8] which is widely but not universally adopted.

We present here data from the AquaTRAIN, CALIBRE and PRAMA networks and also from recent work from other groups that demonstrate that: (i) the 10 µg/L for arsenic in drinking water may not be as conservative a value as for other chemicals; (ii) rice is a major exposure route for many individuals living in the European Union and that re-assessment of the arsenic-in-food regulations within the European Union is required; and (iii) exposure to arsenic through drinking water and rice may result in genetic and other damage in individuals, that are otherwise externally asymptomatic, at least in the earlier stages of the development of cancers and other detrimental sequela, some of which have latency periods of decades.

2. Risks arising from WHO provisional guide value of 10 ug/L

2.1 Arsenic-attributable health risks

Chronic exposure to arsenic at concentrations equivalent to as low as 300 µg/L has been unequivocally linked to a wide variety of detrimental cancer and non-cancer health end-points [3,6,7,9,10,11]. Non-cancer end-points include development of highly visible skin hyperpigmentation and keratoses, as well as hypertension, ischaemic heart disease and diabetes, although there are considerable uncertainties in dose-response data [12,13,14,15], not least of all because of wide variety of dietary, genetic and environmental confounding factors [16, see also references in 3,6,7] Such exposure also contributes to the development of cancers of the skin, bladder, liver and lung – the latter being considered by some as arguably the most significant [11].

2.2 Lung cancer risks attributable to arsenic in drinking water

Smith [17] estimated the lifetime cancer risks per million population attributable to chronic exposure to arsenic in drinking water at 500, 50 and 10 µg/L to be approximately 100,000, 10,000 and 2,000 respectively. These estimates are considerably higher than the values typically utilised by the USEPA as the upper bound for acceptable risks for individual carcinogens in drinking water. [18,19, see Table 1]

Table 1. Comparison of model lifetime cancer risks from exposure to arsenic with those typically used to establish USEPA MCLs (maximum contaminant levels). [a] based on lifetime exposure; [b] USEPA default value; [c] based on data of Smith [11]; [d] note the lack of any safety factor even at 10 µg/L; [e] Whilst the USEPA do not currently prescribe a single value for acceptable lifetime cancer risk, USEPA [18] states that "for regulating chemical carcinogens, ….. MCLs are set as close to the MCLG [maximum contaminant level goal] as is technically and economically feasible, but also with an acceptable cancer risk range of 10^{-4} to 10^{-6}", Cross [19] note that "EPA drinking water MCLs for carcinogens are generally set from about 1 x 10^{-4} to 1 x 10^{-6} theoretical upper-bound lifetime cancer risk".

Source / Daily exposure	**Carcinogen**	**Risk[a] / 10^6**
Well water with 500 µg/l arsenic (2 litre)[b]	Arsenic (1000 µg)	100,000 [c]
Well water with 50 µg/l arsenic (2 litre)[b]	Arsenic (100 µg)	10,000 [c]
Well water with 10 µg/l arsenic (2 litre)[b] [d]	Arsenic (20 µg)	2,000 [c]
USEPA Typical upper range of acceptable cancer risk [e] 10^{-4} lifetime risk		100
USEPA Typical upper range of acceptable cancer risk [e] 10^{-6} lifetime risk		1

2.3 Uncertainties

The estimates of Smith [11] are broadly based upon a linear extrapolation of strong epidemiological data obtained for populations chronically exposed to arsenic in drinking water with concentrations greater than 100 µg/L and assuming that there is no threshold concentration for its carcinogenic impact.

There is not a consensus regarding the how dose-response relationships from arsenic and arsenic-attributable cancers, including lung cancer, should be extrapolated to arsenic concentrations in drinking water near the WHO provisional guide value [1,6,7]. In the absence of such consensus it may be concluded that:

(i) the WHO provisional guide value for arsenic in drinking water is not demonstrably protective of human health as are the values for other chemical components

(ii) further research work is needed to resolve the uncertainties

It is further noted that exposure to arsenic from rice and other foodstuffs may have led to some underestimation of the health effects arising from arsenic in drinking water because the exposure of "unexposed" groups to arsenic may have been underestimated – this is analogous (though not necessarily the same magnitude of effect) to that subsequently noted for early classic studies by Wynder & Graham and Doll & Hill on the impact of smoking of health because of relative high proportion of smokers in the hospital-base reference cohorts [20].

3. Rice is a major route of arsenic exposure

3.1 Case study – Indian Sub-continent

Some of world's areas most highly impacted by geogenic arsenic are in the Indian sub-continent [21,22,23] where the highest arsenic exposed populations are predominantly exposed through consumption of arsenic-bearing drinking water. Where such waters contain, say, 1000 µg/L As, not atypical of many highly impacted areas [21,22], exposure through rice was typically less than 5 % of total exposure [24] – remediation efforts therefore reasonably focussed on drinking water, and rice became generally perceived as an inconsequential exposure route, not least of all because only the inorganic (i-As) content is generally considered to be toxic/carcinogenic.

However, as remediation efforts became effective, the relative importance of rice as an exposure route has increased [25,26,27,28]. Given the high bioavailability of i-As [29], such studies have highlighted that arsenic exposures from rice (e.g. with as little as 100 µg/kg As of which 50 % was inorganic – see Figure 1) may exceed recommended maximum tolerable weekly intakes arising from exposure to drinking water with arsenic concentrations at the WHO provisional guide value [25,26,27,28].

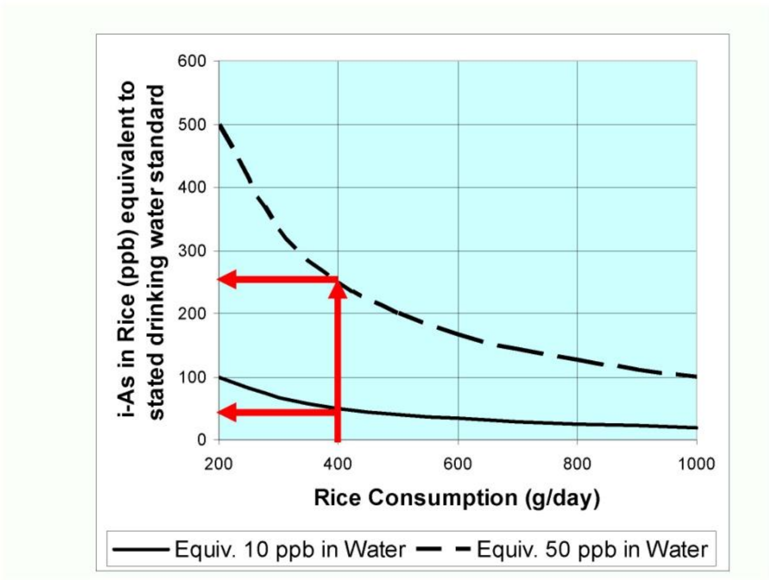

Figure 1. i-As (inorganic arsenic) concentration in rice equivalent to the old (50 ppb (µg/L)) and more recent (10 ppb (µg/L)) WHO provisional guide values in drinking water, assuming consumption of 2 L of drinking water per day.

3.2 Europe

There has been a perception that only rice from areas impacted by high arsenic groundwaters that may be high in arsenic and hence populations in regions such as the USA and Europe are not particularly at risk. This is demonstrably not correct. Indeed, Zavala [30] reports that the mean total arsenic in rice grown in Europe and USA (198 µg/kg) is higher than that for Asia (70 µg/kg) (although the health impacts of this can be ameliorated by differences in the percentage of i-As in rice). Meharg [31,1] clearly demonstrates not only the importance of exposure through rice to certain groups in Europe but also the significant consequent human health risks.

4. Externally asymptomatic citizens may also be at risk

The widespread and often highly visible arsenic-attributable hyper-pigmentation and keratosis has led to the perception that externally asymptomatic people may not be at risk of arsenic attributable diseases. Since there is increasing evidence that good nutrition and certain genetic polymorphisms may be protective [32], the development of such a perception was not altogether unreasonable. Nevertheless studies of genetic damage in symptomatic and asymptomatic groups both chronically exposed to high(> 300 µg/L) As drinking water (see Figure 2) show that both groups have substantially higher genetic damage, as evidenced by micronuclei frequency, than an unexposed group [33] – thus asymptomatic citizens may also be suffering genetic damage from arsenic exposure.

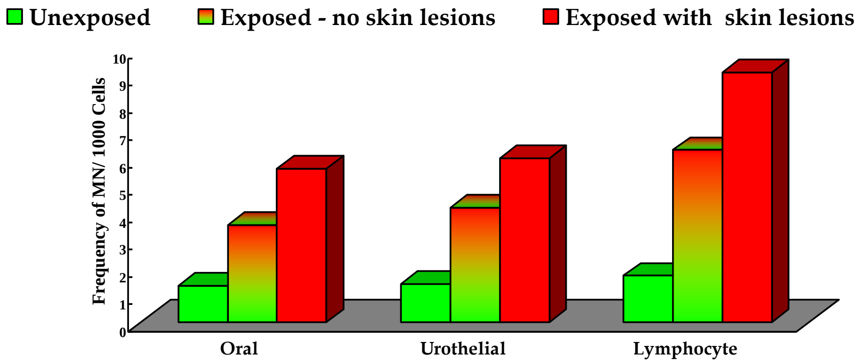

Figure 2. Frequency of micronuclei damage in cohorts (i) unexposed; (ii) exposed to high arsenic drinking water but with no skin lesions; (iii) exposed to high arsenic drinking water and with visible skin lesions. For each and every one of the three cell types investigate, exposed populations exhibited significantly higher frequencies of micronuclei damage than unexposed population, irrespective of whether or not skin lesions were visible. Data from Basu [33].

Within the European Union, hyperpigmentation is very rare in the historically highly exposed population in arsenic-impacted regions of the Pannonian Basin [34], yet excess cancer mortality attributable to arsenic exposure are estimated to be as high as 10 % [35].

5. Discussion & Conclusions

There is a clear and present need for more critically determining the human health and socio-economic impacts of current levels of human exposure to arsenic within the European Union and elsewhere.

The use of known biomarkers of exposure [36], adsorption [37], metabolism [38] and early and late biological effects [39,40] and the development of novel biomarkers may be of considerable assistance in identifying at-risk groups with the population as a whole as well as reducing the uncertainties of does-response relationships for key arsenic attributable sequela.

As shown in Figure 3, the re-evaluation of geogenic arsenic exposure routes and human health risks lead to consideration of revised health targets and of drinking water and other safety plans.

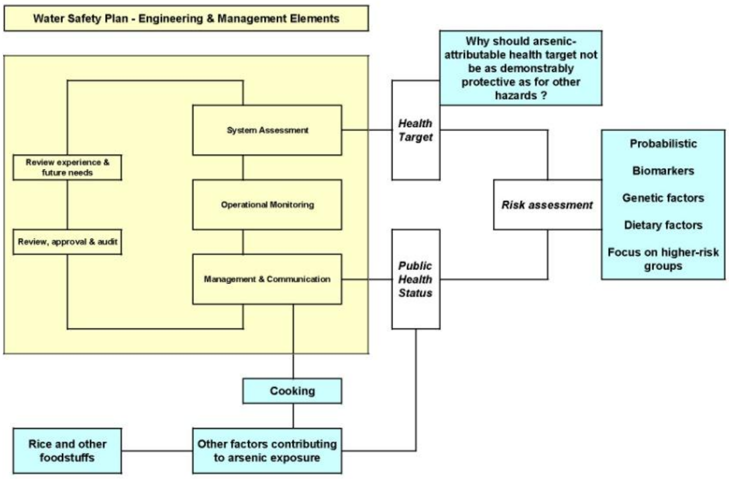

Figure 3. Water safety plan (modified after [41]) showing relationship to public health status, risk assessment and health targets, and to re-evaluation of exposure routes and assessment of geogenic arsenic attributable risks discussed in this study.

Revising regulatory values will ultimately not only take into revised risk assessments, but also consider what are perceived to be acceptable upper bounds of risk [42] and weigh these against economic costs and benefits [43,44]. GIS and other tools for spatial mapping and interpolation of hazard, exposure and environmental and genetic confounding factors impacting dose-response relationships will also be important to facilitate the adoption and implementation of regulatory policies suitable for particular regions and/or population groups [45]. Lastly, the relative merits of regulatory/remediatory strategies need to explicitly take into account substitution of risks.

Acknowledgments

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References

[1] Meharg, A.A., Raab, A., *Environmental Science and Technology*, **2010**, *44*, 4395-4399

[2] Polya, D.A., Berg, M., Gault, A.G. and Takahashi, Y., *Applied Geochemistry*, **2008**, *23*, 2968-2976

[3] Polya, D.A., Mondal, D. And Giri, A.K., in Preedy and Watson (Eds) *Handbook of Disease Burdens and Quality of Life Measures*, **2009**, pp 702-728. Springer-Verlag, ISBN: 978-0-387-78665-0

[4] European Food Standards Authority, *Scientific Opinion on Arsenic in Food*, **2009**, EFSA-Q-2008-425

[5] FAO/WHO Joint Expert Committee on Food Additives, **2010**,TRS 958-JECFA 72.

[6] National Research Council, *Arsenic in Drinking water*, **1999**, National Academy Press, Washington, DC.

[7] National Research Council, *Arsenic in Drinking water*, **2001,** Update. National Academy Press, Washington, DC.

[8] WHO *Environmental Health Criteria 224. Arsenic and Arsenic Compounds*, **2001**, World Health Organization. Geneva.

[9] Brown J., *Public Health Goal for Arsenic in Drinking Water*, **2004** ,Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.

[10] USEPA, *Issue Paper: Inorganic Arsenic Cancer Slope Factor*, Final Draft, July 22, **2005**

[11] Smith, A.H., Lingas, E., Rahman, M. *Bulletin of the World Health Organization*, **2000**, 78, 1093-1103.

[12] Navas-Acien A., Sharrett, A.R., Silbergeld, E.K., Schwartz, B.S., Nachman, K.E., Burke, T.A., Guallar, E., *American Journal of Epidemiology*, **2005**, 162, 1037-1049.

[13] Navas-Acien A., Silbergeld, E.K., Streeter, R.A., Clark, J.M., Burke, T.A., Guallar, E. *Environmental Health Perspectives*, **2006**, 114, 641-648.

[14] Mondal, D., Adamson, G.C.D., Nickson, R., Polya, D.A., *Applied Geochemistry*, **2008**, 23, 2998-3008

[15] Adamson, G.C.D., Polya, D.A., *Journal of Environmental Science and Health Part A*, **2007**, 42, 1909-1917.

[16] Vahter, M.E., *J Nutrition*, **2007**, 137, 2798-2804

[17] Smith, A.H., Steinmaus, C.M., *Annu. Rev. Public Health,* **2008**, 30,107–122; Smith, A.H., Royal Geographical Society Meeting, London, August **2007**, http://www.geog.cam.ac.uk/research/projects/arsenic/symposium/S1.4_A_Smith_et_al.pdf

[18] US Environmental Protection Agency, *Use of Microbial Risk Assessment in Setting US Drinking Water Standards*, **2002**, EPA 814/S-92-001.

[19] Cross, F.B., Byrd, D.M., Lave, L.B., *Admin. Law Review*, **1991**, 61.

[20] Stolley, P.D., Lasky, T., *Investigating disease patterns*, **1995**, Scientific American Library.

[21] Smedley P., Kinniburgh D., *Applied Geochemistry*, **2002**, 17, 517- 568.

[22] Charlet, L., Polya, D.A., *Elements,* **2006**, 2, 91-96.

[23] Mazumder DNG, Haque R, Ghosh N, De BK, Santra A, Chakraborty D, and Smith AH (1998) Int. J. Epidemiol. 27: 871-877

[24] Khattak, S.A., Polya, D.A., Samanta, M., abstract, in Jean, J.-S., *Arsenic 2010*, NCKU, Taiwan, May **2010**.

[25] Juhasz, A. L., Smith, E., Weber, J., Rees, M., Rofe, A., Kuchel, T., Sansom, L., Naidu R. *Environmental Health Perspectives*, **2006**, 114, 1826-1831.

[26] Williams, P.N., Islam, M.R., Adomako, E.E., Raab, A., Hossain, S.A., Zhu, Y.G., Feldmann,J. , Meharg ,A.A., *Environmental Science and Technology*, **2006**, 40, 4903-4908

[27] Mondal, D. and Polya, D.A., *Applied Geochemistry*, **2008**, 23, 2986-2997.

[28] Mondal, D., Banerjee, M., Kundu, M., Banerjee, N., Bhattacharya, U., Giri, A.K., Ganguli, B., Sen Roy, S., Polya, D.A., *Environmental Geochemistry and Health*, **2010**, 32, 463-477.

[29] Kile, M.L., Andres Houseman, E., Breton,C.V., Smith,T., Quamruzzaman, Q., Rahman,M., Mahiuddin,G., Christiani, D.C., *Environmental Health Perspectives*, **2007**, 115, 890-893.

[30] Zavala, Y.J., Duxbury, J.M., *Environmental Science and Technology*, **2008**, 42, 3856-3860.

[31] Meharg, A.A., Williams, P.N., Adiomako, E., Lawgali, Y.Y., Deacon, C., Villada, A., Campbell, R.C.J., Sun, G., Zhu, Y.-G., Feldmann, J., Raab, A., Zhao, F.-J., Islam, R., Hossain, S., Yanai, J., *Environmental Science and Technology*, **2009**, 43, 1612-1617.

[32] Banerjee, M., Sarkar, J., Das, J.K., Mukherjee, A., Sarkar, A.K., Mondal, L. , Giri, A.K. *Carcinogenesis*, **2007**, 28: 672-676.

[33] Basu, A., Ghosh, P., Das, J.K., Banerjee, A., Ray, K., Giri, A.K., *Cancer, Epidemiology, Biomarkers and Prevention*, **2004**, 13, 820-827

[34] Lindberg, A.L., Goessler, W., Gurzau, E., Koppova, K., Rudnai, P., Kumar, R., Fletcher, T., Leonardi, G., Slotova, K., Gheorghiu, E., Vahter, M., *Journal of Environmental Monitoring*, **2006**, 8, 203-208.

[35] Tony Fletcher, London School of Hygiene and Tropical Medicine, pers. comm..

[36] Gault, A.G., Rowland, H.A.L., Charnock, J.M., Wogelius, R.A., Gomez-Morilla, I., Vong, S., Samreth, S., Sampson, M.L. and Polya, D.A. *Science of the Total Environment*, **2008**, 393, 168-176.

[37] Button, M., Watts, M.J., Cave M.R., Harrington C.F., Jenkin, G.T., *Environmental Geochemistry and Health*, **2009**, 31, 273-282.

[38] Brima, E.I., Harrington, C.F., Jenkins, J.O., Gault, A.G., Polya, D.A. and Haris, P.I., *Applied Toxicology and Pharmacology*, **2006**, 216, 122-130.

[39] Bonassi, S., Au, W.W., *Mutation Research*, **2002**, 511, 73-86.

[40] Bonassi, S., Hagmar, L., Stromberg, U., Montagud, A.H., Tinnerberg, H., Forni, A., Helkklla, P., Wanders, S., Wilhardt, P., Hansteen, I.-L., Knudsen, L.E., Norppa, H. For the European Study Group on Cytogenetic Biomarkers and Health, *Cancer Research*, **2000**, 60, 1619-1625.

[41] Medema G., Ashbolt, N. *MICRORISK QMRA : its value for risk management*, **2006**, European Commission FP5 Report (Contract EVK1-CT-2002-00123)

[42] Kelly, K.E., *The Myth of 10^{-6} as a definition of acceptable risk*, Delta Toxicology Inc., updated for 1991, 84th Annual Meeting, AWMA, Vancouver, Canada.

[43] US Environmental Protection Agency, *Arsenic in Drinking Water Rule Economic Analysis*, **2000**, EPA 815/R-00-026.

[44] Smith A.H., Smith, M.M.H. *Toxicology*, **2004**, 198, 39-44.

[45] Rodriguez-Lado, L., Polya, D.A., Winkel, L., Berg, M. and Hegan, A. *Applied Geochemistry*, **2008**, 23, 3010-3018.

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Arsenic exposure from ground waters and rice in Allama Iqbal town Lahore, Punjab, Pakistan

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Naturally occurring arsenic in ground water is a global issue but of particular importance in Asia (Smith et al., 2000, 2006; Smedley and Kinniburgh, 2002; Ravenscroft et al., 2009) including in Pakistan. High groundwater arsenic (up to 2400 µg/L) has been found in the Punjab (Nickson et al., 1998; Kahlown, 2002; PCRWR, 2003, 2008; Ahmed et al., 2004; Farooqi et al., 2007) and Sind (PCRWR, 2003, 2008; Ahmed et al., 2004; Arian et al., 2008) where high arsenic has been found in water used for drinking, cooking & irrigation (Nickson et al., 1998; Ahmed et al., 2004).

Our study aimed to determine the relative importance of rice and water to human exposure in Allama Iqbal town, an arsenic-impacted per-urban part of Lahore, Punjab. Raw rice, ground waters utilised as drinking water from 102 households, hair, nails and urine samples from volunteers of that area were collected and analysed by ICP-MS for total arsenic. All urine samples were lysed to remove any human cells prior to analysis. IC-ICP-MS was used for arsenic speciation. Throughout the study standard methods were followed and for quality assurance measures, Standard reference material, duplicate samples and blanks were included in every set of analysis. Daily intake of water and rice by volunteers was determined through questionnaires. The model of Mondal and Polya (2008) was used to calculate chronic daily intake (CDIs) and excess life time cancer risks.

Groundwater arsenic concentration as high as 1100 µg/L were found (median value of 49 µg/L). Rice arsenic concentrations ranged from 0 .03 - 0.25 mg/kg (median 0.08 mg/kg), of this 40% - 93% (median 69%) was inorganic. CDIs ranged from 0.16 to 36 µg/kg/day (median 1.5 µg/kg/day). The median CDI is broadly comparable to values previously published (Williams et al., 2007; Kile et al., 2007; Mondal and Polya, 2008; Polya et al., 2010a) for other seriously arsenic impacted areas and this is reflected in elevated concentrations of arsenic in hair, nails and urine. Hair arsenic (range 0.03 mg/kg to 14.8 mg/kg; median 0.33 mg/kg) exhibited a significant positive correlation with CDI suggesting that water and rice were collectively the dominant routes of exposure. Water was the dominant route of exposure for 90 % of the volunteers. As in nails (0.53 mg/kg to 64 mg/kg) with a median 0.94 mg/kg and urine (-217- 441µg As/g creatinine) with a median value of 74 µg As/g creatinine.

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References: **Ahmad, T**., et al 2004. Arsenic an emerging issue: Experiences from Pakistan. 30th WEDC International Conference. http://wedc.lboro.ac.uk/conferences/pdfs/30/Ahmad.pdf ; Arain, M.B., et al. 2009. Food and Chemical Toxicology, 47(1), 242-248.; **Farooqi, A**., et al. 2006. Environmental Pollution, 145(3), 839-849. ; **Kahlown, M.A**., et al. 2003. Arsenic Contamination of Groundwater in Southern Punjab PCRWR,-UNICEF Joint Venture. ; **Mondal, D**. and Polya, D.A. 2008. Applied Geochemistry, 23: 2986-2997.; **Nickson, R.T**., et al 2005. Applied Geochemistry, 20 (1), 55-68. ;**PCRWR** 2003, Arsenic Contamination in Groundwater of Southern Punjab. **PCRWR**, Ministry of Science & Technology, Government of Pakistan (Supported by UNICEF).; PCRWR, 2008 PCRWR, Ministry of Science and Technology Government of Pakistan.; **Ravenscroft, P**., et al. . 2009. Arsenic pollution: a global synthesis. Wiley-Blackwell, U.K. ; **Smedley, P.L.** and Kinniburgh, D.G., 2002. Applied Geochemistry, 17, 517-568.; **Smith, A.H.,** et al . 2000. Bull. World Health Org. 78, 1093–1103.; **Smith, A.H**., et al 2006., Environ. Health Perspect. 114, 1293–1296; **Kile, M.L.,** al 2007., Environ. Health Perspect. 115, 889–893. ; **Mondal, D., Polya, D.A.** 2008. Applied Geochemistry 23(11): 2987-2998. ; **Polya, D.A.,** et al . 2010a . Quantification of deaths and DALYs arising from chronic exposure to arsenic in ground waters utilized for drinking, cooking and irrigation of food crops in Preedy, V. and Watson (Eds) Handbook of Disease Burdens and Quality of Life Measures, Springer-Verlag, ISBN: 978-0-387-78665-0 ; **Williams, P.N.,** et al . 2005. Environ Sci. Technol. 39, 5531–5540.

Geogenic Arsenic Attributable Health Risks & Europe

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We present here data from the AquaTRAIN, CALIBRE and PRAMA networks and from recent work from other groups that demonstrate that: (i) the 10 μg/L provisional guideline value for arsenic in drinking water may not be as protective of human health as the guideline values for other chemicals; (ii) rice may be a major exposure route for many individuals; and (iii) chronic exposure to arsenic through drinking water and/or rice may lead to genetic damage in individuals, that are otherwise not obviously externally asymptomatic.

All these findings raise concerns that the deleterious human health impacts of chronic arsenic exposure are not just restricted to areas such as circum-Himalayan Asia, but extend to certain population groups and areas within the European Union (including the United Kingdom) as well. Drinking water and food regulations for arsenic in the European Union are not as demonstrably protective of public health as for those for other chemicals (cf. EFSA (EFSA-Q-2008-425, October 2009) and the FAO/WHO (TRS 958-JECFA 72, March 2010)) and thus reappraisal of these regulations is indicated.

This is a contribution of the EC FP6 funded Aqua TRAIN MRTN (MRTN-CT-2006-035420), the EU Asia-Link CALIBRE Project (KH/AsiaLink/04 142966) and the UKIERI PRAMA (SA07/09) Project. The views expressed here do not necessarily reflect those of any of the funders, which are not liable for any use that may be made of the information contained herein. We acknowledge the prior publication of some of these ideas in Polya et al. (2010) COST Action 637, Kristianstad, Sweden, October, 2010

A4. Scan Copy of Ethical Approval from University of Peshawar for carrying out research with Human derived samples transported and analysed in Manchester University UK, from Allama Iqbal Town, Lahore Pakistan**.**

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April 30, 2009

Ethical Committee on Human Subjects

Chairman
Dr. M. Tahir Shah
Professor
Fulbright & commonwealth fellow

Members
Dr. Nimat Ullah
Professor

Dr. Tazeem Khan
Associate Professor

Dr. Samina Siddiqui
Assistant Professor

The Ethical Approval Committee (EAC) of the National Centre of Excellence in Geology, University of Peshawar has reviewed the application of Miss Seema Anjum Khattak submitted to the "Ethical Committee on Human Subjects" related to Arsenic Exposure and Risk Assessment in Pakistan for the degree of Doctor of Philosophy (PhD) in the school of earth, atmospheric and environmental science, University of Manchester, UK.

The committee is pleased to approve the proposal as per conditions outlined in the Application for ethical approval of the above mention study involving human subjects.

The approval is valid for the duration of 4 years.

Sincerely,

Prof. Dr. M. Tahir Shah
Chainman

A5. Copy of Informed Consent form used during Field Survey for volunteers of Allama Iqbal town Lahore, Punjab Pakistan (English as well as Urdu).

UNIVERSITY OF MANCHESTER VOLUNTEER INFORMED-CONSENT FORM

Project: Arsenic Exposure assessment from ground water and rice in Pakistan

Researchers: Seema Anjum Khattak and Dr David A. Polya, School of Earth, Atmospheric and Environmental Science, University of Manchester, Oxford Road, Manchester, M13 9PL, UNITED KINGDOM. Telephone +44 161 275 5668 / 3818

Fax: +44 161 275 3947; E-mail: seema.khattak@postgrade.man.ac.uk / dave.polya@man.ac.uk

RESEARCHERS' STATEMENT:

SUMMARY OF PURPOSE & NATURE OF STUDY

We are asking you to be involved in a research study. In terms of your direct involvement, this will involve you providing us with some nail and hair samples and answering a series of questions. The overall aim of our study is determine to what extent arsenic from ground waters, used as drinking, cooking/or irrigations waters, and other food material which you eat make their way into people's bodies. Some of these trace elements are beneficial to us; some are not. We hope this study will inform policy makers when they make decisions regarding recommendations for the nature and extent of usage of Ground water for example tube wells, hand pumps, dug wells etc in Pakistan.

PURPOSE OF THIS INFORMED CONSENT FORM

The purpose of this informed consent form is to give you the information you will need to help you decide whether or not to take part in this study. Please read this form or have it read to you. Please ask questions about what we will ask you to do, the risks, the benefits, your rights as a volunteer, or anything else about the research or this form that is not clear. When all of your questions have been answered, you can decide if you want to be involved in this study or not. This process is called "informed consent." We will give you a copy of this form for your records.

PROCEDURES

If, and only if, you consent to take part in this study, we will take nail and/or hair samples. If you agree, we would also like to keep samples of your nail and/or hair. The samples will be kept at the University of Manchester, although we may transport them to other specialist research facilities, mostly in the United Kingdom. The nail and/or hair samples will be kept until they are used up or destroyed. The samples will be used only for research.

We also want to ask you a series of questions, mostly related to your diet – what kind of food and water you use. People of different ages, genders, and with different lifestyles take in trace elements to different extents, so we will also be asking you questions about these things to help with our research study.

RISKS

There are no significant risks to you over and above the risks you would normally encounter cutting your nails or hair.

BENEFITS

The research that is done with your samples will probably not help you directly, however, it might aid decision-making processes by local government agencies and non-governmental organisations in the future.

CONFIDENTIALITY

We will label your samples and the information about you with a number, not your name. We will not keep any record that would link the number with any information that could identify you. Your name will not be used in any published reports about this study.

FEEDBACK

Because we will not be able to link the test results with your name, we will not be able to give you any test results or feedback. We do aim, however, to publish our more general findings and to pass these on to national, regional and other organisations concerned with health and development in Pakistan. Unfortunately, our limited resources do not permit us to thoroughly test the quality of your water.

QUESTIONS

If you have questions about this research or about this study, please contact one of the people listed on this form:

STATEMENT OF PERSON OBTAINING CONSENT

I agree to handle nails and/or hair and information from this volunteer in accordance with the standard operating procedure "Handling of Materials and Information from Volunteers: Trace element accumulation from ground waters in Pakistan" and thereby ensure in as far as it is practicable for me to do so to ensure the confidentiality of any information pertaining to this volunteer.

Signature	Date
Printed name	Date

VOLUNTEER'S STATEMENT

I have read or have had read to me the statement from The University of Manchester regarding their research study into "Trace element accumulation from ground waters in Pakistan**".**

I agree to allow the University of Manchester researchers to collect and store samples of my nails and/or hair to keep a completed questionnaire about me for future research about trace element intake from ground waters in Pakistan.

Your signature	Date
Your printed name	Date

Urdu translated Consent form

مانچسٹر یونیورسٹی کا رضاکارانہ طور پر حصہ لینے والوں کیلئے معلوماتی اور آمادگی کا فارم

پروجیکٹ کا نام :-

" پاکستان میں زیرزمین پانی میں آرسینک کی موجودگی کے متعلق تخمینہ اور اس کے لوگوں میں استعمال کی وجہ سے رونما ہونے والے اثرات کا اندازہ لگانا"۔

تحقیق کرنے والوں کے نام اور پتہ :-

نام :- سیما انجم خٹک ، ڈاکٹر ڈیوڈ پولیا۔

پتہ :- سکول آف ارتھ، ایٹماسفرک اینڈ اینوائرنمنٹل سائنس، مانچسٹر یونیورسٹی
آکسفورڈ روڈ، مانچسٹر (13-ایم ۔ 9پی ایل) یونائیٹڈ کنگڈم

ٹیلیفون نمبر +44 161 275 5668/3818

ای میل :- (1) seema.khattak@postgrad.man.ac.uk
(2) dave.polya@man.ac.uk

تحقیق کرنے والے کا بیان :-

ہم آپ سے اس ریسرچ سٹڈی میں حصہ لینے کی درخواست کرتے ہیں۔ آپکی باقاعدہ شرکت کیلئے آپ کو اپنے بالوں اور ناخنوں کا کچھ حصہ عطیہ کرنا ہوگا۔ اور ہمارے سوالنامے کو پُر کرنا ہوگا۔ اس تحقیق کا مقصد یہ ہے کہ اس بات کا اندازہ لگایا جائے کہ زیرزمین پانی میں موجود آرسینک کیسے ہمارے جسم میں پانی پینے، کھانا پکانے، فصلوں کی اسی پانی سے آبیاری کرنے اور اسی پانی میں اُگنے والی خوراک کی دوسری چیزوں کے ذریعے سرایت کرجاتی ہیں۔ انہی قلیل مقدار میں موجود عناصر میں کچھ تو ہمارے لئے مفید ہیں لیکن کچھ مفید نہیں ہیں۔

ہم یہ اُمید رکھتے ہیں کہ یہ تحقیق مستقبل میں پاکستان کے حکومتی اہلکاروں اور پالیسی بنانے والوں کو زیرزمین پانی کے ذرائع جیسے ٹیوب ویل، کنوئیں اور ہینڈ پمپس کے پانی کی نوعیت اور استعمال سے متعلق مفید معلومات بہم پہنچائے گی۔

1

معلوماتی رضامندی کے فارم کا مقصد:-

اس فارم کا مقصد یہ ہے کہ آپ کو اس تحقیق کے متعلق بنیادی معلومات بہم پہنچائی جائے تاکہ آپ کو اس سروے میں حصہ لینے یا نہ لینے کے فیصلے میں مدد مل جائے۔
مہربانی کرکے اس کو خود پڑھیے یا کسی کی مدد سے پڑھیے۔ آپ کو اگر مزید معلومات درکار ہوں تو ہم سے ضرور پوچھئے گا۔ ہم آپ سے کیا کروانا چاہتے ہیں؟
اس کے علاوہ اس سٹڈی میں حصہ لینے کے فائدے اور نقصان کے متعلق پوچھنا بھی آپکا حق ہے۔

جب آپ کو اپنے سارے سوالات کے جوابات مل جائیں گے تو پھر آپ کو اس سٹڈی میں شرکت کا فیصلہ بھی آسان ہو جائے گا۔

اس پورے طریقہ کار کو معلوماتی رضامندی کہتے ہیں۔

طریقہ عمل:-

آپکی رضامندی کے بعد ہم آپکے ناخنوں اور بالوں کا نمونہ آپ کی اجازت سے لیں گے اور اسکو مانچسٹر یونیورسٹی میں استعمال کیلئے محفوظ کریں گے۔ اس نمونے کو بہتر تحقیقی سہولیات کے پیچھے برطانیہ میں کسی اور جگہ بھی منتقل کیا جا سکتا ہے۔ ناخنوں اور بالوں کا یہ نمونہ استعمال کے وقت تک محفوظ رکھا جائے گا اور بعد میں ضائع کیا جا سکتا ہے۔ یاد رہے کہ یہ نمونے صرف اور صرف تحقیقی مقاصد کیلئے ہی استعمال ہونگے۔

ہم آپ سے آپکی غذا اور غذائی عادات و اطوار سے متعلق سوالات بھی کرینگے۔ مختلف عمروں، جنس اور طرز زندگی کے افراد مختلف حد تک یہ قلیل مقدار میں پائے جانے والے عناصر جیسے آرسینک یا سنکیا جذب رکھنے کی صلاحیت رکھتے ہیں۔ ہم آپ سے اس کے بارے میں بھی سوالات کریں گے کیونکہ یہ ہماری تحقیق میں مفید ثابت ہونگے۔

لاحق خطرہ یا نقصان:-

آپ کو اس سٹڈی میں شرکت کے دوران اس سے کوئی خطرہ درپیش نہیں ہوگا۔ صرف وہی جو کہ عام طور پر آپ کو روز مرہ زندگی میں ناخن یا بال کاٹنے کے دوران ہوتا ہے۔

فائدہ :-

آپ کے دیئے گئے ناخن اور بالوں کے عطیہ سے جو تحقیق ہم کریں گے اُس سے اگرچہ آپ کو کوئی براہ راست فائدہ تو نہیں ہوگا لیکن یہ تحقیق مستقبل میں ہونے والے مقامی حکومت یا غیر سرکاری اداروں کی فیصلہ سازی میں ممد و معاون ثابت ہوگا۔

رازداری :-

آپ سے لیئے ہوئے نمونوں اور معلومات کو رازدارانہ رکھا جائے گا۔ اور اسکو ہم آپ کے نام یا متعلقہ معلومات کی بجائے اعداد سے ظاہر کریں گے۔ ہم ایسی کوئی بھی معلومات اپنے پاس نہیں رکھیں گے جس کی مدد سے آپ تک رسائی ہو یا جس سے آپکی شناخت ہو سکے۔

اس تحقیق سے متعلقہ کسی بھی شائع کی گئی دستاویز میں بھی آپکا نام شامل نہیں کیا جائے گا۔

تحقیق کے نتائج :-

چونکہ ہمارے پاس آپکی ذاتی معلومات نہیں ہونگی اسلئے ہم آپکو نمونوں کے نتائج سے خبردار نہیں کر سکتے۔ اگرچہ ہمارا مقصد ہے کہ ہم ان نتائج کے بارے میں عام معلومات قومی، علاقائی اور مختلف سطح پر پاکستان میں صحت و ترقی کیلئے کام کرنے والی تنظیموں کو بتانا پسند کریں گے۔ تاکہ سب لوگوں کو فائدہ ملے۔ لیکن بدقسمتی سے اپنے محدود وسائل کی وجہ سے ہم آپ کے پانی کی مکمل نوعیت کا اندازہ نہیں لگا سکتے۔

سوالات :-

اگر آپ کو اس تحقیق کے بارے میں کچھ بھی پوچھنا ہو تو فارم میں موجود حضرات کے پتے پر رابطہ کریں۔

رضامندی لینے والے کا بیان :-

میں اس بات سے متفق ہوں کہ اس رضاکار سے لئے گئے بال اور ناخنوں کے نمونے اور متعلقہ معلومات کو پہلے سے معین طریقہ کار کے مطابق طے کرونگا اور اپنی ممکن حد تک رازداری اختیار کرونگا۔

دستخط تاریخ

نام تاریخ

رضاکار کا بیان :-

میں نے خود یا کسی دوسرے کی مدد سے مانچسٹر یونیورسٹی کا پاکستان میں پائی جانے والی آرسینک جوکہ پینے کے پانی میں پائی جاتی ہے سے متعلق بیان پڑھ لیا ہے۔

میں اس بات سے متفق ہوں کے مانچسٹر یونیورسٹی کے ریسرچرز میرے ناخن اور بال کے نمونے کاٹ کر اپنے ساتھ محفوظ کر سکتے ہیں۔ اور اس سے متعلق سوال نامے میں پاکستان کے زیرزمین پانی میں آرسینک یا قلیل مقدار میں موجود عناصر پر تحقیق کی خاطر میرے دیئے گئے معلومات محفوظ رکھ سکتے ہیں۔

دستخط تاریخ

نام تاریخ

4

A6. Copy of Questionnaire used for information collection during Field Survey for volunteers of Allama Iqbal town Lahore, Punjab Pakistan (English and Urdu translated).

Arsenic exposure assessment from Ground water in Pakistan

Questionnaire[1]

Interviewers should be respectful of participants at all times, keeping in mind local cultural issues when posing the questions. People being interviewed are not obliged to answer any questions and the interviewer should warn the participant of any sensitive questions prior to asking them. This questionnaire should only be used for people who have understood and signed an informed consent form.

Sl. No. (serial number)	
Date of interview	
Commune	
Village	

Q no.	**Question**	**Data entry**
1	Respondent's sex	
2	Age	
5	What is your weight?	
6	What is your height?	
7	Relationship to head of household	
8	Marital status (e.g. unmarried, married, widow/widower, separated, divorced)	

9	Occupation (e.g farmer, business, govt. service, private service, unemployed, housewife, student, pre school children	
10.1	If farmer, do you use pesticides	
10.2	If so, what pesticides used?	
10.3	If use pesticides, how much?	
10.4	If use pesticides, when	

Q no.	**Question**	**Data entry**
11	Time resident in home	
12	Time spent in home throughout year	
13.1	Total number of household member(s)	
13.2	What is the highest education of the household? (e.g. no formal education, (Primary, Secondary, Higher)	
13.3	What is the total monthly household income?	
14.1	What is the main source of your drinking water during wet season? (e.g. river, rain, tube well)	
14.2	For how long have you been using this source	
14.3	What is the main source of your drinking water during dry season?	
14.4	For how long have you been using this source	
15.1	What is the main source of your household's cooking water during wet season?	
15.2	For how long have you been using this source	
15.3	What is the main source of your household's cooking water during dry season?	
15.4	For how long have you been using this source	
16	In which year was the tube well was installed?	
17	What is the depth of the tube well?	

18	Type of ownership of the tube well? (e.g. own private tube well, neighbour's private tube well, community)	
19.1	Has the tube well been tested for arsenic?	
19.2	If yes, has it been cleared as safe to drink?	
20.1	What do you usually drink? (e.g. water, fruit juices, coconut water, carbonated drinks, tea)	
20.2	What amount do you usually drink daily?	
21	What amount of water do you require for daily household's drinking water?	
22.1	What amount of water do you require for daily household's cooking purpose?	
22.2	Who does the cooking?	
22.3	Where is cooking done? (e.g. open air, outside)	
23.1.1	What do you eat in breakfast and how much? grams/day	
23.1.2	What do you usually eat in lunch and how much? For example rice, curry, dall, roti, vegetable, meat , etc	
23.1.3	What do you usually eat in dinner and how much? For example rice, curry, dall, roti, vegetable, meat , etc	
23.2.	Which type of rice do you cook mostly?	
23.3	What is the main source of protein for the household? Chicken, meat, fish, eggs, dal etc	
23.4	How many times per weak you cook rice?	
23.5	How many times per weak you cook roti and curry/ Salen?	
23.6	What vegetables do you eat frequently? and how much?	
23.7	What fruits do you eat frequently? and how much?	
23.8	Where do you get your vegetables and fruit from?	
23.9	Where do you get your cereals from? like rice, wheat and barley etc. (Market or cultivated by yourself)	
23.10	What dairy product do you eat daily/ frequently?	

23.11	Where do you get your dairy product from- Own cattle's or market?	
24.1.1	What is the main source of water for bathing during wet season?	
24.1.2	For how long have you been using this source?	
24.1.3	What is the main source of water for bathing during dry season?	
24.1.4	For how long have you been using this source	
24.2.1	What is the main source of water for domestic washing (utensils & clothes washing) during wet season?	
24.2.2	For how long have you been using this source?	
24.2.3	What is the main source of water for domestic washing (utensils & clothes washing) during dry season?	
24.2.4	For how long have you been using this source?	
24.3.1	What is the main source of water for toilet purpose during wet season?	
24.3.2	For how long have you been using this source?	
24.3.3	What is the main source of water for toilet purpose during dry season?	
24.3.4	For how long have you been using this source?	
24.4.1	What is the main source of water for house cleaning purpose during wet season?	
24.4.2	For how long have you been using this source?	
24.4.3	What is the main source of water for house cleaning purpose during dry season?	
24.4.4	For how long have you been using this source?	
24.5.1	What is the main source of water for cattle feeding purpose during wet season?	
24.5.2	For how long have you been using this source?	
24.5.3	What is the main source of water for cattle feeding purpose during dry season?	

24.5.4	For how long have you been using this source?	
24.6.1	What is the main source of water for agriculture purpose during wet season?	
24.6.2	For how long have you been using this source?	
24.6.3	What is the main source of water for agriculture purpose during dry season?	
24.6.4	For how long have you been using this source?	

Q no.	**Question**	**Data entry**
24.1	Do you have any illnesses?	
24.2	Are you receiving treatment/medication	
25.1.1	Do any of the household members have black or black & white spots on his/her trunk of the body or extremities?	
25.1.2	If yes, how many of the household members have this type of skin lesions?	
25.2.1	Do any of the household members have roughness with or without nodules on both the palms and soles?	
25.2.2	If yes, how many of the household members have this type of roughness?	
25.3	Do you have melanosis (dark spots on skin)?	
25.4	Leucomelanosis (white spots on skin)	
25.5.1	Keratosis (hardening of skin) without nodules	
25.5.2	Keratosis with nodules	
25.6	Colour of the feet? (e.g. black or normal)	

Before asking the next set of questions, tell the interviewee in a sensitive way what the questions are about and explain that they don't have to be asked these questions if it might upset them.

Q no.	Question	Data entry
27.1	What is your current smoking status? (e.g. current smoker, ex-smoker, never smoked)	
27.2	If smoker, what do you smoke? (e.g. roll-ups (no filter, manufactured)	
27.3	If smoker, how many per day?	
28.1	What is your current alcohol drinking status? (e.g. current drinker, ex-drinker, never drunk)	
28.2	If drinker, what alcohol do you usually drink?	
28.3	How much alcohol do you usually drink per week?	
29.1	Pulse/minute	
29.2	Has redness of eye?	
29.3	Systolic pressure in mm of Hg	
29.4	Diastolic pressure in mm of Hg	
29.5	What is the tube well code number?	

At the end of the interview ask the interviewees if they have any questions that they would like answered and thank them for their participation in this survey.

[1] This questionnaire is modified from that described in Abul Hasnat Milton's report on "Baseline Survey and Clinical Examination of Arsenicosis among Exposed Population in Kandal Province, Cambodia" to the Cambodian Ministry of Health.

Questionaire in Urdu (translated from the English one)

پاکستان میں زیر زمین پانی میں موجود آرسینک سے درپیش نقصان کا اندازہ

سوال نامہ

نمبر شمار :-
انٹرویو کی تاریخ :-
گلی / محلہ :-
گاؤں :-
عرض بلد و طول بلد :-

نجی معلومات کا خانہ :-

نمبر شمار	سوال
نمبر 1	شرکت کنندہ کی جنس
نمبر 2	عمر
نمبر 3	مذہب
نمبر 4	آپ کا وزن کتنا ہے ؟
نمبر 5	آپ کے قد کی لمبائی کیا ہے ؟

نمبر 6 خاندان کے سربراہ کے ساتھ رشتہ کیا ہے ؟

نمبر 7 گھر کس قسم کا ہے ؟ کچا ۔ پکا ۔ یا دونوں

نمبر 8 ازدواجی حیثیت کیا ہے ؟
شادی شدہ ، غیر شادی شدہ ، بیوہ ، رنڈوا ، طلاق یافتہ

نمبر 9 آپ کا پیشہ کیا ہے ؟
کسان ، مزدور ، سرکاری نوکر ، بے روزگار ، گھریلو خاتون ، طالب علم ، سکول کی عمر سے پہلے

نمبر 10.1 اگر آپ کسان ہیں تو کیا آپ کیمیائی ادویات استعمال کرتے ہیں ؟

نمبر 10.2 اگر کرتے ہیں تو کونسی ؟

نمبر 10.3 کتنی مقدار میں اور کب استعمال کرتے ہیں ؟

1

ع ب 11 اس گھر میں کب سے مقیم ہیں؟

ع ب 12 سال بھر میں کتنا عرصہ گھر میں گزارتے ہیں؟

ع ب 13.1 گھر کے افراد خانہ کی تعداد ؟

ع ب 13.2 گھر کے افراد میں سب سے زیادہ تعلیمی حیثیت کونسی ہے؟

پرائمری   سیکنڈری / مڈل   اعلیٰ تعلیم یافتہ

ع ب 13.3 گھر بھر کی کل ماہانہ آمدنی کتنی ہے؟

ع ب 14.1 گھر کے پانی کا اہم ذریعہ کیا ہے؟ خشک اور تر دونوں موسم کا بتادیں؟

بارش کا پانی . دریا . ٹیوب ویل . کنواں

ع ب 14.2 کتنے عرصے سے آپ یہ استعمال کر رہے ہیں.

ع ب 14.3 گھر کے پانی کے استعمال کے علاوہ اور کونسا پانی آپ پیتے ہیں مثلاً. سکول/کالج یا کام کی جگہ پر؟

ع ب 14.4 اگر ہے تو کتنے عرصے سے آپ یہ استعمال کر رہے ہیں؟

ع ب 15.1 کیا آپ کھانا پکانے کیلئے کوئی دوسرا پانی کا ذریعہ استعمال کرتے ہیں؟

ع ب 15.2 اگر کرتے ہیں تو یہ کتنے عرصے سے زیر استعمال ہے؟

ع ب 16 آپکا ٹیوب ویل / موٹر / کنواں کب لگایا گیا؟ سنہ

ع ب 17 آپ کے زیر استعمال ٹیوب ویل یا کنویں کی گہرائی کتنے میٹر / گز / فٹ ہے؟

ع ب 18 ٹیوب ویل یا کنواں یا ہینڈ پمپ کس کی ملکیت ہے؟

سرکاری . ہمسائے کا یا کمیونٹی کا . پرائیویٹ

2

س 19.1 کیا آپ کے ٹیوب ویل / کنوئیں کو آرسینک یا سنکھیا کیلئے ٹیسٹ کیا گیا ہے؟

س 19.2 اگر یہ ٹیسٹ ہوا ہے تو کیا یہ پانی پینے کے قابل قرار دیا گیا ہے؟

س 20.1 آپ پانی کے علاوہ اور کونسی ڈرنکس زیادہ استعمال کرتے ہیں مثلاً لسی، چائے، دودھ، شربت یا جوس وغیرہ؟

س 20.2 یہ ڈرنکس آپ روزانہ کتنی مقدار میں پی لیتے ہیں؟ کتنے کپ یا گلاس۔

س 20.3 دن بھر میں آپ کتنے گلاس پانی پی لیتے ہیں؟

س 21 گھر بھر میں پینے کا پانی روزانہ کتنی مقدار میں درکار ہوتا ہے؟

س 22.1 آپکے گھر میں روزانہ اندازاً کتنا پانی کھانا پکانے کیلئے استعمال ہوتا ہے؟

س 22.2 گھر کا کھانا وغیرہ کہاں پر پکایا جاتا ہے۔ مثلاً باورچی خانے یا کمرے میں یا کھلے صحن میں؟

س 23.1 آپکے گھر میں صبح کے ناشتے میں عموماً کیا کھایا جاتا ہے؟

س 23.2 گھر بھر کا کھانا عموماً کون پکاتا ہے؟

س 23.3 آپ اندازاً کتنی مقدار میں ناشتہ کھاتے ہیں؟ (gm/day) گرام میں

س 23.4 دوپہر کے کھانے میں عموماً کیا بنتا ہے اور کتنی مقدار میں کھاتے ہیں؟ گرام میں

س 23.5 رات کے کھانے میں عموماً کیا پکایا جاتا ہے مثلاً۔ روٹی، چاول، دال، سبزی، یا گوشت وغیرہ

س 23.6 رات کا کھانا کتنی مقدار میں کھاتے ہیں؟ گرام میں۔

س 23.7 کونسی قسم کے چاول گھر میں زیادہ پکتے ہیں؟

س 23.8 آپ کے چاول کہاں سے آتے ہیں مثلاً۔ اپنی کھیتوں سے یا بازار سے خریدے جاتے ہیں؟

س 23.9 دوسری اجناس جیسے گندم، مکئی، جو اور دالیں کہاں سے لیتے ہیں؟

3

ع 23.10 اہل خانہ کے لیے پروٹین کا اہم ذریعہ کونسا ہے؟ مثلاً گوشت، مرغی، انڈے
مچھلی یا دالیں وغیرہ؟

ع 23.11 ہفتے میں کتنی دفعہ چاول پکتے ہیں؟ آپ کتنی مقدار میں کھاتے ہیں؟

ع 23.12 ہفتے میں کتنی دفعہ روٹی اور سالن پکتا ہے اور آپ کتنی مقدار میں کھاتے ہیں؟

ع 23.14 کونسی سبزی زیادہ رغبت سے کھائی جاتی ہے اور کتنی مقدار میں؟

ع 23.15 کونسا فروٹ / پھل زیادہ رغبت سے کھایا جاتا ہے اور کتنی مقدار میں؟

ع 23.16 آپ اپنی سبزی اور پھل وغیرہ کہاں سے لاتے ہیں؟ خریدتے ہیں یا اُگاتے ہیں۔

ع 23.17 گھر بھر میں دودھ اور دودھ سے بنی ہوئی کونسی اشیاء زیادہ استعمال ہوتی ہیں؟

ع 23.18 دودھ یا اس سے بنی ہوئی اشیاء کہاں سے آتی ہیں! اپنے مال مویشی سے یا بازار سے؟

ع 24.1.1 تر/بھیگے موسم میں نہانے کا پانی کہاں سے استعمال ہوتا ہے؟

ع 24.1.2 یہ آپ کب سے استعمال کر رہے ہیں؟

ع 24.1.3 خشک موسم میں نہانے کا پانی کہاں سے آتا ہے؟

ع 24.1.4 اور یہ آپ کتنے عرصے سے استعمال کر رہے ہیں؟

ع 24.2.1 تر موسم میں گھریلو چیزوں کو / کپڑے، برتن وغیرہ کو دھونے کیلئے پانی کہاں سے لے کر
استعمال ہوتا ہے؟

ع 24.2.2 اور یہ آپ کب سے استعمال کر رہے ہیں؟

ع 24.2.3 خشک موسم میں اپنی چیزوں کی دھلائی کیلئے کونسا پانی استعمال ہوتا ہے؟

ع 24.2.4 اور یہ آپ کتنے عرصے سے استعمال کر رہے ہیں؟

ع 24.3.1 خشک موسم میں ٹوائلٹ کیلئے کونسا پانی استعمال ہوتا ہے؟

ع 24.3.2 یہ کتنے عرصے سے زیر استعمال ہے؟

4

س 24.3.3 تر موسم میں ٹوائلٹ کیلئے کونسا پانی استعمال ہوتا ہے؟

س 24.3.4 یہ آپ کتنے عرصے سے استعمال کر رہے ہیں؟

س 24.4.1 گھر کی صفائی ستھرائی کیلئے کونسا پانی زیر استعمال ہے؟

س 24.4.2 آپ یہ پانی کتنے عرصے سے استعمال کر رہے ہیں؟

س 24.4.3 آپ اپنے مویشیوں کو خشک موسم میں کونسا پانی پلاتے ہیں؟

س 24.4.4 آپ یہ پانی کتنے عرصے سے ان کو پلا رہے ہیں؟

س 24.5.1 عام حالات میں آپ اپنے مویشیوں کو کونسا پانی پلاتے ہیں؟

س 24.5.2 آپ یہ پانی کتنے عرصے سے اپنے مال مویشی کو پلا رہے ہیں؟

س 24.6.1 تر موسم میں کھیتوں کی آبپاشی کس پانی سے کرتے ہیں؟ نہر ۔ ٹیوب ویل ۔ وغیرہ

س 24.6.2 یہ پانی کب سے آپ استعمال کر رہے ہیں؟

س 24.6.3 خشک موسم میں آپ اپنے کھیتوں کی آبپاشی کس پانی سے کرتے ہیں؟

س 24.6.4 یہ پانی آپ کب سے آبپاشی کیلئے استعمال کر رہے ہیں؟

س 25.1 کیا آپ کسی بیماری میں مبتلا ہیں؟

س 25.2 اگر ہیں تو کیا آپ اس کا علاج کر رہے ہیں؟

س 25.3 کیا گھر میں کسی فرد کو یا افراد کے جسم اور بازوں، ٹانگوں پر کالے | کالے اور سفید دھبے موجود ہیں؟

س 25.4 اگر ہیں تو کل کتنے افراد کے جسم پر یہ موجود ہیں؟

س 25.5 کیا اہل خانہ میں کسی کے ہاتھ اور پاؤں کے تلوؤں میں صرف کھردرا پن یا کھردرا پن اور سخت گھٹیاں پایا جاتا ہے؟

س 25.6 اگر ہیں تو کتنے لوگوں کو یہ لاحق ہے؟

س 26.1 کیا آپ کے جسم پر کالے دھبے ہیں؟

س 26.2 کیا آپ کے جسم پر سفید دھبے ہیں؟

س 26.3 کیا آپ کے ہاتھ اور پاؤں کی چمڑی سخت ہے اور گٹھیاں نہیں ہیں؟

س 26.4 کیا آپ کے ہاتھ اور پاؤں کی چمڑی سخت بھی ہے اور گٹھیاں بھی ہیں؟

س 26.5 آپ کے پاؤں کا رنگ کیسا ہے؟ کالا سیاہ یا نارمل

سوالات کا اگلا مرحلہ شروع کرنے سے پہلے رضاکار کو مطلع کیا جائے کہ ان سوالوں کی نوعیت کیا ہے اور اگر وہ ان کا جواب دینے کیلئے کسی بھی وجہ سے تیار نہیں ہیں تو اُن کی سہولت کیلئے ان سے یہ سوالات نہ کیے جائیں۔

س 27.1 کیا آپ سگریٹ نوشی کرتے ہیں؟ پہلے کرتے تھے یا بالکل نہیں کرتے؟

س 27.2 اگر کرتے ہیں تو کیا پیتے ہیں۔ سگریٹ یا بیڑی

س 27.3 دن بھر میں کتنے پی لیتے ہیں؟ تعداد بتائیں؟

س 28.1 کیا آپ شراب نوشی کرتے ہیں؟ پہلے کرتے تھے یا کبھی نہیں کی؟

س 28.2 اگر کرتے ہیں تو عام طور پر کونسی والی پیتے ہیں؟

س 28.3 ہفتے بھر میں اندازاً کتنے گلاس پی لیتے ہیں؟

س 29.1 آپ کے نبض کی رفتار کتنی ہے منٹ کے حساب سے؟

س 29.2 کیا آنکھیں سرخ ہیں؟

س 29.3 آپکا اوپر اور نیچے کا بلڈ پریشر کتنا ہے؟

س 29.4 ٹیوب ویل جو آپکے زیر استعمال ہے کا کوڈ نمبر کیا ہے؟

6

سوال نامے کے اختتام پر رضا کار سے پوچھیئے کہ اگر وہ کسی سوال کا جواب
جاننا چاہتے ہیں تو پوچھ سکتے ہیں اور آخر میں اُن کی تعاون کا شکریہ ادا کریں۔

7

A7. CoSHH Risk Assessment forms for Experimental work done in Williamson Research Centre University of Manchester UK.

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK001

Nature of experiment or procedure

TITLE	Acid washing of equipments
LOCATION	Chemistry lab (1.18)
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	Dilution of concentrated Nitric acid to 5% (v/v) with deionised water. The 5% acid solution is used to soak equipments in a plastic bucket in a fume cupboard overnight. After soaking, the equipments are washed with deionised water. In order to make sure the cleaning process they are rinsed three times. All the equipments are dried before use.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Concentrated HNO_3 (69%)	SM	<0.5 liters inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard.
5% (v/v) HNO_3	FP	app 15 liters inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard/well ventilated area.

* Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK001

Overall risk assessment	Medium
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	n/a
Is Category 1 or Category CARCINOGENS being used or generated?	
If category 1 or category 2 CARCINOGENS are being used or generated, then has safe alternatives been considered? Justify your selection.	
Control/Safety	Safety spectacles, gloves, lab coat, fume cupboard
Method of disposal	To fume cupboard sink with copious dilution using mains water.
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2*

NAME	**Seema Anjum Khattak**	**FORM #:**	**SAK002**

Nature of experiment or procedure

TITLE	Cleaning, grinding & digestion of rice samples
LOCATION	Chem lab (1.18)
FREQUENC Y	As required (<12 days per month)
DETAILS OF PROCEDURE	Rice samples arewashed with deionised water and then dried at 65°C for 48 hours.rice samples are then grounded and 0.1-0.2 grams of this grounded material are weighed accurately in a quartz glass digestion tubes 2 ml of concentrated nitric acid is added and the tubes are capped with clean stoppers and left to digest for overnight at room temperature. The sample are digested at 120 °C, until clear solution and then evaporated to dryness at 140°C . The residue is suspended in 1.2% HNO_3 to a weight of 10 grams.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Concentrated HNO_3 (69%)	SM	50 x 1 ml = 50 ml, inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard.
10% (v/v) HNO_3	FP	50 x 10 ml = 500 ml, inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard/well ventilated area.

* Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP

NAME	Seema Anjum Khattak	FORM #:	SAK002

OVERALL RISK ASSESSMENT	Medium
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	n/a
Is Category 1 or Category CARCINOGENS being used or generated?	
If category 1 or category 2 CARCINOGENS are being used or generated, then has safe alternatives been considered? Justify your selection.	
Control/Safety	Safety spectacles, gloves, lab coat, fume cupboard
Method of disposal	To fume cupboard sink with copious dilution using mains water.
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire					
in case of water failure					
in case of electricity failure					
emergency contact name(s)					
emergency phone number(s)					
ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK003

Nature of experiment or procedure

TITLE	Cleaning of nail samples in 1% Triton-X100
LOCATION	Clean room
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	Visible dirt is removed from the nail samples using a nylon wire brush and deionised water. Then the samples are placed in clean glass beakers, submerged in 25 ml of 1% Triton-X100 (prepared by dilution 10 ml of Triton-X100 with 990 ml of 18.5 MΩ deionised water) and sonicated for 20 minutes. The wash solution is discarded and the nails are rinsed at least 3 times with 18.5 M deionised water before being dried at 60 °C.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Triton X-100	SM	10 ml, skin contact, splashes	Severe eye irritant; harmful if swallowed; possibly harmful if inhaled or in contact with skin	Eye protection to be worn along with lab coat and gloves.
1% Triton X-100	FP	1000 ml, skin contact, splashes	As above, but probably less severe	Eye protection to be worn along with lab coat and gloves.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK003

OVERALL RISK ASSESSMENT	Low
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	NA
Is Category 1 or Category CARCINOGENS being used or generated?	NA
If category 1 or category 2 CARCINOGENS are being used or generated then has safe alternatives been considered? Justify your selection.	NA
Control/Safety	Safety spectacles, gloves, lab coat
Method of disposal	To sink with copious dilution using tap water
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & **COSHH SUPERVISOR**	Dave Polya	Signature:		Date:	

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of

NAME	**Seema Anjum Khattak**	**FORM #:**	**SAK004**

Nature of experiment or procedure

TITLE	Cleaning of hair samples
LOCATION	Clean room
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	Hair samples are taken in a clean glass beaker and 25ml of acetone is added to it and then sonicated for 10 minutes. The solution is discarded and 25 ml of 18.5 MΩdeionised water is added and again sonicated for 10 minutes. The wash solution is discarded and the process is repeated two more times with water and then finally with acetone. The samples are then allowed to dry at room temperature overnight.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Acetone	SM/FP	10 x 25 ml = 250 ml, inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin absorption. Irritant. .	Eye protection to be worn along with lab coat and gloves. Used only in a well-ventilated area.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK004

OVERALL RISK ASSESSMENT	Low
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	NA
Are Category 1 or Category CARCINOGENS being used or generated?	NA
If category 1 or category 2 CARCINOGENS are being used or generated then has safe alternatives been considered? Justify your selection.	NA
Control/Safety	Safety spectacles, gloves, lab coat.
Method of disposal	Evaporate acetone at room temperature in a fume cupboard in Chem lab (1.18).
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

Signatures

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & **COSHH SUPERVISOR**	Dave Polya	Signature:		Date:	

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of

NAME	**Seema Anjum Khattak**	**FORM #:**	**SAK005**

Nature of experiment or procedure

TITLE	Digestion of hair and nail samples
LOCATION	Clean room / Chem lab (1.18)
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	Hair/nail samples are accurately weighed into acid cleaned 10 ml polypropylene test tubes. 1 ml of concentrated nitric acid is added and the tubes are capped with clean stoppers and left to digest for 48 hours with intermittent shaking. After 48 hours, 9 ml of deionised water is added and the mixture is well shaken prior to filtration through a 0.45 µm filter into an acid cleaned polystyrene test tube for analysis. All the equipment used is cleaned in 5% HNO_3 or deionised water where appropriate.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Concentrated HNO_3 (69%)	SM	50 x 1 ml = 50 ml, inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard.
10% (v/v) HNO_3	FP	50 x 10 ml = 500 ml, inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard/well ventilated area.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK005

OVERALL RISK ASSESSMENT	Medium
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	n/a
Is Category 1 or Category CARCINOGENS being used or generated?	
If category 1 or category 2 CARCINOGENS are being used or generated, then has safe alternatives been considered? Justify your selection.	
Control/Safety	Safety spectacles, gloves, lab coat, fume cupboard
Method of disposal	To fume cupboard sink with copious dilution using mains water.
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

Signatures

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & **COSHH SUPERVISOR**	Dave Polya	Signature:		Date:	

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK006

Nature of experiment or procedure

TITLE	Handling of Urine samples
LOCATION	Chemistry lab
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	Urine samples were taken out from freezer where it was kept at -20°C & thawed at room temperature. These samples have already been treated for polio virus (warming to 55°C for 30 minutes) before refrigeration. Then these samples are filtered through 0.45 µm filter and diluted. The filtered and diluted samples can be used both for total arsenic in urine and arsenic speciation in urine. The rest of the samples are stored in freezer at -20°C.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Urine	SM/FP	5 x50 ml = 250 ml, inhalation, skin contact, splashes	Harmful by inhalation, splashes or skin absorption. .	Eye protection to be worn along with lab coat and gloves. Used only in a well-ventilated area. In case of skin contact the area should be washed with soap and water. In case of eye contact wash with plenty of water in case of spillage wear disposable gloves and wipe off the area with 1% Virkon solution.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK006

OVERALL RISK ASSESSMENT	Low
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	NA
Are Category 1 or Category CARCINOGENS being used or generated?	No
If category 1 or category 2 CARCINOGENS are being used or generated then has safe alternatives been considered? Justify your selection.	NA
Control/Safety	Safety spectacles, gloves, lab coat
Method of disposal	Urine disposal after adding 1% Virkon solution via toilet and the containers, filters and syringes are first washed with 1 % Virkon solution and then disposed off via the laboratory waste bin.
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

Signatures

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	25-01-2010
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK07

Nature of experiment or procedure

TITLE	**Form for Digestion of rice samples for arsenic speciation study (open digestion)**
LOCATION	Chem lab (1.18)
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	Rice samples are washed with deionised water and then dried at 65°C for 48 hours. These samples are then grounded and 0.25 g of this grounded material is weighed accurately in a quartz glass digestion tubes. 2 ml of 2M Trifluoroacetic acid is added to the tubes and left to predigest for overnight at room temperature. The sample are digested at 100 °C for 6 hours, and then evaporated to dryness at 160°C. The residue is re suspended in deionised water to a weight of 10 grams.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
2M Trifluoroacetic acid	SM	80 x 2 ml = 160 ml, inhalation, skin contact, splashes	Corrosive, cause burns. Extremely destructive to the upper respiratory tract. Harmful by inhalation, ingestion or absorb through skin. Eye contact may cause sever damage.	Safety goggles or a full face shield where splashing is possible. Wear a lab coat, gloves (butyl rubber, PVC or Viton) and Vapour respirator. Used only in a fume cupboard.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK07
OVERALL RISK ASSESSMENT	Medium		

If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	n/a
Is Category 1 or Category CARCINOGENS being used or generated?	n/a
If category 1 or category 2 CARCINOGENS are being used or generated, then has safe alternatives been considered? Justify your selection.	
Control/Safety	Safety spectacles, gloves (PVC/butyl rubber), lab coat, fume cupboard, Vapour respirator dry earth or sand
Method of disposal	To fume cupboard sink with copious dilution using mains water.
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS http://www.sciencelab.com/msds.php?msdsId=9927309
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s) &Phone Numbers	

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester
Form for Digestion of rice samples for arsenic speciation study Page 1 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK08

Nature of experiment or procedure

TITLE	Digestion of rice samples for speciation arsenic (microwave digestion)
LOCATION	Chem lab (1.18)
FREQUENC Y	As required (<12 days per month)
DETAILS OF PROCEDURE	Rice samples are washed with deionised water and then dried at 65°C for 48 hours. These samples are then grounded and 0.50 g of this grounded material is weighed accurately in a polypropylene centrifuge tubes used for digesting samples. 5 ml of 0.28 molar nitric acid solution is added to the tubes and left to predigest for overnight at room temperature. The sample are digested at 95 °C for 30minutes by using a microwave then centrifuged at 4000rpm for 10 minutes. The supernatant was filtered out and then neutralised with NaOH and Hydrogen peroxide solution, stored in the fridge at 4°C for IC-ICP-MS analysis.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
1% Nitric Acid NaOH Hydrogenperoxid e	SM SM SM	55 x 10 ml = 550 ml, inhalation, skin contact, splashes inhalation, skin contact, splashes inhalation, skin contact, splashes	Corrosive, cause burns. Harmful by inhalation, ingestion or absorb through skin. Eye contact may cause sever damage.	Safety goggles or a full face shield where splashing is possible. Wear a lab coat, gloves and Vapour respirator. Used only in a fume cupboard.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK08
OVERALL RISK ASSESSMENT	Medium		
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	n/a		
Is Category 1 or Category CARCINOGENS being used or generated?			
If category 1 or category 2 CARCINOGENS are being used or generated, then has safe alternatives			

been considered? Justify your selection.	
Control/Safety	Safety spectacles, gloves (PVC/butyl rubber), lab coat, fume cupboard, Vapour respirator dry earth or sand
Method of disposal	To fume cupboard sink with copious dilution using mains water.
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS http://www.sciencelab.com/msds.php?msdsId=9927309
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

Signatures

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK09

Nature of experiment or procedure

TITLE	Cleaning, grinding & digestion of rice samples for total As in Microwave
LOCATION	Chemistry lab (1.18)
FREQUENCY	As required (<12 days per month)

DETAILS OF PROCEDURE	Rice samples are washed with deionised water and then dried at 65°C for 48 hours. Rice samples are then grounded and 0.5 grams of this grounded material are weighed and transferred it to in Teflon microwave vessels. Add concentrated nitric acid in fume coup board. The tubes are capped carefully with clean stoppers and arranged in microwave rack evenly. The sample are digested by using already stored method " rice total" 170°C.the whole cycle is 40-45 minutes. Transferred the digested material to 50 ml centrifuged tubes and dilute it up to 50ml with deionised water (18 milliQ).

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Concentrated HNO_3 (69%)	SM	50 x 1 ml = 50 ml, inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard.
10% (v/v) HNO_3	FP	50 x 10 ml = 500 ml, inhalation, skin contact, splashes	Harmful by inhalation, ingestion or skin/eye contact. Corrosive.	Eye protection to be worn along with lab coat and gloves. Used only in a fume cupboard/well ventilated area.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK09

OVERALL RISK ASSESSMENT	Medium
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	n/a
Is Category 1 or Category CARCINOGENS being used or generated?	
If category 1 or category 2 CARCINOGENS are being used or generated, then has safe alternatives been considered? Justify your selection.	
Control/Safety	Safety spectacles, gloves, lab coat, fume cupboard
Method of disposal	To fume cupboard sink with copious dilution using mains water.
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	Oxford university MSDS web resource: http://physchem.ox.ac.uk/MSDS/#MSDS
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

Signatures

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2

NAME	Seema Khattak	FORM #:	SK10

Nature of experiment or procedure

TITLE	Metra Creatinine Assay – an immunoassay for the quantification of Creatinine in urine. Kit used- Metra Creatinine kit (Quidel Corporation)
LOCATION	Clean room
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	The urine samples are mixed well and allowed to settle for 15-20 minutes or centrifuged at 200 rpm for 2 minutes, it will prevents the debris to interfere during pippetting. The urine samples, controls and standards provided in the Metra Creatinine kit are diluted 1:40 with 18.5Ω deionized water. 18Ω demonized water is used as a blank. The required numbers of strips are placed in the strip well frame. The working coloured solution is prepared by adding 1 ml of stop solution (provided) to each required bottle of colour reagent (provided). 50µl of diluted standards, control and urine samples are added to each wells in of the strips in the frame. 150 µl of the working colour solution is added to each well and incubated at room temperature. The optical density is read at 490 nm within 10 minutes of the completion of the incubation.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM/TP/FP**	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Colour reagent (Picric acid 0.14% in Sodium Borate and SDS	SM/TP	2 X 7 ml	Harmful by inhalation, ingestion or skin absorption. Irritant.	Eye protection to be worn along with lab coat and gloves.
Stop solution (1N NaOH)	SM	15 ml	Corrosive, harmful by inhalation, ingestion or skin absorption and Irritant.	Used only in a well-ventilated area.
Urine samples used	SM		Potential biological hazardous and can be harmful by ingestion and skin contact	Eye protection to be worn along with lab coat and gloves. Use disinfecting wash solution like Virkon etc for cleaning working area and hands.

***** Use continuation page(s) if necessary.** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Khattak	FORM #:	SK10
OVERALL RISK ASSESSMENT	Low		

If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	n/a
Are Category 1 or Category CARCINOGENS being used or generated?	
If category 1 or category 2 CARCINOGENS are being used or generated then has safe alternatives been considered? Justify your selection.	
Control/Safety	Safety spectacles, gloves, lab coat and use of virkon for cleaning the working desk etc.
Method of disposal	In special bags used for hazardous material and incinerated
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire					
in case of water failure					
in case of electricity failure					
emergency contact name(s)					
emergency phone number(s)					
ASSESSOR	Seema Anjum Khattak	Signature:		Date:	07/04/2011
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	07/04/2011

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Rcvd SAC-COSHH		Signature:		Date:	

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COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 1 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK11

Nature of experiment or procedure

TITLE	Handling of Urine samples

LOCATION	Chemistry lab
FREQUENCY	As required (<12 days per month)
DETAILS OF PROCEDURE	Urine samples were taken out from freezer where it was kept at -20°C & thawed at room temperature. These samples have already been treated for polio virus (warming to 55°C for 30 minutes) before refrigeration. Then these samples are filtered through 0.45 μm filter and diluted. The filtered and diluted samples can be used both for total arsenic in urine and arsenic speciation in urine. The rest of the samples are stored in freezer at -20°C.

Risk Assessment and precautions specific to substances used or generated in this experiment

SUBSTANCE	SM /TP /FP* *	AMOUNT & ROUTE OF EXPOSURE	HAZARDS	PRECAUTIONS TO BE TAKEN
Urine	SM/FP	5 x50 ml = 250 ml, inhalation, skin contact, splashes	Harmful by inhalation, splashes or skin absorption. .	Eye protection to be worn along with lab coat and gloves. Used only in a well-ventilated area. In case of skin contact the area should be washed with soap and water. In case of eye contact wash with plenty of water in case of spillage wear disposable gloves and wipe off the area with 1% Virkon solution.

***** Use continuation page(s) if necessary.

** indicate whether chemical is starting material (SM), transient product (TP) or final product (FP)

COSHH RISK ASSESSMENT FORM SEAES, University of Manchester Page 2 of 2*

NAME	Seema Anjum Khattak	FORM #:	SAK11
OVERALL RISK ASSESSMENT	Low		
If risk assessment is VERY HIGH or HIGH then has a safer alternative been considered?	NA		
Are Category 1 or Category CARCINOGENS being used or generated?	No		
If category 1 or category 2 CARCINOGENS are being used or generated then has safe alternatives been considered? Justify your selection.	NA		

Control/Safety	Safety spectacles, gloves, lab coat
Method of disposal	Urine disposal after adding 1% Virkon solution via toilet and the containers, filters and syringes are first washed with 1 % Virkon solution and then disposed off via the laboratory waste bin .
Potential hazards during disposal	Skin/eye contact from splashes. Risk minimised with personal protective equipment used.
Assessment information sources(s)	
Will the experiment run unattended?	No

Emergency Procedures (complete if experiment will run unattended)

in case of fire	
in case of water failure	
in case of electricity failure	
emergency contact name(s)	
emergency phone number(s)	

Signatures

ASSESSOR	Seema Anjum Khattak	Signature:		Date:	
SUPERVISOR & COSHH SUPERVISOR	Dave Polya	Signature:		Date:	

For use by School Advisory Committee on COSHH only

Rcvd SAC-COSHH		Signature:		Date:	

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A.8 Details of protocols for Experimental work done in Williamson Research Centre, University of Manchester UK

Cleaning of nail samples in 1% triton-x100

Visible dirt is removed from the nail samples using a nylon wire brush and deionised water. Then the samples are placed in clean glass beakers, submerged in 25 ml of 1% Triton-X100 (prepared by dilution 10 ml of Triton-X100 with 990 ml of 18.5 M□ deionised water) and sonicated for 20 minutes. The wash solution is discarded and the nails are rinsed at least 3 times with 18.5 M□ deionised water before being dried at 60 °C.

Precautions

Eye protection to be worn along with lab coat and gloves

To sink with copious dilution using tap water

Cleaning of hair samples

Hair samples are placed in a clean glass beaker and washed with 5 ten minute contacts (in an ultrasonic bath) with 25 ml portions of, successively, acetone, water, water, water, acetone, decanting off the wash liquid after each 10 minute wash. Only Anala R grade acetone and 18.5 MΩ deionised water are used. After the last wash step, the hair samples are allowed to dry overnight at room temperature.

Precautions

Eye protection to be worn along with lab coat and gloves. Used only in a well-ventilated area.

Evaporate acetone at room temperature in a fume cupboard in Chem lab

Reference:

Oxford university MSDS web resource:

http://physchem.ox.ac.uk/MSDS/#MSDS

Protocol for preparation of hair sample for analysis of total arsenic content

1. Hair samples are cut from the cello taped end and taken into a clean glass beaker.
2. To it, 25 ml of acetone (measured in a measuring cylinder) is added.
3. The assembly is now put into an ultrasonic bath for 10 minutes.
4. Acetone is decanted and 25 ml of 18mΏ deionized water is added.
5. Washing is repeated for 5 times in the sequence: acetone – water- water- water- acetone.
6. The samples are then allowed to dry overnight at room temperature.
7. The samples are then stored in labelled plastic bags till digestion.
8. Weight 10 mg of hair sample (approximately) into acid cleaned 10 ml polypropylene test tubes.
9. 1 ml of concentrated nitric acid is added and the tubes are capped with clean stoppers and left to digest for 48 hours with intermittent shaking.
10. After 48 hours, 9 ml of deionised water is added.
11. Shake well and filter the solution through 0.45µm filter using a syringe and a straw (one syringe, filter and straw for each sample) and stored the filter samples in labelled plastic test tubes for ICP-MS analysis.
12. The SRM will have to be prepared in the same way as the samples, beginning from step 8. SRM must be analysed in every set of analyses in triplicate.

Note:

- Standards used for analysis of total arsenic concentration of hair in ICP-MS are 1, 5, 10, 50, 100 µg/L.
- All apparatus used in the process have to be washed prior to use.They should first be washed with 15 ΏmilliQ water, then washedovernight in 2% Nitric acid , then in 18 mΏ deionized water and finally dried at 60C.
- Nitric acid used (for digestion) is ultrapure distilled and subdistilled from Aristar grade.
- All the consumables (except glass beakers and microdigetion tubes should be discarded after single use.

Protocol for preparation of nail sample for analysis of total arsenic content

1. About three pieces of nail sample (approximately 100mg) are picked up with the tong scissors and washed in 15mΏ deionized water.
2. They are then cleaned by scrubbing, using nylon brush and then washed again with 15mΏ deionized water.
3. Samples are then taken in to a 100 ml glass beaker and ti it, 25 ml of 1% triton X-100 solution is added, using a plastic measuring cylinder.
4. The assembly is then put in the ultrasonic bath for 20 minutes.

5. Triton X-100 solution is decanted and the samples are rinsed 5 times in 18mΏ deionized water.

6. Beakers containing the nail samples are placed in the oven at 60°C and allowed to dry overnight.

7. Weigh 10 mg of nail sample (approximately) into acid cleaned 10 ml polypropylene test tubes.

8. 1 ml of concentrated nitric acid is added and the tubes are capped with clean stoppers and left to digest for 48 hours with intermittent shaking.

9. After 48 hours, 9 ml of deionised water is added.

10. Shake well and filter the solution through 0.45µm filter using a syringe and a straw (one syringe, filter and straw for each sample) and stored the filter samples in labelled plastic test tubes for ICP-MS analysis.

11. The SRM will have to be prepared in the same way as the samples, beginning from step 8. SRM must be analysed in every set of analyses in triplicate.

Note:

- Standards used for analysis of total arsenic concentration of rice in ICP-MS are 0, 1.0, 5.0, 10.0, 20.0 ppb.
- All apparatus used in the process have to be washed prior to use. They should first be washed with 15 ΏmilliQ water, then washed overnight in 5% Nitric acid , then in 18 mΏ deionized water and finally dried at 60C.
- Nitric acid used (for digestion) is ultrapure distilled and subdistilled from Aristar grade. All the consumables (except glass beakers and microdigetion tubes should be discarded after single use.

Protocol for preparation of rice samples for estimation of total arsenic content (Microwave digestion) in rice by ICP-MS analysis

Chemicals:

HNO_3 double distilled or (Aristar grade) HNO_3, 5% HNO_3 (diluted solution for washing), Certified reference material (NIST Rice Flour 1568a), deionised water (18 MΩ) from Elga Pure lab Deioniser system.

Consumables:

Glass beakers 25 ml or 50 ml, Glass rod, oven at 65°C, Porcelain pestle and mortar or Agate ball mill (Fritsch), plastic envelopes (with writing strips), permanent marker, desiccators, analytical balance, Aluminium foil, CEM (Mars Express) microwave, Microwave vessels 50 ml, Microwave vessels stands, special marker (to write on Teflon vessels), fume cupboard, Plastic wash bottle, 10 ml pippetman, 5ml & 10ml plastic pipit tips, 50 ml centrifuge polypropylene vessels with lids, polypropylene test tubes with stoppers (10 ml), Test tube racks, Plastic trey, Blue paper roll for cleaning.

Washing glass wares:

All the glass wares (beakers, glass rod etc) should be cleaned first with deionised water and any visible dirt can be removed by using nylon brush. Then place all the glass wares in 5% HNO solution bath in a plastic tank for overnight. After acid wash use deionised water (15/ 18 MΩ) to wash the glass wares three times so that all the glass wares become clean properly and then finally dried at 60C° in oven.

Washing and grinding of rice samples:

1. Take rice sample in 50/25 ml glass beaker.
2. Wash it 5 times with deionised water (18 Ω) stirring continuously with a glass rod.
3. Pour out all water and dry the rice sample in 65C° oven for 48 hours with occasional stirring so that whole rice samples get uniformly dry.
4. The dry rice sample is then ground either in the porcelain pestle mortar or with the help of ball mill (at 150 rpm for 5 minutes; if not ground properly, this step can be repeated for another 5 minutes at 150 rpm).
5. The ground rice samples are stored in plastic bags properly labelled with the help of a permanent marker and stored in a dedicator for further use.

Weighing step:

6. Analytical balance (PS-100 Fisher brand) is used for the exact weighing. For digestion we need only 0.5 – 1.5 gm of already grinded rice sample, weigh on a piece of aluminium foil (3 x3 inch piece) and carefully transferred the material to already labelled microwave vessels.

7. For this purpose first of all weigh a piece of aluminium foil (3 x3 inch) and then press tare, it will show the reading zero. Before weighing the piece of aluminium foil, fold this piece of foil length wise and then width wise in the same direction and then open it. This folding and opening will make the foil handling and transferring of grinded material easy. Now carefully put & weigh 0.5gm rice sample and transfer it to the already labelled vessels. Use the special marker for labelling the Teflon vessels.

Digestion by Microwave (Mars Express):

8. In a fume cupboard, add 5ml of concentrated nitric acid (Double distilled) to each Microwave vessel/Teflon Vessel with the help of a pippet man. Use separate pipit tips for every sample and every blank. Cover the vessels with their cushions and led.

9. Carefully check covers of all the vessels and then put all microwave vessels in the rack. Try to distribute these vessels equally if the rack is not full so that there is equal distribution of weight on the microwave rack. The method for total digestion is already stored in the instrument by the name of *Rice total*. Go to Menu select the name and press start button. The conditions are, 10 minutes to reach the temperature (170°C) then 20 minutes heating time at 170°C for the digestion. Power is 1600W which is 100%. The total run time is 30 minutes and the cooling time is 40-45 minutes. There is a beep at the end of run time after that cooling starts.

10. Transfer the vessels from the rack to plastic stands and open it carefully in the fume cupboard. There is release of gases while opening the vessels keep the opening away from you. Now transfer the digest to already labelled 50 ml polypropylene centrifuge tubes. Carefully wash and transfer the wash outs from both lid as well as the vessel to this tube. Using spray of wash bottle for this purpose is helpful but care must be taken to avoid contaminating the tip of wash bottle.

Dilution and filtration:

11. Dilute this digest in the same plastic centrifuge vessels with deionised water (18 Ω) by making its volume to the required point (in this case 50ml to make it ten times diluted).

12. Usually this digest is very clear and does not need to be filtered but if not clear then filter the solution through 0.45µm filter using a syringe and a straw. With the help of the straw, syringe will suck all the solution from the test tube and then remove the straw and use (0.45µm) the filter. Use one syringe, filter and straw for each sample.

13. Store the diluted sample in polypropylene test tubes, properly labelled and capped. Place it in 4C° refrigerator for further use for IC-PMS analysis.

Quality control Measures:

14. The SRM1568a will have to be processed in the same way as the ground rice samples. Standard Reference Material (NIST Rice Flour 1568a) is used in each set of analysis in order to check the analytical accuracy of the digestion procedure of the rice samples. A percentage of duplicate samples and triplicate or duplicate SRM1568a (rice flour) must be analysed in every set of analyses.
15. For quality control purpose, it is good to use 10-20 % of samples in duplicate and procedural blanks (The extractant, double distilled HNO_3 in this case) and deionised water (18 Ω) in triplicate or duplicates.

16. External calibration of the instrument (ICP-MS) was performed by using 1, 5, 10, 20, 50 ppb standards for Rice analysis.

Notes:

- Nitric Acid used (for digestion) is ultrapure, double distilled and sub-distilled from Aristar Grade.
- Double distilled HNO_3 should not be used directly from the bottle but always keep the acid in a new clean plastic vessel during the experiment to avoid the contamination.
- Aluminium foil is used instead of weighing boats to avoid the static problem and for clean transfer of ground sample to the microwave vessels.
- There must be separate Aluminium foil pieces for weighing and pipit tips for transfer of extractant for each sample.
- Lids of microwave vessels must be properly closed and double checked before start of every run (by Paul) in order to avoid sample loss during the run.

- Microwave vessels must be equally distributed inside the rack to properly balance the system during the run/circulation.
- All the consumables (except glass beakers and microwave vessels) should be discarded after single use.
- For the quality control measure it is good to use SRM1568a (rice flour) and procedural blanks in Triplicate.
- External calibration of the instrument (ICP-MS) was performed by using 1, 5, 10, 20, 50 ppb standards for Rice analysis.
- It is good to have a wash run (10 ml of 5% HNO_3 in the vessels at 170 C°) between two sets of analysis for properly cleaning the microwave vessels.

Standard operating procedure for digestion of rice samples for arsenic speciation for IC-ICP-MS using Mars Microwave system

1. Label 50ml disposable centrifuge tubes and caps according to sample number.
2. Weight all empty tubes complete with caps on.
3. Weight approximately 0.5g of rice samples accurately directly into each tube.
4. Weight 0.5g of CRM in triplicate.
5. Weight 0.5g of rice in duplicate for at least 2 of the samples.
6. Leave one tube without sample for the purpose of temperature control.
7. In a fume hood pipette 5ml of 0.28 M HNO_3 to all samples, blanks and standards.
8. Add 5ml of 0.28 M HNO_3 to an empty tube designated for temperature control.
9. Vortex all samples for a few seconds at 1500 rpm, in ensures rice is wetted with solution.
10. Leave them overnight in the fume cupboard
11. Vortex each sample tube at approx 1700 rpm for 5 minutes, so that sample solution only spins to half way up the tube and not to the lid.
12. Loosely place caps on all tubes.
13. Arrange tubes symmetrically on tray in order to ensure even heating.
14. Carefully take the quartz sleeve for the temperature sensor out of its box and place it inside the temperature control tube using a purple lid with a hole, containing only 5ml acid.

15. Carefully place the tube carousel inside the microwave ensuring it is seated correctly onto the four microwave slots, check it is level.
16. Very carefully insert the temperature sensor into the slot on the inside of the microwave, holding it by the white sleeve. Push gently upwards until it clicks and stay in place. Do not bend or wet the temperature sensor.
17. Take the thermocouple and insert it carefully inside the quartz liner all the way to bottom.
18. Carefully secure the temperature sensor in the white central holder, making sure there are no obstructions to the cable to move freely once the carousel is in motion.
19. Double check that the temperature sensor is located inside the tube then close the microwave door.
20. Load AS speciation program *(Speciation Beakers)* on the screen. Check the parameters.

    400W Power: 100%, Ramp time: 5min Control temp: 60oC Hold time: 60min

    400W Power: 100%, Ramp time: 5min Control temp: 95oC Hold time: 60min

    400W Power: 100%, Ramp time: 5min Control temp: 95oC Hold time: 45min
21. Press the START button. Observe the temperature rise up to 60°C in the first stage. If the temperature is not controlling properly or if you start to observe any violent reactions and/or lids blowing off press red stop button to stop the run immediately.
22. Once the program has finished it will perform a 30 minutes cool down period in order to cool the samples to room temperature.
23. After the cooling period is complete, take the lower end of the temperature sensor out of the quartz sleeve and carefully remove the tube carousel from microwave oven and place in the fume hood.
24. Remove the temperature sensor from the microwave ceiling, use both hands and pull down. Ensure the sensor does not bend or wet. Place it carefully back into the designated plastic container.
25. Take the quartz sleeve which has been immersed in acid and rinse the **outside** of it carefully with deionised water and dry it gently a tissue and place it back in the box.
26. Prepare brand new syringes 2ml, 0.45 μm disposable filter devices, labelled ICP tubes with caps.

27. Label new 1.5 ml HPLC vials (9mm screw thread, black and red caps) and weigh with caps on.
28. Filter the supernatant of each sample into the respective labelled ICP tube.
29. Remove with a pipette 0.9ml of each filtered extract and transfer to respective 1.5ml vial, and re-weigh.
30. Add 0.1ml of H_20_2 re- weigh and leave overnight (24hrs).
31. Add o.1 ml of 2M NaOH, re-weigh.
32. Give the completely prepared samples in a sample bow in number order (with a job sheet for analysis) to Paul Lythgoe for IC-ICP-MS analysis.

Notes: The digestion holder can accommodate 50 tubes: 1 tube for temperature control and 49 samples (this should include duplicates, standards (CRM) and blanks).

Do not operate the microwave if you have not been trained. If you are digesting less than 25 samples at one time care must be taken as overheating can occur resulting in loss of sample solution and damage to the microwave. Work cleanly to avoid contamination to samples, reagents and equipment.

A9. Field photographs Arsenicosis in Allama Iqbal Town Lahore Pakistan (Pictures by S A Khattak & patients diagnosed by Prof Dr M Jehangir, Jinnah Hospital Lahore.

A- (Keratosis)

B- (Melanosis)

A10. ICP-MS and IC-ICP-MS data sessions for the analysis of drinking/cooking water, raw rice, hair, nails and urine collected from (house hold surveys) Allama Iqbal town, Lahore and Peshawar basin, KPK Pakistan.

A. Summary of all sessions on ICP-MS and IC-ICPMS

File code	Filename	Date	First	Last	Records	Project	Media	N Cal Stds	N samples	Analyte
1	SKrice24111.xls	1/24/2011	241128	241186	59	Peshawar	Rice	30	29	As
2	AsHair81009.xls	10/08/2009	810091	810202	112	Lahore	Hair	48	64	Multi element
3	water131009.xls	10/13/2009	1310091	1310229	139	Lahore	Water	54	85	Multi element
4	water15709.xls	07/15/2009	323	415	93	Lahore	Water	36	57	As
5	water207009.xls	07/20/2009	416	550	135	Lahore	Water	54	81	As
6	WaterAs167009.xls	07/16/2009	551	685	135	Lahore	Water	54	81	As
7	SKt6411.xls	04/06/2011	64111	64166	56	Lahore	Urine	24	32	As
8	AsNails121009.xls	10/12/2009	1210091	1210250	160	Mixed	Nails	66	94	As
9	AsNails141009.xls	10/14/2009	1410091	1410157	67	Mixed	Nails	30	37	As
10	AsHair22709.xls	7/22/2009	966	1060	95	Lahore	Hair	42	53	As
11	AsHair270709.xls	7/27/2009	1061	1199	139	Mixed (Lahore+India)	Hair	54	85	Multi element
12	SKrice16082010.xls	08/16/2010	168101	168202	102	Lahore	Rice	36	66	As
13	SKrice17082010.xls	08/17/2010	178101	178158	58	Lahore	Rice	24	34	As
14	Skrice_6072009.xls	07/06/2009	775	925	151	Lahore	Rice	10	141	Multi element
15	SKrice27082010.xls	08/27/2010	278101	278214	114	Lahore	Rice	42	72	As
16	dp6611.xls	06/06/2011	111112	111235	124	India	Rice	23	101	As speciation
17	dp7611.xls	07/06/2011	76111	76162	52	India	Rice	14	38	As speciation
18	skrice11110.xls	01/11/2011	111127	111240	114	Lahore	Rice	23	91	As speciation
19	skrice21110.xls	02/11/2011	211102	211157	56	Lahore	Rice	16	40	As speciation
20	sk261010.xls	26/10/2010	2610105	2610138	34	Lahore	Rice	20	14	As speciation
21	skU04052011.xls	04/05/2011	54112.D	54164.D	52	Lahore	Urine	16	36	As speciation

B. Details of analytical sessions of ICP-MS and its QC.

Acq. Date-Time	Type	Level	Sample Name	As Conc [ug/L]	RSD	File name	File code	Project	Media	Non-Blk Cal Std ?	Std Conc	Cal Std ?	CRM ?	% Std Bias	Std OK ?
1/24/2011 10:09 AM	CalBlk	1	blank	0.00	N/A	SKrice24111.xls	1	Peshawar	Rice	FALSE	0	Yes	FALSE		#VALUE!
1/24/2011 10:12 AM	CalStd	2	1ppb	1.02	3.27	SKrice24111.xls	1	Peshawar	Rice	TRUE	1	Yes	FALSE	2%	Yes
1/24/2011 10:14 AM	CalStd	3	5ppb	4.97	2.88	SKrice24111.xls	1	Peshawar	Rice	TRUE	5	Yes	FALSE	-1%	Yes
1/24/2011 10:17 AM	CalStd	4	10ppb	9.44	1.87	SKrice24111.xls	1	Peshawar	Rice	TRUE	10	Yes	FALSE	-6%	No
1/24/2011 10:20 AM	CalStd	5	50ppb	49.69	1.10	SKrice24111.xls	1	Peshawar	Rice	TRUE	50	Yes	FALSE	-1%	Yes
1/24/2011 10:22 AM	CalStd	6	100ppb	100.21	1.06	SKrice24111.xls	1	Peshawar	Rice	TRUE	100	Yes	FALSE	0%	Yes
1/24/2011 10:25 AM	Sample		wash	0.02	74.36	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:28 AM	Sample		pr11	2.05	2.88	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:31 AM	Sample		pr12	2.32	3.63	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:33 AM	Sample		pr13	1.13	4.36	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:36 AM	Sample		pr1dup	1.99	4.27	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:39 AM	Sample		pr3dup	1.07	4.67	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:42 AM	Sample		pr14dup	1.23	3.25	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:44 AM	Sample		pr13dup	1.13	1.95	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:47 AM	Sample		pr14	1.20	2.36	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:50 AM	Sample		lr55	0.61	3.19	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 10:52 AM	CalBlk	1	blank	0.00	N/A	SKrice24111.xls	1	Peshawar	Rice	FALSE	0	Yes	FALSE		#VALUE!
1/24/2011 10:55 AM	CalStd	2	1ppb	1.02	1.34	SKrice24111.xls	1	Peshawar	Rice	TRUE	1	Yes	FALSE	2%	No
1/24/2011 10:58	CalStd	3	5ppb	5.05	1.76	SKrice24111.xls	1	Peshawar	Rice	TRUE	5	Yes	FALSE	1%	Yes

AM															
1/24/2011 11:00 AM	CalStd	4	10ppb	9.74	3.01	SKrice24111.xls	1	Peshawar	Rice	TRUE	10	Yes	FALSE	-3%	Yes
1/24/2011 11:03 AM	CalStd	5	50ppb	49.37	1.71	SKrice24111.xls	1	Peshawar	Rice	TRUE	50	Yes	FALSE	-1%	Yes
1/24/2011 11:06 AM	CalStd	6	100ppb	100.34	1.15	SKrice24111.xls	1	Peshawar	Rice	TRUE	100	Yes	FALSE	0%	Yes
1/24/2011 11:09 AM	Sample		wash	0.02	15.74	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 11:11 AM	Sample		lr28	1.00	3.50	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 11:14 AM	Sample		crm1	2.31	2.21	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	TRUE		
1/24/2011 11:17 AM	Sample		65	0.31	7.62	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 11:20 AM	Sample		55	0.17	4.39	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 11:22 AM	Sample		28	0.37	7.36	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 11:25 AM	Sample		lr65	1.32	3.41	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 11:28 AM	Sample		crm2	2.27	2.82	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	TRUE		
1/24/2011 11:30 AM	Sample		crm3	2.36	2.55	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	TRUE		
1/24/2011 11:33 AM	Sample		crm4	0.89	2.24	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	TRUE		
1/24/2011 11:36 AM	Sample		crm5	1.06	3.15	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	TRUE		
1/24/2011 11:39 AM	Sample		crm6	0.85	1.47	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	TRUE		
1/24/2011 11:41 AM	CalBlk	1	blank	0.00	N/A	SKrice24111.xls	1	Peshawar	Rice	FALSE	0	Yes	FALSE		#VALUE!
1/24/2011 11:44 AM	CalStd	2	1ppb	1.04	4.43	SKrice24111.xls	1	Peshawar	Rice	TRUE	1	Yes	FALSE	4%	Yes
1/24/2011 11:47 AM	CalStd	3	5ppb	5.00	1.68	SKrice24111.xls	1	Peshawar	Rice	TRUE	5	Yes	FALSE	0%	Yes
1/24/2011 11:49 AM	CalStd	4	10ppb	9.68	1.63	SKrice24111.xls	1	Peshawar	Rice	TRUE	10	Yes	FALSE	-3%	No
1/24/2011 11:52 AM	CalStd	5	50ppb	49.56	0.79	SKrice24111.xls	1	Peshawar	Rice	TRUE	50	Yes	FALSE	-1%	No
1/24/2011 11:55 AM	CalStd	6	100ppb	100.25	0.84	SKrice24111.xls	1	Peshawar	Rice	TRUE	100	Yes	FALSE	0%	Yes
1/24/2011 11:58 AM	Sample		wash	0.04	36.23	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		

1/24/2011 12:00 PM	Sample		lr55dup	0.61	2.84	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:03 PM	Sample		blank hno3 1	0.01	95.41	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:06 PM	Sample		blank hno3 2	0.00	#####	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:08 PM	Sample		diw1	<0.000	N/A	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:11 PM	Sample		diw2	<0.000	N/A	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:14 PM	CalBlk	1	blank	0.00	N/A	SKrice24111.xls	1	Peshawar	Rice	FALSE	0	Yes	FALSE		#VALUE!
1/24/2011 12:17 PM	CalStd	2	1ppb	1.03	2.00	SKrice24111.xls	1	Peshawar	Rice	TRUE	1	Yes	FALSE	3%	No
1/24/2011 12:19 PM	CalStd	3	5ppb	4.95	1.97	SKrice24111.xls	1	Peshawar	Rice	TRUE	5	Yes	FALSE	-1%	Yes
1/24/2011 12:22 PM	CalStd	4	10ppb	9.58	1.90	SKrice24111.xls	1	Peshawar	Rice	TRUE	10	Yes	FALSE	-4%	No
1/24/2011 12:25 PM	CalStd	5	50ppb	49.21	1.24	SKrice24111.xls	1	Peshawar	Rice	TRUE	50	Yes	FALSE	-2%	No
1/24/2011 12:27 PM	CalStd	6	100ppb	100.44	0.70	SKrice24111.xls	1	Peshawar	Rice	TRUE	100	Yes	FALSE	0%	Yes
1/24/2011 12:49 PM	Sample		pr1	2.12	2.65	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:52 PM	Sample		pr2	1.94	3.24	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:55 PM	Sample		pr3	1.07	4.56	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:57 PM	Sample		pr4	1.10	3.73	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 1:00 PM	Sample		pr5	0.61	3.39	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 1:03 PM	Sample		pr6	0.66	3.50	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 1:05 PM	Sample		pr7	0.61	2.98	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 1:08 PM	Sample		pr8	0.66	3.37	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 1:11 PM	Sample		pr9	0.96	1.07	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 1:14 PM	Sample		pr10	0.63	0.93	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
1/24/2011 12:30 PM	CalBlk	1	blank	0.00	N/A	SKrice24111.xls	1	Peshawar	Rice	FALSE	0	Yes	FALSE		#VALUE!
1/24/2011 12:33 PM	CalStd	2	1ppb	1.02	2.14	SKrice24111.xls	1	Peshawar	Rice	TRUE	1	Yes	FALSE	2%	Yes
1/24/2011 12:35 PM	CalStd	3	5ppb	5.00	1.08	SKrice24111.xls	1	Peshawar	Rice	TRUE	5	Yes	FALSE	0%	Yes
1/24/2011 12:38 PM	CalStd	4	10ppb	9.75	0.36	SKrice24111.xls	1	Peshawar	Rice	TRUE	10	Yes	FALSE	-3%	No

1/24/2011 12:41 PM	CalStd	5	50ppb	49.15	1.51	SKrice24111.xls	1	Peshawar	Rice	TRUE	50	Yes	FALSE	-2%	No
1/24/2011 12:44 PM	CalStd	6	100ppb	100.45	1.15	SKrice24111.xls	1	Peshawar	Rice	TRUE	100	Yes	FALSE	0%	Yes
1/24/2011 12:46 PM	Sample		wash	0.05	11.15	SKrice24111.xls	1	Peshawar	Rice	FALSE		No	FALSE		
10/8/2009 9:32 AM	CalBlk	1	blk	0.00	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 9:35 AM	CalStd	2	1ppb	1.01	1.40	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	1%	Yes
10/8/2009 9:37 AM	CalStd	3	5ppb	4.91	1.04	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-2%	No
10/8/2009 9:40 AM	CalStd	4	10ppb	9.87	0.19	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	-1%	No
10/8/2009 9:42 AM	CalStd	5	50ppb	49.70	0.27	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	-1%	No
10/8/2009 9:45 AM	CalStd	6	100ppb	100.16	0.66	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	0%	Yes
10/8/2009 9:48 AM	Sample		h74	0.96	4.80	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 9:50 AM	Sample		h75	8.32	1.00	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 9:53 AM	Sample		h76	0.80	3.85	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 9:55 AM	Sample		h77	0.14	7.95	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 9:58 AM	Sample		h78	17.10	4.26	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:00 AM	Sample		h79	0.31	5.31	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:03 AM	Sample		h80	0.01	53.42	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:05 AM	Sample		h81dup	0.71	1.76	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:08 AM	Sample		h81	1.64	2.61	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:11 AM	Sample		h82	1.21	2.45	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:13 AM	CalBlk	1	blk	0.00	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 10:16 AM	CalStd	2	1ppb	0.99	1.81	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	-1%	Yes
10/8/2009 10:18 AM	CalStd	3	5ppb	4.74	0.84	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-5%	No
10/8/2009 10:21 AM	CalStd	4	10ppb	9.83	1.19	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	-2%	No
10/8/2009 10:23 AM	CalStd	5	50ppb	50.03	0.33	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	0%	Yes
10/8/2009 10:26 AM	CalStd	6	100ppb	100.01	1.64	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	0%	Yes
10/8/2009 10:28 AM	Sample		h83	2.09	0.17	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		

10/8/2009 10:31 AM	Sample		h84	3.15	0.61	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:34 AM	Sample		h73	0.63	2.06	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:36 AM	Sample		h72	1.30	4.95	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:39 AM	Sample		h71	1.84	1.87	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:41 AM	Sample		h70	5.23	1.80	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:44 AM	Sample		h69	1.88	2.46	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:46 AM	Sample		h68	2.58	3.31	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:49 AM	Sample		h67	1.05	1.61	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:51 AM	Sample		h66	1.44	2.09	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 10:54 AM	CalBlk	1	blk	0.00	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 10:56 AM	CalStd	2	1ppb	0.99	3.64	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	-1%	Yes
10/8/2009 10:59 AM	CalStd	3	5ppb	4.77	1.59	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-5%	No
10/8/2009 11:02 AM	CalStd	4	10ppb	9.63	0.93	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	-4%	No
10/8/2009 11:04 AM	CalStd	5	50ppb	49.29	1.31	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	-1%	No
10/8/2009 11:07 AM	CalStd	6	100ppb	100.40	1.93	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	0%	Yes
10/8/2009 11:13 AM	Sample		h65	3.24	1.03	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:16 AM	Sample		h64	3.53	1.60	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:18 AM	Sample		h64	3.49	3.37	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:21 AM	Sample		h63	0.78	1.44	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:23 AM	Sample		h62	4.33	1.63	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:26 AM	Sample		h62	9.93	1.95	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:28 AM	Sample		h61	1.39	0.48	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:31 AM	Sample		h60	0.28	3.02	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		

10/8/2009 11:33 AM	Sample		h57	1.06	0.36	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:36 AM	Sample		h56	0.56	1.84	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:39 AM	CalBlk	1	blk	<0.000	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 11:41 AM	CalStd	2	1ppb	0.99	2.68	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	-1%	Yes
10/8/2009 11:44 AM	CalStd	3	5ppb	4.81	1.44	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-4%	No
10/8/2009 11:46 AM	CalStd	4	10ppb	9.97	0.36	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	0%	Yes
10/8/2009 11:49 AM	CalStd	5	50ppb	49.19	1.50	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	-2%	No
10/8/2009 11:51 AM	CalStd	6	100ppb	101.19	0.70	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	1%	No
10/8/2009 11:54 AM	Sample		h55	1.08	2.31	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:56 AM	Sample		h54dup	0.32	2.06	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 11:59 AM	Sample		h54	0.19	1.88	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:02 PM	Sample		ph28	0.63	1.72	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:04 PM	Sample		ph26	1.26	1.35	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:07 PM	CalBlk	1	blk	0.00	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 12:09 PM	CalStd	2	1ppb	0.95	0.55	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	-5%	No
10/8/2009 12:12 PM	CalStd	3	5ppb	4.60	1.67	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-8%	No
10/8/2009 12:14 PM	CalStd	4	10ppb	9.57	0.85	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	-4%	No
10/8/2009 12:17 PM	CalStd	5	50ppb	49.14	1.14	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	-2%	No
10/8/2009 12:19 PM	CalStd	6	100ppb	100.49	0.95	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	0%	Yes
10/8/2009 12:22 PM	Sample		ph25	1.77	3.31	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:25 PM	Sample		ph24	0.45	3.01	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:27 PM	Sample		ph23	1.00	1.56	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:30 PM	Sample		ph22	0.71	2.86	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		

10/8/2009 12:32 PM	Sample		ph21	0.55	5.71	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:35 PM	Sample		ph20	1.74	1.99	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:37 PM	Sample		ph19	0.84	2.21	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:40 PM	Sample		ph18	1.16	2.78	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:42 PM	Sample		ph17	0.13	6.43	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:45 PM	Sample		ph16	0.51	2.28	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 12:47 PM	CalBlk	1	blk	0.00	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 12:50 PM	CalStd	2	1ppb	0.97	2.78	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	-3%	No
10/8/2009 12:52 PM	CalStd	3	5ppb	4.77	1.46	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-5%	No
10/8/2009 12:55 PM	CalStd	4	10ppb	9.87	0.13	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	-1%	No
10/8/2009 12:58 PM	CalStd	5	50ppb	49.78	1.65	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	0%	Yes
10/8/2009 1:00 PM	CalStd	6	100ppb	100.14	1.65	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	0%	Yes
10/8/2009 1:03 PM	Sample		ph15	0.91	3.02	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:05 PM	Sample		ph14	0.46	5.93	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:08 PM	Sample		ph13	0.33	2.85	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:10 PM	Sample		ph12	0.61	1.18	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:13 PM	Sample		ph12b	0.39	4.23	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:16 PM	Sample		ph11	0.21	4.91	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:18 PM	Sample		ph10	0.24	7.26	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:21 PM	Sample		ph9	0.35	1.10	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:23 PM	Sample		ph8	2.23	2.71	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:26 PM	Sample		ph7	0.46	1.75	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:28 PM	CalBlk	1	blk	0.00	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 1:31 PM	CalStd	2	1ppb	0.97	3.93	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	-3%	Yes
10/8/2009 1:33 PM	CalStd	3	5ppb	4.69	2.68	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-6%	No
10/8/2009 1:36 PM	CalStd	4	10ppb	9.70	0.94	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	-3%	No
10/8/2009 1:39 PM	CalStd	5	50ppb	49.22	0.31	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	-2%	No
10/8/2009 1:41 PM	CalStd	6	100ppb	100.43	0.80	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	0%	Yes

10/8/2009 1:44 PM	Sample		ph6	0.91	8.84	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:46 PM	Sample		ph5	1.07	1.10	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:49 PM	Sample		ph4	0.66	0.76	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:51 PM	Sample		ph3	0.25	0.61	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:54 PM	Sample		ph2	1.32	3.44	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:56 PM	Sample		ph1	2.27	5.05	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 1:59 PM	Sample		crm2	1.83	1.81	AsHair81009.xls	2	Lahore	Hair	FALSE		No	TRUE		
10/8/2009 2:01 PM	Sample		crm1	1.69	3.22	AsHair81009.xls	2	Lahore	Hair	FALSE		No	TRUE		
10/8/2009 2:04 PM	Sample		blank1	0.01	26.79	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 2:07 PM	Sample		blank2	0.05	4.43	AsHair81009.xls	2	Lahore	Hair	FALSE		No	FALSE		
10/8/2009 2:09 PM	CalBlk	1	blk	0.00	N/A	AsHair81009.xls	2	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
10/8/2009 2:12 PM	CalStd	2	1ppb	1.00	0.57	AsHair81009.xls	2	Lahore	Hair	TRUE	1	Yes	FALSE	0%	Yes
10/8/2009 2:14 PM	CalStd	3	5ppb	4.73	0.77	AsHair81009.xls	2	Lahore	Hair	TRUE	5	Yes	FALSE	-5%	No
10/8/2009 2:17 PM	CalStd	4	10ppb	9.58	0.35	AsHair81009.xls	2	Lahore	Hair	TRUE	10	Yes	FALSE	-4%	No
10/8/2009 2:19 PM	CalStd	5	50ppb	48.41	1.00	AsHair81009.xls	2	Lahore	Hair	TRUE	50	Yes	FALSE	-3%	No
10/8/2009 2:22 PM	CalStd	6	100ppb	100.85	0.60	AsHair81009.xls	2	Lahore	Hair	TRUE	100	Yes	FALSE	1%	No
10/13/2009 9:22 AM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
10/13/2009 9:24 AM	CalStd	2	1ppb	1.09	3.68	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	9%	No
10/13/2009 9:27 AM	CalStd	3	5ppb	5.04	1.77	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	1%	Yes
10/13/2009 9:29 AM	CalStd	4	10ppb	10.41	0.74	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	4%	No
10/13/2009 9:31 AM	CalStd	5	50ppb	52.70	0.86	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	5%	No
10/13/2009 9:34 AM	CalStd	6	100ppb	105.13	0.78	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	5%	No
10/13/2009 9:36 AM	CalStd	7	700ppb	699.07	0.56	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes
10/13/2009 9:38 AM	Sample		4a	22.25	3.59	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:40 AM	Sample		4b	21.97	1.64	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:43 AM	Sample		4tb	24.49	1.27	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:45 AM	Sample		5a	24.15	1.86	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:48 AM	Sample		5b	27.88	3.52	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		

10/13/2009 9:50 AM	Sample		6a	28.18	1.61	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:52 AM	Sample		6b	15.52	2.02	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:55 AM	Sample		7a1well	10.41	1.47	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:57 AM	Sample		7b1well	21.42	0.86	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 9:59 AM	Sample		8a	20.89	1.28	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:02 AM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
10/13/2009 10:04 AM	CalStd	2	1ppb	1.10	8.12	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	10%	No
10/13/2009 10:06 AM	CalStd	3	5ppb	5.29	4.39	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	6%	No
10/13/2009 10:09 AM	CalStd	4	10ppb	10.80	0.72	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	8%	No
10/13/2009 10:11 AM	CalStd	5	50ppb	53.62	1.09	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	7%	No
10/13/2009 10:13 AM	CalStd	6	100ppb	106.21	2.44	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	6%	No
10/13/2009 10:15 AM	CalStd	7	700ppb	698.84	1.01	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes
10/13/2009 10:18 AM	Sample		8b	18.17	1.05	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:20 AM	Sample		9b	18.01	0.97	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:22 AM	Sample		9a	24.63	3.41	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:25 AM	Sample		10a	26.37	1.90	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:27 AM	Sample		10b	30.65	3.85	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:29 AM	Sample		11a	30.70	1.02	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:32 AM	Sample		11b	32.42	0.79	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:34 AM	Sample		12a	33.00	1.37	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:36 AM	Sample		12b	24.31	1.46	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:39 AM	Sample		13a	23.66	2.35	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:41 AM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!

10/13/2009 10:43 AM	CalStd	2	1ppb	1.06	6.19	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	6%	Yes
10/13/2009 10:46 AM	CalStd	3	5ppb	5.28	2.37	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	6%	No
10/13/2009 10:48 AM	CalStd	4	10ppb	10.35	0.85	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	3%	No
10/13/2009 10:50 AM	CalStd	5	50ppb	52.00	0.44	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	4%	No
10/13/2009 10:53 AM	CalStd	6	100ppb	106.17	0.49	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	6%	No
10/13/2009 10:55 AM	CalStd	7	700ppb	698.97	1.95	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes
10/13/2009 10:57 AM	Sample		13b	32.22	0.91	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 10:59 AM	Sample		14a	33.16	1.54	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:02 AM	Sample		14b	29.51	0.02	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:04 AM	Sample		15a	29.44	2.34	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:06 AM	Sample		15b	26.21	1.02	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:09 AM	Sample		16a	26.99	1.34	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:11 AM	Sample		16b	11.47	2.08	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:13 AM	Sample		17a	10.84	3.26	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:16 AM	Sample		17b	7.71	2.59	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:18 AM	Sample		18a	7.66	2.25	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:20 AM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
10/13/2009 11:23 AM	CalStd	2	1ppb	1.14	4.17	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	14%	No
10/13/2009 11:25 AM	CalStd	3	5ppb	5.05	2.80	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	1%	Yes
10/13/2009 11:27 AM	CalStd	4	10ppb	10.29	2.56	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	3%	No
10/13/2009 11:30 AM	CalStd	5	50ppb	51.46	3.06	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	3%	Yes
10/13/2009 11:32 AM	CalStd	6	100ppb	102.54	2.20	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	3%	No
10/13/2009 11:34 AM	CalStd	7	700ppb	699.53	0.31	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes

10/13/2009 11:36 AM	Sample		18b19a	4.40	2.04	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:39 AM	Sample		19b	4.15	3.47	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:41 AM	Sample		20a	3.71	2.55	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:43 AM	Sample		20b	3.73	1.83	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:46 AM	Sample		21a	12.54	0.73	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:48 AM	Sample		21b	12.32	4.54	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:50 AM	Sample		22a	19.80	2.13	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:53 AM	Sample		22b	19.19	0.45	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:55 AM	Sample		23a	16.68	1.97	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 11:57 AM	Sample		23b	16.87	3.33	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:00 PM	Sample		24a	11.60	0.72	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:02 PM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
10/13/2009 12:04 PM	CalStd	2	1ppb	1.04	8.66	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	4%	Yes
10/13/2009 12:07 PM	CalStd	3	5ppb	5.08	1.38	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	2%	No
10/13/2009 12:09 PM	CalStd	4	10ppb	10.10	5.78	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	1%	Yes
10/13/2009 12:11 PM	CalStd	5	50ppb	52.69	0.91	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	5%	No
10/13/2009 12:14 PM	CalStd	6	100ppb	104.43	0.99	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	4%	No
10/13/2009 12:16 PM	CalStd	7	700ppb	699.17	1.95	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes
10/13/2009 12:18 PM	Sample		24b	9.58	3.94	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:20 PM	Sample		25a	7.54	2.29	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:23 PM	Sample		25b	7.72	3.01	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:25 PM	Sample		26a	65.26	1.59	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:27 PM	Sample		26b	69.61	1.40	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		

10/13/2009 12:30 PM	Sample		27a	6.45	3.14	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:32 PM	Sample		27b	5.71	3.16	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:34 PM	Sample		28a	83.74	0.89	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:37 PM	Sample		28b	83.60	2.10	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:39 PM	Sample		29a	28.39	2.07	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 12:41 PM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
10/13/2009 12:44 PM	CalStd	2	1ppb	1.10	6.49	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	10%	No
10/13/2009 12:46 PM	CalStd	3	5ppb	5.61	2.35	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	12%	No
10/13/2009 12:48 PM	CalStd	4	10ppb	10.53	5.45	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	5%	Yes
10/13/2009 12:51 PM	CalStd	5	50ppb	52.61	1.68	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	5%	No
10/13/2009 12:53 PM	CalStd	6	100ppb	107.05	1.46	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	7%	No
10/13/2009 12:55 PM	CalStd	7	700ppb	698.79	1.79	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes
10/13/2009 12:58 PM	Sample		29b	28.78	2.25	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:00 PM	Sample		30a	21.13	2.24	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:02 PM	Sample		30b	21.25	2.11	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:04 PM	Sample		31a	16.47	3.51	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:07 PM	Sample		31b	15.38	1.55	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:09 PM	Sample		32a	1.17	8.36	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:11 PM	Sample		32b	1.00	3.88	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:14 PM	Sample		33a	23.05	0.47	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:16 PM	Sample		33b	29.11	4.32	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:18 PM	Sample		34a	14.09	0.87	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:21 PM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!

10/13/2009 1:23 PM	CalStd	2	1ppb	0.97	6.14	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	-3%	Yes
10/13/2009 1:25 PM	CalStd	3	5ppb	4.98	2.20	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	0%	Yes
10/13/2009 1:28 PM	CalStd	4	10ppb	9.99	1.62	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	0%	Yes
10/13/2009 1:30 PM	CalStd	5	50ppb	49.82	1.69	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	0%	Yes
10/13/2009 1:32 PM	CalStd	6	100ppb	102.60	1.85	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	3%	No
10/13/2009 1:35 PM	CalStd	7	700ppb	699.64	1.79	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes
10/13/2009 1:37 PM	Sample		34b	13.90	1.45	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:39 PM	Sample		36a	0.30	16.31	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:42 PM	Sample		36b	0.11	14.18	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:44 PM	Sample		r8a	19.25	1.16	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:46 PM	Sample		r8b	18.61	2.67	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:49 PM	Sample		r9a	25.24	3.31	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:51 PM	Sample		r9b	27.16	2.13	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:53 PM	Sample		r10a	14.54	3.58	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:56 PM	Sample		r10b	14.39	1.58	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 1:58 PM	Sample		7b2tw	14.32	0.72	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 2:00 PM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
10/13/2009 2:02 PM	CalStd	2	1ppb	1.05	3.07	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	5%	No
10/13/2009 2:05 PM	CalStd	3	5ppb	5.19	3.36	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	4%	No
10/13/2009 2:07 PM	CalStd	4	10ppb	10.32	4.97	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	3%	Yes
10/13/2009 2:09 PM	CalStd	5	50ppb	51.28	0.11	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	3%	No
10/13/2009 2:12 PM	CalStd	6	100ppb	102.74	2.23	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	3%	No
10/13/2009 2:14 PM	CalStd	7	700ppb	699.51	0.49	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes

10/13/2009 2:16 PM	Sample		35a2tw	14.91	1.99	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 2:19 PM	Sample		7a2tw	30.06	0.81	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 2:21 PM	Sample		35b2tw	16.61	0.69	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 2:23 PM	Sample		35b1hp	30.39	1.75	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 2:26 PM	Sample		35a1hp	16.01	2.09	water131009.xls	3	Lahore	Water	FALSE		No	FALSE		
10/13/2009 2:28 PM	CalBlk	1	blk	0.00	N/A	water131009.xls	3	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
10/13/2009 2:30 PM	CalStd	2	1ppb	1.06	3.91	water131009.xls	3	Lahore	Water	TRUE	1	Yes	FALSE	6%	No
10/13/2009 2:33 PM	CalStd	3	5ppb	5.04	2.46	water131009.xls	3	Lahore	Water	TRUE	5	Yes	FALSE	1%	Yes
10/13/2009 2:35 PM	CalStd	4	10ppb	9.94	3.22	water131009.xls	3	Lahore	Water	TRUE	10	Yes	FALSE	-1%	Yes
10/13/2009 2:37 PM	CalStd	5	50ppb	51.05	1.49	water131009.xls	3	Lahore	Water	TRUE	50	Yes	FALSE	2%	No
10/13/2009 2:40 PM	CalStd	6	100ppb	101.87	0.48	water131009.xls	3	Lahore	Water	TRUE	100	Yes	FALSE	2%	No
10/13/2009 2:42 PM	CalStd	7	700ppb	699.66	0.09	water131009.xls	3	Lahore	Water	TRUE	700	Yes	FALSE	0%	Yes
7/15/2009 10:03 AM	CalBlk	1	blk	0.01	20.77	water15709.xls	4	Lahore	Water	FALSE	0	Yes	FALSE		No
7/15/2009 10:06 AM	CalStd	2	1ppb	1.29	1.63	water15709.xls	4	Lahore	Water	TRUE	1	Yes	FALSE	29%	No
7/15/2009 10:08 AM	CalStd	3	5ppb	7.60	1.97	water15709.xls	4	Lahore	Water	TRUE	5	Yes	FALSE	52%	No
7/15/2009 10:11 AM	CalStd	4	10ppb	15.67	1.03	water15709.xls	4	Lahore	Water	TRUE	10	Yes	FALSE	57%	No
7/15/2009 10:13 AM	CalStd	5	50ppb	57.47	0.70	water15709.xls	4	Lahore	Water	TRUE	50	Yes	FALSE	15%	No
7/15/2009 10:16 AM	CalStd	6	100ppb	104.99	0.77	water15709.xls	4	Lahore	Water	TRUE	100	Yes	FALSE	5%	No
7/15/2009 10:18 AM	CalStd	7	640ppb	638.53	0.47	water15709.xls	4	Lahore	Water	TRUE	640	Yes	FALSE	0%	Yes
7/15/2009 10:21 AM	Sample			305.48	2.30	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:23 AM	Sample			299.59	0.58	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:26 AM	Sample			997.00	1.23	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:29 AM	Sample			1006.93	1.18	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		

7/15/2009 10:31 AM	Sample			27.99	0.47	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:34 AM	Sample			27.92	0.35	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:36 AM	Sample			60.72	0.48	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:39 AM	Sample			60.57	0.31	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:41 AM	Sample			0.64	1.73	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:44 AM	Sample			0.59	3.11	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 10:46 AM	CalBlk	1	blk	0.05	13.39	water15709.xls	4	Lahore	Water	FALSE	0	Yes	FALSE		No
7/15/2009 10:49 AM	CalStd	2	1ppb	1.38	1.15	water15709.xls	4	Lahore	Water	TRUE	1	Yes	FALSE	38%	No
7/15/2009 10:51 AM	CalStd	3	5ppb	8.13	1.05	water15709.xls	4	Lahore	Water	TRUE	5	Yes	FALSE	63%	No
7/15/2009 10:54 AM	CalStd	4	10ppb	16.44	0.26	water15709.xls	4	Lahore	Water	TRUE	10	Yes	FALSE	64%	No
7/15/2009 10:57 AM	CalStd	5	50ppb	59.00	0.45	water15709.xls	4	Lahore	Water	TRUE	50	Yes	FALSE	18%	No
7/15/2009 10:59 AM	CalStd	6	100ppb	107.43	0.19	water15709.xls	4	Lahore	Water	TRUE	100	Yes	FALSE	7%	No
7/15/2009 11:02 AM	CalStd	7	640ppb	646.60	0.39	water15709.xls	4	Lahore	Water	TRUE	640	Yes	FALSE	1%	No
7/15/2009 11:04 AM	Sample			21.20	2.29	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:07 AM	Sample			32.09	0.88	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:09 AM	Sample			1.58	1.44	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:12 AM	Sample			1.93	0.34	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:14 AM	Sample			7.69	1.61	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:17 AM	Sample			7.49	0.61	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:20 AM	Sample			8.44	0.95	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:22 AM	Sample			7.87	0.26	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:25 AM	Sample			14.52	1.36	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:27 AM	Sample			14.68	1.31	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		

7/15/2009 11:30 AM	CalBlk	1	blk	0.03	3.40	water15709.xls	4	Lahore	Water	FALSE	0	Yes	FALSE		No
7/15/2009 11:32 AM	CalStd	2	1ppb	1.32	2.40	water15709.xls	4	Lahore	Water	TRUE	1	Yes	FALSE	32%	No
7/15/2009 11:35 AM	CalStd	3	5ppb	7.98	0.72	water15709.xls	4	Lahore	Water	TRUE	5	Yes	FALSE	60%	No
7/15/2009 11:37 AM	CalStd	4	10ppb	16.45	0.60	water15709.xls	4	Lahore	Water	TRUE	10	Yes	FALSE	64%	No
7/15/2009 11:40 AM	CalStd	5	50ppb	59.76	0.50	water15709.xls	4	Lahore	Water	TRUE	50	Yes	FALSE	20%	No
7/15/2009 11:43 AM	CalStd	6	100ppb	107.02	0.37	water15709.xls	4	Lahore	Water	TRUE	100	Yes	FALSE	7%	No
7/15/2009 11:45 AM	CalStd	7	640ppb	638.09	0.27	water15709.xls	4	Lahore	Water	TRUE	640	Yes	FALSE	0%	No
7/15/2009 11:48 AM	Sample			100.04	2.61	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:50 AM	Sample			106.37	0.25	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:53 AM	Sample			9.01	0.72	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:55 AM	Sample			8.87	0.45	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 11:58 AM	Sample			20.91	1.62	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:00 PM	Sample			21.00	0.78	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:03 PM	Sample			23.61	0.93	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:06 PM	Sample			222.52	1.27	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:08 PM	Sample			39.67	1.40	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:11 PM	Sample			40.82	1.17	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:13 PM	CalBlk	1	blk	0.05	12.87	water15709.xls	4	Lahore	Water	FALSE	0	Yes	FALSE		No
7/15/2009 12:16 PM	CalStd	2	1ppb	1.34	1.53	water15709.xls	4	Lahore	Water	TRUE	1	Yes	FALSE	34%	No
7/15/2009 12:18 PM	CalStd	3	5ppb	7.92	0.76	water15709.xls	4	Lahore	Water	TRUE	5	Yes	FALSE	58%	No
7/15/2009 12:21 PM	CalStd	4	10ppb	16.19	0.36	water15709.xls	4	Lahore	Water	TRUE	10	Yes	FALSE	62%	No
7/15/2009 12:23 PM	CalStd	5	50ppb	58.76	0.22	water15709.xls	4	Lahore	Water	TRUE	50	Yes	FALSE	18%	No
7/15/2009 12:26 PM	CalStd	6	100ppb	106.34	0.16	water15709.xls	4	Lahore	Water	TRUE	100	Yes	FALSE	6%	No

7/15/2009 12:28 PM	CalStd	7	640ppb	643.05	0.22	water15709.xls	4	Lahore	Water	TRUE	640	Yes	FALSE	0%	No
7/15/2009 12:31 PM	Sample			12.36	3.44	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:34 PM	Sample			12.02	0.94	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:36 PM	Sample			0.95	5.31	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:39 PM	Sample			0.92	3.46	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:41 PM	Sample			75.45	1.17	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:44 PM	Sample			85.00	0.71	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:46 PM	Sample			31.71	1.03	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:49 PM	Sample			31.77	0.78	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:51 PM	Sample			45.45	0.70	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:54 PM	Sample			45.18	1.15	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 12:56 PM	CalBlk	1	blk	0.04	5.94	water15709.xls	4	Lahore	Water	FALSE	0	Yes	FALSE		No
7/15/2009 12:59 PM	CalStd	2	1ppb	1.32	1.08	water15709.xls	4	Lahore	Water	TRUE	1	Yes	FALSE	32%	No
7/15/2009 1:01 PM	CalStd	3	5ppb	7.89	0.82	water15709.xls	4	Lahore	Water	TRUE	5	Yes	FALSE	58%	No
7/15/2009 1:04 PM	CalStd	4	10ppb	16.25	0.62	water15709.xls	4	Lahore	Water	TRUE	10	Yes	FALSE	63%	No
7/15/2009 1:07 PM	CalStd	5	50ppb	59.12	0.21	water15709.xls	4	Lahore	Water	TRUE	50	Yes	FALSE	18%	No
7/15/2009 1:09 PM	CalStd	6	100ppb	106.54	0.27	water15709.xls	4	Lahore	Water	TRUE	100	Yes	FALSE	7%	No
7/15/2009 1:12 PM	CalStd	7	640ppb	638.05	0.22	water15709.xls	4	Lahore	Water	TRUE	640	Yes	FALSE	0%	No
7/15/2009 1:14 PM	Sample			562.16	1.74	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:17 PM	Sample			540.86	0.63	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:19 PM	Sample			150.41	0.70	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:22 PM	Sample			152.79	0.93	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:24 PM	Sample			194.02	0.87	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:27 PM	Sample			362.73	0.21	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:30 PM	Sample			364.11	0.52	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:32 PM	Sample			47.74	0.60	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:35 PM	Sample			47.08	0.33	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		

7/15/2009 1:37 PM	Sample			188.72	0.70	water15709.xls	4	Lahore	Water	FALSE		No	FALSE		
7/15/2009 1:40 PM	Sample		crm	28.19	0.49	water15709.xls	4	Lahore	Water	FALSE		No	TRUE		
7/15/2009 1:43 PM	CalBlk	1	blk	0.08	9.03	water15709.xls	4	Lahore	Water	FALSE	0	Yes	FALSE		No
7/15/2009 1:45 PM	CalStd	2	1ppb	1.32	4.85	water15709.xls	4	Lahore	Water	TRUE	1	Yes	FALSE	32%	No
7/15/2009 1:48 PM	CalStd	3	5ppb	7.93	0.46	water15709.xls	4	Lahore	Water	TRUE	5	Yes	FALSE	59%	No
7/15/2009 1:51 PM	CalStd	4	10ppb	16.31	0.41	water15709.xls	4	Lahore	Water	TRUE	10	Yes	FALSE	63%	No
7/15/2009 1:53 PM	CalStd	5	50ppb	58.61	0.42	water15709.xls	4	Lahore	Water	TRUE	50	Yes	FALSE	17%	No
7/15/2009 1:56 PM	CalStd	6	100ppb	106.87	0.12	water15709.xls	4	Lahore	Water	TRUE	100	Yes	FALSE	7%	No
7/15/2009 1:58 PM	CalStd	7	640ppb	644.94	0.58	water15709.xls	4	Lahore	Water	TRUE	640	Yes	FALSE	1%	No
7/20/2009 10:24	CalBlk	1	Blnk	0.00	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 10:26	CalStd	2	1ppb	1.63	15.50	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	63%	No
7/20/2009 10:29	CalStd	3	5ppb	5.48	8.70	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	9%	Yes
7/20/2009 10:31	CalStd	4	10ppb	10.67	5.20	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	7%	No
7/20/2009 10:33	CalStd	5	50ppb	51.20	0.20	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	2%	No
7/20/2009 10:36	CalStd	6	100ppb	99.30	1.40	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	-1%	Yes
7/20/2009 10:40	Sample			294.89	0.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:43	Sample			297.56	0.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:45	Sample			950.23	0.80	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:47	Sample			969.48	0.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:49	Sample			27.19	1.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:52	Sample			26.84	3.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:54	Sample			61.30	1.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:56	Sample			61.17	1.50	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 10:59	Sample			<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:01	Sample			<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:03	CalBlk	1	blk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 11:06	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 11:08	CalStd	3	5ppb	3.03	5.10	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-39%	No
7/20/2009 11:10	CalStd	4	10ppb	8.67	1.80	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-13%	No
7/20/2009 11:12	CalStd	5	50ppb	51.69	1.70	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	3%	No
7/20/2009 11:15	CalStd	6	100ppb	101.61	2.30	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	2%	Yes
7/20/2009 11:19	Sample			19.96	1.10	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:22	Sample			25.76	0.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		

7/20/2009 11:24	Sample			<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:26	Sample			<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:29	Sample			5.84	1.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:31	Sample			5.82	3.50	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:33	Sample			6.49	1.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:36	Sample			6.03	10.00	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:38	Sample			13.12	1.70	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:40	Sample			13.32	0.40	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 11:43	CalBlk	1	blnk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 11:45	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 11:47	CalStd	3	5ppb	2.49	3.10	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-50%	No
7/20/2009 11:49	CalStd	4	10ppb	8.00	2.90	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-20%	No
7/20/2009 11:52	CalStd	5	50ppb	50.92	1.10	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	2%	No
7/20/2009 11:54	CalStd	6	100ppb	101.67	1.70	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	2%	Yes
7/20/2009 11:59	Sample			101.91	0.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:01	Sample			108.15	0.80	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:03	Sample			6.08	3.50	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:06	Sample			6.39	0.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:08	Sample			17.82	1.00	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:10	Sample			18.65	1.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:13	Sample			21.45	1.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:15	Sample			217.69	0.40	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:17	Sample			35.23	1.50	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:19	Sample			36.87	1.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:22	CalBlk	1	blnk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 12:24	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 12:26	CalStd	3	5ppb	2.37	8.10	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-53%	No
7/20/2009 12:29	CalStd	4	10ppb	8.21	3.30	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-18%	No
7/20/2009 12:31	CalStd	5	50ppb	51.53	0.80	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	3%	No
7/20/2009 12:33	CalStd	6	100ppb	102.87	0.50	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	3%	No
7/20/2009 12:38	Sample			9.57	5.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:40	Sample			9.06	2.10	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:43	Sample			<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		

7/20/2009 12:45	Sample			<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:47	Sample			74.11	2.40	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:49	Sample			83.12	0.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:52	Sample			28.08	1.10	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:54	Sample			28.56	0.40	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:56	Sample			41.49	0.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 12:59	Sample			40.82	1.80	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:01	CalBlk	1	blnk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 13:03	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 13:06	CalStd	3	5ppb	2.15	4.00	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-57%	No
7/20/2009 13:08	CalStd	4	10ppb	7.96	3.10	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-20%	No
7/20/2009 13:10	CalStd	5	50ppb	51.27	1.00	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	3%	No
7/20/2009 13:13	CalStd	6	100ppb	102.48	1.50	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	2%	No
7/20/2009 13:17	Sample			531.27	1.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:20	Sample			539.68	0.50	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:22	Sample			140.40	0.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:24	Sample			138.19	0.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:26	Sample			183.94	1.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:29	Sample			360.21	0.40	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:31	Sample			352.36	0.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:33	Sample			41.98	1.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:36	Sample			41.16	0.40	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:38	Sample			178.42	0.10	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 13:40	Sample		crm	26.15	0.40	water207009.xls	5	Lahore	Water	FALSE		No	TRUE		
7/20/2009 13:43	CalBlk	1	Blnk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 13:45	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 13:47	CalStd	3	5ppb	1.75	1.70	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-65%	No
7/20/2009 13:50	CalStd	4	10ppb	7.44	2.50	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-26%	No
7/20/2009 13:52	CalStd	5	50ppb	48.74	1.10	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	-3%	No
7/20/2009 13:54	CalStd	6	100ppb	99.29	0.80	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	-1%	Yes
7/20/2009 13:59	Sample			18.70	1.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:01	Sample			19.02	3.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:04	Sample			21.98	2.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		

7/20/2009 14:06	Sample			19.59	1.00	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:08	Sample			23.79	1.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:11	Sample			23.78	0.70	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:13	Sample			11.49	6.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:15	Sample			13.38	2.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:17	Sample			16.45	2.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:20	Sample			26.36	1.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:22	CalBlk	1	Blnk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 14:24	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 14:27	CalStd	3	5ppb	1.50	2.40	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-70%	No
7/20/2009 14:29	CalStd	4	10ppb	6.91	1.30	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-31%	No
7/20/2009 14:31	CalStd	5	50ppb	47.71	1.50	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	-5%	No
7/20/2009 14:34	CalStd	6	100ppb	94.39	1.50	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	-6%	No
7/20/2009 14:38	Sample			13.93	1.80	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:41	Sample			13.41	0.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:43	Sample			21.02	1.70	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:45	Sample			19.69	0.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:47	Sample			15.43	2.10	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:50	Sample			15.34	3.70	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:52	Sample			26.05	2.10	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:54	Sample			26.51	2.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:57	Sample			27.78	3.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 14:59	Sample			26.94	0.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:01	CalBlk	1	Blnk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 15:04	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 15:06	CalStd	3	5ppb	1.69	13.40	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-66%	No
7/20/2009 15:08	CalStd	4	10ppb	6.86	2.10	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-31%	No
7/20/2009 15:11	CalStd	5	50ppb	47.48	2.40	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	-5%	No
7/20/2009 15:13	CalStd	6	100ppb	94.14	1.00	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	-6%	No
7/20/2009 15:18	Sample			8.00	4.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:20	Sample			7.04	1.30	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:22	Sample			3.53	8.50	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:25	Sample			3.22	7.90	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		

7/20/2009 15:27	Sample			0.03	#####	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:29	Sample			0.09	#####	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:32	Sample			0.85	4.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:34	Sample			1.18	12.20	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:36	Sample			27.61	1.40	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:38	Sample			24.84	1.60	water207009.xls	5	Lahore	Water	FALSE		No	FALSE		
7/20/2009 15:41	CalBlk	1	Blnk	<0.000	N/A	water207009.xls	5	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/20/2009 15:43	CalStd	2	1ppb	<0.000	N/A	water207009.xls	5	Lahore	Water	TRUE	1	Yes	FALSE	#####	#VALUE!
7/20/2009 15:45	CalStd	3	5ppb	1.31	20.10	water207009.xls	5	Lahore	Water	TRUE	5	Yes	FALSE	-74%	No
7/20/2009 15:48	CalStd	4	10ppb	6.68	4.80	water207009.xls	5	Lahore	Water	TRUE	10	Yes	FALSE	-33%	No
7/20/2009 15:50	CalStd	5	50ppb	45.78	0.70	water207009.xls	5	Lahore	Water	TRUE	50	Yes	FALSE	-8%	No
7/20/2009 15:52	CalStd	6	100ppb	91.69	0.50	water207009.xls	5	Lahore	Water	TRUE	100	Yes	FALSE	-8%	No
7/16/2009 11:30 AM	CalBlk	1	Blnk	0.00	N/A	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/16/2009 11:32 AM	CalStd	2	1ppb	1.00	8.78	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	0%	Yes
7/16/2009 11:34 AM	CalStd	3	5ppb	5.41	0.98	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	8%	No
7/16/2009 11:37 AM	CalStd	4	10ppb	11.10	1.65	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	11%	No
7/16/2009 11:39 AM	CalStd	5	50ppb	53.24	1.37	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	6%	No
7/16/2009 11:41 AM	CalStd	6	100ppb	98.25	0.29	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	-2%	No
7/16/2009 11:46 AM	Sample		I7a	84.63	1.00	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 11:48 AM	Sample		I7b	86.71	1.60	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 11:51 AM	Sample		I17a	70.04	0.55	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 11:53 AM	Sample		I17b	69.46	1.58	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 11:55 AM	Sample		I8a	2.41	2.81	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 11:58 AM	Sample		I8b	2.30	5.30	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:00 PM	Sample		I9a	34.98	0.46	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:02 PM	Sample		I9b	36.09	1.42	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:05	Sample		I10a	10.90	6.00	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		

PM															
7/16/2009 12:07 PM	Sample		I10b	11.09	2.11	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:09 PM	CalBlk	1	Blnk	0.01	65.47	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		No
7/16/2009 12:12 PM	CalStd	2	1ppb	0.97	5.72	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	-3%	Yes
7/16/2009 12:14 PM	CalStd	3	5ppb	5.30	3.77	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	6%	No
7/16/2009 12:16 PM	CalStd	4	10ppb	10.76	1.37	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	8%	No
7/16/2009 12:18 PM	CalStd	5	50ppb	55.71	1.13	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	11%	No
7/16/2009 12:21 PM	CalStd	6	100ppb	102.71	0.62	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	3%	No
7/16/2009 12:25 PM	Sample		I11a	1.80	2.72	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:28 PM	Sample		I11b	2.85	4.34	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:30 PM	Sample		I12a	16.51	1.37	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:32 PM	Sample		I12b	17.52	2.26	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:35 PM	Sample		I13a	2.23	11.27	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:37 PM	Sample		I13b	2.35	6.52	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:39 PM	Sample		I14a	4.71	2.07	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:42 PM	Sample		I14b	4.86	5.18	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:44 PM	Sample		IA1(said.M)a	484.53	0.40	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:46 PM	Sample		IA1(said.M)b	464.80	0.61	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 12:48 PM	CalBlk	1	Blnk	0.15	8.22	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		No
7/16/2009 12:51 PM	CalStd	2	1ppb	1.15	3.67	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	15%	No
7/16/2009 12:53 PM	CalStd	3	5ppb	5.69	2.57	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	14%	No
7/16/2009 12:55 PM	CalStd	4	10ppb	11.37	0.85	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	14%	No
7/16/2009 12:58 PM	CalStd	5	50ppb	57.20	1.22	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	14%	No

7/16/2009 1:00 PM	CalStd	6	100ppb	104.46	0.82	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	4%	No
7/16/2009 1:05 PM	Sample		M1a	39.98	2.29	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:07 PM	Sample		M1b	39.51	0.62	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:09 PM	Sample		M2a	7.03	7.29	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:12 PM	Sample		M2b	10.98	2.90	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:14 PM	Sample		M3a	39.22	1.04	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:16 PM	Sample		M3b	39.59	3.18	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:19 PM	Sample		M4a	45.57	1.15	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:21 PM	Sample		M4b	45.55	1.42	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:23 PM	Sample		M5a	5.51	3.52	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:26 PM	Sample		M5b	5.53	2.22	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:28 PM	CalBlk	1	Blnk	<0.000	N/A	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/16/2009 1:30 PM	CalStd	2	1ppb	1.02	6.23	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	2%	Yes
7/16/2009 1:32 PM	CalStd	3	5ppb	5.18	0.95	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	4%	No
7/16/2009 1:35 PM	CalStd	4	10ppb	10.49	1.21	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	5%	No
7/16/2009 1:37 PM	CalStd	5	50ppb	53.93	0.32	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	8%	No
7/16/2009 1:39 PM	CalStd	6	100ppb	101.89	0.66	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	2%	No
7/16/2009 1:44 PM	Sample		M6a	23.44	2.69	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:46 PM	Sample		M6b	26.86	1.07	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:49 PM	Sample		M7a	18.18	2.36	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:51 PM	Sample		M7b	19.99	1.01	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:53 PM	Sample		M8a Tw	6.98	1.94	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:56 PM	Sample		M8b Tw	6.59	4.31	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 1:58 PM	Sample		P1a	33.65	2.10	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:00 PM	Sample		P1b	33.63	0.29	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:03 PM	Sample		P2a	7.27	5.65	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:05 PM	Sample		P2b	7.39	1.44	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:07 PM	CalBlk	1	Blnk	<0.000	N/A	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/16/2009 2:10 PM	CalStd	2	1ppb	1.04	3.50	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	4%	No
7/16/2009 2:12 PM	CalStd	3	5ppb	5.58	3.12	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	12%	No
7/16/2009 2:15 PM	CalStd	4	10ppb	11.19	2.86	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	12%	No
7/16/2009 2:18 PM	CalStd	5	50ppb	56.20	0.69	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	12%	No
7/16/2009 2:20 PM	CalStd	6	100ppb	103.91	2.45	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	4%	No

7/16/2009 2:24 PM	Sample		P3a	6.34	7.19	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:27 PM	Sample		P3b	6.33	1.09	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:29 PM	Sample		P4a	25.04	1.41	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:31 PM	Sample		P4b	26.22	2.95	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:34 PM	Sample		P5a	447.54	0.47	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:36 PM	Sample		P5b	438.48	0.40	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:38 PM	Sample		P6a	22.80	1.95	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:41 PM	Sample		P6b	20.88	1.16	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:43 PM	Sample		P7a	1.37	5.08	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:45 PM	Sample		P7b	1.25	4.43	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 2:48 PM	CalBlk	1	Blnk	<0.000	N/A	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/16/2009 2:50 PM	CalStd	2	1ppb	1.02	5.15	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	2%	Yes
7/16/2009 2:52 PM	CalStd	3	5ppb	5.33	0.85	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	7%	No
7/16/2009 2:55 PM	CalStd	4	10ppb	10.78	1.08	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	8%	No
7/16/2009 2:57 PM	CalStd	5	50ppb	54.47	1.67	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	9%	No
7/16/2009 2:59 PM	CalStd	6	100ppb	101.26	0.41	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	1%	No
7/16/2009 3:04 PM	Sample		P8a hp	9.71	0.91	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:06 PM	Sample		P8b hp	10.01	5.05	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:08 PM	Sample		P8a motr	22.55	3.79	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:11 PM	Sample		P8b motr	21.68	1.74	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:13 PM	Sample		P9a	3.32	2.14	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:15 PM	Sample		P9b	3.48	4.58	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:18 PM	Sample		P10a hp	2.95	3.27	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:20 PM	Sample		P10b hp	3.07	4.48	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:22 PM	Sample		P10a bore	7.02	2.25	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:25 PM	Sample		P10b bore	7.05	0.53	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:27 PM	CalBlk	1	Blnk	<0.000	N/A	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		#VALUE!
7/16/2009 3:29 PM	CalStd	2	1ppb	1.06	8.13	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	6%	Yes
7/16/2009 3:32 PM	CalStd	3	5ppb	5.36	1.66	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	7%	No
7/16/2009 3:34 PM	CalStd	4	10ppb	10.60	4.56	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	6%	No
7/16/2009 3:36 PM	CalStd	5	50ppb	54.65	0.19	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	9%	No
7/16/2009 3:39 PM	CalStd	6	100ppb	100.30	1.25	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	0%	Yes
7/16/2009 3:43 PM	Sample		P11a	110.38	0.72	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		

7/16/2009 3:43 PM	Sample		P11b	111.77	1.27	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		P13a	9.08	0.17	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		P13b	8.97	0.12	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		P12a	2.05	0.07	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		P12b	3.00	0.12	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		Rtw8 a	13.87	0.43	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		Rtw8 b	12.62	0.20	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L0 a	10.64	0.17	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L0 b	10.86	0.23	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	CalBlk	1	Blnk	0.00	0.00	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		No
7/16/2009 3:43 PM	CalStd	2	1ppb	0.94	0.13	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	-6%	No
7/16/2009 3:43 PM	CalStd	3	5ppb	5.20	0.19	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	4%	No
7/16/2009 3:43 PM	CalStd	4	10ppb	10.58	0.16	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	6%	No
7/16/2009 3:43 PM	CalStd	5	50ppb	53.79	0.24	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	8%	No
7/16/2009 3:43 PM	CalStd	6	100ppb	97.91	1.14	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	-2%	No
7/16/2009 3:43 PM	Sample		Ktw a	13.71	0.43	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		Ktw b	12.18	0.10	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		Eme a	178.39	0.85	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		Eme b	185.56	2.45	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L1a	23.05	0.16	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L1b	22.42	0.14	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L2a	23.46	0.66	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L2b	23.55	0.33	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L3a	22.64	0.70	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	Sample		L3b	22.63	0.54	WaterAs167009.xls	6	Lahore	Water	FALSE		No	FALSE		
7/16/2009 3:43 PM	CRM 1640		crm	27.26	0.23	WaterAs167009.xls	6	Lahore	Water	FALSE		No	TRUE		
7/16/2009 3:43 PM	CalBlk	1	Blnk	0.01	0.01	WaterAs167009.xls	6	Lahore	Water	FALSE	0	Yes	FALSE		No
7/16/2009 3:43 PM	CalStd	2	1ppb	0.89	0.02	WaterAs167009.xls	6	Lahore	Water	TRUE	1	Yes	FALSE	-11%	No
7/16/2009 3:43 PM	CalStd	3	5ppb	4.83	0.16	WaterAs167009.xls	6	Lahore	Water	TRUE	5	Yes	FALSE	-3%	No
7/16/2009 3:43 PM	CalStd	4	10ppb	9.73	0.27	WaterAs167009.xls	6	Lahore	Water	TRUE	10	Yes	FALSE	-3%	No
7/16/2009 3:43 PM	CalStd	5	50ppb	49.33	0.78	WaterAs167009.xls	6	Lahore	Water	TRUE	50	Yes	FALSE	-1%	No
7/16/2009 3:43 PM	CalStd	6	100ppb	93.24	1.20	WaterAs167009.xls	6	Lahore	Water	TRUE	100	Yes	FALSE	-7%	No
4/6/2011 11:41 AM	CalBlk	1	blank	<0.010	N/A	SKt6411.xls	7	Lahore	Urine	FALSE	0	Yes	FALSE		#VALUE!

4/6/2011 11:44 AM	CalStd	2	1ppb	1.05	2.84	SKt6411.xls	7	Lahore	Urine	TRUE	1	Yes	FALSE	5%	No
4/6/2011 11:47 AM	CalStd	3	5ppb	5.05	0.47	SKt6411.xls	7	Lahore	Urine	TRUE	5	Yes	FALSE	1%	No
4/6/2011 11:50 AM	CalStd	4	10ppb	10.22	1.15	SKt6411.xls	7	Lahore	Urine	TRUE	10	Yes	FALSE	2%	No
4/6/2011 11:52 AM	CalStd	5	50ppb	49.98	0.83	SKt6411.xls	7	Lahore	Urine	TRUE	50	Yes	FALSE	0%	Yes
4/6/2011 11:55 AM	CalStd	6	100ppb	100.18	0.55	SKt6411.xls	7	Lahore	Urine	TRUE	100	Yes	FALSE	0%	Yes
4/6/2011 11:58 AM	Sample		wash	0.02	7.99	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:00 PM	Sample		1	4.84	1.46	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:03 PM	Sample		2	24.14	1.25	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:06 PM	Sample		3	20.15	1.74	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:09 PM	Sample		4	14.46	1.29	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:11 PM	Sample		5	10.13	1.37	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:14 PM	Sample		6	13.18	0.84	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:17 PM	Sample		7	2.60	1.67	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:19 PM	Sample		8	30.90	1.04	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:22 PM	Sample		9	307.33	0.40	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:25 PM	Sample		10	110.72	0.85	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:27 PM	CalBlk	1	blank	<0.013	N/A	SKt6411.xls	7	Lahore	Urine	FALSE	0	Yes	FALSE		#VALUE!
4/6/2011 12:30 PM	CalStd	2	1ppb	1.00	1.72	SKt6411.xls	7	Lahore	Urine	TRUE	1	Yes	FALSE	0%	Yes
4/6/2011 12:33 PM	CalStd	3	5ppb	4.95	0.98	SKt6411.xls	7	Lahore	Urine	TRUE	5	Yes	FALSE	-1%	Yes
4/6/2011 12:36 PM	CalStd	4	10ppb	10.06	0.88	SKt6411.xls	7	Lahore	Urine	TRUE	10	Yes	FALSE	1%	Yes
4/6/2011 12:38 PM	CalStd	5	50ppb	49.12	0.22	SKt6411.xls	7	Lahore	Urine	TRUE	50	Yes	FALSE	-2%	No
4/6/2011 12:41 PM	CalStd	6	100ppb	100.44	0.79	SKt6411.xls	7	Lahore	Urine	TRUE	100	Yes	FALSE	0%	Yes
4/6/2011 12:44 PM	Sample		wash	<0.013	N/A	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:46 PM	Sample		11	172.43	0.85	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:49 PM	Sample		12	3.73	0.40	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:52 PM	Sample		13	28.22	1.45	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:55 PM	Sample		14	1.83	0.71	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 12:57 PM	Sample		15	20.87	0.93	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:00 PM	Sample		16	50.69	1.30	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:03 PM	Sample		17	33.68	0.33	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:05 PM	Sample		18	84.54	1.07	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:08 PM	Sample		19	109.89	0.88	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:11 PM	Sample		20	13.18	0.35	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		

4/6/2011 1:14 PM	CalBlk	1	blank	<0.010	N/A	SKt6411.xls	7	Lahore	Urine	FALSE	0	Yes	FALSE		#VALUE!
4/6/2011 1:16 PM	CalStd	2	1ppb	0.98	1.92	SKt6411.xls	7	Lahore	Urine	TRUE	1	Yes	FALSE	-2%	No
4/6/2011 1:19 PM	CalStd	3	5ppb	4.95	1.90	SKt6411.xls	7	Lahore	Urine	TRUE	5	Yes	FALSE	-1%	Yes
4/6/2011 1:22 PM	CalStd	4	10ppb	10.02	0.73	SKt6411.xls	7	Lahore	Urine	TRUE	10	Yes	FALSE	0%	Yes
4/6/2011 1:24 PM	CalStd	5	50ppb	49.59	0.56	SKt6411.xls	7	Lahore	Urine	TRUE	50	Yes	FALSE	-1%	No
4/6/2011 1:27 PM	CalStd	6	100ppb	100.21	0.74	SKt6411.xls	7	Lahore	Urine	TRUE	100	Yes	FALSE	0%	Yes
4/6/2011 1:30 PM	Sample		wash	<0.010	#####	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:33 PM	Sample		21	63.88	0.38	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:35 PM	Sample		22	85.90	0.89	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:38 PM	Sample		23	51.49	1.37	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:41 PM	Sample		b1	0.05	8.71	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:44 PM	Sample		b2	<0.010	56.55	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:46 PM	Sample		2dup	24.28	0.95	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:49 PM	Sample		3dup	18.89	0.74	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:52 PM	Sample		neis18crm	30.36	1.74	SKt6411.xls	7	Lahore	Urine	FALSE		No	TRUE		
4/6/2011 1:54 PM	Sample		5dup	9.72	1.25	SKt6411.xls	7	Lahore	Urine	FALSE		No	FALSE		
4/6/2011 1:57 PM	CalBlk	1	blank	<0.007	N/A	SKt6411.xls	7	Lahore	Urine	FALSE	0	Yes	FALSE		#VALUE!
4/6/2011 2:00 PM	CalStd	2	1ppb	1.04	4.65	SKt6411.xls	7	Lahore	Urine	TRUE	1	Yes	FALSE	4%	Yes
4/6/2011 2:02 PM	CalStd	3	5ppb	5.05	0.33	SKt6411.xls	7	Lahore	Urine	TRUE	5	Yes	FALSE	1%	No
4/6/2011 2:05 PM	CalStd	4	10ppb	10.31	0.71	SKt6411.xls	7	Lahore	Urine	TRUE	10	Yes	FALSE	3%	No
4/6/2011 2:08 PM	CalStd	5	50ppb	50.11	1.23	SKt6411.xls	7	Lahore	Urine	TRUE	50	Yes	FALSE	0%	Yes
4/6/2011 2:11 PM	CalStd	6	100ppb	99.91	0.77	SKt6411.xls	7	Lahore	Urine	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 9:48 AM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 9:50 AM	CalStd	2	1ppb	1.04	2.19	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	4%	No
10/12/2009 9:53 AM	CalStd	3	5ppb	4.99	0.68	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	0%	Yes
10/12/2009 9:56 AM	CalStd	4	10ppb	10.05	0.70	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	0%	Yes
10/12/2009 9:58 AM	CalStd	5	50ppb	50.52	1.20	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	1%	Yes
10/12/2009 10:01 AM	CalStd	6	100ppb	99.73	0.96	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 10:03 AM	Sample		k1	38.07	0.95	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:06	Sample		k2	34.81	2.08	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		

AM															
10/12/2009 10:08 AM	Sample		k3	5.73	1.47	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:11 AM	Sample		k4	11.28	0.94	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:13 AM	Sample		k5	9.68	1.91	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:16 AM	Sample		k6	7.83	2.40	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:19 AM	Sample		k7	0.56	4.30	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:21 AM	Sample		k8	1.57	2.66	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:24 AM	Sample		k9	0.42	1.64	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:26 AM	Sample		k13	3.65	0.60	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:29 AM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 10:31 AM	CalStd	2	1ppb	1.04	1.40	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	4%	No
10/12/2009 10:34 AM	CalStd	3	5ppb	5.09	1.20	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	2%	No
10/12/2009 10:36 AM	CalStd	4	10ppb	10.10	0.47	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	1%	No
10/12/2009 10:39 AM	CalStd	5	50ppb	51.42	1.10	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	3%	No
10/12/2009 10:41 AM	CalStd	6	100ppb	99.27	1.03	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	-1%	Yes
10/12/2009 10:44 AM	Sample		k14	3.56	2.93	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:47 AM	Sample		k15	3.47	0.87	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:49 AM	Sample		k16	6.33	0.83	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:52 AM	Sample		k17b	0.83	0.10	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:54 AM	Sample		k2m male	32.35	1.18	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:57 AM	Sample		ka2	4.27	0.93	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 10:59 AM	Sample		kwd	5.82	2.20	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:02 AM	Sample		l1a	1.39	3.03	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		

10/12/2009 11:04 AM	Sample		l1b	1.96	2.69	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:07 AM	Sample		l2	0.75	3.07	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:10 AM	Sample		l3	4.18	2.25	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:12 AM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 11:15 AM	CalStd	2	1ppb	1.02	0.59	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	2%	No
10/12/2009 11:17 AM	CalStd	3	5ppb	4.97	1.66	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-1%	Yes
10/12/2009 11:20 AM	CalStd	4	10ppb	10.01	1.25	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	0%	Yes
10/12/2009 11:22 AM	CalStd	5	50ppb	50.01	1.17	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	0%	Yes
10/12/2009 11:25 AM	CalStd	6	100ppb	99.99	0.62	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 11:27 AM	Sample		l4	1.38	0.87	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:30 AM	Sample		l8a	1.66	0.73	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:33 AM	Sample		l8b	2.70	2.44	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:35 AM	Sample		l9	0.53	2.29	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:38 AM	Sample		l10	2.21	2.92	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:40 AM	Sample		l11	5.66	1.19	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:43 AM	Sample		l12	1.86	2.11	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:45 AM	Sample		l13	3.15	2.09	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 11:48 AM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 11:50 AM	CalStd	2	1ppb	1.01	2.84	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	1%	Yes
10/12/2009 11:53 AM	CalStd	3	5ppb	4.94	1.96	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-1%	Yes
10/12/2009 11:55 AM	CalStd	4	10ppb	9.76	1.76	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	-2%	No
10/12/2009 11:58 AM	CalStd	5	50ppb	50.39	1.17	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	1%	Yes
10/12/2009 12:01 PM	CalStd	6	100ppb	99.83	3.39	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes

10/12/2009 12:03 PM	Sample		l14	6.32	1.19	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:06 PM	Sample		l15a	5.91	1.49	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:08 PM	Sample		l15b	5.73	6.78	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:11 PM	Sample		l16	0.65	3.34	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:13 PM	Sample		l17	1.74	3.05	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:16 PM	Sample		l18	3.12	2.21	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:19 PM	Sample		l19	0.41	5.94	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:21 PM	Sample		l21	0.37	2.42	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:24 PM	Sample		l22	4.84	2.42	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:26 PM	Sample		l23	1.30	2.86	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:29 PM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 12:31 PM	CalStd	2	1ppb	1.00	2.88	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	0%	Yes
10/12/2009 12:34 PM	CalStd	3	5ppb	4.94	1.46	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-1%	Yes
10/12/2009 12:36 PM	CalStd	4	10ppb	9.97	1.22	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	0%	Yes
10/12/2009 12:39 PM	CalStd	5	50ppb	49.93	1.63	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	0%	Yes
10/12/2009 12:41 PM	CalStd	6	100ppb	100.04	1.23	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 12:44 PM	Sample		l27	0.40	3.74	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:47 PM	Sample		l29	2.65	3.06	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:49 PM	Sample		l30	0.57	3.29	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:52 PM	Sample		l32	1.54	2.61	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:54 PM	Sample		l33	2.09	1.07	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:57 PM	Sample		l34	0.61	1.16	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 12:59 PM	Sample		m1	0.74	1.38	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		

10/12/2009 1:02 PM	Sample		m2	0.86	0.99	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:04 PM	Sample		m2	0.15	1.56	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:07 PM	Sample		m3	1.37	2.53	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:38 PM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 1:10 PM	CalStd	2	1ppb	0.94	1.50	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	-6%	No
10/12/2009 1:12 PM	CalStd	3	5ppb	4.74	0.39	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-5%	No
10/12/2009 1:15 PM	CalStd	4	10ppb	9.53	2.07	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	-5%	No
10/12/2009 1:17 PM	CalStd	5	50ppb	49.81	1.14	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	0%	Yes
10/12/2009 1:20 PM	CalStd	6	100ppb	100.16	0.66	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 1:22 PM	Sample		m4	1.47	1.59	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:25 PM	Sample		m5	1.77	1.93	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:27 PM	Sample		m6	33.47	1.02	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:30 PM	Sample		mqs	13.16	2.07	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:33 PM	Sample		i2d	15.73	1.40	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:35 PM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 1:38 PM	CalStd	2	1ppb	0.89	1.29	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	-11%	No
10/12/2009 1:40 PM	CalStd	3	5ppb	4.75	1.27	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-5%	No
10/12/2009 1:43 PM	CalStd	4	10ppb	9.54	1.42	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	-5%	No
10/12/2009 1:45 PM	CalStd	5	50ppb	49.99	0.12	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	0%	Yes
10/12/2009 1:48 PM	CalStd	6	100ppb	100.06	0.18	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 1:50 PM	Sample		i6	27.77	2.04	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:53 PM	Sample		i2a1	8.71	1.17	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 1:55 PM	Sample		i2a2	17.64	2.04	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		

10/12/2009 1:58 PM	Sample		i8	2.25	1.12	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:01 PM	Sample		i11	0.87	1.59	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:03 PM	Sample		i15	3.09	2.88	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:06 PM	Sample		i2m	4.81	0.11	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:08 PM	Sample		i9	0.74	2.76	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:11 PM	Sample		i10	4.81	2.97	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:13 PM	Sample		n25	0.25	1.77	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:16 PM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 2:18 PM	CalStd	2	1ppb	1.00	2.88	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	0%	Yes
10/12/2009 2:21 PM	CalStd	3	5ppb	4.88	2.11	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-2%	No
10/12/2009 2:25 PM	CalStd	4	10ppb	9.90	0.37	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	-1%	No
10/12/2009 2:28 PM	CalStd	5	50ppb	50.49	0.79	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	1%	No
10/12/2009 2:30 PM	CalStd	6	100ppb	99.77	1.41	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 2:33 PM	Sample		n24	0.68	2.29	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:35 PM	Sample		n23	0.91	2.31	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:38 PM	Sample		n22b	0.78	3.47	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:40 PM	Sample		n21	0.21	8.80	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:43 PM	Sample		n20b	4.37	0.69	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:46 PM	Sample		n20a	2.97	1.26	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:48 PM	Sample		n19	1.10	1.92	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:51 PM	Sample		n18	1.19	0.39	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:53 PM	Sample		n17a	0.52	4.44	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 2:56 PM	Sample		n12a	0.71	2.04	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		

10/12/2009 2:58 PM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 3:01 PM	CalStd	2	1ppb	0.99	2.12	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	-1%	Yes
10/12/2009 3:03 PM	CalStd	3	5ppb	4.94	1.76	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-1%	Yes
10/12/2009 3:06 PM	CalStd	4	10ppb	10.01	0.72	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	0%	Yes
10/12/2009 3:08 PM	CalStd	5	50ppb	50.49	0.47	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	1%	No
10/12/2009 3:11 PM	CalStd	6	100ppb	99.76	1.46	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/12/2009 3:14 PM	Sample		n26	1.51	0.40	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:16 PM	Sample		n28b	0.64	3.42	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:19 PM	Sample		r10	400.33	2.09	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:21 PM	Sample		r9	3.17	0.57	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:24 PM	Sample		r8	6.80	0.78	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:26 PM	Sample		p1	2.14	0.69	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:29 PM	Sample		p2	0.35	1.11	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:31 PM	Sample		p3	1.13	2.26	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:34 PM	Sample		p4	0.61	5.06	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:36 PM	Sample		p5	30.37	1.35	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:39 PM	CalBlk	1	blk	0.06	1.73	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		No
10/12/2009 3:42 PM	CalStd	2	1ppb	0.99	3.43	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	-1%	Yes
10/12/2009 3:44 PM	CalStd	3	5ppb	4.93	0.51	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-1%	No
10/12/2009 3:47 PM	CalStd	4	10ppb	9.80	0.12	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	-2%	No
10/12/2009 3:49 PM	CalStd	5	50ppb	49.22	0.78	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	-2%	No
10/12/2009 3:52 PM	CalStd	6	100ppb	97.61	2.38	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	-2%	No
10/12/2009 3:54 PM	Sample		p5b	20.35	0.82	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		

10/12/2009 3:57 PM	Sample		p6	0.51	2.90	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 3:59 PM	Sample		p7	20.60	2.23	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:02 PM	Sample		p8	0.83	2.15	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:04 PM	Sample		p9	4.69	2.58	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:07 PM	Sample		p11	5.85	2.50	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:10 PM	Sample		p13	1.24	0.69	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:12 PM	Sample		crm1	1.95	6.62	AsNails121009.xls	8	Mixd	Nails	FALSE		No	TRUE		
10/12/2009 4:15 PM	Sample		crm2	2.16	2.35	AsNails121009.xls	8	Mixd	Nails	FALSE		No	TRUE		
10/12/2009 4:17 PM	Sample		blank1	0.02	21.35	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:20 PM	Sample		balnk2	0.01	#####	AsNails121009.xls	8	Mixd	Nails	FALSE		No	FALSE		
10/12/2009 4:22 PM	CalBlk	1	blk	0.00	N/A	AsNails121009.xls	8	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/12/2009 4:25 PM	CalStd	2	1ppb	1.00	1.85	AsNails121009.xls	8	Mixd	Nails	TRUE	1	Yes	FALSE	0%	Yes
10/12/2009 4:27 PM	CalStd	3	5ppb	4.91	0.45	AsNails121009.xls	8	Mixd	Nails	TRUE	5	Yes	FALSE	-2%	No
10/12/2009 4:30 PM	CalStd	4	10ppb	9.86	0.87	AsNails121009.xls	8	Mixd	Nails	TRUE	10	Yes	FALSE	-1%	No
10/12/2009 4:32 PM	CalStd	5	50ppb	50.52	0.26	AsNails121009.xls	8	Mixd	Nails	TRUE	50	Yes	FALSE	1%	No
10/12/2009 4:35 PM	CalStd	6	100ppb	99.76	1.09	AsNails121009.xls	8	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/14/2009 9:30 AM	CalBlk	1	blk	0.00	N/A	AsNails141009.xls	9	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/14/2009 9:32 AM	CalStd	2	1ppb	1.00	1.85	AsNails141009.xls	9	Mixd	Nails	TRUE	1	Yes	FALSE	0%	Yes
10/14/2009 9:35 AM	CalStd	3	5ppb	4.76	1.95	AsNails141009.xls	9	Mixd	Nails	TRUE	5	Yes	FALSE	-5%	No
10/14/2009 9:37 AM	CalStd	4	10ppb	9.74	0.23	AsNails141009.xls	9	Mixd	Nails	TRUE	10	Yes	FALSE	-3%	No
10/14/2009 9:40 AM	CalStd	5	50ppb	49.28	0.39	AsNails141009.xls	9	Mixd	Nails	TRUE	50	Yes	FALSE	-1%	No
10/14/2009 9:43 AM	CalStd	6	100ppb	100.40	0.29	AsNails141009.xls	9	Mixd	Nails	TRUE	100	Yes	FALSE	0%	No
10/14/2009 9:45 AM	Sample		blank	0.03	31.38	AsNails141009.xls	9	Mixd	Nails	FALSE	0	Yes	FALSE		No

10/14/2009 9:48 AM	Sample		crm3	2.69	1.79	AsNails141009.xls	9	Mixd	Nails	FALSE		No	TRUE		
10/14/2009 9:50 AM	Sample		i1a	10.92	2.30	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 9:53 AM	Sample		i1b	7.99	1.77	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 9:55 AM	Sample		i3	4.45	2.40	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 9:58 AM	Sample		i4	31.73	1.98	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:01 AM	Sample		i7a	7.11	1.92	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:03 AM	Sample		i7b	15.65	1.68	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:06 AM	Sample		i14	1.12	1.78	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:08 AM	Sample		ka1	14.38	0.73	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:11 AM	CalBlk	1	blk	0.00	N/A	AsNails141009.xls	9	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/14/2009 10:13 AM	CalStd	2	1ppb	0.93	1.53	AsNails141009.xls	9	Mixd	Nails	TRUE	1	Yes	FALSE	-7%	No
10/14/2009 10:16 AM	CalStd	3	5ppb	4.77	0.59	AsNails141009.xls	9	Mixd	Nails	TRUE	5	Yes	FALSE	-5%	No
10/14/2009 10:18 AM	CalStd	4	10ppb	9.58	1.08	AsNails141009.xls	9	Mixd	Nails	TRUE	10	Yes	FALSE	-4%	No
10/14/2009 10:21 AM	CalStd	5	50ppb	49.62	0.49	AsNails141009.xls	9	Mixd	Nails	TRUE	50	Yes	FALSE	-1%	No
10/14/2009 10:23 AM	CalStd	6	100ppb	100.24	0.37	AsNails141009.xls	9	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/14/2009 10:26 AM	Sample		ka2	14.99	1.30	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:29 AM	Sample		ka3	18.43	2.08	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:31 AM	Sample		ka4	11.54	1.87	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:34 AM	Sample		ka5	9.35	2.17	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:36 AM	Sample		ka6	2.80	4.14	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:39 AM	Sample		ka7	60.00	2.03	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:41 AM	Sample		k10	9.46	0.32	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:44 AM	Sample		k11	0.71	4.68	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		

10/14/2009 10:46 AM	Sample		k12	1.44	3.77	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:49 AM	Sample		n1	<0.000	N/A	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:51 AM	Sample		n2	0.17	17.63	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 10:54 AM	CalBlk	1	blk	0.00	N/A	AsNails141009.xls	9	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/14/2009 10:57 AM	CalStd	2	1ppb	0.98	3.49	AsNails141009.xls	9	Mixd	Nails	TRUE	1	Yes	FALSE	-2%	Yes
10/14/2009 10:59 AM	CalStd	3	5ppb	4.88	1.00	AsNails141009.xls	9	Mixd	Nails	TRUE	5	Yes	FALSE	-2%	No
10/14/2009 11:02 AM	CalStd	4	10ppb	9.91	1.64	AsNails141009.xls	9	Mixd	Nails	TRUE	10	Yes	FALSE	-1%	Yes
10/14/2009 11:04 AM	CalStd	5	50ppb	50.40	0.85	AsNails141009.xls	9	Mixd	Nails	TRUE	50	Yes	FALSE	1%	Yes
10/14/2009 11:07 AM	CalStd	6	100ppb	99.82	0.48	AsNails141009.xls	9	Mixd	Nails	TRUE	100	Yes	FALSE	0%	Yes
10/14/2009 11:09 AM	Sample		n3	0.17	17.29	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:12 AM	Sample		n4	0.50	0.54	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:15 AM	Sample		n4b	0.32	3.73	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:17 AM	Sample		n5	0.80	3.37	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:20 AM	Sample		n6	0.91	0.93	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:22 AM	Sample		n7	0.77	0.90	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:25 AM	Sample		n8	2.71	1.49	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:27 AM	Sample		n9	0.87	3.14	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:30 AM	CalBlk	1	blk	0.00	N/A	AsNails141009.xls	9	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/14/2009 11:32 AM	CalStd	2	1ppb	1.02	1.19	AsNails141009.xls	9	Mixd	Nails	TRUE	1	Yes	FALSE	2%	No
10/14/2009 11:35 AM	CalStd	3	5ppb	4.86	2.34	AsNails141009.xls	9	Mixd	Nails	TRUE	5	Yes	FALSE	-3%	No
10/14/2009 11:37 AM	CalStd	4	10ppb	10.07	0.87	AsNails141009.xls	9	Mixd	Nails	TRUE	10	Yes	FALSE	1%	Yes
10/14/2009 11:40 AM	CalStd	5	50ppb	49.17	0.70	AsNails141009.xls	9	Mixd	Nails	TRUE	50	Yes	FALSE	-2%	No
10/14/2009 11:42 AM	CalStd	6	100ppb	100.42	0.13	AsNails141009.xls	9	Mixd	Nails	TRUE	100	Yes	FALSE	0%	No

10/14/2009 11:45 AM	Sample		n10	0.66	3.89	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:48 AM	Sample		n11	0.21	2.31	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:50 AM	Sample		n12	0.31	0.74	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:53 AM	Sample		n13	0.32	1.88	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:55 AM	Sample		n14	0.64	2.10	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 11:58 AM	Sample		n15	0.17	4.86	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 12:00 PM	Sample		n16	0.49	1.31	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 12:03 PM	Sample		n28a	0.18	2.45	AsNails141009.xls	9	Mixd	Nails	FALSE		No	FALSE		
10/14/2009 12:05 PM	CalBlk	1	blk	0.00	N/A	AsNails141009.xls	9	Mixd	Nails	FALSE	0	Yes	FALSE		#VALUE!
10/14/2009 12:08 PM	CalStd	2	1ppb	0.99	1.13	AsNails141009.xls	9	Mixd	Nails	TRUE	1	Yes	FALSE	-1%	Yes
10/14/2009 12:11 PM	CalStd	3	5ppb	4.93	1.09	AsNails141009.xls	9	Mixd	Nails	TRUE	5	Yes	FALSE	-1%	No
10/14/2009 12:13 PM	CalStd	4	10ppb	9.87	0.56	AsNails141009.xls	9	Mixd	Nails	TRUE	10	Yes	FALSE	-1%	No
10/14/2009 12:16 PM	CalStd	5	50ppb	48.46	1.32	AsNails141009.xls	9	Mixd	Nails	TRUE	50	Yes	FALSE	-3%	No
10/14/2009 12:18 PM	CalStd	6	100ppb	100.79	0.38	AsNails141009.xls	9	Mixd	Nails	TRUE	100	Yes	FALSE	1%	No
7/22/2009 10:05	CalBlk	1	blk	0.00	N/A	AsHair22709.xls	10	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
7/22/2009 10:08	CalStd	2	1ppb	1.13	13.02	AsHair22709.xls	10	Lahore	Hair	TRUE	1	Yes	FALSE	13%	Yes
7/22/2009 10:10	CalStd	3	5ppb	5.36	1.48	AsHair22709.xls	10	Lahore	Hair	TRUE	5	Yes	FALSE	7%	No
7/22/2009 10:12	CalStd	4	10ppb	10.32	1.76	AsHair22709.xls	10	Lahore	Hair	TRUE	10	Yes	FALSE	3%	No
7/22/2009 10:14	CalStd	5	50ppb	51.31	2.01	AsHair22709.xls	10	Lahore	Hair	TRUE	50	Yes	FALSE	3%	No
7/22/2009 10:16	CalStd	6	100ppb	99.29	1.19	AsHair22709.xls	10	Lahore	Hair	TRUE	100	Yes	FALSE	-1%	Yes
7/22/2009 10:20	Sample			14.34	0.57	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:22	Sample			78.62	1.16	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:24	Sample			5.41	5.19	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:26	Sample			1.22	4.66	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:28	Sample			144.03	4.41	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:31	Sample			2.70	2.12	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:33	Sample			3.33	2.97	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		

7/22/2009 10:35	Sample			3.26	4.07	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:37	Sample			6.36	1.48	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:39	Sample			1.88	11.47	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:41	Sample	1	blk	0.09	44.60	AsHair22709.xls	10	Lahore	Hair	FALSE	0	Yes	FALSE		No
7/22/2009 10:43	Sample	2	1ppb	1.05	14.95	AsHair22709.xls	10	Lahore	Hair	TRUE	1	Yes	FALSE	5%	Yes
7/22/2009 10:45	Sample	3	5ppb	4.96	4.93	AsHair22709.xls	10	Lahore	Hair	TRUE	5	Yes	FALSE	-1%	Yes
7/22/2009 10:47	Sample	4	10ppb	9.60	0.14	AsHair22709.xls	10	Lahore	Hair	TRUE	10	Yes	FALSE	-4%	No
7/22/2009 10:49	Sample	5	50ppb	47.78	1.23	AsHair22709.xls	10	Lahore	Hair	TRUE	50	Yes	FALSE	-4%	No
7/22/2009 10:51	Sample	6	100ppb	93.34	1.37	AsHair22709.xls	10	Lahore	Hair	TRUE	100	Yes	FALSE	-7%	No
7/22/2009 10:56	Sample			1.91	6.43	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 10:58	Sample			0.50	4.51	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:00	Sample			0.95	6.40	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:02	Sample			1.72	24.66	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:04	Sample			2.64	5.26	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:06	Sample			2.93	2.69	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:08	Sample			1.88	1.76	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:10	Sample			0.48	7.22	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:12	Sample			0.78	13.71	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:14	CRM		crm	3.05	0.31	AsHair22709.xls	10	Lahore	Hair	FALSE		No	TRUE		
7/22/2009 11:16	Sample	1	blk	0.09	56.76	AsHair22709.xls	10	Lahore	Hair	FALSE	0	Yes	FALSE		No
7/22/2009 11:19	Sample	2	1ppb	0.94	1.54	AsHair22709.xls	10	Lahore	Hair	TRUE	1	Yes	FALSE	-6%	No
7/22/2009 11:21	Sample	3	5ppb	4.16	1.56	AsHair22709.xls	10	Lahore	Hair	TRUE	5	Yes	FALSE	-17%	No
7/22/2009 11:23	Sample	4	10ppb	8.58	2.66	AsHair22709.xls	10	Lahore	Hair	TRUE	10	Yes	FALSE	-14%	No
7/22/2009 11:25	Sample	5	50ppb	42.45	1.77	AsHair22709.xls	10	Lahore	Hair	TRUE	50	Yes	FALSE	-15%	No
7/22/2009 11:27	Sample	6	100ppb	82.38	1.49	AsHair22709.xls	10	Lahore	Hair	TRUE	100	Yes	FALSE	-18%	No
7/22/2009 11:31	Sample			3.13	1.53	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:33	Sample			32.84	2.08	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:35	Sample			42.88	4.21	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:37	Sample			28.68	2.56	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:40	Sample			4.95	2.21	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:42	Sample			8.78	3.50	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:44	P.Blank			0.15	18.16	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:46	Sample			145.53	0.87	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		

7/22/2009 11:48	Sample			1.50	12.27	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:50	Sample			3.22	6.37	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 11:52	Sample	1	blk	0.05	#####	AsHair22709.xls	10	Lahore	Hair	FALSE	0	Yes	FALSE		Yes
7/22/2009 11:54	Sample	2	1ppb	0.90	3.41	AsHair22709.xls	10	Lahore	Hair	TRUE	1	Yes	FALSE	-10%	No
7/22/2009 11:56	Sample	3	5ppb	4.35	2.65	AsHair22709.xls	10	Lahore	Hair	TRUE	5	Yes	FALSE	-13%	No
7/22/2009 11:58	Sample	4	10ppb	8.48	0.96	AsHair22709.xls	10	Lahore	Hair	TRUE	10	Yes	FALSE	-15%	No
7/22/2009 12:00	Sample	5	50ppb	42.56	0.49	AsHair22709.xls	10	Lahore	Hair	TRUE	50	Yes	FALSE	-15%	No
7/22/2009 12:02	Sample	6	100ppb	81.21	1.75	AsHair22709.xls	10	Lahore	Hair	TRUE	100	Yes	FALSE	-19%	No
7/22/2009 12:07	CRM		crm	0.26	8.30	AsHair22709.xls	10	Lahore	Hair	FALSE		No	TRUE		
7/22/2009 12:09	Sample			0.84	5.61	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:11	Sample			1.00	14.01	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:13	Sample			1.88	9.00	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:15	Sample			21.01	1.58	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:17	Sample			2.68	5.52	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:19	Sample			3.34	2.84	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:21	Sample			0.18	36.49	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:23	Sample			1.82	5.16	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:25	Sample			4.30	3.58	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:27	Sample	1	blk	<0.000	N/A	AsHair22709.xls	10	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
7/22/2009 12:30	Sample	2	1ppb	0.85	9.46	AsHair22709.xls	10	Lahore	Hair	TRUE	1	Yes	FALSE	-15%	No
7/22/2009 12:32	Sample	3	5ppb	4.19	2.11	AsHair22709.xls	10	Lahore	Hair	TRUE	5	Yes	FALSE	-16%	No
7/22/2009 12:34	Sample	4	10ppb	8.49	1.29	AsHair22709.xls	10	Lahore	Hair	TRUE	10	Yes	FALSE	-15%	No
7/22/2009 12:36	Sample	5	50ppb	42.92	1.42	AsHair22709.xls	10	Lahore	Hair	TRUE	50	Yes	FALSE	-14%	No
7/22/2009 12:38	Sample	6	100ppb	80.33	0.33	AsHair22709.xls	10	Lahore	Hair	TRUE	100	Yes	FALSE	-20%	No
7/22/2009 12:42	Sample			3.12	3.89	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:44	Sample			0.07	27.55	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:46	Sample			17.52	1.32	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:48	CRM		crm	1.04	7.69	AsHair22709.xls	10	Lahore	Hair	FALSE		No	TRUE		
7/22/2009 12:51	Sample			1.06	3.84	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:53	Sample			9.82	3.31	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:55	Sample			2.51	6.13	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:57	Sample			1.84	1.68	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 12:59	Sample			3.10	2.49	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		

7/22/2009 13:01	Sample			4.15	2.96	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 13:03	Sample	1	blk	0.12	22.30	AsHair22709.xls	10	Lahore	Hair	FALSE	0	Yes	FALSE		No
7/22/2009 13:05	Sample	2	1ppb	0.80	1.81	AsHair22709.xls	10	Lahore	Hair	TRUE	1	Yes	FALSE	-20%	No
7/22/2009 13:07	Sample	3	5ppb	3.86	1.31	AsHair22709.xls	10	Lahore	Hair	TRUE	5	Yes	FALSE	-23%	No
7/22/2009 13:09	Sample	4	10ppb	7.71	4.96	AsHair22709.xls	10	Lahore	Hair	TRUE	10	Yes	FALSE	-23%	No
7/22/2009 13:11	Sample	5	50ppb	37.65	3.51	AsHair22709.xls	10	Lahore	Hair	TRUE	50	Yes	FALSE	-25%	No
7/22/2009 13:14	Sample	6	100ppb	70.72	2.93	AsHair22709.xls	10	Lahore	Hair	TRUE	100	Yes	FALSE	-29%	No
7/22/2009 13:18	Sample			0.35	20.59	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 13:20	Sample			0.64	3.95	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 13:22	Sample			4.84	0.20	AsHair22709.xls	10	Lahore	Hair	FALSE		No	FALSE		
7/22/2009 13:24	Sample	1	blk	<0.000	N/A	AsHair22709.xls	10	Lahore	Hair	FALSE	0	Yes	FALSE		#VALUE!
7/22/2009 13:26	Sample	2	1ppb	0.72	17.82	AsHair22709.xls	10	Lahore	Hair	TRUE	1	Yes	FALSE	-28%	No
7/22/2009 13:28	Sample	3	5ppb	3.91	6.31	AsHair22709.xls	10	Lahore	Hair	TRUE	5	Yes	FALSE	-22%	No
7/22/2009 13:30	Sample	4	10ppb	7.80	5.02	AsHair22709.xls	10	Lahore	Hair	TRUE	10	Yes	FALSE	-22%	No
7/22/2009 13:32	Sample	5	50ppb	39.17	1.48	AsHair22709.xls	10	Lahore	Hair	TRUE	50	Yes	FALSE	-22%	No
7/22/2009 13:34	Sample	6	100ppb	76.66	0.63	AsHair22709.xls	10	Lahore	Hair	TRUE	100	Yes	FALSE	-23%	No
7/27/2009 11:24	CalBlk	1	blk	0.00	N/A	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		#VALUE!
7/27/2009 11:26	CalStd	2	1ppb	1.11	3.44	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	11%	No
7/27/2009 11:29	CalStd	3	5ppb	5.04	1.69	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	1%	Yes
7/27/2009 11:32	CalStd	4	10ppb	10.24	2.36	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	2%	Yes
7/27/2009 11:34	CalStd	5	50ppb	51.27	0.53	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	3%	No
7/27/2009 11:37	CalStd	6	100ppb	99.34	0.41	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-1%	No
7/27/2009 11:39	Sample			3.27	3.08	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 11:42	Sample			2.82	2.44	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 11:44	Sample			2.04	1.36	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 11:47	Sample			0.73	1.52	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 11:49	Sample			2.45	1.81	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 11:52	Sample			16.11	1.20	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 11:54	Sample			2.77	1.93	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 11:57	Sample			7.24	1.75	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:00	Sample			2.03	0.33	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:02	Sample			11.83	1.68	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:05	CalBlk	1	blk	0.02	#####	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		Yes

7/27/2009 12:07	CalStd	2	1ppb	0.93	2.45	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	-7%	No
7/27/2009 12:10	CalStd	3	5ppb	4.44	1.34	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-11%	No
7/27/2009 12:12	CalStd	4	10ppb	9.11	1.42	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-9%	No
7/27/2009 12:15	CalStd	5	50ppb	46.12	0.44	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	-8%	No
7/27/2009 12:17	CalStd	6	100ppb	88.37	0.60	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-12%	No
7/27/2009 12:20	Sample			8.17	1.59	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:23	Sample			1.67	1.04	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:25	Sample			37.81	0.89	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:28	Sample			0.89	4.30	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:30	Sample			19.20	1.87	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:33	Sample			5.57	2.46	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:35	Sample			1.66	2.48	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:38	Sample			0.31	6.76	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:40	Sample			1.86	5.01	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:43	Sample			0.64	1.10	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 12:46	CalBlk	1	blk	<0.000	N/A	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		#VALUE!
7/27/2009 12:48	CalStd	2	1ppb	0.92	0.32	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	-8%	No
7/27/2009 12:51	CalStd	3	5ppb	4.47	0.76	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-11%	No
7/27/2009 12:53	CalStd	4	10ppb	9.02	0.43	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-10%	No
7/27/2009 12:56	CalStd	5	50ppb	45.93	0.62	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	-8%	No
7/27/2009 12:58	CalStd	6	100ppb	88.78	0.91	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-11%	No
7/27/2009 13:01	Sample			1.50	1.68	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:03	Sample			0.71	1.27	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:06	Sample			0.98	3.19	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:08	Sample			1.69	3.48	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:11	Sample			10.09	2.44	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:14	Sample			2.99	1.47	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:16	Sample			0.17	4.74	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:19	Sample			10.45	1.77	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:21	Sample			8.36	1.80	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:24	Sample			1.92	3.66	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:26	CalBlk	1	blk	0.01	#####	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		Yes
7/27/2009 13:29	CalStd	2	1ppb	0.97	2.79	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	-3%	Yes

7/27/2009 13:31	CalStd	3	5ppb	4.38	1.13	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-12%	No
7/27/2009 13:34	CalStd	4	10ppb	8.97	0.69	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-10%	No
7/27/2009 13:36	CalStd	5	50ppb	45.72	0.14	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	-9%	No
7/27/2009 13:39	CalStd	6	100ppb	89.20	1.74	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-11%	No
7/27/2009 13:42	Sample			0.65	0.47	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:44	Sample			0.45	6.36	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:47	Sample			11.67	1.89	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:49	Sample			2.93	2.02	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:52	Sample			0.65	3.40	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:54	Sample			0.99	5.52	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 13:57	Sample		crm	1.86	0.51	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	TRUE		
7/27/2009 13:59	Sample		crm	2.99	2.94	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	TRUE		
7/27/2009 14:02	Sample			1.82	3.42	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:05	Sample			0.94	1.81	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:07	Sample			4.20	1.57	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:10	CalBlk	1	blk	0.00	#####	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		Yes
7/27/2009 14:12	CalStd	2	1ppb	1.00	0.38	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	0%	Yes
7/27/2009 14:15	CalStd	3	5ppb	4.53	1.56	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-9%	No
7/27/2009 14:17	CalStd	4	10ppb	9.20	0.62	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-8%	No
7/27/2009 14:20	CalStd	5	50ppb	46.50	0.88	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	-7%	No
7/27/2009 14:22	CalStd	6	100ppb	92.69	0.70	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-7%	No
7/27/2009 14:25	Sample			0.46	6.61	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:27	Sample			3.28	2.50	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:30	Sample			5.35	2.02	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:33	Sample			2.42	4.13	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:35	Sample			4.66	2.65	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:38	Sample			1.12	1.02	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:40	Sample			5.59	3.26	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:43	Sample			5.46	1.61	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:45	Sample			13.35	2.38	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:48	Sample			2.28	2.44	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:50	Sample			2.21	1.12	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 14:53	CalBlk	1	blk	0.00	#####	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		Yes

7/27/2009 14:55	CalStd	2	1ppb	1.00	2.73	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	0%	Yes
7/27/2009 14:58	CalStd	3	5ppb	4.70	2.09	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-6%	No
7/27/2009 15:00	CalStd	4	10ppb	9.50	0.67	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-5%	No
7/27/2009 15:03	CalStd	5	50ppb	48.62	0.30	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	-3%	No
7/27/2009 15:06	CalStd	6	100ppb	94.85	1.18	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-5%	No
7/27/2009 15:08	Sample			7.53	2.15	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:11	Sample			0.24	3.37	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:13	Sample			0.15	5.28	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:16	Sample			3.63	2.61	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:18	Sample			1.98	1.77	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:21	Sample			0.66	4.16	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:23	Sample			17.26	1.81	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:26	Sample			1.32	0.72	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:29	Sample			2.06	1.58	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:31	Sample			3.01	2.16	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:34	CalBlk	1	blk	0.03	93.31	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		No
7/27/2009 15:36	CalStd	2	1ppb	1.02	2.77	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	2%	Yes
7/27/2009 15:39	CalStd	3	5ppb	4.77	1.28	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-5%	No
7/27/2009 15:41	CalStd	4	10ppb	9.65	1.44	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-3%	No
7/27/2009 15:44	CalStd	5	50ppb	48.66	0.66	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	-3%	No
7/27/2009 15:46	CalStd	6	100ppb	95.42	1.08	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-5%	No
7/27/2009 15:49	Sample			1.90	4.82	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:51	Sample			2.01	3.71	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:54	Sample			6.22	2.71	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:57	Sample			3.75	1.96	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 15:59	Sample			0.87	3.49	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:02	Sample			0.24	7.00	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:04	Sample			0.48	1.37	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:07	Sample			9.08	1.55	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:09	Sample			7.16	3.01	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:12	Sample			5.49	1.82	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:14	CalBlk	1	blk	0.03	32.37	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		No
7/27/2009 16:17	CalStd	2	1ppb	1.04	1.97	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	4%	No

7/27/2009 16:19	CalStd	3	5ppb	4.86	0.83	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-3%	No
7/27/2009 16:22	CalStd	4	10ppb	9.75	2.11	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-3%	No
7/27/2009 16:25	CalStd	5	50ppb	49.89	0.67	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	0%	Yes
7/27/2009 16:28	CalStd	6	100ppb	96.42	1.43	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-4%	No
7/27/2009 16:30	Sample			0.90	2.53	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:33	Sample			0.41	8.79	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:35	Sample			8.53	1.74	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:38	Sample			1.63	2.47	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:40	Sample			5.29	1.80	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:43	Sample			1.41	2.16	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 16:45	Sample		crm	0.30	7.52	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	TRUE		
7/27/2009 16:48	Sample		crm	1.23	1.68	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	TRUE		
7/27/2009 16:50	Sample			0.04	2.97	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 17:59	Sample			<0.000	N/A	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 18:02	Sample			0.75	2.69	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 18:04	Sample			3.91	2.20	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 18:07	Sample			<0.000	N/A	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE		No	FALSE		
7/27/2009 18:09	CalBlk	1	blk	<0.000	N/A	AsHair270709.xls	11	Mixd(lahore+india)	Hair	FALSE	0	Yes	FALSE		#VALUE!
7/27/2009 18:12	CalStd	2	1ppb	0.99	2.80	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	1	Yes	FALSE	-1%	Yes
7/27/2009 18:15	CalStd	3	5ppb	4.83	2.37	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	5	Yes	FALSE	-3%	No
7/27/2009 18:17	CalStd	4	10ppb	9.74	2.39	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	10	Yes	FALSE	-3%	No
7/27/2009 18:20	CalStd	5	50ppb	50.06	1.03	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	50	Yes	FALSE	0%	Yes
7/27/2009 18:22	CalStd	6	100ppb	99.26	1.03	AsHair270709.xls	11	Mixd(lahore+india)	Hair	TRUE	100	Yes	FALSE	-1%	Yes
8/16/2010 11:05 AM	CalBlk	1	blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 11:08 AM	CalStd	2	1ppb	0.98	23.51	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	-2%	Yes
8/16/2010 11:10 AM	CalStd	3	5ppb	5.03	4.14	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	1%	Yes
8/16/2010 11:13 AM	CalStd	4	10ppb	10.07	3.72	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	1%	Yes
8/16/2010 11:16 AM	CalStd	5	50ppb	49.98	1.21	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 11:21 AM	Sample		wash	5.51	8.68	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:24 AM	Sample		washeslr1	0.42	96.61	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		

8/16/2010 11:27 AM	Sample		2	0.36	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:29 AM	Sample		3	0.30	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:32 AM	Sample		4	0.24	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:35 AM	Sample		5	0.10	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:38 AM	Sample		6	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:40 AM	Sample		7	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:43 AM	Sample		8	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:46 AM	Sample		9	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:48 AM	Sample		10	0.03	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 11:51 AM	Sample	1	blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 11:54 AM	Sample	2	1ppb	0.98	18.95	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	-2%	Yes
8/16/2010 11:57 AM	Sample	3	5ppb	5.07	3.67	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	1%	Yes
8/16/2010 11:59 AM	Sample	4	10ppb	9.85	3.13	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/16/2010 12:02 PM	Sample	5	50ppb	50.02	0.27	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 12:07 PM	Sample		wash	5.09	4.01	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:10 PM	Sample		11	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:13 PM	Sample		12	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:16 PM	Sample		13	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:18 PM	Sample		14	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:24 PM	Sample		15	0.04	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:27 PM	Sample		16	0.06	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:29 PM	Sample		17	0.11	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:32 PM	Sample		18	0.03	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		

8/16/2010 12:35 PM	Sample		19	0.06	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:37 PM	Sample	1	blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 12:40 PM	Sample	2	1ppb	0.95	19.35	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	-5%	Yes
8/16/2010 12:43 PM	Sample	3	5ppb	4.84	3.37	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-3%	Yes
8/16/2010 12:45 PM	Sample	4	10ppb	9.85	1.98	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-2%	Yes
8/16/2010 12:48 PM	Sample	5	50ppb	50.05	1.04	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 12:54 PM	Sample		wash	3.92	4.09	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:56 PM	Sample		20	0.04	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 12:59 PM	Sample		21	0.05	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:02 PM	Sample		22	0.05	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:05 PM	Sample		23	0.10	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:07 PM	Sample		24	0.10	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:10 PM	Sample		25	0.04	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:13 PM	Sample		26	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:15 PM	Sample		27	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:18 PM	Sample		28	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:21 PM	Sample		29	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:23 PM	Sample		30	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:26 PM	Sample	1	blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 1:29 PM	Sample	2	1ppb	1.06	12.79	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	6%	Yes
8/16/2010 1:32 PM	Sample	3	5ppb	4.94	1.81	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-1%	Yes
8/16/2010 1:34 PM	Sample	4	10ppb	9.93	2.78	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/16/2010 1:37 PM	Sample	5	50ppb	50.02	0.94	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 1:40 PM	Sample		wash	4.25	2.12	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:42 PM	Sample		31	0.31	67.74	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:45 PM	Sample		32	0.24	88.69	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:48 PM	Sample		33	0.14	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:51 PM	Sample		34	0.13	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:53 PM	Sample		35	0.11	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		

8/16/2010 1:56 PM	Sample		36	0.08	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 1:59 PM	Sample		37	0.06	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:01 PM	Sample		diw1	0.06	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:04 PM	Sample		diw2	0.13	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:07 PM	Sample		diw3	0.13	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:10 PM	Sample	1	blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 2:12 PM	Sample	2	1ppb	1.03	8.13	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	3%	Yes
8/16/2010 2:15 PM	Sample	3	5ppb	5.03	3.49	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	1%	Yes
8/16/2010 2:18 PM	Sample	4	10ppb	9.87	2.43	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/16/2010 2:20 PM	Sample	5	50ppb	50.02	0.73	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 2:23 PM	Sample		wash	4.18	2.89	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:26 PM	Sample		diw4	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:29 PM	Sample		lr30dup	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:31 PM	Sample		lr24dup	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:34 PM	Sample		37dup	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:37 PM	Sample		15dup	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:39 PM	Sample		1dup	0.01	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:42 PM	Sample		3dup	0.05	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:45 PM	Sample		10dup	0.07	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:48 PM	Sample		blnk4	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:50 PM	Sample		blnk5	0.04	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 2:53 PM	Sample	1	blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 2:56 PM	Sample	2	1ppb	0.99	2.37	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	-1%	Yes
8/16/2010 2:58 PM	Sample	3	5ppb	4.92	2.78	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-2%	Yes
8/16/2010 3:01 PM	Sample	4	10ppb	9.87	4.33	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/16/2010 3:04 PM	Sample	5	50ppb	50.04	1.01	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 3:06 PM	Sample		wash	4.07	3.36	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:09 PM	Sample		blnk6	0.01	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:12 PM	Sample		blnk3	0.04	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:15 PM	Sample		blnk2	0.01	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:17 PM	Sample		blnk1	0.02	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:20 PM	Sample		washcrm6	0.08	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 3:23 PM	Sample		washcrm5	0.11	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		

8/16/2010 3:25 PM	Sample		washcrm4	0.05	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 3:28 PM	Sample		washcrm3	0.02	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 3:31 PM	Sample		washcrm2	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 3:34 PM	Sample		washescrm1	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 3:36 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 3:39 PM	Sample		1ppb	1.08	8.35	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	8%	Yes
8/16/2010 3:42 PM	Sample		5ppb	4.94	1.99	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-1%	Yes
8/16/2010 3:44 PM	Sample		10ppb	9.87	2.53	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/16/2010 3:47 PM	Sample		50ppb	50.03	1.07	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 3:50 PM	Sample		wash	4.05	2.44	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:53 PM	Sample		blank2	0.30	55.36	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:55 PM	Sample		diw1	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 3:58 PM	Sample		blnk3	0.30	75.71	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:01 PM	Sample		blnk1	0.19	64.29	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:03 PM	Sample		diw2	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:06 PM	Sample		lr10dup	1.26	13.47	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:09 PM	Sample		15dup	1.52	21.20	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:11 PM	Sample		3dup	1.06	24.71	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:14 PM	Sample		1dup	1.06	21.79	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:17 PM	Sample		crm3	2.85	13.85	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 4:20 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 4:22 PM	Sample		1ppb	0.97	9.85	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	-3%	Yes
8/16/2010 4:25 PM	Sample		5ppb	4.93	1.74	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-1%	Yes
8/16/2010 4:28 PM	Sample		10ppb	9.90	1.12	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/16/2010 4:30 PM	Sample		50ppb	50.03	0.60	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 4:33 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:36 PM	Sample		crm2	3.00	12.64	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 4:39 PM	Sample		crm1	3.24	10.49	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 4:41 PM	Sample		lr1	0.49	37.28	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:44 PM	Sample		2	0.71	23.68	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:47 PM	Sample		3	0.72	16.72	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:49 PM	Sample		4	0.76	31.70	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:52 PM	Sample		5	0.83	27.69	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		

8/16/2010 4:55 PM	Sample		6	0.49	52.12	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 4:57 PM	Sample		7	0.53	33.46	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:00 PM	Sample		8	1.42	22.61	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:03 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 5:06 PM	Sample		1ppb	0.92	19.68	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	-8%	Yes
8/16/2010 5:08 PM	Sample		5ppb	4.93	1.82	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-1%	Yes
8/16/2010 5:11 PM	Sample		10ppb	10.08	2.49	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	1%	Yes
8/16/2010 5:14 PM	Sample		50ppb	49.99	0.46	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 5:16 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:19 PM	Sample		9	0.38	51.81	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:22 PM	Sample		10	1.41	21.16	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:25 PM	Sample		11	0.71	40.79	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:27 PM	Sample		12	1.51	17.13	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:30 PM	Sample		13	0.67	39.33	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:33 PM	Sample		14	0.67	34.18	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:35 PM	Sample		15	1.15	21.45	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:38 PM	Sample		16	0.94	40.98	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:41 PM	Sample		17	2.57	12.43	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:44 PM	Sample		18	0.90	20.97	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 5:46 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 5:49 PM	Sample		1ppb	1.03	10.89	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	3%	Yes
8/16/2010 5:52 PM	Sample		5ppb	4.96	4.46	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-1%	Yes
8/16/2010 5:54 PM	Sample		10ppb	9.97	3.09	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	0%	Yes
8/16/2010 5:57 PM	Sample		50ppb	50.01	1.22	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 6:00 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:03 PM	Sample		19	0.68	27.06	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:05 PM	Sample		20	1.13	18.98	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:08 PM	Sample		21	0.47	38.21	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:11 PM	Sample		22	0.78	25.54	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:13 PM	Sample		23	0.77	11.27	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:16 PM	Sample		24	1.30	16.52	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:19 PM	Sample		25	0.51	32.41	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:21 PM	Sample		26	1.07	15.04	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		

8/16/2010 6:24 PM	Sample		27	0.61	29.65	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:27 PM	Sample		28	1.31	11.38	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:30 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 6:32 PM	Sample		1ppb	1.06	7.46	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	6%	Yes
8/16/2010 6:35 PM	Sample		5ppb	5.03	2.33	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	1%	Yes
8/16/2010 6:38 PM	Sample		10ppb	10.04	2.43	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	0%	Yes
8/16/2010 6:40 PM	Sample		50ppb	49.99	0.24	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 6:43 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:46 PM	Sample		29	0.84	14.68	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:49 PM	Sample		30	1.06	11.02	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:51 PM	Sample		31	2.01	5.92	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:54 PM	Sample		32	1.02	13.59	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:57 PM	Sample		33	0.66	29.47	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 6:59 PM	Sample		34	1.12	17.25	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:02 PM	Sample		35	0.84	16.86	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:05 PM	Sample		36	0.98	19.57	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:07 PM	Sample		37	0.90	19.68	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:10 PM	Sample		30dup	1.04	16.12	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:13 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 7:16 PM	Sample		1ppb	1.05	4.82	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	5%	Yes
8/16/2010 7:18 PM	Sample		5ppb	5.07	2.96	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	1%	Yes
8/16/2010 7:21 PM	Sample		10ppb	9.87	1.10	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	No
8/16/2010 7:24 PM	Sample		50ppb	50.02	0.67	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 7:26 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:29 PM	Sample		37dup	0.68	21.42	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:32 PM	Sample		24dup	1.17	14.38	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:35 PM	Sample		crm4	2.77	6.72	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 7:37 PM	Sample		crm3(5)	2.67	6.82	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 7:40 PM	Sample		crm6	3.19	6.48	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 7:43 PM	Sample		blnk4	0.13	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:45 PM	Sample		blnk5	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:48 PM	Sample		blnk6	0.00	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:51 PM	Sample		diw3	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		

8/16/2010 7:54 PM	Sample		diw4	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 7:56 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 7:59 PM	Sample		1ppb	1.08	9.60	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	8%	Yes
8/16/2010 8:02 PM	Sample		5ppb	5.14	3.28	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	3%	Yes
8/16/2010 8:04 PM	Sample		10ppb	10.10	2.35	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	1%	Yes
8/16/2010 8:07 PM	Sample		50ppb	49.96	2.26	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 8:10 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:13 PM	Sample		lr38	0.72	22.47	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:15 PM	Sample		39	1.92	6.28	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:18 PM	Sample		40	0.69	20.75	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:21 PM	Sample		41	0.87	19.19	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:23 PM	Sample		42	0.62	29.22	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:26 PM	Sample		43	0.84	12.93	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:29 PM	Sample		44	1.03	16.91	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:32 PM	Sample		45	0.46	30.91	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:34 PM	Sample		46	0.76	15.94	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:37 PM	Sample		47	1.17	16.25	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:40 PM	Sample		48	0.83	22.24	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:42 PM	Sample		49	0.92	9.84	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 8:45 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 8:48 PM	Sample		1ppb	1.04	5.93	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	4%	Yes
8/16/2010 8:50 PM	Sample		5ppb	4.90	2.14	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-2%	Yes
8/16/2010 8:53 PM	Sample		10ppb	9.67	2.10	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-3%	No
8/16/2010 8:56 PM	Sample		50ppb	50.07	1.92	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 8:59 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:01 PM	Sample		50	0.66	22.62	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:04 PM	Sample		51	0.73	17.32	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:07 PM	Sample		57dup	0.79	20.20	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:09 PM	Sample		blnk8	0.21	52.09	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:12 PM	Sample		blnk9	0.10	95.53	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:15 PM	Sample		lr52	0.26	24.37	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:18 PM	Sample		42dup	0.58	15.39	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:20 PM	Sample		54	0.94	9.63	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		

8/16/2010 9:23 PM	Sample		53	0.94	15.18	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:26 PM	Sample		crm9	2.56	8.22	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 9:28 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 9:31 PM	Sample		1ppb	1.06	8.13	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	6%	Yes
8/16/2010 9:34 PM	Sample		5ppb	4.96	2.79	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-1%	Yes
8/16/2010 9:37 PM	Sample		10ppb	9.83	1.52	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-2%	No
8/16/2010 9:39 PM	Sample		50ppb	50.04	1.01	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/16/2010 9:42 PM	Sample		wash	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:45 PM	Sample		blnk7	0.02	#####	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:47 PM	Sample		diw5	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:50 PM	Sample		lr55	0.69	11.91	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:53 PM	Sample		diw6	<0.000	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 9:56 PM	Sample		crm7	2.65	5.40	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 9:58 PM	Sample		crm8	2.68	5.85	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	TRUE		
8/16/2010 10:01 PM	Sample		38dup	0.64	18.84	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 10:04 PM	Sample		56dup	0.36	29.86	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 10:06 PM	Sample		57	0.61	24.36	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 10:09 PM	Sample		42dup	0.68	19.55	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 10:12 PM	Sample		lr56	0.50	20.82	SKrice16082010.xls	12	Lahore	Rice	FALSE		No	FALSE		
8/16/2010 10:15 PM	Sample		blank	0.00	N/A	SKrice16082010.xls	12	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/16/2010 10:17 PM	Sample		1ppb	1.00	8.02	SKrice16082010.xls	12	Lahore	Rice	TRUE	1	Yes	FALSE	0%	Yes
8/16/2010 10:20 PM	Sample		5ppb	4.85	4.97	SKrice16082010.xls	12	Lahore	Rice	TRUE	5	Yes	FALSE	-3%	Yes
8/16/2010 10:23 PM	Sample		10ppb	9.88	1.19	SKrice16082010.xls	12	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	No
8/16/2010 10:25 PM	Sample		50ppb	50.04	0.86	SKrice16082010.xls	12	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/17/2010 8:45 AM	CalBlk	1	blank	0.00	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/17/2010 8:48 AM	CalStd	2	1ppb	1.12	2.20	SKrice17082010.xls	13	Lahore	Rice	TRUE	1	Yes	FALSE	12%	No
8/17/2010 8:51 AM	CalStd	3	5ppb	5.05	1.55	SKrice17082010.xls	13	Lahore	Rice	TRUE	5	Yes	FALSE	1%	Yes
8/17/2010 8:53 AM	CalStd	4	10ppb	9.98	1.58	SKrice17082010.xls	13	Lahore	Rice	TRUE	10	Yes	FALSE	0%	Yes
8/17/2010 8:56 AM	CalStd	5	50ppb	50.00	0.55	SKrice17082010.xls	13	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes

8/17/2010 9:01 AM	Sample		wash	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:04 AM	Sample		wash blnk7	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:07 AM	Sample		washblnk8	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:10 AM	Sample		washblnk9	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:12 AM	Sample		washcrm7	0.00	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	TRUE		
8/17/2010 9:15 AM	Sample		washcrm8	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	TRUE		
8/17/2010 9:18 AM	Sample		washcrm9	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	TRUE		
8/17/2010 9:20 AM	Sample		diw5	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:23 AM	Sample		diw6	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:26 AM	Sample		lr38	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:29 AM	Sample		39	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:31 AM	Sample	1	blank	0.00	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/17/2010 9:34 AM	Sample	2	1ppb	1.09	7.26	SKrice17082010.xls	13	Lahore	Rice	TRUE	1	Yes	FALSE	9%	No
8/17/2010 9:37 AM	Sample	3	5ppb	5.15	0.41	SKrice17082010.xls	13	Lahore	Rice	TRUE	5	Yes	FALSE	3%	No
8/17/2010 9:39 AM	Sample	4	10ppb	10.15	0.58	SKrice17082010.xls	13	Lahore	Rice	TRUE	10	Yes	FALSE	2%	No
8/17/2010 9:42 AM	Sample	5	50ppb	49.95	0.96	SKrice17082010.xls	13	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/17/2010 9:45 AM	Sample		wash	0.03	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:48 AM	Sample		wlr40	0.09	93.13	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:50 AM	Sample		41	0.06	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:53 AM	Sample		42	0.06	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:56 AM	Sample		43	0.01	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 9:58 AM	Sample		44	0.00	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:01 AM	Sample		45	0.04	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:04 AM	Sample		46	0.04	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:06 AM	Sample		47	0.06	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:09 AM	Sample		48	0.04	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:12 AM	Sample	1	blank	0.00	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/17/2010 10:15 AM	Sample	2	1ppb	1.15	5.99	SKrice17082010.xls	13	Lahore	Rice	TRUE	1	Yes	FALSE	15%	No
8/17/2010 10:17 AM	Sample	3	5ppb	5.15	2.69	SKrice17082010.xls	13	Lahore	Rice	TRUE	5	Yes	FALSE	3%	No
8/17/2010 10:20	Sample	4	10ppb	9.86	2.99	SKrice17082010.xls	13	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes

AM															
8/17/2010 10:23 AM	Sample	5	50ppb	50.01	0.62	SKrice17082010.xls	13	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/17/2010 10:25 AM	Sample		wash	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:28 AM	Sample		49	0.03	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:31 AM	Sample		50	0.06	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:34 AM	Sample		51	0.04	98.23	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:36 AM	Sample		52	0.03	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:39 AM	Sample		53	0.05	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:42 AM	Sample		54	0.05	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:44 AM	Sample		55	0.04	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:47 AM	Sample		56	0.05	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:50 AM	Sample		wlr38dup	0.02	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:53 AM	Sample		42dup	<0.000	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:55 AM	Sample		56dup	0.04	99.22	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 10:58 AM	Sample		57dup	0.07	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 11:01 AM	Sample		wlr57	0.05	#####	SKrice17082010.xls	13	Lahore	Rice	FALSE		No	FALSE		
8/17/2010 11:03 AM	Sample	1	blank	0.00	N/A	SKrice17082010.xls	13	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/17/2010 11:06 AM	Sample	2	1ppb	1.07	2.63	SKrice17082010.xls	13	Lahore	Rice	TRUE	1	Yes	FALSE	7%	No
8/17/2010 11:09 AM	Sample	3	5ppb	5.04	0.69	SKrice17082010.xls	13	Lahore	Rice	TRUE	5	Yes	FALSE	1%	No
8/17/2010 11:11 AM	Sample	4	10ppb	9.97	0.32	SKrice17082010.xls	13	Lahore	Rice	TRUE	10	Yes	FALSE	0%	No
8/17/2010 11:14 AM	Sample	5	50ppb	50.00	0.60	SKrice17082010.xls	13	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/27/2010 9:20 AM	CalBlk	1	blank	0.00	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/27/2010 9:23 AM	CalStd	2	1ppb	1.12	6.49	SKrice27082010.xls	15	Lahore	Rice	TRUE	1	Yes	FALSE	12%	No
8/27/2010 9:26 AM	CalStd	3	5ppb	4.93	4.40	SKrice27082010.xls	15	Lahore	Rice	TRUE	5	Yes	FALSE	-1%	Yes

8/27/2010 9:28 AM	CalStd	4	10ppb	9.86	1.60	SKrice27082010.xls	15	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/27/2010 9:31 AM	CalStd	5	20ppb	20.70	0.26	SKrice27082010.xls	15	Lahore	Rice	TRUE	20	Yes	FALSE	4%	No
8/27/2010 9:34 AM	CalStd	6	50ppb	49.75	0.87	SKrice27082010.xls	15	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
8/27/2010 9:37 AM	Sample		wash	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 9:39 AM	Sample		lr69	0.86	28.17	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 9:42 AM	Sample		lr59dup	0.87	16.17	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 9:45 AM	Sample		lr74	0.71	23.16	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 9:48 AM	Sample		lr65	1.86	14.06	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 9:50 AM	Sample		lr59	0.70	23.26	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 9:53 AM	Sample		crm12	2.56	6.95	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	TRUE		
8/27/2010 9:56 AM	Sample		lr76	0.83	14.88	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 9:58 AM	Sample		lr58	0.53	24.11	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:01 AM	Sample		lr58dup	0.86	22.54	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:04 AM	Sample		lr70	1.20	13.78	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:07 AM	Sample	1	blank	0.00	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/27/2010 10:09 AM	Sample	2	1ppb	1.06	12.46	SKrice27082010.xls	15	Lahore	Rice	TRUE	1	Yes	FALSE	6%	Yes
8/27/2010 10:12 AM	Sample	3	5ppb	5.09	0.81	SKrice27082010.xls	15	Lahore	Rice	TRUE	5	Yes	FALSE	2%	No
8/27/2010 10:15 AM	Sample	4	10ppb	10.00	1.02	SKrice27082010.xls	15	Lahore	Rice	TRUE	10	Yes	FALSE	0%	Yes
8/27/2010 10:17 AM	Sample	5	20ppb	20.88	0.52	SKrice27082010.xls	15	Lahore	Rice	TRUE	20	Yes	FALSE	4%	No
8/27/2010 10:20 AM	Sample	6	50ppb	49.64	0.46	SKrice27082010.xls	15	Lahore	Rice	TRUE	50	Yes	FALSE	-1%	No
8/27/2010 10:23 AM	Sample		wash	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:26 AM	Sample		lr71	0.56	24.49	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:28 AM	Sample		lr60	2.03	8.14	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:31 AM	Sample		lr75	0.71	23.10	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:34 AM	Sample		lr67	0.69	15.25	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:36 AM	Sample		lr72	0.43	39.54	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:39	Sample		lr73	0.53	30.37	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		

AM															
8/27/2010 10:42 AM	Sample		lr62	0.79	13.73	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:44 AM	Sample		lr67	0.75	20.67	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:47 AM	Sample		lr68	0.67	16.97	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 10:50 AM	Sample	1	blank	0.00	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/27/2010 10:53 AM	Sample	2	1ppb	1.10	5.98	SKrice27082010.xls	15	Lahore	Rice	TRUE	1	Yes	FALSE	10%	No
8/27/2010 10:55 AM	Sample	3	5ppb	5.09	2.54	SKrice27082010.xls	15	Lahore	Rice	TRUE	5	Yes	FALSE	2%	Yes
8/27/2010 10:58 AM	Sample	4	10ppb	9.97	0.60	SKrice27082010.xls	15	Lahore	Rice	TRUE	10	Yes	FALSE	0%	Yes
8/27/2010 11:01 AM	Sample	5	20ppb	20.97	0.40	SKrice27082010.xls	15	Lahore	Rice	TRUE	20	Yes	FALSE	5%	No
8/27/2010 11:03 AM	Sample	6	50ppb	49.61	0.50	SKrice27082010.xls	15	Lahore	Rice	TRUE	50	Yes	FALSE	-1%	No
8/27/2010 11:06 AM	Sample		wash	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:09 AM	Sample		lr77	0.64	13.95	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:12 AM	Sample		lr61	1.92	4.49	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:14 AM	Sample		lr63	0.25	29.40	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:17 AM	Sample		lr66	0.87	7.46	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:20 AM	Sample		lr64	0.61	13.13	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:22 AM	Sample		lr63dup	0.35	38.04	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:25 AM	Sample		lr78	1.16	9.21	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:28 AM	Sample		crm10	2.98	6.34	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	TRUE		
8/27/2010 11:30 AM	Sample		crm11	2.88	6.16	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	TRUE		
8/27/2010 11:33 AM	Sample		blnk12	0.05	99.90	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:36 AM	Sample		blnk11	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:39 AM	Sample		blnk10	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		

8/27/2010 11:41 AM	Sample		diw7	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 11:44 AM	Sample	1	blank	0.00	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/27/2010 11:47 AM	Sample	2	1ppb	1.12	7.10	SKrice27082010.xls	15	Lahore	Rice	TRUE	1	Yes	FALSE	12%	No
8/27/2010 11:49 AM	Sample	3	5ppb	5.10	2.62	SKrice27082010.xls	15	Lahore	Rice	TRUE	5	Yes	FALSE	2%	Yes
8/27/2010 11:52 AM	Sample	4	10ppb	9.91	1.26	SKrice27082010.xls	15	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/27/2010 11:55 AM	Sample	5	20ppb	21.17	0.73	SKrice27082010.xls	15	Lahore	Rice	TRUE	20	Yes	FALSE	6%	No
8/27/2010 11:57 AM	Sample	6	50ppb	49.54	1.02	SKrice27082010.xls	15	Lahore	Rice	TRUE	50	Yes	FALSE	-1%	Yes
8/27/2010 12:00 PM	Sample		wash	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:03 PM	Sample		diw8	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:06 PM	Sample		wash blnk12	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:08 PM	Sample		lr75	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:11 PM	Sample		lr76	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:14 PM	Sample		washblnk11	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:16 PM	Sample		washblnk10	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:19 PM	Sample		lr74	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:22 PM	Sample		lr73	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:25 PM	Sample		lr72	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:27 PM	Sample		diw1	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:30 PM	Sample	1	blank	0.00	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/27/2010 12:33 PM	Sample	2	1ppb	1.04	3.47	SKrice27082010.xls	15	Lahore	Rice	TRUE	1	Yes	FALSE	4%	No
8/27/2010 12:35 PM	Sample	3	5ppb	5.04	1.16	SKrice27082010.xls	15	Lahore	Rice	TRUE	5	Yes	FALSE	1%	Yes
8/27/2010 12:38 PM	Sample	4	10ppb	9.72	1.92	SKrice27082010.xls	15	Lahore	Rice	TRUE	10	Yes	FALSE	-3%	No
8/27/2010 12:41 PM	Sample	5	20ppb	21.32	0.84	SKrice27082010.xls	15	Lahore	Rice	TRUE	20	Yes	FALSE	7%	No

8/27/2010 12:44 PM	Sample	6	50ppb	49.52	0.38	SKrice27082010.xls	15	Lahore	Rice	TRUE	50	Yes	FALSE	-1%	No
8/27/2010 12:46 PM	Sample		wash	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:49 PM	Sample		lr78	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:52 PM	Sample		diw2	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:54 PM	Sample		lr77	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 12:57 PM	Sample		washcrm12	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	TRUE		
8/27/2010 1:00 PM	Sample		washcrm11	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	TRUE		
8/27/2010 1:03 PM	Sample		washcrm10	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	TRUE		
8/27/2010 1:05 PM	Sample		lr58	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:08 PM	Sample		lr59	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:11 PM	Sample		lr60	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:13 PM	Sample		lr61	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:16 PM	Sample	1	blank	0.00	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/27/2010 1:19 PM	Sample	2	1ppb	1.10	4.13	SKrice27082010.xls	15	Lahore	Rice	TRUE	1	Yes	FALSE	10%	No
8/27/2010 1:21 PM	Sample	3	5ppb	5.10	1.96	SKrice27082010.xls	15	Lahore	Rice	TRUE	5	Yes	FALSE	2%	Yes
8/27/2010 1:24 PM	Sample	4	10ppb	9.95	2.39	SKrice27082010.xls	15	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	Yes
8/27/2010 1:27 PM	Sample	5	20ppb	21.21	0.57	SKrice27082010.xls	15	Lahore	Rice	TRUE	20	Yes	FALSE	6%	No
8/27/2010 1:30 PM	Sample	6	50ppb	49.51	0.73	SKrice27082010.xls	15	Lahore	Rice	TRUE	50	Yes	FALSE	-1%	No
8/27/2010 1:32 PM	Sample		wash	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:35 PM	Sample		lr62	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:38 PM	Sample		lr63	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:41 PM	Sample		lr63dup	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:43 PM	Sample		lr58dup	0.11	56.98	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:46 PM	Sample		lr67	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:49 PM	Sample		lr68	0.01	#####	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:51 PM	Sample		lr70	0.00	#####	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:54 PM	Sample		lr71	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:57 PM	Sample		lr60	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 1:59 PM	Sample		lr59dup	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 2:02 PM	Sample		lr66	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		

8/27/2010 2:05 PM	Sample		lr65	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 2:08 PM	Sample		lr64	<0.000	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE		No	FALSE		
8/27/2010 2:10 PM	Sample	1	blank	0.00	N/A	SKrice27082010.xls	15	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
8/27/2010 2:13 PM	Sample	2	1ppb	1.13	2.44	SKrice27082010.xls	15	Lahore	Rice	TRUE	1	Yes	FALSE	13%	No
8/27/2010 2:16 PM	Sample	3	5ppb	5.08	2.76	SKrice27082010.xls	15	Lahore	Rice	TRUE	5	Yes	FALSE	2%	Yes
8/27/2010 2:18 PM	Sample	4	10ppb	10.15	1.41	SKrice27082010.xls	15	Lahore	Rice	TRUE	10	Yes	FALSE	1%	No
8/27/2010 2:21 PM	Sample	5	20ppb	21.34	1.34	SKrice27082010.xls	15	Lahore	Rice	TRUE	20	Yes	FALSE	7%	No
8/27/2010 2:24 PM	Sample	6	50ppb	49.43	0.04	SKrice27082010.xls	15	Lahore	Rice	TRUE	50	Yes	FALSE	-1%	No
7/6/2009 10:35 AM	CalBlk	1	blk	0.00	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 10:37 AM	CalStd	2	1ppb	0.86	6.85	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-14%	No
7/6/2009 10:40 AM	CalStd	3	5ppb	4.72	4.25	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	-6%	No
7/6/2009 10:42 AM	CalStd	4	10ppb	9.59	1.72	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	-4%	No
7/6/2009 10:44 AM	CalStd	5	20ppb	19.69	1.80	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	-2%	Yes
7/6/2009 10:47 AM	CalStd	6	50ppb	50.23	0.64	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
7/6/2009 10:49 AM	Sample		crm	0.26	4.66	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 10:51 AM	Sample		crm	1.10	18.85	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 10:54 AM	Sample		crm	2.71	3.84	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 10:56 AM	Sample		crm	4.50	2.76	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 10:58 AM	Sample			0.02	#####	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:00 AM	Sample			1.05	3.05	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:03 AM	Sample			1.27	4.12	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:05 AM	Sample			1.17	5.26	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:07 AM	Sample			1.53	4.47	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:10 AM	Sample			1.76	4.38	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:12 AM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 11:14 AM	Sample	2	1ppb	0.96	7.31	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-4%	Yes
7/6/2009 11:17 AM	Sample	3	5ppb	5.00	2.79	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	0%	Yes
7/6/2009 11:19 AM	Sample	4	10ppb	10.22	3.34	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	2%	Yes
7/6/2009 11:21 AM	Sample	5	20ppb	20.05	0.74	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	0%	Yes
7/6/2009 11:23 AM	Sample	6	50ppb	49.17	0.82	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	-2%	No
7/6/2009 11:26 AM	Sample			0.90	11.89	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:28 AM	Sample			0.73	2.56	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:30 AM	Sample			1.74	2.68	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		

7/6/2009 11:33 AM	Sample			1.06	7.55	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:35 AM	Sample			2.37	9.94	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:37 AM	Sample			0.73	7.41	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:40 AM	Sample			2.63	7.01	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:42 AM	Sample			0.65	8.18	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:44 AM	Sample			0.81	10.13	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:47 AM	Sample			1.64	5.55	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 11:49 AM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 11:51 AM	Sample	2	1ppb	0.88	2.63	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-12%	No
7/6/2009 11:53 AM	Sample	3	5ppb	4.77	3.96	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	-5%	No
7/6/2009 11:56 AM	Sample	4	10ppb	9.87	0.19	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	-1%	No
7/6/2009 11:58 AM	Sample	5	20ppb	18.76	1.21	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	-6%	No
7/6/2009 12:00 PM	Sample	6	50ppb	46.60	0.94	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	-7%	No
7/6/2009 12:03 PM	Sample			0.60	3.90	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:05 PM	Sample			3.49	6.97	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:07 PM	Sample			1.41	7.56	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:10 PM	Sample			0.84	5.80	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:12 PM	Sample			1.59	4.57	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:14 PM	Sample			0.28	2.08	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:17 PM	Sample			0.99	1.55	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:19 PM	Sample		crm	5.15	2.41	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 12:21 PM	Sample		crm	5.30	5.44	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 12:24 PM	Sample			<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:26 PM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 12:28 PM	Sample	2	1ppb	0.85	8.90	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-15%	No
7/6/2009 12:30 PM	Sample	3	5ppb	4.87	3.36	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	-3%	Yes
7/6/2009 12:33 PM	Sample	4	10ppb	10.40	0.62	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	4%	No
7/6/2009 12:35 PM	Sample	5	20ppb	19.53	0.39	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	-2%	No
7/6/2009 12:37 PM	Sample	6	50ppb	48.25	1.44	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	-4%	No
7/6/2009 12:40 PM	Sample			1.01	2.40	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:42 PM	Sample			1.73	4.42	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:44 PM	Sample			0.82	11.54	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:47 PM	Sample			1.63	2.89	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		

7/6/2009 12:49 PM	Sample			0.71	7.04	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:51 PM	Sample			2.06	9.60	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:54 PM	Sample			1.37	2.65	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:56 PM	Sample			1.65	4.93	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 12:58 PM	Sample			2.23	4.16	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:00 PM	Sample			1.56	3.54	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:03 PM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 1:05 PM	Sample	2	1ppb	0.94	9.86	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-6%	Yes
7/6/2009 1:07 PM	Sample	3	5ppb	5.42	1.83	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	8%	No
7/6/2009 1:10 PM	Sample	4	10ppb	10.42	3.11	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	4%	No
7/6/2009 1:12 PM	Sample	5	20ppb	20.40	2.45	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	2%	Yes
7/6/2009 1:14 PM	Sample	6	50ppb	49.98	0.45	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
7/6/2009 1:17 PM	Sample			0.98	2.07	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:19 PM	Sample			1.91	1.56	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:21 PM	Sample			1.24	6.11	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:24 PM	Sample			1.56	4.50	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:26 PM	Sample			1.21	9.77	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:28 PM	Sample			1.12	9.65	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:31 PM	Sample			4.96	0.51	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:33 PM	Sample			0.77	13.51	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:35 PM	Sample			1.04	7.26	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:37 PM	Sample			1.07	13.50	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:40 PM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 1:42 PM	Sample	2	1ppb	0.87	10.16	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-13%	No
7/6/2009 1:44 PM	Sample	3	5ppb	5.31	6.54	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	6%	Yes
7/6/2009 1:47 PM	Sample	4	10ppb	10.80	3.86	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	8%	No
7/6/2009 1:49 PM	Sample	5	20ppb	20.87	0.18	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	4%	No
7/6/2009 1:51 PM	Sample	6	50ppb	51.47	0.21	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	3%	No
7/6/2009 1:54 PM	Sample			1.24	6.74	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:56 PM	Sample			1.27	6.18	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 1:58 PM	Sample			0.34	6.78	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:00 PM	Sample			1.13	3.87	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:02 PM	Sample			1.19	1.71	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		

7/6/2009 2:04 PM	Sample			1.52	8.59	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:06 PM	Sample			1.51	7.74	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:09 PM	Sample			1.38	7.07	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:11 PM	Sample			1.54	2.51	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:13 PM	Sample			0.45	11.10	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:15 PM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 2:18 PM	Sample	2	1ppb	1.03	6.08	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	3%	Yes
7/6/2009 2:29 PM	Sample	3	5ppb	5.35	2.56	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	7%	No
7/6/2009 2:31 PM	Sample	4	10ppb	10.40	4.15	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	4%	Yes
7/6/2009 2:34 PM	Sample	5	20ppb	20.38	0.47	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	2%	No
7/6/2009 2:36 PM	Sample	6	50ppb	50.02	1.35	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
7/6/2009 2:38 PM	Sample			1.68	2.96	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:41 PM	Sample			1.82	3.77	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:43 PM	Sample			1.75	10.84	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:45 PM	Sample			0.57	7.75	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:48 PM	Sample			1.07	8.17	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:50 PM	Sample			1.01	9.03	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:52 PM	Sample			0.98	8.71	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:54 PM	Sample			4.12	4.63	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:57 PM	Sample			3.25	0.18	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 2:59 PM	Sample			1.43	2.64	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:01 PM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 3:04 PM	Sample	2	1ppb	0.92	6.23	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-8%	No
7/6/2009 3:06 PM	Sample	3	5ppb	5.22	3.52	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	4%	No
7/6/2009 3:08 PM	Sample	4	10ppb	10.76	1.48	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	8%	No
7/6/2009 3:11 PM	Sample	5	20ppb	20.32	0.58	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	2%	No
7/6/2009 3:13 PM	Sample	6	50ppb	50.88	1.67	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	2%	No
7/6/2009 3:15 PM	Sample			0.50	12.15	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:18 PM	Sample			1.34	9.07	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:20 PM	Sample			2.86	4.26	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:22 PM	Sample			0.03	33.35	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:24 PM	Sample		crm	5.69	3.58	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 3:27 PM	Sample			0.04	24.74	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		

7/6/2009 3:29 PM	Sample		crm	5.65	0.62	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 3:31 PM	Sample		crm	5.34	1.53	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	TRUE		
7/6/2009 3:34 PM	Sample			1.74	4.16	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:36 PM	Sample			1.13	2.87	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:38 PM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 3:41 PM	Sample	2	1ppb	0.94	9.32	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-6%	Yes
7/6/2009 3:43 PM	Sample	3	5ppb	5.28	0.73	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	6%	No
7/6/2009 3:45 PM	Sample	4	10ppb	10.86	1.20	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	9%	No
7/6/2009 3:47 PM	Sample	5	20ppb	20.77	1.09	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	4%	No
7/6/2009 3:50 PM	Sample	6	50ppb	49.99	0.51	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	0%	Yes
7/6/2009 3:52 PM	Sample			1.66	7.92	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:54 PM	Sample			0.84	7.64	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:57 PM	Sample			1.36	11.56	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 3:59 PM	Sample			1.61	5.30	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:01 PM	Sample			0.55	12.76	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:04 PM	Sample			0.79	6.92	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:06 PM	Sample			0.78	11.59	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:08 PM	Sample			1.34	8.90	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:10 PM	Sample			1.80	5.67	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:13 PM	Sample			1.29	6.42	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:15 PM	Sample			1.96	1.03	Skrice_6072009.xls	14	Lahore	Rice	FALSE		No	FALSE		
7/6/2009 4:17 PM	Sample	1	blk	<0.000	N/A	Skrice_6072009.xls	14	Lahore	Rice	FALSE	0	Yes	FALSE		#VALUE!
7/6/2009 4:19 PM	Sample	2	1ppb	0.94	13.39	Skrice_6072009.xls	14	Lahore	Rice	TRUE	1	Yes	FALSE	-6%	Yes
7/6/2009 4:22 PM	Sample	3	5ppb	5.40	1.34	Skrice_6072009.xls	14	Lahore	Rice	TRUE	5	Yes	FALSE	8%	No
7/6/2009 4:24 PM	Sample	4	10ppb	10.49	4.29	Skrice_6072009.xls	14	Lahore	Rice	TRUE	10	Yes	FALSE	5%	No
7/6/2009 4:26 PM	Sample	5	20ppb	20.77	0.79	Skrice_6072009.xls	14	Lahore	Rice	TRUE	20	Yes	FALSE	4%	No
7/6/2009 4:29 PM	Sample	6	50ppb	51.25	1.54	Skrice_6072009.xls	14	Lahore	Rice	TRUE	50	Yes	FALSE	3%	No

A. Details of analytical sessions of IC-ICP-MS

Acq. Date-Time	Type	Level	Sample Name	75 AsB	75 DMA	75 MMA	75 T i As	File name	AsB -As	DMA-As	MMA -As	iAs-As	Total-As	% i-As
				Conc. [µg/l]	Conc. [µg/l]	Conc. [µg/l]	Conc. [µg/l]		0.4	0.5	0.5	1.0		
6/6/2011 9:41 AM	CalBlk	1	blank				0.00	dp6611.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
6/6/2011 9:46 AM	CalStd	2	1ppb	0.95	1.08	1.11	0.95	dp6611.xls	0.4	0.6	0.6	0.9	2.5	37%
6/6/2011 9:51 AM	CalStd	3	5ppb	5.02	5.05	5.02	5.00	dp6611.xls	2.1	2.7	2.7	5.0	12.6	40%
6/6/2011 9:56 AM	CalStd	4	10ppb	9.58	10.20	10.01	9.93	dp6611.xls	4.0	5.5	5.4	9.9	24.9	40%
6/6/2011 10:01 AM	CalStd	5	50ppb	50.08	49.95	49.99	50.01	dp6611.xls	21.1	27.1	27.1	50.0	125.4	40%
6/6/2011 10:06 AM	Sample		cr1		1.18		22.91	dp6611.xls	0.0	0.6	0.0	22.9	23.6	97%
6/6/2011 10:11 AM	Sample		cr2	0.13	8.26		48.54	dp6611.xls	0.1	4.5	0.0	48.5	53.1	91%
6/6/2011 10:16 AM	Sample		cr3		3.80		19.66	dp6611.xls	0.0	2.1	0.0	19.7	21.7	91%
6/6/2011 10:21 AM	Sample		cr4		2.57		15.82	dp6611.xls	0.0	1.4	0.0	15.8	17.2	92%
6/6/2011 10:26 AM	Sample		cr5		5.34	0.35	26.70	dp6611.xls	0.0	2.9	0.2	26.7	29.8	90%
6/6/2011 10:31 AM	Sample		cr6		2.47		12.01	dp6611.xls	0.0	1.3	0.0	12.0	13.4	90%
6/6/2011 10:36 AM	Sample		cr7		2.87	0.36	35.08	dp6611.xls	0.0	1.6	0.2	35.1	36.8	95%
6/6/2011 10:40 AM	Sample		cr8	0.15	9.06		52.68	dp6611.xls	0.1	4.9	0.0	52.7	57.7	91%

6/6/2011 10:45 AM	Sample		cr9	0.09	11.66	0.46	63.24	dp6611.xls	0.0	6.3	0.2	63.2	69.9	91%
6/6/2011 10:50 AM	Sample		cr10		7.27		47.49	dp6611.xls	0.0	3.9	0.0	47.5	51.4	92%
6/6/2011 10:55 AM	Sample	1	blank				0.12	dp6611.xls	0.0	0.0	0.0	0.1	0.1	100%
6/6/2011 11:00 AM	Sample	2	1ppb	0.95	1.05	0.99	1.04	dp6611.xls	0.4	0.6	0.5	1.0	2.5	41%
6/6/2011 11:05 AM	Sample	3	5ppb	5.08	5.13	5.12	5.06	dp6611.xls	2.1	2.8	2.8	5.1	12.8	40%
6/6/2011 11:10 AM	Sample	4	10ppb	10.08	10.02	10.22	10.01	dp6611.xls	4.2	5.4	5.5	10.0	25.2	40%
6/6/2011 11:15 AM	Sample	5	50ppb	49.48	49.30	50.20	49.12	dp6611.xls	20.8	26.8	27.3	49.1	124.0	40%
6/6/2011 11:20 AM	Sample		cr11		3.68	0.28	30.27	dp6611.xls	0.0	2.0	0.2	30.3	32.4	93%
6/6/2011 11:25 AM	Sample		cr12		5.29	0.42	22.46	dp6611.xls	0.0	2.9	0.2	22.5	25.6	88%
6/6/2011 11:30 AM	Sample		cr13		2.90		14.46	dp6611.xls	0.0	1.6	0.0	14.5	16.0	90%
6/6/2011 11:35 AM	Sample		cr14		2.67		12.36	dp6611.xls	0.0	1.5	0.0	12.4	13.8	89%
6/6/2011 11:40 AM	Sample		cr15		2.99		23.72	dp6611.xls	0.0	1.6	0.0	23.7	25.3	94%
6/6/2011 11:45 AM	Sample		cr16		2.36		18.33	dp6611.xls	0.0	1.3	0.0	18.3	19.6	93%
6/6/2011 11:49 AM	Sample		cr17		0.93		12.46	dp6611.xls	0.0	0.5	0.0	12.5	13.0	96%
6/6/2011 11:54 AM	Sample		cr18		1.68		10.03	dp6611.xls	0.0	0.9	0.0	10.0	10.9	92%
6/6/2011 11:59 AM	Sample		cr19		2.23	0.08	16.16	dp6611.xls	0.0	1.2	0.0	16.2	17.4	93%
6/6/2011 12:04 PM	Sample		cr20		1.71		14.08	dp6611.xls	0.0	0.9	0.0	14.1	15.0	94%
6/6/2011 12:09 PM	Sample		blank				-0.14	dp6611.xls	0.0	0.0	0.0	-0.1	-0.1	100%
6/6/2011 12:14 PM	Sample		10ppb	9.76	9.82	10.11	9.88	dp6611.xls	4.1	5.3	5.5	9.9	24.8	40%
6/6/2011 12:19 PM	Sample		cr21		2.19		20.49	dp6611.xls	0.0	1.2	0.0	20.5	21.7	95%
6/6/2011 12:24 PM	Sample		cr22		0.98		27.18	dp6611.xls	0.0	0.5	0.0	27.2	27.7	98%

6/6/2011 12:29 PM	Sample		cr23		6.61		17.08	dp6611.xls	0.0	3.6	0.0	17.1	20.7	83%
6/6/2011 12:34 PM	Sample		cr24	0.17	8.81		52.37	dp6611.xls	0.1	4.8	0.0	52.4	57.2	92%
6/6/2011 12:39 PM	Sample		cr25		3.77	0.10	54.86	dp6611.xls	0.0	2.0	0.1	54.9	57.0	96%
6/6/2011 12:44 PM	Sample		cr26	0.10	5.08		17.00	dp6611.xls	0.0	2.8	0.0	17.0	19.8	86%
6/6/2011 12:49 PM	Sample		cr27		2.29		11.15	dp6611.xls	0.0	1.2	0.0	11.1	12.4	90%
6/6/2011 12:54 PM	Sample		cr28		3.36		23.31	dp6611.xls	0.0	1.8	0.0	23.3	25.1	93%
6/6/2011 12:59 PM	Sample		cr29		1.96		2.76	dp6611.xls	0.0	1.1	0.0	2.8	3.8	72%
6/6/2011 1:03 PM	Sample		cr30		0.73		8.74	dp6611.xls	0.0	0.4	0.0	8.7	9.1	96%
6/6/2011 1:08 PM	Sample		blank				0.11	dp6611.xls	0.0	0.0	0.0	0.1	0.1	100%
6/6/2011 1:13 PM	Sample		10ppb	9.92	10.16	10.41	10.29	dp6611.xls	4.2	5.5	5.7	10.3	25.6	40%
6/6/2011 1:18 PM	Sample		cr31		2.37		52.39	dp6611.xls	0.0	1.3	0.0	52.4	53.7	98%
6/6/2011 1:23 PM	Sample		cr32		2.42	0.07	23.52	dp6611.xls	0.0	1.3	0.0	23.5	24.9	95%
6/6/2011 1:28 PM	Sample		cr33		1.51		7.98	dp6611.xls	0.0	0.8	0.0	8.0	8.8	91%
6/6/2011 1:33 PM	Sample		cr34		0.55		19.53	dp6611.xls	0.0	0.3	0.0	19.5	19.8	98%
6/6/2011 1:39 PM	Sample		cr35		2.11	0.09	11.56	dp6611.xls	0.0	1.1	0.1	11.6	12.8	91%
6/6/2011 1:44 PM	Sample		lr251		2.25		3.09	dp6611.xls	0.0	1.2	0.0	3.1	4.3	72%
6/6/2011 1:48 PM	Sample		lr252		2.20		3.18	dp6611.xls	0.0	1.2	0.0	3.2	4.4	73%
6/6/2011 1:53 PM	Sample		r282		14.17		3.23	dp6611.xls	0.0	7.7	0.0	3.2	10.9	30%
6/6/2011 1:58 PM	Sample		or1		1.38		30.36	dp6611.xls	0.0	0.8	0.0	30.4	31.1	98%
6/6/2011 2:03 PM	Sample		or2		1.98		24.13	dp6611.xls	0.0	1.1	0.0	24.1	25.2	96%
6/6/2011 2:08 PM	Sample		blank				0.16	dp6611.xls	0.0	0.0	0.0	0.2	0.2	100%

6/6/2011 2:13 PM	Sample		10ppb	9.81	10.35	10.50	10.47	dp6611.xls	4.1	5.6	5.7	10.5	25.9	40%
6/6/2011 2:18 PM	Sample		or3	0.51	15.78		52.16	dp6611.xls	0.2	8.6	0.0	52.2	60.9	86%
6/6/2011 2:23 PM	Sample		blank1		0.00		0.07	dp6611.xls	0.0	0.0	0.0	0.1	0.1	98%
6/6/2011 2:28 PM	Sample		blank2				-0.05	dp6611.xls	0.0	0.0	0.0	0.0	0.0	100%
6/6/2011 2:33 PM	Sample		blank3		-0.01		-0.07	dp6611.xls	0.0	0.0	0.0	-0.1	-0.1	95%
6/6/2011 2:38 PM	Sample		crm1		35.41		9.64	dp6611.xls	0.0	19.2	0.0	9.6	28.9	33%
6/6/2011 2:43 PM	Sample		crm2		31.04	0.64	8.16	dp6611.xls	0.0	16.9	0.3	8.2	25.4	32%
6/6/2011 2:48 PM	Sample		crm3		30.18	0.70	8.20	dp6611.xls	0.0	16.4	0.4	8.2	25.0	33%
6/6/2011 2:53 PM	Sample		r28-1		14.86		3.07	dp6611.xls	0.0	8.1	0.0	3.1	11.1	28%
6/6/2011 2:58 PM	Sample		cr36	0.14	8.90		51.26	dp6611.xls	0.1	4.8	0.0	51.3	56.2	91%
6/6/2011 3:03 PM	Sample		cr37		2.30		12.18	dp6611.xls	0.0	1.2	0.0	12.2	13.4	91%
6/6/2011 3:08 PM	Sample		blank				0.10	dp6611.xls	0.0	0.0	0.0	0.1	0.1	100%
6/6/2011 3:13 PM	Sample		10ppb	9.72	10.02	10.28	10.32	dp6611.xls	4.1	5.4	5.6	10.3	25.4	41%
6/6/2011 3:18 PM	Sample		cr38		2.52	0.18	8.34	dp6611.xls	0.0	1.4	0.1	8.3	9.8	85%
6/6/2011 3:23 PM	Sample		cr39		4.89	0.20	215.78	dp6611.xls	0.0	2.7	0.1	215.8	218.5	99%
6/6/2011 3:28 PM	Sample		cr40	0.08	2.95	0.25	24.47	dp6611.xls	0.0	1.6	0.1	24.5	26.2	93%
6/6/2011 3:33 PM	Sample		cr41		6.12	0.24	39.49	dp6611.xls	0.0	3.3	0.1	39.5	42.9	92%
6/6/2011 3:38 PM	Sample		cr42	0.25	3.74	0.20	16.38	dp6611.xls	0.1	2.0	0.1	16.4	18.6	88%
6/6/2011 3:43 PM	Sample		cr43		2.35	0.12	33.97	dp6611.xls	0.0	1.3	0.1	34.0	35.3	96%
6/6/2011 3:48 PM	Sample		cr44	0.25	1.78		18.23	dp6611.xls	0.1	1.0	0.0	18.2	19.3	94%
6/6/2011 3:53 PM	Sample		cr45	0.19	1.73		16.57	dp6611.xls	0.1	0.9	0.0	16.6	17.6	94%

6/6/2011 3:58 PM	Sample		cr46	0.07	2.50		10.71	dp6611.xls	0.0	1.4	0.0	10.7	12.1	89%
6/6/2011 4:03 PM	Sample		cr47		3.43		6.83	dp6611.xls	0.0	1.9	0.0	6.8	8.7	79%
6/6/2011 4:08 PM	Sample		blank				0.22	dp6611.xls	0.0	0.0	0.0	0.2	0.2	100%
6/6/2011 4:13 PM	Sample		10ppb	9.94	9.70	10.03	10.32	dp6611.xls	4.2	5.3	5.4	10.3	25.2	41%
6/6/2011 4:18 PM	Sample		cr48	0.57	6.15		9.24	dp6611.xls	0.2	3.3	0.0	9.2	12.8	72%
6/6/2011 4:23 PM	Sample		cr49		5.63		8.40	dp6611.xls	0.0	3.1	0.0	8.4	11.5	73%
6/6/2011 4:28 PM	Sample		cr50		6.09		8.67	dp6611.xls	0.0	3.3	0.0	8.7	12.0	72%
6/6/2011 4:33 PM	Sample		cr51	0.00	6.76		10.04	dp6611.xls	0.0	3.7	0.0	10.0	13.7	73%
6/6/2011 4:38 PM	Sample	1	blank	0.06			0.20	dp6611.xls	0.0	0.0	0.0	0.2	0.2	89%
6/6/2011 4:43 PM	Sample	2	1ppb	0.94	1.04	1.00	1.06	dp6611.xls	0.4	0.6	0.5	1.1	2.6	41%
6/6/2011 4:48 PM	Sample	3	5ppb	4.94	5.10	4.98	5.16	dp6611.xls	2.1	2.8	2.7	5.2	12.7	41%
6/6/2011 4:53 PM	Sample	4	10ppb	9.29	9.80	9.71	10.07	dp6611.xls	3.9	5.3	5.3	10.1	24.6	41%
6/6/2011 4:58 PM	Sample	5	50ppb	48.21	48.68	49.18	51.67	dp6611.xls	20.3	26.4	26.7	51.7	125.1	41%
6/7/2011 9:01 AM	CalBlk	1	blank			0.00	0.00	dp7611.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
6/7/2011 9:06 AM	CalStd	2	1ppb	0.95	1.06	1.06	1.04	dp7611.xls	0.4	0.6	0.6	1.0	2.6	40%
6/7/2011 9:11 AM	CalStd	3	5ppb	5.06	4.99	4.96	4.83	dp7611.xls	2.1	2.7	2.7	4.8	12.4	39%
6/7/2011 9:16 AM	CalStd	4	10ppb	9.87	9.83	10.15	9.66	dp7611.xls	4.2	5.3	5.5	9.7	24.7	39%
6/7/2011 9:21 AM	CalStd	5	50ppb	50.02	50.03	49.97	50.08	dp7611.xls	21.1	27.2	27.1	50.1	125.4	40%
6/7/2011 9:26 AM	Sample		cr52		3.49		22.27	dp7611.xls	0.0	1.9	0.0	22.3	24.2	92%
6/7/2011 9:31 AM	Sample		cr53	0.02	3.73	0.22	7.32	dp7611.xls	0.0	2.0	0.1	7.3	9.5	77%
6/7/2011 9:36 AM	Sample		cr54	0.06	7.08	0.56	10.84	dp7611.xls	0.0	3.8	0.3	10.8	15.0	72%

6/7/2011 9:41 AM	Sample		cr55		9.13	0.02	10.98	dp7611.xls	0.0	5.0	0.0	11.0	15.9	69%
6/7/2011 9:46 AM	Sample		cr56		6.28	0.41	8.59	dp7611.xls	0.0	3.4	0.2	8.6	12.2	70%
6/7/2011 9:51 AM	Sample		cr57		2.40	0.00	5.57	dp7611.xls	0.0	1.3	0.0	5.6	6.9	81%
6/7/2011 9:56 AM	Sample		blank		0.02	0.01	0.02	dp7611.xls	0.0	0.0	0.0	0.0	0.0	46%
6/7/2011 10:01 AM	Sample		10ppb	9.98	10.13	9.74	10.07	dp7611.xls	4.2	5.5	5.3	10.1	25.1	40%
6/7/2011 10:31 AM	Sample		cr58	0.04	2.94	0.03	4.88	dp7611.xls	0.0	1.6	0.0	4.9	6.5	75%
6/7/2011 10:36 AM	Sample		cr59	0.01	3.84	0.19	5.94	dp7611.xls	0.0	2.1	0.1	5.9	8.1	73%
6/7/2011 10:40 AM	Sample		cr60	0.02	4.40	0.04	6.19	dp7611.xls	0.0	2.4	0.0	6.2	8.6	72%
6/7/2011 10:45 AM	Sample		cr61	0.02	4.76	0.01	8.15	dp7611.xls	0.0	2.6	0.0	8.2	10.7	76%
6/7/2011 10:50 AM	Sample		cr62		3.89	0.03	6.28	dp7611.xls	0.0	2.1	0.0	6.3	8.4	75%
6/7/2011 10:55 AM	Sample		cr63	0.01	3.92	0.31	6.30	dp7611.xls	0.0	2.1	0.2	6.3	8.6	73%
6/7/2011 11:00 AM	Sample		cr64	0.10	5.76	0.08	6.73	dp7611.xls	0.0	3.1	0.0	6.7	9.9	68%
6/7/2011 11:05 AM	Sample		cr65	0.01	4.91	0.04	9.80	dp7611.xls	0.0	2.7	0.0	9.8	12.5	78%
6/7/2011 11:10 AM	Sample		cr66	0.01	3.54	0.03	4.36	dp7611.xls	0.0	1.9	0.0	4.4	6.3	69%
6/7/2011 11:15 AM	Sample		cr67		3.96	0.01	6.48	dp7611.xls	0.0	2.1	0.0	6.5	8.6	75%
6/7/2011 11:20 AM	Sample		rr1		1.71	0.01	5.24	dp7611.xls	0.0	0.9	0.0	5.2	6.2	85%
6/7/2011 11:25 AM	Sample		rr2		2.98	0.01	9.72	dp7611.xls	0.0	1.6	0.0	9.7	11.3	86%
6/7/2011 11:30 AM	Sample		rr3		2.02	0.04	19.24	dp7611.xls	0.0	1.1	0.0	19.2	20.4	95%
6/7/2011 11:35 AM	Sample		blank				0.06	dp7611.xls	0.0	0.0	0.0	0.1	0.1	100%
6/7/2011 11:40 AM	Sample		10ppb	10.09	9.92	10.15	9.95	dp7611.xls	4.2	5.4	5.5	10.0	25.1	40%
6/7/2011 11:45 AM	Sample		rr4		4.93		10.32	dp7611.xls	0.0	2.7	0.0	10.3	13.0	79%

6/7/2011 11:50 AM	Sample		rr5	0.21	2.13	0.00	11.00	dp7611.xls	0.1	1.2	0.0	11.0	12.2	90%
6/7/2011 11:55 AM	Sample		rr6	0.04	2.98		9.82	dp7611.xls	0.0	1.6	0.0	9.8	11.5	86%
6/7/2011 12:00 PM	Sample		rr7		7.13		19.50	dp7611.xls	0.0	3.9	0.0	19.5	23.4	83%
6/7/2011 12:04 PM	Sample		pr6-1		3.35		3.60	dp7611.xls	0.0	1.8	0.0	3.6	5.4	66%
6/7/2011 12:09 PM	Sample		pr6-2		3.23	0.01	3.18	dp7611.xls	0.0	1.8	0.0	3.2	4.9	64%
6/7/2011 12:14 PM	Sample		pr10-1		2.84	0.05	3.17	dp7611.xls	0.0	1.5	0.0	3.2	4.7	67%
6/7/2011 12:19 PM	Sample		pr10-2		3.00	0.01	3.28	dp7611.xls	0.0	1.6	0.0	3.3	4.9	67%
6/7/2011 12:24 PM	Sample		blank4			0.07	-0.16	dp7611.xls	0.0	0.0	0.0	-0.2	-0.1	132%
6/7/2011 12:29 PM	Sample		blank5			0.03	-0.18	dp7611.xls	0.0	0.0	0.0	-0.2	-0.2	110%
6/7/2011 12:34 PM	Sample		blank6			0.02	-0.18	dp7611.xls	0.0	0.0	0.0	-0.2	-0.2	105%
6/7/2011 12:39 PM	Sample		crm4		34.18		8.55	dp7611.xls	0.0	18.6	0.0	8.6	27.1	32%
6/7/2011 12:44 PM	Sample		crm5		35.14		8.87	dp7611.xls	0.0	19.1	0.0	8.9	27.9	32%
6/7/2011 12:49 PM	Sample		crm6		29.47		7.29	dp7611.xls	0.0	16.0	0.0	7.3	23.3	31%
6/7/2011 12:54 PM	Sample	1	blank	0.03	0.03		0.11	dp7611.xls	0.0	0.0	0.0	0.1	0.1	80%
6/7/2011 12:59 PM	Sample	2	1ppb	0.97	1.08	1.04	1.12	dp7611.xls	0.4	0.6	0.6	1.1	2.7	42%
6/7/2011 1:04 PM	Sample	3	5ppb	5.05	4.91	5.01	5.17	dp7611.xls	2.1	2.7	2.7	5.2	12.7	41%
6/7/2011 1:09 PM	Sample	4	10ppb	9.85	9.84	9.78	9.76	dp7611.xls	4.1	5.3	5.3	9.8	24.6	40%
6/7/2011 1:14 PM	Sample	5	50ppb	50.96	49.60	50.21	51.94	dp7611.xls	21.5	26.9	27.3	51.9	127.6	41%
11/1/2010 10:32 AM	CalBlk	1	blank		0		0	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 10:37 AM	CalStd	2	1ppb	1.61	1.73	1.66	1.78	skrice11110.xls	0.7	0.9	0.9	1.8	4.3	41%
11/1/2010 10:42 AM	CalStd	3	5ppb	5.71	5.85	5.80	5.74	skrice11110.xls	2.4	3.2	3.2	5.7	14.5	40%

11/1/2010 10:48 AM	CalStd	4	10ppb	11.22	10.94	10.84	10.23	skrice11110.xls	4.7	5.9	5.9	10.2	26.8	38%
11/1/2010 10:53 AM	CalStd	5	50ppb	49.67	49.71	49.74	49.86	skrice11110.xls	20.9	27.0	27.0	49.9	124.8	40%
11/1/2010 9:38 AM	Sample		crm2	0.02	114.82	4.59	35.07	skrice11110.xls	0.0	62.3	2.5	35.1	99.9	35%
11/1/2010 9:43 AM	Sample		crm1	0.03	83.42	5.48	25.63	skrice11110.xls	0.0	45.3	3.0	25.6	73.9	35%
11/1/2010 9:48 AM	Sample		1	0.04	5.12	0.06	5.54	skrice11110.xls	0.0	2.8	0.0	5.5	8.4	66%
11/1/2010 9:54 AM	Sample		2		2.03		1.95	skrice11110.xls	0.0	1.1	0.0	1.9	3.0	64%
11/1/2010 9:59 AM	Sample		3	0.03	4.85		5.25	skrice11110.xls	0.0	2.6	0.0	5.2	7.9	66%
11/1/2010 10:05 AM	Sample		4		8.15	0.23	4.78	skrice11110.xls	0.0	4.4	0.1	4.8	9.3	51%
11/1/2010 10:10 AM	Sample		5		8.12	0.06	3.12	skrice11110.xls	0.0	4.4	0.0	3.1	7.6	41%
11/1/2010 10:15 AM	Sample		6		3.24		5.68	skrice11110.xls	0.0	1.8	0.0	5.7	7.4	76%
11/1/2010 10:21 AM	Sample		7	0.03	2.59		4.84	skrice11110.xls	0.0	1.4	0.0	4.8	6.3	77%
11/1/2010 10:26 AM	Sample		8	0.12	9.73	0.06	6.71	skrice11110.xls	0.1	5.3	0.0	6.7	12.1	56%
11/1/2010 10:59 AM	Sample		blank	0.00			0.00	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 11:04 AM	Sample		1ppb	0.97	0.97	1.09	1.10	skrice11110.xls	0.4	0.5	0.6	1.1	2.6	42%
11/1/2010 11:09 AM	Sample		5ppb	4.99	5.02	5.04	5.20	skrice11110.xls	2.1	2.7	2.7	5.2	12.8	41%
11/1/2010 11:15 AM	Sample		10ppb	9.69	9.45	9.43	9.56	skrice11110.xls	4.1	5.1	5.1	9.6	23.9	40%
11/1/2010 11:20 AM	Sample		50ppb	50.06	50.11	50.11	50.07	skrice11110.xls	21.1	27.2	27.2	50.1	125.6	40%
11/1/2010 11:26 AM	Sample		9		2.48		2.95	skrice11110.xls	0.0	1.3	0.0	2.9	4.3	69%
11/1/2010 11:31 AM	Sample		10		4.71	0.39	7.14	skrice11110.xls	0.0	2.6	0.2	7.1	9.9	72%
11/1/2010 11:36 AM	Sample		11		2.03	0.07	2.12	skrice11110.xls	0.0	1.1	0.0	2.1	3.3	65%
11/1/2010 11:42 AM	Sample		12		10.38	0.34	4.87	skrice11110.xls	0.0	5.6	0.2	4.9	10.7	46%

11/1/2010 11:47 AM	Sample		13	0.00	1.52		3.46	skrice11110.xls	0.0	0.8	0.0	3.5	4.3	81%
11/1/2010 11:53 AM	Sample		14		2.00	0.04	2.61	skrice11110.xls	0.0	1.1	0.0	2.6	3.7	70%
11/1/2010 11:58 AM	Sample		15	0.05	6.14	0.24	3.72	skrice11110.xls	0.0	3.3	0.1	3.7	7.2	52%
11/1/2010 12:03 PM	Sample		16	0.00	0.02		0.00	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	27%
11/1/2010 12:09 PM	Sample		17	0.01	4.83		4.83	skrice11110.xls	0.0	2.6	0.0	4.8	7.5	65%
11/1/2010 12:14 PM	Sample		18		3.95		3.49	skrice11110.xls	0.0	2.1	0.0	3.5	5.6	62%
11/1/2010 12:19 PM	Sample		blank				0.00	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 12:25 PM	Sample		10ppb	9.21	9.42	9.27	9.26	skrice11110.xls	3.9	5.1	5.0	9.3	23.3	40%
11/1/2010 12:30 PM	Sample		19		2.07	0.09	2.71	skrice11110.xls	0.0	1.1	0.0	2.7	3.9	70%
11/1/2010 12:36 PM	Sample		20		2.80		4.65	skrice11110.xls	0.0	1.5	0.0	4.7	6.2	75%
11/1/2010 12:41 PM	Sample		21	0.01	0.30		1.55	skrice11110.xls	0.0	0.2	0.0	1.6	1.7	90%
11/1/2010 12:46 PM	Sample		22		1.95	0.01	3.00	skrice11110.xls	0.0	1.1	0.0	3.0	4.1	74%
11/1/2010 12:52 PM	Sample		23		2.09		2.14	skrice11110.xls	0.0	1.1	0.0	2.1	3.3	65%
11/1/2010 12:57 PM	Sample		24		6.48		4.12	skrice11110.xls	0.0	3.5	0.0	4.1	7.6	54%
11/1/2010 1:03 PM	Sample		25		3.00	0.08	4.52	skrice11110.xls	0.0	1.6	0.0	4.5	6.2	73%
11/1/2010 1:08 PM	Sample		26	0.03	4.09	0.28	5.80	skrice11110.xls	0.0	2.2	0.2	5.8	8.2	71%
11/1/2010 1:13 PM	Sample		27	0.06	2.09		1.98	skrice11110.xls	0.0	1.1	0.0	2.0	3.1	63%
11/1/2010 1:19 PM	Sample		28		8.54	0.26	3.23	skrice11110.xls	0.0	4.6	0.1	3.2	8.0	40%
11/1/2010 1:24 PM	Sample		blank				0.00	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 1:30 PM	Sample		10ppb	9.42	9.26	9.34	9.45	skrice11110.xls	4.0	5.0	5.1	9.5	23.5	40%
11/1/2010 1:35 PM	Sample		29		3.43	0.19	4.36	skrice11110.xls	0.0	1.9	0.1	4.4	6.3	69%

11/1/2010 1:40 PM	Sample		30	0.04	6.82	0.12	5.89	skrice11110.xls	0.0	3.7	0.1	5.9	9.7	61%
11/1/2010 1:46 PM	Sample		31		2.67	0.02	10.34	skrice11110.xls	0.0	1.5	0.0	10.3	11.8	88%
11/1/2010 1:51 PM	Sample		32		5.89	0.12	5.20	skrice11110.xls	0.0	3.2	0.1	5.2	8.5	61%
11/1/2010 1:57 PM	Sample		33	0.03	3.37		3.47	skrice11110.xls	0.0	1.8	0.0	3.5	5.3	65%
11/1/2010 2:02 PM	Sample		34	0.04	3.36	0.04	5.45	skrice11110.xls	0.0	1.8	0.0	5.4	7.3	74%
11/1/2010 2:07 PM	Sample		35	0.02	3.89		4.26	skrice11110.xls	0.0	2.1	0.0	4.3	6.4	67%
11/1/2010 2:13 PM	Sample		36	0.03	0.56		1.37	skrice11110.xls	0.0	0.3	0.0	1.4	1.7	81%
11/1/2010 2:41 PM	Sample		37					skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 2:46 PM	Sample		38		3.39	0.04	4.88	skrice11110.xls	0.0	1.8	0.0	4.9	6.7	72%
11/1/2010 2:52 PM	Sample		blank			0.00	0.00	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 2:57 PM	Sample		10ppb	9.43	9.37	9.25	9.13	skrice11110.xls	4.0	5.1	5.0	9.1	23.2	39%
11/1/2010 3:02 PM	Sample		37		4.77	0.17	5.20	skrice11110.xls	0.0	2.6	0.1	5.2	7.9	66%
11/1/2010 3:08 PM	Sample		39	0.04	4.12		6.91	skrice11110.xls	0.0	2.2	0.0	6.9	9.2	75%
11/1/2010 3:13 PM	Sample		40	0.03	1.32		2.59	skrice11110.xls	0.0	0.7	0.0	2.6	3.3	78%
11/1/2010 3:19 PM	Sample		41	0.03	1.92		3.35	skrice11110.xls	0.0	1.0	0.0	3.3	4.4	76%
11/1/2010 3:24 PM	Sample		42	0.02	1.84	0.03	3.56	skrice11110.xls	0.0	1.0	0.0	3.6	4.6	78%
11/1/2010 3:29 PM	Sample		43	0.02	2.71		3.69	skrice11110.xls	0.0	1.5	0.0	3.7	5.2	71%
11/1/2010 3:35 PM	Sample		44		3.47	0.13	3.72	skrice11110.xls	0.0	1.9	0.1	3.7	5.7	66%
11/1/2010 3:40 PM	Sample		45		0.69		1.62	skrice11110.xls	0.0	0.4	0.0	1.6	2.0	81%
11/1/2010 3:46 PM	Sample		46		2.69		3.25	skrice11110.xls	0.0	1.5	0.0	3.3	4.7	69%
11/1/2010 3:51 PM	Sample		47		4.35		5.26	skrice11110.xls	0.0	2.4	0.0	5.3	7.6	69%

11/1/2010 3:56 PM	Sample		48	0.01	3.58	0.01	3.93	skrice11110.xls	0.0	1.9	0.0	3.9	5.9	67%
11/1/2010 4:02 PM	Sample		blank				0.00	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 4:07 PM	Sample		10ppb	9.08	9.16	9.10	9.24	skrice11110.xls	3.8	5.0	4.9	9.2	23.0	40%
11/1/2010 4:13 PM	Sample		49		3.67		3.35	skrice11110.xls	0.0	2.0	0.0	3.4	5.3	63%
11/1/2010 4:18 PM	Sample		50	0.04	1.60		4.13	skrice11110.xls	0.0	0.9	0.0	4.1	5.0	82%
11/1/2010 4:24 PM	Sample		51	0.01	2.22		3.05	skrice11110.xls	0.0	1.2	0.0	3.0	4.3	72%
11/1/2010 4:29 PM	Sample		52		0.72		2.06	skrice11110.xls	0.0	0.4	0.0	2.1	2.4	84%
11/1/2010 4:34 PM	Sample		53		2.47		4.18	skrice11110.xls	0.0	1.3	0.0	4.2	5.5	76%
11/1/2010 4:40 PM	Sample		blank	0.00			0.00	skrice11110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/1/2010 4:45 PM	Sample		1ppb	0.93	1.02	1.08	1.08	skrice11110.xls	0.4	0.6	0.6	1.1	2.6	41%
11/1/2010 4:51 PM	Sample		5ppb	5.06	5.06	5.11	5.02	skrice11110.xls	2.1	2.7	2.8	5.0	12.7	40%
11/1/2010 4:56 PM	Sample		10ppb	10.19	10.04	10.13	9.95	skrice11110.xls	4.3	5.5	5.5	10.0	25.2	39%
11/1/2010 5:01 PM	Sample		50ppb	49.96	49.98	49.96	50.01	skrice11110.xls	21.0	27.1	27.1	50.0	125.3	40%
11/2/2010 9:11 AM	CalBlk	1	blank		0.00	0.00		skrice21110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/2/2010 9:17 AM	CalStd	2	1ppb	0.94	1.00	1.03	1.07	skrice21110.xls	0.4	0.5	0.6	1.1	2.6	42%
11/2/2010 9:22 AM	CalStd	3	5ppb	4.74	4.80	4.88	4.66	skrice21110.xls	2.0	2.6	2.6	4.7	11.9	39%
11/2/2010 9:28 AM	CalStd	4	10ppb	9.46	9.67	9.51	9.45	skrice21110.xls	4.0	5.3	5.2	9.5	23.8	40%
11/2/2010 9:33 AM	CalStd	5	50ppb	50.14	50.09	50.11	50.14	skrice21110.xls	21.1	27.2	27.2	50.1	125.7	40%
11/2/2010 9:38 AM	Sample		54		4.68		3.61	skrice21110.xls	0.0	2.5	0.0	3.6	6.1	59%
11/2/2010 9:44 AM	Sample		55		4.76		3.64	skrice21110.xls	0.0	2.6	0.0	3.6	6.2	58%
11/2/2010 9:49 AM	Sample		56		0.60		2.98	skrice21110.xls	0.0	0.3	0.0	3.0	3.3	90%

11/2/2010 9:55 AM	Sample		57	0.03	3.47	-0.01	3.27	skrice21110.xls	0.0	1.9	0.0	3.3	5.2	63%
11/2/2010 10:00 AM	Sample		58	0.02	0.65		2.99	skrice21110.xls	0.0	0.4	0.0	3.0	3.3	89%
11/2/2010 10:06 AM	Sample		blank	0.02	-0.01	-0.02	0.00	skrice21110.xls	0.0	0.0	0.0	0.0	0.0	-104%
11/2/2010 10:11 AM	Sample		10ppb	9.01	9.52	9.48	9.51	skrice21110.xls	3.8	5.2	5.1	9.5	23.6	40%
11/2/2010 10:16 AM	Sample		59	0.05	1.21	-0.02	3.38	skrice21110.xls	0.0	0.7	0.0	3.4	4.0	84%
11/2/2010 10:22 AM	Sample		60		9.87	0.03	7.14	skrice21110.xls	0.0	5.4	0.0	7.1	12.5	57%
11/2/2010 10:27 AM	Sample		61		3.30	0.25	9.53	skrice21110.xls	0.0	1.8	0.1	9.5	11.5	83%
11/2/2010 10:33 AM	Sample		62		1.13		4.62	skrice21110.xls	0.0	0.6	0.0	4.6	5.2	88%
11/2/2010 10:38 AM	Sample		63		0.45		1.84	skrice21110.xls	0.0	0.2	0.0	1.8	2.1	88%
11/2/2010 10:43 AM	Sample		64	0.02	1.13		3.37	skrice21110.xls	0.0	0.6	0.0	3.4	4.0	84%
11/2/2010 10:49 AM	Sample		65		10.74	0.00	4.47	skrice21110.xls	0.0	5.8	0.0	4.5	10.3	43%
11/2/2010 10:54 AM	Sample		66		6.35	0.01	3.88	skrice21110.xls	0.0	3.4	0.0	3.9	7.3	53%
11/2/2010 11:00 AM	Sample		67					skrice21110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/2/2010 11:05 AM	Sample		68		3.07	0.00	4.48	skrice21110.xls	0.0	1.7	0.0	4.5	6.1	73%
11/2/2010 11:10 AM	Sample		blank					skrice21110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/2/2010 11:16 AM	Sample		10ppb	8.95	9.24	8.82	8.78	skrice21110.xls	3.8	5.0	4.8	8.8	22.4	39%
11/2/2010 11:21 AM	Sample		69	0.03	1.36	0.43	2.63	skrice21110.xls	0.0	0.7	0.2	2.6	3.6	73%
11/2/2010 11:27 AM	Sample		70		4.15		3.26	skrice21110.xls	0.0	2.3	0.0	3.3	5.5	59%
11/2/2010 11:32 AM	Sample		71		3.53		2.35	skrice21110.xls	0.0	1.9	0.0	2.4	4.3	55%
11/2/2010 11:37 AM	Sample		72		0.16		1.11	skrice21110.xls	0.0	0.1	0.0	1.1	1.2	93%
11/2/2010 11:43 AM	Sample		73		1.55	-0.04	3.55	skrice21110.xls	0.0	0.8	0.0	3.5	4.4	81%

11/2/2010 11:48 AM	Sample		74		0.16	0.18	0.78	skrice21110.xls	0.0	0.1	0.1	0.8	1.0	81%
11/2/2010 11:53 AM	Sample		75	0.00	3.73		3.47	skrice21110.xls	0.0	2.0	0.0	3.5	5.5	63%
11/2/2010 11:59 AM	Sample		75	0.04	5.20	0.04	3.85	skrice21110.xls	0.0	2.8	0.0	3.9	6.7	57%
11/2/2010 12:04 PM	Sample		77		2.80		3.16	skrice21110.xls	0.0	1.5	0.0	3.2	4.7	68%
11/2/2010 12:10 PM	Sample		78	0.04	8.31	0.13	3.28	skrice21110.xls	0.0	4.5	0.1	3.3	7.9	42%
11/2/2010 12:15 PM	Sample		control				0.43	skrice21110.xls	0.0	0.0	0.0	0.4	0.4	100%
11/2/2010 12:21 PM	Sample		dup65		10.37		4.12	skrice21110.xls	0.0	5.6	0.0	4.1	9.8	42%
11/2/2010 12:26 PM	Sample		dup41		2.25		3.50	skrice21110.xls	0.0	1.2	0.0	3.5	4.7	74%
11/2/2010 12:31 PM	Sample		blank				0.01	skrice21110.xls	0.0	0.0	0.0	0.0	0.0	100%
11/2/2010 12:37 PM	Sample		10ppb	8.00	8.11	8.43	8.19	skrice21110.xls	3.4	4.4	4.6	8.2	20.5	40%
11/2/2010 1:00 PM	Sample		dup33	0.03	4.02	0.01	3.79	skrice21110.xls	0.0	2.2	0.0	3.8	6.0	63%
11/2/2010 1:09 PM	Sample		dup43	0.01	3.34		3.75	skrice21110.xls	0.0	1.8	0.0	3.7	5.6	67%
11/2/2010 1:14 PM	Sample		dup42		1.93		3.16	skrice21110.xls	0.0	1.0	0.0	3.2	4.2	75%
11/2/2010 1:19 PM	Sample		crm5		24.08	1.48	7.14	skrice21110.xls	0.0	13.1	0.8	7.1	21.0	34%
11/2/2010 1:25 PM	Sample		dup14		4.53	0.11	4.63	skrice21110.xls	0.0	2.5	0.1	4.6	7.1	65%
11/2/2010 1:30 PM	Sample		crm6	0.04	24.96	1.44	7.33	skrice21110.xls	0.0	13.6	0.8	7.3	21.7	34%
11/2/2010 1:36 PM	Sample		dup40		1.35		2.41	skrice21110.xls	0.0	0.7	0.0	2.4	3.1	77%
11/2/2010 1:41 PM	Sample		dup7		0.75		1.25	skrice21110.xls	0.0	0.4	0.0	1.3	1.7	75%
11/2/2010 1:46 PM	Sample		crm4		24.83	1.28	7.45	skrice21110.xls	0.0	13.5	0.7	7.4	21.6	34%
11/2/2010 1:52 PM	Sample		dup10	0.04	14.49	1.67	20.17	skrice21110.xls	0.0	7.9	0.9	20.2	29.0	70%
11/2/2010 1:57 PM	Sample		crm3		51.59	3.38	14.63	skrice21110.xls	0.0	28.0	1.8	14.6	44.5	33%

11/2/2010 2:03 PM	Sample		dup15	0.03	6.66	0.24	4.00	skrice21110.xls	0.0	3.6	0.1	4.0	7.8	52%
11/2/2010 2:08 PM	CalBlk	1	blank					skrice21110.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
11/2/2010 2:14 PM	CalStd	2	1ppb	0.92	1.03	1.02	1.10	skrice21110.xls	0.4	0.6	0.6	1.1	2.6	42%
11/2/2010 2:19 PM	CalStd	3	5ppb	4.77	4.83	4.87	4.90	skrice21110.xls	2.0	2.6	2.6	4.9	12.2	40%
11/2/2010 2:24 PM	CalStd	4	10ppb	8.95	8.82	8.74	8.67	skrice21110.xls	3.8	4.8	4.7	8.7	22.0	39%
11/2/2010 2:30 PM	CalStd	5	50ppb	50.23	50.25	50.26	50.27	skrice21110.xls	21.1	27.3	27.3	50.3	126.0	40%
10/26/2010 10:13 AM	CalBlk	1	wash	0.00	0.00	0.00	0.00	sk261010.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
10/26/2010 10:18 AM	CalStd	2	1ppb	0.82	1.14	1.17	1.13	sk261010.xls	0.3	0.6	0.6	1.1	2.7	41%
10/26/2010 10:24 AM	CalStd	3	5ppb	4.88	5.30	5.34	5.36	sk261010.xls	2.1	2.9	2.9	5.4	13.2	41%
10/26/2010 10:29 AM	CalStd	4	10ppb	9.84	10.35	10.40	10.46	sk261010.xls	4.1	5.6	5.6	10.5	25.9	40%
10/26/2010 10:35 AM	CalStd	5	50ppb	50.05	49.90	49.88	49.87	sk261010.xls	21.1	27.1	27.1	49.9	125.1	40%
10/26/2010 10:40 AM	Sample		10ppb all species	9.06	19.71	10.15	13.82	sk261010.xls	3.8	10.7	5.5	13.8	33.9	41%
10/26/2010 10:46 AM	Sample		20ppb matrix spike	18.95	21.79	20.24	47.12	sk261010.xls	8.0	11.8	11.0	47.1	77.9	60%
10/26/2010 10:51 AM	Sample		lr1	-0.01	1.59	0.01	3.45	sk261010.xls	0.0	0.9	0.0	3.5	4.3	80%
10/26/2010 10:57 AM	Sample		lr4	-0.02	2.79	0.07	2.14	sk261010.xls	0.0	1.5	0.0	2.1	3.7	58%
10/26/2010 11:02 AM	Sample		lr5	0.03	6.24	0.00	3.15	sk261010.xls	0.0	3.4	0.0	3.2	6.5	48%
10/26/2010 11:07 AM	Sample		lr6	-0.03	1.60	-0.01	3.81	sk261010.xls	0.0	0.9	0.0	3.8	4.7	82%
10/26/2010 11:13 AM	Sample		lr6b	0.06	1.86	-0.01	4.19	sk261010.xls	0.0	1.0	0.0	4.2	5.2	80%
10/26/2010 11:18 AM	Sample		lr9	-0.02	3.33	-0.01	4.53	sk261010.xls	0.0	1.8	0.0	4.5	6.3	72%
10/26/2010 11:24 AM	Sample		lr10	-0.03	4.55	-0.01	7.62	sk261010.xls	0.0	2.5	0.0	7.6	10.1	76%

10/26/2010 11:29 AM	Sample	1	blank	0.00	0.00	0.00	0.00	sk261010.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
10/26/2010 11:35 AM	Sample	2	1ppb	0.60	1.03	1.08	1.08	sk261010.xls	0.3	0.6	0.6	1.1	2.5	44%
10/26/2010 11:40 AM	Sample	3	5ppb	4.68	5.12	5.20	5.17	sk261010.xls	2.0	2.8	2.8	5.2	12.7	41%
10/26/2010 11:46 AM	Sample	4	10ppb	9.72	10.51	10.70	10.66	sk261010.xls	4.1	5.7	5.8	10.7	26.3	41%
10/26/2010 11:51 AM	Sample	5	50ppb	50.10	49.88	49.84	49.85	sk261010.xls	21.1	27.1	27.1	49.8	125.1	40%
10/26/2010 11:57 AM	Sample		lr10b	-0.15	-0.05	0.00	-0.03	sk261010.xls	-0.1	0.0	0.0	0.0	-0.1	29%
10/26/2010 12:02 PM	Sample		lr21	-0.14	0.37	0.04	2.09	sk261010.xls	-0.1	0.2	0.0	2.1	2.2	93%
10/26/2010 12:08 PM	Sample		lr30	-0.07	4.23	0.02	4.78	sk261010.xls	0.0	2.3	0.0	4.8	7.1	68%
10/26/2010 12:13 PM	Sample		lr40	-0.13	1.33	0.00	3.40	sk261010.xls	-0.1	0.7	0.0	3.4	4.1	84%
10/26/2010 12:19 PM	Sample		lr46	-0.14	4.28	0.00	7.37	sk261010.xls	-0.1	2.3	0.0	7.4	9.6	76%
10/26/2010 12:24 PM	Sample		lr53a	-0.12	3.93	0.00	4.57	sk261010.xls	0.0	2.1	0.0	4.6	6.7	69%
10/26/2010 12:30 PM	Sample		lr53b	-0.15	7.76	0.19	2.42	sk261010.xls	-0.1	4.2	0.1	2.4	6.7	36%
10/26/2010 12:35 PM	Sample		(crm6)f	-0.09	26.48	0.56	9.13	sk261010.xls	0.0	14.4	0.3	9.1	23.8	38%
10/26/2010 12:40 PM	Sample		blank b3	-0.12	-0.06	0.00	1.18	sk261010.xls	0.0	0.0	0.0	1.2	1.1	107%
10/26/2010 12:46 PM	Sample	1	blank	0.00	0.00	0.00	0.00	sk261010.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
10/26/2010 12:51 PM	Sample	2	1ppb	0.54	1.01	1.05	1.07	sk261010.xls	0.2	0.6	0.6	1.1	2.4	44%
10/26/2010 12:57 PM	Sample	3	5ppb	4.84	5.16	5.11	5.20	sk261010.xls	2.0	2.8	2.8	5.2	12.8	41%
10/26/2010 1:02 PM	Sample	4	10ppb	9.68	10.16	10.03	10.12	sk261010.xls	4.1	5.5	5.4	10.1	25.2	40%
10/26/2010 1:08 PM	Sample	5	50ppb	50.09	49.95	49.98	49.95	sk261010.xls	21.1	27.1	27.1	50.0	125.3	40%
10/26/2010 1:24 PM	Sample		w1.9	-0.05	-0.02	-0.03	0.00	sk261010.xls	0.0	0.0	0.0	0.0	-0.1	7%
10/26/2010 1:30 PM	Sample		2.9	0.04	-0.03	-0.03	0.00	sk261010.xls	0.0	0.0	0.0	0.0	0.0	1%

10/26/2010 1:35 PM	Sample		3.9	-0.05	-0.03	-0.02	0.12	sk261010.xls	0.0	0.0	0.0	0.1	0.1	164%
10/26/2010 1:40 PM	Sample		16.9	-0.03	56.71	-0.03	3.51	sk261010.xls	0.0	30.8	0.0	3.5	34.3	10%
10/26/2010 1:46 PM	Sample		17.9	-0.01	21.71	-0.02	1.36	sk261010.xls	0.0	11.8	0.0	1.4	13.1	10%
10/26/2010 1:51 PM	Sample		18.9		29.93		0.76	sk261010.xls	0.0	16.3	0.0	0.8	17.0	4%
10/26/2010 1:57 PM	Sample		25.9		14.11	0.00	0.62	sk261010.xls	0.0	7.7	0.0	0.6	8.3	7%
10/26/2010 2:02 PM	Sample		26.9		15.65	-0.03	0.61	sk261010.xls	0.0	8.5	0.0	0.6	9.1	7%
10/26/2010 2:08 PM	Sample		27.9		21.71	-0.01	1.17	sk261010.xls	0.0	11.8	0.0	1.2	12.9	9%
10/26/2010 2:13 PM	Sample	1	blank	0.00	0.00	0.00	0.00	sk261010.xls	0.0	0.0	0.0	0.0	0.0	#DIV/0!
10/26/2010 2:19 PM	Sample	2	1ppb	0.75	1.03	1.00	0.96	sk261010.xls	0.3	0.6	0.5	1.0	2.4	40%
10/26/2010 2:24 PM	Sample	3	5ppb	4.73	5.09	5.20	5.13	sk261010.xls	2.0	2.8	2.8	5.1	12.7	40%
10/26/2010 2:29 PM	Sample	4	10ppb	9.68	10.27	10.38	10.35	sk261010.xls	4.1	5.6	5.6	10.4	25.6	40%
10/26/2010 2:35 PM	Sample	5	50ppb	50.10	49.94	49.90	49.92	sk261010.xls	21.1	27.1	27.1	49.9	125.2	40%