LEVELS OF HEAVY METALS (Pb, Hg, Mn, Cu and Cr) AND HUMAN HEALTH IMPLICATIONS OF SOME SELECTED COSMETICS COMMONLY SOLD IN NIGERIA

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Abstract

Cosmetics application cuts across all gender and tribe and is considered as essential components in life. This study investigates the levels of heavy metals (Pb, Hg, Mn, Cu and Cr) and human health implications of some selected cosmetics commonly sold in Nigeria. Twenty-one (21) randomly selected cosmetics samples was analyzed in triplicate using Atomic Absorption Spectrophotometer (AAS) Varian Spectra AA 55B Model and cold vapor unit for Hg. The results of the analysis revealed varying levels of the metal contaminants in the selected cosmetics and in the order: lotions > creams > soaps. The mean metal levels observed were below the suggested permissible limits for skin protection as set by WHO and US FDA standards. Statistical analysis of experimental data showed that metal levels in the studied cosmetics were significantly different ($p < 0.05$). Risk to human health on exposure was evaluated at 50% and 100% bio-accessibility of the selected metals and also revealed that Margin of Safety (MoS) levels ranged from 3.29E–01 to 1.23E+07 and 1.64E–01 to 6.17E+06 in lotions; 3.02E–01 to 8.15E+06 and 1.51E–01 to 4.08E+06 in creams; 1.28E+04 to 1.52E+11 and 6.41E+03 to 7.59E+10 in soaps at 50% and 100% bio-accessibility respectively. The highest and lowest systemic exposure dosage (SED) values ($mgKg^{-1}BWday^{-1}$) were recorded for Pb (1.33E+00 and 1.68E–05), while hazard quotient (HQ), hazard index (HI) and lifetime cancer risk (LCR) levels were higher than permissible limits except for Hg. Thus, continuous usage over time poses threats to human health.

Key words: heavy metals, cosmetics, Nigeria, human health and hazard index.

Introduction

The application of cosmetic products appears to cut across all race, gender, age, tribe, socio-economic strata as well as value system; and following the dawn of civilization, cosmetics have continued to constitute a part of routine body care by all sphere of the society (Ojezele et al., 2018), leading to a gain in its popularity and usage by both males and females (Sharma & Meenakshi, 2018). A recent study by (Khan & Alam, 2019) revealed that globally the estimated value of cosmetic industry today is around 20 billion dollar per annum, showing a big boost in the cosmetic industries by the production of the various types of cosmetics which are needed for the care and beautification of the skin, hairs, nails, teeth and the general external parts of the human body (Onojah & Emurotu, 2017). It is therefore worthy of note that cosmetics represent an important source of sensitization, since they are used every day and are applied often to the thinnest areas of the skin, such as the pre-ocular areas and lips including the external genitals and bruced or injured surfaces, where absorption is usually very high (Roopa, & Yadawe. 2017). This has however, posed several health concerns on exposures to any of the possible contaminating components that may likely be present in the cosmetics (Ojezele et al., 2018; Amit et al., 2010). Several studies have revealed the presence of harmful chemicals, including heavy metals, capable of attacking the skin (Ojezele et al., 2018; Okereke et al., 2015;

Omenka & Adeyi, 2016; Iwegbue et al., 2016; Sani et al., 2016; & Alizadeh et al., 2017). Since skin care products fall in general category of cosmetics and are used to improve the appearance and health of the skin (Liubov, 2016), hence the need to evaluate human health implications due to levels of heavy metal (Pb, Hg, Mn, Cu and Cr) in some selected cosmetics commonly sold in Nigeria.

Materials and Method

Research Design

Random sampling of Twenty-one (21) commonly used cosmetics (seven cosmetic lotions, seven cosmetic creams and seven cosmetic soaps) were obtained from major supermarkets in Eke Market, Afikpo, Afikpo North Local Government Area of Ebonyi State, Nigeria. Samples brands were coded and preserved in a cool dry place prior to laboratory analysis.

Sample Digestion and Analysis

Wet digestion methods of (Onojah & Emurotu, 2017) and (Oyelakin et al., 2010) were employed with some adjustments. For mercury, micro-wave assisted digestion was employed. The selected heavy metal levels were analysed according to the method described by (APHA/AWWA/WPCF, 1998). To ensure precision, determination was performed in triplicates for each metal using Varian Spectra AA 55B Model Atomic Absorption Spectrophotometer (AAS). In the case of mercury (Hg) determination, a cold vapour unit AAS was used.

Exposure and Safety Evaluation of Selected Cosmetics

In this study, focus was limited to dermal absorption pathway only as this is the main pathway of exposure by humans to heavy metals on application of cosmetic lotions, cosmetic creams and cosmetic soaps. Evaluation of human health risk on exposure to metallic impurities was carried out according to the methods of (Abd El-Aziz et al., 2017). The following formulas were employed:

$$\text{Margin of Safety, (MoS)} = \text{NOAEL} / \text{SED}$$

$$\text{Where NOAEL} = \text{RfD} \times \text{UF} \times \text{MF; and}$$

$$\text{Systemic Exposure DosageSED} = \frac{Cs \times AA \times SSA \times F \times RF \times BF \times 10^{-3}}{BW} \quad (\text{mg/kg BW day}^{-1})$$

$$\text{Hazard Quotient, HQ} = \text{SED} / \text{RfD}$$

$$\text{Hazard Index, HI} = \sum HQ = HQ_{Pb}+HQ_{Hg}+HQ_{Cr}+HQ_{Cu}+HQ_{Mn}$$

$$\text{And Lifetime Cancer Risk, LCR} = \text{SED} \times \text{SF}$$

Where Cs is the concentration of metal in the selected cosmetic product (mg kg^{-1} or ppm) and BW is human body weight (kg). A default body weight of 65 kg was used in this study. RfD is Dermal Reference Dose, UF is the uncertainty factor usually 100 (reflecting the overall confidence in the various data sets) and MF is the modifying factor usually 1 (based on the scientific judgment used). In this case the default RfDs values ($mgkg^{-1}day^{-1}$) and carcinogenic slope factors (SF) used are given as shown:

Table 1.0: Reference dose and carcinogenic slope factor of some selected heavy metals (Samuel 2016; USEPA, 2011).

Metal	RfD Value ($mgkg^{-1}day^{-1}$)	SF Value ($mgkg^{-1}day^{-1}$)
Pb	4.0×10^{-3}	8.5×10^{-3}
Hg	3.0×10^{4}	–
Mn	1.4×10^{-1}	–
Cu	4.0×10^{-2}	–
Cr	3.0×10^{-3}	5.0×10^{-1}

Other assessment parameters and their default values are indicated in the Table below:

Table 2.0: Default values of parameters for calculating SED (SCCS, 2018).

PARAMETER	VALUE ASSIGNED
Skin surface area involved (cm^2) for body lotion and creams (SSA)	15670 (17500 for soaps)
Estimated daily amount applied (g/d) (AA)	7.82 (0.19 for soap)
Retention factor (RF)	1.00 (0.01 for soap)
Frequency of application (F)	2.28/day (1.43/day for soap)

Dermal bio-accessibility of an element was considered suitable at 50% and 100%, of dermally administered dose. Thus, a substance is safe for use if MoS calculated is ≥ 100 and vice-versa (Abd El-Aziz et al., 2017; John, 2018; & SCCS, 2012). In addition, the exposed local population (consumers) is said to be safe if calculated HQ < 1 but unsafe if calculated HQ > 1. Hence, potential health risk is said to have occurred. The slope factor represents an estimated upper bound of the probability of an individual's carcinogenic response per unit intake dose of a chemical over an average lifetime (USEPA, 2011; Liu et al., 2013).

Results and Discussion

Results

The mean values of Pb, Hg, Cu, Cr and Mn for each class of cosmetics (lotion, cream and soap) were compared using SPSS® for Windows® version 23.0 (IBM SPSS Statistics) to find out if there are significant variations (P>0.05) in the heavy metal levels observed in the different cosmetic samples analyzed. Safety evaluation of metals at 50% and 100% bio-accessibility on exposure to any cosmetic product containing the selected metals are also presented in Tables.

Table 3.0: Mean metal levels of selected cosmetic brands studied (ppm) ± standard deviation and their percentage composition (%)

Parameter	Mean Metal Conc. in Lotions (ppm)	Mean Metal Conc. in Creams (ppm)	Mean Metal Conc. in Soaps (ppm)	Percentage Composition in Samples (%)
Pb	0.566±0.524	0.617±0.459	0.046±0.027	18.51
Hg	0.113±0.147	0.171±0.082	0.054±0.064	5.09
Mn	0.396±0.356	0.227±0.144	0.054±0.037	10.20
Cu	0.205±0.320	0.131±0.084	0.089±0.141	6.40
Cr	0.144±0.091	0.174±0.201	0.064±0.059	5.75
Minimum	0.113±0.147	0.131±0.084	0.046±0.027	5.09
Maximum	0.566±0.524	0.617±0.459	0.089±0.141	18.51

Data represents mean metal values of triplicate determinations ± standard deviation

Discussion

The results of the levels of Pb, Hg, Mn, Cu and Cr in Table 3.0 above revealed varying levels in the different brands of cosmetics studied. In all the cosmetic brands studied, lead (Pb) (0.617±0.459 ppm) in the cream, lead (Pb) (0.566±0.524 ppm) in the lotion and copper (Co) (0.089±0.141 ppm) in soap samples studied were recorded the highest. In the same vein, the lowest mean contents were determined as Hg (0.113±0.147 ppm) in lotions, Cu (0.131±0.084 ppm) in creams and Pb (0.046±0.027 ppm) in the cosmetic soaps. Manganese in the cosmetic lotions and creams indicated as the second most abundant metal detected but having equal concentration with mercury (Hg) in the cosmetic soap samples studied. Comparing with their corresponding permissible limits of WHO and US FDA, the metal mean contents in the various cosmetic samples studied were lower. Similarly, the obtained metal levels for this study were relatively lower than those obtained by (Ojezele et al., 2018; Nzekwe et al. 2016; Nasirudeen & Amaechi, 2015), but similar to the findings of (Onojah & Emurotu, 2017; John, 2018). The results also revealed that for the cosmetic lotions, creams and soaps, the selected heavy metal mean contents are in the order: Pb > Mn > Cu > Cr > Hg; Pb > Mn > Cr > Hg > Cu and Cu > Cr > Hg = Mn > Pb respectively as shown in Figure 1.0. The order of Pb, Hg and Cr levels in the selected cosmetics is creams > lotions > soaps. Similarly, the order of Mn and Cu levels in the selected cosmetics is lotions > creams > soaps; making the metal detected levels in soap samples the lowest.

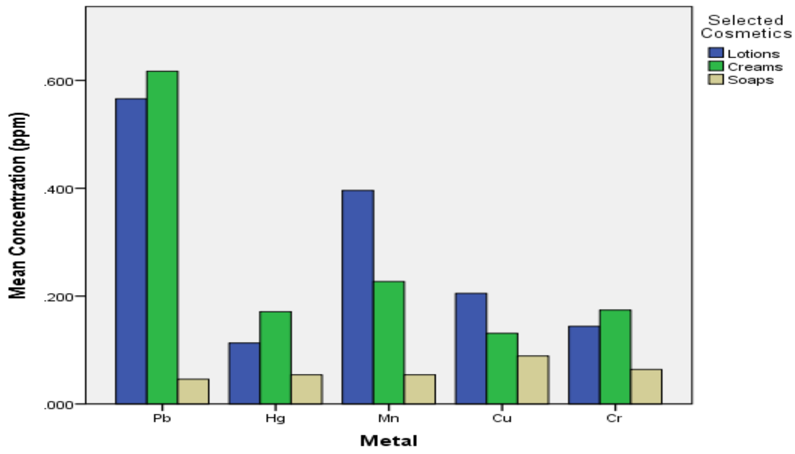
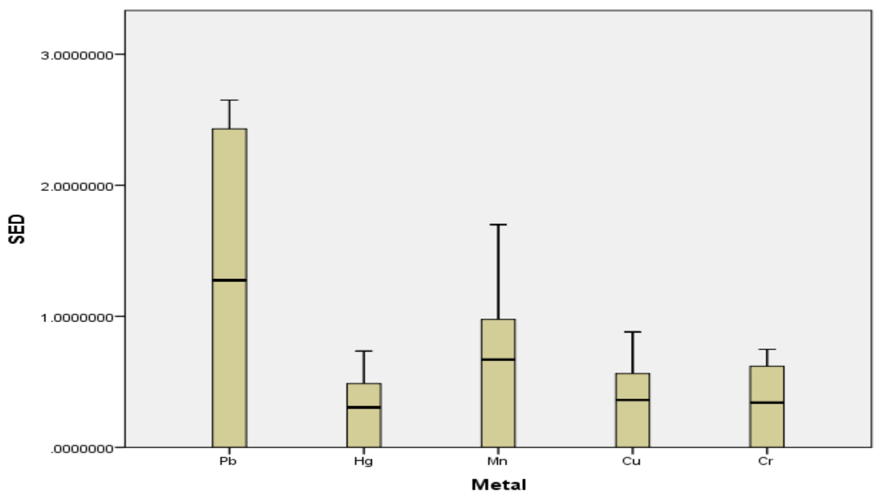


Figure 1.0: Clustered Bar Chart of Metal Mean Levels in the Selected Cosmetic Brands Studied

Tukey Post Hoc multiple tests results revealed high significant difference ($p < 0.05$) in the mean levels of the selected heavy metals for the studied cosmetics, with the Adjusted R^2 value of 0.521. The arising differences in the selected cosmetics metal levels may have occurred due to differences in raw material types, conditions of formulating equipment, as well as the manufacturing processes employed.

For human safety evaluation, the results estimated for SED ($mgKg^{-1}BWday^{-1}$) and MoS levels of metals at 50% and 100% bio-accessibility as shown in Figure 2.0 revealed higher SED values than their respective recommended intake values for cream and lotion samples, but lower levels for soap samples than the respective recommended intake values. In this study, MoS ranged from Pb (1.51E–01) in cream samples to Hg (1.52E+11) in soap samples. The estimated MoS of metals in the cosmetic creams and lotion (except for Hg) and unlike the selected cosmetic soaps, were less than the minimum value of 100 proposed by the WHO and SCCS to conclude that a substance is safe for use, thus indicating a potential health risk over a lifetime duration. Similarly, Table 4.0 and 5.0 respectively show the estimated HQ and HI and LCR in the cream and lotion samples (except for soap samples) which revealed potential health hazards due to the presence of Pb, Mn, Cu and Cr with exception of Hg. comparatively, HQ, HI and LCR levels in the selected cosmetic samples were all in the order: soaps < creams < lotions.



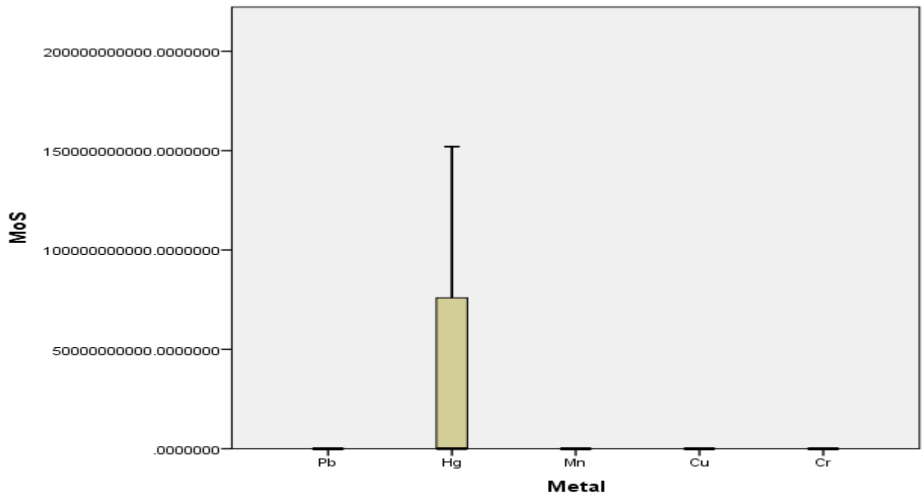


Figure 2.0: Boxplots of Estimated SED and MoS levels of metals at 50% and 100% bio-accessibility

Table 4.0: Estimated hazard quotients and hazard index of metals at 50% and 100% bio-accessibility

Metal	**HQ** in Lotions	**HQ** in Creams	**HQ** in Soaps	**HQ** in Lotions	**HQ** in Creams	**HQ** in Soaps
	At 50% Bio-accessibility			At 100% Bio-accessibility		
Pb	3.05E+02	3.32E+02	4.20E–03	6.08E+02	6.63E+02	8.40E–03
Hg	8.10E–06	1.23E–05	7.00E–10	1.62E–05	2.45E–05	1.30E–09
Mn	6.08E+00	3.49E+00	1.41E–04	1.22E+01	6.97E+00	2.82E–04
Cu	1.10E+01	7.05E+00	8.15E–04	2.20E+01	1.41E+01	1.63E–03
Cr	1.03E+02	1.25E+02	7.80E–03	2.06E+02	2.49E+02	1.56E–02
HI	4.25E+02	4.68E+02	1.30E–02	8.48E+02	9.33E+02	2.59E–02

Table 5.0: Estimated Lifetime Cancer Risk at 50% and 100% Bio-accessibility of metals. Note: SF of Hg, Mn and Cr for cosmetics are not available

Metal	LCR in Lotions	LCR in Creams	LCR in Soaps	LCR in Lotions	LCR in Creams	LCR in Soaps
	At 50% bio-accessibility			At 100% bio-accessibility		
Pb	1.04E–02	1.13E–02	1.43E–07	2.07E–02	2.25E–02	2.86E–07
Cr	1.55E–01	1.87E–01	1.17E–05	3.10E–01	3.74E–01	2.34E–05

Conclusion

Evidence of some levels of harmful metal in the selected cosmetics was revealed in the order: lotions > creams > soaps, with levels lower than permissible limits set by WHO and US FDA. Human health risk evaluation also revealed significant health threat due to continuous application of the lotion and cream samples since even at low level, the presence of harmful metal poses some health hazards. Therefore, in consequence of the continuous application of such cosmetics, it is pertinent to pay special attention to several cosmetic products as evidence from the study has revealed significant detrimental threats to health. Hence, this study recommends that an urgent need for policy regulation and monitoring of cosmetic products both in Nigeria and other parts of the world. In addition, further research should be carried out on other brands of cosmetics to ensure human health and the environment.

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