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Research Article

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Heavy metal content of selected personal care products (PCPS) used by students of Kogi State University, Anyigba, Kogi State, Nigeria

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Abstract

The study assessed the heavy metal content of selected personal care products used by students of Kogi State University, Anyigba. Kogi State, Nigeria. A total of 24 cosmetic samples, including foundations, face powders, lip glosses and body creams were collected from 6 different locations within and around the campus of Kogi State University, Anyigba. The samples were analyzed for concentrations of lead (Pb), Chromium (Cr), Cadmium (Cd), Arsenic (As) and Mercury (Hg) using atomic absorption spectrophotometry. The values obtained were subsequently compared to WHO maximum permissible limits (MPLs). The results revealed significant concentration across several products categories. Pb concentration in face powders and lip glosses frequently exceeded the MPL of 10.00 mg/kg, with some samples containing Pb levels as high as 20 mg/kg. Hg was detected in foundation, body creams and face powders with concentrations up to 5.73 mg/kg in foundations, far exceeding the MPL of 1.00 mg/kg. Cadmium was found in foundation samples at levels above the MPL of 0.30 mg/kg with the highest concentration being 0.58 mg/kg. As was consistently present across all product types, though it remained within the MPL of 3.00 mg/kg. Cr levels were generally within safe limits, though it was detected in some face powder and foundation samples. These findings indicate a potential health risk for users due to the high levels of toxic metals, particularly lead and mercury, in the PCPs analyzed. The widespread contamination across different product types highlights the need for stricter regulatory controls and quality assurance in the production and distribution of PCPs. This study underscores the importance of continuous monitoring to prevent heavy metal exposure and safeguard the health of consumers.

Keywords: Personal care products (PCPs), Heavy Metals, Drug Discovery, Mechanistic Insights, Pharmacological Potentials

1. 0 Introduction

The worldwide consumption of beauty products has risen at an unprecedented pace because of the never-ending pursuit of human adornment. One of the major concerns with cosmetic products is the presence of high levels of impurities and heavy metals (Zakaria and Ho, 2015; Zainy, 2017). Lipsticks have long been a concern for public health because of the potential health hazards, most particularly, due to continuous exposure of high levels of impurities and heavy metals from dermal contact and oral ingestion (Pinto *et al*., 2018). Usually, lipstick is applied on the lips to make them more appealing and glamorous, but the price of this practice results to the exposure of heavy metals found in the lipstick items. The presence of heavy metals, such as lead, cadmium, and chromium, have already been detected in lipsticks (Malvandi and Sancholi, 2018; Zakaria and Ho, 2015). Fortunately, lipstick consumers are only exposed to heavy metals in limited amounts, but they are exposed to chronic health risks over a long-time period, which makes them notable (Zakaria and Ho, 2015). When customers eat and drink, a minuscule amount of lipstick can be swallowed, resulting in exposure to a minuscule amount of lipstick. It has been estimated that a woman advertently ingests 1.8 kg of lipstick during her lifetime (Rahman, *et al*, 2021).

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 (Ajayi *et al*., 2002). 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 (Nwakanma and Nwosu, 2021). 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 (Adepoju-Bello *et al*., 2022). 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 (WHO, 2013).

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 (Nwakanma and Nwosu, 2021).

A few factors like notice, peer pressing factor and social acknowledgment, impact the decision of skincare items applied by most ladies. An examination directed uncovered that ladies who apply makeup 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. 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 (Ahmed, 2016). Some authors revealed the presence of Cd, Cr, Cu, Hg, Pb, and metal oxides in body or sunscreen creams (Oyedeji *et al*., 2021).

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. 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 (Nwakanma and Nwosu, 2021). This study is aimed at evaluating heavy metals in cosmetic products used by students of Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria

2.0 Materials and Methods

2.1 Materials

2.1.1 Sample Collection

Four (4) common personal care products (Foundation, Lip gloss, Face powder and Body cream) were collected from 6 different students' hostels and lodges within and outside Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria. The sampling locations were designated as L1, L2, L3, L4, L5 and L6. Samples were collected in triplicates in polythene bags from each of the locations and labeled properly and taken to the laboratory for appropriate analysis.

2.2 Methods

2.2.1 Sample Preparation for Determination of Heavy Metal Concentrations

Sample preparation for the heavy metal analysis in cosmetics involved digestion with concentrated acids according to the procedures described by Sahu *et al*. (2014). Briefly, each sample (about 1 g) was digested with a mixture of concentrated HNO3 and HClO4 in a 3:1 ratio (25 mL) for 1-2 hours on a hot plate. The digestion process continued till no evolution of white fumes was observed. Each digested sample was dissolved in distilled water (10 mL) and filtered through a Whatman No. 4 filter paper into a 100-mL volumetric flask and made up to the mark with distilled water ready for the metal analysis in AAS.

2.3 Statistical Analysis

Descriptive statistics (mean and standard error) was used to analyze results obtained for different heavy metals and pesticides in each grain. All analyses were performed using GraphPad prism 6 software.

3.0 Results

3.1 List of Selected Personal Care Products (PCPs) used by Students of Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria

The analysis of selected personal care products (PCPs) used by students across six locations at Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria, revealed significant inconsistencies in product labeling and regulatory compliance.

Among the products evaluated, several were found without NAFDAC registration numbers. They were no NAFDAC numbers in compact powder in Location 1 and the powder in Location 2, likewise, the foundation in Location 5 was similarly unregistered. Moreover, crucial information such as net weight, manufacturing dates, and expiry dates were missing in a number of products. The luxury radiance foundation in Location 1 and the lip gloss in Location 2 lacked both manufacturing and expiry dates, creating potential risks for users due to the uncertainty of the products' shelf life. However, some products, like the body cream from Location 4 and the powder from Location 5, had complete and compliant information, indicating a mix of regulated and unregulated products in circulation among the students.

Table 3.1: List of Selected Personal Care Products (PCPs) used by Students of Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria

S/No	PCP	Location	Product name	NAFDAC No	Net Weight	Manufacturing Date	Expiry Date
1	Powder	L1	Compact powder	-	06202/20 g	11/2023	11/2026
2	Foundation	L1	Luxury radiance	-	45g	-	-
3	Lip gloss	L1	Asolute			2022	2025
4	Body cream	L1	Clear Therapy	0723	250ml/18.456/102	11/2023	11/2025
5	Powder	L2	Green tea	-	-	11/2020	11/2025
6	Foundation	L2	Normal bliss	Ny10118	-	-	-
7	Lip gloss	L2	-	-	-	-	-
8	Body cream	L2	Skin pride	0013	380ml	04/2023	04/2026
9	Powder	L3	Fair makeup	-	21.68g	2023/09	2027/09
10	Foundation	L3	Adventure	-	30ml/101/fl0z	-	-
11	Lip gloss	L3	Shine Luobalabra	CBB158	-	-	-
12	Body cream	L3	African queen	A2-5639	275ml	07/2023	07/2026
13	Powder	L4	Melilai compact		1bo1040313		
14	Foundation	L4	HD foundation	30ml	-	-	-
15	Lip gloss	L4	Beauty model	CBB158	-		
16	Body cream	L4	Body treat	02-4793	-	05/2023	05/2025
17	Powder	L5	Sacha macre			09/2023	09/2027
18	Foundation	L5	Mary kay	-	1f/02/29ml	-	-
19	Lip gloss	L5	Aloe lipgloss	-		-	-
20	Body cream	L5	Dove fair body smooth	LG2214	15g10.53f10.2	12/12/2023	12/12/2026
21	Powder	L6	Msyaho		21.6g	2023/09	2023/09
22	Foundation	L6	Zaron	F002		09/2023	09/2026
23	Lip gloss	L6	Absolute	-	-	19/02/2024	13/08/2028
24	Body cream	L6	Skin docker	-	-	-	-

LI= Location 1 (Assembly lodge), L2= Location 2 (Precious lodge), L3= Location 3 (Victory lodge), L4= Location 4 (MH hostel), L5= Location 5 (FH hostel), L6= Location 6 (Inikpi hostel)

3.2: Heavy Metal Concentrations in 'Foundation' Samples from Different Locations

Result showed that lead was not detected in the cosmetic samples collected from different locations except sample sourced from location 1 which recorded a lead concentration of 0.43 mg/kg. Chromium concentration of the cosmetic samples ranged from 0.23-045 mg/kg. The concentration of cadmium ranged from 0.37-0.58mg/kg. Arsenic and mercury concentration ranged from 1.25-2.28 and 0.21-5.23 mg/kg respectively. The result obtained showed that samples from location 1, 2 and 3 exhibited elevated concentration of cadmium exceeding the WHO MPLs, likewise samples from locations 2, 3, 4, 5 and 6 showed high level of mercury exceeding the WHO MPLs. Encouragingly, all samples had lead and chromium concentration below the WHO permissible limits, indicating relatively safe level.

Table 3.2: Heavy Metal Concentrations in 'Foundation' Samples from Different Locations

Heavy metals (mg/kg)	MPLs	L1	L2	L3	L4	L5	L6
Lead, Pb	10.00	0.43 ± 0.01	ND	ND	ND	ND	ND
Chromium, Cr	1.00	BDL	0.45 ± 0.02	BDL	0.23 ± 0.01	BDL	BDL
Cadmium, Cd	0.30	0.44 ± 0.00*	0.58 ± 0.01*	0.37 ± 0.01*	BDL	BDL	BDL
Arsenic, As	3.00	1.45 ± 0.23	2.22 ± 0.45	1.85 ± 0.05	1.25 ± 0.85	1.58 ± 0.47	2.28 ± 0.10
Mercury, Hg	1.00	0.81 ± 0.01	2.3 ± 0.06*	1.83 ± 0.09*	5.23 ± 0.11*	3.42 ± 0.12*	5.73 ± 0.16*

*Values for heavy metal concentrations were expressed as mean of triplicate determinations; LI= Location 1 (Assembly lodge), L2= Location 2 (Precious lodge), L3= Location 3 (Victory lodge), L4= Location 4 (MH hostel), L5= Location 5 (FH hostel), L6= Location 6 (Inikpi hostel), BDL= Below Detection Limit, ND= Not detected, MPLs = Maximum Permissible Limit (WHO, 2016), * Exceeded MPL*

3.3: Heavy Metal Concentrations in 'Face Powder' Samples from Different Locations

The results of heavy metals concentration in face powder from different locations in Anyigba are presented in Table 3.3. Lead concentration in all the face powder samples from the 6 different locations ranged from 0.46-20.60 mg/kg. Chromium level ranged from 0.44-0.68 mg/kg. Cadmium was not detected in all the face powder sample from the 6 different locations. Arsenic and mercury ranged from 1.78-2.11 mg/kg and 2.45 - 3.01 mg/kg respectively. None of these metals was higher than the WHO maximum permissible limits in all the face powder samples collected from 4 different locations in Anyigba except cadmium (location 1 and 4) and mercury (location 1 and 2) which had high values above WHO MRLs.

Table 3.4: Heavy Metal Concentrations in 'Face Powder' Samples from Different Locations

Heavy metals (mg/kg)	MPLs	L1	L2	L3	L4	L5	L6
Lead, Pb	10.00	20.00 ± 1.01*	5.21 ± 0.46	4.96 ± 0.75	18.24 ± 1.55*	3.05 ± 0.96	6.11 ± 0.71
Chromium, Cr	1.00	0.68 ± 0.01	0.44 ± 0.01	ND	0.56 ± 0.02	ND	ND
Cadmium, Cd	0.30	BDL	BDL	BDL	BDL	BDL	BDL
Arsenic, As	3.00	ND	ND	ND	ND	2.11 ± 0.01	1.78 ± 0.09
Mercury, Hg	1.00	2.45 ± 0.01*	3.01 ± 0.05*	BDL	BDL	BDL	BDL

*Values for heavy metal concentrations were expressed as mean of triplicate determinations; LI= Location 1 (Assembly lodge), L2= Location 2 (Precious lodge), L3= Location 3 (Victory lodge), L4= Location 4 (MH hostel), L5= Location 5 (FH hostel), L6= Location 6 (Inikpi hostel), BDL= Below Detection Limit, ND= Not detected, MPLs = Maximum Permissible Limit (WHO, 2016), * Exceeded MPL*

3.5: Heavy Metal Concentrations in 'Lip Gloss' Samples from Different Locations

The results of heavy metals concentration in lip gloss from different locations in Anyigba are presented in Table 3.4. Lead concentration ranged from 3.22-15.23 mg/kg. Chromium and cadmium were not detected in all the lipgloss samples collected from the 6 different location, while arsenic and mercury ranged from 1.14-1.78 mg/kg and 0.28- 0.32 mg/kg respectively. None of these metals was higher than the WHO maximum permissible limits in all the lipglose samples collected from 6 different locations in Anyigba except samples from location 1 and 4 which recorded a higher lead concentration above WHO maximum permissible limits.

Table 3.5: Heavy Metal Concentrations in 'Lip Gloss' Samples from Different Locations

Heavy metals (mg/kg)	MPLs	L1	L2	L3	L4	L5	L6
Lead, Pb	10.00	10.67 ± 1.34*	15.23 ± 1.26*	7.55 ± 0.98	12.49 ± 1.26*	3.22 ± 0.85	6.11 ± 0.92
Chromium, Cr	1.00	ND	ND	ND	ND	ND	ND
Cadmium, Cd	0.30	ND	ND	ND	ND	ND	ND
Arsenic, As	3.00	1.45 ± 0.57	1.26 ± 0.15	1.14 ± 0.94	1.78 ± 0.46	1.21± 0.20	1.32 ± 0.74
Mercury, Hg	1.00	0.32 ± 0.01	0.28 ± 0.00	BDL	BDL	BDL	BDL

*Values for heavy metal concentrations were expressed as mean of triplicate determinations; LI= Location 1 (Assembly lodge), L2= Location 2 (Precious lodge), L3= Location 3 (Victory lodge), L4= Location 4 (MH hostel), L5= Location 5 (FH hostel), L6= Location 6 (Inikpi hostel), BDL= Below Detection Limit, ND= Not detected, MPLs = Maximum Permissible Limit (WHO, 2016), * Exceeded MPL*

3.6 Heavy Metal Concentrations in 'Body Cream' Samples from Different Locations

The results of heavy metals concentration in body cream from different locations in Anyigba are presented in Table 3.5. Lead was not detected in all the samples collected from the 6 different location. The concentration of chromium, cadmium, arsenic and mercury ranged from 0.25-0.51 mg/kg, 0.11-0.41 mg/kg, 1.03-2.50 mg/kg and 1.89-2 mg/kg. From the result obtained, none of this heavy metals were above WHO MRLs except for cadmium which had higher value above WHO MPLs in body cream collected from location 6, mercury which was higher in sample collected from location 1, 2, 3 and 4

Table 3.6: Heavy Metal Concentrations in 'Body Cream' Samples from Different Locations

Heavy metals (mg/kg)	MPLs	L1	L2	L3	L4	L5	L6
Lead, Pb	10.00	BDL	BDL	BDL	BDL	BDL	BDL
Chromium, Cr	1.00	ND	0.25 ± 0.01	0.44 ± 0.06	ND	ND	0.51 ± 0.01
Cadmium, Cd	0.30	ND	0.20 ± 0.01	0.11 ± 0.00	ND	ND	0.41 ± 0.04*
Arsenic, As	3.00	1.37 ± 0.21	1.83 ± 0.21	2.05 ± 0.26	1.23 ± 0.11	2.50 ± 0.26	1.03 ± 0.01
Mercury, Hg	1.00	1.89 ± 0.01*	2.44 ± 0.20*	2.78 ± 0.52*	1.99 ± 0.22*	ND	ND

*Values for heavy metal concentrations were expressed as mean of triplicate determinations; LI= Location 1 (Assembly lodge), L2= Location 2 (Precious lodge), L3= Location 3 (Victory lodge), L4= Location 4 (MH hostel), L5= Location 5 (FH hostel), L6= Location 6 (Inikpi hostel), BDL= Below Detection Limit, ND= Not detected, MPLs = Maximum Permissible Limit (WHO, 2016), * Exceeded MPL*

4. 0 Discussion

Majority of the cases, unregulated chemical content of skin lightening products, especially in developing countries is alarming, whereas, the European Union Cosmetics Directive highlights the lead and their compounds as unacceptable constituents of cosmetic products (Tamara and Everaldo, 2022). The cosmetic product includes whitening cream and lipstick of different brand and colour and they are commonly used products among students in Anyigba. The heavy metals were detected in some of the samples with varying concentration. It is very important understand the maximum permissible concentration of heavy metals among the different age groups where as children are more susceptible to heavy metal poisoning compared to adults, quantum of product used and the site of applied (Ababneh and Al-Momani, 2018).

Table 3.1 revealed some personal care products (PCPs) used by students across six locations at Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria. Across the six locations, a total of 24 personal care products were identified. Notably, several products lacked NAFDAC registration numbers, which are essential for regulatory compliance. For instance, the compact powder from Location 1 and the luxury radiance foundation lacked NAFDAC numbers, such as several other products across the locations. Additionally, the net weight and expiry dates were missing in some entries, raising concerns about the authenticity and safety of these products. Although, most products had manufacturing and expiry dates, a few, such as the lip gloss in Location 2 and the foundation in Location 5, did not, which could lead to potential health risks from the use of expired or improperly stored products (Tamara and Everaldo, 2022).

The permissible limit of Pb in cosmetic products recommended by WHO is 10.00 mg/kg. Result showed that lead was not detected in the foundation samples collected from different locations except sample collected from location 1 which recorded a lead concentration of 0.43 mg/kg (Table 3.2). The estimated concentration of Pb in the face powder collected from different locations in Anyigba ranged from 0.46-20.60 mg/kg. This concentration is however, below the permissible limit except in the sample sourced from location 1 and 4, which recorded the lead concentration of 20.00 and 18.44 mg/kg that is above the 10.00 mg/kg permissible limit set by WHO (Table 3.3). Likewise, lip gloss obtained from obtained from location 1 and 4 recorded a high concentration of lead above WHO permissible limits (Table 3.4). However, lead was not detected in all the body cream analysed (Table 3.5). The values recorded in the face powder and lip gloss collected from location 1 and 4 was higher than the value reported by Prakash and Manjushree (2019) in India. They are also higher than the level reported by Lim *et al*., (2018). Given the high lead concentration detected in some samples from Anyigba, there is a potential

public health risk, especially for consumers who use these products regularly. Chronic exposure to cadmium through contaminated cosmetics could lead to long-term health consequences. The presence of lead above the MPL in cosmetics is particularly alarming due to its well-documented toxic effects. Lead is a heavy metal that can accumulate in the body over time, leading to serious health issues. Prolonged exposure, even at low levels, has been linked to kidney damage, bone demineralization, and an increased risk of cancer, particularly lung and breast cancer. In the context of cosmetics, lead can be absorbed through the skin or ingested inadvertently when products like lipsticks are used (Vafaei *et al*., 2018).

Chromium is a naturally occurring element that is widely distributed in the earth crust. Chromium exist both in organic and inorganic forms also in found in nature and in manmade products. Low levels of chromium are found in soil, water and air (Ezeilo *et al*., 2020). The permissible limit of chromium in cosmetic products recommended by WHO is 1.0 mg/kg. In the foundation sample, the concentration of chromium was recorded below the permissible limit. The estimated concentration of chromium in the rice samples ranged from 0.23 0.45 mg/ kg (Table 3.2). The presence of chromium in the face powder samples sourced from different locations ranges from 0.44-0.58 mg/kg (Table 3.3). For lip gloss and body cream, the chromium was not detected (Table 3.4 and 3.5). The results showed that the level of the heavy metal (chromium) in all the cosmetic samples (foundation, face powder, lip gloss and body cream) collected from different location were below the maximum limit set by World Health Organization. Research from different parts of the world has reported varying levels of chromium in cosmetics, sometimes exceeding permissible limits. For example, studies in India and Europe have found chromium concentrations in some cosmetics ranging from trace amounts to several mg/kg, occasionally surpassing the MPL, which raises concerns due to chromium's potential health risks (Malvandi and Sancholi, 2018).

Although the levels detected in these samples are within safe limits, high concentrations of chromium in cosmetics can have significant health implications. Chromium, especially in its hexavalent form (Cr(VI)), is a known carcinogen and can cause allergic reactions, including contact dermatitis, when applied to the skin. Prolonged exposure to elevated levels of chromium through cosmetic use could lead to chronic skin conditions and, in severe cases, increase the risk of cancer (Poccinini *et al*., 2013).

The presence of Cd in the foundation samples collected from different location ranged from 0.37-0.58 mg/kg. The recorded Cd concentration in the foundation sample collected from location 1-3 were above the maximum permissible concentration of 0.30 mg/kg set by W.H.O (Table 3.2). For the face powder and lip gloss collected from different location, the concentration of cadmium was not detected (Table 3.3 and 3.4). Cadmium in body cream ranged from 0.11-0.41 mg/kg. Given the high cadmium levels detected in some samples from Anyigba, there is a potential public health risk, especially for consumers who use these products regularly. Chronic exposure to cadmium through contaminated cosmetics could lead to long-term health consequences. The presence of cadmium above the MPL in cosmetics is particularly alarming due to its well-documented toxic effects. Cadmium is a heavy metal that can accumulate in the body over time, leading to serious health issues. Prolonged exposure, even at low levels, has been linked to kidney damage, bone demineralization, and an increased risk of cancer, particularly lung and breast cancer. Cadmium can be absorbed through the skin or ingested inadvertently when products like lipsticks are used (Alam *et al*., 2019).

Cd has no known biological functions in the body but it interferes with some essential function of Zn, thereby inhibiting enzyme reactions and nutrient utilization. It catalyzes oxidation reactions, generating free-radical tissue damage. Zinc, an essential trace element is more toxic in salt form than in elemental form. Its ingestion causes gastrointestinal toxicity, pulmonary

toxicity, nephrotoxicity and neurotoxicity (Chavatte *et al*., 2020). Though there has been paucity of information on reported carcinogenicity by oral route, most classifications are based on occupational exposure to cadmium with inhalation as the primary route of exposure. A study also reported an association between environmental exposure to cadmium and cancer via tropical exposure (Alam *et al*., 2019).

Arsenic concentration in the foundation samples obtained from different location in Anyigba, Kogi State Nigeria ranged from 1.25-2.28 mg/kg (Table 3.2). For the face powder, the estimated concentration of the samples ranged from 1.78-2.118mg/kg (Table 3.3) while the arenic concentration of lip gloss and body cream samples ranged from 1.14-1.78 mg/kg and 1.03-2.05 mg/kg respectively (Table 3.4 and 3.5). The results of this study indicates that arsenic concentration of the cosmetic samples sourced from different location in were below the maximum permissible concentration of 3.00 mg/kg set by WHO, making it safe without posing any serious health issues. In the long term, toxicity might however, arise from chronic accumulation of arsenic if these products are continuously used. The range estimated in this study is however, lower than the report of Prakash and Manjushree (2019) in India.

Arsenic is a well-known carcinogen and can cause a range of health problems with prolonged exposure. Chronic exposure to arsenic, even at low levels, can lead to skin lesions, cardiovascular diseases, neurotoxicity, and an increased risk of various cancers, including skin, bladder, and lung cancer. According to Alam (2019), the presence of arsenic in cosmetics, even below the MPL, warrants attention. Consumers using these products regularly may face cumulative exposure, leading to potential health risks over time.

The elevated levels of mercury found in some of the cosmetic samples from Anyigba carry serious health implications. Mercury is a highly toxic metal with detrimental effects on various organs and systems in the body. When absorbed through the skin, mercury can lead to a range of acute and chronic health issues. Chronic exposure to mercury is particularly concerning because it can result in significant neurological damage. Mercury is known to be a neurotoxin that affects the central nervous system, potentially causing symptoms such as tremors, cognitive decline, memory loss, and mood disturbances. Over time, exposure can lead to more severe neurological disorders, including tremor disorders and peripheral neuropathy, which can severely impact a person's quality of life. The kidneys are also at risk from mercury exposure. The metal tends to accumulate in renal tissues, where it can disrupt normal kidney function. This can lead to kidney damage and, in severe cases, kidney failure. The gradual buildup of mercury in the kidneys can impair their ability to filter toxins from the blood effectively, resulting in broader systemic effects and potentially life-threatening conditions (Saadatzadeh *et al*., 2019).

Chronic mercury exposure is linked to cardiovascular problems. Research has shown that long-term exposure to mercury can contribute to hypertension and increase the risk of cardiovascular diseases, including heart attacks and strokes. This is due to mercury's impact on the cardiovascular system, which can lead to vascular inflammation and damage. Pregnant women are particularly vulnerable to the effects of mercury. The metal can cross the placental barrier and accumulate in the developing fetus, leading to serious developmental and neurological issues. Infants exposed to mercury in utero can suffer from developmental delays, cognitive impairments, and motor skill deficiencies. The long-term consequences for these children can include learning difficulties and behavioral problems (Lim *et al*., 2018).

The high levels of mercury detected in the cosmetic samples can result to a significant public health risk. The potential for serious health issues, including neurological damage, kidney impairment, cardiovascular problems, and developmental harm to unborn children, highlights the need for stringent quality control and regulatory measures to prevent mercury contamination in cosmetic products (Soo *et al*.,

2003). Ensuring that these products are free from harmful levels of mercury is crucial to safeguarding consumer health. Mercury, particularly in its methylmercury form, is highly toxic and poses significant health risks, especially to vulnerable populations such as pregnant women, infants, and young children. The primary route of mercury exposure is through inhalation of vaporized mercury, ingestion of contaminated food or water, and dermal contact with mercury-containing dust. Systemically, Hg may exhibit a range of signs which include vomiting, nausea and kidney damage, central nervous system effect which include irritability, tremors, weakness, nervousness, fatigue and memory loss. It may affect also the sensorial systems, that is, loss in hearing, taste and vision. Finally, high Hg content may lead to death (Agorku *et al*., 2016). In some instances, following dermal absorption and systemic uptake, Hg may induce autoimmune glomerulonephritis. Studies reveal significant accumulation of mercury in several organs and body fluids, such as hair (22.5 ppm, twice that in non-cosmetic users), blood (up to 233 nmol/l, more than four times than that in non-cosmetic users] and urine (up to 2531 nmol/day, fifty times more than that in non-cosmetic users) (Soo *et al*., 2003). Chronic exposure to mercury, even at low levels, can lead to severe neurological and developmental disorders. In children, exposure to mercury can impair cognitive functions, motor skills, and cause developmental delays. In adults, chronic exposure is associated with tremors, memory problems, and in severe cases, kidney damage, and respiratory failure (Soo *et al*., 2003).

Conclusion

The analysis of cosmetic products from various locations reveals significant contamination with heavy metals, particularly lead, mercury, and cadmium. In several samples, mercury levels exceeded the Maximum Permissible Limits (MPLs), especially in foundations and body creams. Additionally, face powders and lip glosses showed lead concentrations well above the MPL, raising serious concerns due to the toxic nature of lead and its potential health impacts. The consistent detection of these heavy metals across different cosmetic products indicates a widespread issue that poses a substantial risk to consumer health. Due to the frequent and direct application of these products, the potential for chronic exposure is high, which could lead to long-term health complications. These findings highlight the urgent need for stricter regulatory oversight and rigorous quality control within the cosmetics industry to ensure that products are safe for consumer use and free from harmful levels of heavy metals.

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