Level of selected heavy metals in some commercially available cosmetic products in Dar es Salaam, Tanzania

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ABSTRACT

The study was conducted in order to assess heavy metal content in some commercially available cosmetics products that are manufactured in United Kingdom (UK), United States of America (USA), India and the Peoples Republic of China (PRC) and sold in Dar es Salaam, Tanzania. Face creams, beauty soaps, lipsticks and body lotions from the mentioned countries were purchased from local markets in Dar es Salaam and analytical procedures were employed to determine the contents of lead (Pb), cadmium (Cd) and copper (Cu) using Flame Atomic Absorption Spectrometry (FAAS). The results showed that lipstick samples contained the highest Pb at 23.36 µg/g, Cd at 23.30 µg/g and Cu at 22.91 µg/g. The highest concentrations in the beauty soap samples showed 21.99 µg/g Pb, 0.98 µg/g Cd and 18.8 µg/g Cu. Face cream samples contained the least contents of Pb at 6.52 µg/g, Cd at 0.16 µg/g, and Cu at 3.75 µg/g. In body lotions, no Pb and Cd were detected; in contrast, the contents of Cu was high (up to 1.4 µg/g). The products evaluated contained toxic heavy metals, though, not at an alarming concentration. Further research and analysis on the health risks of these products is proposed and extreme attention must be given to heavy metals during manufacture.

Keywords: Cosmetics; Heavy metals; FAAS; Lipsticks; Beauty Soaps; Face Creams

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INTRODUCTION

In simple terms, a cosmetic product might be defined as a substance/preparation intended to be placed or applied to various

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external parts of the body to change appearance or body odor (Reed, 2007; Oyedeji *et al*., 2011). Therefore, cosmetics products contain mixtures of some surfactants, oils, and other additives that are necessary for long lasting and stable appearance. These products might be in the form of lipstick, lip gloss, powder, rouge, mascara, nail polish and others (Rao and Prathiba, 1998).

Millions of people use cosmetics under daily basis as part of routine body care since the beginning of civilization (Brown, 2013). Also, heavy metals are naturally found in the rocks, soils and water, thus, their existence in the cosmetics products is not surprising. External contact with cosmetics contaminated with heavy metals may lead to exposing oral cavity and mucosa, and therefore significant systemic exposure. Additionally, contaminated cosmetic products may produce skin effects like irritation, sensitization or photoreactions. With relatively significant uncontrolled exposure to contaminated cosmetic products, a thorough evaluation of their safety prior to marketing is thus of high priority.

Many dermatologists have considered cosmetic products more harmful than good, believed to contain ingredients linked to cancer, birth defects, developmental and reproductive harm (Groot *et al.,* 1994); thus, the ban of coal tar colors, formaldehyde, glycol ethers, lead, mercury, parabens, phenylenediamine, phthalates containing cosmetics products.

Although various physical parameters may influence the absorption of heavy metals through skin, a consideration on the exposure through diet, medications and from the environment is also important (CDC, 2003). The use of cosmetics especially underarm cosmetics has been investigated as a possible cause of breast cancer (Lilley *et al.,* 1988). It is the expectation that dermal exposure plays significant role in human body heavy metals contamination (Darbre, 2003). However, information on exposure to heavy metals through skin contact have been scanty (Sainio *et al.,* 2000). The complete understanding and knowledge on the dermal-heavy metal interaction is of practical significance.

Many studies concerning heavy metal pollution determination in river waters, industrial effluents, city particulate matter, and roadside vegetables have been done in Tanzania (Mwegoha and

Kihampa, 2010; Mohammed and Khamis, 2012; Ghanima, 2018). Some reports on the analysis of heavy metals contents in cosmetics exist, such as Nasirudeen and Amaechi (2015) who determined heavy metals contents in cosmetics available in Kaduna Metropolis, Nigeria. Others include Chauhan et al. (2010) and Mayildurai et al. (2015). In Tanzania, Mahugija (2018) reported levels of heavy metals in some cosmetic products sold in the country. However, Mahugija (2018) did not give details, and therefore, the present study was intended to provide a detailed assessment of heavy metal contents in various cosmetic products sold in Dar es Salaam.

MATERIALS AND METHODS

Sample Collection

Cosmetics product samples including face creams, beauty soaps, lipsticks and body lotions manufactured in UK, USA, PRC, and India were purchased from Mlimani city shopping mall, Kariakoo, Mwenge and Riverside shopping areas, in Dar es Salaam, Tanzania. A total of sixteen samples were collected (Table 1).

Table 1. Sample Categories, Names, Sources and Codes

Sample Category	Sample Name	Manufacturer country	Sample Code
Beauty Soaps	Sandal Wood	PRC	A1
	Tetmosol	India	A2
	Dettol	UK	A3
	Carambola	USA	A4
Lipsticks	Apocalips	PRC	B1
	Iman	India	B2
	Milan	UK	B3
	Classic lipstick	USA	B4
Face Creams	Roushun whitening cream	PRC	C1
	Dermasol cream	India	C2
	Fair Lady Extra Whitening	UK	C3
	Dagget & Ramsdell cream	USA	C4
Body Lotions	Roushun body lotion	PRC	D1
	Vaseline lotion	India	D2
	Fair Lady Body Milk	UK	D3
	Razac hand & body lotion	USA	D4

UK = United Kingdom; USA = United States of America; PRC = Peoples Republic of China

Sample Preparation

All glassware were thoroughly washed and soaked in 5% HNO_3 solution for 24 h, followed by rinsing with deionized water before using them. Solid samples of cosmetics were oven dried (105 °C) until constant weight was obtained, and stored in desiccators. About 3.5 g of each of the dried cosmetic sample was placed in a porcelain crucible followed by dry-ashing in a muffle furnace for few hours (≤ 550 °C). The obtained ash samples were subjected to digestion using 1M HNO_3, on a hot plate evaporated to near dry in fume hood (Ayenimo *et al.,* 2010), followed by cooling and filtering using Whatmann filter papers (Saeed *et al.,* 2011). The solution was diluted to 100 mL in a calibrated flask.

Wet samples such as creams and lotions could not be conveniently prepared by dry-ashing method, thus, wet digestion was used (Saeed *et al.,* 2011), where, a mixture of nitric acid and perchloric acid (4:1) were added to the test sample on a hot plate in fuming hood and evaporated to near dryness (Ayenimo *et al.,* 2010). The temperature was slowly increased for about 2–3 h, where brown or black color was obtained, the procedure was repeated by slowly adding the concentrated acid mixture and slowly heating until white fumes evolved marking the end of the digestion process (Theresa *et al.,* 2011). These solutions were cooled, filtered and diluted to 100 mL in a calibrated flask. Blank samples were prepared in a similar way, except there was no sample addition during digestion process. The sample solutions were subsequently analyzed for lead, cadmium and copper by using FAAS (Thermo Fisher Scientific instrument, model iCE 3000 v1.3).

Sample Analysis

Various methods could be used in the heavy metal determination including ICP-MS (Inductively Coupled Plasma-Mass Spectrometer) (Al-Dayel *et al.,* 2011), SF-ICPMS (Sector Field-Inductively Coupled Plasma Mass Spectrometer) (Bocca *et al.,* 2007), Plasma Fission Spectrograph and inductively coupled plasma optical emission spectrometry (Parry and Eaton, 1991; Liu *et al.,* 2009). However, FAAS is frequently used as an analytical method in determining heavy metal content in cosmetics (Amartey *et al.,* 2011; Saeed *et al.,* 2011). Thus, this study was carried out on Flame Atomic Absorption Spectrophotometer for Pb, Cu and Cd determination. Calibration curves were prepared for each metal before sample analysis by running standard solutions at different concentrations. To correct reagent impurities, a reagent blank sample was analyzed and subtracted from the samples.

Quality Control

Recovery tests were performed by using selected cosmetic samples and distilled water for quality control experiments. For recovery tests, the recovery samples were spiked with standard solutions of the metals. These were processed following the same procedures used in cosmetics sample treatment. For recoveries determination, the amount of metals in the cosmetic samples was determined before spiking, and after spiking. Thus, percentage recoveries were established by using the formula:

$$\% \text{ Recoveries} = \frac{[\text{Spiked}] - [\text{Unspiked}]}{[\text{added}]} \times 100\%$$

Therefore, the recovery experiments were repeated for each metal, and results were used in determining the accuracy and precision of the method. Recoveries of 95-110% and precision relative standard deviation of <5% were suitable.

Statistics Analysis

Total of sixteen cosmetics samples sold in Dar es Salaam were analyzed for heavy metal estimation and values obtained are presented in Table 2 as mean±SD, with BDL representing Below Detection Limit. Data were analyzed by using one-way ANOVA (analysis of variance), and comparisons done by *t*-test with the GraphPad InStat software.

Reagents and Standards

All sample preparations were done by using double distilled water. Samples of cosmetics were prepared by analytical grade nitric acid (65%, Sigma Aldrich) and perchloric acid (70–72%, Sigma Aldrich). The certified standard stock solutions (1000 ppm-manufactured under ISO 9001 Quality Assurance system-Perkin Elmer) were used to prepare calibration standards ranging from 0.5 to 10 ppm for each analyzed heavy metal.

RESULTS AND DISCUSSION

In this study, an attempt was made to evaluate lead, copper and cadmium contents in face creams, lipsticks, body lotions and beauty soaps manufactured from India, Peoples Republic of China, United Kingdom and United States of America. The number of the selected cosmetics was sixteen (16), grouped into four, which are lipsticks, body lotions, creams and beauty soaps. In each category (group) products from the four manufacturing countries were obtained for analysis. Without neglecting the importance of analyzing body lotions, creams and soaps that have direct contact with human skin, it is considered important to analyze the amounts of heavy metals in lipsticks products since they have direct access to the body systemic (via ingestion). Upon analysis of concentrations of Cu, Pb and Cd in the selected cosmetics, values lower than the detection limits were treated as Below Detection Limit (BDL) (Table 2).

Table 2. Mean Levels of Pb, Cd and Cu (in μg/g) in the Sampled Cosmetics

Sample	**Code**	**Manufacturer**	**Pd**	**Cd**	**Cu**
Beauty Soaps	A1	PRC	22.0±0.009	0.99±0.001	18.8±0.005
	A2	India	8.7±0.005	0.74±0.008	0.4±0.005
	A3	UK	BDL	0.06±0.003	0.1±0.004
	A4	USA	7.3±0.001	0.16±0.005	0.2±0.008
Lipsticks	B1	PRC	23.4±0.005	23.3±0.008	22.9±0.005
	B2	India	18.0±0.008	17.0±0.008	21.8±0.008
	B3	UK	BDL	BDL	1.9±0.005
	B4	USA	BDL	BDL	2.4±0.005
Face Creams	C1	PRC	6.5±0.05	0.16±0.008	3.8±0.001
	C2	India	1.1±0.009	BDL	1.4±0.005
	C3	UK	BDL	BDL	0.7±0.009
	C4	USA	BDL	BDL	1.1±0.008
Body Lotions	D1	PRC	BDL	BDL	1.4±0.008
	D2	India	BDL	BDL	1.3±0.002
	D3	UK	BDL	BDL	0.7±0.006
	D4	USA	BDL	BDL	1.2±0.004

BDL = Below Detection Limit; UK = United Kingdom; USA = United States of America; PRC = Peoples Republic of China

Cosmetics have been used since the beginning of civilization by people regardless of their race, gender or age to beautify, or even modify/alter one's appearance. According to some studies, toxic metals occur in some cosmetics products (Chauhan *et al.,* 2010; Faruruwa and Bartholomew, 2014). This implies the need to investigate the amounts of these toxic heavy metals. It has been proven that high doses of some heavy metals could be fatal, but also long-term exposure to low doses of these metals have been described to cause some types of cancer. For instance, the effects of exposures to higher concentrations of lead has been well documented, but it is of major concern that the possibility of continual exposure to even lower concentrations in cosmetic and other products may potentially pose health risks (Muhamad-Darus *et al.,* 2011).

Generally, it can be observed from Table 2 and Figure 1 that there are substantial amounts of Pb and Cd in beauty soaps and lipsticks, and a little lesser in face creams, and the concentrations were below detection limits for Pb, and Cd in body lotions. On the other hand, varying amounts of Cu have been observed across all cosmetic samples analyzed.

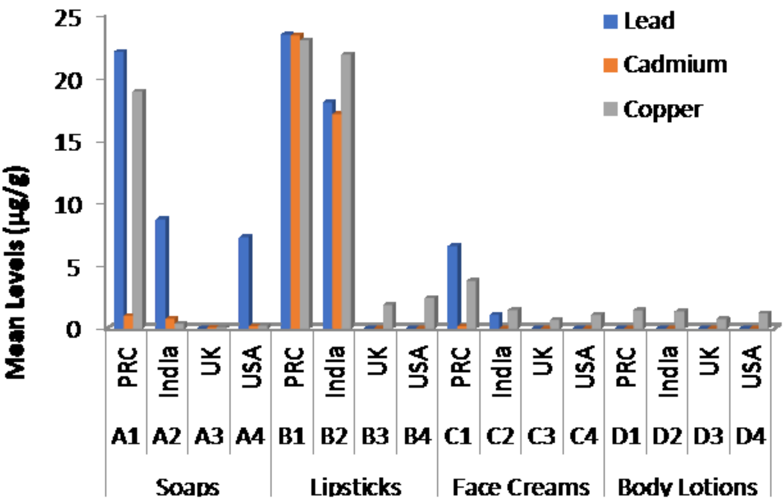

Figure 1. Heavy metal contents analyzed by FAAS in sampled cosmetics.

Concentrations of Pb

Lipsticks samples

In this study, Pb concentrations in analyzed lipstick products ranged from BDL – 23.4 µg/g. The highest Pb concentrations were observed in lipstick samples from PRC (23.4±0.005 µg/g) followed by those from India (18.0±0.008 µg/g), and BDL amounts were observed in samples from UK and USA. Significant differences were observed in the concentrations of Pb among lipstick samples from PRC, India, UK and USA ($F_{2, 23} = 24.458$, $P < 0.0001$).

The results indicate that the amount of Pb in lipstick was about 9 times higher compared to previous study reports (Al-Saleh and Al-Enazi, 2011). The report indicated the maximum Pb concentration in the lipsticks analyzed was 2.4 µg/g. Lipsticks contained 0.286 to 6.234 µg/g Pb according to Khalid *et al*. (2013) or 2.58 to 11.33 µg/g Pb according to Ullah *et al*. (2013).

Beauty Soaps

Lead concentrations in beauty soaps ranged from 0.07 – 18.8 µg/g. The lowest Pb concentrations observed were in samples from UK, followed by those from USA. The concentrations are highest in beauty soaps samples from PRC followed by those from India. One-way ANOVA indicated significant differences in the concentrations of Pb among beauty soaps samples from PRC, India, UK and USA ($F_{2, 23} = 11.814$, p = 0.0001).

Face creams and body lotions

Some amounts of Pb were observed in face creams samples from PRC (6.5±0.05 µg/g), followed by those from India (1.1±0.009 µg/g), while BDL amounts were observed in samples from UK and USA. BDL amounts of Pb were observed in all body lotions samples studied.

Concentrations of Cadmium

The highest Cd concentrations in analyzed lipstick samples was observed to be 23.3±0.008 µg/g in samples from PRC followed by those from India (17.0±0.008 µg/g). One-way ANOVA showed significant differences in the concentrations of Cd among lipstick samples from PRC, India, UK and USA ($F_{2, 23} = 24.123$, $P <$

0.0001). On the other hand, the concentrations were lower and BDL in beauty soaps, face creams and body lotions.

Concentrations of Copper

The concentrations of Cu in the analyzed cosmetic samples ranged from 22.9 to 0.1 µg/g. The highest Cu concentrations were observed in lipstick samples from PRC 22.9±0.005 µg/g and India 21.8±0.008 µg/g, as well as in beauty soaps from PRC 18.8±0.005 µg/g. Cosmetic samples from UK and USA contained minimum amounts of Cu. With an exception of lipsticks samples from PRC and India, and beauty soaps from PRC, the rest of the samples contained minimum amounts of Cu. Statistical analyses indicated significant difference in Cu amounts among lipstick samples from UK, USA, PRC and India ($F_{2, 23} = 16.934$, $P < 0.0001$).

Knowledge concerning the prolonged use of contaminated cosmetic products with their subsequent health effects are lacking among local populations. With the current type of culture that likes lipstick at very young age for women, coupled with the amounts of lead in the lipsticks studied possibilities are that upon ingestion, the levels of Pb might increase in the body (CSC, 2007). The high levels of Pb observed in lipstick products and beauty soaps may affect pregnant women and their babies. Highly contaminated eye product would be absorbed at 5-15% for adults and about 41% for children (Al-Dayel *et al.,* 2011), suggesting the susceptibility of children. These heavy metals bind with the protein in the cell, thus, blocking its function and ultimately causing death of the respective cells, leading to multiple diseases (Shanker, 2008).

It is worth noting that toxic metals reported herein were not listed as ingredients on any of the products, thus, possibilities are that consumers as well as producers are unaware of the contaminants. It is clear that heavy metals in the products evaluated are unintentional contaminants. The contaminants might have gained access to the final cosmetic products when contaminated/poor quality raw materials are used. Therefore, manufacturers of cosmetics products are encouraged to remove these toxic impurities from the final products.

Although the levels of the toxic heavy metals in some of the studied cosmetic products is not alarming, exposure to low concentrations of these metals could be harmful to biological system if allowed to accumulate over time. Due to their longer half-life, these metals are known to accumulate in the human body organs. There are some reports that these metals can interfere with essential nutrients with similar oxidation states like calcium and zinc (Adepoju-Bello and Alabi, 2005).

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