Nigerian Research Journal of Chemical Sciences **(ISSN: 2682-6054)**
Volume 8, Issue 2, 2020

EVALUATION OF HEAVY METALS LEVEL IN HAIR DYES AND THEIR POTENTIAL HEALTH RISK

[1]Yashim, Z.I.,[*1]Dallatu, Y.A., [1]Bolarin-Akinwade, O.O. and [1]Obebe, E.O.

[1]Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria

*Corresponding author: zakkayashim@gmail.com; ziyashim@abu.edu.ng;

ABSTRACT

The research was undertaken to determine some heavy metal content in hair dye samples which are sold at Samaru market, Zaria, Nigeria. Wet digestion was done on the samples using the mixture of HNO_3/ HCl and H_2SO_4/H_2O_2. The concentration of heavy metals (Pb, Cr, Cd, Ni, and Cu) was determined using atomic absorption spectrophotometer (AAS). The result showed the concentrations in mg/kg of heavy metals for (1) Pure mineral dye: 97.10±0.013 (Pb), 42.45±0.002 (Cr), 3.80±0.005 (Cd), 7.40±0.008 (Ni), and 65.10±0.003 (Cu). (2) Henna: 19.50±0.003 (Pb), 7.20±0.000 (Cr), 5.40±0.002 (Cd), 6.60±0.005 (Ni), and 22.00±0.001 (Cu). (3) Black shampoo oil: 5.52±0.003 (Pb), 3.92±0.004 (Cr), 1.50±0.013 (Cd), 5.68±0.010 (Ni), and 33.60±0.001 (Cu). (4) Black shampoo jelly: 6.76±0.007 (Pb), 7.36±0.004 (Cr), 1.20±0.002 (Cd), 5.76±0.004 (Ni), and 3.50±0.029 (Cu). These results showed that the pure mineral and Henna which are natural dyes have higher concentrations of the heavy metals than the black shampoo oil and black shampoo jelly which are synthetic dyes, and only the concentrations of Pb and Cd in synthetic dyes were lower than the recommended limit set by Canada Health Standard. Pure mineral and Henna dyes pose more health risk to human health than the synthetic dyes. Regulatory agencies saddled with maintaining standard of products should regularly monitor these products for long-term health benefits of the users.

Keywords: Cosmetics, hair dyes, heavy metals, health risk, toxicity

INTRODUCTION

A cosmetic product is any substance applied to the body in order to improve the body's appearance [1]. Shampoo is one of the most commonly used cosmetic products. It is a hair care product that is used for cleaning scalp and hair. Shampoos are most likely utilized as beautifying agents and are viscous solution of detergents containing suitable additives, preservatives and

active ingredients [2, 3]. It is usually applied on wet hair, massaging the hair, and cleansed by rinsing with water. The purpose of using shampoo is to remove dirt that is build up on the hair without stripping out of the serum. Many synthetic shampoos are present in the market, both medicated and non-medicated. However, herbal shampoos are popular due to natural origin which is safer, increased consumer demand and few side effects.

In synthetic shampoos, surfactants (synthetic) are added mainly for their cleansing and foaming property, but the continuous use of these surfactants leads to serious effects such as eye irritation, scalp irritation, loss of hair and dryness of hair. Alternative to synthetic shampoo that can be used are pure herbal organic, a hair darkening shampoo. However, formulating cosmetic products containing only natural substances is very difficult. There are a number of medicinal plants with potential effects on hair used traditionally over the years around the world and are incorporated in shampoo formulation. These medicinal plants may be used in extracts form, powdered form, crude form, or their derivatives. According to Jaishankar et al [4], to develop a shampoo containing one natural substance which would be safer with milder effect, than the synthetic shampoo is difficult and also it should possess good foaming, detergent, and solid content like synthetic shampoo.

The practice of changing the colour of hair is called “hair colouring”. The main purpose for this process is to cover grey hair, change a hair colour to a more fashionable one, or get back the original hair colour. Hair dyeing, which is an ancient art involves treatment of the hair with various chemical items [5 – 7]. Early hair dyes were made from plants, metallic compounds, or a mixture of the two [8]. The complexity of formulas in commercial hair dye, with dozens of components, and the formulas are different between the manufacturers. In general, the components of hair dyes contain dyes, soap, antioxidants, modifiers, alkali, ammonia, soap, fragrance, wetting agents, and many other chemical materials which are used in small amounts that transfer special qualities to hair (such as softening the tissue) or give a desired process to the dye (such as making it more or less enduring).

Usually the dye chemical materials contain amino compounds, and show up on hair dye components list with such names as 4-amoni-2-hydroxytoluene and M-amino phenol. Metal oxides, such as titanium dioxide and iron oxide, may be added as pigments as well [9]. Various different chemical materials are used to transfer special qualities and features to a manufacturer’s formula. They may be fragrances, chemicals that make the formula creamy, foamy, or thick, or

contribute to the overall action of the formula [10]. Metals or metal compounds are immersed into the herbal products that are not essential for the healthy skin which WHO considers them as possible carcinogens. Many of the synthetic dyes are considered safer to use [11, 12].

Hence the aim of this work is to determine the levels of some heavy metals in selected hair dyes.

MATERIALS AND METHODS

All plastics and glass wares were thoroughly washed with detergents, rinsed many times with distilled water and then soaked in 5% HNO_3 solution for a minimum of 24 hr, then washed and rinsed with distilled water before use.

Sample Collection and Preparation

A total of twenty five (25) samples of each hair dye product were purchased from different locations in Samaru market (Lat. 11º10´0˝N and Long. 7º37´60˝E), Zaria, Nigeria. The solid pure mineral hair dye and Henna dye samples were separately mixed and ground together to form a composite sample, while the viscous herbal pure organic hair dyes (black shampoo oil and black shampoo jelly) samples were separately drained into a 150 cm^3 beaker and thoroughly mixed to give a composite sample.

About One gram (1 g) of the powdered hair dye was weighed and digested using 20 cm^3 of mixture of concentrated HNO_3 and HCl (ratio 3:1). Also 1 g of the viscous herbal pure organic hair dye was weighed and digested using 15 cm^3 mixture of concentrated H_2SO_4 and H_2O_2 (ratio 2:1). The digestions were carried out in a fume chamber and the clear solutions obtained were allowed to cool, filtered through ashless Whatman filter paper No. 42 into 100 cm^3 standard volumetric flask and then made up to the mark with distilled water. The concentration of lead, cadmium, chromium, nickel and copper were determined using atomic absorption spectrophotometer (Model AAS-HP MY14470001). The analysis was done in triplicate [13].

RESULTS AND DISCUSSION

Figure 1 shows the mean concentration for lead in hair dyes studied. The results indicated that concentration of lead in the pure mineral dye was 97.1 ± 0.013 mg/kg, Henna dye 19.50±0.003 mg/kg, black shampoo oil 5.52±0.007 mg/kg and black shampoo jelly 6.67±0.007 mg/kg. The level of lead in the pure mineral dye and Henna dye were higher than the maximum permissible limit (10 ppm) set by Canada Health Standard [14] for cosmetics external use, while the oil and the jelly black shampoo have their lead level lower than the standard. Iwegbue *et al*. [15]

reported 0.5 – 28 ppm of Pb in hair dyes from South-South Nigeria. Umar and Caleb [16] reported values of 0.43 – 1.3 ppm in FCT – Abuja, Nigeria, but this study showed higher values. Some of these plant-derived dyes were mixed with metals to produce more lasting or richer shades. Black hair dyes can become contaminated with lead via the use of contaminated raw materials or through the use of pigments that contain it. Skin contact with lead occurs daily, and some have been found to be absorbed through the skin [10]. Exposure to high level of lead can result to damage of the nervous system causing brain disorder and kidney damage. Pregnant women and young children are particularly vulnerable because it can cross the placenta with ease and enter the foetal brain. It can also be transferred to infants through breastfeeding and stored in bones. Lead exposure has also been linked to miscarriage, hormonal changes, reduced fertility in men and women, menstrual irregularities, delays in puberty onset in girls [17, 18]. It has been reported that an estimated 99% of lead that enters an adult human body and 33% that enters a child body are excreted in about two weeks [19]. From this study the use of pure mineral dye and Henna dye which are natural dyes pose more health risk than the synthetic dye products studied.

Mean copper concentrations (Figure 2) in the four studied samples of black shampoo hair dyes showed that pure mineral dye (65.10±0.003 mg/kg) > black shampoo oil (33.60±0.001 mg/kg) > black shampoo jelly (30.50±0.029 mg/kg) > Henna dye (22.00±0.001 mg/kg). These values are higher than those reported by Iwegbue et al. [15] which was 0.5 – 6.0 ppm of Cu in various hair dyes from South -South Nigeria, while Umar and Caleb [16] reported values of 0.05 – 31.80 ppm in FCT – Abuja, Nigeria. Although copper is an essential element in both human and animal, nevertheless, excessive amount in the soft tissue of the body has adverse effect. The most common ones are hair loss chiefly in women [13]. Copper has been implicated as the main cause of increased menstrual blood and pain in women from its use in intrauterine devices, IUDs [20].

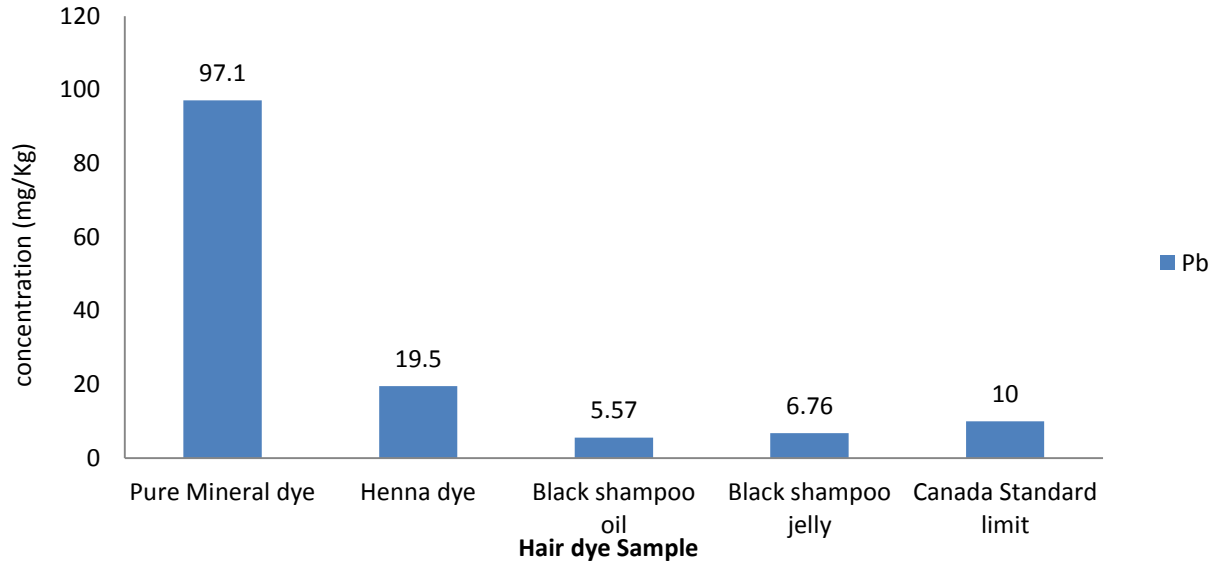

Figure 1: Mean concentration of Pb (mg/kg) in four different Hair dyes

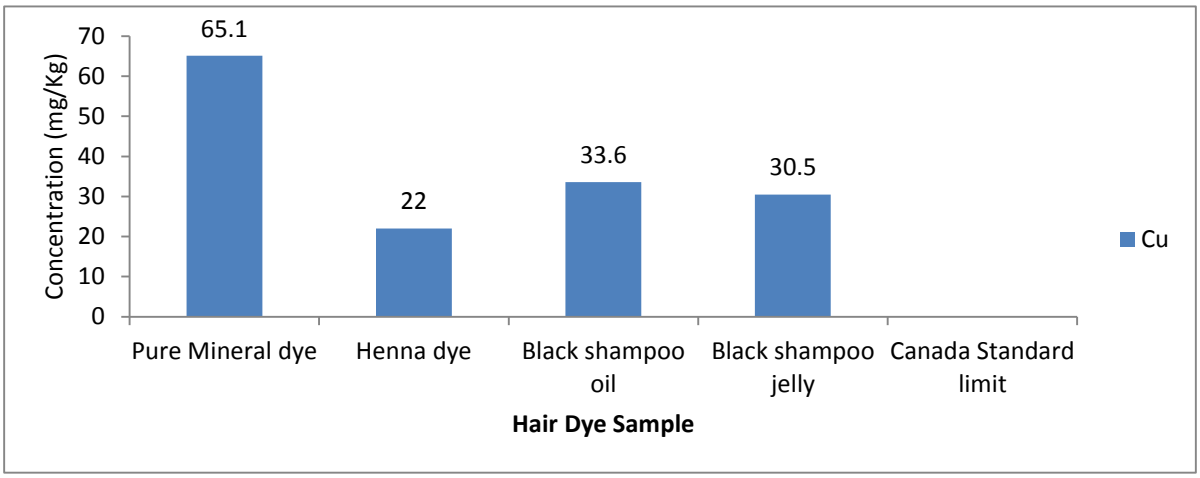

Figure 2: Mean concentration of Cu (mg/kg) in four different Hair Dye Samples

Figure 3 shows the mean concentration for chromium in the four samples. The results indicated that pure mineral dye has the highest value (42.45±0.001 mg/kg), followed by black shampoo jelly (7.36±0.004 mg/kg), then Henna dye (7.20±0.000 mg/kg) and black shampoo oil (3.92±0.004 mg/kg). Iwegbue *et al*. [15] reported 2.5 – 4.2 ppm of Cr in hair dyes from South – South Nigeria, while Umar and Caleb [16] reported values of 0.43 – 4.9 ppm in FCT – Abuja Nigeria. Acute oral toxicity ranges from 1.5 to 3.3 mg/kg. The toxicity of chromium compounds depends on the oxidation state of the metal. Hexavalent form is more toxic than trivalent form. Hexavalent chromium (Cr^{+6}) is corrosive and allergic to the skin. Cr^{+6} compounds are enlisted as

carcinogens by the International Agency for Research on Cancer [21]. Cr^{+6} permeate the skin more than Cr^{+3} due to its high solubility. The rate of permeation of Cr through the skin is related to the contact time [18]. Adverse health effects associated with hexavalent chromium exposure include skin irritation or ulceration, allergic contact dermatitis, occupational asthma, nasal irritation and ulceration, perforated nasal septa, rhinitis, nosebleed, respiratory irritation, nasal cancer, sinus cancer, eye irritation and damage, perforated eardrums, kidney damage, liver damage, pulmonary congestion and edema, epigastric pain and erosion and discoloration of teeth [3].

The mean concentrations for nickel in various black shampoo hair dyes studied are presented in Figure 4 and are in the order: pure mineral dye (7.40±0.008 mg/kg) > Henna dye (6.60±0.005 mg/kg) > black shampoo jelly (5.76±0.004 mg/kg) > black shampoo oil (5.68±0.010 mg/kg). The health Canada permissible limit for nickel was 5 ppm [14]. The results for this study is in agreement with that of Iwegbue *et a*l. [15] who reported 1.5 – 7.5 ppm of Ni in hair dyes from South – South Nigeria, while Umar and Caleb [16] reported lower values of 0.83 – 3.11 ppm in FCT – Abuja, Nigeria. Nickel in contact with sweat on human skin can undergo oxidation to form soluble and diffusible compounds that penetrate the stratum corneum through appendageal, transcellular or intracellular routes. The rate of diffusion of nickel is limited to <1% and it is influenced by many factors which include the counter ions (acetate, chloride, nitrate, sulphate), oxidizing capacity of sweat, sex (male or female), exposure time and amount applied (dosage). Considering the prolonged contact time of cognitive products with the skin, the rise of allergic dermatitis contact might be increased [22].

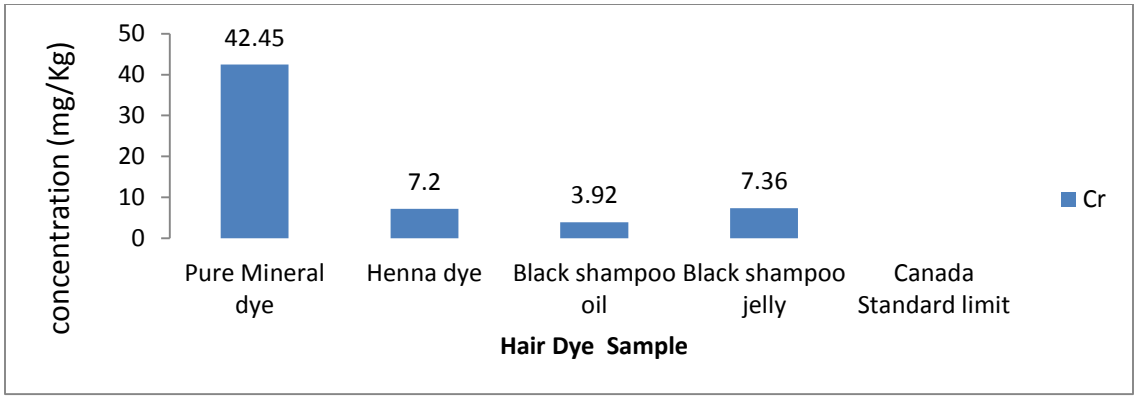

Figure 3: Mean concentration of Cr (mg/kg) in four different Hair Dye samples

The ability of nickel to bind with amino acid residues to form Ni-complexed proteins could be the main factor responsible for contact allergy and irritation caused by exposure to nickel [15, 18]. From this study the use of pure mineral dye and Henna dye which are natural dyes pose more health risk than the synthetic dye products.

The results for the mean concentration of cadmium in the four different black shampoo hair dyes are shown in Figure 5. The results indicated that Henna dye has highest concentration of cadmium (5.40±0.002 mg/kg), followed by pure mineral dye (3.80±0.005 mg/kg), then black shampoo oil (1.50±0.013 mg/kg) and black shampoo jelly (1.20±0.002 mg/kg). Iwegbue *et al*. [15] reported Cd levels of 0.9 – 3.0 ppm in hair dyes from South – South Nigeria, while Umar and Caleb [16] reported values of 2.58 – 6.95 ppm in FCT – Abuja, Nigeria. This study indicated that Henna and pure mineral dyes have concentrations of cadmium which exceeded the permissible limit (3 ppm) as established by Health Canada [14]. Cadmium is considered to be "carcinogenic to humans" by the International Agency for Research on Cancer [21] and its compounds categorized as human carcinogens by the United States Department of Health and Human Services [10]. Ingestion of high levels of cadmium can lead to severe stomach irritation, vomiting and diarrhoea, while exposure to lower levels for a long time can lead to kidney damage, bone deformity, and the ability of bones to break easily [10]. Most of the metals ingested into humans and animals are excreted and only small proportions are actually retained in the body [19]. Cadmium is a potent cell poison, which cause different kinds of damage, including cell death or increase in cell proliferation. It can affect the nervous system and neurological disorder such as learning disabilities and hyperactivity in children may occur [23]. In neuronal cells, cadmium induces oxidative stress which produces protein damage and subsequently neuro-degeneration [24]. The presence of cadmium in various hair dyes does not have to be present in abundance in products to produce hypertension [2].

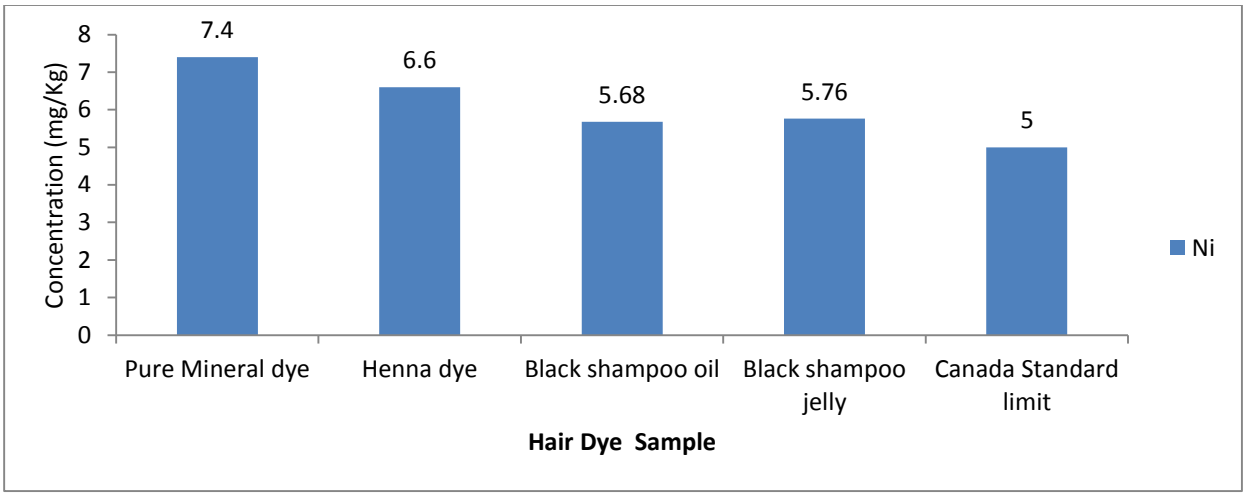

Figure 4: Mean concentration of Ni (mg/kg) in four different Hair Dye samples

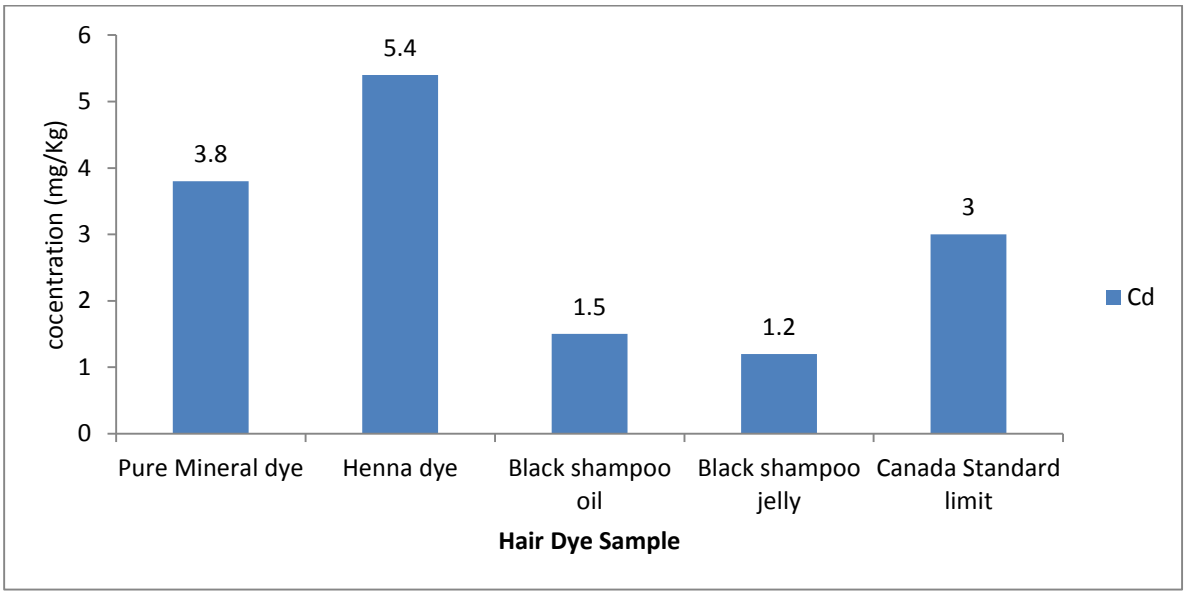

Figure 5: Mean concentration of Cd (mg/kg) in four different Hair Dye samples

Using a one way ANOVA (Turkey post hoc) comparison test at a 95% confidence level, there was a significant difference ($p < 0.05$) in metal levels across the studied samples. The sources of heavy metals in the hair dye products could be from raw materials used and or as contaminants arising from the manufacturing processes [16]. The heavy metal ions in contact with human body get absorbed and form complexes with carboxylic acid (-COOH), amine ($-NH_2$) and thiol (-SH) of proteins resulting in malfunctioning or death of the cells and consequently lead to a variety of diseases [25]. Human toxicity of heavy metals can be as a result of long-term and the frequency

of usage of these products [26]. From this study the use of pure mineral dye and Henna dye which are natural dyes pose more health risk than the studied synthetic dye products.

CONCLUSION

The results of this study showed that there is presence of lead, copper, chromium, nickel and cadmium in all the hair dye samples analyzed. The pure mineral and Henna dyes have higher concentrations of the heavy metals than the synthetic dyes studied. Long term and the frequency of usage of these products polluted with such heavy metals should be avoided. These may cause slow release of these metals into the human body and may pose a serious health risk to their users. Regulatory agencies saddled with maintaining standard of products should regularly monitor these products for long-term health benefits of the users.

REFERENCES

[1]. Faruruwa, M. A. (2014). Study of Heavy Metals Content in Facial Cosmetics Obtained from Opened Markets and Superstores within Kaduna metropolis. *American Journal of Chemistry Application*, 27 – 33.

[2]. Salve, K. S.1. & Sonwane, N.S. (2015). Detection of Heavy Metals in Cosmetics. *World Journal of Pharmaceutical Research,* 4(4), 1368-1372.

[3]. Sahu, R., Saxena, P. & Sapna, J. (2014). Heavy Metals in Cosmetics fact sheet.Ottawa, Ontario, Health Canada (http://www.hcsc.gc.ca/cps-spc/pubs/indust/heavy_metals-metaux_lourds/index-eng.php).

[4]. Jaishankar, M., Tseten, T., Anbalagan, N., Mathew, B.B., Beerergowda, K.N. (2014). Toxicity, Mechanism and health effects of some heavy metals. *Interdisciplinary.Toxicology*. 7(2), 60-72

[5]. Amira, S. A. Rehab, M. E, Hatem, A. A. & Samia, S. B. (2016). Human Hair and Nails as Bio-indicator of Heavy Metals Contamination by Hair Dye Exposure among Population in Saudi Arabia. *World Journal of Pharmaceutical and Medical Research,* 2(6), 130-137.

[6]. Hussein, H. J. (2015). Evaluation of the Concentration of Some Heavy Metals in Hair Dyes in Baghdad. *International Journal of Science and Research*. 4(9), 687 – 691

[7]. Al-Ghamdia, K.M. & Moussab, N.A. (2011). Knowledge and practices of, and attitudes towards, the use of hair dyes among females visiting a teaching hospital in Riyadh, Saudi Arabia. *Annuals of Saudi Medicine*, 31, 613–619.

[8]. Foltz-Gray, D. (1996). Declare Your Right to Dye. *Health*, pp. 54-57

[9]. Pehlić, E., Husein, N., Huska, J. & Aldina, A. (2019). Determination of Heavy Metals in Hair Dyes by the Atomic Absorption Spectrophotometry. Springer International Publishing AG, part of Springer Nature In: Karabegović (Ed.): NT 2018, LNNS 42, pp. 561–567. https://doi.org/10.1007/978-3-319-90893-9_65

[10]. Okereke, J. N., Udebuani, A. C., Ezeji, E. U., Obasi, K. O. & Nnoli, M. C. (2015). Possible Health Implications Associated with Cosmetics: A Review. *Science Journal of Public Health*. Special Issue: Who Is Afraid of the Microbes. 3(5-1): 58-63. doi: 10.11648/j.sjph.s.2015030501.21

[11]. Narayana, S., Krishnaswamy, B. & Patel, D. (2013): Trends in Use of Hair Dye: A cross-sectional study. *International Journal of Trichology*, 5, 140.

[12]. Tchounwou, P. B, Yedjou, C.G, Patlolla, A. K. & Sutton, D.J. (2012): Heavy Metals Toxicity and the Environment. *Experientia Supplementum*, 101, 133-164.

[13]. Amartey, E.O., Asumadu-Sakyi, A.B., Adjei. C.A., Quashie, F.K, Duodu, G.O. & Bentil, N.O. (2011). Determination of Heavy Metals Concentration in Hair Pomades on the Ghanaian Market Using Atomic Absorption Spectrometry Technique, *British Journal of Pharmacology and Toxicology*, 2 (4), 192-198.

[14]. Health Canada (2010). Report on Human Bio monitoring of Environmental Chemicals in Canada: Results of the Canadian Health Measures Survey Cycle 1 (2007–2009). Ottawa.

[15]. Iwegbue, C.M.A., Emakunu, O., Obi, G., Nwajei, G. E. & Martincigh, B. S. (2016). Evaluation of Human Exposure to Metals from some commonly used hair Dye Products in Nigeria. *Toxicology Reports*, 3, 796-803.

[16]. Umar, M. H. & Caleb, H. (2013). Analysis of Metals in some Cosmetic Products in FCT – Abuja Nigeria. *International Journal of Cosmetic Sciences*, 3, 14 – 18.

[17]. Pachaun, V. & Flora, S. J.S. (2010). Chelation metal intomication. *International. Journal of Environmental Research in Public Health* (7), 2745-2788

[18]. World Health Organization (2013), Mercury in skin lightening product. World Health Organization (preventing disease through healthy environment series), Geneva. http://www.who.int/phe/new/mercury-flyer.pdf,

[19]. Vesey, D. A. (2010). Transport Pathways for Cadmium in the Intestine and Kidney Proximal Tubule: Focus on the Interaction with Essential Metals. *Toxicology Letters*, 198(1): 13.

[20]. Dong, M. H. (2014). An Introduction to Environmental Toxicology.3rd Edition, Create Space Publication, North Charleton, SC.

[21]. Agents Classified by the IARC Monographs, Volumes 1–100. Retrieved November 3, 2010, from http://monographs.iarc.fr/ENG/Classification/index.php

[22]. Al- Dayel, O., Hefne, J. & Al-Ajyan, T. (2011). Human Exposure to Heavy Metals from Cosmetics. *Orientation Journal of Changhai* , 27 (1), 01-11.

[23]. Ramakant, S., Poornima, S. & Sapna, J. (2014). Heavy Metals in Cosmetics. Centre for Science and Environment, Tughlakabad Institutional Area, New Delhi, website: www.cseindia.org

[24]. Mohamed, A. N., Salah, M., Asma, G., Marouen, B. Y., Dorra, A., Hayet, G. & Abderrazek, H. (2016). Health Risk Assessment of Heavy Metals in Traditional Cosmetics Sold in Tunisian Pure mineral Markets, *International Scholarly Research Notices* Volume 2016, Article ID 6296458, 12 pages.

[25]. Ullah, H., Noreen, S., Rehman, A., Waseem, A., Zubsir, S., Adnan, M. & Ahmad, I. (2017). Comparative Study of Heavy Metals Content in Cosmetic Products of Different Countries Marketed in Khyber Pakhtunkhwa, Pakistan. *Arabian Journal of Chemistry*, 19: 10 – 18.

[26]. Ahmed, H. A. M., Goher, A. S. & Alzubaidi, A. A. M. (2019). Risk Assessment of Heavy Metals Content in Different Hair Dyes and their Users' Urine Samples. *International Journal of Environmental Analytical Chemistry*