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LEVELS OF HEAVY METALS IN SELECTED FACIAL COSMETICS MARKETED IN DAR ES SALAAM, TANZANIA

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ABSTRACT

The aim of this study was to determine the levels of heavy metals: lead, cadmium, copper, zinc, arsenic and mercury in facial cosmetics (lipstick, lip glossy, facial powder, foundation, eyeliner, eye shadow and mascara) which were purchased randomly in Dar es Salaam, Tanzania. The levels of lead, cadmium, copper and zinc were determined using Atomic Absorption Spectrometry (AAS). The levels of arsenic were determined using Hydride Generation Atomic Absorption Spectrometry (HGAAS), and levels of mercury were determined using Cold Vapour Atomic Absorption Spectrometry. Prior to determination of the concentration of heavy metals, the samples were acid digested. The average order of concentration of heavy metals in the sample was found to be zinc > lead > cadmium > copper >arsenic > mercury (foundation), zinc > cadmium > lead > arsenic > copper > mercury (powder), copper > lead > cadmium > zinc > arsenic > mercury > (eye shadows), zinc > copper > lead > cadmium > mercury > arsenic (eyeliners), zinc > cadmium > mercury > copper > lead >arsenic (mascaras), zinc > lead > cadmium > arsenic > copper > mercury (lipsticks), lead > cadmium > zinc > copper >arsenic > mercury (lip glossy). The observed higher percentage concentrations of heavy metals beyond limits of Canadian standards for cosmetics were as follows: lead 62.79%, cadmium 16.28%, arsenic 34.88% and mercury 6.98%.

Keywords:

INTRODUCTION

The majority of Tanzanians use varieties of cosmetic substances, in most cases for cleansing, beautifying, promoting attractiveness or altering the appearance. Cosmetics are applied on the human body by rubbing, pouring, steaming, sprinkling or spraying (Ministry of Health 2003). Although the Tanzania Food and Drug Authority (TFDA) has a role of protecting the public health by ensuring quality, safety and effectiveness of food, drugs, medical devices and cosmetics, it is still very important to establish the safety status of the cosmetics. This is because contaminants, such as heavy metals, may either be added in cosmetics deliberately as ingredients or preservatives or be added accidentally through manufacturing processes and packaging (Sahu et al. 2014).

Despite the presence of many heavy metals on earth, only few are useful for human health while the remaining are harmful, *e.g.*, lead is not required even in trace concentration. Apart from lead, other toxic heavy metals include arsenic, cadmium and nickel, which adversely affect body systems and functions (Life Extension^{sm} 2003). Since heavy metals may find their way to the human body via dermal absorption, the presence of toxic heavy metals in cosmetics may adversely affect the health status of the users. For example, lipsticks and lip glosses which are applied on lips could be ingested, and at the same time can be absorbed into the body through skin contact. Although the basic constituents of these facial cosmetics are mainly waxes, oils, pigments and moisturizers, in some cases they have been found to be contaminated with heavy metals (Environmental Defence Canada 2011). While the use of mercury compounds in eye makeup (eyeliners, eye shadows and mascaras) at concentrations up to 65 ppm is allowed, adulterated cosmetics with higher mercury concentrations have been documented (Clarke et al. 2008). Another category of facial cosmetics consists of foundations and powders which are used to create a uniform colour to the facial skin as well as to cover flaws. In several countries, heavy metal contamination in cosmetic products has been reported (Al-Saleh and Al-Enazi 2011, Ullah et al. 2013, Chauhan et al. 2010); in contrary to Tanzania where it is still difficult to find scientific research report regarding the presence of heavy metal in facial cosmetics, despite a recent increase in application of cosmetics amongst Tanzanians, especially young females.

It is apparent that a routine application of cosmetics containing toxic heavy metals can lead to unsafe exposure levels since most of the toxic heavy metals are cumulative in living organisms. In Tanzania however, little attention has been given to the levels of toxic metals in cosmetic products as illustrated by inadequate scientific literature on this issue, apart from an increasing number of cosmetic products being marketed in the country. A large amount of time and manpower is generally needed for regular inspections of the levels of heavy metal contaminations in the marketed cosmetics. This is an indication of the difficulties faced by our regulatory agency, TFDA. As a strategy towards public awareness concerning their health, it was deemed necessary in this work to assess the levels of selected heavy metals in commonly used facial cosmetics (lipsticks, lip glosses, eyeliners, eye shadows, mascaras, foundations and powders) marketed in Dar es Salaam.

MATERIALS AND METHODS

Sample Collection

Lipsticks, lip glosses, eyeliners, eye shadows, foundations and powders were bought randomly from different shops in Dar es Salaam and brought to the laboratory of Chemistry Department, UDSM, for preliminary preparations and analysis.

The samples were organized by coding them. Each samples trade name was provided followed by its code name in brackets as follows: Talc fond de teint (1 A), Pop popular no 5 (1 B), Pour le visage sexy (1 C), Pond's dream flower (1D), Vestline baby powder (1 E), Jenifer Powder Cake (1 F), A face (1 G), Royal touch (1 H), Lily cosmetics (2 A), JS (2 B), P. P (2 C), JMX (2D), Soft touch (2 E), Absolute (3 A), ATI (3 B), Lanmey (3 C), Dexz (3 D), Dexz lip glow (3 E), DFXZ (3 F), Wendy (4 A), Miss Rose (4 B), Die an Fen (4 C), Channel (4 D), Goldy (4 E), Starlet Kajal (5 A), Yalina (5 B), Lindanxiu (5 C), Budlat (5 D), Airemain (5 E), M. A. C (5 F), Extremely (6 A), Yalina (6 B), Virgin (6 C), Amor (6 D), Rose (6 E), Ms Yardley (7 A), Amura (7 B), Labiali (7 C), Matte (7 D), Titanic (7 E), Le femme beuty (7 F), Yardly (7 G), Prime collection (7 H), Voysd (7 I). The sample codes and cosmetics type in brackets 1A-1H (Facial powders), 2A-2E (eye shadows), 3A-3F (lip gloss), 4A-4E (foundation), 5A-5F (eye liners), 6A-6E (mascaras) and 7A-7H (lipsticks).

Reagents

The analytical grade reagents comprise of 70% HNO_3 with specific gravity of 1.42 and 30% H_2O_2 bought from Lab Chemicals Limited in Dar es Salaam, Tanzania. Standard solutions used were prepared from standard stock solution of salts of lead, copper, zinc, arsenic, cadmium and mercury each with concentration of 1000 ppm purchased from Assurance Spex Certiprep Q

(1-800-lab.spex), USA. Other reagents used were $NaBH_4$, $SnCl_2$ and 50% KI. Distilled water was obtained from Chemistry Laboratory, UDSM. Acetylene and nitrous oxide gases for AAS work obtained from Tanzania Oxygen Ltd (TOL), Dar es Salaam.

Sample Preparation

Glassware, crucibles and plastic containers were washed with liquid soap, rinsed with distilled water and soaked in 10% HNO_3 acid for 24 hours, then re-cleaned with distilled water and left to dry. Cosmetics samples were dried to constant weight in an oven (Genlab) at 110 °C. Digestions of samples were carried in a fume chamber prior to AAS analysis in order to remove organic material and convert the metals present into soluble forms. About 1 g of each dried sample was measured using electronic balance. The samples were digested with 6 mL 70% HNO_3 and 2 mL of $HClO_4$, evaporated near to dryness on a hot plate, cooled, and then 3 mL of H_2O_2 was added and heated on hot plate for 15 minutes until evolution of white fumes indicating the end of the digestion process (Nourmoradi et al. 2013). Digests were then filtered through whatman filter paper (Grade Number 41) into a 25 cm^3 volumetric flask and made up to the mark with deionized water before poured into vials. To validate the method, the blank samples were prepared in a similar way except that no sample was added during digestion process.

For mercury analysis, a peristaltic pump was used to introduce the sample and stannous chloride into a gas liquid separator where a stream of dry and pure gas was bubbled through the mixture to release mercury vapour which then the mercury was transported in the carrier gas (argon) through a dryer and into an atomic absorption cell. For arsenic analysis 50% KI was added to the digested sample followed $NABH_4$ to produce gaseous hydride. Gaseous hydride was separated from liquid reagents by gas liquid separator device. Gaseous hydride was transported by argon into heated cell where analyte got atomised before AAS analysis. To validate the method, the blank samples were prepared in a similar way except that no sample was added.

Standard solutions of Zn, Cu, Pb, As, Hg and Cd were prepared from the stock standard solutions containing 1000 ppm of the element in distilled water. A 10 mL sample was pippeted from 1000 ppm stock solution and transferred followed by adding distilled water to the mark. The resulting homogeneous 1000 ppm was successively diluted to 10 ppm, 5 ppm, 2 ppm, 1 ppm and 0.5 ppm solutions of the analytes. These solutions were used to obtain calibration curves for each analyte. The digested cosmetic and blank samples were subsequently analysed for lead, copper, cadmium and zinc by using flame AAS at department of Chemistry, UDSM. Mercury and arsenic were analysed using CVAAS and HGAAS respectively at SEAMIC, Dar es Salaam, Tanzania.

Statistical Analysis

T-test (in Microsoft excel 2007) was used to check if there are significant differences between obtained concentrations and that of Canada standards.

RESULTS AND DISCUSSION

The concentration of the analyte in the original sample was given by $\frac{X \text{ mg/L}}{40\,Y \text{ g/L}} = \frac{X}{40\,Y} \text{ mg g}^{-1}$, where X mg/L is the analyte concentration given by AAS analysis.

Concentrations of Heavy Metals (µg/g) in Facial Cosmetics

The concentration of selected heavy metals (µg/g) in facial cosmetics are summarized in Tables 1 to 7.

Table 1: Concentration of heavy metals (µg/g) in powders

Sample	Concentration of metals (µg/g)					
	Cu	Pb	Zn	Cd	As	Hg
1A	0.340	0.860	5.300	212.340	20.760	BDL
1B	1.250	6.320	2.790	32.830	0.330	BDL
1C	1.660	1.300	2.790	24.330	1.830	0.228
1D	2.250	3.630	1456.800	BDL	0.360	0.383
1E	2.930	6.700	37.990	1.050	BDL	0.320
1F	0.140	42.140	902.380	20.850	2.102	BDL
1G	0.790	28.630	15.780	BDL	18.960	0.128
1H	BDL	26.970	BDL	18.370	BDL	BDL
Average	1.337	14.569	346.260	51.628	7.390	0.264

BDL- Below Detection Limit

Table 2: Concentration of heavy metals (µg/g) in eye shadows

Sample	Concentration of metals (µg/g)					
	Cu	Pb	Zn	Cd	As	Hg
2A	152.675	10.830	3.330	23.010	3.550	0.058
2B	211.885	8.415	20.640	37.580	2.080	0.960
2C	57.310	12.425	24.875	8.0280	8.028	1.043
2D	140.365	15.935	17.945	12.285	2.335	BDL
2E	163.388	110.468	16.150	7.353	5.678	BDL
Average	145.125	31.615	16.588	17.651	4.334	0.687

BDL- Below Detection Limit

Table 3: Concentration of heavy metals (μg/g) in lip gloss

Sample	Concentration of metals (μg/g)					
	Cu	Pb	Zn	Cd	As	Hg
3A	1.2250	3.4600	4.3700	9.4500	0.9525	BDL
3B	3.7450	0.0400	3.5000	2.3700	0.3650	0.0175
3C	5.9830	22.3130	6.1700	18.6600	12.4075	BDL
3D	BDL	31.0530	BDL	6.9530	1.7525	0.6575
3E	BDL	28.9830	2.1580	12.4800	0.9300	2.3925
3F	BDL	29.1200	BDL	0.7500	0.5900	2.6600
Average	3.6510	19.1615	4.0495	8.4438	2.83292	1.4319

BDL- Below Detection Limit

Table 4: Concentration of heavy metals (μg/g) in foundations

Sample	**Concentration of metals (μg/g)**					
	Cu	Pb	Zn	Cd	As	Hg
4A	2.270	5.230	6.660	1.660	1.703	0.185
4B	6.440	3856.880	7670.080	9.660	2.008	0.865
4C	15.940	8.480	3095.080	22.780	9.658	0.155
4D	20.573	0.830	114.288	14.405	1.788	0.532
4E	10.630	23.830	281.270	10.895	5.895	BDL
Average	11.171	779.050	2233.480	11.880	4.210	0.434

Table 5: Concentration of heavy metals (μg/g) in eye liners

Sample	Concentration of metals (μg/g)					
	Cu	Lead	Zn	Cd	As	Hg
5A	2.040	0.370	1.880	8.200	2.103	0.085
5B	4.120	3.730	2.763	9.820	3.830	0.653
5C	BDL	9.133	15.925	3.718	1.558	2.410
5D	87.338	58.458	22.533	4.078	BDL	BDL
5E	31.438	37.838	130.560	23.780	9.530	BDL
5F	44.045	61.218	39.120	15.935	BDL	17.050
Average	33.796	28.458	35.464	10.922	4.255	5.049

BDL- Below Detection Limit

Table 6 Concentration of heavy metals (µg/g) in mascaras

Code	Concentration of metals (µg/g)					
	Cu	Pb	Zn	Cd	As	Hg
6A	4.910	0.560	5.410	8.830	1.078	0.025
6B	2.250	BDL	7.170	3.870	0.320	3.958
6C	4.190	BDL	10.240	12.360	1.990	0.160
6D	8.220	0.896	17.070	4.800	7.085	22.400
6E	5.440	12.510	12.360	16.140	3.400	2.588
Average	5.002	4.655	10.450	9.200	2.775	5.826

BDL- Below Detection Limit

Table 7: Concentration of heavy metals (µg/g) in lipsticks

Sample	Concentration of metals (µg/g)					
	Cu	Pb	Zn	Cd	As	Hg
7A	0.270	8.820	1.800	6.850	4.190	1.308
7B	1.450	16.480	3.200	20.020	9.905	BDL
7C	7.240	23.360	23.300	22.910	11.305	1.695
7D	21.775	17.968	456.700	17.025	9.868	BDL
7E	3.055	16.670	16.773	1.630	10.258	8.325
7F	0.780	19.130	1.460	9.830	BDL	1.530
7G	3.070	17.030	BDL	BDL	1.545	0.778
7H	BDL	20.100	0.900	4.130	BDL	BDL
7I	2.440	20.530	14.300	BDL	13.648	0.160
Average	5.010	17.788	64.804	11.771	8.674	2.299

BDL- Below Detection Limit

Copper. Mean concentration of copper in the cosmetic samples are between 211.8850 µg/g and 0.140 µg/g. The highest value of 211.885 µg/g was obtained in 2B (JS), whereas the lowest value of 0.1350 µg/g was obtained in 1F (Jenifer powder cake). In sample number 3D (Dexz), 3E (Dexz lip glow), 3F (DFXZ), 5C (Lidanxiu) and 7H (Prime collection) the copper concentrations were below detection limit. In lines with literature, Cu was observed in all tested samples of eye shadows and found to range from 1.67 µg/g up to 465 µg/g (Omolaoye et al. 2010). In this study the highest concentration of Cu was found in all eye shadows samples that range from 57.31 to 211.89 µg/g. The presence of copper in cosmetics may be attributed to the use of copper compounds as pigment formulations (Umar and Caleb 2013).

Lead. For all tested samples, the highest concentration of lead was registered from sample 4B which is a foundation (Miss Rose). The lowest concentration was found from lip gloss 3B (ATI). In sample number 6B (Yalina) and 6C (Virgin) which are mascaras, lead concentrations were below detection limit. Except for these samples with lead concentration below detection limit, lead concentrations were found to be higher than the highest allowable levels in Canada cosmetics standards (10 µg g^{-1}, P-value = 0.279). The study by Al-Saleh and Al-Enazi (2011), 48 lipsticks from 26 brands were analysed and showed that the levels of lead in their lipstick samples ranged from 0.27 to 3760 ppm. The presence of lead in cosmetics can be due to impurities present in components of the cosmetics or additive ingredients of the formulations of the cosmetics.

Zinc. Maximum concentration of Zinc was detected in 4B (Miss Rose), while the minimum concentration was found in 3B (ATI). In sample 1H (Royal touch), 3D (Dexz), 3F (DFXZ) and 7G (Yardly) the zinc concentrations were below detection limit. Zinc concentration found in this study was in line with results from other researchers (Omolaoye et al. 2010, Sukender et al. 2012).

Cadmium. In this study, the concentration of cadmium was found to range from 0.7450 µg/g to 212.335 µg/g was reported in this study. The lowest concentration was obtained in sample 3F (DFXZ), while the highest was obtained in 1A (Talc fond de teint). In sample 1D (Pond's dream flower), 1G (A Face) and 7G (Yardly) the cadmium concentrations were below detection of the instrument. The reported mean cadmium concentrations are lower than that of Canada cosmetic standards of 3 µg/g (P-value = 0.009) in all the studied samples.

Arsenic. The cosmetic sample with highest level of arsenic was 1A (Talc fond de teint) which is facial powder while the lowest level was found in 6B (Yalina) which is mascara. In sample 1E (Vestline baby powder), 1H (Royal touch), 5D (Budlat), 5F (M. A. C), 7F (Le femme beuty) and 7H (Prime collection) the arsenic concentrations were below detection limit. The arsenic concentrations reported in this study is higher than that of Canada cosmetics standards of 3.0 µg/g. (P- value = 0.071). The high concentration of arsenic might be due to contaminants from the inorganic raw materials used during manufacturing processes.

Mercury. Maximum concentration of mercury was detected in 6D (M. A. C), whereas the minimum concentration was found in 3B (ATI). Mercury was not detected in sample 1A (Talc fond de teint), 1B (Pop popular no 5), 1F (JENIFER Powder Cake), 1H (Royal touch), 2D (Jmx), 2E (Soft touch), 3A (Absolute), 3C (Lanmey), 4E (Besy line), 5D (Budlat), 5E (Airemain), 7B (Amura), 7D (Matte) and 7H (Prime collection). The mercury concentrations reported in this study is less than that of Canada standards of 3.0 µg/g. (P-value = 0.045).

CONCLUSION

Heavy metals might get to the cosmetic product whether intentionally or as impurities due to ingredients, manufacturing process and during packaging. The concentrations of heavy metals (lead, cadmium, mercury, arsenic, copper and zinc) in named facial cosmetics were investigated and provided new data on heavy metal concentration in cosmetic products used in Dar es Salaam, Tanzania. The obtained results signified that the level of heavy metals varies amongst the facial cosmetics whereby other heavy metals were not detected in some cosmetics. Although concentrations of heavy metal in the majority of facial cosmetics analyzed were found to be within tolerable concentrations, we strongly recommend quality controls for cosmetics which are intended to be in contact with the skin.

REFERENCES

Al-Saleh I and Al-Enazi S 2011 Trace metals in lipsticks. *Toxicol. Environ. Chem.* **93:**1149-1165.

Chauhan SA, Bhadauria R, Singh AK, Lodhi SS, Chaturvedi DK, Tomar VS 2010 Determination of lead and cadmium in cosmetic products**.** *J. Chem. Pharm. Res.* **2**:92-97.

Clarke HD, Forsberg JA, and John L 2008 Mercury determination in cosmetics, using the CETAC Quick Trace™ M-7500 CVAAS; Application Note. *http://www.cetac.com/pdfs/AP-M7506.pdf* Accessed on 14 June 2014.

Environmental Defence Canada 2011 Heavy metal hazards: The health risks of hidden heavy metals in face makeup. *http://environmentaldefence.ca/reports/heavy-metal-hazard-health-risks-hidden-heavy-metals-in-face-makeup* Accessed on 21 April 2018.

LifeExtension[sm] 2003 Heavy metal toxicity *http://www2.hcmuaf.edu.vn/data/quoctuan/Heavy%20metal%20toxicity.pdf* Accessed on 21 April 2018.

Ministry of Health 2003 The Tanzania food, drugs and cosmetics act No. 1 of the United republic of Tanzania.

Nourmoradi H, Foroghi M, Farhadkhani M and Dastjerdi MV 2013 Assessment of Lead and Cadmium Levels in Frequently Used Cosmetic Products in Iran. J. Environ. Publi. Health. Volume 2013, Article ID 962727 http://dx.doi.org/10.1155/2013/962727.

Omolaoye JA, Uzairu A, and Gimba C 2010 Heavy metal assessment of some eye shadow products imported into Nigeria from China. *Arch. Appl. Sci. Res.* **2 (5)**: 76-84.

Sahu R, Saxena P and Johnson S 2014 Heavy metals in cosmetics. *Centre for Science and Environment.* PML/PR-45/2014.

Sukender K, Jaspreet S, Sneha D and Munish G 2012 AAS Estimation of heavy metals and trace elements in Indian herbal cosmetic preparations. *Res. J. Chem. Sci.* **2:**46-51.

Ullah H, Noreen S, Fozia, Rehman A, Waseem A, Zubair S, Adnan M and Ahmad I 2013 Comparative study of heavy metals content in cosmetic products of different countries marketed in Khyber Pakhtunkhwa, Pakistan. *Arabian J. Chem. INCOMPLETE*

Umar M. A. And Caleb H 2013 Analysis of Metals in Some Cosmetic Products in FCT-Abuja, Nigeria. *Int. J. Res. in Cosmetic Sci*.**3**: 14-18.