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Evaluation of Heavy Metals Concentration in Different Local Brands of Selected Cleanser Products

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ABSTRACT

Heavy metals' concentration in cleanser products can cause health hazards. The present study was conducted to evaluate the concentrations of heavy metals in different local brands of selected cleanser products with special emphasis on their health risk assessment. Five heavy metals including Pb, Cu, Cd, Zn and Hg were quantified in different brands using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). All cleanser samples were labelled as Sample A, B, C, and D. Risk to consumers' health was determined using systemic exposure dosage (SED) and margin of safety (MoS). On comparative basis, Sample A had the highest concentration of Zn, Pb and Hg (12.350 ± 0.04, 0.020 ± 0.001, 0.710 x 10^{-3} ± 0.16 x 10^{-3} mg/kg, respectively), whereas Sample D had the highest level of Cu at 0.190 ± 0.02 mg/kg. SED and MoS values were estimated for 50 % and 100 % bio-accessibility for all the samples. Based on the results, MoS values for samples B, C and D were greater than 100 mg/kg/d , which showed that the evaluated samples were safe for use. Nevertheless, in Sample A, the MoS values for Pb and Zn at 100 % bio-accessibility were below 100 mg/kg/d, which denoted that the product is not safe for use, particularly concerning the heavy metals contamination. Hence, regular use of these cleanser products would result in accumulation of the heavy metals in the human body which can cause risks for human health.

Keywords: *cleanser product;health risk;heavy metal*

1. INTRODUCTION

Cosmetics have been used as a part of regular body care by the public [1]. Facial cosmetics are substances that are rubbed to the face for the purpose of cleansing, beautifying or altering the appearance and promoting attractiveness function [2]. The urge for cosmetic products has increased recently, resulting in huge production by cosmetic manufacturers [3]. Cosmetics are combinations of some surfactants, oils, and other ingredients that are required to be effective, lifelong, secure, and safe for human use.

Despite that, there are concerns regarding the existence of toxic chemicals, including heavy metals, in these products [1]. Various heavy metals can be discovered in cosmetics, these metals may purposely be added as preservatives or as active ingredients, or they can be found as residual impurities in the raw materials of cosmetics [4]. Dermal exposure is expected to be the most important path since most cosmetic products are directly applied to the skin, especially cleanser products [3].

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As the metal contents of cleanser products are not usually listed on the ingredient label, it is important to carry out a chemical analysis of the levels of toxic metals in such products especially those from local brands. The intentional use of metals as active ingredients in cosmetic products is forbidden by legislation in most states, but metal contaminations do exist in such products due to their persistence and omnipresent natures [5]. The focus of this study is on heavy metals with known important toxicological properties such as Lead (Pb), Arsenic (As), Cadmium (Cd) and Mercury (Hg). Also, the essential elements such as Copper (Cu) and Zinc (Zn) at high levels may cause adverse effects on human health [3].

Metals exhibit a wide range of toxic and chronic health effects, such as cancer, reproductive, developmental and neurological disorders, cardiovascular, kidney and renal problems, lung damage, contact dermatitis, brittle hair and hair loss [5]. Globally, various brands and types of cosmetics have been reported to contain different levels of toxic elements; Pb was detected in lipsticks and eye-shadows [3, 6]; Hg was detected in skin whitening products [7]; Cd, Ni, Cr, Co, Cu, Fe, Mn and Zn were detected in facial cosmetics [4,5,8] and face powder [9].

Cosmetics and their ingredients have to be harmless under the circumstances of normal use and must be comprehensively evaluated prior to advertising. Safety evaluation should be performed on finished products taking into consideration the toxicological profile of the ingredients, their chemical structure, and their possibility to produce local and systemic effects [3]. As heavy metal concentrations of cosmetic products are not typically listed on the ingredient label, it is important to carry out chemical evaluation of the levels of toxic metals in such products.

In this context, the study was focused on the determination of heavy metal concentrations in selected local brands of cleanser products and on appraising health risks associated with exposure to the metals in these cleanser products. This study would provide crucial information related to the health risk associated with the prolonged use of the cleanser products especially from local brands.

2. METHODOLOGY

2.1 Sample Collection and Preparation

Four different local brands of solid form cleanser products were randomly purchased from the local markets with three replicates. The target samples were only soap bar cleanser products because they are widely used among the population and are not high quality brand cosmetic products that are generally sold in beauty stores or pharmacies. The samples were labelled as A, B, C and D. The samples were cut into small pieces and dried in an oven at 50°C overnight as shown in Figure 1.

One gram of each sample was accurately weighed using analytical balance and placed into a 50 mL conical flask. The acid digestion method used in this study was based on procedures recommended by Massadeh et al., [3], Nasirudeen and Amaechi [10], Arshad et al., [11], Ahmed et al., [12]. A mixture of acids which were HCl (37%), HNO_3 (65%) , and H_2O_2 with a ratio 3:1:1 was added to each sample. Subsequently, the mixture solution was heated on a hot plate by slowly increasing the temperature up to 150 ℃. After the appearance of brown fumes, the mixture solution was allowed to cool. Then, 20 ml of deionised water was added and then filtered through a Whatman No 42 filter paper. The solution was then diluted up to the calibration mark of 100 ml volumetric flask.

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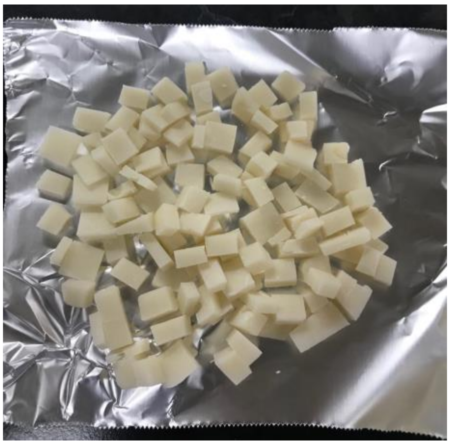
Sample A



Sample B

Sample C

Sample D

Figure 1: Sample of cleanser products

2.2 Sample Analysis

All of the cleanser samples were analysed for heavy metal contents using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (Model Perkin, Elmer-Optima 5100DV). ICP-OES has high sample throughput, high sensitivity, accuracy, robustness and its low detection limits are typically in the µg/L range [13,14]. However, mercury analysis was conducted by a cold vapour-atomic absorption spectrophotometer (CV-AAS) since it has fewer interferences, is cheaper and a better instrument [15]. The ICP-OES allowed multi-element detection while calibration of CV-AAS used with Hg standard solution by a series of concentrations 4, 8, 12, 16 and 20 ppb [17,18]. This sample solution was prepared to give concentrations of 2, 4, 6, 8 and 10 ppm [16] for ICP-OES analysis. Three replicates were performed for each cleanser sample [14,19,20]. The analysis was carried out at the proper wavelength for each metal (Zn: 206.200 nm; Pb: 220.353 nm; Cu: 327.395 nm). This standard solution was used for calibration of the instrument with an R^2 value of 0.99995 whereas the distilled water was used as a blank solution.

2.3 Safety Evaluation of Cleanser Products

The risk of human exposure to heavy metal impurities in these cleanser products can be assessed by making use of the uncertainty factor called Margin of Safety (MoS). The MoS is calculated

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by dividing the No Observed Adverse Effect Level (NOAEL) value of the cleanser substance under study with estimated Systemic Exposure Dosage (SED) [21].

$$MoS = \frac{NOAEL}{SED} \quad (1)$$

The systemic availability of a cleanser substance is estimated by taking into consideration the amount of the cleanser product applied to the skin per day, the concentration of metals in the cleanser product under study, the dermal absorption of the metal and a human body weight value. The SED is given by the formula [21]:

$$SED\left(\frac{\frac{mg}{kg}}{d}\right) = \frac{Cs \times AA \times SSA \times F \times RF \times BF}{BW} \times 10^{-3} \quad (2)$$

Where
Cs indicates metal concentration in the sample (mg/kg),
SSA is the surface area of skin onto which the cleanser product is applied (cm^2),
AA shows the quantity applied per day (g/cm^2),
RF is the retention factor,
F indicates the application frequency of a product/day,
BF is the bioaccessibility factor, 10^{-3} (mg/kg) is used as unit conversion factor,
BW is the average body weight (60 kg).

The values of AA, F, SSA, and RF used in this study were standard values established by the Scientific Committee on Consumer Safety (SCCS) [21] as shown in Table 1 below.

Table 1: The ReferenceValues Use for Equation 2

	Value	References
Quantity applied per day (AA)	0.005 g	[5; 21]
Surface area of skin (SSA)	563 cm^2	[5; 21]
Retention factor (RF)	1.0	[21]
Bioaccessibility factor (BF)	1.0	[21]
Application frequency of a product/day (F)	2	[21]

NOAEL is the highest dose or exposure level where no adverse treatment-related findings are observed. NOAEL values were calculated from the oral reference doses (RFDs) as follows:

$$NOAEL = RFD \times UF \times MF \quad (3)$$

Where
UF is an uncertainty factor
MF is the modifying factor.

In this case, the default values of UF and MF were 100 and 1 respectively. The RFDs for Pb is 4 x 10^{-3} mg/kg/day [5,22], Cu is 4.0 x 10^{-2} mg/kg/day and Zn is 3.0 x 10^{-1} mg/kg/day [5,9,23, 24].

MoS value up to 100 mg/kg/d is tolerable and a product with MoS value above 100 mg/kg/d is considered secure for consumption [5,8]. Value of MoS below 100 mg/kg/d is an uncontrollable

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level. In many traditional calculations of the MoS, the oral bioavailability of a substance is assumed to be 100 % if oral absorption data are unavailable. However, it is considered appropriate to assume that not more than 50 % of an orally administered dose is systemically accessible [21].

3. RESULT AND DISCUSSIONS

3.1 Heavy Metal Concentrations in Cleanser Samples

The mean concentrations (± standard deviation) of metals in different local brands of cleanser products were shown in Table 2. The concentrations of Pb and Hg in Samples B, C and D were found to be below detection limits while in Sample A, Pb and Hg were 0.020 ± 0.001 and 0.710 x 10^{-3} ± 0.16 x 10^{-3} mg/kg, respectively. The concentration of Cu was highest in Sample D with 0.190 ± 0.02 mg/kg, while in Sample C, Cu was below the detection limit. Zn concentration was recorded the highest in Sample A with 12.350 ± 0.04 mg/kg compared with the other samples.

Table 2: The Concentration of Heavy Metals in Selected Local Brands Cleanser Product (mg/kg) (mean ± standard deviation, n = 3)

Sample	Pb	Cu	Zn	Hg (x 10^{-3})
A	0.020 ± 0.001	0.096 ± 0.05	12.350 ± 0.04	0.710 ± 0.16
B	UDL	0.050 ± 0.02	0.026 ± 0.01	UDL
C	UDL	UDL	0.040 ± 0.02	UDL
D	UDL	0.190 ± 0.02	UDL	UDL

UDL = under detection limit

All cleanser products examined contained heavy metal concentrations eventhough under the detection limit levels. This suggests that these products could be sources of heavy metals ingestion and dermal contamination. These findings were predictable since as previously mentioned, many local products were homemade prepared without precautions against contamination by heavy metals [25]. Their presence in the cleanser samples might be from colourants and as impurities in raw materials due to inadequate purification during the manufacturing process [26,27].

Based on Table 2, even though the concentration of Pb was under the detection limits for all the samples except for Sample A, exposure to low concentrations of Pb can cause disorders such as behavioural abnormalities, decreased learning and hearing abilities, permanent neurological damage, and may have adverse effects on the reproductive, hepatic and renal systems [8].

Hg concentrations were also recorded high in Sample A. Hg function is to lighten the skin. Mercury is toxic and can enter the blood circulation via dermal or oral routes which can result in systemic toxicity [4,28]. The concentration of Hg must be less than 1 ug/L with a permissible limit provided by [29].

According to Iwegbuwe et al., [8], Zinc plays an important role in many enzymes including carbonic anhydrase and a group of proteases, such as carboxypeptidase. Despite the significance

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of these metals to humans and other organisms, the existence of some of these metals in cleanser products constitutes a serious health problem, one of which is allergy.

3.2 Toxicity Assessment

3.2.1 Estimation of Systemic Exposure Dosage (SED) and Margin of Safety (MoS)

The safety assessment of metals in cosmetics should start from the knowledge of the type and concentration of ingredients contained in the products [30]. The estimated SED (mg/kg/d) and MoS of selected heavy metals from the use of these cleanser products at 50 % and 100 % bio-accessibility are displayed in Tables 3 and Table 4. The Scientific Committee on Consumer Safety (SCCS) [21] recognises the fact that in many traditional calculations of the MoS, the oral bioavailability of a substance is assumed to be 100% if oral absorption data are unobtainable.

However, it is considered appropriate to assume that not more than 50% of an orally administered dose is systemically available. The systemic exposure to cleanser products predicts the concentration of chemicals that enter the human body through various exposure routes. It was noted that at 50 % bio-accessibility, SED values for Cu and Zn ranged from 7.75 x 10^{-4} to 2.95 x 10^{-3} and 6.20 x 10^{-4} to 1.9 x 10^{-1} mg/kg/d, respectively.

However, Pb and Hg values only on Sample A were 3.11 x 10^{-4} and 1.1 x 10^{-4} mg/kg/d. Likewise, SED levels at 100 % bio-accessibility for Cu and Zn ranged from 1.55 x 10^{-3} to 5.90 x 10^{-3} and 8.07 x 10^{-4} to 3.80 x 10^{-1} mg/kg/d, respectively. The respective SED levels of Pb and Hg are 6.21 x 10^{-4} and 2.20 x 10^{-4} at 100 % bio-accessibility.

Table 3: SED values (mg/kg/d) of selected heavy metals in cleanser product

Sample	Pb	Cu	Zn	Hg
50 % bio-accessibility				
A	3.11 x 10^{-4}	1.49 x 10^{-3}	1.90 x 10^{-1}	1.10 x 10^{-4}
B	-	7.75 x 10^{-4}	4.04 x 10^{-4}	-
C	-	-	6.20 x 10^{-4}	-
D	-	2.95 x 10^{-3}	-	-
100 % bio-accessibility				
A	6.21 x 10^{-4}	2.98 x 10^{-3}	3.80 x 10^{-1}	2.20 x 10^{-4}
B	-	1.55 x 10^{-3}	8.07 x 10^{-4}	-
C	-	-	1.24 x 10^{-3}	-
D	-	5.90 x 10^{-3}	-	-

Risk to human health on exposure to metallic impurities present in the cleanser products was evaluated by applying Margin of Safety (MoS) [11]. Based on Table 4, Sample B, C and D show MoS values greater than 100, which revealed that the evaluated samples were safe for use. However, in Sample A, the MoS values for Pb and Zn at 100 % bio-accessibility were below 100, which indicated that the product is not safe for use, particularly with reference to heavy metals contamination.

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Table 4: MoS values (mg/kg/d) of selected heavy metals in cleanser product

Sample	Pb	Cu	Zn	Hg
50 % bio-accessibility				
A	1.29×10^3	2.68×10^3	1.58×10^2	2.73×10^2
B	-	5.16×10^3	7.43×10^4	-
C	-	-	4.84×10^4	-
D	-	1.36×10^3	-	-
100 % bio-accessibility				
A	6.44×10^1	1.34×10^3	7.89×10^1	1.36×10^2
B	-	2.58×10^3	3.72×10^4	-
C	-	-	2.42×10^4	-
D	-	6.78×10^2	-	-

4. CONCLUSION

The results of the present study indicate that heavy metals were detected in all local brands of cleanser products even in low detection limits. Sample A was recorded with MoS values for Pb and Zn below 100 mg/kg/d which indicates that Pb has the potential to cause a health risk and is not safe for use. The continued use of these products contaminated with such heavy metals may cause slow penetration of these metals into the human body and thus show their harmful effects. Therefore, the increasing use of those products should be avoided.

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