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HEAVY METAL CONTAMINATION IN COSMETICS: AN ANALYSIS OF LEAD AND MERCURY LEVELS IN COMMONLY USED PRODUCTS AND ASSOCIATED HEALTH RISKS

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ABSTRACT:

Cosmetic products are widely used for personal care and enhancement, but concerns about their safety have emerged due to the presence of toxic heavy metals. This study investigates the concentration of lead and mercury in commonly used cosmetic products and assesses the potential health risks associated with their exposure. Heavy metals detected in the tested samples were classified as unintentional contaminants, originating from raw materials and manufacturing processes. The analysis revealed varying concentrations of lead and mercury, with some samples containing dangerously high levels. Mercury, commonly found in skin-lightening creams, was detected at concentrations as high as 105.59 ppm, while lead levels reached up to 6.3748 ppm in certain products. Prolonged exposure to these metals can lead to bioaccumulation, interfering with essential biological functions and posing risks such as skin allergies, contact dermatitis, and systemic toxicity. The findings highlight the need for stricter regulatory oversight, improved manufacturing practices, and increased consumer awareness to ensure the safety of cosmetic products.

KEYWORDS: Heavy metals, cosmetics, lead & mercury toxicity, skin-lightening creams, health risks, bioaccumulation, environmental contaminants, consumer safety.

INTRODUCTION:

Cosmetic products play a crucial role in personal grooming and self-care routines worldwide. From skincare creams to makeup products, cosmetics are extensively used by individuals of all ages and genders. However, concerns regarding the safety of these products have increased due to the presence of toxic heavy metals such as lead and mercury (1-3). These metals, often found as unintentional contaminants, pose potential health risks when absorbed into the human body through prolonged use. Despite regulations and quality control measures, heavy metal contamination in cosmetics remains a significant public health issue that warrants further investigation (4-6).

Heavy metals are naturally occurring elements that can be toxic to living organisms even at low concentrations. While some metals, such as iron and zinc, are essential for biological functions, others, like lead and mercury, have no beneficial role in the human body and can cause severe health complications (7-9). Lead and mercury are known for their toxic effects, particularly when they accumulate in body tissues over time. The absorption of these metals through the skin, inhalation, or accidental ingestion can lead to adverse physiological and neurological effects, emphasizing the need for stringent monitoring and regulation in the cosmetic industry (10-12).
Mercury, in particular, has been widely used in skin-lightening creams due to its ability to inhibit melanin production. However, exposure to high levels of mercury can result in severe dermatological and systemic effects, including skin rashes, kidney damage, and neurological disorders. Studies have shown that continuous exposure to mercury can lead to bioaccumulation, causing long-term health complications (13-16). In addition, mercury exposure can be especially harmful to pregnant women, as it may affect fetal development and lead to birth defects. Despite international efforts to regulate its use, mercury remains a prevalent contaminant in some cosmetic products, particularly in unregulated markets (17-19).

Lead is another toxic heavy metal frequently detected in cosmetics, particularly in lipsticks, eyeliners, and skin creams. The presence of lead in these products is often linked to contaminated raw materials, such as pigments used in color cosmetics. Lead exposure has been associated with various health issues, including neurotoxicity, reproductive disorders, and cardiovascular diseases (20-22). Unlike mercury, lead does not degrade or get excreted easily from the body, making its accumulation over time a significant concern. Even low levels of lead exposure can be detrimental, especially in children and pregnant women, as it affects cognitive function and neurological development (23).

The presence of heavy metals in cosmetics raises concerns about the effectiveness of current regulations and the responsibility of manufacturers in ensuring product safety. While regulatory bodies such as the U.S. Food and Drug Administration (FDA) and the European Union have set permissible limits for heavy metal contamination in cosmetics, enforcement remains a challenge (24). Many cosmetic products, especially those sold in informal markets or imported from countries with lax regulations, continue to contain hazardous levels of lead and mercury. This highlights the need for stronger regulatory oversight, better quality control measures, and increased consumer awareness regarding the potential risks associated with contaminated cosmetics (25).

Given the widespread use of cosmetics and the potential for long-term health risks, this study aims to assess the concentration of lead and mercury in commonly used cosmetic products. By analyzing various samples, the study seeks to determine the extent of heavy metal contamination and its possible implications for human health (26). The findings of this research will provide valuable insights into the need for stricter regulations and improved manufacturing practices to ensure consumer safety. Ultimately, understanding the presence and effects of heavy metals in cosmetics can lead to more informed choices by consumers and greater accountability within the cosmetic industry.

EXPERIMENTAL:

SAMPLING:

A total of 25 skin whitening cream samples from various brands and countries were randomly collected from cosmetic shops in Bagbanpura and Mughalpura markets. To maintain anonymity, brand names were concealed, and unique codes were assigned to each sample. These codes followed a pattern, such as SAI, SBI, SCI, and SDI, corresponding to creams 1, 2, 3, and 4, respectively.

REAGENT AND SOLUTION:

All chemicals used in this study were of analytical reagent grade or the highest available purity. Doubly distilled deionized water, which does not absorb ultraviolet radiation, was used throughout the process.

Glassware was thoroughly cleaned by soaking in acidified solutions of either potassium permanganate ($KMnO_4$) or potassium dichromate ($K_2Cr_2O_7$), followed by washing with concentrated nitric acid (HNO_3) and multiple rinses with deionized water.

Stock solutions and environmental water samples (1000 mL each) were stored in polypropylene bottles containing 1 mL of concentrated nitric acid to maintain stability and prevent contamination.

PREPARATION OF STANDARD STOCK SOLUTIONS AND WORKING STANDARDS:

SODIUM DODECYL SULFATE (SDS) SOLUTION 0.6 M:

A 500 mL solution of sodium dodecyl sulfate (SDS) was prepared by dissolving 86.4 g of pure SDS in 250–300 mL of doubly distilled deionized water. The mixture was sonicated for 15 minutes until it became transparent, then further diluted with deionized water to reach the final volume of 500 mL.

DIPHENYLTHIOCARBAZONE (DITHIZONE) SOLUTION PREPARATION:

A 0.005% solution of diphenylthiocarbazone (dithizone) was prepared by dissolving the required amount in a known volume of isoamyl alcohol. More dilute solutions were prepared as needed.

Mercury (II) Standard Solution:

A 100 mL stock solution of divalent mercury (Hg^{2+}) was prepared by dissolving 135 mg of mercuric chloride ($HgCl_2$) in deionized water containing 1–2 mL of nitric acid (1+1). Aliquots of this stock solution were used to prepare standard solutions as needed.

Additionally, a 100 mL mercury (II) stock solution was prepared by dissolving 117.68 mg of purified-grade mercuric chloride ($HgCl_2$) in deionized water. The working standard of mercury (II) was obtained using the ashing procedure (Figure 1).

Figure 1: stock solution

METHODOLOGY:

PREPARATION OF ASH:

An empty crucible was weighed using a measuring balance, and approximately 5 g of each cream sample was placed into the crucible. The samples were first heated over an open flame and then subjected to an ashing process. After cooling, the ashed samples were placed in a **muffle furnace at 550°C** for **3–4 hours**.

Once removed from the furnace, the ash samples were processed as follows:

1. Each ash sample was dissolved in **5 mL of 6N HCl** along with a small amount of distilled water.
2. The crucible was gently warmed over a flame (without boiling) to aid dissolution.
3. The resulting solutions were filtered and diluted to **50 mL** with distilled water.
4. The prepared solutions were stored in bottles for further analysis.
5. After preparing all individual solutions, they were combined in a test tube for further testing (figure 2).

Figure 2: cream samples

Preparation and Detection of Mercury (Hg) and Lead (Pb) in Cream Samples

1 mL of each cream solution was transferred into test tubes and arranged in numerical order. The following reagents were then added to each test tube:

- **1 mL** of a slightly acidic solution containing **0.5–100 µg of mercury (II)**
- **5 mL** of **0.6 M sodium dodecyl sulfate (SDS)**
- **1 mL** of **1 M sulfuric acid (H_2SO_4)**

The mixture was then diluted to the desired volume using deionized water.

After preparation, the absorbance of the mixture was measured at **490 nm** against a corresponding reagent blank. The **mercury (Hg) content** in the unknown samples was determined based on the absorbance values (figure 3).

The same procedure was followed to detect **lead (Pb) content**, with the only modification being the replacement of the mercury standard solution with a **lead standard solution**. The lead content in the cream samples was then analyzed accordingly (figure 4).

Lead (Pb) Standard Solution Preparation:

1. Dissolve 1.000 g of lead metal in 50 mL of 2M nitric acid (HNO_3).
2. Dilute the solution to 1 liter in a volumetric flask using deionized water.

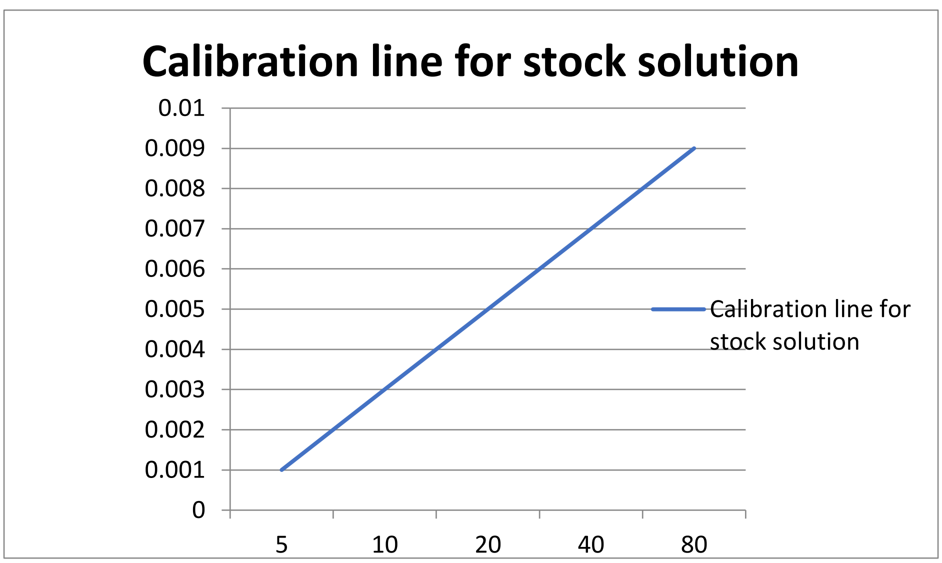

Figure 3: Representation of Calibration Line for Mercury Stock solution

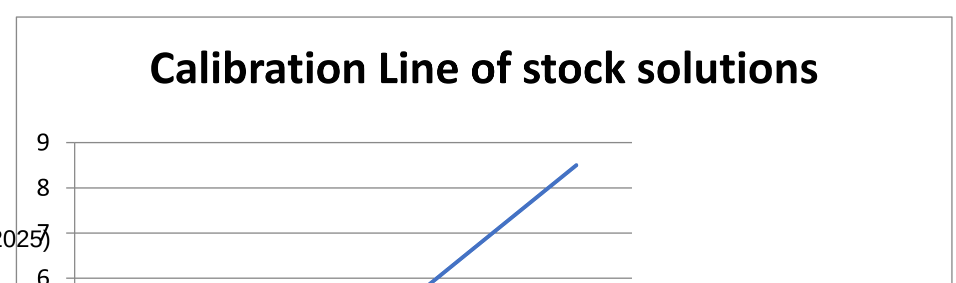

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Figure 4: Representation of calibration for Lead stock solution

RESULTS AND DISCUSSION:

DETERMINATION OF HEAVY METALS:

The levels of mercury (Hg) and lead (Pb) in skin whitening creams sold in the market were determined using the ashing process for both metals. The accuracy of the technique was evaluated through recovery studies, and the results are presented in Table 1.

In 2022, a total of 25 cosmetic cream samples from different markets were analyzed for their mercury and lead content. The concentrations of these elements, measured in parts per million (ppm), are shown in Table 1.

Currently, no specific upper limits for mercury and lead in cosmetics have been established due to their low toxicity at trace levels. However, prolonged exposure to these elements from cosmetics, as well as other sources such as drinking water, food, air, and occupational exposure, may lead to their accumulation in the body, potentially causing health risks.

To assess potential exposure risks, the upper allowed limits established by various health agencies for daily intake were used as a reference. Considering the application of 2–5 grams of body creams or lotions and the absorption of metals through the skin, the estimated amount of metal absorbed via this route was compared with the established limits. For face powders, a daily application of less than one gram was assumed due to the product's dry nature.

Table 1: Amount of mercury and lead in whitening creams

Sample code	Mercury contents	Lead contents
MAI	98.065	ND
MBI	72.945	ND
MCI	ND	ND
MDI	ND	ND
MEI	44.716	ND
MFI	ND	ND
MGI	105.59	0.7676

MHI	ND	6.3748
MII	ND	0.350
MJI	51.72	1.3344
MKI	ND	ND
MLI	ND	ND
MMI	ND	0.2407
MNI	ND	ND
MOI	ND	ND
MPI	ND	ND
MQI	ND	ND
MRI	48.901	ND
MSI	ND	1.7036
MTI	5.2871	1.2371
MUI	ND	ND
MVI	ND	ND
MWI	58.178	3.7354
MXI	ND	0.6706
MYI	24.943	1.1656

ND=Not Detected
Hg concentration = 5.2871_105.5
Pb concentration = 0.2407_6.3748

DETERMINATION OF MERCURY (HG):
Mercury (Hg) was detected in various branded whitening creams, with concentrations ranging from 5.2871 to 105.59 ppm. Significant differences were observed between different brands, as Hg was detected in 9 out of 25 cream samples, with 7 of them containing mercury in high amounts (figure 5).

The presence of mercury in cosmetics can be attributed to its common use as a skin-lightening agent. While some creams contained Hg levels below the maximum WHO-recommended limit of 1 ppm, certain samples exceeded this limit (WHO, 1995).

The statistical differences in Hg levels between brands may be due to compositional variations in the products or differences in environmental conditions during manufacturing. However, these factors were not specifically investigated in this study.

The variation in mercury levels among brands raises concerns regarding consumer safety and product selection. Although the detected levels may suggest some degree of safety, continuous exposure to Hg-containing cosmetics poses potential health risks. Previous studies have reported

elevated mercury levels in the urine and blood of cosmetic users, highlighting the dangers of Hg absorption through the skin or other exposure routes.
Therefore, caution should be exercised when using these products, especially those exceeding recommended Hg limits.

DETERMINATION OF LEAD (PB):
Lead (Pb) was detected in various branded whitening creams, with concentrations ranging from 0.2407 to 6.3748 ppm. Significant differences were observed between different brands, with lead detected in 10 out of 25 cream samples (figure 6).
Lead is a well-known contaminant in cosmetics. In this study, the levels of lead in all tested creams were below the WHO maximum recommended limit of 10 ppm (WHO, 1995). However, while some of the recorded values were lower than those reported in previous studies, others were relatively higher, reaching up to 6.3748 ppm.
The observed differences in Pb levels among brands may be attributed to variations in product composition and manufacturing conditions, as discussed in the previous section. Despite these differences, studies have shown that lead can be absorbed through the skin, potentially leading to serious health issues such as:

- Anemia
- Colic (severe abdominal pain)
- Neuropathy (nerve damage)
- Nephropathy (kidney disease)
- Sterility
- Coma
- Behavioral abnormalities
- Learning impairments

Although the detected lead levels were within the permissible limits, long-term exposure through repeated use of contaminated cosmetics could pose significant health risks. Therefore, caution should be exercised when selecting and using these products.

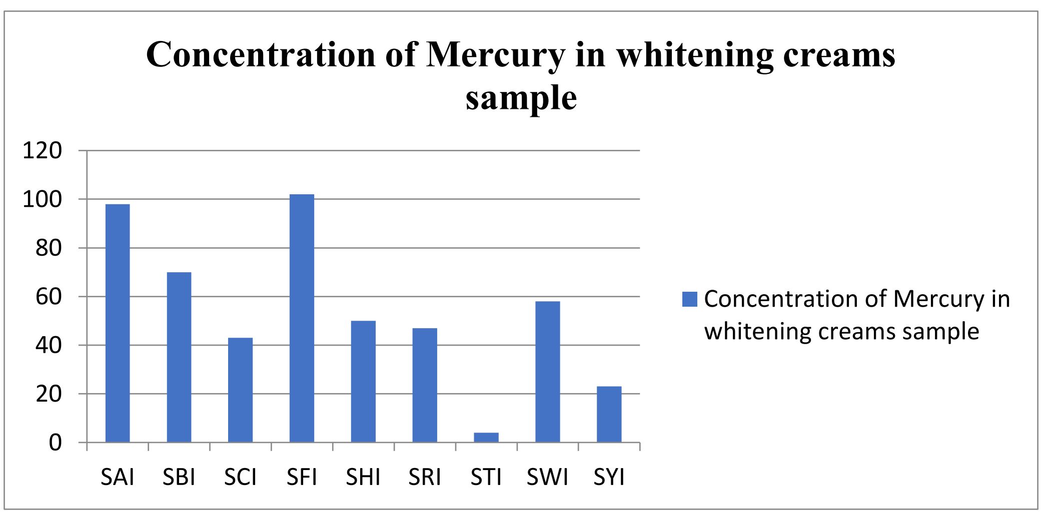

Figure no 5: Representation of concentration of mercury in whitening cream

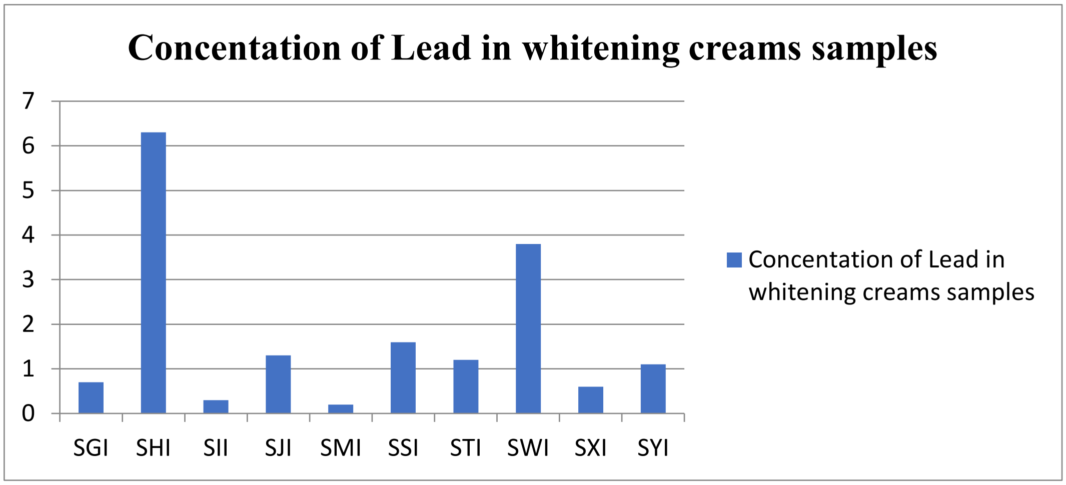

Figure 6: Representation of concentration of Lead in skin whitening creams.

DISCUSSION:

Cosmetics are considered a significant source of heavy metal contamination in both the environment and the human body. Given this concern, there is a growing need to analyze the concentration of toxic metals in widely used cosmetic products.

The potential physiological and behavioral effects of toxic metal exposure on the human population are becoming increasingly worrisome. While the harmful effects of high lead exposure are well-documented, recent attention has shifted to the risks associated with prolonged, low-level exposure through cosmetic products. Continuous exposure to these metals may pose serious health risks, including skin allergies and contact dermatitis.

In this study, various cosmetic products were tested for the presence of lead and mercury. Table 1 presents the concentration of these heavy metals in different cosmetic samples, measured in parts per million (ppm). The detected heavy metals are classified as unintentional contaminants, meaning they are not deliberately added to the product formulation but instead appear as impurities. These impurities arise from the manufacturing process, ingredient degradation, or environmental contamination of raw materials.

Heavy metals persist in the environment due to their natural presence in rocks, soil, and water, leading to their unintentional inclusion in cosmetic pigments and other raw materials. While manufacturers are expected to minimize these contaminants, lenient regulations allow many companies to bypass thorough removal processes to save costs. Although the detected heavy metals were present in trace amounts, their gradual accumulation in the human body over time could be harmful. These metals have a long half-life and may accumulate in organs, interfering with essential nutrients such as calcium and zinc.

Mercury, for example, is commonly used in skin whitening products because it inhibits melanin production, which determines skin and hair pigmentation. Results from cream samples revealed that some contained dangerously high levels of mercury, with sample SAI measuring 98.065 ppm posing a significant risk to the skin. Lead was also detected in certain cream samples, with the highest concentration found in sample SJI at 1.3344 ppm.

While some cosmetic products were free of heavy metals like mercury and lead, others contained both, making them hazardous to human skin. The detected mercury concentrations ranged from 5.2871 to 105.59 ppm, while lead concentrations varied between 0.2407 and 6.3748 ppm. These findings highlight the need for stricter regulations and increased consumer awareness regarding the presence of toxic metals in cosmetics.

CONCLUSION:

The presence of heavy metals in cosmetic products remains a significant concern due to their potential health risks and environmental impact. This study highlights the presence of lead and mercury as unintentional contaminants in some commonly used cosmetic products. While these metals are not deliberately added, their persistence in the environment and their incorporation into raw materials used in cosmetic manufacturing contribute to their presence in final products.

Our findings indicate that certain cosmetic samples contain elevated levels of mercury and lead, which may pose serious health hazards upon prolonged exposure. The accumulation of these metals in the human body over time can interfere with essential biological processes, leading to adverse physiological and behavioral effects. Of particular concern is the use of mercury in skin-lightening creams, where high concentrations were detected, raising the risk of dermatological and systemic toxicity.

The results underscore the need for stricter regulatory measures and improved quality control in the cosmetic industry to minimize the presence of toxic heavy metals. Manufacturers must implement better purification processes, and consumers should be informed about potential health risks associated with long-term exposure to contaminated products. Further research and policy interventions are essential to ensure the safety of cosmetic products and to mitigate the health risks associated with heavy metal contamination.

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DISCLOSURE STATEMENT:

No potential conflict of interest.

REFERENCES:

1. Arshad, H., Mehmood, M. Z., Shah, M. H., & Abbasi, A. M. (2020). Evaluation of heavy metals in cosmetic products and their health risk assessment. *Saudi Pharmaceutical Journal, 28*(7), 779–790. https://doi.org/10.1016/j.jsps.2020.05.006
2. Arshad, H., Mehmood, M. Z., Shah, M. H., & Abbasi, A. M. (2020). Evaluation of heavy metals in cosmetic products and their health risk assessment. *Saudi Pharmaceutical Journal*, *28*(7), 779–790. https://doi.org/10.1016/j.jsps.2020.05.006
3. Coursey, J. S., Schwab, D. J., Tsai, J. J., & Dragoset, R. A. (2015). Atomic weights and isotopic compositions. *National Institute of Standards and Technology*. *Journal of Toxicology & Environmental Safety*, *3*(18), 95–107.
4. Gamero Vega, A. Y. (2019). *Concentración de plomo en sangre de aves xcoquita (Turdus grayi) en la ciudad de Mérida, Yucatán* (Master's thesis). Centro de Investigación y de Estudios Avanzados del IPN Unidad Mérida.

5. Rowley, A. (2022). *A city of steel, and a heart of lead: An analysis of lead exposure and its effect on cardiovascular disease* (Doctoral dissertation). University of Pittsburgh.
6. Desta, K., & Amare, M. (2017). Validated UV-visible spectrometry using water as a solvent for determination of chloroquine in tablet samples. *Chemistry International*, *3*(3), 288–295.
7. Ansari, A. Q., Ahmed, S. A., Waheed, M. A., & Juned, S. A. (2015). Extraction and determination of antioxidant activity of *Withania somnifera* Dunal. *European Journal of Experimental Biology*, *3*(5), 502–507.
8. Odukudu, F. B., Ayenimo, J. G., Adekunle, A. S., Yusuff, A. M., & Mamba, B. B. (2015). Safety evaluation of heavy metals exposure from consumer products. *International Journal of Consumer Studies*, *5*(9), 3–8.
9. Siti Zulaikha, R., Sharifah Norkhadijah, S. L., & Praveena, S. M. (2015). Hazardous ingredients in cosmetics and personal care products and health concern. *Public Health and Research Journal*, *5*(1), 7–15.
10. Nasirudeen, M. B., & Amaechi, A. U. (2015). Spectrophotometric determination of heavy metals in cosmetics sourced from Kaduna metropolis, Nigeria. *Scientific World Journal*, *10*(3), 4–10.
11. Rohman, A., & Wijayanti, E. (2015). Development and validation of atomic absorption spectrometry for the determination of zinc and mercury analyzer for determination of mercury in cream cosmetics. *Journal of Food and Pharmaceutical Sciences*, *3*(5), 23–26.
12. Farrag, E., & Abu-Seleek, M. (2015). Study of heavy metals concentration in cosmetics purchased from Jordan markets by ICP-MS and ICP-OES. *International Journal of Applied Environmental Sciences*, *9*(4), 2–8.
13. Islam, F., Rahman, M. M., Akhtar, P., & Mohammad, A. S. (2015). Determination of heavy metals and trace elements in worldwide branded shampoo available in the local market of Bangladesh. *Asian Journal of Chemistry*, *5*(5), 5–10.
14. Dahab, A. A. (2015). Investigation of mercury content in cosmetic products by using direct mercury analyzer. *American Journal of Pharmaceutical Technology Research*, *5*(5), 2249–3387.
15. Hussein, H. J., & Khaleel, M. I. (2016). Determination of mercury level in skin whitening creams. *Journal of Environmental and Analytical Toxicology*, *1*(8), 378–385.
16. Gbetoh, M. H., & Amyot, M. (2016). Mercury, hydroquinone, and clobetasol propionate in skin lightening products in West Africa and Canada. *World Journal of Pharmacy and Medical Research*, *150*(6), 403–410.
17. Barghasha, S. S., Elgharabawy, R. M., Ahmed, H. A. M., Al-Otaibi, R., & Alkhaile, B. A. (2016). Detection of heavy metals in cosmetic creams and antiperspirants marketed in Saudi Arabia. *World Journal of Pharmacy and Medical Research*, *3*(1), 30–39.
18. Issa, S. Y. I., Maguid, R. A., & Alazroua, M. (2016). Determination of toxic contents and metals in different cosmetic products in the Arabian market. *Journal of Environmental and Analytical Toxicology*, *6*(3), 120–125.
19. Iwegbue, C. M. A., Emakunu, O. S., Nwajei, G. E., Bassey, F. I., & Martincigh, B. S. (2017). Evaluation of human exposure to metals from some commonly used bathing soaps and shower gels in Nigeria. *Journal of Regulatory Toxicology and Pharmacology*, *83*(27), 38–45.
20. Agrawal, S. S., & Sharma, P. (2017). Current status of mercury level in skin whitening creams. *Journal of Current Medicine and Research*, *2*(7), 47–50.

21. Chisvert, A., Benedé, J. L., Peiró, M., Pedrón, I., & Salvador, A. (2017). Determination of N-nitrosodiethanolamine in cosmetic products by reversed-phase dispersive liquid-liquid microextraction followed by liquid chromatography. *Talanta*, *166*, 81–86.
22. Sukamto, K., & Hutuba, A. (2021). Analysis of hydroquinone content in whitening cream circulating in Gorontalo City using UV-Vis spectrophotometry. *Journal of Health, Technology and Science (JHTS)*, *2*(4), 60–69.
23. Chen, Z.-Y., Gupta, A., & Chattopadhyay, S. (2021). Detection of mercury in spiked cosmetics by surface-enhanced Raman spectroscopy using silver-shelled iron oxide nanoparticles. *Sensors and Actuators B: Chemical*, *337*, 129788.
24. Ho, J. L., Wisneski, H. H., & Yates, R. L. (1981). High-pressure liquid chromatographic-thermal energy determination of N-nitrosodiethanolamine in cosmetics. *Journal of the Association of Official Analytical Chemists*, *64*(4), 800–804.
25. Tan, X., Liu, H., Wang, Z., & Liu, M. (2019). Safety assessment of arsenic in cosmetic face creams by inductively coupled plasma atomic emission spectrometer. *American Journal of Applied Chemistry*, *7*(1), 35–41.
26. Prasertboonyai, K., Liawraungrath, B., Pojanakaroon, T., & Liawraungrath, S. (2016). Mercury (II) determination in commercial cosmetics and local Thai traditional medicines by flow injection spectrophotometry. *International Journal of Cosmetic Science*, *38*(1), 68–76.