# Impact of Brick Kiln Emissions on the Ambient Air Quality and Vegetation: A Case Study of District Budgam

**DISSERTATION SUBMITTED TO THE**
**UNIVERSITY OF KASHMIR**
**IN PARTIAL FULFILMENT OF THE**
**REQUIREMENT FOR THE AWARD OF DEGREE OF**
**MASTER OF PHILOSOPHY**
**IN**

**ENVIRONMENTAL SCIENCE**


**BY**

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**April 2011**

*Post Graduate Department of Environmental Science*

**The University of Kashmir, Srinagar–190006**

# Certificate

*This is to certify that the dissertation titled* "**Impact of Brick Kiln Emissions on the Ambient Air Quality and Vegetation: A case study of District Budgam**" *which is being submitted by* ***Ms. Irm Fatima****, Bearing University Registration No. 39625-W-2003, in partial fulfillment of the requirement for the award of* ***M. Phil. Degree in Environmental Science*** *of the University of Kashmir, is a record of her own work carried out by her under our supervision and guidance. The matter embodied in this dissertation has not been carried out for the award of any other degree. The candidate has fulfilled all the formalities as required under statutes and the dissertation is forwarded herewith for the acceptance and award of the degree.*

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*To my beloved parents*

# Acknowledgements

First of all, all praise is due to Almighty Allah the most Beneficent the most Merciful by whose grace I was able to complete my work.

My deep felt gratitude is towards my esteemed guide Prof. G. A. Bhat for imparting valuable guidance, constructive criticism, friendly spirit and constant encouragement right from the initiation to the completion, and shaping of the manuscript.

I owe a deep sense of gratitude to my co-supervisor Prof. A. N. Kamili (Head, Department of Environmental Science) for her valuable suggestions and constant advice from time to time.

I have no words to express my thanks to the research scholars of Terrestrial Ecology Laboratory especially Mr. Mudasir Ali and Ms. Shazia Punjoo for their generous help and cooperation.

I am also thankful to non-teaching staff of the department for their constant help.

It would have been impossible to accomplish the study without the blessings, good wishes, constant and unfailing encouragement of my parents. They have been all long a source of inspiration and motivation for me to accomplish the objectives of the present endeavor.

Irm Fatima

# Contents

# *Chapter 1*

# Introduction

It has been said that the study of bricks is the study of civilization. Bricks made of mud and straw have been used for thousands of years. Some bricks over ten thousand years old have been discovered. In India, the history of making bricks is almost 5000 years old which is as old as the earliest known Indian civilization "Indus Valley Civilization". It is actually owing to the discovery of some old bricks during the construction of railway track from Karachi to Punjab in mid 19th century that ultimately led archaeologists to the discovery of Indus Valley Civilization. The people of that civilization extensively used bricks to lay complex mathematically planned cities. Some of these towns were almost 3 miles in diameter and housed as many as 30,000 residents. Even now, nearly 5000 years later, bricks are being used extensively across the country, so much so, that India is the second largest producer of bricks after China. Estimated brick production during 2000-2001 was close to 140 billion, most of which was in unorganized sector in small units. Today there are more than one lac brick kilns clustered in rural and peri-urban areas of the country (Maithel *et al.* 2003).

One of the first building materials created by man, bricks, are still a highly desired choice of this day. The bricks are formed by hand and left in the sun to dry.

But there is a problem with plain mud bricks. Over time, rain water will dissolve them and cause them to crumble and break apart. Early brick makers eventually learned that if they would “burn” the bricks by baking them in a very hot oven called a “kiln”, the bricks would become very hard and durable. Sun-dried mud bricks were one of the first building material which, as Man made advance in the art of pottery, were later dried and burned in kilns to impart strength to it. Kilns are thermally insulated chambers or ovens in which controlled chamber temperature regimens are produced. They are used to harden, burn or dry the material.

Brick Kilns fall into one, or both, of the following categories–*Intermittent Kilns*- bricks are fired in batches e.g., Clamp, Scove and Scotch; and/ or *Continous Kilns*- firing occurs all the time, e.g., Hoffman, Bull’s Trench, Habla, etc. The following kilns are most commonly in use today:

*Clamp Kiln,* Ancient technology- 4,000 B.C. The most commonly used kilns in the developing world. These kilns have a devastating impact on both on the environment and workers. Generally built with four brick walls like a room, then green bricks are stacked inside. They are inefficient in fuel, labour intensive and highly polluting. They are only operated in intermittent mode. To produce higher brick production clamp kilns are frequently built, grouped and operated in clusters.

*Hoffman Kiln,* Invented in Germany, 1858. These kilns have a large permanent arched masonry and a tall masonry chimney of about 30m. They must operate in continuous mode. Used in Australia from 1883 until approximately 1975.

*Bull’s Trench Kiln,* Invented in England, 1876. Commonly used in India, this kiln uses movable metal chimneys which are man-handled by a team of workers into different positions as the fire moves through the kiln. The improved Bull’s Trench Kiln has a permanent brick chimney over 30m high. The chimney requires skilled brick layers to construct and is costly to build. The kiln can only be operated in continuous mode. It has no roof and can only be used outside the monsoon season.

*Tunnel kiln,* Invented in Germany, 1877. Most common in developed world countries since their invention. Tunnel kilns have now become highly automated and are for large brick production. Bricks move mechanically through a long stationary fire zone. They have minimal labour requirements but a very high capital cost. They must be operated in continuous mode and require a guaranteed electricity supply.

*Habla Kiln,* Invented in Germany, 1927. The Habla zig-zag kiln is the most fuel efficient kiln yet invented and the cheapest to build. It features a long fire zone advanced by suction fan. The Habla Kiln consumes less fuel, uses less mechanical energy and requires far less capital outlay with almost no maintenance. It also has a roof resulting in improved working conditions and longer operational time during monsoon conditions.

*Vertical Shaft Kiln,* Invented in China, 1958. Reasonably fuel efficient, however, the kiln is limited due to a low throughput. Green bricks are loaded into the shaft and, therefore, must be hauled up a ramp to the top of the kiln.

Across India brick making is still typically a manual process. The most common type of kilns used here to fire bricks is Bull's trench kilns (BTK). This sector consumes about 24 million tonnes of coal and several million tonnes of biomass every year. The share of energy cost in brick production varies between 35%-50%.

Bricks may be made from clay, shale, soft slate, calcium silicate, concrete, or shaped from quarried stone. Clay is the most common material, with modern clay bricks formed in one of three processes- soft mud, dry press, or extruded. Normally, bricks contain the ingredients as Silica (Sand) – 50-60% by weight; Alumina (Clay) – 20-30% by weight; Lime – 2-50% by weight; Iron oxide – 5-6% (not greater than 7%) by weight; and Magnesia – less than 1% by weight.

The soft mud method is the most common, as it is the most economical. It starts with the raw clay, preferably in a mix with 25-30% sand to reduce shrinkage. The clay is first grounded and mixed with water to the desired consistency. The clay

is then pressed into steel moulds with a hydraulic press. The shaped clay is then fired (“burned”) at 900-1000 °C to achieve strength.

The process of making bricks generally consists of the steps– gathering, crushing, grinding, screening and mixing the raw materials, making the brick; and setting, drying, firing, packaging and inventorying the final product. The process can be briefly summarized as:

Excavation of Mud  Mixing the ingredients  Moulding  Drying  Loading the kiln  Firing the kiln (progressively)  Taking out the burnt bricks (Progressively)  Inspection  Delivery

The manufacturing of bricks begins with the gathering of surface clays and shales from the quarry. The large chunks are crushed and screened in which the fine material passes through to the next step. Upto this point the material has been kept dry. Now the water is added to provide the proper plasticity. The next step is to make the material into the shape of the brick. There are three basic methods that can be used to shape the material: hand made, machine moulded or extruded. In hand made method, a soft mixture is forced through an extruder, cut into slugs and conveyed to work stations. The slugs are then individually picked up, rolled in sand and thrown into a pre-sanded wooden mould by a worker. Excess raw material is removed by a wire and endless belt. As the filled mold boxes continue on their journey, they are mechanically bumped on their ends to loosen the brick from the mold prior to dumping.

After the brick unit is formed, the units are hand or mechanically set onto kiln cars (carts). Prior to entering the kiln, the unfired or green brick must be properly dried. This is an extremely important part of the manufacturing process. Moisture in the brick must be limited at this time to prevent scumming and certain mechanical defects from occurring when the brick is subjected to the intense heat of the kiln. Generally, the drying process is done by placing the green brick under

the sun. The next step is burning or firing the green brick. The pre-heating, burning and cooling is done in zones varying in temperature. The color variations results with the extremes of dark color nearest the fire or in the crown on the kiln and the light color at the end where the brick have the lowest temperature. The remainder of the brick will have medium tones. After exiting the kiln, the brick is allowed to cool prior to handling. Proper sorting and packaging of the brick after burning is extremely important. Broken, twisted and otherwise mechanically defective bricks are discarded at this stage. Brick color and range is carefully monitored to assure a quality product. The finished product is packaged and distributed to customers.

## Impacts associated with the operations of Brick Kilns

Production of burnt clay bricks requires consumption of coal leading to green house gas emissions. The primary raw material used for bricks is the soil, which is often taken from prime agricultural land causing land degradation as well as economic loss due to diversion of agricultural land. Use of traditional technologies in firing the bricks results in significant local air pollution. The burnt clay brick industry in India produces over 180 billion clay bricks annually with a strong impact on soil erosion and unprocessed emissions. Emission of huge quantity of toxic elements from brick kilns is causing serious health hazards. The brick kilns emit toxic fumes containing suspended particulate matters rich in carbon particles and high concentration of carbon monoxides and oxides of sulphur (SOx) that are harmful to eyes, lungs and throat. These toxic fumes also affect crops and plants in the areas adjacent to brick fields.

Brick kilns are increasingly being setup in agricultural lands and reducing their fertility. Traditionally brick kilns were concentrated at the river bank areas. This was mainly because of easy access to sediments and alluvium soil, which was used for the preparation of the bricks. But from 2000, brick kilns are being constructed inside villages, far away from the rivers.

Brick kiln is one of the principal agents of top soil degradation and environmental pollution. Brick kilns are destroying large areas of lands every year where bricks are made by collecting soils in agricultural land. These affected areas are expanding rapidly due to the increase in brick production. Brick burning not only alters the physico-chemical properties and habitats of the nearby soils but also contributes to the pollution of environments and ecosystems. The top soil nutrient elements and soil biota are destroyed through brick burning. Brick burning are largely influencing the concentrations of greenhouse gases in the atmosphere.

Across most of the developing countries like India, it is seen that brick kilns mostly use low cost waste material as primary source of fuel. The design of kilns, fuel characteristics and lack of complete combustion and emission control contribute to the release of contaminants and high concentration of pollutants from brick kilns in the form of flue gases. The flue gases which are emitted from the stacks of brick kilns mainly comprise of fly ash, $SO_2$, $CO_2$, $NO_X$, CO, particulate matter, respirable particulate matter many a times having high concentration of toxic metals and volatile organic compounds. Being one of the largest consumers of coal in the country, it is one of the important sources of carbon dioxide emission in the country. Other air pollutants from brick kilns include *SPM (suspended particulate matter)* – in the flue gases which is generated mainly due to incomplete combustion of fuel (black smoke) or comes from fine coal dust, ash present in coal and burnt clay particles; *Hydrocarbons and carbon monoxide* – due to incomplete combustion of fuel; *Sulphur oxides,* concentration of which mainly depends on the amount of sulphur present in the coal is significant where high sulphur content coal is used (e.g., Assam coal, Kutch lignite); and *Dust pollution* generated during removal and laying down of ash layer on the top of the kiln and also due to blowing of ash stacked on the top and sides of the kiln. At local level (in the vicinity of brick kilns) some of these pollutants are injurious to human health, animal and plant life. At global level, pollutants like carbon dioxide contributes to the phenomena of global warming and climate change.

It is estimated that more than 1.3 billion urban residents are exposed to air pollution levels above the recommended limits. Humans on an average breathe 14 kilograms of air into their lungs per day. The effects of air pollution are both immediate and delayed. The immediate effects are borne by the respiratory system resulting in acute bronchitis. If pollution is intense it may even result in immediate death due to suffocation. The delayed effects linked to air pollution are respiratory allergies, chronic bronchitis, emphysema, bronchial asthama, skin diseases and eye disorders. In addition, it has also been found to play a significant role in the development of various malignancies, lung cancer being one of the representative examples (Park, 2000).

It has been demonstrated through experiments that plants are more sensitive to air pollutants, thus, it is fairly a common sight to spot damaged vegetation or barren tracks downwind from smelters or thermal power plants both utilizing coal as an energy source, sulphur dioxide being the main culprit (Muton, 1998). Loss in agriculture production due to air pollution is now a well known phenomenon. It is believed that wild native vegetation and forests are affected much more than agricultural crops due to air pollution. Also forests under stress from pollutants are more susceptible to damage by pathogens and other agents than are unstressed forests (Likens *et al.*, 1996).

Vegetation around brick kilns is not impacted only by air pollution but also by land degradation which occurs as a consequence of utilization of best quality top soil in brick making, eroding this very precious natural resource. Particulate matter such as dust and carbon soot deposited on vegetation can inhibit the normal respiration and photosynthesis mechanisms within the leaf.

Sulphur Dioxide enters the leaves mainly through the stomata and the resultant injury is either acute or chronic. The symptoms appear as 2-sided (bifacial) lesions that usually occur between the veins and occasionally along the margins of the leaves. Recently expanded leaves usually are the most sensitive to acute $SO_2$ injury,

the very youngest and oldest being somewhat more resistant. The symptoms of chronic injury appears as yellowing or chlorosis of the leaf, and occasionally as a bronzing on the under surface of the leaves.

It has been observed that although Ministry of Environment and Forests, Government of India notified emission standards and chimney heights for brick kilns during 1996, most of the brick kilns operating around the country are not complying with any of the standards and are thus contributing to the environmental pollution in rural and peri-urban areas where they mainly operate. The major environmental problems associated with operation of brick kilns are encountered due to the unchecked and uncontrolled emission of flue gases.

## Problem Statement and objectives of the study

Introduction of potentially harmful substances like gases and particulate matter from modern industrial civilization is recognized as having tremendous negative and harmful impact on living organisms. These pollutants of atmosphere exist in all the solid, liquid and gaseous states and interfere with the legitimate use of the air by the organisms creating various problems for them. The State of Jammu & Kashmir in general and the valley of Kashmir in particular has witnessed mushrooming of brick kilns consequent upon the tremendous construction boom that has been going on for the past two decades. The operation of these kilns releases huge amounts of toxic pollutants into the environment which progressively make the area around their location unfit for healthy growth and living of the flora and fauna.

The primary aim of this study was to make an attempt to undertake survey of a prominent brick kiln area of the valley and analyze its effects on the prevalent surrounding vegetation as a function of the distance (i.e. going downwind from the source) to infer the impact of these brick kiln emissions. The secondary data on land degradation that occurs due to their operation was also collected.

# *Chapter 2*

# Review of Literature

The effect of various gaseous and particulate pollutants emanating from Brick kilns on the surrounding vegetation was worked out by Sarkar and Kundu (1996). The relative densities of different herbs showed that there was definite decrease in densities of herbs in the vicinity of brick kiln as compared to control. However, some plants like *Blumia lacera, Calotropis spp*. and *Gnaphalium spp*. remained relatively unaffected. The percent frequency of the plant community revealed that excepting *Blumia lacera* and *Calotropis procera*, the occurrence of plant species diminished towards the brick kilns.

Christian *et al.* (2007) studied the Brick kilns in Central Mexico and found that wood-fueled brick making kilns emitted a suite of trace gases similar to those from biomass burning, but with much lower emission factors. Smoke from these kilns has a very high EC/OC ratio and produce 16% of the particulate matter and 43% of the $SO_2$ in the urban airshed.

Gupta and Narayan (2010) studied the long term impacts, associated with Brick kiln industry, on biomass and diversity structure of plant communities in Bulandshahr, U.P. The study revealed that long term Brick kiln industrial activity

affected the soil characteristics and concomitantly the structure of plant biomass (particularly the below-ground biomass), and species diversity.

Agarwal and Agarwal (1989) carried out the phyto-monitoring of air pollution around Obra Thermal Power Plant to assess the impact of air pollutants on vegetation around the thermal power plant. The responses of plants to air pollutants in terms of presence of foliar injury symptoms and changes in chlorophyll, ascorbic acid and sulphur content were measured. These changes were correlated with ambient $SO_2$ and suspended particulate matter (SPM) concentrations and amount of dust settled on leaf surfaces.

Pawar & Dubey (1985); and Gilbert (1968) showed that chlorophyll content is essential for the photosynthetic activity and reduction in chlorophyll content is an indicator of air pollution.

Kim and Kim (1989) worked on the composition of forest vegetation and the contents of polluted material in the needles in an air polluted area and observed that pH of soils, organic matter, importance value of each species and total Nitrogen; total number of species was low near the source of air pollutant whereas sulphur content was high. They further observed that *Pinus theunbergii, Quercus serrata and Smilax china* were tolerant and *Rhododendron mucronulatum, Rhododendron yedoeouse Var. Poukhancuse*, *Platycarya strobilacca* and *Lespedeza maritima* were sensitive to air pollution.

Sandelius *et al.* (1995) studied that the pollutants ($SO_2$, NOx) reduced the synthesis of chlorophyll and enhance degradation of chlorophyll.

Fulford and Murray (1990) studied the morphogenic changes in *Eucalyptus gomphocephala* exposed to $SO_2$ and observed that exposed plants grew taller without increase in above-ground plant weight, with thinner leaves and stems and more chlorophyll in healthy leaves than control plants.

Schmidt *et al.* (1990) worked out the comparison of effects of air pollutants ($SO_2$, $O_3$, $NO_2$) on intact leaves by measurement of chlorophyll, fluorescence and

P700 absorbance changes and observed that various air pollutants cause different damage in the photosynthetic apparatus of the leaves.

Singh *et al.* (1990) made study on effects of air pollutants on chlorophyll content and pollen fertility of some plants around Mathura refinery and found that there was loss in chlorophyll a and chlorophyll b content of *Cajanus cajan Milli* species, *Brassica nigra Koch*. and *Acacia nilotica Del*. They also observed loss in the pollen fertility of all the three species referred above. Prakesh *et al.* (2002) in a study on the effect of $SO_2$ exposure on chlorophyll content in *Raphanus sativus L*. and *Brassica rapa L*. fumigated with three different concentrations of $SO_2$ and observed that both chlorophyll a and b decreased with increased concentration of $SO_2$. The chlorophyll a showed more reduction than chlorophyll b.

The earliest recorded air pollution problems to vegetation were related to $SO_2$ (Haselhoff & Lindau, 1903). Tuladhar (2006) showed that Brick kilns of the Kathmandu valley were responsible for 27% of PM10 and 31% of TSP. The results showed that TSP, PM10 level was about two times higher and $SO_2$ level was three times higher in Brick Kiln season compared to off season. Ferdausi *et al.* (2008) observed that Gabtoli receives the highest amount of particulates leading to concentrations greater than 200 ug/$m^3$ due to Brick kilns only. Knudson *et al.* (1977)(cited in Unsworth and Omrod, 1982) explained that chlorophyll content could be a useful indicator for the evaluation of injury induced by pollutants (like NOx, $SO_2$).

Keller and Hedwig (1984) while studying the effects of $SO_2$ on the germination of conifer pollen observed inhibition of germination of pollen when fumigated with $SO_2$ at 0.225ppm. They concluded that *Pinus nigra* and *Pinus sylvertis* were more sensitive than *Pinus mugo* which responded in the same way as pollen of *Abies alba.*

Materna (1984) studied the harmful impacts of air pollution on mountainous Spruce stands and observed that a major part of the symptom injuries in foliage

was due to the direct effects of $SO_2$ and great nutritional disorders. The nutritional disorder arose after great losses of nutrients in forest soil due to acid deposition.

Riding and Percy (1985) worked on the effects of $SO_2$ and other pollutants on the morphology of epicuticular waxes on needles of *Pinus strobus* and *Pinus banksiana*. They observed that exposure of elongated needles of *Pinus strobus L*. to $SO_2$ and other unidentified air pollutants delayed wax deposition in the epistomatal chambers. Following completion of wax deposition, the wax rod-lets fused, forming plant like sheets. No alteration of wax form was evident on needles of *Pinus banksiana Lamb*., even under conditions which led to acute $SO_2$ foliar injury. Lace and Mainwaring (1985) determined soil sensitivity to acid deposition and made a series of curves of pH as a function of Base Exchange as a first step in determining the sensitivity of the major soil types to acid precipitation. They interpreted the curves in trees of standard soil characteristic to produce some generalized conclusion about soil sensitiveness.

Werschnitzky and Hubertus (1993) in a study on the influence of air pollution on the soil, areas of water, flora and fauna observed heaviest deposition of air pollutants in the soil of immediate vicinity of the sources. They further observed that the influence of air pollution on flora and fauna varied in intensity according to the ecosystem involved.

Zeiger and Taiz (2006) has shown that dust on leaves blocks stomata and lowers their conductance to $CO_2$. Polluting gases such as $SO_2$ and NOx enter leaves through stomata thus interfering with photosystem II. Chan *et al.* (2007) and Chen *et al.* (1990, 2007) explained that exposure to moderate level of $NO_2$ had a favourable effect on plants, whereas the exposure to high $NO_2$ concentration caused a reduction in total chlorophyll content. Saarinen and Liski (1993) while studying the effect of industrial air pollution on chlorophyll fluorescence and pigment contents of Scots pine (*Pinus sylvestris*) needles determined pigment

content of leaves. They suggested that $SO_2$ as a potential factor affecting the light reaction of photosynthesis.

Baur and Wild (1998) studied the biochemical indicators for Noval forest decline in Spruce to know the impact of air pollution on 2 year old spruce trees at 24 stands, and observed that chlorophyll content and protein decreased rapidly in relation to the redox components P700 and cytochrome f. Also, the PSII/ PSI stoichiometry kept on dropping suggesting unfavorable values, as the chlorophyll content diminished. The alpha-tocopherol concentration increased while the D1 protein content decreased.

Lalman and Singh (1990) determined phytotoxic influence of $SO_2$ pollution on leaf growth of Vigna mungo Linn. and observed a reduction in the number of leaflets, total leaf area and dry biomass in all the $SO_2$ fumigated plants as compared to control plants. They concluded that toxic effect of $SO_2$ was found to be directly proportional to the exposure time and concentration.

Saquib *et al.* (1992) studied the impact of air pollution on some weeds of tropical agro ecosystem. They observed that the pollution ($SO_2$ and fly ash) caused by coal burning in the thermal power plant significantly damaged the development of leaves and fruits, growth and biomass of roots and shoot in *Anagalis arvensis Linn*. while only the root length and fruit number were effected significantly in *Trigonella insica benth*. In both the species the loss was minimum with respect to root length and maximum with respect to fruit number per plant in the polluted locality. Protibha and Sharma (2000) observed the changes in chlorophyll and total free amino acids gram in response to $SO_2$ exposure under field conditions. They observed that the 20-day old plants of gram (*Cicerarietinum L. JG-315*) when exposed to 1 ppm $SO_2$ developed visible injury symptoms and suffered growth reductions and also depressed chlorophyll. There was also an increase in total free amino acid in the leaves of fumigated plants. Shahare and Varsheney (1994) worked on the effect of $SO_2$ pollution on some trees with reference to their growth

and observed that the exposure of $SO_2$ in field conditions adversely affected the plant as indicated by foliar injury in the form of chlorosis and necrosis, and phytomass was considerably suppressed.

Joshi *et al.* (1993) in a study on air quality monitoring at Indore city with special reference to $SO_2$ and tree bark pH observed that bark of the trees growing in polluted areas showed increased acidic nature, which corresponds to the concentration of $SO_2$ in air. The maximum change in bark pH was recorded in *Eugenia jambolana* whileas *Eucalyptus* species remained least affected. Assessment of air pollution tolerance of two common tree species against $SO_2$ was done by Tiwari and Bansal (1993). Two species, namely *Mimusops elengi* (evergreen) and *Ficus religiosa* (deciduous) were selected and exposed to different concentration of $SO_2$. It was found that the degree of foliar injury was directly proportional to the concentration of pollutant. Deciduous species was more susceptible to pollution stress than the evergreen species. Joshi and Luthra (1993) worked on $SO_2$ induced changes in $CO_2$ fixation and photosynthetic pigments in sorghum (*Sorghum bicolor L.)* leaves by exposing the plants to 0,1 to 3 ppm $SO_2$ for a period of 40 days. The parameters measured were found to be lower in exposed sets than in control. The reductions were greater in total chlorophyll, chlorophyll a and chlorophyll b. Total as well as specific activity of PEP-carboxylase also decreased with $SO_2$ level. Rath *et al.* (1996) observed that the fumigation of $SO_2$ at 1.0 ppm for 3 hours adversely affected the number of buds, flowers, fruits, dry matter and the chlorophyll content of the leaves. Mandal and Mukherji (1999) studying on changes in chlorophyll content, chlorophyllase activity, photosynthetic CO2 uptake, and sugar and starch contents in five dicotyledonous plants exposed to air pollution, found that there was decrease in plant productivity. Agarwal (2002) has shown the reductions in chlorophyll content of a variety of crop plants due to $NO_2$, $SO_2$ and O3 exposure.

Kim and Kang Lee (1996) studied the effect of air pollution on the forest vegetation structure in the vicinity of Sa-sang industrial complex in Korea. Forest

vegetation structure surrounding industrial complex was studied. It was concluded that plant species in the vicinity were less diverse due to impact of air pollution. The impacts also included stunted growth, reduced leaf area and degradation of chlorophyll contents. Iqbal *et al.* (1999) while studying the foliar responses of *Peristrophe bicalyculata* to coal smoke pollution observed a reduction in stomatal size, pore length, density and index, as well as the photosynthetic rate and total chlorophyll content growing at polluted site in pre-flowering, flowering and post-flowering stage of plant growth. The stomatal conductance was observed to increase at each stage.

Tzvetkova and Dimitar (1996) while working on effects of air pollution on carbohydrate and nutrient concentrations in some deciduous tree species like *Alianthus glandulosa, Carpinus betalus L., Tilia argentea* and *Quercus cerris L.* observed lower concentrations of starch, total and soluble sugar in polluted regions as compared to the unpolluted regions. They further observed a high accumulation of heavy metals at the end of the growing seasons and found that *Q. cerris* was tolerant to air pollution. Khan (1996) worked on the air pollution and root symbionts and observed that air pollution particularly $SO_2$, $O_3$ and flyash at higher levels inhibit root nodule bacteria and VAM fungi.

The effect of coal-smoke pollutants on the growth, yield and leaf epidermal features of *Abelmoschus esculentus Moench* was made by Gupta (1987) (cited in Agarwal 2002). The decrease in plant height and stem diameter, jeopardized the production of leaves and flower buds and stimulated leaf and flower fall, leading to decrease in the number of fruits per plant. The length of fruits was affected and the circumference and fresh weight suffered significantly, causing a decrease in plant yield. The net productivity of stems, roots and leaves incurred losses of 22.5%, 24.0% and 37.5% respectively and resulted in 28.3% loss in the total net productivity of polluted plants. Farooq and Ghouse (1992) (cited in Agarwal 2002) in their study on responses of leaf epidermis of *Punica granatorm L*. to coal smoke pollution recorded a significant decrease in stomatal index, frequency of stomata in

lower epidermis and dimensions of stomatal pore in polluted condition. The frequency of epidermal cells in both upper and lower surface also decreased significantly while their size increased considerably in polluted area. Bajwa *et al.* (1997) studied the impact of air pollution on mungbean, *Vigna radiate L.* wilczek grown in open top chamber system in Pakistan. Wilczek, mungbean was exposed to air environment of charcoal filtered, unfiltered and ambient air conditions for a period of 3 months. The results revealed a considerable loss in plant biomass, plant height and yield. Panicucei *et al.* (1998) studied differential photosynthetic response of two Mediterranean species (*Arbutus unedo* and *Viburnum tinus*) to $SO_2$, the response of young plants to exposures of $SO_2$ (25 and 60 ppb) for long term, was investigated. It was found that the photosynthetic activity and growth of Arbutus unedo was markedly reduced in connection to partial stomatal closure. In *Viburnum tinus* $CO_2$ assimilation did not change although stomatal conductance was significantly decreased. Chauhan (2008) and Chauhan and Joshi (2010) studied the effect of ambient air pollutants NOx, $SO_2$, SPM and RSPM on wheat and mustard crops grown in the urban and industrial areas of Haridwar city. The study clearly shows that the gaseous ($SO_2$ and NOx) and particulate pollutants (SPM and RSPM) have detrimental effects on the crops. Changes in morphological characteristics, photosynthetic pigments and yield of wheat and mustard plants directly corresponded to the levels of air pollution.

Ahmad and Hussain (2007) (cited in Chauhan and Joshi, 2010) studied the pollutant load within the cluster region of Brick kilns of Bangladesh for $SO_2$ and particulate matter. It was found that particulate matter was a major pollutant in that region. Ambient concentration of particulate matters was very high compared to Bangladesh standard in every observation made in that region. In studies carried out by Srivastava *et al.* (1980) on *Tbernaemontava cornaria willed*, Yunis (1984) on *Calotropis procera R.Br*. and Srivastava (2005) on *Crotan sparsiflorus Morong*, polluted populations were collected from the vicinity of a major thermal power station and Brick kiln complexes, and comparative studies were made with several

populations of each species collected from healthy or non-polluted environments. In all such comparison to healthy populations, all polluted populations revealed a uniform increase in the frequency in the epidermal cells, stomata and trichomes, and a decrease in the size of epidermal cells and stomata. Necrotic lesion injury symptoms were also recorded on the upper epidermis. Durasovic and Tatjana (1997) studied the effects of dust particles in polluted air on stomata and chlorophyll content in northeastern Slovenia. They noted a trend towards a decline in the occlusion of stomata by dust particles in the entire area under observation and the percentage of occluded stomata of conifers decreased with distance from the source of dust particle emission. Saha *et al.* (2000) worked on five tree species such as *Anogeissus latifolia wall*., *Azadirachta indica juss*, *Bauthinia racemosa Lam., Pithecellobium dulce Benth*., and *Tamarindus indica L.* growing in industrial areas and reported an increase in stomatal density with decline in stomatal size and epidermal cell density at polluted sites as compared to control. Verma *et al.* (1990) in a comparative study of dust fall on the leaves in high pollution and low pollution areas and its effect on carbohydrates, revealed that industrial dust pollution caused adverse effect on plants. The total sugar and reducing sugar contents were observed less in dust loaded leaves of high pollution areas in comparison to clean leaves of low pollution areas. Singh *et al.* (2002) in a study on monitoring of dust pollution on leaves observed reduction in chlorophyll concentration and relative water content. The dust deposition on different trees varies in respect to leaf structure, surface geometry, height and canopy of trees. They further observed a reduction in leaf surface area at polluted sites. Increase in dust deposition and subsequent decrease in chlorophyll content might be positively correlated. Lauenroth and Doeld (1981) (cited in Unsworth and Omrod, 1982) found that in Western wheatgrass exposed to controlled $SO_2$ concentrations, chlorophyll a and chlorophyll b were significantly decreased without visible plant necrosis. Chlorophyll a was more sensitive than chlorophyll b sensitivity of chlorophylls to $SO_2$ changed as the growth progressed, indicating cumulative effects and

interactions with normal senescence. Dwivedi and Tripathi (2007) observed that the amount of sulphate in leaves shows positive correlation with $SO_2$ in air. Robinson et al, (1998) studied the disturbances in stomatal behaviors caused by air pollutants. They demonstrated that many atmospheric pollutants even when present at relatively low concentrations may interfere with the control of stomatal aperture, and thus have the potential to upset the water balance of the leaf or the whole plant. Although at high concentration, pollutant such as $SO_2$ and $O_3$ usually causes stomatal closure. Increased pollutants also affect $CO_2$ assimilation and hence cause decrease in plant productivity. Klumpp *et al.* (1998) studied the effects of complex air pollution on tree species of the Atlanta rain forest near Cubatao, Brazil and observed that the young leaves respond to pollution and accumulated toxic elements like fluoride and sulphur and undergo alteration of mineral economy, metabolic changes typical for stress situation and modifications of growth characteristics.

Khan *et al.* (2007) carried out the study on degradation of agricultural soils arising from brick burning in Western part of Bangladesh. Burning of soils significantly decreased the average pH values of soils by 0.4 pH units but increased the average electrical conductivity values from 0.26 to 1.77 mS/cm. The average losses were amounted to 63% for organic matter, 56-86% and 23-88% for available and total N, P, K, and S respectively. Rauni *et al.* (1994) studied the influence of gaseous pollutants like $SO_2$ and $NO_2$ and elevated $CO_2$ concentration on forest soils. Experiment on the effects of gaseous pollutants on soil biota included fumigation of both mycorrhizal and non-mycorrhizal tree seedlings, mycorrhizal bacteria and soil animals. Various active parameters like biomass were studied. Most of the experiments were of short duration (1-4 months) and usually performed at relatively high concentrations. The direct effects of pollutants on most of the soil organisms were found to be detrimental. $CO_2$ in many cases had different effect from those of gaseous pollutants and has a major impact on carbon allocation in the ecosystem. Stjernquist et al (1997) while investigating effect of air pollutants

($SO_2$) on soil and forest vitality in Kola Penninsula, indicated strong soil acidification at a distance of 20-30 km from the strongest $SO_2$ emission source. Toxic concentrations of Ni and Co in the soil organic layer were supposed to effect tree vitalities. Haapala *et al.* (1996) (cited in Agarwal 2002) studied the effects of simultaneous large acidic and alkaline air borne pollutants on forest soil in Scots pine (*Pinus sylvestris L*.) characterized by large amount of acidic and basic pollutants, mainly $SO_2$ and calcium and observed that alkalinization dominated the processes in the soil, since sulphur was absorbed in small quantities and calcium was better absorbed. The pH of the soil rose to 8.3 and the total Aluminum (Al) content was high in heavily polluted sites whereas exchangeable Al was low in those sites. They further observed that plots had acidic soils in which Al was in exchangeable form. Krupa and Legge (1998) have provided an integrative analysis of $SO_2$ exposure and elemental sulphur deposition and its impact on Boreal Pine forests near White court, Alberta, Canada. They concluded that it increased microbial oxidation, soil acidification and needle concentration while as litter decomposition, needle greenness, photosynthesis and needle ATP content in Pine decreases.

Joshi and Dudani (2008) studied the environmental health effects of Brick kilns in Kathmandu valley and found that the concentration of various air pollutants was higher during the operation of Brick kilns and the health status of school children attending the school close to the vicinity of the Brick kiln was worse compared to the students attending the school away from the Brick kiln.

# *Chapter 3*

# Study Area

Budgam district is the smallest district in Jammu and Kashmir, covering an area of 1,371 sq. km. accounting for nearly 1% of the total area of the state and 6% of its population. Bounded by the districts of Baramulla and Srinagar in the north, Pulwama in the south and the Poonch border in the south-west. Budgam (Fig. 1) is one of the youngest districts of the state, carved out as it was from the erstwhile district Srinagar in 1979. Situated at an average height of 5,281 ft. above sea level and at 75 degree E longitude and 34 degree N latitude, the district was known as Deedmarbag in ancient times. The topography of the district is mixed with both mountainous and plain areas. The climate is of the temperate type with the upper reaches receiving heavy snowfall in winter. The average annual rainfall of the district is 585 mm.

While the southern and south-western parts are mostly hilly, the eastern and northern parts of the district are plain. The total area under forest cover is 721 sq. km. The soil is loose and mostly denuded karewas dot the landscape.

Comprising Budgam, Beerwah and Chadoora tehsils, the district has been divided into eight blocks, which serve as prime units of economic development.

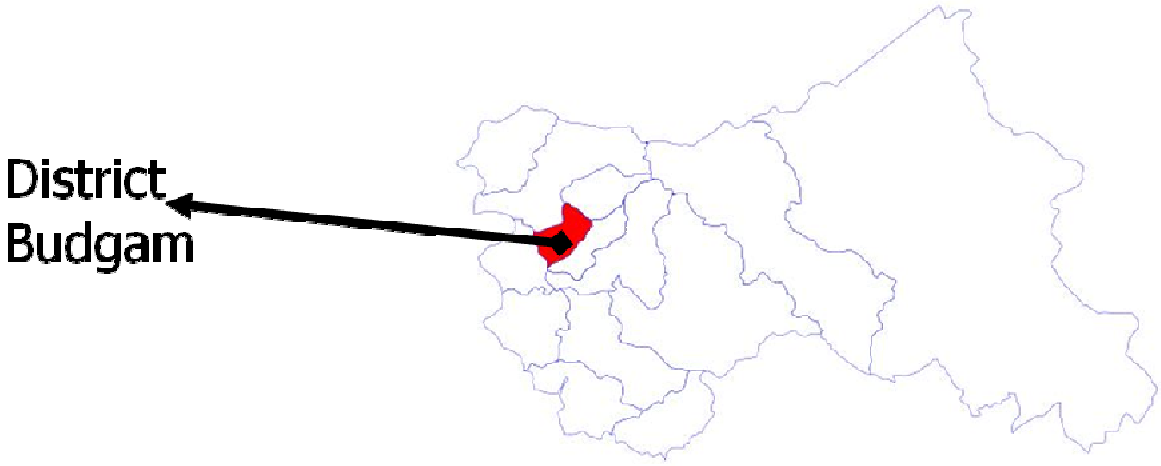


Fig.1 Location of District Budgam on the map Jammu and Kashmir State

## Study Sites

A detailed survey of Lasjan brick kiln area of the valley was done and its effect on the vegetation growing in the surrounding area was analyzed to infer the impact of these brick kiln emissions. Lasjan is included in the Block BK Pora of District Budgam. A total of 3 study sites were taken in the Lasjan area (Fig. 2). The first site was located nearby to the Kiln Periphery. The rest of the sites were taken as a function of distance i.e. going downwind from the source, and were approximately 200m away from each other.


Fig.2 Location of study sites. The bright yellowish spots on the image are the brick kilns. The cross intersection on the image shows the main brick kiln on the periphery of which Study Site 1 was located. The rest of the sites are located 200m away from each other. The sites were selected in such a way so that the influence of other brick kilns was significantly minimized.

Fig.3 Satellite image of the Lasjan area.

Fig.4 Satellite image of the Lasjan area.

Fig.5 Satellite image showing the brick kiln in the vicinity of which study site 1 was selected.

Fig.6 Brick kilns on the satellite image subset of Budgam Block.

Fig.7 Satellite image of the Block Budgam showing the Brick Kilns.

Fig.8 Satellite image of the Block Budgam. Brick kilns can be prominently seen in the image.

# *Chapter 4*

# Methodology

In order to achieve the objectives of the study standard methods for the analysis of the air, vegetation and soil were followed for drawing the results.

## Air Analysis

For the estimations of $NO_2$, $SO_2$, SPM and RSPM from the air samples, High Volume Air Sampler/ Respirable Dust Sampler (AMP-460 NL, EnviroTech) was used.

### Nitrogen dioxide

The method used to measure NOx was Sodium Arsenite method/Gliess-Saltzman method. In this method $NO_2$ is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide and N-(1-naphthyl)-ethylene diamine di hydrochloride (NEDA) and measuring the absorbance of the highly colored azo dye at 540 nm.

**Method:** High Volume Air Sampler (AMP-460 NL, EnviroTech) was used for air sampling. Air was collected at a flow rate of 1L/min in 30ml of absorbing reagent. The sampler was allowed to stand for 1 hour. Absorbance of the sample solution was then measured *vs* a reagent blank at 540 nm.

**Reagents**

1. Distilled water.
2. Sodium Hydroxide.
3. Sodium Arsenite.
4. Absorbing Reagents- Dissolve 4.0 g of sodium hydroxide in distilled water, add 1.0 g of sodium arsenite and dilute to 1000 ml with distilled water.
5. Sulfanilamide.
6. N-(1-Naphthyl)-ethylenediamine Di-hydrochloride (NEDA) – A 1% aqueous solution should have only one absorption peak at 320 nm over the range of 260-400 nm.
7. Hydrogen Peroxide-30%.
8. Phosphoric Acid-85%.
9. Sulfanilamide solution- Dissolve 20 g of sulfanilamide in 700 ml of distilled water. Add with mixing, 50 ml of 85% phosphoric acid and dilute to 1000 ml.
10. NEDA solution- Dissolve 0.5 g of NEDA in 500 ml of distilled water.
11. Hydrogen Peroxide solution- Dilute 0.2 ml of 30% hydrogen peroxide to 250 ml with distilled water.

**Procedure**

1. Preparation of Calibration Graph.
2. Sodium Nitrite- Assay of 97% $NaNO_2$ or greater.
3. Sodium Nitrite Stock Solution (1000 μg$NO_2$/ml)- Dissolved 1.5 g of desiccated sodium nitrite in distilled water and diluted to 1000 ml such that a solution containing 1000 μg $NO_2$/ml was obtained.
4. Sodium Nitrite working standard (1.0 μg $NO_2$/ml)

5. Solution A- Pipetted out 5 ml of the stock solution into a 500 ml volumetric flask and diluted to volume with distilled water. This contains 10 µg $NO_2$/ml.
6. Solution B- Pipetted out 25 ml of solution A into a 250 ml volumetric flask and diluted to volume with absorbing solution. This contains 1 µg $NO_2$/ml.
7. Prepared Calibration Curve using 1 µg/ml working standards.

## Sampling

The sampling apparatus was assembled at the sampling site. Added exactly 30 ml of absorbing reagent to the calibrated absorber and maintained the flow rate at 1L/min. The instrument was made to run for 1 hour.

## Analysis

1. Replaced any water lost by evaporation during sampling by adding distilled water upto the calibration mark on the absorber. Mixed thoroughly.
2. Pipetted out 10 ml of the collected sample into a test tube. Pipetted in 1 ml of hydrogen peroxide solution, 10 ml of sulfanilamide solution, and 1.4 ml of NEDA solution, with thorough mixing after the addition of each reagent and made upto 50 ml with distilled water.
3. Prepared a blank in the same manner using 10 ml of unexposed absorbing reagent.
4. After a 10 minute color development interval, measured and recorded the absorbance at 540 nm against the blank.
5. Determined µg$NO_2$ from the calibration curve.

The concentration of $NO_2$ in the air sample was determined from the below given equation:

$NO_2$ ($\mu g/m^3$) = $\mu g/NO_2$ x Vs/Va x 0.82 x Vt x D

$\mu g/NO_2$ = $NO_2$ conc. in analyzed sample.

Va = volume of air sample, $m^3$.

0.82 = sampling efficiency.

D = dilution factor (D = 1 for no dilution; D = 2 for 1:1 dilution)

Vs= final volume of sampling solution

Vt = aliquot taken for analysis

$NO_2$ (ppm) = ($\mu g$ $NO_2/m^3$) x $5.32 \times 10^{-4}$

## Sulphur dioxide

$SO_2$ estimation was done by using modified West-Gaeke method. $SO_2$ from air is absorbed in a solution of potassium tetrachloro-mercurate (TCM). A dichlorosulphitomercurate complex is formed. Once formed, this complex is stable to strong oxidants. The complex is made to react with pararosaniline and formaldehyde to form the intensely coloured pararosanilinemethlysulphonic acid. The absorbance of the solution is measured at 560 nm.

## Reagents

1. Distilled water.
2. Absorbing reagents, 0.04 M Potassium Tetrachloro mercurate (TCM)- Dissolved 10.86 g mercuric chloride, 0.066 g EDTA, and 6.0 g potassium chloride or 4.68 g of sodium chloride in distilled water and bring to the mark in a 1 litre volumetric flask.
3. Sulphamic acid (0.6%)- Dissolved 0.6 g sulphamic acid in 100 ml distilled water.

4. Formaldehyde (0.2%)- Diluted 5 ml formaldehyde solution (36-38%) to 1 litre with distilled water.
5. Stock Iodine solution (0.1 N)- Placed 12.7 g of iodine in a 250 ml beaker, add 40 g potassium iodide and 25 ml water. Stir until all is dissolved, then dilute to 1 litre with distilled water.
6. Iodine solution (0.01 N)- Prepare approximately 0.01 N iodine solution by diluting 50 ml of stock solution to 500 ml with distilled water.
7. Starch indicator solution- Triturated 0.4 g soluble starch and 0.002 g mercuric iodide preservative with a little water and added the paste slowly to 200 ml boiling water. Continued boiling until the solution was clear.
8. Stock Sodium Thiosulfate solution (0.1 N)- Prepared a stock solution by placing 25 g sodium thiosulfate pentahydrate in a beaker, add 0.1 g sodium carbonate and dissolved using boiled, cooled distilled water making the solution upto a final volume of 1 litre.
9. Sodium Thiosulphate Titrant (0.01 N)- Diluted 100 ml of the stock thiosulfate solution to 1 litre with freshly boiled and cooled distilled water.
10. Standardized Sulphite solution for preparation of Working Sulphite-TCM solution- Dissolved 0.30 g of sodium metabisulphite ($Na_2S_2O_5$) or sodium sulphite ($Na_2SO_3$) in 500 ml of recently boiled, cooled, distilled water. This solution contains the equivalent of 320-400 µg/ml of $SO_2$. The actual concentration of the solution was determined by adding excess iodine and back-titrating with standard sodium thiosulfate solution. To back-titrate, measure, by pipette, 50 ml of the 0.01 N iodine solution into each of two 500 ml iodine flasks A and B. To flask A (blank) add 25 ml distilled water and into flask B (sample) measure 25 ml sulphite solution by pipette. Stoppered the flasks and allowed to react for 5 minutes. Prepare the working sulphite-TCM solution at the same time iodine solution is added to the flasks. By means of a burette containing standardized 0.01N thiosulfate, titrate each

flask in turn to a pale yellow. Then added 5 ml starch solution and continue the titration until the blue color disappears.

11. Working Sulphite-TCM solution- Measured 2 ml of the standard solution into a 100 ml volumetric flask by pipette and bring to mark with 0.04 M TCM. Calculate the concentration of sulphur dioxide in the working solution in micrograms of sulphur dioxide per milliliter.
12. Pararosaniline Stock solution- Dissolved 0.500 g of specially purified pararosaniline (PRA) in 100 ml of distilled water and kept for 2 days.
13. Pararosaniline Working solution- 10 ml of stock PRA was taken in a 250 ml volumetric flask. Added 15 ml concentrated HCl and make up to volume with distilled water.

## Sampling

Assembled the sampling apparatus at the sampling site. Added 10 ml of TCM solution to the impinger. Samples were collected at 1 litre/minute flow rate for 1 hour. After sample collection, the solutions were stored at 5 °C in a refrigerator. At 22 °C losses of sulphur dioxide occur at the rate of 1% per day. It is mentioned that when samples are stored at 5 deg. C for 30 days, no detectable losses of sulphur dioxide occur.

## Analysis

For each set of determinations prepared a reagent blank by adding 10 ml of unexposed TCM solution to a 25 ml volumetric flask. Prepared a control solution by measuring 2 ml of working sulphite-TCM solution and 8 ml TCM solution into a 25 ml volumetric flask by pipette. To each flask containing either sample, control solution, or reagent blank, added 1 ml 0.6% sulphamic acid and allow to react for 10 minutes to destroy the nitrite resulting from oxides of nitrogen. Measured by pipette and added 2 ml of 0.2% formaldehyde solution and 2 ml pararosaniline

solution. Start the timer that has been set for 30 minutes. Bring all flasks to volume with freshly boiled and cooled distilled water and mix thoroughly. After 30 minutes and before 60 minutes, determine the absorbance of the sample, A, reagent blank, Ao, and the control solution at 560 nm using cells with a 1 cm path length. Use distilled water; and not the reagent blank, as the optical reference.

**Calibration Curve-Procedure with Sulphite Solution**

Measured by pipette graduated amounts of the working sulphite-TCM solution into a series of 25 ml volumetric flasks. Add sufficient TCM solution to each flask to bring the volume to approximately 10 ml. Then add the remaining reagents. Plot the absorbance against the total concentration in micrograms sulphur dioxide for the corresponding solution. The total micrograms sulphur dioxide in solution equals the concentration of the standard in micrograms sulphur dioxide per milliliter times the milliliter of sulphite solution added.

**Method:** 10ml of TCM solution was taken in the impinger of High Volume Air Sampler and exposed the solution for 1 hour. After this the solution was taken to the laboratory for further analysis. Absorbance of the sample solution was then measured against a blank reagent at 560 nm.

Conc. of $SO_2$ in $\mu g/m^3$ in the sample is calculated as:

$C\ (SO_2\ \mu g/m^3) = (A\text{-}A_0) \times 10^3 \times B/V$

A = sample absorbance

Ao = reagent blank absorbance

$10^3$ = conversion of litres to cubic metres

B = calibration factor, µg/absorbance

V = volume of air sampled in litres

*ppm $SO_2$ = µg $SO_2/m^3$ x 3.82 x 10-4*

## Respirable Suspended Particulate Matter (RSPM)

The air was passed through a pre-weighed oven-dried filter paper, which was mounted in the hood of the instrument using Respirable Dust/ High Volume Air Sampler and kept near the inflow point. Sampling was carried out for one hour and the flow rate of air was recorded from the manometer.

Initial weight of the filter paper = x mg

Final weight of the filter paper = y mg

Increased weight of the filter paper = (y-x) mg = z mg

RSPM= z mg x 1000/ vol.of air passed (lit./$m^3$)= X mg/$m^3$

## Suspended Particulate Matter (SPM)

For measuring the suspended particulate matter fraction of the dust, the pre-weighed cyclone cup was positioned in the cyclone of the High Volume Air Sampler. The final weight of the box was taken after running the instrument for 1 hour.

Initial weight of the cyclone cup = x mg

Final weight of the cyclone cup = y mg

Increased weight of the cyclone cup = (y-x) mg = z mg

SPM= z mg x 1000/ vol.of air passed (lit./$m^3$)= X mg/$m^3$

## Vegetation Analysis

### Chlorophyll Estimation

Chlorophyll pigment occupies a unique role in the economy of green plants. Quantity of chlorophyll is an indicator of photosynthetic capacity of a plant and quantity is influenced dramatically by biotic and abiotic stresses. The standard and most commonly used procedure involves extraction of chlorophyll in an organic solvent and subsequent identification by spectrophotometry. The vegetation samples prevalent at the study sites were collected and taken to the laboratory for the analysis of the chlorophyll pigments.

### Method

The amount of chlorophyll was calculated according to Arnon (1949). 1 sq. cm. of leaf tissue was suspended in 10ml of 80% acetone, and kept in dark overnight in a fridge. The absorbance was recorded at 663nm & 645nm in spectrophotometer.

Chlorophyll 'a' = 1.07(O.D.663)-0.094(O.D.645)

Chlorophyll 'b' = 1.77(O.D.645)-0.280(O.D.663)

Total Chlorophyll = 20.2(O.D.645) +8.02(O.D.663)

## Soil Analysis

Soil samples were collected from the depth profile 0-15cm. The composite soil samples representing the 5-6 sub-samples from uniform field were then brought to the laboratory after packing in air tight polythene bags. Coarse concretions, stones and pieces of roots, leaves and other undecomposed organic residues were

removed. Soil moisture, pH and electrical conductivity were determined on the fresh soil samples. For other parameters, the soil samples were air dried and mixed during drying. After air drying soil samples were crushed gently in pestle and mortar and sieved through a 2 mm sieve.

### Soil Moisture

Percent moisture content for the fresh composite soil samples was determined on oven dry weight basis as per the method given by Michael (1984). 50g of soil sample was dried in an oven at 105 °C until constant weight was achieved. The samples were then cooled in the dessicator and weighed again.

$$Moisture\ content\ (\%) = x_1 - x_2/x_1\ x100$$

$X_1$ = initial weight of the sample (g)

$X_2$ = final weight of the sample (g)

### pH

For the measurement of pH, the method recommended by Gliessman (1998) was followed. The oven dried soil samples were gradually diluted with the help of distilled water in the ratio of 1:2.5 (W:V). These were allowed to mix until a uniform paste homogenous solution was formed. Then after a gap of 1 hour the pH of the soil sample was measured with a combined electrode and calibrated milivolt meter (model 101E). The pH meter was calibrated using known standard buffer solutions of pH 4, 7 and 9.2 before taking the reading of the selected soil samples.

### Electrical Conductivity

The method given by Gliessman (1998) was followed for measurement of electrical conductivity. The digital conductivity meter (model 611E) was warmed up for 20 minutes before carrying out observations and was calibrated with 0.01M KCl solution. The conductivity cell was rinsed with distilled water and then with sample. The temperature and cell constant was adjusted on conductivity meter. The conductivity cell was dipped in the sample and conductivity values were recorded in μS/cm.

## Soil Organic Carbon

Organic carbon (%) was estimated by Wet digestion method of Walkey and Black (1934) as described by Piper (1966). An air dried & well grinded soil sample of 0.5g was weighed. To this 10ml of $K_2Cr_2O_7$ solution was added & gradually there after 20ml of concentrated sulphuric acid was also added. The samples were then left for half an hour without any disturbance. After the break 200ml of double distilled water was added. After adding double distilled water, 10ml of ortho-phosphoric acid, 0.2g of sodium floride and 1ml of diphenyl amine indicator were added. The flasks were then shaken and then titrated against ferrous ammonium sulphate solution till the dull green color changes through turbid blue to brilliant green.

Calculation:

Organic matter (mg/g) = 6.791/W[1-T1/T2] x 10

Organic matter (%) = 6.791/W[1-T1/T2]

Carbon (%) = 6.791/W x 1.724[1-T1/T2]

Where, W= mass of soil (g)

T1= vol. of titrate used against samples (ml)

T2= vol. of titrate used against distilled water blank (ml)

### Loss on Ignition

The method given by Hanna (1964) was followed for estimation of Loss on Ignition. This was carried out by taking 5g of oven dried soil in a crucible and exposing the sample in a muffle furnace to a temperature of 700 deg. C for half an hour. The sample was then cooled in desiccator and weighed again.

LOI = X1-X2/X1 x 100

Where, X1= initial weight of sample (g)

X2= final weight of sample (g)

## Status Survey of the Brick Kilns in Lasjan area

A standard questionnaire (Appendix 1) was drafted to ascertain the status of the brick kilns in the study area.

# *Chapter 5*

# Results

The observations recorded as a result of analysis of air, vegetation, soil and other information acquired via the interview schedule are presented below:

## Air Analysis

Air analysis for different air pollutants was carried out at the study sites and following observations were recorded regarding their concentrations.

### Sulphur Dioxide

The concentration of $SO_2$ at Site 1 was high during the operational phase of the brick kiln. The concentration of $SO_2$ was above permissible levels during the operational phase of the brick kiln. The concentration of $SO_2$ at the site near the brick kiln (Site 1) ranged between 25 and 42 $\mu g/m^3$ while the concentration of $SO_2$ at Site 2 and Site 3 ranged between 15 and 32 $\mu g/m^3$ and 14 and 28 $\mu g/m3$ respectively (Table 1).

## Nitrogen Dioxide

The concentration of $NO_2$ at site near the brick kiln was high as compared to sites away from the brick kiln. The concentration of $NO_2$ at site near the brick kiln (Site 1) ranged between 20 and 34 µg/$m^3$ as compared to 13 and 23 µg/$m^3$ at S2 and 10 and 18 µg/$m^3$ at S3 (Table 2).

**Table 1. Concentration of SOx (µg/$m^3$)**

| | Site1 | Site2 | Site3 |
|---|---|---|---|
| May | 32 | 28 | 25 |
| June | 25 | 15 | 14 |
| July | 40 | 30 | 27 |
| August | 42 | 26 | 23 |
| September | 38 | 32 | 28 |

**Table 2. Concentration of NOx (µg/$m^3$)**

| | Site1 | Site2 | Site3 |
|---|---|---|---|
| May | 20 | 13 | 10 |
| June | 22 | 16 | 12 |
| July | 28 | 19 | 15 |
| August | 32 | 23 | 16 |
| September | 34 | 20 | 18 |

Table 3. Concentration of SPM ($\mu g/m^3$)

| | Site1 | Site2 | Site3 |
|---|---|---|---|
| May | 12.20 | 18.46 | 15.73 |
| June | 77.06 | 59.12 | 65.44 |
| July | 72.11 | 39.06 | 13.02 |
| August | 123.35 | 88.60 | 53.87 |
| September | 96.43 | 78.62 | 66.52 |

Table 4. Concentration of RSPM ($\mu g/m^3$)

| | Site1 | Site2 | Site3 |
|---|---|---|---|
| May | 24.60 | 22.51 | 19.08 |
| June | 160.79 | 153.46 | 138.31 |
| July | 193.28 | 157.48 | 170.60 |
| August | 190.63 | 162.10 | 173.05 |
| September | 187.08 | 166.58 | 159.52 |

## Suspended Particulate Matter (SPM)

The concentration of SPM was high at the site close to the brick kiln during the operational phase of the kiln. The concentration of SPM at the site near the brick kiln (Site 1) ranged between 12.20 and 123.35 $\mu g/m^3$ as compared to 18.46 and 88.60 $\mu g/m^3$ at Site 2 and 13.02 and 66.52 $\mu g/m^3$ at Site 3 (Table 3).

## Respirable Particulate Matter (RSPM)

The concentration of RSPM was also high during the operational phase of the brick kiln. The RSPM at the site near the brick kiln (Site 1) ranged between 24.60 and 193.82 μg/$m^3$ as compared to 22.51 and 166.58 μg/$m^3$ at Site 2 and 19.08 and 173.05 μg/$m^3$ at Site 3 (Table 4).

## Chlorophyll Content

The component species of vegetation growing at the study sites were analyzed for the chlorophyll content (Tables 5-10) to ascertain any deviations from the normal which could most likely be responsible for inferring that the changes that are induced as a result of the operation of the brick kilns.

1) *Anthemis cotula* L.

*Anthemis cotula* was found at all the three study sites during the study period. The content of 'chlorophyll a' at study site 1 near the brick kiln ranged between 0.048 mg/$cm^2$ (October) to 0.357 mg/$cm^2$ (June) as compared to the content at study site 2 which ranged between 0.089 mg/$cm^2$ in May and 0.274 mg/$cm^2$ in October and at site 3 as 0.887 mg/$cm^2$ in August and 0.942 mg/$cm^2$ in July. The values for 'chlorophyll b' at site 1 were found to occur between 0.015 mg/$cm^2$ in August and 0.220 mg/$cm^2$ in June, at site 2 as 0.016 mg/$cm^2$ in May and 0.1 mg/$cm^2$ in September while at site 3 these varied between 0.141 mg/$cm^2$ in July and 0.321 mg/$cm^2$ in October.

The 'total chlorophyll' content (mg/$cm^2$) at study site 1 was between 0.75 in August and 6.44 in June, at site 2 it was 1.15 in May and 4.07 in September and at site 3 it varied between 7.52 in May and 13.55 in October.

2) *Xanthium strumarium* L.

*Xanthium strumarium* was found to exist at all the three study sites during the whole study period. The values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.02 mg/cm$^2$ in July and 0.16 mg/cm$^2$ in October as compared to the values at site 2 which ranged between 0.19 mg/cm$^2$ in June and 1.37 mg/cm$^2$ in August and at site 3 as 0.40 mg/cm$^2$ in May and 1.18 mg/cm$^2$ in October. The content of 'chlorophyll b' for the species at site 1 was found to be between 0.003 mg/cm$^2$ in July and 0.08 mg/cm$^2$ in October, at site 2 it was 0.004 mg/cm$^2$ in May and 0.48 mg/cm$^2$ in August and at site 3 it varied between 0.025 mg/cm$^2$ in July and 0.40 mg/cm$^2$ in October.

The total chlorophyll at site 1 was found to be between 0.16 mg/cm$^2$ in July and 2.74 mg/cm$^2$ in October, at site 2 as 2.42 mg/cm$^2$ in May and 20.32 mg/cm$^2$ in August and at site 3 as 3.73 mg/cm$^2$ during May and 17.39 mg/cm$^2$ during October.

3) *Convolvulus arvensis* L.

*Convolvulus arvensis* was not found at the site 3 and during the months of September and October. The recorded values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.035 mg/cm$^2$ (August) to 0.055 mg/cm$^2$ (July) as compared to the recorded values at site 2 which ranged between 0.052 mg/cm$^2$ (July) to 0.09 mg/cm$^2$ (June). The recorded values of 'chlorophyll b' at site 1 ranged between 0.004 mg/cm$^2$ (May) to 0.015 mg/cm$^2$ (June) and at site 2 as 0.015 mg/cm$^2$ (May) to 0.039 mg/cm$^2$ (June).

The recorded values of total chlorophyll at site 1 ranged between 0.454 mg/cm$^2$ (August) to 0.913 mg/cm$^2$ (June) and at site 2 as 0.881 mg/cm$^2$ (August) to 1.432 mg/cm$^2$ (June).

| Table 5. Chlorophyll concentration (mg/sq.cm) at different study sites during the month of May. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Plant species | Chl. a (mg/sq. cm) | | | Chl. b (mg/sq.cm) | | | Total chl. | | |
| | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 |
| *Anthemis cotula* L. | 0.285 | 0.089 | 0.897 | 0.187 | 0.016 | 0.168 | 5.275 | 1.154 | 7.520 |
| *Xanthium strumarium* L. | 0.029 | 0.222 | 0.405 | 0.009 | 0.004 | 0.048 | 0.426 | 2.419 | 3.730 |
| *Convolvulus arvensis* L. | 0.050 | 0.081 | N/A | 0.004 | 0.015 | N/A | 0.586 | 1.049 | N/A |
| *Cynodon dactylon* L. | 0.067 | 0.132 | 0.670 | 0.048 | 0.010 | 0.143 | 1.296 | 1.535 | 5.400 |
| *Erigeron bellidiodes* Benth. | 0.043 | 0.173 | 0.835 | 0.021 | 0.183 | 0.167 | 0.720 | 4.041 | 6.865 |
| *Iris ensata* Thunb. | 0.091 | 0.623 | N/A | 0.037 | 0.007 | N/A | 1.420 | 6.719 | N/A |
| *Populus nigra* L. | 0.041 | 0.143 | 0.112 | 0.060 | 0.025 | 0.014 | 1.165 | 1.825 | 1.363 |
| *Populus nigra (kiln periphery)* | 0.071 | N/A | N/A | 0.003 | N/A | N/A | 0.727 | N/A | N/A |
| *Robinia pseudoacacia* L. | 0.021 | 0.098 | 0.299 | 0.010 | 0.047 | 0.059 | 0.350 | 1.618 | 2.475 |
| *Salix alba* L. | 0.050 | 0.018 | 0.385 | 0.004 | 0.024 | 0.043 | 0.586 | 0.495 | 3.577 |
| *Salix alba* L. *(kiln periphery)* | 0.025 | N/A | N/A | 0.007 | N/A | N/A | 0.362 | N/A | N/A |
| *Urtica dioica* L. | 0.034 | 0.117 | 0.372 | 0.008 | 0.070 | 0.081 | 0.466 | 2.093 | 2.980 |
| *Cannabis sativa* L. | N/A | 0.297 | 0.497 | N/A | 0.053 | 0.093 | N/A | 3.091 | 4.169 |
| *Digitaria sanguinale* L. | N/A | 0.359 | 0.724 | N/A | 0.048 | 0.105 | N/A | 3.364 | 6.431 |
| *Polygonum amphibium* L. | N/A | 0.433 | 0.562 | N/A | 0.017 | 0.005 | N/A | 5.182 | 5.910 |
| *Circium wallichii* DC. | N/A | N/A | 0.273 | N/A | N/A | 0.016 | N/A | N/A | 4.077 |

| Table 6. Chlorophyll concentration (mg/sq.cm) at different study sites during the month of June | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Plant species | Chl. a (mg/sq. cm) | | | Chl. b(mg/sq.cm) | | | Total chl. | | |
| | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 |
| *Anthemis cotula* L. | 0.357 | 0.111 | 0.897 | 0.220 | 0.054 | 0.168 | 6.443 | 1.835 | 7.520 |
| *Xanthium strumarium* L. | 0.040 | 0.189 | 0.405 | 0.034 | 0.039 | 0.048 | 0.846 | 2.489 | 3.730 |
| *Convolvulus arvensis* L. | 0.068 | 0.090 | N/A | 0.015 | 0.039 | N/A | 0.913 | 1.432 | N/A |
| *Cynodon dactylon* L. | 0.083 | 0.136 | 0.670 | 0.035 | 0.025 | 0.143 | 1.316 | 1.757 | 5.400 |
| *Erigeron bellidiodes* Benth. | 0.037 | 0.150 | 0.835 | 0.007 | 0.163 | 0.167 | 0.490 | 3.554 | 6.865 |
| *Iris ensata* Thunb. | 0.086 | 0.646 | N/A | 0.026 | 0.008 | N/A | 1.231 | 6.976 | N/A |
| *Populus nigra* L. | 0.063 | 0.153 | 0.112 | 0.084 | 0.050 | 0.014 | 1.684 | 2.237 | 1.363 |
| *Populus nigra (kiln periphery)* | 0.076 | N/A | N/A | 0.013 | N/A | N/A | 0.969 | N/A | N/A |
| *Robinia pseudoacacia* L. | 0.018 | 0.077 | 0.299 | 0.017 | 0.063 | 0.059 | 0.406 | 1.587 | 2.475 |
| *Salix alba* L. | 0.047 | 0.019 | 0.385 | 0.001 | 0.043 | 0.043 | 0.522 | 0.734 | 3.577 |
| *Salix alba* L. *(kiln periphery)* | 0.043 | N/A | N/A | 0.020 | N/A | N/A | 0.700 | N/A | N/A |
| *Urtica dioica* L. | 0.069 | 0.140 | 0.372 | 0.006 | 0.097 | 0.081 | 0.812 | 2.662 | 2.980 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Cannabis sativa* L. | N/A | 0.351 | 0.672 | N/A | 0.053 | 0.169 | N/A | 3.091 | 5.125 |
| *Digitaria sanguinale* L. | N/A | 0.370 | 0.650 | N/A | 0.048 | 0.112 | N/A | 3.364 | 5.566 |
| *Polygonum amphibium* L. | N/A | 0.507 | 0.550 | N/A | 0.017 | 0.107 | N/A | 5.182 | 4.564 |
| *Circium wallichii* DC. | N/A | N/A | 0.273 | N/A | N/A | 0.012 | N/A | N/A | 3.054 |

**Table 7. Chlorophyll concentration (mg/sq.cm) at different study sites during the month of July**

| Plant species | Chl. a (mg/sq. cm) | | | Chl. b (mg/sq.cm) | | | Total chl. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 |
| *Anthemis cotula* L. | 0.289 | 0.120 | 0.942 | 0.098 | 0.046 | 0.141 | 4.257 | 1.847 | 8.317 |
| *Xanthium strumarium* L. | 0.019 | 0.207 | 0.458 | 0.003 | 0.055 | 0.025 | 0.164 | 2.868 | 4.563 |
| *Convolvulus arvensis* L. | 0.055 | 0.052 | N/A | 0.009 | 0.031 | N/A | 0.707 | 0.934 | N/A |
| *Cynodon dactylon* L. | 0.075 | 0.139 | 0.893 | 0.037 | 0.038 | 0.233 | 1.252 | 1.943 | 6.696 |
| *Erigeron bellidiodes* Benth. | 0.033 | 0.119 | 0.928 | 0.041 | 0.056 | 0.153 | 0.858 | 1.940 | 8.023 |
| *Iris ensata* Thunb. | 0.095 | 0.606 | N/A | 0.041 | 0.005 | N/A | 1.513 | 6.389 | N/A |
| *Populus nigra* L. | 0.045 | 0.160 | 0.387 | 0.063 | 0.078 | 0.031 | 1.237 | 2.644 | 3.743 |
| *Populus nigra (kiln periphery)* | 0.079 | N/A | N/A | 0.002 | N/A | N/A | 0.864 | N/A | N/A |
| *Robinia pseudoacacia* L. | 0.018 | 0.087 | 0.446 | 0.009 | 0.072 | 0.081 | 0.305 | 1.808 | 3.764 |
| *Salix alba* L. | 0.045 | 0.038 | 0.488 | 0.008 | 0.052 | 0.028 | 0.595 | 1.039 | 4.856 |
| *Salix alba* L. *(kiln periphery)* | 0.017 | N/A | N/A | 0.005 | N/A | N/A | 0.196 | N/A | N/A |
| *Urtica dioica* L. | 0.036 | 0.098 | 0.671 | 0.007 | 0.037 | 0.151 | 0.482 | 1.489 | 5.327 |
| *Cannabis sativa* L. | N/A | 0.391 | 0.837 | N/A | 0.057 | 0.208 | N/A | 3.476 | 6.400 |
| *Digitaria sanguinale* L. | N/A | 0.402 | 0.938 | N/A | 0.040 | 0.138 | N/A | 3.786 | 8.305 |
| *Polygonum amphibium* L. | N/A | 0.528 | 0.812 | N/A | 0.012 | 0.142 | N/A | 5.464 | 6.927 |
| *Circium wallichii* DC. | N/A | N/A | 0.517 | N/A | N/A | 0.015 | N/A | N/A | 5.323 |

**Table 8. Chlorophyll concentration (mg/cm$^2$) at different study sites during the month of August**

| Plant species | Chl. a (mg/sq. cm) | | | Chl. b (mg/sq.cm) | | | Total chl. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 |
| *Anthemis cotula* L. | 0.052 | 0.254 | 0.887 | 0.015 | 0.099 | 0.284 | 0.752 | 3.891 | 12.83 |
| *Xanthium strumarium* L. | 0.124 | 1.370 | 1.152 | 0.018 | 0.480 | 0.377 | 1.540 | 20.32 | 16.76 |
| *Convolvulus arvensis* L. | 0.035 | 0.059 | N/A | 0.006 | 0.021 | N/A | 0.454 | 0.881 | N/A |
| *Cynodon dactylon* L. | 0.096 | 0.217 | 0.510 | 0.011 | 0.084 | 0.140 | 1.162 | 3.320 | 7.109 |
| *Erigeron bellidiodes* Benth. | 0.024 | 0.109 | 0.432 | 0.012 | 0.065 | 0.073 | 0.414 | 1.948 | 5.481 |
| *Iris ensata* Thunb. | 0.097 | 0.839 | N/A | 0.032 | 0.269 | N/A | 1.420 | 12.14 | N/A |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Populus nigra* L. | 0.155 | 0.509 | 0.052 | 0.046 | 0.234 | 0.010 | 2.213 | 8.232 | 0.683 |
| *Populus nigra (kiln periphery)* | 0.318 | N/A | N/A | 0.143 | N/A | N/A | 5.104 | N/A | N/A |
| *Robinia pseudoacacia* L. | 0.010 | 0.211 | 0.185 | 0.007 | 0.077 | 0.070 | 0.201 | 3.171 | 2.809 |
| *Salix alba* L. | 0.030 | 0.360 | 0.100 | 0.007 | 0.169 | 0.005 | 0.414 | 5.857 | 1.064 |
| *Salix alba* L. *(kiln periphery)* | 0.238 | N/A | N/A | 0.112 | N/A | N/A | 3.880 | N/A | N/A |
| *Urtica dioica* L. | 0.038 | 0.076 | 0.387 | 0.012 | 0.032 | 0.132 | 0.559 | 1.199 | 5.706 |
| *Cannabis sativa* L. | N/A | 0.062 | 0.273 | N/A | 0.027 | 0.069 | N/A | 0.994 | 3.745 |
| *Digitaria sanguinale* L. | 0.048 | 0.065 | 0.321 | 0.016 | 0.036 | 0.088 | 0.720 | 1.139 | 4.477 |
| *Polygonum amphibium* L. | 0.044 | 0.221 | 0.419 | 0.004 | 0.088 | 0.143 | 0.518 | 3.413 | 6.177 |
| *Solanum nigrum* | 0.198 | 0.215 | 0.551 | 0.054 | 0.091 | 0.206 | 2.764 | 3.393 | 8.334 |
| *Plantago major* L. | 0.085 | 0.086 | 0.706 | 0.029 | 0.045 | 0.211 | 1.271 | 1.461 | 10.03 |

**Table 9. Chlorophyll concentration (mg/sq.cm) at different study sites during the month of September**

| Plant species | Chl. a (mg/sq. cm) | | | Chl. b(mg/sq.cm) | | | Total chl. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 |
| *Anthemis cotula* L. | 0.060 | 0.270 | 0.905 | 0.033 | 0.100 | 0.279 | 1.038 | 4.072 | 12.97 |
| *Xanthium strumarium* L. | 0.151 | 1.354 | 1.178 | 0.044 | 0.450 | 0.370 | 2.140 | 19.78 | 16.96 |
| *Cynodon dactylon* L. | 0.101 | 0.356 | 0.534 | 0.041 | 0.044 | 0.134 | 1.573 | 4.322 | 7.285 |
| *Iris ensata* Thunb. | 0.090 | 0.835 | N/A | 0.047 | 0.514 | N/A | 1.533 | 15.04 | N/A |
| *Populus nigra* L. | 0.228 | 0.522 | 0.075 | 0.060 | 0.257 | 0.004 | 3.158 | 8.639 | 0.860 |
| *Populus nigra (kiln periphery)* | 0.521 | N/A | N/A | 0.146 | N/A | N/A | 7.298 | N/A | N/A |
| *Robinia pseudoacacia* L. | 0.034 | 0.208 | 0.189 | 0.013 | 0.069 | 0.069 | 0.527 | 3.046 | 2.841 |
| *Salix alba* L. | 0.040 | 0.367 | 0.120 | 0.015 | 0.188 | 0.005 | 0.615 | 6.163 | 1.217 |
| *Salix alba* L. *(kiln periphery)* | 0.253 | N/A | N/A | 0.162 | N/A | N/A | 4.635 | N/A | N/A |
| *Urtica dioica* L. | 0.023 | 0.080 | 0.364 | 0.009 | 0.036 | 0.138 | 0.366 | 1.292 | 5.529 |
| *Cannabis sativa* L. | N/A | 0.073 | 0.257 | N/A | 0.038 | 0.073 | N/A | 1.244 | 3.625 |
| *Digitaria sanguinale* L. | 0.052 | 0.059 | 0.296 | 0.024 | 0.059 | 0.095 | 0.853 | 1.341 | 4.293 |
| *Plantago major* L. | 0.097 | 0.087 | 0.898 | 0.065 | 0.055 | 0.160 | 1.820 | 1.598 | 11.48 |

| Table 10. Chlorophyll concentration (mg/cm$^2$) at different study sites during the month of October | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Plant species | Chl. a (mg/sq. cm) | | | Chl. b(mg/sq.cm) | | | Total chl. | | |
| | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 | Site1 | Site2 | Site3 |
| *Anthemis cotula* L. | 0.048 | 0.274 | 0.912 | 0.025 | 0.054 | 0.321 | 0.821 | 2.263 | 13.54 |
| *Xanthium strumarium* L. | 0.167 | 1.358 | 1.182 | 0.080 | 0.466 | 0.402 | 2.741 | 20.02 | 17.39 |
| *Cynodon dactylon* L. | 0.113 | 0.409 | 0.547 | 0.057 | 0.037 | 0.184 | 1.892 | 4.804 | 8.032 |
| *Populus nigra* L. | 0.377 | 0.528 | 0.087 | 0.042 | 0.264 | 0.008 | 4.523 | 8.788 | 1.029 |
| *Populus nigra (kiln periphery)* | 0.612 | N/A | N/A | 0.173 | N/A | N/A | 8.581 | N/A | N/A |
| *Robinia pseudoacacia* L. | 0.029 | 0.216 | 0.196 | 0.008 | 0.060 | 0.121 | 0.406 | 3.021 | 3.539 |
| *Salix alba* L. | 0.052 | 0.375 | 0.129 | 0.024 | 0.201 | 0.037 | 0.853 | 6.409 | 1.830 |
| *Salix alba* L. *(kiln periphery)* | 0.274 | N/A | N/A | 0.221 | N/A | N/A | 5.567 | N/A | N/A |
| *Urtica dioica* L. | 0.050 | 0.069 | 0.359 | 0.023 | 0.030 | 0.137 | 0.817 | 1.102 | 5.477 |
| *Cannabis sativa* L. | N/A | 0.082 | 0.296 | N/A | 0.044 | 0.129 | N/A | 1.409 | 4.713 |
| *Digitaria sanguinale* L. | 0.072 | 0.065 | 0.332 | 0.064 | 0.071 | 0.124 | 1.547 | 1.559 | 5.018 |
| *Plantago major* | 0.095 | 0.092 | 0.748 | 0.090 | 0.068 | 0.210 | 2.095 | 1.800 | 10.481 |

4) *Cynodon dactylon* (L.)

*Cynodon dactylon* was found at all the three sites during the whole study period. The recorded values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.067 mg/cm$^2$ (May) to 0.113 mg/cm$^2$ (October) as compared to the recorded values at site 2 which ranged between 0.132 mg/cm$^2$ (May) to 0.409 mg/cm$^2$ (October) and at site 3 as 0.51 mg/cm$^2$ (August) to 0.893 mg/cm$^2$ (July). The recorded values of 'chlorophyll b' at site 1 ranged between 0.011 mg/cm$^2$ (August) to 0.057 mg/cm$^2$ (October), at site 2 as 0.01 mg/cm$^2$ (May) to 0.084 mg/cm$^2$ (August) and at site 3 as 0.134 mg/cm$^2$ (September) to 0.233 mg/cm$^2$ (July).

The recorded values of total chlorophyll at site 1 ranged between 1.16 mg/cm$^2$ (August) to 1.89 mg/cm$^2$ (October), at site 2 as 1.53 mg/cm$^2$ (May) to 4.80 mg/cm$^2$ (October) and at site 3 as 5.4 mg/cm$^2$ (May) to 8.03 mg/cm$^2$ (October).

*5) Erigeron bellidiodes* Benth.

*Erigeron bellidiodes* was not found during the month of September and October. The recorded values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.024 mg/cm$^2$ (August) to 0.043 mg/cm$^2$ (May) as compared to the recorded values at site 2 which ranged between 0.109 mg/cm$^2$ (August) to 0.173 mg/cm$^2$ (May) and at site 3 as 0.432 mg/cm$^2$ (August) to 0.928 mg/cm$^2$ (July). The recorded values of 'chlorophyll b' at site 1 ranged between 0.007 mg/cm$^2$ (June) to 0.041 mg/cm$^2$ (July), at site 2 as 0.056 mg/cm$^2$ (July) to 0.183 mg/cm$^2$ (May) and at site 3 as 0.073 mg/cm$^2$ (August) to 0.167 mg/cm$^2$ (May).

The recorded values of 'total chlorophyll' at site 1 ranged between 0.414 mg/cm$^2$ (August) to 0.858 mg/cm$^2$ (July), at site 2 as 1.94 mg/cm$^2$ (July) to 4.041 mg/cm$^2$ (May) and at site 3 as 5.481 mg/cm$^2$ (August) to 8.023 mg/cm$^2$ (July).

*6) Iris ensata* Thunb.

*Iris ensata* was not found at the site 3 and during the month of October at the other sites. The recorded values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.086 mg/cm$^2$ (June) to 0.097 mg/cm$^2$ (August) as compared to the recorded values at site 2 which ranged between 0.60 mg/cm$^2$ (July) to 0.84 mg/cm$^2$ (August). The recorded values of 'chlorophyll b' at site 1 ranged between 0.026 mg/cm$^2$ (June) to 0.047 mg/cm$^2$ (September) and at site 2 as 0.005 mg/cm$^2$ (July) to 0.514 mg/cm$^2$ (September).

The recorded values of 'total chlorophyll' at site 1 ranged between 1.23 mg/cm$^2$ (June) to 1.53 mg/cm$^2$ (September) and at site 2 as 6.38 mg/cm$^2$ (July) to 15.04 mg/cm$^2$ (September).

7) *Populus nigra* L.

*Populus nigra* was found at all the three sites. The values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.041 mg/cm$^2$ (May) to 0.377 mg/cm$^2$ (October) as compared to the recorded values at site 2 which ranged between 0.14 mg/cm$^2$ (May) to 0.53 mg/cm$^2$ (October) and at site 3 as 0.052 mg/cm$^2$ (August) to 0.387 mg/cm$^2$ (July).

The recorded values of 'chlorophyll b' at site 1 ranged between 0.042 mg/cm$^2$ (October) to 0.084 mg/cm$^2$ (June), at site 2 as 0.025 mg/cm$^2$ (May) to 0.264 mg/cm$^2$ (October) and at site 3 as 0.004 mg/cm$^2$ (September) to 0.031 mg/cm$^2$ (July). The recorded values of 'total chlorophyll' at site 1 ranged between 1.16 mg/cm$^2$ (May) to 4.52 mg/cm$^2$ (October), at site 2 as 1.82 mg/cm$^2$ (May) to 8.79 mg/cm$^2$ (October) and at site 3 as 0.68 mg/cm$^2$ (August) to 3.74 mg/cm$^2$ (July).

8) *Populus nigra* (at kiln periphery) near Site 1

The recorded values of the *Populus nigra* at the kiln periphery (i.e. at Site 1 only) showed values of the 'chlorophyll a' at site 1 to be ranging between 0.071 mg/cm$^2$ (May) to 0.612 mg/cm$^2$ (October). The chlorophyll 'b' ranged between 0.002 mg/cm$^2$ (July) to 0.173 mg/cm$^2$ (October). The recorded values of total chlorophyll ranged between 0.72 mg/cm$^2$ (May) to 8.58 mg/cm$^2$ (October).

9) *Robinia pseudoacacia* L.

*Robinia pseudoacacia* was found at all the three sites during the study period. The recorded values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.01 mg/cm$^2$ (August) to 0.034 mg/cm$^2$ (September) as compared to the recorded values at site 2 which ranged between 0.077 mg/cm$^2$ (June) to 0.216 mg/cm$^2$ (October) and at site 3 as 0.18 mg/cm$^2$ (August) to 0.44 mg/cm$^2$ (July). The recorded values of 'chlorophyll b' at site 1 ranged between 0.007 mg/cm$^2$ (August) to 0.017 mg/cm$^2$ (June), at site 2 as 0.047 mg/cm$^2$ (May) to 0.077 mg/cm$^2$ (August) and at site 3 as 0.059 mg/cm$^2$ (May) to 0.121 mg/cm$^2$ (October).

The recorded values of total chlorophyll at site 1 ranged between 0.20 mg/cm$^2$ (August) to 0.52 mg/cm$^2$ (September), at site 2 as 1.58 mg/cm$^2$ (June) to 3.17 mg/cm$^2$ (August) and at site 3 as 2.47 mg/cm$^2$ (May) to 3.76 mg/cm$^2$ (July).

*10) Salix alba* L.

*Salix alba* was found at all the three sites during the study. The recorded values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.03 mg/cm$^2$ (August) to 0.05 mg/cm$^2$ (October) as compared to the recorded values at site 2 which ranged between 0.018 mg/cm$^2$ (May) to 0.375 mg/cm$^2$ (October) and at site 3 as 0.1 mg/cm$^2$ (August) to 0.49 mg/cm$^2$ (July).

The recorded values of 'chlorophyll b' at site 1 ranged between 0.001 mg/cm$^2$ (June) to 0.024 mg/cm$^2$ (October), at site 2 as 0.024 mg/cm$^2$ (May) to 0.201 mg/cm$^2$ (October) and at site 3 as 0.005 mg/cm$^2$ (August) to 0.043 mg/cm$^2$ (May).

The recorded values of 'total chlorophyll' at site 1 ranged between 0.41 mg/cm$^2$ (August) to 0.85 mg/cm$^2$ (October), at site 2 as 0.49 mg/cm$^2$ (May) to 6.41 mg/cm$^2$ (October) and at site 3 as 1.06 mg/cm$^2$ (August) to 4.85 mg/cm$^2$ (July).

*11) Salix alba* [at kiln periphery]

The 'chlorophyll a' for the tree species *Salix alba* at the kiln periphery showed a minimum of 0.017 mg/cm$^2$ in July at site 1 to 0.274 mg/cm$^2$ in October. The chlorophyll b at this site was found to exist between 0.0005 mg/cm$^2$ in July and 0.221 mg/cm$^2$ in October. The total chlorophyll was between 0.196 mg/cm$^2$ (July) and 5.567 mg/cm$^2$ (October).

*12) Urtica dioica* L.

*Urtica dioica* was found at all the three sites. The values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.023 mg/cm$^2$ (September) to 0.069 mg/cm$^2$ (June) as compared to the recorded values at site 2 which ranged between 0.069

mg/cm$^2$ (October) to 0.14 mg/cm$^2$ (June) and at site 3 as 0.359 mg/cm$^2$ (October) to 0.671 mg/cm$^2$ (July).

The recorded values of 'chlorophyll b' at site 1 ranged between 0.006 mg/cm$^2$ (June) to 0.023 mg/cm$^2$ (October), at site 2 as 0.03 mg/cm$^2$ (October) to 0.097 mg/cm$^2$ (June) and at site 3 as 0.081 mg/cm$^2$ (May) to 0.151 mg/cm$^2$ (July). The recorded values of total chlorophyll at site 1 ranged between 0.366 mg/cm$^2$ (September) to 0.817 mg/cm$^2$ (October), at site 2 as 1.102 mg/cm$^2$ (October) to 2.662 mg/cm$^2$ (June) and at site 3 as 2.98 mg/cm$^2$ (May) to 5.706 mg/cm$^2$ (August).

*13) Cannabis sativa* L.

*Cannabis sativa* was not found at the site 1. The 'chlorophyll a' at site 2 ranged between 0.062 mg/cm$^2$ in August and 0.391 mg/cm$^2$ in July as compared to the values at site 3 which ranged between 0.257 mg/cm$^2$ in September and 0.837 mg/cm$^2$ in July. Chlorophyll 'b' at site 2 varied between 0.027 mg/cm$^2$ in August and 0.057 mg/cm$^2$ in July as compared to the values at site 3 which ranged between 0.069 mg/cm$^2$ in August and 0.208 mg/cm$^2$ in July. The total chlorophyll at site 2 ranged between 0.994 mg/cm$^2$ (August) to 3.476 mg/cm$^2$ (July) as compared to the recorded values at site 3 which ranged between 3.62 mg/cm$^2$ (September) to 6.4 mg/cm$^2$ (July).

*14) Digitaria sanguinale* (L.)

*Digitaria sanguinale* was not found at site 1 during the study period. The recorded values of 'chlorophyll a' at site 2 ranged between 0.059 mg/cm$^2$ (September) to 0.402 mg/cm$^2$ (July) as compared to the recorded values at site 3 which ranged between 0.296 mg/cm$^2$ (September) to 0.938 mg/cm$^2$ (July).

The recorded values of 'chlorophyll b' at site 2 ranged between 0.036 mg/cm$^2$ (August) to 0.071 mg/cm$^2$ (October) as compared to the recorded values at site 3 which ranged between 0.088 mg/cm$^2$ (August) to 0.138 mg/cm$^2$ (July).

The recorded values of total chlorophyll at site 2 ranged between 1.14 mg/cm$^2$ (August) to 3.78 mg/cm$^2$ (July) as compared to the recorded values at site 3 which ranged between 4.29 mg/cm$^2$ (September) to 8.30 mg/cm$^2$ (July).

*15) Polygonum amphibium* L.

*Polygonum amphibium* was not found at site 1 and also during the months of September and October at the rest of the sites. The values of 'chlorophyll a' at site 2 for this species ranged between 0.22 mg/cm$^2$ in August and 0.52 mg/cm$^2$ in July as compared to the chlorophyll 'a' content at site 3 which ranged between0.419 mg/cm$^2$ (August) to 0.812 mg/cm$^2$ (July). The 'chlorophyll b' at site 2 ranged between 0.012 mg/cm$^2$ (July) to 0.088 mg/cm$^2$ (August) as compared to the recorded values at site 3 which ranged between 0.005 mg/cm$^2$ (May) to 0.143 mg/cm$^2$ (August). The recorded values of total chlorophyll at site 2 ranged between 3.413 mg/cm$^2$ (August) to 5.464 mg/cm$^2$ (July) as compared to the recorded values at site 3 which ranged between 4.564 mg/cm$^2$ (June) to 6.927 mg/cm$^2$ (July).

*16) Circium wallichii* DC.

*Circium wallichii* was found only at site 3 during the first three months of the study period i.e. May, June & July. The recorded values of chlorophyll 'a' at site 3 ranged between 0.273 mg/cm$^2$ (May) to 0.517 mg/cm$^2$ (July). The recorded values of total chlorophyll at site 3 ranged between 3.054 mg/cm$^2$ (June) to 5.323 mg/cm$^2$ (July).

*17) Plantago major* L.

*Plantago major* was found only during the last three months of the study period i.e. August, September and October. The values of 'chlorophyll a' at site 1 near the brick kiln ranged between 0.085 mg/cm$^2$ (August) to 0.097 mg/cm$^2$ (September) as compared to the recorded values at site 2 which ranged between 0.086 mg/cm$^2$ (August) to 0.092 mg/cm$^2$ (October) and at site 3 as 0.706 mg/cm$^2$ (August) to 0.898 mg/cm$^2$ (September). The recorded values of 'chlorophyll b' at site 1 ranged between 0.029 mg/cm$^2$ (August) to 0.09 mg/cm$^2$ (October), at site 2 as 0.045

mg/cm$^2$ (August) to 0.068 mg/cm$^2$ (October) and at site 3 as 0.16 mg/cm$^2$ (September) to 0.211 mg/cm$^2$ (August).

The recorded values of 'total chlorophyll' at site 1 ranged between 1.271 mg/cm$^2$ (August) to 2.09 mg/cm$^2$ (October), at site 2 as 1.461 mg/cm$^2$ (August) to 1.8 mg/cm$^2$ (October) and at site 3 as 10.039 mg/cm$^2$ (August) to 11.482 mg/cm$^2$ (September).

## Soil Analysis

The observations for some of the soil parameters estimated during the study period are presented as under:

### Moisture Content

The percent moisture content at the site near the brick kiln was comparatively higher than at the other two sites. The percent moisture content at the site near the brick kiln (Site 1) ranged between 9.53 and 10.77%, while at Sites 2 and 3 it varied between 4.68% and 8.73% and 4.36% and 8.36% respectively (Table 11).

### pH

The pH values were found between neutral (7.0) to slightly alkaline (7.69). The pH of the soil at site near the brick kiln ranged between 7.00 and 7.35 while for the soils of the sites 2 and 3 varied between 7.20 and 7.52 and 7.38 and 7.69 respectively (Table 12).

### Electrical Conductivity

The electrical conductivity of the samples from the site near the brick kiln (Site1) ranged between 86 and 105 µS/cm while for the Sites 2 and 3 ranged between 88 and 116 µS/cm and 92 and 103 µS/cm respectively (Table 13).

## Loss on Ignition

The percent loss on ignition of the oven dried soil samples at the site near the brick kiln were slightly lesser as compared to those of the sites away from the kiln. The percent loss on ignition at Site 1 ranged between 5% and 8.20% while for the samples of Site 2 ranged between 5% and 7.80% and for the samples of Site 3, it varied between 5.70% & 8% (Table 14).

## Organic Carbon

The content of organic carbon at the site near the brick kiln (Site 1) ranged between 0.40 and 0.85% while at Sites 2 and 3 it ranged between 0.5% and 0.9% and 0.35% & 0.88% respectively (Table 15).

**Table 11. Soil moisture Content (%) at different study sites**

| Month | Site1 | Site2 | Site3 |
|---|---|---|---|
| **May** | 10.482 | 8.729 | 8.364 |
| **June** | 10.769 | 6.331 | 5.893 |
| **July** | 9.66 | 5.122 | 6.622 |
| **August** | 10.28 | 4.678 | 4.366 |
| **September** | 9.658 | 5.326 | 5.487 |
| **October** | 9.528 | 6.435 | 5.89 |

**Table 12. pH values of surface soils at different study sites**

| Month | Site1 | Site2 | Site3 |
|---|---|---|---|
| **May** | 7.3 | 7.49 | 7.45 |
| **June** | 7.1 | 7.42 | 7.52 |
| **July** | 7.1 | 7.2 | 7.38 |
| **August** | 7 | 7.4 | 7.46 |
| **September** | 7.2 | 7.52 | 7.6 |
| **October** | 7.35 | 7.5 | 7.69 |

**Table 13. Electrical Conductivity (µS/cm)**

| Month | Site1 | Site2 | Site3 |
|---|---|---|---|
| **May** | 100 | 105 | 96 |
| **June** | 105 | 115 | 100 |
| **July** | 98 | 88 | 100 |
| **August** | 86 | 103 | 98 |
| **September** | 89 | 108 | 92 |
| **October** | 98 | 116 | 103 |

**Table 14. Loss on ignition (%)**

| Month | Site1 | Site2 | Site3 |
|---|---|---|---|
| **May** | 5.60 | 7.80 | 7.60 |
| **June** | 5.40 | 5.00 | 5.75 |
| **July** | 8.20 | 7.40 | 8.00 |
| **August** | 5.00 | 7.20 | 6.70 |
| **September** | 5.00 | 6.00 | 5.70 |

| | | | |
|---|---|---|---|
| **October** | 5.00 | 7.60 | 5.75 |

**Table 15. Organic Carbon (%) at different study sites**

| Month | Site1 | Site2 | Site3 |
|---|---|---|---|
| **May** | 0.52 | 0.90 | 0.88 |
| **June** | 0.40 | 0.50 | 0.55 |
| **July** | 0.85 | 0.85 | 0.75 |
| **August** | 0.55 | 0.90 | 0.80 |
| **September** | 0.45 | 0.58 | 0.44 |
| **October** | 0.52 | 0.72 | 0.35 |

## Status of the Brick Kilns in Lasjan area: Questionnaire Survey

The results compiled from the questionnaire survey (Number of respondents, N= 27) in the Brick Kiln area of Lasjan are summarized in the Table 16. The kiln types found in the study area and also in other places of the Kashmir locality is the Bull's Trench Kiln. On an average, 60-90 kanals (30,351 sq m – 45,527 sq m) of land was occupied by each unit for its related activities. Overall, there were found to be 27 brick kilns in total in the Lasjan area and the average number of workers at each kiln was approximately 144 individuals. The labourers were mostly the migrant Bihari people. The heating source mostly comprised of the charcoal of the type Assam coal and steam coal. Saw dust, and wood of the locally growing timber tree *Rubinia* species was also used as a firing fuel. The stack height of the kiln was on average 115 feet high. The survey of the Brick kiln area revealed that no pollution control devices were installed by the operational units.

Table 16. Questionnaire survey (number of respondents, N= 27) in the Brick Kiln area of Lasjan for evaluating the status of the brick kilns in the area.

1. Brick kiln type = Bull's Trench Kiln

2. Average number of workers in the kilns= 143.57

3. Average production capacity of the kilns= 24.71 lac bricks

4. Number of times kiln is operated during a year= 1

5. Heating source to the kiln= coal (charcoal) and wood (commonly used tree species as source of wood: *Rubinia sp.*)

6. Coal type used= Assam coal and steam coal

7. Approximate amount of coal used in a year= 2179 quintals

8. Average price of coal during 2008= Rs. 1093 /100 kg

9. Average price of coal during 2009= Rs. 1093 /100 kg

10. Average price of bricks during 2008= Rs. 9029 / 3000 bricks

11. Average price of bricks during 2009= Rs. 9029 / 3000 bricks

12. Number of brick kilns operating in the area= 27

13. Pollution control devices installed= nil

14. Average area of land under brick kilns= 67.85 kanals (34,322 sq m)

15. Average range of land area under brick kilns = 60-90 Kanals (30,351 sq m – 45,527 sq m)

16. Average height of the stack/ chimney = 115 feet

***Table 17. Brick Kiln Numbers in the District Budgam.***

**1. Block BK Pora.**

Number of Working/Existing Brick Klins = 31.

Number of Non Working = 1.

1st Klin was registered in the year 1980.

Latest Klin was registered in the year 2008.

**2. Block Budgam**

Number of Working/Existing Brick Klins = 48.

Number of Non Working = Nil.

1st Klin was registered in the year 1988.

Latest Klin was registered in the year 2008.

**3. Block Chadoora**

Number of Working/Existing Brick Klins = 11.

Number of Non Working = 1.

1st Klin was registered in the year 1993.

Latest Klin was registered in the year 2009 (March 12).

(Latest Registered Klin among all)

**4. Block Nagam** - Nil

**5. Block Khan Sahib**

Number of Working/Existing Brick Klins = 1.

Number of Non Working = Nil.

Klin was registered in the year 1992.

**6. Block Beerwah**

Number of Working/Existing Brick Klins = 6.

Number of Non Working = Nil.

1st Klin was registered in the year 1991.

Latest Klin was registered in the year 2008.

**7. Block Narbal** – Nil

**8. Block Khag** – Nil

*(Source: District Industries Centre, Budgam)*

***Table 18. Brick Kiln Numbers in the District Budgam.***

- Number of Brick Kilns registered in the DIC, Budgam = 97
- Number of Brick Kilns which got consent by the State Pollution Control Board = 60
- Number of unregistered Brick Kilns = 113 (approx.)
- Average area of land under 1 Brick Kiln = 80 kanals
- Average area of land under 210 Brick Kilns = 16800 kanals

Units Registered from 1973 – 2000 (in 27 years) = 41
Units Registered from 2001 – 2009 (in last 8 years) = 56
Registration of Brick Klins were banned w.e.f January 2010.

*(Source: District Industries Centre, Budgam)*

**Table 19. Number of Brick kilns in the District Budgam as enumerated using the Google Earth Satellite Images.**

- Number of Brick Kilns enumerated on the satellite images of the area (using Google Earth, 2009) = 210 (approx.)

*[BRICK MAKING PROCESS – PHOTO PLATE.]*

1 Excavation of Mud 2

3 Mixing the Ingredients 4

5 Moulding 5

6 Making the Bricks 7

8 Drying 8

9 Loading the Kiln (Local transportation – Taking dried bricks to the Kiln site) 10

11 Kiln Loading 12

14

15

Firing the Kiln (Progressively)

16

17

Emissions from the stack

18 Material used for the Firing Process (wood and saw dust) 19

20 Material used for the Firing Process (coal) 20

21 Taking out the burnt / baked bricks 22

23 Delivery 23

# *Chapter 6*

# Discussion

The results acquired as a result of analysis of air, vegetation, soil and other information acquired via the interview schedule are discussed as under:

### Air analysis

Brick making is one of the traditional crafts. In recent years, with increasing urbanization and the demand for construction materials for development work, brick kilns have grown both in numbers and capacity. Operation of Brick kilns are known to be a leading cause of air pollution (Joshi & Dudani, 2008). Brick making has directly or indirectly caused a series of environment and health problems. At a local level (in the vicinity of a brick kiln), environmental pollution from brick-making operations is injurious to human health, other animals and plant life. At a global level, environmental pollution from brick-making operations contributes to the phenomena of global warming and climate change. Biomass burning is responsible

for the emissions of trace and non-trace greenhouse gasses, such as $CO_2$, $CH_4$, CO, $N_2O$, NOx and NO (World Bank, 1998). EBRD (2005) also mentioned that nitrogen oxides, carbon monoxide and carbon dioxide are emitted from the burning of hydrocarbon fuels in the brick making industries and from the effect of heat on clay, sulphur dioxides are also generated. So, brick making industries are important sources of greenhouse gases as they use huge quantity of fuelwood and considerable amount of coal for burning of bricks (Alam, 2006).

The concentration of SPM showed a mean value of 151.38 μg/$m^3$ at site 1 and 132.42 μg/$m^3$ at site 2, while as the mean value at site 3 were 132.11 μg/$m^3$ (Fig. 9). The high values of SPM related to the operation of brick kilns could be the responsible factor. Similar results indicating the high level of dust in the atmosphere had been observed by Joshi and Dudani (2008) relating it to the operation of Brick kilns. Average value of total suspend particles for the pre operation time was 0.033 mg/$m^3$ whereas, it reached 0.056 mg/$m^3$ during the brick kiln operation period (Joshi and Dudani, 2008). Similarly, the concentration of RSPM showed a mean value of 76.23 μg/$m^3$ at Site 1 and 56.77 μg/$m^3$ and 42.91 μg/$m^3$ at Site 2 and Site 3 respectively (Fig. 10), which is in harmony with the studies conducted by Joshi and Dudani (2008) showing the average value of RSPM raising from 0.029 mg/$m^3$ to 0.050 mg/$m^3$ from pre-operation time to operation time.

According to a study conducted by the World Bank in 1996, the main contributing sources for total suspend particles (TSP) in the Kathmandu Valley are cement factory (36%), brick kilns (31%), domestic fuel combustion (14%), road re-suspension (9%) and vehicle exhaust (3.5%). However, for the particulate matter of size less than 10 microns ($PM_{10}$) concentration, which is of a more concern as these particles can enter the respiratory system; contribution of brick kilns was found to be more than other sources. The share of brick kilns was 28%, domestic fuel

combustion (25%), cement factory (17%), vehicle exhaust (12%) and road resuspension (9%) (World Bank, 1997).

PM10 is generally thought to be responsible for a large proportion of the total non-carcinogenic adverse health impacts of air pollution (Pope *et al.*, 1995). Brick kilns' impacts are highly localized geographically. A concentration profile for PM10 emissions from the brickyard Mexico, shows that virtually all of a brick kiln's PM10 emissions are deposited less than 500 meters away. This result stems from the fact that brick kilns have very low "stack-heights" and low emissions velocities (Blackman, 2000).

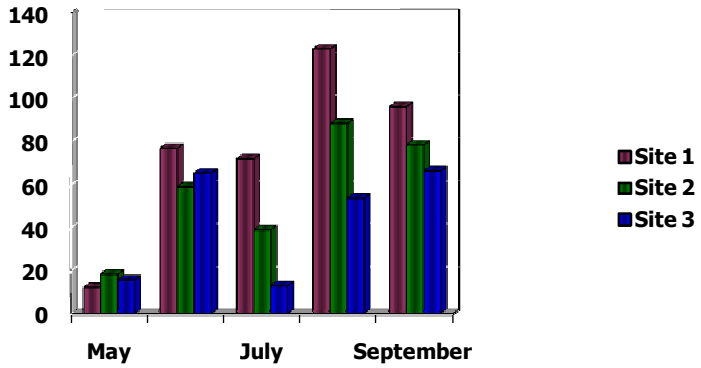


Fig.9 SPM Concentration (µg/m3)

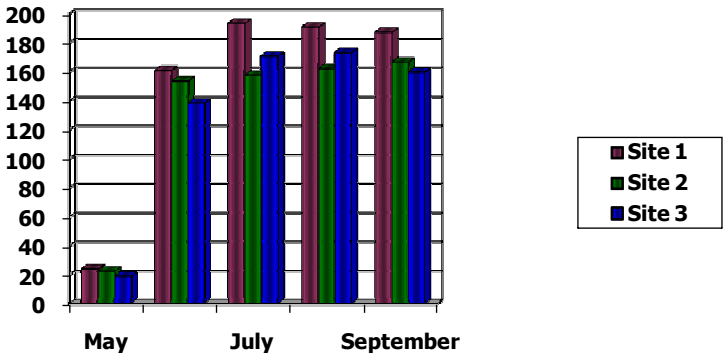


Fig.10 RSPM Concentration (µg/m3)

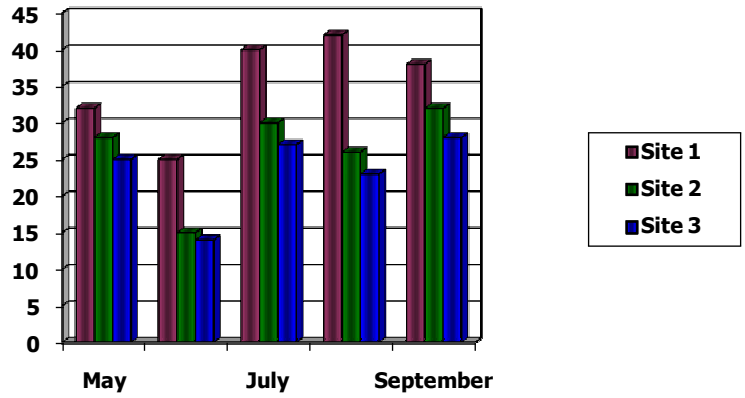


Fig.11 $SO_2$ Concentration (µg/$m^3$) at different study sites

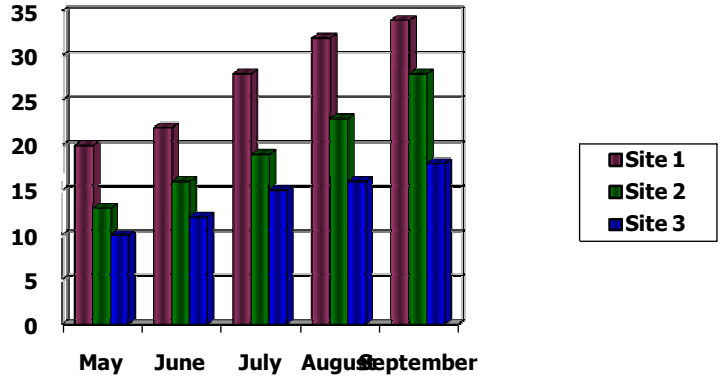


Fig.12 NOx Concentration (µg/m3)

Table 20. National Ambient Air Quality Standards

| S.No. | Pollutant | Time weighted average | Concentration in ambient air | | |
|---|---|---|---|---|---|
| | | | Industrial Areas | Residential & Rural Areas | Sensitive Areas |
| 1 | $SO_2$ | Annual average | 80(µg/m3) | 60(µg/m3) | 15(µg/m3) |
| | | 24 hours | 120(µg/m3) | 80(µg/m3) | 30(µg/m3) |
| 2 | $NO_2$ | Annual average | 80(µg/m3) | 60(µg/m3) | 15(µg/m3) |
| | | 24 hours | 120(µg/m3) | 80(µg/m3) | 30(µg/m3) |
| 3 | SPM | Annual average | 360(µg/m3) | 140(µg/m3) | 70(µg/m3) |
| | | 24 hours | 500(µg/m3) | 200(µg/m3) | 100(µg/m3) |
| 4 | RSPM | Annual average | 120(µg/m3) | 60(µg/m3) | 50(µg/m3) |

| | | | | |
|---|---|---|---|---|
| | 24 hours | 150(µg/m3) | 100(µg/m3) | 75(µg/m3) |

Table 21. Air Quality Category Based on Air Quality Index

| Category | AQI (µg/m3) | Description |
|---|---|---|
| I | <10 | Very Clean |
| II | 10-25 | Clean |
| III | 25-50 | Fairly Clean |
| IV | 50-75 | Moderately Polluted |
| V | 75-100 | Polluted |
| VI | 100-125 | Heavily Polluted |
| VII | >125 | Severely Polluted |

**Table 22. Air Quality at the different study sites on the basis of Air Quality Index**

| | AQI (µg/m3) | Remarks |
|---|---|---|
| SITE 1 | 42.93 | FAIRLY CLEAN |
| SITE 2 | 33.50 | FAIRLY CLEAN |
| SITE 3 | 28.87 | FAIRLY CLEAN |

Coal and biomass fuels are used for firing the bricks in the kilns. The estimated coal consumption in the brick sector of the country is about 24 million tonnes per year. With such a large consumption of coal, the brick industry is the cause of significant air pollution in terms of suspended particulate matter (SPM).

Ahmad and Hussain (2007) (cited in Chauhan and Joshi, 2010) studied the pollutant load within the cluster region of Brick kilns of Bangladesh for $SO_2$ and particulate matter. It was found that particulate matter was a major pollutant in that region. Ambient concentration of particulate matters was very high compared to Bangladesh standard in every observation made in that region.

Brick making has also been identified as one of the most polluting (air pollution) industries in the small scale sector by the Central Pollution Control Board (CPCB). The CPCB initiated enforcement of environmental standards since 1996 mainly air pollution (suspended particulate matter - SPM) and minimum heights for chimneys. These standards also ban use of moving chimney brick kilns. The technical skills available in the brick industry are quite low (NEERI, 1993).

The concentration of $SO_2$ were found to be highest at site 1 which is the site near to the brick kiln as compared to the other far away sites (Fig. 11). During the study period the concentration of $SO_2$ at site 1 showed a mean value of 32.4 $\mu g/m^3$ which is above the permissible levels as recommended by Central Pollution Control Board, New Delhi, i.e. 30 $\mu g/m^3$. The mean values of concentration of $SO_2$ at site 2 and site 3 were 26.2 $\mu g/m^3$ and 23.4 $\mu g/m^3$ respectively. The linear relationship of sulphate showed a positive correlation with atmospheric sulphur dioxide significant at 0.1 percent level of significance at all the sites during a survey by Dwivedi and Tripathi (2007). The $SO_2$ showed a similar trend of lower values as going away from the source (Dwivedi and Tripathi, 2007).

Earlier and recent ambient air monitoring studies have shown that the brick sector has become the number one polluter with regards to $SO_2$ emissions and the second highest polluter with regards to SPM emissions (second only to automobile vehicle exhaust) (Urban air quality management strategy in Asia).

During the study period the concentration of NOx was found to be highest at Site 1 which is the site nearest to the brick kiln showed a mean value of 27.2 $\mu g/m^3$. At Site 2, the concentration of NOx showed a mean value of 18.2 $\mu g/m^3$ and at Site

3 it was 14.2 μg/$m^3$ (Fig. 12). The oxides of nitrogen involved in air pollution, denoted by NOx are $N_2O$, NO, $NO_2$, $N_2O_3$ and $N_2O_5$. These enter the atmosphere both in stationary and mobile phase. The main sources of NOx is automobiles and through combustion of fossil fuels. Mostly the oxides of nitrogen are not so dangerous, but the role they play in the formation of photochemical oxidants etc. constitute the most harmful effect. Higher concentrations of $NO_2$ damage the leaves of plants, retard the photosynthesis activity and cause chlorosis. Combined effect of NOx and $SO_2$ cause chlorophyll degradation, reduction in photosynthetic activity, less accumulation of biomass, reduced plant growth and ultimately reduced productivity (Wellburn, 1982). Perennial grass species and trees are more susceptible to the combination of these pollutants and the effects are more than additive (Ashenden and Mansfield, 1978; Frevet and Klemm, 1984).

The brick kilns emit toxic fumes containing suspended particulate matters rich in carbon particles and high concentration of carbon monoxides and oxides of sulphur (SOx) that are harmful to eye, lungs, throat and also stunt the mental and physical growth of children (SOS-Arsenic.net, 2005). The recent scientific report states the combustion of clay and fuels for making bricks in the brickfields produces dioxins and furans as by-products, which first enter into the air from where the humans, birds and other animals either directly inhale or intake through different contaminated foodstuff both vegetable and animal origin. According to the Standard Toolkit prescribed by the United Nations Environment Programme (UNEP), under well-controlled processes 0.2 microgram TEQ (toxic equivalents) of dioxins and furans are emitted as by-product into the air during the production of each tonne of brick (Rahman, 2005).

## Chlorophyll content

Air pollution has become a serious environmental stress to plants due to increasing industrialization and urbanization during last few decades (Rajput and Agrawal, 2004). The particulates and gaseous pollutants, alone and in combination,

can cause serious setbacks to the overall physiology of plants (Ashenden and Williams, 1980; Mejstrik, 1980; Anda, 1986). Of all plant parts, the leaf is the most sensitive part to the air pollutants and several other such external factors (Lal and Singh, 1990). Plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollutant level in the air environment (Warren, 1973; Shannigrahi *et al.,* 2004). Air pollution is most dangerous among all type of pollutions because man and even plants need fresh air for their normal metabolic pathways. Honjyo *et al.* (1980) in a study found that the trees in the polluted area show vital decay. Rao (1985) argued that pollutants and their combinations cast toxic effects on plants.

During this study in which chlorophyll 'a', chlorophyll 'b' and total chlorophyll were estimated at three differently located sites for 17 plant species, the chlorophyll 'a' content was in general found to be low in the species growing closest to the brick kiln (Site 1), especially in the community comprising of *Xanthium strumarium, Convolvulus arvensis, Cynodon dactylon, Erigeron bellidiodes, Iris ensata, Urtica dioica, Cannabis sativa, Digitaria sanguinale, Polygonum amphibium* and *Robinia pseudoacacia* (Figs 13-18). This probably could be due to the sensitiveness of the species towards the emissions and activities associated with the operations of Brick Kilns in the area. However, in case of some plants, it appeared that the chlorophyll 'a' concentration was comparatively reduced at Site 2 than at Site 1. This could be likely attributed to the fact that the emissions from the stacks were dispersed in the atmosphere and then fallout at a distance away from the kiln. This response was noted particularly in some tree species including *Populus nigra* and *Salix alba.* The trees being acclimated for a longer duration at the affected sites could be showing this response of depressed chlorophyll content in their leaf tissues due to the brick kiln emissions.

A similar trend for chlorophyll 'b' was observed in floristic community comprising of *Convolvulus arvensis, Urtica dioica, Cannabis sativa, Digitaria sanguinale, Xanthium strumarium, Erigeron bellidiodes, Polygonum amphibium* and

*Robinia pseudoacacia.* However, the chlorophyll 'b' concentration was higher in case of *Iris ensata* at the site located close to the kiln, i.e. Site 1. In case of the tree species *Populus nigra,* again the chlorophyll 'b' concentration was found to be comparatively higher at the Site 1 than at Site 2. In *Anthemis cotula, Circium wallichii* and *Populus nigra,* the chlorophyll 'b' concentration was found to be depressed at the Site 2 which could be because of the reason that kiln stack emissions fallout at a distance away from the Site 1.

The total chlorophyll concentration was found to be depressed in the community inhabiting Site 1 which included plant species *Xanthium strumarium, Convolvulus arvensis, Cynodon dactylon, Erigeron bellidiodes, Iris ensata, Robinia pseudoacacia, Urtica dioica, Cannabis sativa, Digitaria sanguinale* and *Polygonum amphibium.* A reverse trend was observed in rest of the plant species excepting *Anthemis cotula, Circium wallichii, Salix alba* and *Populus nigra* where the total chlorophyll concentration was found to be depressed at Site 2 than at Site 1 and Site 3 which could be because of the reasons mentioned earlier.

The smoke from brick kiln contains dust, a byproduct of brick production that may cause hazardous effects upon the nearby vegetation. After settling down on leaves and shoots the dust can clog stomatal openings to interfere with the normal gaseous exchange and thus exerting considerable bearing on photosynthesis (Creed *et al.,* 1973). Hence air pollutants can be viewed as additional stress agents that can limit tree growth and productivity in concert with other stresses (Winner, 1994).

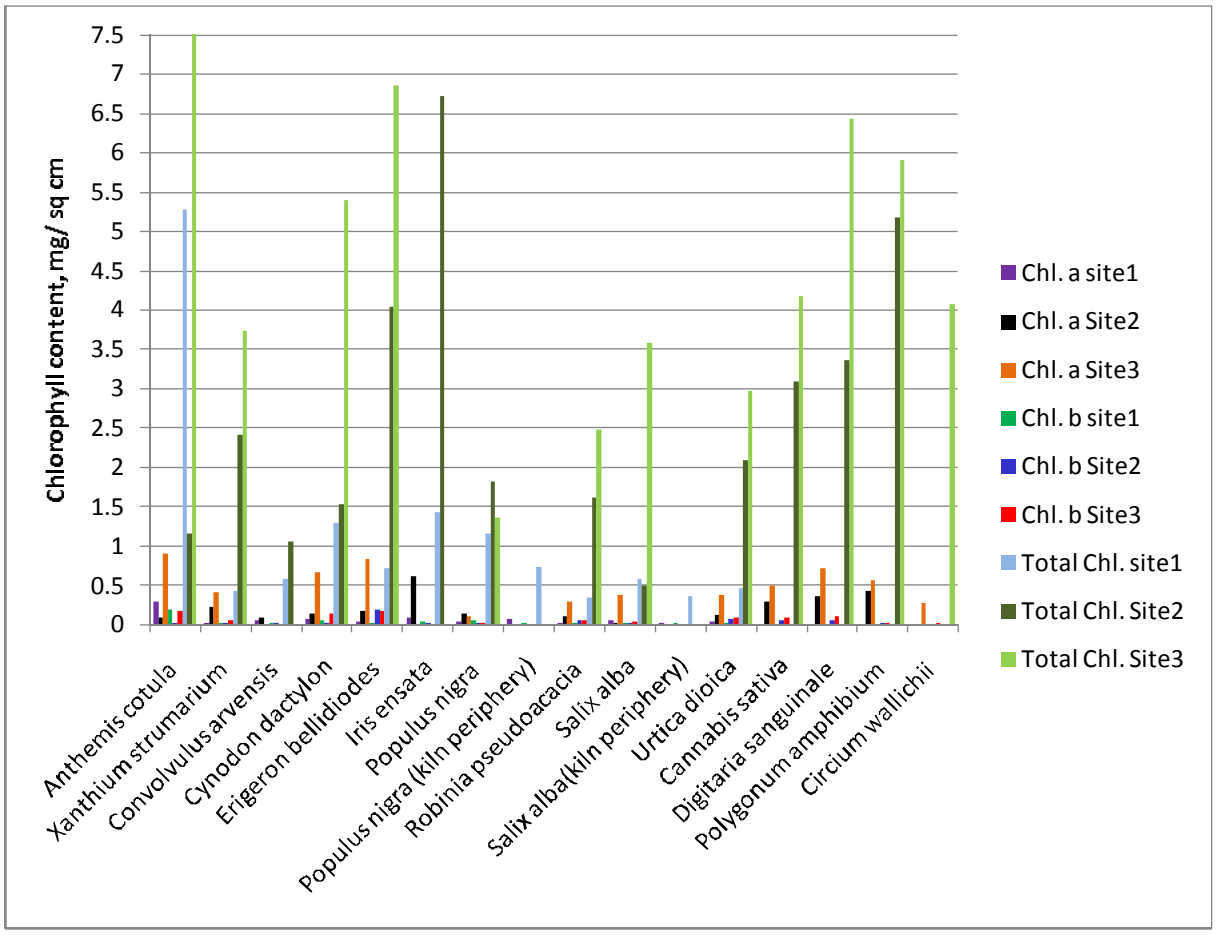


**Fig.13 Chlorophyll content (mg/sq.cm) at different study sites during the month of May.**

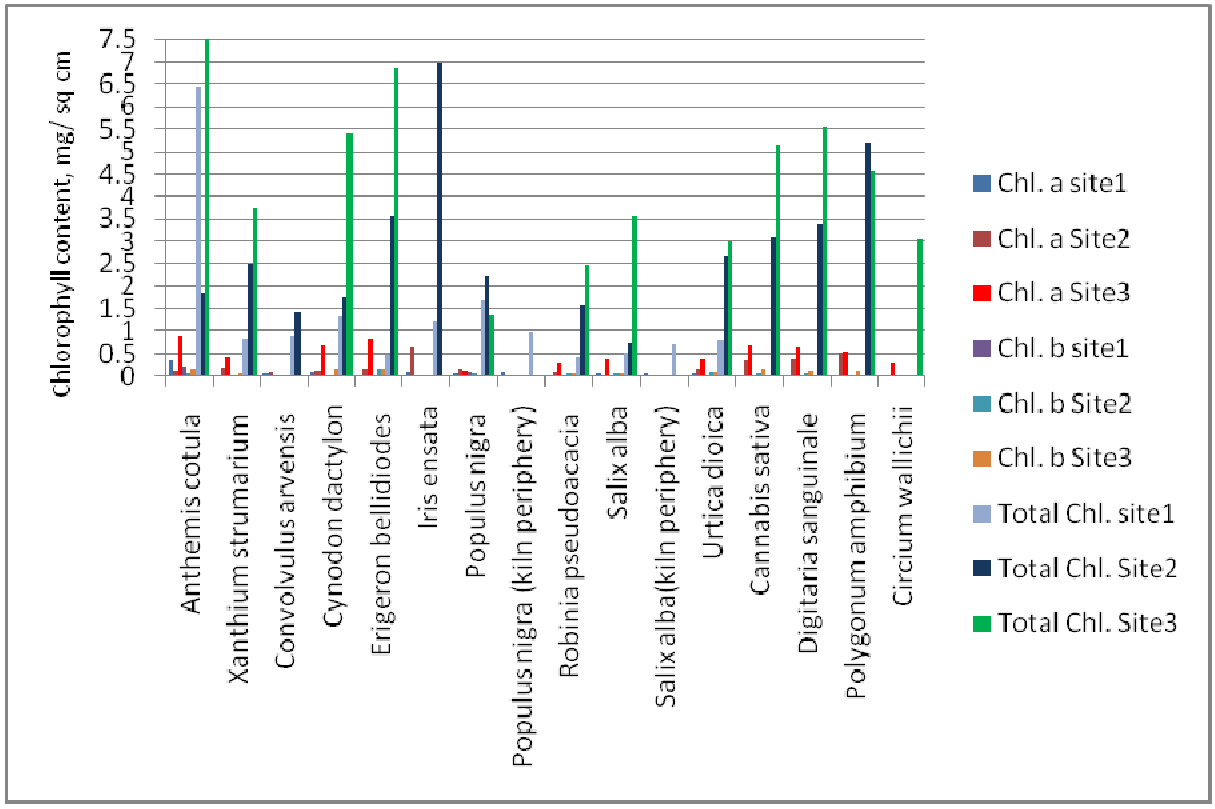


**Fig.14 Chlorophyll concentration (mg/sq.cm) at different study sites during the month of June.**

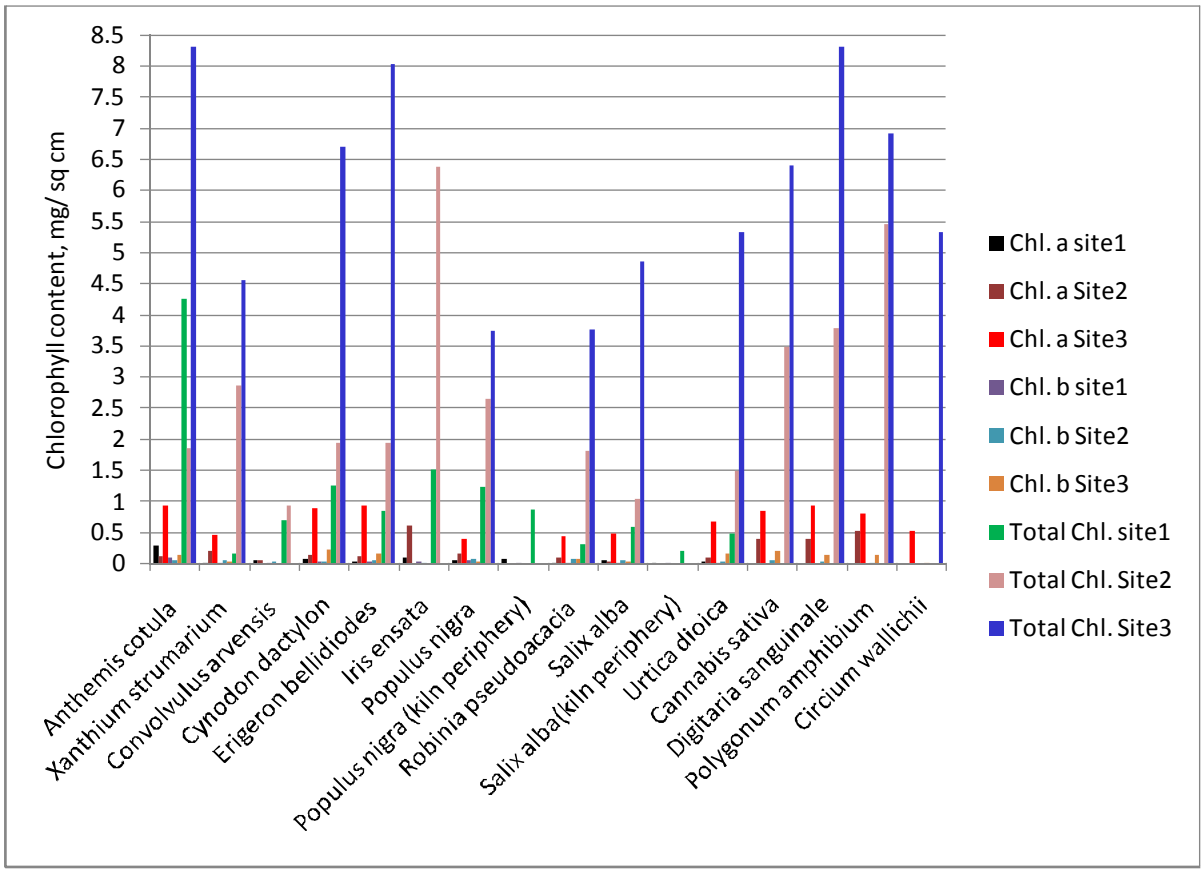


**Fig.15 Chlorophyll concentration (mg/sq.cm) at different study sites during the month of July.**

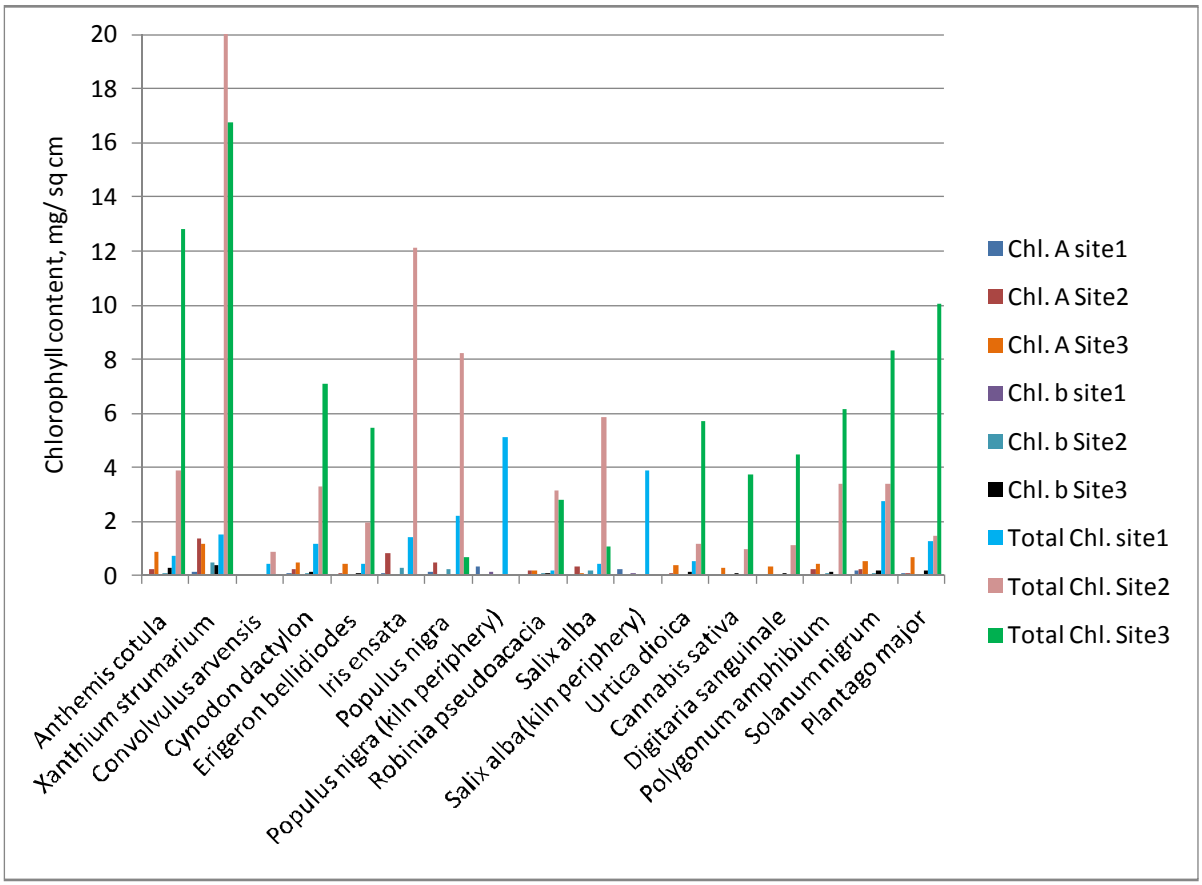


**Fig.16 Chlorophyll concentration (mg/sq.cm) at different study sites during the month of August.**

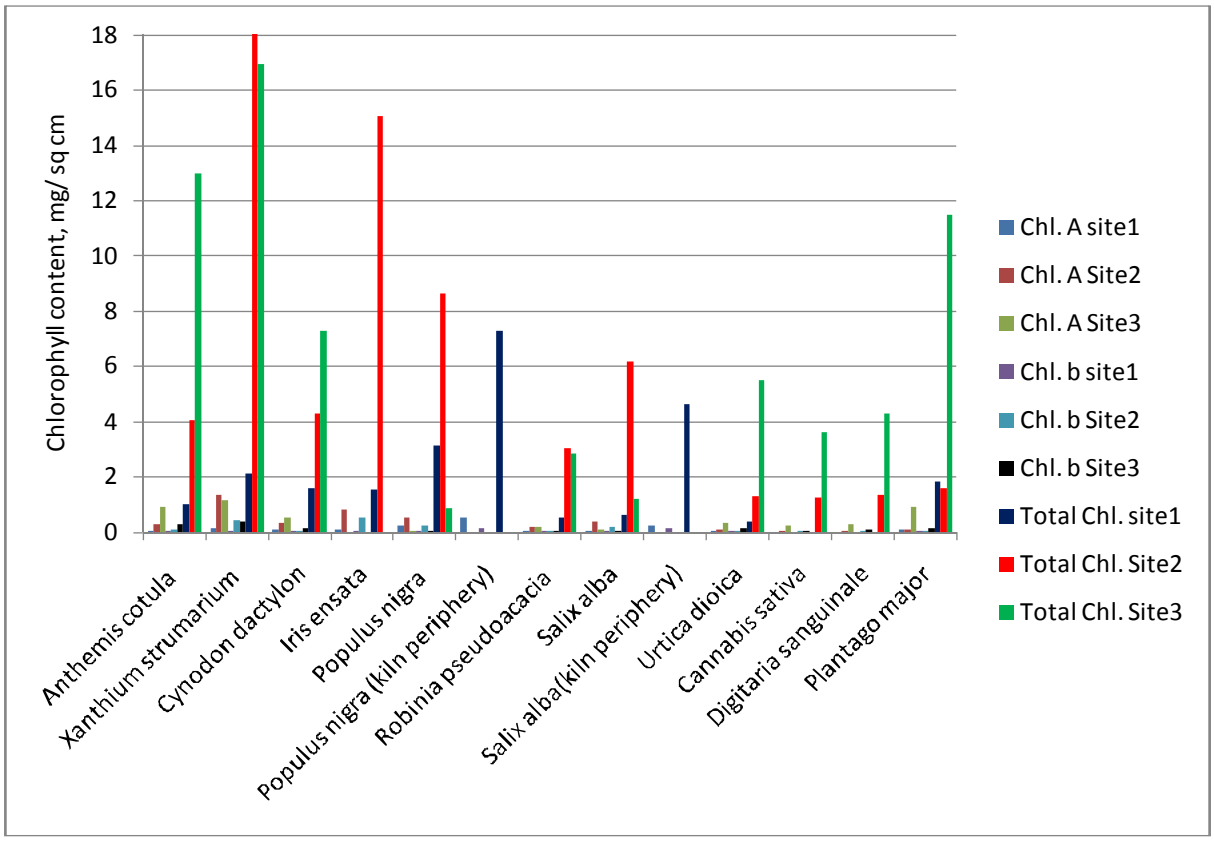


**Fig.17 Chlorophyll Content (mg/sq.cm) at different study sites during the month of September.**

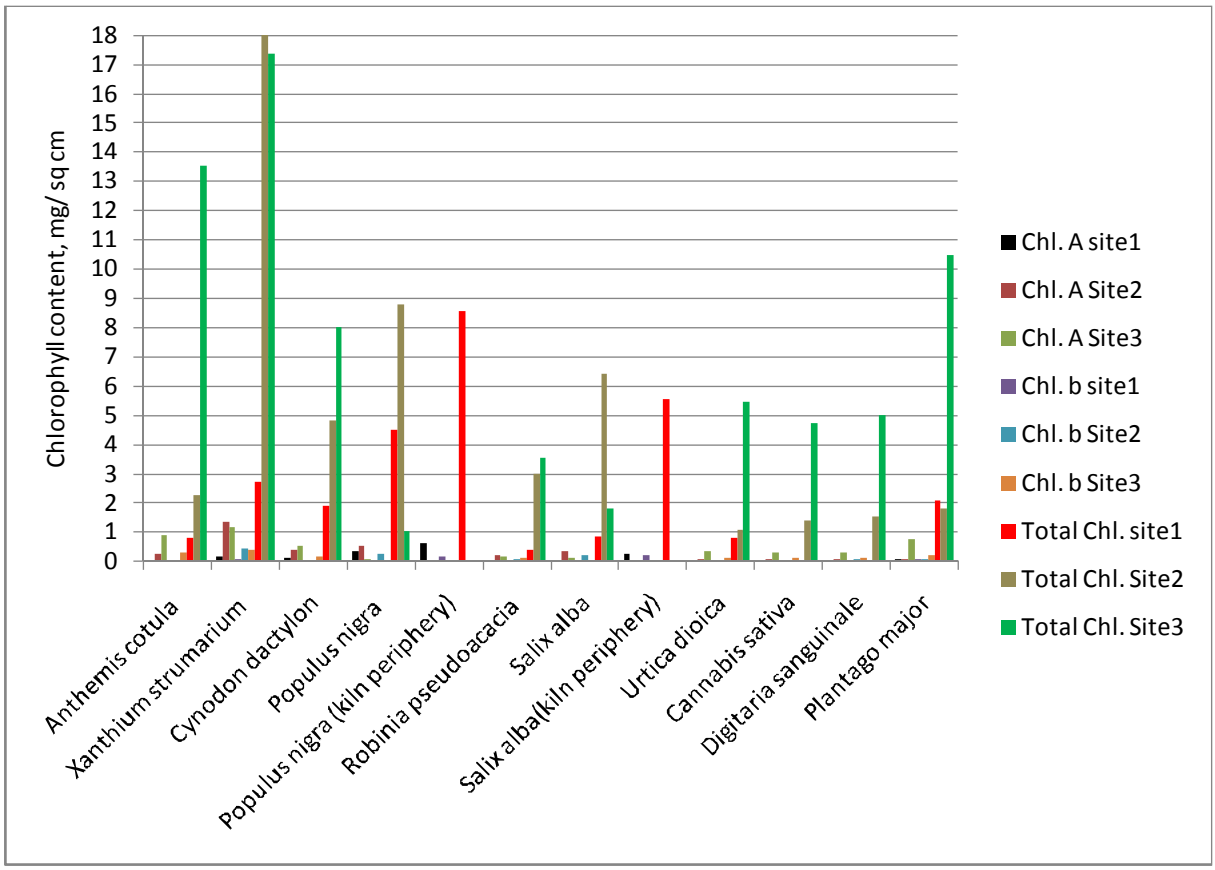


**Fig.18 Chlorophyll Content (mg/sq.cm) at different study sites during the month of October.**

Elevated levels of the trace gases $SO_2$, NOx, $CO_2$ and $O_3$ resulting from industrial emissions have well-documented physiological effects on trees (Keller, 1984; Ceulemans and Mousseau, 1994; Matyssek *et al.,* 1995). With the exception of $CO_2$ these trace gases are toxic to plants and cause reductions in tree growth (Matyssek *et al.,* 1995). These gases enter leaves almost exclusively through the stomata and impact the internal physiology of the tree through effects on mesophyll tissue. The resultant reductions in photosynthetic processes in tree leaves are the primary mechanism of direct effects of these pollutants on tree growth and productivity. Indirect effects of these pollutants arise from the chemical changes that emitted pollutants undergo in the atmosphere resulting in ozone ($0_3$) production and wet and dry deposition of sulfur and nitrogen compounds with subsequent cascade effects on various components of the forest ecosystem (Schulze *et al.*, 1989; Taylor *et al.*, 1994). The chlorophyll content is essential for the photosynthetic activity and reduction in chlorophyll content is an indicator of air pollution (Pawar & Dubey, 1985); Gilbert, 1968). The pollutants ($SO_2$, NOx) reduced the synthesis of chlorophyll and enhance degradation of chlorophyll (Sandelius *et al.,* 1995). Knudson *et al.* (1977) (cited in Unsworth and Omrod, 1982) explained that chlorophyll content could be a useful indicator for the evaluation of injury induced by pollutants (like NOx, $SO_2$).

Brickfields' without the chimney and scrubber, emitted particles along with the carbon monoxide, sulphur dioxide and florine which directly spread into the air and fall on the vegetation community and crop plants of the locality. The layer of these particles plug the stomata, the pores on the leaves by which the plant inhales both carbon dioxide and oxygen respectively to carry out its photosynthesis process and respiration. If these processes remain inactive for a long time the plant itself may suffer mortality. Department of Agriculture Extension (DAE) of Bangladesh, carried out a research to find out the impacts of brick making industries' emission on agriculture and forestry and found that the presence of the brickfields has made agriculture impossible in 2,000 acres of land in Savar area near

Dhaka, the capital city of Bangladesh; crop production declined from 70% - 80% in 3,000 acres affected by the emission of the gases from the brickfields; pollination and rice formation processes in paddy were disturbed and as a result, the total rice production decreased. Besides, sulphur dioxide reacting with the water vapour produced sulphuric acid, which on falling on the ground mixed with rain and dew. Consequently, increasing the acidity of the soil and turning the grass and crops yellow (SEHD, 1998). Most of the studies regarding ambient air quality monitoring direct towards the higher concentration of sulphur dioxide, as also reported by Rao *et al.* (2005), Wagh *et al.* (2006) and Sharma *et al.* (2005). The concentration of sulphur dioxide in surroundings was largely affected by anthropogenic interference through burning of the fossil fuel. Brick kilns, located along periphery of cities, played significant role in elevating the $SO_2$ concentration in the ambient air, as they were fed with sulphur rich, inferior quality coal (Dwivedi and Tripathi, 2007). In India, there are about 1 lakh small or large brick industries. Baking of 1000 bricks required about 180 kg of coal. As per one estimate on an average about 20 million tonnes of coal were consumed by brick industries each year in India. According to Pandey (1997) 0.4536 kg of sulphur dioxide is produced by burning of 1 tonne coal. Consequently, 9.072 million kg of sulphur dioxide was released in the atmosphere by the brick kilns during summer and winter, when the kilns are functional. Objects in vicinity of such areas, are subjected to the exposure to very high concentration of $SO_2$ during the period.

## Soil Analysis

Khan *et al.* (2007) carried out a study on degradation of agricultural soils arising from brick burning in Western part of Bangladesh. Burning of soils significantly decreased the average pH values of soils by 0.4 pH units but increased the average electrical conductivity values from 0.26 to 1.77 mS/cm. The average losses were

amounted to 63% for organic matter, 56-86% and 23-88% for available and total N, P, K, and S respectively.

During the study, the pH values at the three sites ranged from neutral to slightly alkaline (Fig. 19). The pH at Site 1 showed a mean value of 7.17 and at Site 2 and Site 3 as 7.42 and 7.51 respectively. Nature tends to stimulate either acidity or alkalinity in soils. In humid regions, soils tend to be quite acidic. The acidity develops because there is sufficient rainfall to leach out much of the base-forming cations ($Ca^{2+}$, $Mg^{2+}$, $K^{+}$, $Na^{+}$) leaving the colloidal complex dominated by $H^{+}$ and $Al^{3+}$ ions. In low rainfall areas, the opposite is true. Leaching is not very intense, and the base forming cations are left to dominate the exchange complex in place of $Al^{3+}$ and $H^{+}$. This leads to neutrality or even alkalinity.

Soluble salts present in soil dissociate into their respective cations and anions when come in soil solution. These ions carry current and impart conductivity. Higher the concentration of ions in solution more is its electrical conductance (less the resistance to electric current). Thus the measurement of electrical conductivity can be directly related to the soluble salt concentration. The values of Electrical Conductivity in the sampled surface soils showed mean values at site 1 as 96 uS/cm, at site 2 as 105 uS/cm and at site 3 as 98.16 uS/cm (Fig. 20). The increased specific conductivity values are an indicator of pollution (Berg *et al.,* 1958).

Smoke from these kilns has a very high EC/OC ratio and produce 16% of the particulate matter and 43% of the $SO_2$ in the urban airshed (Christian *et al.,* 2007). Long term Brick kiln industrial activity affected the soil characteristics and concomitantly the structure of plant biomass (particularly the below-ground biomass), and species diversity (Gupta and Narayan, 2010).

Loss on ignition is a key parameter in determining the pollution of soil due to unburnt hydrocarbons in the form of soot. The average values of loss on ignition at site 1 were found to be 5.7%, at site 2 as 6.83% and at site 3 as 6.58% (Fig.23). The

results showed that there was more deposition of soot at site 2 which was 200m away from the brick kiln, confirming that the soot particles emitted along with the smoke fall at some distance away from the source.

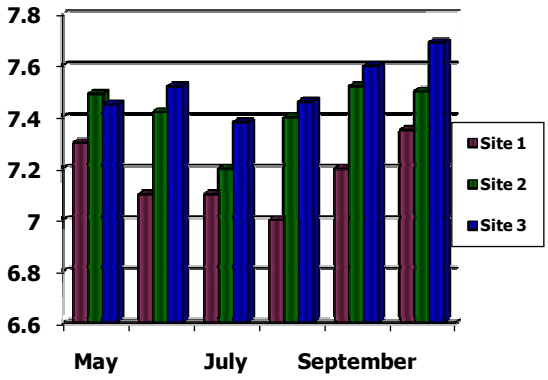


Fig. 19 pH of surface soil samples at different study sites

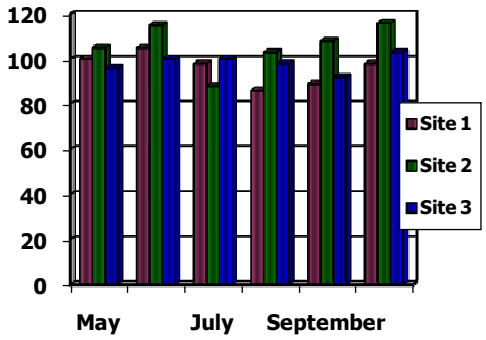


Fig. 20 Electrical Conductivity (µS/cm) during the various months

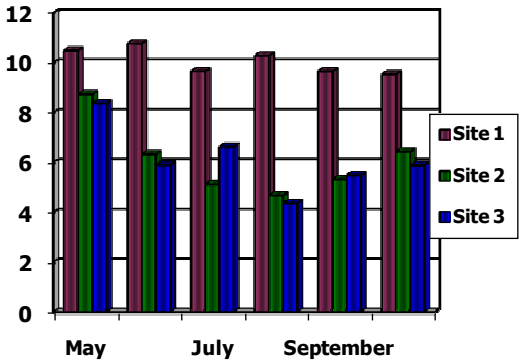


Fig. 21 Soil moisture Content (%) at different study sites

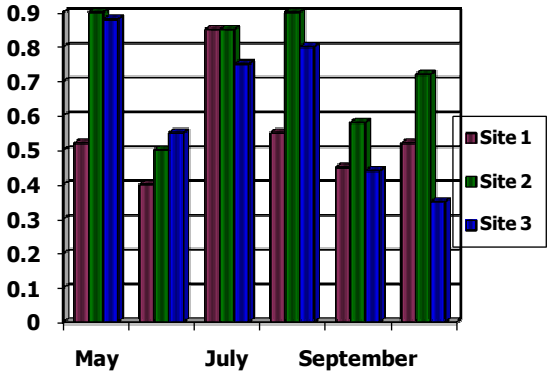


Fig. 22 Organic Carbon (%)

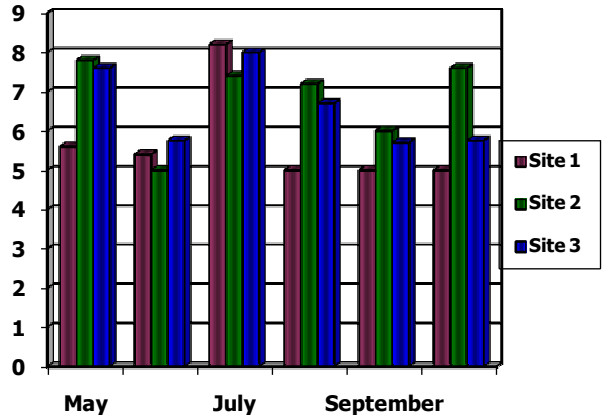


Fig. 23 Loss on Ignition (%)

Soil organic carbon is the main source of nutrients to the soils. Soil organic carbon is degraded by soil microorganisms and converted to humus. Humus refers to all organic matter found in the soil. Humus is present in almost every type of soil in the form of colloidal substances which are formed by decomposition of plant and animal remains. Organic matter is a major source of nitrogen, 5-60% of phosphorous and about 80% of sulphur. The amount of organic carbon during the study period at Site 1 showed a mean value of 0.54% and at Site 2 as 0.74%, while at Site 3 as 0.62% (Fig. 22). The cause for increased concentration of organic carbon at Site 2 could also be attributed to the deposition of unburnt hydrocarbon in the form of soot on plant surface and soil.

Water content is simply the amount of water in a particular piece of soil. Soil water content is commonly expressed as a fraction of the soil dry weight, or sometimes as a fraction of the bulk volume or of the pore space. The soil moisture content at site 1 showed a mean value of 10.05% and at site 2 and site 3 as 6.09% and 6.1% respectively (Fig. 21). Knowledge of soil moisture content and how it changes over time is a key basis for the management of soil systems (Gliessman, 2007; Brady & Weil, 1996).

Because of repeated high temperature in brick kiln areas, dried up soil shows low permeability, reduced porosity, low moisture content and high dielectric constant. This is one of the reasons of low infiltration of rainwater in this area. Soil properties and land use pattern are major contributing factors to hydrogeomorphology of particular area (Mukherjee *et al.,* 2003).

### Land degradation and other effects

The construction sector in India is huge, contributing about 10 percent to the Gross Domestic Product and registering an annual growth of about nine percent. To feed this growth, an estimated 140 billion bricks are produced each year. Brick production consumes 24 million tones of coal and huge quantity of biomass fuel. The total carbon dioxide emission from brick production is estimated at 41.6 million tonnes, accounting for 4.5 percent of the total greenhouse gas emissions from India (Ministry of Environment and Forests, Government of India; and The Energy and Resources Institute 2009.) 60% of $CO_2$ Emissions in Construction Sector are contributed by cement, steel and bricks (Anonymous 2005). Brick production can be harmful to the environment and may deplete local sources of fuel wood; increase deforestation and associated environmental impacts (such as soil erosion), leaving less wood for future use (Takaaki *et al.,* 1980).

The negative environmental consequences of brick production have not only to do with firewood, but are also to do with the land that is being used for the brick kilns. It is usually valuable agricultural land on the outskirts of the towns that would otherwise be used for agriculture or horticulture; renting this land to brick kiln operators is now more lucrative. But the digging of clay soils is proving very destructive, especially where the sites are not being flooded and re-silted each year (UNEP, 2008).

The total annual quantity of fuelwood consumed by the 25 surveyed brick making industries by Alam (2005) was 2,381 t dry matter. Accordingly, the

observed total potential deforested wood was 10,624 $m^3$, in which the total deforested round wood was 3,664 m3 and deforested branches was 6,961 m3. The study observed that a total of 2,990 t biomass fuels (fuelwood and dung cake) consumed annually by the surveyed brick making industries for brick burning. Consequently, estimated total annual emissions of greenhouse gases were 4,832 t CO2, 21 t CH4, 184 t CO, 0.15 t N20, 5 t NOX and 3.5 t NO while the total carbon released in the atmosphere was 1,318 t. Overall, the total annual greenhouse gases emissions from biomass fuels burning was 5,046 t; of which 4,104 t from fuelwood and 943 t from dung cake burning. Similarly, according to the results, due to the consumption of fuelwood in the brick making industries (3,450 units) of Sudan, the amount of wood lost from the total growing stock of wood in forests and trees in Sudan annually would be 1,466,000 $m^3$ encompassing 505,000 $m^3$ round wood and 961,000 $m^3$ branches annually. By considering all categories of biofuels (fuelwood and dung cake), it was estimated that, the total emissions from all the brick making industries of Sudan would be 663,000 t CO2, 2,900 t CH4, 25,300 t CO, 20 t N2O, 720 t NOX and 470 t NO per annum, while the total carbon released in the atmosphere would be 181,000 t annually (Alam, 2005). The environmental consequences of the huge growth in brick production are devastating. The firing of one brick kiln to produce 100,000 bricks requires, in just one production cycle in the year, to burn over 52,000 trees-worth of firewood; this is undoubtedly not an underestimate (UNEP, 2008).

Huge chunks of agriculturally fertile lands are consumed by each brick kiln (3–4 ha), which get converted into wastelands as a result of industrial operation in the life of a brick kiln (8–12 years). These industries are also reported to normally use 4–5 million metric tones of coal each year (NEERI, 2006) indicating that these brick kilns have immense disturbance potential to cause ecological alterations. Disturbance has been widely recognized as one of the major factors influencing variations in species diversity (Connell *et al.,* 1996) and productivity (Brooks, 2006). The disturbance generated by the brick-manufacturing process is reportedly a

threat to land and environment (Asgher, 2004) that adversely affects human health and vegetation (Bhanarkar *et al.,* 2002), soils (Jha *et al.,* 2008) and productivity (Haack and Khatiwada*,* 2007). The brick kiln operation over the years not only covers the neighbouring area of vegetation with layers of brick dust, but also consistently dissipates heat all around. It alters the physicochemical properties and habitats of nearby soils by destroying the top soil nutrient elements and soil biota (Khan *et al.,* 2007) which are likely to impact species diversity and biomass structure of the neighbouring plant communities.

In developing countries, urban clusters of manufacturers which are "informal"—smallscale, unlicensed and virtually unregulated—can have severe environmental impacts (Bartone and Benavides 1997). Further, informal firms are a significant source of employment and are often situated in poor residential areas. As a result, their emissions directly affect a considerable population. Even though informal firms create acute environmental problems, pollution control efforts in developing countries have traditionally focused on large industrial sources. One reason is that applying conventional regulatory instruments in the informal sector is problematic. Informal firms are difficult to monitor since they are small, numerous and (by definition) have few preexisting ties to the state. Also, such firms have few resources to invest in pollution control (Blackman, 2000; Blackman and Bannister, 1997; Dasgupta, 2000; Frijns and Van Vliet, 1999).

Brick production is one of the most environmentally damaging activities in the construction sector. The kilns tend to be highly inefficient, and use low-quality coal with high sulfur content. This leads to intense local air pollution, as well as a significant contribution to greenhouse gas emissions. One of the main problems associated with the BTK is the excessive local pollution as well as their high greenhouse gas emissions. Local people often complain about brick kilns for the high local pollution that they cause. The government has banned the use of Moving Chimney BTK (Appendix 2) and therefore, the brick entrepreneurs need to shift towards VSBK technology which is more energy efficient and reduces GHG

emissions and local air pollutants significantly. VSBKs have air pollution emissions within the permissible limit of the government's emission standard.

In the brick kiln industry, the work force is largely migrant labourers contracted to the kiln owners through middlemen. Since the kilns close during off season, these workers are temporarily left without jobs and are forced to take advances to tide them over until the kilns re-open, creating a cycle of debt (Srivastava *et al.* 2004). (A similar seasonal cycle affects many bonded agricultural labourers, who must borrow in order to survive the lean time between harvests). Kiln workers are also typically low-caste and landless; the latter helps to explain why many of them migrate to find work (Srivastava, 2005).

Brick industry is a source of air pollution in the form of GHGs (mainly carbon dioxide), particulate matter, sulfur oxides, carbon monoxide etc. The industry needs environmentally sound technologies (ESTs) for firing bricks, primarily to address local environmental concerns as well as to enhance energy-efficiency (which will also lead to reduction in GHG emissions). Local environmental concerns have led to the formulation of emission standards for brick kilns that were announced by the Government of India in 1996. The emission standards specify the permissible limits for suspended particulate matter in flue gases from brick kilns. The standards also propose ban on the use of moving chimney Bull's trench kiln (BTK) for firing brick by June 2000. Energy efficiency is important for the industry because fuels cost accounts for 30-40% of the production costs and hence even a small saving in energy has a positive impact on the profitability of the enterprise.

Jammu and Kashmir Legislative Assembly passed a bill in October 2010 to regulate and control establishment of brick kilns in the state with proposed amendments. The bill was moved by Minister for Consumer Affairs and Public Distribution in the House. The House considered the Bill and passed it with the voice vote with some amendments. The fee for grant of licence shall be Rs 30,000 and the renewal fee for such licences shall be Rs 10,000 per annum. Government

has identified 43 brick kilns, 8 stone crushers and 3 hot mixes in the district Budgam for closure (DD News 10:00 PM April 09, 2011/ Greater Kashmir April 11, 2011). The need for a scientific approach and a well-knit policy for control and operation of brick klins to ensure environmental safeguards are felt.

# *Chapter 7*

# Conclusion

The primary aim of this study was to make an attempt to undertake survey of a prominent brick kiln area of the valley and analyze its effects on the surrounding vegetation as a function of the distance (i.e. going downwind from the source) to infer the impact of these brick kiln emissions. Land degradation that occurs due to their operation was also inferred through the survey.

The concentration of $SO_2$, $NO_2$, SPM and RSPM at Site 1 was found to be above the permissible levels during the operational phase of the brick kiln.

The chlorophyll 'a', chlorophyll 'b' and total chlorophyll content was in general found to be low in the species growing closest to the brick kiln, especially in the community comprising of *Xanthium strumarium, Convolvulus arvensis, Cynodon dactylon, Erigeron bellidiodes, Iris ensata, Urtica dioica, Cannabis sativa, Digitaria sanguinale, Polygonum amphibium* and *Robinia pseudoacacia.* A reverse trend was observed in rest of the plant species excepting *Anthemis cotula, Circium wallichii,*

*Salix alba* and *Populus nigra* where the chlorophyll content was found to be depressed at Site 2 than at Site 1 and Site 3.

The pH of the soil ranged from neutral (7.0) to slightly alkaline (7.69). The electrical conductivity of the samples from the site near the brick kiln (Site1) was slightly higher compared to sites away from the brick kiln. The percent moisture content at the site near the brick kiln was comparatively lesser than that at the other sites. Similarly, the percent loss on ignition of the oven dried soil samples at the site near the brick kiln was slightly lesser as compared to the sites away from the kiln. However, the content of organic carbon at all the sites was nearly uniform.

The survey of the Brick kiln area revealed that no pollution control devices were installed by the operational units. Moreover, land degradation was noticeable in these areas. The need for a scientific approach and a well-knit policy for control and operation of brick kilns to ensure environmental safeguards are felt.

# Appendix 1– Questionnaire

- Name of the kiln:
- Name of the kiln owner:
- Name of the place:
- Number of workers in the kiln:
- What is the production capacity of the kiln ( i.e. no. of bricks manufactured in a year):
- How many times kiln is operated during a year:
- What is the heating source to the kiln:
- How much amount of coal is used in a year:
- What was the price of the coal during the previous/present year ( Rs……./100 kg):
- What was the range of price during: 2009……/ 2008……..…….
- Average price of bricks during 2008= Rs. ……/3000 bricks
- Average price of bricks during 2009= Rs. ……/3000 bricks
- How many brick kilns operate in the whole area:
- What is the height of the stake or chimney:
- What is the area of land on which kiln is built:
- Pollution control devices installed, if any:
- Other Information:
  ……

  ……

  ……

# Appendix 2

MINISTRY OF ENVIRONMENT AND FORESTS

NOTIFICATION

New Delhi, the 22nd July, 2009

G.S.R.543 (E).—In exercise of the powers conferred by Sections 6 and 25 of the Environment (Protection) Act, 1986 (29 of 1986), the Central Government hereby makes the following rules further to amend the Environment (Protection) Rules, 1986, namely :—

1. (1) These rules may be called the Environment (Protection) Fourth Amendment Rules, 2009.

(2) They shall come into force on the date of their publication in the Official Gazette.

2. In the Environment (Protection) Rules, 1986, in Schedule I, for serial number 74, relating to 'Emission Standards for Brick Kilns' and entries relating thereto, the following serial number and entries shall be substituted, namely :—

| Sl. No. | Industry | Parameter | | Standard |
|---|---|---|---|---|
| (1) | (2) | (3) | | (4) |
| "74 | Brick Kilns | Emission Standards | | |
| | | i. Bull's Trench Kiln (BTK) | | |
| | | | Category* | Limiting concentration in mg/Nm³ |
| | | Particular matter | small | 1000 |
| | | | medium | 750 |
| | | | large | 750 |
| | | | | *minimum (metre)* |
| | | Stack height | small | 22 or induced draft fan operating with minimum draft of 50 mm WG with 12 metre stack height. |
| | | | medium | 27 or induced draft fan operating with minimum draft of 50 mm WG with 15 metre stack height. |
| | | | large | 30 or induced draft fan operating with minimum draft 50 mm WG with 17 metre stack height. |
| | | *Category* | *Trench width (m)* | *Production (bricks/day)* |
| | | small BTK | <4.50 | Less than 15,000 |
| | | medium BTK | 4.50-6.75 | 15,000-30,000 |



| (1) | (2) | (3) | | (4) |
|---|---|---|---|---|
| | | large BTK | above 6.75 | above 30,000 |
| | | **(ii) Down-Draft Kiln (DDK)** | | |
| | | | *Category*** | *limiting concentration in mg/Nm³* |
| | | Particular matter | small/large/medium | 1200 |
| | | | | *minimum (metre)* |
| | | Stack height | small | 12 |
| | | | medium | 15 |
| | | | large | 18 |
| | | ***Category* | *Production (bricks/day)* | |
| | | small DDK | Less than 15,000 | |
| | | medium DDK | 15,000—30,000 | |
| | | large DDK | above 30,000 | |
| | | **(iii) Vertical Shaft Kiln (VSK)** | | |
| | | | *Category*** | *limiting concentration in mg/Nm³* |
| | | Particular matter | small/large/medium | 250 |
| | | | | *minimum (metre)* |
| | | | small | 11 (at least 5.5 m from loading platform) |
| | | | medium | 14 (at least 7.5 m from loading platform) |
| | | Stack height | large | 16 (at least 8.5 m from loading platform) |
| | | ***Category* | *No. of shafts* | *Production (bricks/day)* |
| | | small VSK | 1—3 | Less than 15,000 |
| | | medium VSK | 4—6 | 15,000—30,000 |
| | | large VSK | 7 or more | above 30,000 |

**Notes—**

1. Gravitational Settling Chamber along with fixed chimney of appropriate height shall be provided for all Bull's Trench kilns.
2. One chimney per shaft in Vertical Shaft Kiln shall be provided. The two chimneys emanating from a shaft shall either be joined (at the loading platform in case of brick chimney or at appropriate level in case of metal chimney) to form a single chimney.
3. The above standards shall be applicable for different kilns if coal, firewood and/or agricultural residues are used as fuel."

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