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TOXICOLOGICAL EVALUATION OF FACIAL COSMETICS PRODUCTS USED BY STUDENTS OF TWO TERTIARY INSTITUTIONS IN SOUTHEASTERN NIGERIA

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ABSTRACT

An evaluation of toxicity concentrations of cosmetic products utilized by students of two tertiary institutions [Abia State University (ABSU) and Michael Okpara University of Agriculture, Umudike (MOUAU)] in Abia State, Nigeria was carried out in this study. Ten (10) heavy metal comprising Lead (Pb), Iron (Fe), Mercury (Hg), Arsenic (As), Copper (Cu), Manganese (Mn), Zinc (Zn), Chromium (Cr), Cadmium (Cd) and Nickel (Ni) were analyzed using Atomic Absorption Spectrometry. Margin of Safety, Hazardous Index, Cancer Risk and Potency Factor were calculated following recommended standard. The concentrations from both Universities forNi, Fe, Cr, Pb and Cdwere above the suggested safe limit for Personal Care Products (PCPs).The margin of safety (MOS) values obtained in both Universities were greater than 100, indicating that the concentrations of metals investigated in these cosmetics exert higher risk, ABSU (205,016.06 μg^{g-1}) and MOUAU (191,5708.81 μg $^{g-1}$). From ABSU, the maximum value of oral cancer risk was detected in Lip liner product at0.645408, while the maximum value of cancer risk index was observed in Lip liner product at 99.225. Whereas, for cosmetics products collected from MOUAU, the maximum value of oral cancer risk was observed in face powder (Base jelly) and the maximum value of cancer risk index was observed in Lip liner products. In ABSU the maximum value of potency factor risk (CSF) was detected in eye pencil while in MOUAU, the maximum value of potency factor risk was detected in face powder (Base jelly). In conclusion, the study suggests that the continuous use of these cosmetic products can lead to the absorption of metals which will eventually lead to chronic health effects.

Keywords: Cosmetics, Toxicology, Risk assessment, Heavy metals, Hazardous index

INTRODUCTION

Cosmetics are items applied to the body to embellish, purifying, or further developing appearance and improving appealing highlights (Singh, 2010). In developing countries, concentration of heavy metals materials or compounds tends to increase due to the industrial development of some sophisticated products of which majority of them contain these toxic metals (Adebanjo,2002). The impacts of this heavy metals concentration on human health, skins and environment have an issue of global concern over the years (ATSDR, 2015). Furthermore, the presence of heavy metals at high concentrations in cosmetics products has been found to induce toxic effects to human skins, eye lid etc., making it difficult to treat skin cancer, eye ocular defeat biologically (Funtua and Oyewake, 1997; Anderson and Anderson, 1998).

In 2007, the Campaign for Safe Cosmetics tried for and discovered lead in various top-selling lipsticks (CSC, 2007). Underarm beauty care products are being explored as a potential reason for bosom disease (Anderson and Anderson, 1998; Nnorom*et al*., 2005 and Alani, 2013) while bath powders have been seen to contain asbestiform and sizeable groupings of Ni, Cr and Co (Nnorom*et al*., 2005).There is expanding proof that the compound constituents of underarm and body-care beautifiers applied to the facial region, underarm and bosom region might be engaged with the rising occurrence of bosom malignant growth and skin disease (Darbre, 2001., Darbre, 2003; Harvey and Darbre, 2004).Similar investigations, of conventional make-ups utilized in Nigeriahave revealed extremely significant degrees of follow metals (nickel, cobalt, manganese, mercury, titanium and lead) in privately sourced eye make-up (Ajayi *et al*., 2002; Ayenimo*etal*., 2010).

The utilization of beautifying agents by Nigerian ladies is an antiquated custom. Ladies, youthful and old, apply and embellish themselves with makeup of various surface and shadings, particularly during merry periods. Makeup is accepted to work on the best highlights and cover the imperfections on the individual wearing them. A few factors like notice, peer pressing factor and social acknowledgment, impact the decision of skincare items applied by most ladies. An examination directed by (Robertson *et al*., 2008) uncovered that ladies who apply make-up are uncertain, restless, and not sure about themselves. Considering the prolonged contact time of cosmetic products with the facial areas and skin area, the risk of Adrenocortical dysplasia protein homolog (ACD) might be increased (Kang and Lee, 2006). As a support to this, there are several studies evidencing the presence of Co, Cr, Ni, and Pb at levels of μg g-1 in henna dye, eye shadows, and lip liners with frequent positive reactions to patch tests (Hardy *et al.,* 2004; Kang and Lee, 2006 and Ahmed, 2016). Some authors revealed the presence of Cd, Cr, Cu, Hg, Pb, and metal oxides in body or sunscreen creams (Oyedeji*et al.*, 2011).

In Africa, eye cosmetics such as Kohl and Surma have been identified as a source of Pb exposure to the ocular system defect in adults and children.Also, similar studies reported on traditional facial cosmetics showed very high levels of trace metals (nickel, cobalt, manganese, mercury, titanium, and lead) in locally sourced eye make-up (Ajayi *et al.,* 2002). Surprisingly, in spite of the regulations put in place to prevent or minimize the presence of such ingredients in

cosmetic brands, heavy metals, organic and inorganic chemical substances are still very much in them. A reason given for this is that such substances may be a major component of the raw materials used in cosmetic manufacture or are deliberately included in cosmetics (Adepoju-Bello *et al.*, 2012; WHO, 2013).

Cosmetic products appear not to be subjected to clinical trials or laboratory testing(s) by regulatory authority in Nigeria before premarket approval. This is evident from legal document setting up the Nigerian National Agency for Food and Drug Administration and Control (Nigeria Nursing World, 2013). The study was necessary because it will determine the toxicity effects of heavy metals concentration on facial cosmetics used by students in two Nigerian Universities;Abia State University Uturu, and Michael Okpara University of Agriculture Umudike, Abia State, which will in turn enhance the knowledge of the people using facial cosmetics and the effects of heavy metals contamination and as well the possible sources of facial cancers and their possible health implications on human beings.

MATERIALS AND METHODS

The study was conducted in Abia State University,Uturu (ABSU) and Michael Okpara University of Agriculture,Umudike (MOUAU) in Abia State. Abia State University Uturu (ABSU) is a town located within latitudes 05.33°N and 06.03°N, in the northern part of Abia State, Nigeria. It is in the transition from rural to urban status, so it is witnessing many development activities (Chigbu, 2015). The population of Uturu has been growing at a high rate over decades, until the last decade. Its present population is over 40,000. Michael Okpara University of Agriculture, Umudike(MOUAU) is a semi-urban settlement in Ikwuano LGA in Abia State, Nigeria, about 11 kilometers Southeast of Umuahia, the State Capital City. MOUAU lies between Longitudes 59^{o} 192$^{'}$ 09$^{''}$and Latitude 42^{o} 36$^{'}$ 07$^{''}$ in the rainforest zone of the southeastern Nigeria and elevation of 148 m above sea level. The annual rainfall of the study area ranges from 3000mm to 4000mm while the average annual temperature is 59.18^{o}C, the relative humidity ranges from 65 – 85% (NRCRI, 2010).

About twenty-four (24) different brands of facial cosmetics products were collected from low shops fashion, cosmetics make-up stylist shops in Abia State University,Uturu,and Michael Okpara University of Agriculture,Umudike, in Abia State. The choice of brands was carefully made to reflect the types of cosmetics used by the students. The facial cosmetics were classified into six broad groups, namely, Lipsticks (L_S),Eye shadows (Es), Eye pencils (Ep) Face Powders (Fp), Skin creams (Sc) and Lip liner (Ll).

The blank and calibration standards were prepared by diluting 1000mg L−1 commercial standards of Cd, Pb, Ni, Cr, Cu, Zn, Fe, As, Mn and Hg (Chemistry Department of MOUAU) and adding 2 drops of (HNO_3 69% v/v). Also, Atomic Absorption Spectrophotometer (Model: AA320N, Wincom Company Ltd. China) was used for metal ions estimation. Samples were digested by the wet digestion method. A mass of about 1.0g of each sample was placed into a Teflon vessel and treated with 20 mL of HNO_3 and 10 mL of HCL and 5mL of H_2O_2. The digested samples were allowed to cool to room temperature after heating for 2 to 3 hours at 60^{o}C. Filtered and then made up to 20 ml with de-ionized water.

The Lipsticks, Skin cream, Eye shadow, Lip liner, Eye pencil and Face powder were allowed to stand for 24hrs in the refrigerator. All digested samples were subjected to analysis for metal concentrations according to recommended standards (USEPA, 2011; Vlope*et al.,* 2012 and Iwegbue*et al.,* 2016).The clear solutions of the digested heavy metal samples were analyzed for concentrations of Chromium (Cr), Copper (Cu), Iron (Fe), Lead (Pb), Zinc (Zn), Manganese (Mn), Nickel (Ni) and Arsenic (As) according to the standard method of AOAC(2005), which was performed using Atomic Absorption Spectrophotometer (AAS) (AA320N, Wincom Company Ltd. China). The risk of human exposure to these metals in these cosmetic products were calculated using recommended standards for systematic exposure dosage (SED) andMargin of Safety (MoS).

$$SED(\mu g/kgBWday^{-1}) = \frac{Cs \times AA \times SSA \times F \times RF \times BF \times 10-3}{BW} \ldots\ldots (1)$$

$$MoS = \frac{NOAEL}{SED} \ldots\ldots (2)$$

Data obtained were presented as mean plus or minus of the standard deviation of the means (Mean ± SD), the significant difference among means were analyze using the analysis of variance (ANOVA).

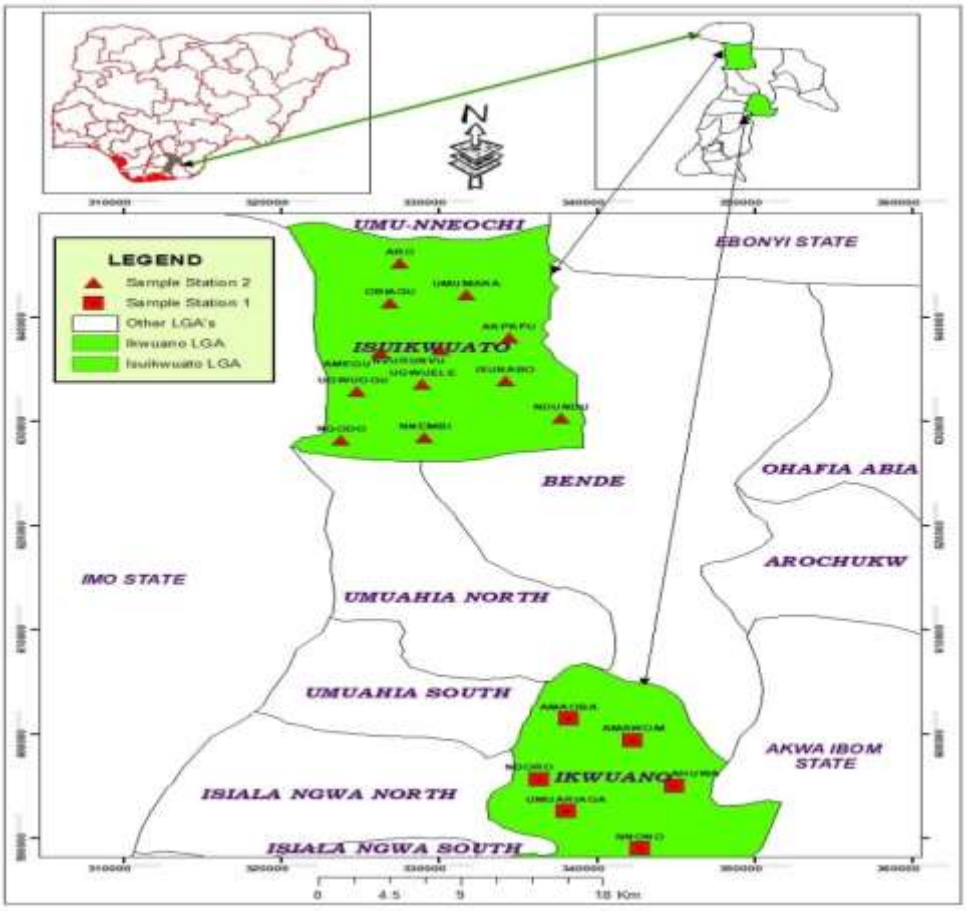


Figure 1: Map of Study Locations in Abia State

RESULTS AND DISCUSSION

The concentrations (µg/g) of heavy metals among different personal care products (PCPs) of facial cosmetics collected from Abia State University Uturuare presented in Figure2 and 3.Values of Cd ranged from 4.03 to 5.62µg/g in eye shadow samples and 5.46to 7.06µg/g in eye pencil, 1.13 to 5.13µg/g in lip liner. In lipstick the concentration ranged from not detected *ND* to 85.71µg/g, while in face powder was *ND*to 0.28µg/g and in skin cream was *ND* to 0.24µg/g. Results obtained in this study when compared with the available international permissible limits 5ppm for US FDA (2011),and 3ppm for Health Canada (2010), most of the samples in this study were above the permissible limits andare likely to present health risk. Mean concentrations of Arsenic (As) were 7.99 to 13.89µg/g (lipstick), 33.54 to 39.19µg/g (skin creams), 21.11 to 24.74µg/g (face powder), 20.15 to 26.11µg/g (eye pencil), 30.44 to 32.51µg/g (lip liner) and 22.11 to 25.66µg/g (eye shadows). Concentrations of Ni ranged in the following order as eye pencils > lipsticks > face powder > lip liner > eye shadows and skin creams. Comparing results with those of (Iwegbue*et al*., 2016), they were almost similar. Eye make-up samples sold in Nigeria showed very high Ni levels with mean values in eye liners (9.2µg/g), eye pencils (13.4µg/g) and in lipstick (14.6µg/g) (Nnorom*et al*., 2005). Although, which was contrary to report by (Adepoju-Bello *et al*., 2012) for products of lipsticks, lip glosses and skin lightening creams sold in Nigeria presented a very low mean level for Ni (0.05µg /g).

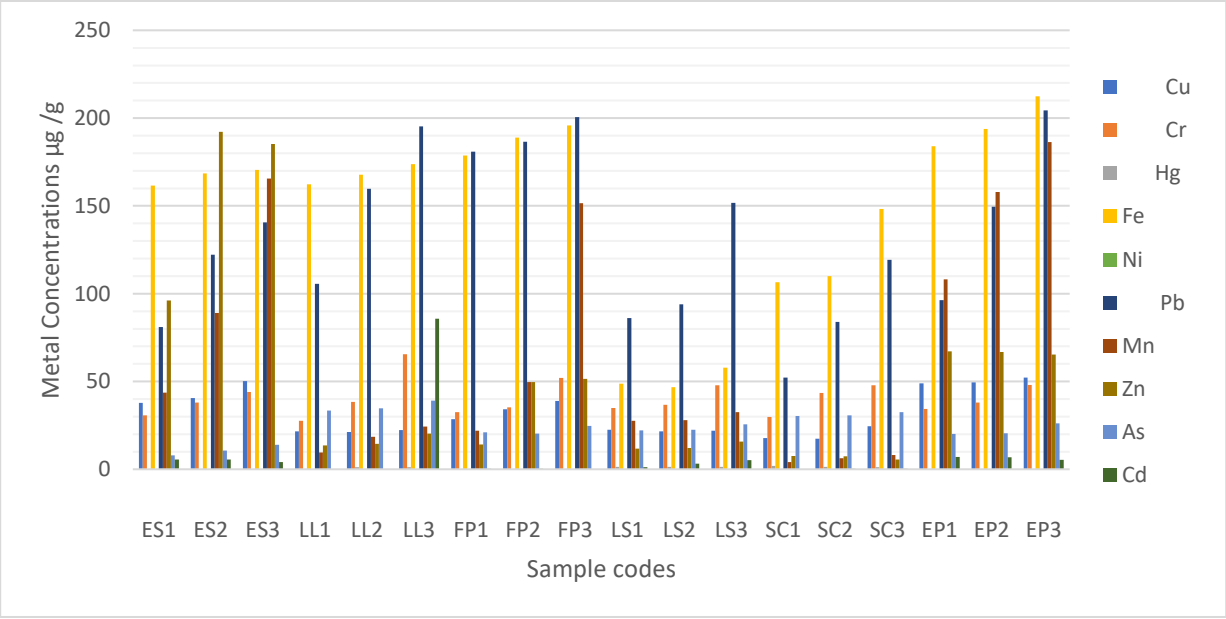


Figure 2: Plot of metals concentrations (µg/g) of some identified facial cosmetics products commonly used in ABSU;*Sample Codes:LS_{1-3} (Lips stick), SC_{1-3}(Cream) FP_{1-3}(Face powder), EP_{1-3} (Eye pencil), LL_{1-3}(Lip liner), & ES_{1-3}(Eye shadow- mascara).*

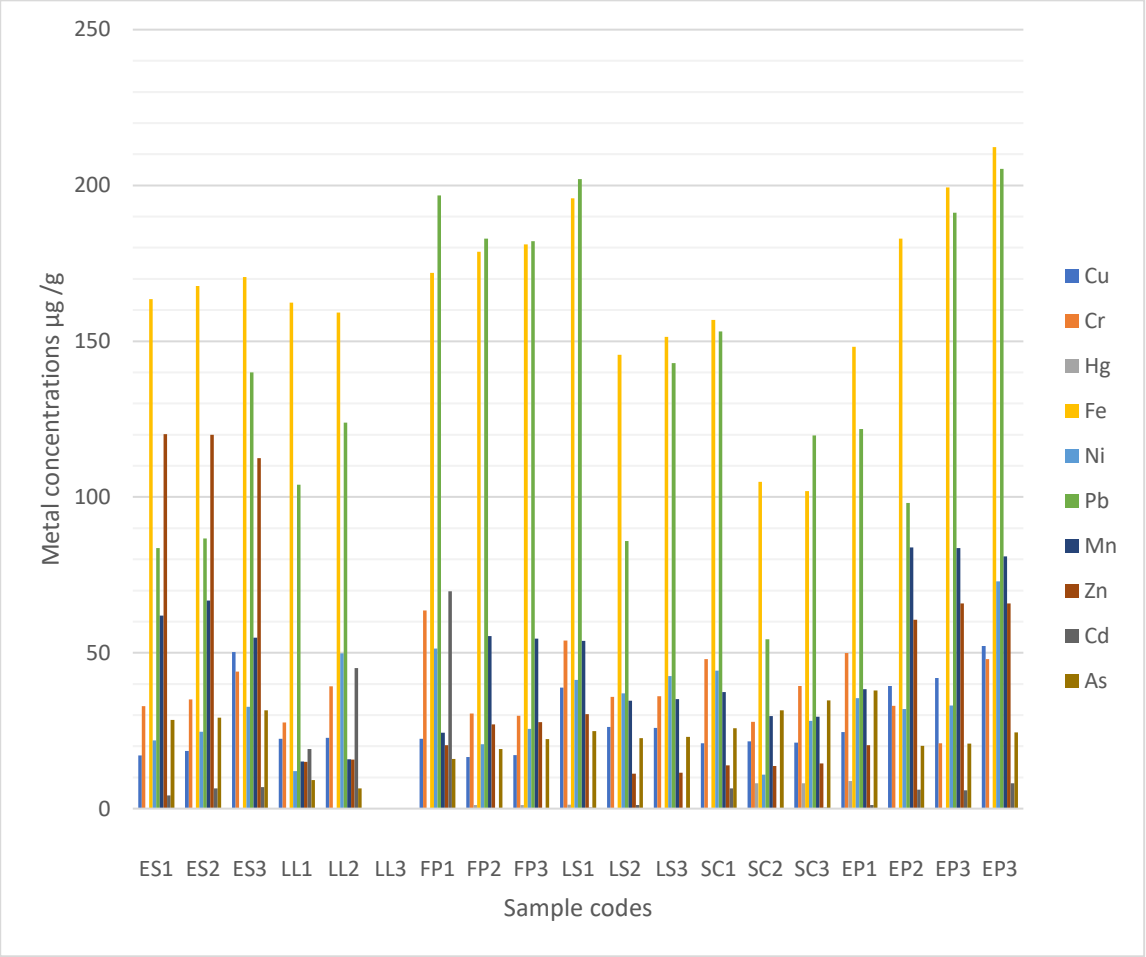


Figure3: Plot of metals concentrations (µg/g) of some identified facial cosmetics products commonly used in MOUAU; *Sample Codes: LS_{1-3} (Lips stick), SC_{1-3}(Cream) FP_{1-3}(Face powder), EP_{1-3} (Eye pencil), LL_{1-3}(Lip liner), & ES_{1-3}(Eye shadow- mascara).*

The concentrations (µg/g) of heavy metals among the different personal care products (PCPs) of collected from Michael Okpara University of Agriculture Umudikeare presented in Figure 3. Chromium ranged from 27.63to 63.57µg/g in lipstick, 29.89 to 47.90µg/g in Skin cream, 35.85 to 47.93µg/g in lip liner, 32.51 to 53.98µg/g in face powder, 34.36to 47.96µg/g in eye pencil, and 30.80 to 43.97µg/g in eye shadow. The order of cadmium concentrations in the samples were lipsticks > eye shadows > eye pencils > lip liner> face powder > Skin cream. Chronic exposure to low levels of Cd can also cause the bones to become fragile and break easily. This assessment was based on carcinogenic effects on lungs after inhalation, oral entering but tumors in other organs (prostate and kidney) have been observed. Arsenic concentration in cosmetic were higher in skin cream > eye shadow >lip liner > face powder> eye pencil > and lipstick.

The estimated SED (µg/kg) and MOS of the metals from the use of these facial cosmetic products are presented in Table 1 and 2 below.

Table 1: Risk assessment of systemic exposure dosage and margin of safety from facial cosmetic products in ABSU (µg /kg)

Sample Code	Cu	Cr	Hg	Fe	Ni	Pb	Mn	Zn	Cd	As
Systemic exposure dosage (SED)										
ES	1.5701×10^{-7}	1.3761×10^{-10}	7.3371×10^{-10}	6.1199×10^{-6}	1.0202×10^{-6}	4.2013×10^{-6}	3.6488×10^{-6}	5.7622×10^{-6}	2.0727×10^{-7}	3.9957×10^{-7}
LL	3.1917×10^{-8}	6.4347×10^{-6}	8.8046×10^{-11}	2.4659×10^{-7}	4.7853×10^{-4}	2.2529×10^{-7}	2.4976×10^{-8}	2.3758×10^{-8}	4.1352×10^{-8}	5.2402×10^{-8}
FP	1.4633×10^{-7}	1.7596×10^{-7}	0.000×10^{-7}	$8.2580 \times 1.4550_{7} \times 10^{-}$		8.1693×10^{-7}	3.3268×10^{-7}	1.6808×10^{-7}	4.5344×10^{-9}	1.0517×10^{-7}
LS	3.4729×10^{-7}	6.1602×10^{-7}	1.5562×10^{-8}	8.0676×10^{-6}	8.0676×10^{-7}	$7.0353x\ 10^{-7}$	$4.5685x\ 10^{-7}$	2.1047×10^{-8}	4.6690×10^{-8}	3.6270×10^{-7}
SC	2.4432×10^{-6}	5.1266×10^{-5}	1.4999×10^{-6}	1.5489×10^{-4}	2.4381×10^{-5}	1.0898×10^{-4}	8.5803×10^{-6}	8.6312×10^{-6}	1.3347×10^{-6}	3.9686×10^{-5}
EP	0351×10^{-8}	5.4611×10^{-8}	1.3901×10^{-9}	2.3584×10^{-4}	7.2359×10^{-8}	1.8006×10^{-7}	1.7992×10^{-7}	7.9502×10^{-8}	8.0413×10^{-9}	2.6592×10^{-8}
Margin of Safety (MoS)										
ES	191070.63	218007.41	40888089.30	11438095.39	1960399.216	95208.63	3836877.88	5206344.79	482462.49	150183.98
LL	939937.96	4662222.02	34073098.15	28387014.30	41794662.82	1775489.37	560538116.6	1262732553.0	2418262.72	1144994.47
FP	205016.06	1704932.94	0.000	84766287.24	13745704.47	489638.04	42082481.66	178486435.00	22053634.44	57054.90
LS	86383.14	486997.18	1927772.78	8676682.04	2479052.01	568561.40	30644631.72	142538128.9	2141786.25	165425.97
SC	1227.90	5851.83	200001.33	451933.63	82031.09	3670.40	1631644.58	3475762.35	74923.20	1511.87
EP	497092.01	5493398.77	21581181.21	296811.40	27639961.86	2221481.73	77812361.05	377348997.5	12435800.18	2256317.69

Personal Care Products: (LS) Lipstick, (SC) Skin Cream, (FP) Face powder, (EP) Eye pencil, (LL) lip liner, & (ES) Eye shadow (mascara).

Table 2: Risk assessment of systemic exposure dosage and margin of safety from facial cosmetic products in MOUAU (µg /kg)

Sample Code	Cu	Cr	Hg	Fe	Ni	Pb	Mn	Zn	Cd	As
Systemic exposure dosage (SED)										
ES	9.6549×10^{-7}	1.2758×10^{-10}	1.7143×10^{-9}	5.7326×10^{-7}	9.1577×10^{-7}	3.5835×10^{-6}	2.1003×10^{-6}	4.0131×10^{-6}	1.9954×10^{-7}	1.0214×10^{-6}
LL	3.0912×10^{-8}	5.960×10^{-6}	1.3714×10^{-11}	2.2498×10^{-7}	5.1168×10^{-8}	1.9409×10^{-7}	2.4741×10^{-8}	2.3575×10^{-8}	5.9218×10^{-8}	1.4414×10^{-8}
FP	9.9730×10^{-8}	1.5660×10^{-7}	4.1143×10^{-11}	7.6353×10^{-7}	1.1952×10^{-7}	7.3880×10^{-7}	2.2493×10^{-7}	1.1676×10^{-7}	8.2697×10^{-9}	9.3806×10^{-8}
LS	3.5338×10^{-7}	5.7499×10^{-7}	1.4544×10^{-8}	2.1796×10^{-6}	5.9702×10^{-7}	1.8339×10^{-6}	5.1480×10^{-7}	2.3414×10^{-7}	5.060×10^{-10}	3.4330×10^{-7}
SC	2.6635×10^{-5}	4.6688×10^{-5}	2.1384×10^{-6}	1.4092×10^{-4}	2.9474×10^{-5}	1.1717×10^{-4}	3.8658×10^{-5}	1.9233×10^{-5}	1.2474×10^{-6}	4.1247×10^{-5}
EP	4.9795×10^{-5}	3.8046×10^{-8}	1.1648×10^{-8}	2.2198×10^{-7}	5.0826×10^{-8}	1.8463×10^{-7}	9.2658×10^{-8}	7.2061×10^{-8}	7.4032×10^{-9}	2.3722×10^{-8}
Margin of Safety (MoS)										
ES	31072.31	235146.57	17499.85	122108641.80	21839541.49	111622.72	66657154.42	7475517.68	501152.65	5874.90
LL	970496.89	503355.70	2187545574	311138767.90	39086929.33	2060899.58	565862333.80	1272534461.0	1688675.74	4162619.68
FP	300812.19	1915708.81	72411296.16	91679436.3	16733601.07	541418.52	62241586.27	25693730.73	12092337.09	639617.93
LS	84894.45	521748.20	2062706.27	32115984.58	3349971.53	218104.89	27195027.2	128128470.1	173611111.1	174774.25
SC	1126.34	6425.63	140291.807	496735.73	67856.42	3413.84	362150.14	1559819.06	80166.75	1454.65
EP	602.470	7885191.61	25755494.51	315343724.7	39349939.01	2166495.15	151093267.7	416313956.2	13507672.36	2529297.70

Personal Care Products: (LS) Lipstick, (SC) Skin Cream, (FP) Face powder, (EP) Eye pencil, (LL) lip liner, & (ES) Eye shadow (mascara).

Results shows that Heavy metal contents within the cosmetics products studied increased according to the following ordered as Fe>Pb>Mn>Zn>Cr>As>Ni>Cu>Cd and Hg. While the dominant elements in Personal Care Products (PCPs) were Fe, Pb, Mn, Cr, Ni, Zn, As, Cu and the minimum concentrations were noted for Cd and Hg for both Universitywhich agrees with the findings by several authors (Tsankov*et al.*, 1992; Nicolopoulou*et al*., 2015).

The study revealed that Pb, Cr, Cu, Mn, Zn, Fe and as were present in the facial cosmetic products at concentrations above their specified limits by the Health Canada (2010) while Ni, Fe, Zn, Pb, Mn and Cr were above the suggested technically avoidable limits and Hg concentrations was below the normal standard limits in both Universities (US FDA, 2011). Systemic exposure dosage of heavy metals in PCPs in this study were higher and the estimated margin of safety (MoS) for metals in these facial cosmetic products was greater than the proposed value of 100 set by the World Health Organization, 2013.

Eye pencils cosmetics in ABSU samples and Lip liner in MOUAU cosmetics samples had the highest MoS values compared with other facial cosmetic products investigated. The MoS values indicate that there is a little risk associated with the concentrations of metals in these products. Hazardous Quotients (HQ) value concentrations was higher than 1 in As, Cr, Cu, Hg, Cd, Zn, Mn, and Ni, while in Fe and Pb was lower than 1 in ABSU samples. For MOUAU samples, HQ value concentrations of heavy metals was higher than 1 in all PCPs except in Fe, indicating that the overall risks in both exposure pathways are not within safe level except in Fe.

The Hazardous Index (HI) values concentrations was higher than 1 in all PCPs samples of ABSU in use and HI values was higher than 1 in eye pencil, lip liner, skin cream, lipstick, eye shadow and face powder respectively, indicating that there was little or high risk associated with using these personal care products samples. The maximum value concentrations of oral cancer risk were observed in eye shadow (mascara) and the minimum value was in face powder PCPs collected from ABSU, followed by the maximum value concentrations of oral cancer risk inPCPs samples was in Face powder samples from MOUAU. In addition to the maximum value of cancer risk index of 91.370 was observed in lip liner from ABSU sample while in MOUAU samples, the maximum value concentrations of cancer risk index were 98.085 was observed in lip liner.

The maximum value concentrations for potency factor risk (CSF) for PCPs samples of ABSU was 3.0190 in eye pencil and the minimum (0.1020) in eye shadow while in MOUAU the maximum value for potency factor risk (CSF) concentrations was 4.9865 in face powder (base jelly) and the minimum concentrations (0.32) in lip liner samples. The study emphasizes the urgent needs for strict national regulations for manufacturing of personal care products in accordance with reports conducted by Leron (2019).

CONCLUSION AND RECOMMENDATIONS

Studies of different authors have shown that cosmetic products may be potential routes of entry of toxic metals into the body. This study shows that cosmetic products contain certain amounts of metals more than just the ingredients

which can be linked to many diseases like cancer, birth defects, development and reproductive impairments, allergic and irritating harmful effects on human health.Highly toxic metals like lead and cadmium were in the tested samples which varied depending on the additives used along with the method of production. The presence of these metals in the products certainly indicate that it is necessary to monitor and determine the content of toxic heavy metals in these products by regulatory authority especially because they are in direct contact with skin or mucous membranes and are often used in daily life. Furthermore, research should be carried out on the potentials of other personal care products not analyzed in this study, to assess, observe and identify other heavy metals not covered in this research, due to the companies that may not be working under current regulations and legislation laws to avoid endangering human skins, health, and life.

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