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ASSESSMENT OF HEAVY METALS IN SELECTED PERSONAL CARE PRODUCTS IN AKURE METROPOLIS, NIGERIA AND RISK FOR HUMAN HEALTH

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Abstract - This study was undertaken in order to determine the concentration of heavy metals in selected personal care products purchased within Akure city, Nigeria. It was undertaken to make a comparative metal composition in personal care products with information reported in different literature. Samples were analysed for heavy metals using Atomic Absorption Spectroscopy (AAS) after dry ashing. The mean concentration was analysed in the samples for Cr, Cd, Co, Mn, Zn, Ni, Pb, and Cu while also the estimated daily intake and health risk index are considered. The concentration of Mn in face powder samples has the highest with a range of ND (not detected) to 3.30 mg/kg followed by Zn concentration with a range of 0.35 to 0.47 mg/kg. Metals of Pb, Ni, Cr, and Cd were not detected for most of the samples, while the concentration of Mn Cu and Zn were detected mostly with a mean concentration of Mn ranging from ND to 0.37 mg/kg for eye pencil samples, 0.04 to 0.13mg/kg for soap samples, and 0.05 to 0.07mg/kg. The possible effects of metals have both acute and chronic effects and this has called for the continual need of government agencies to regulate the toxic metals in consumer products including personal care products.

Key Words: Personal Care Products, Health Risk Index, Oral Reference Doses, Heavy Metals, Atomic Absorption Spectroscopy

I. INTRODUCTION

Over the centuries, Humans have been more sensitive and conscious of their appearance and their appeal toward themselves and others which has imbedded into Humans of the deliberate consciousness to take care of itself and in this event, exposure to different matter which has different level of dangers can occur, that is

in the search to improve and be improved. Humans' self-consciousness span through to the physical appearance in need to look healthier, appear young (and younger if possible), looking attractive and so on. These every day needs over the years have given birth to personal care products [1] which are used varyingly in quantity depending on the individual, the standard of living, location, race, culture, and religion.

Personal care products are consumer products used in personal hygiene and for beautification, these include shampoo, facial treatments, toothpaste, toilet paper, shaving cream, moisturizer, talcum powder, facial cleanser, hand soap, makeup, lotion, lip balm, lipstick, lip gloss, hair clippers, facial tissue, eyeliner, deodorant, cotton pads and so on [2-3]. Personal care products (PCP) have contributed to the level of metal intake into the body and some of the products contain heavy metals as its components and these metals are usually dangerous when accumulation occurs. Heavy metals such as chromium has been described to have its Cr(VI) to be more toxic and more mobile (with labile centre) than trivalent chromium which is inert and in biological pH its trivalent undergoes precipitation as hydroxide while its hexavalent chromium remains in the solution [4]. Cr is associated with allergic dermatitis[5] and Chromium hydroxide $[\text{Cr}_2\text{O}(\text{OH})_4]$ and chromium oxide $[\text{Cr}_2\text{O}_3]$ are used as colouring agents in cosmetic products such as eye shadow [6]. Eye cosmetics such as eye pencils have been identified as a suspected source of Pb exposure to the ocular system in a number of adults and children. The use of leaded eye cosmetics has been observed to be strongly correlated with elevated blood Pb levels [7]. Cd metal gets absorbed by humans which will accumulate inside the body throughout life. Lead is an extremely toxic heavy metal that disturbs various plant physiological processes and unlike other metals, such as zinc, copper, and manganese, it does not play any



biological functions. Heavy metals contamination may occur through different means such as through diet, from medications, from the environment [8]. Dermal exposure has been suggested to be the most significant route because most of the cosmetics products are directly applied to the skin [9]. Oral exposure can occur from wearing cosmetics products containing heavy metal impurities around the mouth and also from hand to mouth contact [6]. The Heavy metal ions which come in contact with the human body, get absorbed and form complexes with carboxylic acid ($-\text{COOH}$), amine ($-\text{NH}_2$), and thiol ($-\text{SH}$) of proteins resulting in malfunctioning or death of the cells and consequently lead to various diseases [10]. The toxicity of metal ions to human systems is due to the chemical reactivity of the ions with cellular structural proteins, enzymes and membrane systems. Toxicity of a specific metal occurs in organs that accumulate the highest concentration of the metals, which is often dependent on the route of exposure and the chemical compound of the metal which will lead to the formation of a complex compound. The treatment of metal intoxication is achieved by using chelation therapy that binds with the metal ions and the complexes are then eliminated from the body [11]. The skin absorption of salt of heavy metals varies with different parameters [12]. Metals have been shown to causes acute as well as chronic poisoning in humans and other experimental animals. Cadmium and cadmium compounds are known human carcinogens. Ingesting very high levels severely irritates the stomach, leading to vomiting and diarrhea [13]. Cadmium in the environment is toxic to plants and animals and many micro-organisms. Manganese can be regarded as an essential metal for the body but the introduction of methylcyclopentadienyl manganese tricarbonyl (MMT) as a gasoline additive became world concerns. MMT has been linked with the development of Parkinson's disease-like syndrome. Exposure to elevated levels of manganese can result in Manganism (neurotoxicity), characterized by rigidity, tremor, a mask-like expression, gait disturbances, bradykinesia, micrographia, memory and cognitive dysfunction, and mood disorder. The symptoms of manganism are very similar to that of Parkinson's disease. [14]. The consequence of Cu accumulation leads to Wilson's disease and is generally ascribed to Cu-induced oxygen radical-mediated damage [15-16].

In a report by Health Canada on cosmetic products, 100% of all products subjected to test, tested positive for nickel and over 90% tested positive for both lead and beryllium [17]. They report at least 4 of the 8 metals of concern (arsenic, cadmium, lead, mercury, beryllium, nickel, selenium, and thallium) on average.

Furthermore, Health Canada listed metals such as Ar, Pb, and Hg as being banned and some restricted such as aluminum, also Health Canada defined guidelines on heavy metal impurities in cosmetics products with specificity in limit of 1 mg/kg for mercury, 10 mg/kg for Lead and 3 mg/kg for arsenic [17]. The German Federal Government also reported on metal contents in various cosmetic products and metal levels as an impurity in cosmetic products were given a limit of 5 mcg / g for As, 1 mcg/g for Hg, 20 mcg/g for Pb. [18]. Due to the toxicity level been known, the US FDA [19] puts a ban on nine ingredients which include coal tar colors, bithionol, chlorofluorocarbons propellants, chloroform, halogenated salicylanilides, hexachlorophen, methylene chloride, vinyl chloride, zirconium containing complexes, mercury, and sunscreen in cosmetic products, also Directive 76/768/EEC banned the use of heavy metals, Cd, Co, Cr, Ni, and Pb as impurities in the preparation of cosmetics [20].

PCPs contain different level of heavy metals, even though research has shown various result but new batches of these products have always been produced with improved and totally new products claiming specific care, also combination of these products usage can lead to increase of heavy metal intake through different surface of the body thus accumulating the percentage in the body which can lead to issues and complication to human health. Furthermore, since it is hard to keep track of the safety of all personal care products a continual check of products is of necessity. Thus this study is aimed at the determination of heavy metals present in selected personal care products which are used in Akure, Ondo State, Nigeria, and to determine the estimated daily intake of these metals in each selected PCPs.

II. MATERIALS AND METHODOLOGY

Sample collections

Eighteen cosmetics (PCPs) samples inform of eye pencils, makeup powders, soaps, and detergents were bought from stores and various shops in the Oja Oba market, Akure, Nigeria.

Reagents and chemicals used were distilled water, Analytical grade nitric acid (95%) and perchloric acid (70%), 10% nitric acid and 1M nitric acid.

Sample preparation

Glassware and plastic were washed, rinsed with tap water and soaked in 5% HNO_3 solution for 24 hours. They were then rinsed with distilled water. The samples were each oven-dried to a constant weight and



0.2g each was weighed into porcelain crucible, it was pre-ashed on a hot plate in the fume hood to eliminate most of its organic contents, before been dry-ashed in a muffle furnace by a stepwise increase of temperature to 550°C for several hours [21]. The ashed samples were cooled and 5ml of 1M HNO₃ was added, diluted to 50ml and filtered through Whatman No. 42 into sample bottles ready for analysis this process was done in triplicate for each sample.

III. SAMPLE ANALYSIS

All samples were analysed in triplicate with Atomic Absorption Spectroscopy for Cadmium, Nickel, Lead, Manganese, Copper, Zinc, Cobalt, and Chromium using BUCK SCIENTIFIC model 210 (AAS).

Table 1 sample ID used in this study

Face powders(makeups)	Eye pencils	Soaps	detergents
P1	E1	S1	D1
P2	E2	S2	D2
P3	E3	S3(medicated)	
P4	E4	S4(medicated)	
P5	E5		
P6	E6		

IV. STATISTICAL ANALYSIS

Data collected were tabulated and analysed using SPSS version 22.0 to find a statistical difference between the concentrations of the element, one-way ANOVA was applied at a 95% confidence level.

V. RISK ASSESSMENT

Risk assessment of metal-contaminated cosmetic products to human health was characterized by estimated daily intake (EDI) which is expressed in mg/kg/day and health risk index (HRI). The estimated daily intake (EDI) was calculated to estimate the daily metal intake by the body system of specified bodyweight of a consumer, the EDI was calculated using the following formula [22-24].

$$EDI = \frac{C \times D_f}{BW}$$

Where EDI is the estimated daily of metals (mg/kg/day); C is the concentration of the metal under consideration in (mg/kg); D_f is the daily intake of a fraction of cosmetic products and BW is the body weight (kg) which is taken to be 70kg in this study. The HRI was calculated from the EDI of metals and Reference Oral Dose (RfD). The R_fD is an estimated

exposure of metal to the human body per day that has no effect during lifetime [23]. The formula below was used to calculate the HRI.

$$HRI = \frac{EDI}{RfD}$$

The value of oral reference doses (RfD) for the heavy metals considered in this study are summarized in Table 2 [23,25]. The values of D_f used were derived from SCCS (Scientific Committee on Consumer Safety)[26].

Table 2 Reference Oral Doses for selected metals

Heavy metals	Cr	Cu	Mn	Zn
RfD (mg/kg/day)	1.5	0.04	0.005	0.3

VI. RESULT AND DISCUSSION

The mean concentration (mean ± standard deviation) of heavy metals in face powders (P), eye pencils (E), soap (S) and detergents (D) samples are presented respectively in table 3, 4, 5 and 6.

Table 3 Mean concentration (mean ± standard deviation) of heavy metals in selected face powder samples

SAMPLES	P1	P2	P3	P4	P5	P6
Mn (mg/kg)	ND	3.30±0.019	ND	ND	1.24±0.036	3.30±0.152



Cu (mg/kg)	ND	0.14±0.004	0.13±0.005	ND	ND	0.14±0.019
Zn (mg/kg)	ND	0.81±0.056	ND	ND	ND	0.76±0.058
Co (mg/kg)	ND	ND	ND	ND	ND	ND
Cr (mg/kg)	ND	0.1715±0.0085	ND	ND	ND	ND
Cd (mg/kg)	ND	ND	ND	ND	ND	ND
Pb (mg/kg)	ND	ND	ND	ND	ND	ND
Ni (mg/kg)	ND	ND	ND	ND	ND	ND

ND- not detected

Table 4 Mean concentration (mean ± standard deviation) of heavy metals in selected eye pencil samples

SAMPLES	E1	E2	E3	E4	E5	E6
Mn (mg/kg)	ND	0.33±0.043	0.37±0.020	ND	ND	0.05±0.005
Cu (mg/kg)	ND	ND	0.12±0.009	ND	ND	0.05±0.001
Zn (mg/kg)	0.07±0.008	0.72±0.056	0.65±0.051	0.03±0.014	0.04±0.004	0.19±0.005
Co (mg/kg)	ND	ND	ND	ND	ND	ND
Cr (mg/kg)	ND	ND	ND	ND	ND	ND
Cd (mg/kg)	ND	ND	ND	ND	ND	ND
Pb (mg/kg)	ND	ND	ND	ND	ND	ND
Ni (mg/kg)	ND	ND	ND	ND	ND	ND

ND-not detected

Table 5 Mean concentration (mean ± standard deviation) of heavy metals in selected soap samples

SAMPLES	S1	S2	S3	S4
Mn (mg/kg)	0.04±0.006	0.07±0.005	0.13±0.004	0.09±0.006
Cu (mg/kg)	0.03±0.004	0.05±0.001	0.12±0.002	0.18±0.010
Zn (mg/kg)	0.16±0.011	0.21±0.003	0.64±0.006	0.23±0.014
Co (mg/kg)	ND	ND	ND	ND
Cr (mg/kg)	ND	ND	ND	ND
Cd (mg/kg)	ND	ND	ND	ND
Pb (mg/kg)	ND	ND	ND	ND
Ni (mg/kg)	ND	ND	ND	ND



ND – not detected

Table 6 Mean concentration (mean ± standard deviation) of heavy metals in selected detergents samples

SAMPLES	D1	D2
Mn (mg/kg)	0.07±0.010	0.05±0.006
Cu (mg/kg)	0.05±0.006	0.05±0.003
Zn (mg/kg)	0.09±0.003	0.14±0.005
Co (mg/kg)	ND	ND
Cr (mg/kg)	ND	ND
Cd (mg/kg)	ND	ND
Pb (mg/kg)	ND	ND
Ni (mg/kg)	ND	0.1455±0.00808

ND- not detected

Calculated Estimated daily intake (EDI) for each metals concentration detected in each sample and the health risk index (HRI) of each metals are presented in table 7 and table 8 respectively.

Table 7 Estimated Daily Intake (EDI)

Samples	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
P1	-	-	-	-	-	-	-	-
P2	-	-	1.25×10 ⁻⁶	1.02×10 ⁻⁶	2.40×10 ⁻⁵	-	-	5.9×10 ⁻⁶
P3	-	-	-	9.47×10 ⁻⁷	-	-	-	-
P4	-	-	-	-	-	-	-	-
P5	-	-	-	-	9.03×10 ⁻⁶	-	-	-
P6	-	-	-	1.02×10 ⁻⁶	2.40×10 ⁻⁵	-	-	5.54×10 ⁻⁶
E1	-	-	-	-	-	-	-	5.0×10 ⁻⁹
E2	-	-	-	-	2.36×10 ⁻⁸	-	-	5.14×10 ⁻⁸
E3	-	-	-	8.57×10 ⁻⁹	2.64×10 ⁻⁸	-	-	4.64×10 ⁻⁸
E4	-	-	-	-	-	-	-	2.14×10 ⁻⁹
E5	-	-	-	-	-	-	-	2.86×10 ⁻⁹
E6	-	-	-	3.57×10 ⁻⁹	3.57×10 ⁻⁹	-	-	1.36×10 ⁻⁸
S1	-	-	-	8.14×10 ⁻⁸	1.09×10 ⁻⁷	-	-	4.34×10 ⁻⁷
S2	-	-	-	1.36×10 ⁻⁷	1.9×10 ⁻⁷	-	-	5.70×10 ⁻⁷
S3	-	-	-	3.26×10 ⁻⁷	3.53×10 ⁻⁷	-	-	1.74×10 ⁻⁶
S4	-	-	-	4.89×10 ⁻⁷	2.44×10 ⁻⁷	-	-	6.24×10 ⁻⁷

Table 8 Health Risk Index (HRI)

Samples	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
P1	-	-	-	-	-	-	-	-
P2	-	-	8.0×10 ⁻⁷	3.0×10 ⁻⁵	4.81×10 ⁻³	-	-	2.0×10 ⁻⁵
P3	-	-	-	2.0×10 ⁻⁵	-	-	-	-
P4	-	-	-	-	-	-	-	-
P5	-	-	-	-	1.81×10 ⁻³	-	-	-
P6	-	-	-	3.0×10 ⁻⁵	4.81×10 ⁻³	-	-	2.0×10 ⁻⁵



E1	-	-	-	-	-	-	-	2.0×10^{-8}
E2	-	-	-	-	4.71×10^{-6}	-	-	2.0×10^{-7}
E3	-	-	-	2.0×10^{-7}	5.29×10^{-6}	-	-	2.0×10^{-7}
E4	-	-	-	-	-	-	-	7.0×10^{-9}
E5	-	-	-	-	-	-	-	1.0×10^{-8}
E6	-	-	-	9.0×10^{-8}	7.14×10^{-7}	-	-	5.0×10^{-8}
S1	-	-	-	2.0×10^{-6}	2.17×10^{-5}	-	-	1.0×10^{-6}
S2	-	-	-	3.0×10^{-6}	3.80×10^{-5}	-	-	2.0×10^{-6}
S3	-	-	-	8.0×10^{-6}	7.06×10^{-5}	-	-	6.0×10^{-6}
S4	-	-	-	1.0×10^{-5}	4.89×10^{-5}	-	-	2.0×10^{-6}

VII. DISCUSSION

From Table 3 the metals present in the face powder in this study are Manganese, Copper, Zinc, and Chromium while sample P1 and P4 having no detected metals. The mean concentration of Mn shows the highest concentration between the four metals detected. The mean concentration of Mn ranges from ND to 3.30mg/kg, a related study by Ali (2016)[27] shows a mean concentration of 27.45mk/kg for the high price powder and 21.08mk/kg for low price powders which is relatively high compared to the mean concentration in this study. The Mn mean concentration of sample P5 is significantly different at ($p < 0.05$) level of significance. The present of Mn can be a result of the use of gluconolactone containing manganese which is used as a skin conditioning agent [28]. The toxicology effect of Manganese has been said to possess Parkinson's disease-like syndrome with tremor, gait disorder, postural disability and cognitive disorder [14]. The concentration of Cu ranges from ND to 0.14mg/kg, the detected metals are in sample P2, P3, and P6. A study by Ullah *et al* (2017)[10] showed a mean concentration with a range of 1.095mg/kg to 1.515mg/kg and Ali (2016)[27] reported a mean concentration of 4.24mg/kg and 6.78, the use of copper in copper powder as ingredient to impart brown colour to which the powders in this study has various shade of brown colour can be the source of Cu in the face powder make-ups, and the acute poisoning of Cu can cause temporary gastrointestinal distress with symptoms such as nausea, vomiting, while high level of exposure to Cu can cause destruction of red blood cells, damage to the liver and kidney [29]. The mean concentration of Zn ranges from ND to 0.81mg/kg, Zn is detected in sample P2 and P6, Zn mean concentration reported by Ullah *et al*. (2017) [10] ranges from 1.818 to 1067mg/kg. The detection of Zn in these samples can be as a result of ZnO used as a key sunscreen ingredient [28]. Accumulation of Zn may result in pain, muscular stiffness and irritability [30-31]. The mean concentration of the detected metals in sample P2 and

P6 showed a close range in each metal, this may indicate similar ingredients being used in their production. Chromium with a mean concentration of 0.1715mg/kg is detected in sample P2 which is significantly different at ($p < 0.05$) level of significance. Report from Ullah *et al*. (2017) [10] had a mean concentration with range of ND to 0.262mg/kg in powder, also Nnorom (2011) [32] reported a mean concentration with a range of ND to 2.7mg/kg while Ali (2016) [27] reported a mean concentration of 0.012mg/kg for high price powders. Cr may be from chromium oxide or chromium hydroxide [28] used as a pigment. Cr has been said to be associated with allergic dermatitis in humans [5].

The mean concentrations of metals analysed in the eye pencils are shown in Table 4, it showed that only Cu, Mn and Zn are present out of the eight metals, the concentration of Cu in the eye pencils ranges from ND to 0.12mg/kg while the mean concentration of Mn ranges from 0.05mg/kg to 0.37g/kg and that of Zn ranges from 0.03 to 0.72mk/kg. The detected metals obtained by Nnorom *et al*. (2005) [33] include Pb, Cd, Cr, Ni, and Zn, the mean concentration. The use of manganese violet as colour pigment might be the source of Mn in the eye pencils samples [28]. It was reported by Nnorom *et al*. (2005) [33] on eye pencils containing Pb, Cd, Cr, Ni, and Zn, the mean concentration reported was with a range of 36.3 to 198.7mg/kg which compared to the mean concentration in this study is far too high. The Zn concentration of E2 and E3 are significantly different at ($p < 0.05$) level of significance. Zn may be present as a result of ZnO which can be used as a bulking agent or colourant [28].

In Table 5, the metals present in the soap samples are Cu, Mn, and Zn with Zn showing the highest mean concentrations. The mean concentration of Cu in the soap samples ranges from 0.03 to 0.18mg/kg which maybe as a result of Cu in water used during the soap production process or tag along with ingredient of colour. The non-medicated soap samples are S1 and



S2 while the medicated soaps are sample S3 and S4. The mean concentration of Cu in this study for medicated and non-medicated soaps is lower than that obtained for medicated soaps and non-medicated soaps by Ayenimo *et al.* (2010) [21] which has copper with a mean range of 0.185 to 0.875mg/kg and a range 0.103 to 0.516mg/kg respectively. Copper is said to be needed because of its serves as components of several enzymes necessary for normal metabolic functions in human it is recommended at a median intake through diet by the US FDA [34] as 0.9mg per day while the safe highest level intake for an extended period is 10mg per day but an acute poisoning of Cu can cause temporary gastrointestinal distress with symptoms such as nausea, vomiting, while high level of exposure to Cu can cause destruction of red blood cells, damage to the liver and kidney [29]. The mean concentration of Zn in the soap ranges from 0.16 to 0.64mg/kg which is relatively close to that reported by Ayenimo *et al.* (2010) [21] which ranges from 0.422 to 0.88mg/kg. Accumulation of zinc is likely to cause inhibition of oxygen and calcium transportation in the body that reduced IQ (intelligent quotient) and learning disability, intrauterine fetal death, low body weight. Due to the oversensitivity of some human, it can cause metal fever (a flu-like condition) which goes away after two days. Zinc can be dangerous to the newborn and unborn through mothers' blood or milk [35]. Zn in the non-medicated soap may be due to the use of zinc ingredients such as zinc sulphate used as cosmetic astringents also zinc pyrithione, zinc phenol sulfonate and zinc acetate [28] are used in inhibiting the growth of microorganism most especially in the medicated soaps. The mean concentration of Mn in the soap sample ranges from 0.04 to 0.13mg/kg which could be a result of impurities such as metal complex formation with some of the ingredients of soap production, such as organic salts of Mn which can be soluble in lipid [14]. Table 6 shows the mean concentration of powdered detergents with Zn, Mn, Cu, and Ni being detected, a similar study on detergent by Sani and Shehu (2018) [36] reported on the detection of Cr, Cd, Ni, and Pb, where the concentration of Ni ranges from 1.56 to 7.81mg/kg whereas the mean concentration of Ni in this study ranges from ND to 0.1455mg/kg. A limit of 0.5 mg/cm² per week of nickel release was suggested as a safe limit for nickel exposure [36]. Metals are toxic, causing irritant contact dermatitis, ulceration or granuloma, and contact allergy. Nickel is the most common cause of contact allergy of all skin sanitizer and it is a cause of hand eczema. Sensitivity to nickel is generally caused by direct and prolonged skin contact with items that release nickel ions which are dependent on the amount of Ni per skin unit area [36]. Mn ranges from 0.05 to 0.07mg/kg, while that of

Zn ranges from 0.09 to 0.145mg/kg and the mean concentration of Cu is 0.05mg/kg.

Estimated Daily Intake (EDI)

The degree of toxicity of heavy metals to humans depends upon the daily intake as described by Gebreyohannes & Gebrekidan (2018) [23]. Table 7 shows the estimated daily intake of the cosmetic products considered in this study, with Manganese (Mn) showing the highest values in the face powder samples with 0.0000240mg/kg/day, 0.0000240mg/kg/day, and 0.00000903mg/kg/day for P2, P6, and P5 respectively.

Health Risk Assessment (HRI)

The HRI represents the harmful effects of the heavy metals present in the personal care products in which are used, the values of the HRI are presented in Table 8. It has been stated in literature that when the value of HRI is less than 1, the use of its products or consumable is safe or it is said not to pose any health hazards but when is greater than 1, there may be concerns for possible health risk associated with overexposure [24,23]. All the values of HRI for all the metals considered in this study are below 1 as presented in Table 9.

VIII. CONCLUSION

The results obtained in this study show the mean concentration of metals such as lead, cadmium, zinc, nickel, chromium, manganese and cobalt in personal care products (PCPs) commonly used in Akure. The levels of most metals in this study are lower than those in reported studies. Through investigation of some heavy metals in some PCPs in literature, it has indicated some heavy metals to be below the acceptable level while some are above but continuous use of PCPs may result in an increase in the trace quantity of the heavy metals in the human body, thus the use of PCPs may be considered as sources of toxic metal poisoning. Based on the health risk index, it can be said that the heavy metals pose no health risk to humans. Metal contamination of PCPs is from contamination of raw materials and the use of sub-standard raw material, lack of compliance by small scale manufacturer and lack of strict regulation.

This study recommends the need for continual monitoring of the presence of heavy metals in PCPs continually been used in Nigeria to avert heavy metal poisoning through dermal poisoning, especially vulnerable groups such as children and women.



Further studies on heavy metals in PCPs are recommended to keep PCPs in-check and should include other metals in different categories of PCPs commonly used in Nigeria to prevent associated heavy metal risks.

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