Assessment of the Level of Mercury Present in Soaps by the Use of Cold Vapour Atomic Fluorescence Spectrometric Analysis – A Gambian Case Study

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Abstract

Sixteen brands of soap were analysed for their total mercury content using cold vapour atomic fluorescence spectrometry. The aim was to find out if the soaps contained mercury and if so, what quantity. In addition, are the quantities acceptable for health purposes. Mercury was found to be present in some soaps which did not indicate it on their labels, as required by law. The amounts of mercury found in the soaps were generally low, and may not lead to any short term mercury-linked health problems. A very low limit of detection was obtained.

Keywords*: Mercury, The Gambia, Soaps, Indigenous industry, Fluorescence*

Introduction

Mercury is a heavy metal and it exists in three main forms. They are elemental, inorganic and organic mercury. It has many harmful effects on health and environment. In spite of its lethal effect, mercury in the inorganic form especially mercuric iodide is used as a constituent of skin lightening creams, soaps, an antiseptic in creams and ointments (UNEP, 2002; Chemical Agent Briefing Sheet Mercury 2006).

Large concentrations of mercury have been found in the hair of women who use soaps containing mercury, (California Poison Control System, 2002), this was according to a study carried out by Masazumi Harada *et al* (1999) on people living near Lake Victoria. The harmful effects of mercury are usually a function of its form; elemental, inorganic or organic. Symptoms observed include: dermatitis, facial acne, facial hypertricosis, cutaneous atrophy, stretch marks, hyper- and hypo-pigmentation. The use of skin lightening soaps is widespread in The Gambia. Many of them do not carry labels that indicate that they contain mercury. This research was aimed at finding out if soaps sold in The Gambia contain mercury, and if so, how much. In addition, how lethal is the quantity as it relates to levels acceptable by regulation of the National Environment Agency, The Gambia.

Methodology

Reagents

Ultra pure deionised water, hydrochloric acid, (trace element standard containing less than 5pg/ml Hg), hydroxylamine hydrochloride, stannous chloride, bromine monochloride, mercury standard, (National Institute of Standards and Technology, NIST, certified) and high grade gases: nitrogen and ultra pure UTP argon.

Equipment and Material

Cold vapour atomic fluorescence spectrometer model 2500 (TERAN, Toronto). Sample and analytical traps and soda lime traps.

Sixteen different brands of soap were purchased from different supermarkets, these were representative of all the soaps available in The Gambia. The categories were: medicated, toilet, skin-lightening and laundry soaps (Table 1). Among the soaps, only four, (all of which were medicated soaps) indicated the presence of mercury on their labels. They were Crusader, Robert, Movate and Mekako. Three of the soaps, (two medicated: Fan and Tura; and a laundry soap from an indigenous industry, SSS) did not indicate the presence of any ingredients on their labels. The remaining soaps had labels with ingredients listed, however, mercury was not listed as part of their ingredients. Analysis of the soaps was carried out at the Chesapeake Biological Laboratory, Maryland, United States of America.

Cold vapour atomic fluorescence spectrometry (CV-AFS) was used to analyse the total mercury content of all the samples. The method used was according to the United States Environmental Protection Agency Method 1631 Revision E (Masazumi *et al*, 1999; National Environment Agency, 1999; EPA, 2002). Other methods of analysis exist which include combustion trap atomic fluorescence spectrometry (CT-AFS), cold vapour atomic absorption spectrometry (CV-AAS), inductively coupled plasma atomic emission spectrometry (ICP-AES) and inductively coupled plasma mass spectrometry (ICP-MS). The limits of detection of these techniques have been tabulated in Table 2. It

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can be seen from the table that the method used in this study (Cold vapour atomic fluorescence spectrometry (CV-AFS)) has the lowest limit of detection(0.05ppt); this shows that it is a sensitive and reliable method of analysing for mercury.

Table 1. Soaps purchased for mercury analysis

Type of Soap	Name of Soap
Medicated toilet soap	Crusader
	Roberts
	Movate
	Rico
	Mekako
	Fan
	Tura
	Asepso
Skin lightening toilet soap	Fair & Light
	Méti Cée
	Clear & Net
	Body Clear
	Classic White
Ordinary toilet soap	Giv
	Savoy
Laundry soap	SSS soap

Table2. The limits of detection of some techniques used in the analysis of mercury

Method of Mercury Analysis	Detection Limit
CV-AFS	0.05ppt
CT-AFS	0.05ppb
CV-AAS	1ppt
ICP-AES	0.02ppm
ICP-MS	0.001ppb

Sample Digestion

0.1g of each soap was measured into pre-weighed Teflon vials and 2ml of digest acid comprising 70% HNO_3 and 30% H_2SO_4 was added. It was capped tightly and placed in an oven at 60^0C for 12hr. 6ml deionised water and 2ml BrCl were added when the digested sample had cooled.

Calibration and Standardization

Calibration was done with NIST reference material.

Preparation of Standards

0.5ml of the working standard and 0.5ml $SnCl_2$ were combined, placed in a bubbler and swirled to make 50pg/ml standard. Five more standards of different concentrations of Hg were prepared: 25pg/ml, 75pg/ml, 100pg/ml, 250pg/ml and 500pg/ml. The standards were analysed starting with the one with the lowest concentration. The peak areas were tabulated with the concentration of Hg used (Masazumi *et al;* 1999).

The following equation was used to calculate the calibration factor, CF_x,

$$CF_x = \frac{A_x - A_{bb}}{C_X}$$

Where A_x is the peak height or height of Hg in standard

A_{bb} is the mean peak area or height of blank

C_x is the mass of Hg in standard

The mean calibration factor, CF_m, standard deviation of calibration factor and the relative standard deviation, RSD of calibration factor were calculated using,

$$RSD = \frac{100SD}{CF_m}$$

Calculation of mercury concentration in sample

Mercury concentration in each sample was calculated using the equation;

$$[Hg]pg/ml = \frac{A_s - A_{bb}}{CF_m V}$$

Where, A_s is the peak area or height of Hg in sample

A_{bb} is the mean peak area or height of Hg in bubbler blank

CF_m is the mean calibration factor

V is the volume of sample, ml

Result and Discussion

Table 3 showed the peak areas obtained for the standards that were analysed.

Table 3. Standards and their respective peak areas

Hg concentration (pg/ml)	Peak area
23	1.53
50	2.48
75	3.36
100	3.56
250	11.20
500	21.55

For the purpose of calibration, the value in Table 4 were obtained.

Table 4. Statistical values of calibration

Parameter	Value
Calibration points, *CP*	1.25, 2.21, 3.09, 3.29, 10.93, 21,28
Calibration factors, *CF*	0.05, 0.04, 0.04, 0.03, 0.04, 0.04
Mean calibration factor, CF_M	0.04
Standard deviation of calibration factors, *SD*	0.0051
Relative standard deviation, *RSD*	11.96%

Table 5 showed the Concentration levels of mercury (Hg) in Soap Samples

Table 5. T-Hg levels found in the soaps

Type of Soap	Name of Soap	T-Hg(ng/g)	T-Hg(10^{-7}%)	Mean T-Hg
Medicated toilet soap	Crusader	5.66	5.66	6.57ng/g 6.57x10^{-7}%
	Roberts	8.82	8.82	
	Movate	5.70	5.70	
	Mekako	12.61	12.61	
	Rico	4.03	4.03	
	Fan	3.97	3.97	
	Tura	6.80	6.80	
	Asepso	4.97	4.97	
Skin lightening toilet soaps	Fair & Light	3.61	3.61	3.57ng/g 3.57x10^{-7}
	Méti Cée	3.82	3.82	
	Clear & Net	3.31	3.31	
	Body Clear	4.22	4.22	
	Classic White	2.88	2.88	
Ordinary toilet soaps	Giv	2.87	2.87	3.50ng/g 3.57x10^{-7}
	Savoy	4.13	4.13	
Laundry Soap	SSS	9.26	9.26	

T-Hg = total mercury content

Discussion

Different soaps had different levels of mercury. Mekako medicated soap has the highest concentration of mercury(12.6), followed by SSS laundry soap(9.26) which was assumed to be free of mercury being a laundry soap. SSS laundry is produced by an indigenous industry; it had the second highest level of mercury concentration (Table 5).

Regulation in The Gambia requires that soaps carry labels indicating their contents. Of the soaps analysed, only crusader, robert, movate and mekako indicated the presence of mercury on their labels, therefore, there is a need to strengthen this regulation.

According to a study carried out on the use of skin-lightening soaps in Kenya, in which some toilet soaps and hair of some users were analyzed for mercury; there was no elevated level of mercury (above 10ppm) found in the hair of people who used soaps that contained $5.3x10^{-4}\%$ HgI_2, which corresponds to $2.3x10^{-2}\%$ of total mercury content and below. 10ppm total mercury level, according to the researchers can be taken as the upper limit of normal hair mercury content (Masazumi Harada, 2001). This implies that the users of soaps which contain mercury below $5.3x10^{-4}\%$ might not experience short term health problems associated with the use of mercury. The minimum hair mercury level at which Minimata disease symptoms appears is about 50ppm (Masazumi Harada, 2001). If these findings are related to this project, where the highest level of mercury found in the soaps was $1.26x10^{-6}\%$, which is far below $2.3x10^{-2}\%$, it is logical to conclude that these soaps are not likely to cause any serious health problems associated with mercury. The levels found in the soaps could be considered safe since they are all below the lower limit. On the short-term, these soaps would pose no mercury related health problems; however, on the long-term, they would not be considered safe, especially for individuals who use them for skin-lightening purposes. This is easy to understand since such persons must continue to use them in order to maintain a fair skin colour. The half-life of mercury in the body is large, thus, over a long period of time, there would be accumulation in the body of users.

Conclusion

Though, the soaps tested in this study have relatively low levels of mercury concentration, many of them failed to comply with the regulations, and the enforcement agencies would need to gear up in their actions as to protect the consumers because it has been identified that the long run effect of the use of such soaps has the capacity to affect the health of consumers and with greater social cost for government in terms of health services provision.

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