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(RESEARCH ARTICLE)

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Harmful effects of heavy metals in cosmetics

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Abstract

This study was carried out to investigate the harmful effects of heavy metals in cosmetics. To achieve this objective the researcher used test and observation. From the study, the levels of heavy metals in mercury, lead, cadmium, chromium, nickel in some branded skin-whitening lotions, lip-sticks, anti aging cream and lip-balm were determined using CV-AAS for mercury and AAS for lead, cadmium, chromium, and nickel. The mean levels (ppm) of heavy metals were found to fall in the following ranges: In lip-sticks, chromium 1.14, 1.09, 1.34, Nickel 2.19, 2.14, 2.36. In fairness cream, mercury 1.79, 1.52, 0.10. Lip-balm and anti-aging cream no trace of heavy metal found. In today's world the use of cosmetics on daily basis has become very common. Consumers can limit their exposure by avoiding products that contain harmful chemicals. Especially with regard to possible long term effects as the products may be used extensively over a long period of time may contain ingredients whose safety is not certain or which are known to cause health risks. Alternatively one can buy a product which contains chemicals in certain quantity which will not cause the adverse effect. In Nigeria, National Agency for Food and Drug Administration and Control (NAFDAC), which is the agency responsible for the control of the safety of cosmetics products, is working hard to ensure safety of the consumers of these products, whereas the manufactures of these products on their part have the responsibility to ensure the clinical safety of their products. It is recommended that the use of heavy chemicals contained in cosmetics should be avoided. Consumers can limit their exposure by avoiding products that contain harmful chemicals. Alternatively one can buy a product which contains the chemicals in small quantity which will not cause the adverse reactions. Organic based cosmetics should be used since it is produced from natural sources.

Keywords: Harmful; Effects; Heavy Metals; Cosmetics

1. Introduction

The word "cosmetic" is derived from the Greek word "kosmetikos" which means skilled in decoration". Since the dawn of civilization, cosmetics have been utilized by people irrespective of their race, gender or age to beautify, modify or alter ones' physical appearances. Cosmetics or makeup are substances or preparations used to enhance the beauty of the human body [8].The general acceptance of cosmetics worldwide can be seen in the estimated sales by cosmetic industries in 2014, which is over 230 billion U.S dollars in total worth of sales in America, Europe, Australia, Asia and Africa [15].Most commonly used cosmetics in various parts of the world include facial make-up such as-lipsticks, lipglosses, foundations, concealers, powders, rouges, mascaras, eyeliners, eye shadows. Others include skin care creams, shampoos, hair dyes, deodorant and perfumes, nail polishes and mouth washes which find different application on different body parts. The toxicity of product ingredients in various cosmetics is evaluated almost exclusively by a self-policing industry safety committee - the Cosmetic Ingredient Review (CIR).Researchers in the United States of America have shown that one in eight of the 82,000ingredientsusedinpersonalcareproductsare industrial care chemicals [18]which have been banned as intentional ingredients due to their plausible side effects. The continual patronage of

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cosmetics and the increasing views that the use of make-up, as cosmetics are colloquially known, does not necessarily make up beauty as asserted in the definition of the term has been an unaddressed issue. The above scenario prompted this study. This study aims at enlightening the public and users of make-up on the presence of any eleterious constituents present in these products, its grave consequences and its enormous economic implication. Also, this study would inculcate the need to use right doses of skin friendly products as the precise assessment of heavy metal concentration would narrow the margin between overconsumption and adequate use of any cosmetic product. Several researches have shown the presence of heavy metals in wide range of cosmetic products. [8]assessed heavy metals concentrations in facial cosmetic samples and reported varying abnormal concentrations of the metals; chromium (Cr), nickel (Ni), zinc (Zn) and iron (Fe). They established that the facial cosmetics analysed contained toxic metals and over exposure could lead to an increase in metal levels in the body beyond permissible limit. Furthermore, a study revealed mercury (Hg) in alarming levels ranging from 878 to 36,000ppm as recorded in six (6) out of sixteen (16) samples when Mexican skin lightening creams where analysed [13]. Another study which specifically assessed heavy metals (Pb, Ni, Cu, Co, Cr, Mn, Zn, Cd) in some eye shadows imported from China into Nigeria reported the presence of these metals in varying concentrations [12] They reported that the obvious presence of these metals from the study indicated that these metals in facial cosmetics expose users to low levels of heavy metals. The study also showed that all the metals assessed except Chromium (Cr) where beyond permissible limits. Similar studies were carried out in New York and Hong Kong [17]. In both studies, geometrical mean urine mercury (Hg) concentration identified a previously unrecognized source of exposure to inorganic mercury from the use of skin care products among residents. The urine mercury concentration was particularly high in residents that had used a beauty cream, within the last 45 days, before the experimental analysis .However no known work has been done to investigate the presence of arsenic (As), mercury (Hg), cadmium (Cd) and lead (Pb) in samples such as lipsticks, eye liners and hair dyes.

1.1. Literature review

Figure 1 Facial cosmetics (Source: wholenewmom.com/health-concerns/heavy-metals-in-cosmetics 2018)

Cosmetics are substances which are applied by means of rubbing, pouring, sprinkling on the body for purposes of cleansing, beautifying, promoting attractiveness or even altering the general human appearance [10]. They are categorized as creams, emulsions, lotions, gels and oils for the skin. More products also exist in the form of face masks, make up powders, toilet soaps, perfumes, shower and bath preparations, deodorants and antiperspirants, depilatories, hair care products and shaving products [1]. More still are products for internal intimate hygiene, sunbathing products, skin whitening products and anti-wrinkle products [1]. The ingredients used in cosmetics can either be herbal or synthetic [6] and [3]. Formaldehyde and formaldehyde releasing ingredients, hydroquinone, parabens and phthalates are ingredients used in synthetic cosmetics which could be harmful to human body [3].Formaldehyde and formaldehyde releasing agents are used in the manufacture of water based consumer products such as soaps to prevent bacterial growth while in storage. Formaldehyde is easily absorbed by the human skin and can cause cancer. Hydroquinone is

used for skin lightening. It causes decline in the production of melanin pigments. It is carcinogenic and the reduction in melanin increases the risks of cancer due to reduced protection against UV rays. Hydroquinone affects natural immunity and also brings about reproductive and developmental defects [3]. Parabens are used in cosmetics to inhibit microbial growth while in storage. They are carcinogens and are easily absorbed by the skin and enter the bloodstream and the digestive system. Phthalates are used as binding agents for colour and scent in cosmetic products. They disrupt human hormonal system [3]. *Aloe vera*, neem and olive oil are the herbal ingredients commonly used in cosmetics and whose demand is increasing [16].Cosmetics can either be herbal or synthetic depending on the ingredients from which they are made and either will serve the purpose of cosmetics [10]. The former however, are milder, biodegradable and have low toxicity profile [4]. Further, they whip up the circulation, refine the pores, refresh the skin leaving it soft and glowing and promote the skin's capacity to absorb. [9]. Herbal cosmetics have preventive, protective, corrective and curative actions ideal for maintaining the health of the skin.

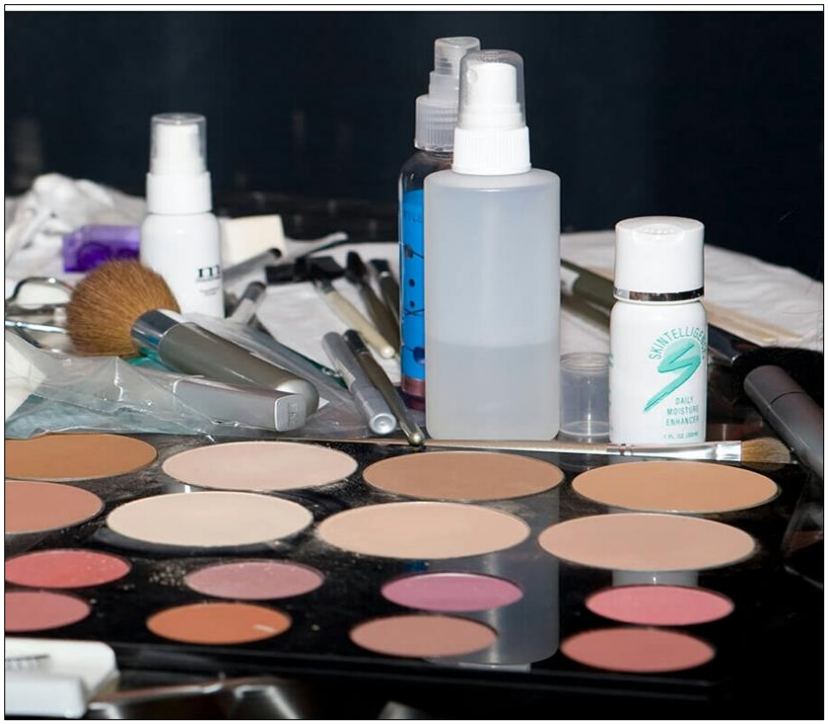

Figure 2 Facial cosmetics(Source: wholenewmom.com/health-concerns/heavy-metals-in-cosmetics 2018)

1.1.1. Heavy metals

Heavy metals have densities higher than 3g/cm3 and are known to cause adverse effects if present at levels beyond those that are recommended [2] and [14]. A number of these occur as natural constituents of the earth crust including arsenic (As), cadmium (Cd), chromium (Cr), lead (Pd), mercury (Hg), manganese (Mn), zinc (Zn) and nickel (Ni) among others [7] and [2]. The adverse effects occur due to their undegradable and undestructive nature. The nature of effects could be toxic (acute, chronic or sub chronic), neurotoxic, carcinogenic, mutagenic or teratogenic [11] and [7]. The toxicity can result to damaged or reduced mental and central nervous function, lower energy levels and damage to blood composition, lungs, liver, kidneys and other vital organs [11]. Through dermal contact, heavy metals can be absorbed through a moist skin [12]. Lead for example was found in 7 out of 9 adult males to have been elevated in hair and other parts of their body after applying a hair dye containing lead acetate [12].

2. Material and methods

2.1. Sampling methodology

3 samples of lipsticks, 3 samples of fairness creams, 3 samples of lip-balm and 3 samples of anti-ageing creams were purchased from local market in Kafanchan. The details of the samples are presented in tables 1 and 2.

2.1.1. Equipment

Atomic Absorption Spectrometer (Thermo) Solar M-6 Series, equipped with Flame and Flameless techniques was used for analysis.

2.1.2. Glassware

All the glassware were cleaned with detergent and 10% nitric acid and rinsed thoroughly with distilled water before use.

2.1.3. Chemicals

All the chemicals used were purchased from Ezenwa chemicals in Kafanchan Kaduna state. The water used in all the experiments was ultrapure water obtained from Jauri water purification system.

2.2. Sample preparation for lead, cadmium, chromium and nicke determination

Lipstick, lip-balm and anti-ageing creams were analyzed for lead, cadmium, chromium and nickel. Sample preparation for the determination of Lead, Cadmium, Chromium and Nickel was done following the method of[5]. About 1.0 g of each sample was digested in 5.0 ml mixture of concentrated acid HNO_3:$HClO_4$ (3:1) for 2-3 hours on a hot plate at 90 ℃. Then 3.0 mL of acid mixture was again added and then again heated for 2-3 hours to complete the digestion. The above digested samples were cooled and about 5.0 mL ultra pure water was added mixed well and volume made up to 25 mL in volumetric flask. The solution was then finally filtered through Whatman filter paper. The clear solution was used for metal quantification.

2.3. Sample preparation for mercury determination

Fairness creams were analyzed for mercury. Application note provided by. of CETAC Technologies of USA was used for the sample preparation for mercury estimation. The samples were weighed (~0.2g) into the beaker. The samples were predigested with 2 mL of H_2SO_4 and 2 mL HNO_3 for 1.5 hours at 800 ℃. This initial predigest step dissolved/dispersed the samples and then allowed to cool to room temperature. Then 7.0 mL of 5% KMnO4 and 5 mL 3% HCl were added to each beaker and then heated at 950C for 2 hours. After again cooling to room temperature, 3.0 mL of 12% hydroxylamine solution was added to reduce the KMnO4. The beakers were swirled to assure complete reaction with the excess $KMnO_4$. They were then brought up to a final volume of 25 mL with 3% HCl with thorough mixing prior to instrument analysis of the samples.

2.4. Sample analysis for lead, cadmium, chromium, and nickel determination

Lead, Cadmium, Chromium and Nickel were determined using flame atomic absorption spectrometry. Air-acetylene flame was used for Lead, Cadmium and Nickel while air-acetylene-nitrous oxide flame was used for Chromium determination. Standard solutions were prepared in five different concentrations for each metal separately to obtain calibration curve for quantitative analysis. All the measurements were run in triplicate for the samples and standard solutions. Deuterium lamp was used for background correction.

2.5. Sample analysis for mercury determination

Digested samples were analyzed for Mercury using flameless atomic absorption spectrometry. Standard solutions were prepared in five different concentrations to obtain calibration curve for quantitative analysis. All the measurements were run in triplicate for the samples and standard solutions. Deuterium lamp was used for background correction. Recovery test was performed for all the metals. Recovery was found to be more than 90% in all the cases.

2.6. Principle and methodology of atomic absorption spectroscopy (aas)

2.6.1. Principle

Atomic absorption spectroscopy (AAS) is a spectro analytical procedure for the quantitative determination of chemical element using the absorption of optical radiation (light) by free atoms in the gaseous state.

The technique makes use of the atomic absorption spectrum of a sample in order to assess the concentration of specific analytes within it. It requires standards with known analyte content to establish the relationship between the measured absorbance and the analyte concentration and relies therefore on the Beer-Lambert law.

3. Results

The levels of heavy metals mercury, lead, cadmium, chromium, and nickel in some branded skin-whitening lotions, lip-sticks, anti-aging creams and lip-balm were determined using CV-AAS for mercury and AAS for lead, cadmium, chromium, and nickel. The results obtained are presented in tables prior to their discussions.

Table 1 Cosmetic Samples Purchased from Kafanchan Markets kaduna state

S/N	Sample Code	Brand	Color	BatchNo	Manufactured by	Used before
Lip-sticks						
1	LS 1	MAC (Satin Lipstick)	Pink (A52)	M3EW	Estee Lauder, New York, N. Y. 10022	05/2024
2	LS 2	Classic make up	Nude girl	122651	Made in Canada	10/2024
3	LS 3	Estee Lauder	Scarlet red (73)	A92	Lauder, New York, N. Y. 10022	09/2024
Fairness cream						
1	FC 1	Olay Natural White		B6918	Procter & Gamble Home Products Ltd., Industrial Area, Katha,	01/2025
2	FC 2	Clinic clear	Creamy	Cf0218	Dodo cosmetics Togo-lome 11 BP112	07/2024
3	FC 3	Fair & Lovely Winter Fairness	White	B 33	Hindustan Unilever Ltd., Unit – 8, Plot No. 1-(1-H), Sec 1A, SidculRanipur, Haridwar	10/2025
Lip-balm						
1	LB 1	Maybellin New York	Velvety Rose	SPF 20	Made in China	01/2025
2	LB 2	Absolute	Berry Crush	fJ257M	Made in Thailand	03/2024
3	LB 3	Lotus	Fresh mint	BCG 20.	Lotus Herbals Color Cosmetics, 80-B, Jharmajri, Baddi.	01/2025
Anti aging cream						
1	AAC 1	Olay (7 in one, Anti-aging Night Firming Treatment)	White	2184PRF	Distr. By – Proctor & Gamble, Cincinnati, OH – 45202	11/2024
2	AAC 3	L'Oreal (Paris) (Anti-wrinkle Day Cream)	Yellow	28J302	Made in Germany	01/2024
3	AAC 3	Ponds Age Miracle (Day Cream)	White	B040	Hindustan Unilever Ltd., Unit – 4, I. Industrial Estate, Haridwar – 249403	01/2024

Table 2 Heavy Metals Concentration in Cosmetics

S/n	Sample	Sample code	Lead mg	Chromium mg	Cadmium mg	Nickel mg	Mercury mg	Remark
Lip-stick								
1	MAC (Satin Lipstick)	LS 1	-	1.14	-	2.19	-	
2	Classic make up	LS 2	-	1.09	-	2.14	-	
3	Estee Lauder	LS 3	-	1.34	-	2.36	-	
Fairness cream								
1	Olay Natural White	FC 1	-	-	-	-	1.79	
2	Clinic clear	FC 2	-	-	-	-	2.52	
3	Fair & Lovely	FC 3	-	-	-	-	0.10	
Lip-balm								
1	Maybellin New York	LB 1	-	-	-	-	-	
2	Absolute	LB 2	-	-	-	-	-	
3	Lotus	LB 3	-	-	-	-	-	
Anti-aging cream								
1	Olay	AAC 1	-	-	-	-	-	
2	L'Oreal (Paris)	AAC 2	-	--	-	-	-	
3	Ponds Age Miracle	AAC 3	-	-	-	-	-	

4. Discussion

A total of 3 lipsticks, 3 lip-balms and 3 anti-ageing creams were tested for lead, cadmium, total chromium and nickel and 3 samples of fairness creams for mercury.

4.1. Lipstick

4.1.1. Chromium

Total chromium was detected in3 samples in the range of 1.09 ppm to 1.34 ppm *(*Table 2*)*. Total Cr detected in lipstick samples was compared with Average Daily Intake (ADI) of Cr+6. Recognizing the need for extra precaution, all Cr has been assumed as Cr+6. This assumption is made by most health regulators, including the USEPA while setting standards. The ADI value of 0.0001 mg/day for a 50 kg woman for Cr+6 derived by Liu *et. al.* (2009) was used for estimating exposure risk. This ADI value is derived based on the cancer risk posed by Cr+6. An average use of 24 mg/day and high use of 87 mg/day of lipstick suggested by Loretz*et. al.* (2005) were used for estimating the exposure risk. 100% in case of 3 samples of lip-stick detected with chromium *(*Table2*)*. The highest concentration of 1.34 ppm of total chromium was found in shade of ColorBar lipstick. The second highest concentration - 1.14 ppm was found in MAC lip-stick. While the lowest concentration is 1.09 in classic make up. The toxicity of chromium compounds depends on the oxidation state of the metal. Hexavalent form is more toxic than trivalent form. Hexavalent chromium is recognized as a human carcinogen when it is inhaled. Chronic inhalation of Hexavalent chromium has been shown to increase risk of lung cancer and may also damage the small capillaries in kidneys and intestines. Other adverse health effects associated with Hexavalent chromium exposure, according to the National Institute for Occupational Safety and Health (NIOSH), 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 teeth27.

4.1.2. Nickel

It was detected in 100% 3 samples in the range of 2.19 ppm to 2.36 ppm. The highest concentration of 2.36 ppm was found in MAC (satin) pink shade of lipstick. The second highest concentration of 2.19 ppm was found in Hearts & Tarts (080V) shade of ColorBar lipstick (**Table 2**). High levels of Nickel exposure can lead to health effects depending on route and the kind of nickel exposed to. Certain types of nickel (oxidic, sulphidic, and soluble nickel) were considered to be toxic because of concern to health due to carcinogenicity. Metallic nickel and alloys have been classified as possibly carcinogenic to humans. Allergy to nickel is common and it can cause severe contact dermatitis. The first case of nickel allergy caused by eye shadow was reported twelve years ago and it has been reported that even 1 ppm may trigger a pre-existing allergy.

Lead and Cadmium were not detected in any of the samples.

4.2. Lip-balm and Anti-ageing Creams

None of the heavy metals tested were detected in lip-balm and anti-ageing creams.

4.3. Mercury in Fairness (Skin Whitening) Creams

Mercury was detected in about 100% (3) samples in the range of 0.10 ppm to 2.52 ppm as total mercury (**Table 2**). According to the Drugs and Cosmetic Act, mercury in Fairness creams is prohibited. Therefore 3 samples that contained mercury violated the Act. The concentration of total mercury detected in the skin whitening creams were converted to concentration of mercuric chloride ($HgCl_2$) because skin whitening creams commonly use inorganic mercury in the form of ammoniated mercuric chloride and mercuric iodide (**Table 2**). Conversion of total Hg to $HgCl_2$ is done by considering the molecular weight of Hg as 200.592 and that of $HgCl_2$ as 271.496. It is assumed that all mercury (Total Hg) in the skin whitening creams is $HgCl_2$. Oral Reference Dose (RfD) of $HgCl_2$ set by USEPA is 0.0003 mg/kg-day which translates into an Average Daily Intake (ADI) for a 50 kg person as 0.015 mg. Loretz*et. al.* (2005) has estimated that the average use of creams is 2.05 g/day and high use is 3.99 g/day33. Considering 100% dermal absorption the amount of $HgCl_2$ obtained after conversion was compared as percentage the above ADI of $HgCl_2$ (0.015 mg for a 50 kg person) ***(*Table 2*)***.

Aroma Magic Fair Lotion had the highest mercury concentration of 1.97 ppm as total mercury (2.67 ppm equivalent $HgCl_2$) which is 36.4% of ADI for average use of cream (2.05 g/day) and considering the high use (3.99 g/day) it is 70.9% of ADI ***(*Table2*)***. Fair and Lovely Ayurvedic Care had the lowest concentration 0.10 ppm as total mercury and 0.14 ppm as HgCl2 which is 1.8% of ADI for average use of cream (2.05 g/day) and considering the high use (3.99 g/day) it is 3.6% of ADI.

Out of 6 Fairness Creams for men, mercury was detected in only one sample (Garnier Men Power Light) at a level of 0.24 ppm as total mercury. According to the FDA, the permissible limit for mercury in Cosmetics other than eye products is 1 ppm. Out of 32 samples tested three samples (10.7%) exceeded the limit of 1 ppm given by FDA ***(*Table2*)***. Repeated application of these skin whitening creams could cause cumulative effect of prolonged low level mercury exposure, which could lead to nephritic syndrome Mercury can also be transferred from the mother to the fetus during pregnancy34. Mercury from soap and cream has been reported to be readily absorbed through the skin and via inhalation.

5. Conclusion

In today's world the use of cosmetics on daily basis has become very common. Consumers can limit their exposure by avoiding products that contain harmful chemicals. Especially with regard to possible long term effects as the products may be used extensively over a long period of time may contain ingredients whose safety is not certain or which are known to cause health risks. Alternatively one can buy a product which contains chemicals in certain quantity which will not cause the adverse effect.

In Nigeria, National Agency for Food and Drug Administration and Control (NAFDAC), which is the agency responsible for the control of the safety of cosmetics products, is working hard to ensure safety of the consumers of these products, whereas the manufactures of these products on their part have the responsibility to ensure the clinical safety of their products.

Compliance with ethical standards

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Disclosure of conflict of interest

All Authors have declare they have no conflict of interest.

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