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Elemental burdens of cosmetics and associated health and environmental impacts: A global view

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Abstract

The use of diverse chemicals in beauty, skin, hair, and nail care products may be traced back to ancient times. Preservatives, stabilizers, mineral pigments, colour, and shine were added to these goods to improve their quality and increase their effects. This review which covers 28 countries, highlights the heavy metal content of some cosmetics, and their associated health and environmental implications, and the use of multivariate statistics to understand the dynamics and interrelationship between the elements. From the study, cosmetic products pose debilitating impacts on human health because some products contain potentially toxic elements including Pb, Zn, Cd, As, Fe, Sb, Cr, Co, Hg, and Ni beyond allowable levels. However, the concentrations of these elements in cosmetics are country, product, and manufacturer variants. Principal Component Analysis (PCA) and correlation matrix revealed possible interrelationships between different elements in cosmetic products, which have harmful implications. This suggests potential harmful interactions and the need for strict safety measures in their formulation and usage. Indiscriminate disposal of these products containing toxic heavy metals may pose detrimental impacts on the environment and various ecological systems. It is recommended that manufacturers of cosmetics invest in non-toxic materials that pose no or fewer impacts on the environment and consumer health.

Keywords: Cosmetics; Heavy metals; Health and Environmental impacts; Multivariate analysis; Review

1. Introduction

Most chemical products used in cosmetology present potential side effects. More than 10,000 chemicals are included in cosmetics, many of which have been related to conditions such as cancer, birth abnormalities, and reproductive and developmental problems. The US FDA (Food and Drug Administration) has prohibited some chemicals from cosmetic goods, including coal tar, formaldehyde, glycol ethers, lead, mercury, parabens, phenylenediamine, and phthalates [1]. These chemicals are used in a wide range of skincare products. A large number of these products, varying in quality and quantity from different manufacturers are in the present markets. Lip gloss, nail polish, eyeliner, eye shadow, and make-up powder are examples of common cosmetic beauty items [2,6].

The most harmful hair products available in today's market are styling products [2]. These products often contain toxic chemicals, including butane, ether, and polymers. Some of these chemicals, found in mousses, gels, and hairsprays, are commonly used in various other products such as plastics, engine lubricants, degreasers, insect repellents, emulsifiers, refrigerants, shellac, paints, propellants, flammable gases, and furniture finishes. When these chemicals are inhaled, they can enter the bloodstream, while others may find their way into the bloodstream through hair follicles, sweat glands, and sebaceous glands. Heavy metals may also enter the body through the skin and infiltrate bodily fluids, allowing them to reach vital organs [2,6]. They increase the absorption rate of the skin by up to 230 times its original

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rate. Even products described as "natural" contain multitudes of harmful chemicals. Higher levels of these compounds are added to improve the quality of cosmetic products. Mineral pigments like dye and glitter are used in cosmetics to give them a broader colour range and more sparkle. Aluminium, lead, zinc, and tin are present as integral parts or impurities in these auxiliary components [3]. Heavy metals included in cosmetics can harm the epithelium and cause skin irritation. Severe diseases on the skin and mucous membranes may develop as a result of the cumulative impact of these metals.

Studies including Al-Ashban et al. [4], Bocca et al. [5], and Kaličanin and Velimirović [6] have demonstrated that cosmetics might be a source of hazardous metals entering the body. No laws are governing the disclosure of chemicals in cosmetics. Manufacturers often disguise these chemicals by names from the typical consumer [7]. There is little literature on the health and environmental implications associated with the usage of cosmetic products. Based on the varied studies that have been done on cosmetics, this study sought to project the regulations related to their production, supply, and usage, their elemental constituents, as well as their health and environmental implications. This study seeks to bridge this gap by reviewing the effects of cosmetics to create awareness for studies into these products. This will function as a conceptual framework to guide policymakers and researchers in their endeavours to conduct studies related to cosmetics.

1.1. History of cosmetics

The production and use of cosmetics date back into human history. For instance, the application of cosmetics is mentioned in the Old Testament of the Bible in around 840 BC (2 Kings 9:30) when Jezebel painted her face. Also, presented in the book of Esther (Esther 2:9, 12) and Jeremiah 4:30 is a description of the use of various beauty treatments [8]. Cosmetics were widely utilized in ancient Rome, including the use of lead-based formulations to whiten the face and kohl to decorate the eyelids [9]. Venustas-Makeup [10] indicated that the application of cosmetics has been well documented in ancient Egypt. For instance, remedies for treating wrinkles were composed of ingredients including gum from fresh moringa and frankincense. Burns and scars have also been treated using ointment produced from sycamore juice, red ochre, and kohl [10]. In Persia (now Iran), cosmetic products were largely used. It is reported that in the 3000 BCs, in China, people stained their nails with beeswax, gelatine, egg white, and Arabic gum [92].

Likewise, in Japan, geisha utilized makeup created by grinding safflower petals to accentuate the contours of their eyebrows, eyes, and lips along with the use of bintsuke wax sticks as a makeup foundation [10]. In the early 1900s, the production and usage of makeup were excessively unpopular. However, after a decade, it became fashionable in Europe and the USA due to the influence of theatre stars and ballet. When the Russian Ballet arrived in Paris in 1910, coloured cosmetics were adopted, with ochres and crimsons being the most common shades [11].

After WWII, the cosmetic industry adapted aerosol spray technology for use with bug sprays during the war, and hairspray became popular. Women's hairstyles like the beehive and the bouffant were made possible thanks to this breakthrough. Although the trend of more "natural" hairstyles has reduced the usage of hairspray, it is still widely used by both men and women. In the aftermath of the armistice, the beauty industry recognized the “power” of the aerosol containers, which were pressurized by a fluorocarbon, or liquefied gas [12]. In comparison to the twentieth century, the cosmetics market now has a distinct dynamic.

2. Materials and methods

2.1. Research approach

The study focused on cosmetics and regulations governing their production, supply, usage, disposal, and associated health and environmental implications. Information from a range of literature sources including reports, journals, and articles on cosmetics obtained from Google Scholar, Science.gov, Microsoft Academic, Baidu Scholar, Semantic Scholar, and CORE, BASE were synthesized and triangulated. To source credible information, keywords including cosmetics, health effects/impacts of cosmetics, environmental impacts/effects of cosmetics, and regulations on cosmetics were searched in the aforementioned search engines.

Data were sourced from 28 countries which covered Europe (Italy, Turkey, Germany, Spain, Netherlands, Monaco, Switzerland, France, Poland, and Bulgaria), America, Canada, Asia (India, China, Saudi Arabia, Japan, Iran, Palestine, Korea, Iraq and Pakistan), Africa (Ghana, South Africa, Zambia, Egypt, Morocco, Nigeria, and Mauritania) (Fig. 1). A combined total of 213 papers and online sources were uncovered through the literature search. A total of 213 papers and online sources were identified from the literature search.

Figure 1 Areas considered in the study

2.1.1. Screening process

The methodology used in this study was a refined approach inspired by previous research [96,97]. Following the initial search, a meticulous screening process (refer to Fig. 2) was applied to pinpoint and include pertinent literature sources relevant to the study's focus. Employing specific inclusion and exclusion criteria, the following variables were thoughtfully evaluated, with each being allocated a total weight of 100%. The screening process involved evaluating and ranking literature sources based on specific criteria with assigned weights.

The title and keywords of papers were assessed, accounting for 20% of the total weight (T_w), where the title (T_l) contributed 10% and the keywords (K_d) contributed 10%.

The abstracts of selected literature received the highest weight of (A_b) 35% and were further divided into three components: overall purpose and problem (P_i) (5%), research design (R_d) (10%), key findings (K_f) (15%) and conclusion or take-home message (5%) (CT_m).

The credibility of the journals (Cj_i) in which the papers were published was considered, assigning a weight of 10% to eliminate articles from unreliable sources while still prioritizing the contents of these materials.

The content of the retained literature sources (C_a) was thoroughly examined, and this assessment carried the most significant weight of 45%. The evaluation process further consisted of five aspects, each contributing to the final selection: novelty of the study (No) (10%), presentation of results (Pe) (7%), relationship with existing literature (Re) (7%), depth of information and contextual analysis (Da) (15%), and conclusion and potential implications (Ci) (6%).

The appropriateness of the literature for this study was determined based on the equations outlined in Eqn. 1-3.

This comprehensive approach ensured the inclusion of relevant and high-quality sources for the investigation of the elemental constituents of cosmetics and their public health and environmental implications.

$$T_w = T_l + K_d \quad (1)$$

$$A_b = P_i + R_d + K_f + CT_m \quad (2)$$

$$C_a = N_o + P_e + R_e + D_a + C_i \quad (3)$$

The chosen literature was assessed and ranked on a 100% scale. As depicted in the classification (Table 1), sources of literature that were rated as poor were excluded from this study. Consequently, a more targeted search was conducted, ultimately resulting in the utilization of 96 literature sources (Fig. 2).

Table 1 Evaluation of the reliability of the acquired literature sources.

Description	Scale (%)
Poor	0 – 40
Moderate	41 – 70
Suitable	71 – 100

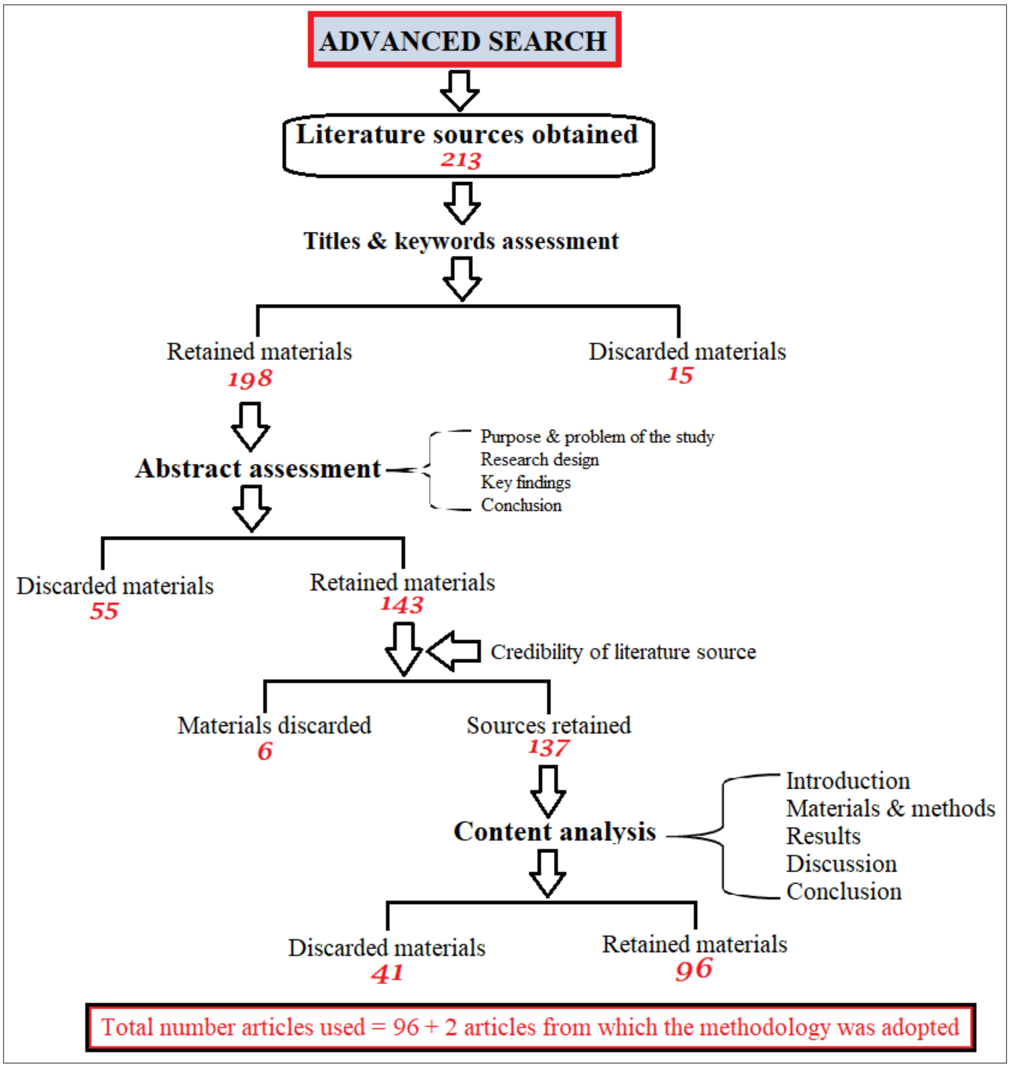

Figure 2 Flowchart description of the research design

2.2. Data analysis

Data analysis in this study adopted a narrative synthesis approach, which systematically examined and integrated the findings from the selected research articles, with a specific focus on the outcomes related to the elemental burdens of cosmetics and their associated health and environmental impacts from a global perspective. It is essential to emphasize that all the studies incorporated in this review had a quantitative nature, but it is noteworthy that this review did not involve conducting a meta-analysis. Multivariate analyses of elemental levels in cosmetics were performed using Minitab 21.3 and SPSS version 27.

3. Results and discussion

3.1. Regulations on cosmetics in selected countries

3.1.1. Europe

European Union (EU) cosmetic regulations were established under the framework of Council Directive 76/768/EEC, dated July 27, 1976. This directive aimed to harmonize the laws of EU Member States concerning cosmetic products, commonly known as the Cosmetics Directive [13]. This directive was re-evaluated in 2009 to harmonize EU-wide cosmetics legislation, and it went into effect in July 2013. The Cosmetics Regulation's concept is to guarantee that cosmetics-related rules and policies are harmonized throughout member states and that all cosmetic producers have equal and quick access to the market, allowing them to freely enjoy the European market [14]. The EU Cosmetics Regulation prescribes guidelines for the assessment of product and ingredient safety, which include strict criteria for ingredient selection to uphold safety standards. Manufacturers are obliged to make their choices from a predefined roster of preservatives outlined in the EU Cosmetics Regulation. These preservatives have undergone rigorous scientific assessments and approval processes, including evaluations by the Scientific Committee on Consumer Safety (SCCS) [15]. In the EU, ingredients in cosmetic products must be indicated/labelled following EU legislation. Also, the labelling terms for a cosmetic product must be consistent throughout Europe and globally. This poses awareness for people with allergies to certain products to ensure that cosmetic products do not pose deleterious impacts on public health [16]. Besides that, this may help in toxicological and diagnostics studies in cases of toxicity.

3.1.2. America

In the United States, cosmetic products are subject to regulation under the Federal Food, Drug, and Cosmetic Act (FFDCA) of 1938, and the responsibility for overseeing adherence to these regulations lies with the US FDA [17]. The US FDA operates the Voluntary Cosmetics Registration Program (VCRP), a post-market reporting system designed for cosmetic manufacturers, packagers, and distributors of commercially available cosmetics within the United States [17]. It is important to note that the VCRP is specific to cosmetics intended for consumer use within the United States and does not cover cosmetics exclusively designated for professional usage, such as those employed in beauty salons, spas, and skincare clinics. It also excludes products like hotel samples, handcrafted gifts, and cosmetics exchanged among friends [18]. In cases where a cosmetic product's safety is not sufficiently demonstrated, regulatory measures may be taken [19]. Manufacturers are also responsible for determining the product's shelf life, which is a crucial aspect of ensuring product safety [18].

3.1.3. India

The Drugs and Cosmetics Act (1940) enforces cosmetics regulations in India. When making cosmetics for sale or distribution, the producer must build the plant according to the rules in Schedule M-II and fill out Form 31 to apply for permission and pay Rs in permit fees. The local state licensing office reviews this information and provides it on Form 32 [16, 20]. Cosmetic ingredients must be stated in India in order of appearance of concentration and the best use must be replaced before the declaration date, that is, xx months/year packaging from the date of declaration [16, 21].

3.1.4. China

In June 2020, China introduced the new Cosmetics Supervision and Administration Regulations (CSAR) [22]. Compared to the previous "Regulations on Hygiene Supervision of Cosmetics" (CHSR) with only 35 articles, CSAR is more comprehensive, comprising 6 chapters with 80 articles. These chapters cover various aspects, including general provisions, ingredients and products, production and distribution, supervision and administration, legal responsibility, and supplementary provisions [23]. A notable change outlined in Article 22 of CSAR is that the requirement for toxicological tests of final cosmetic products is no longer compulsory for general domestic cosmetics, as long as risk assessment supports their safety [24]. The CSAR also emphasizes the need for scientific evidence to substantiate claims and efficacy of cosmetics, heralding the implementation of an updated monitoring system for cosmetics. These regulations embody a forward-looking approach, encouraging innovation, the application of technology, and emphasizing scientific research in the cosmetics industry, which is expected to significantly influence the development of cosmetics and new ingredients [23].

3.1.5. South Africa (SA)

In SA, the general self-regulatory nature of the cosmetic industry makes it vulnerable to low-quality and illegally imported cosmetic products. Regardless, businesses must adhere to certain regulations, such as Good Manufacturing Practices (GMP). Manufacturers who utilize organic ingredients from indigenous plants like Baobab and Marula must get a biodiversity license to export their raw materials. However, according to Bosiu et al. [25], the permit application procedure is extremely time-consuming; the application form is extensive and complex, and the permission takes a long time to be approved. Retailers demand that items they sell be tested but the South African Bureau of Standards (SABS) is now unable to do so. Small producers have difficulty since private testing is prohibitively expensive (up to R40,000) [25].

3.1.6. Zambia

According to the Standards (Amendment) Act, Cap. 416 of 1997, the Zambia Bureau of Standards (ZABS) is one of the major regulatory agencies responsible for fostering product quality assurance, creating Zambian standards, and encouraging their usage. Product accreditation is offered by ZABS in two forms: authorization to supply and certification. For all necessary items, permission to supply is necessary, whereas certification is an optional accreditation that may be used to affix a quality label to any product to indicate to customers that it satisfies the ZABS requirements [26]. There are mandatory standards for certain cosmetic items, such as glycerine, hair oils and creams, and petroleum jelly, as well as toilet soap, domestic and dishwashing liquid, and laundry soap, in the current catalogue of Zambian Standards. Standards for synthetic detergents (powder, liquids, and pastes) as well as all-purpose and home cleaning products are also available from ZABS, although they are optional [25]. ZABS has made attempts to embrace the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), and European Standard (EN) and harmonize standards with the Common Market for Eastern and Southern Africa (COMESA) and Southern African Development Community (SADC). These do not include standards for soaps, detergents, and cosmetic products, hence access to regional export markets may be hampered. To address some of these issues, ZABS has signed bilateral agreements with Botswana and Namibia on standards and the export of certain items [24].

3.2. Major potentially toxic elements in cosmetic products

3.2.1. .Zinc (Zn)

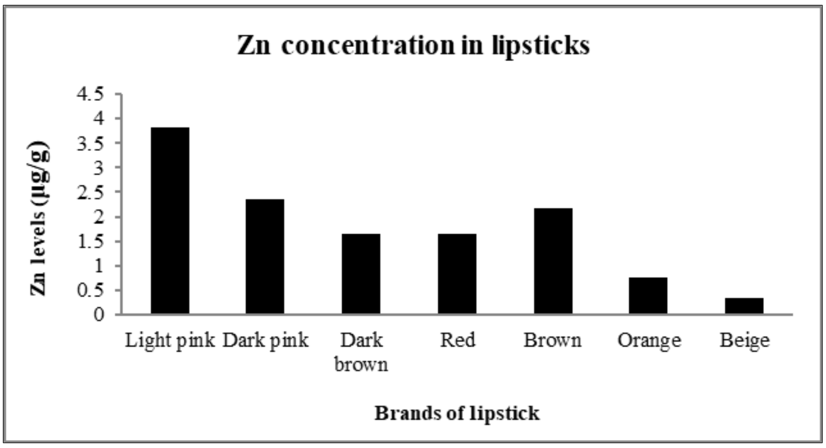

Figure 3 Zn levels in lipsticks [6]

Zn is a mineral that is required for human growth, development, and normal function. Increased Zn concentrations in the body, on the other hand, are toxic to humans. Research has shown that elevated Zn intake can result in copper deficiency in the liver, serum, and heart, leading to a decrease in the activity of copper metalloenzymes (as depicted in Figs. 3 and 4) [6, 27]. Increased Zn consumption, according to Walsh et al. [28], can harm iron(Fe) storage and may lead to anaemia. However, it forms a major part of most cosmetics. For instance, Citracakralogam [29] indicates that mineral makeup powders are made up of nearly 25% zinc oxide. In a comparative study by Chisvert and Salvador [3], Zn was higher in all the tested cosmetic samples than lead. Zn compounds (oxide and stearate) are added to cosmetics to improve water resistance and reduce discomfort during use, which may explain the higher concentration of Zn than Pb. It also helps to prevent sunburn. Zn levels in lipstick samples examined ranged from 0.35 mg/g to 3.81mg/g. The highest Zn content was detected in the pearlescent bright pink lipstick. Using various additional chemicals to increase the quality of lipsticks accounts for disparities in Zn concentration between different hues of lipstick [6]. Zn concentration ranged from 210 μg/g to 424 μg/g. In an analytical study of commonly used facial makeups in Nigeria, Nnorom et al. [30] reported a Zn range of 88 μg/g – 101 μg/g. They showed an average content of Zn in eyeliners (91.5 μg/g), eye pencils (100.9 μg/g), and lipstick (88.0 μg/g). Similarly, Ajayi et al. [31] indicated that 35.8 % of local eye shadows studied in Nigeria had elevated levels of Zn. Eye shadow has the highest Zn concentration of 15.62 46.45 g/g, according to Lim et al. [32]. The findings presented suggest that the levels of Zn in cosmetic products vary based on the manufacturer and type of product. This shows that the elemental content of cosmetics must be ascertained before application/usage.

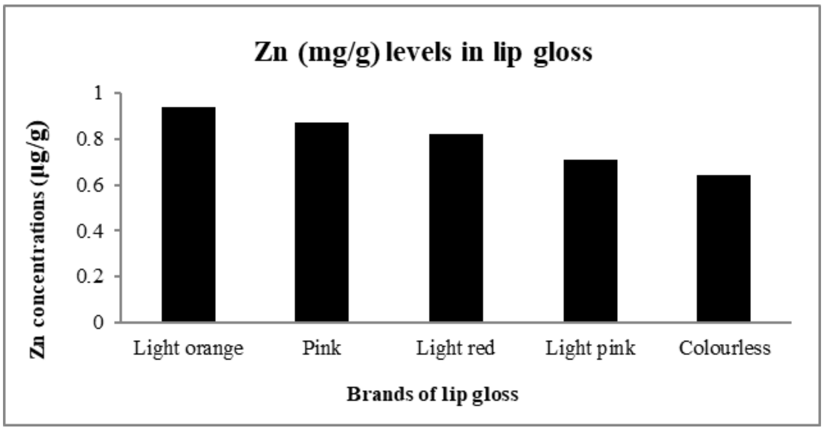

Figure 4 Zn concentrations in lip gloss [6]

3.2.2. Lead (Pb)

Pb is a dangerous metal that can be absorbed by the body through inhalation, ingestion, or skin absorption and has long-term negative effects [33]. Pb is mostly deposited in the bones, despite its high concentration in the liver and kidneys. Although elemental Pb is not an environmental problem to most life forms, it does become a real concern when it dissolves and becomes ionized. It also interacts physiologically with important metals including calcium (Ca), Fe, Cu, and Zn, causing problems with kidney function, the neurological and cardiovascular systems, and heme biosynthesis [33]. According to Nnorom et al. [30], Shannon [34], and Nourmoradi et al. [35], the usage of cosmetics such as lipstick and eye shadow has been proven to harm humans, particularly pregnant women, young children, and foetuses, owing to their high Pb concentration. Eventually, Pb becomes deposited in bone, where it replaces Ca because Pb^{2+} and Ca^{2+} ions are similar in size. Pb absorption by the body increases in persons having a Ca (or Fe) deficiency and is much higher in children than in adults. Pb has been found to affect the IQ of children. Following these, the WHO and EU have respectively stipulated an allowable limit of 10 μg/g and 0.5 μg/g for Pb [36, 37].

A study conducted in Pakistan by Ullah et al. [1], discussed that Pb content in lipsticks varies between 16.67 and 105.60 g/g which exceeds the permitted limit of 20 g/g. Light pink pearly sheen lipsticks had the greatest Pb level, whereas beige lipsticks had the lowest. The presence of hazardous metals in the examined lipsticks can relate to mica, pearls, and lead chromate, which gives colour to lipsticks [38]. According to Al-Saleh and Al-Enazi [39], pearlescent lipsticks contain more Pb than matte lipsticks. These findings show that lipstick's other supplementary components might be a source of toxic metals. Improper handling of the final product during manufacturing, storage, and transportation might be a source of Pb toxicity. The total amount of Pb in the human body varies between 100 and 400 mg and rises with age. Pb levels in the blood should be less than 400 ng/ml [40].

According to the given allowable limit, the concentration of Pb in cosmetics can be classified as dangerous. The Pb level of the lip gloss products examined ranged from 12.77g/g to 20.17 g/g which is lower than the acceptable lipstick limit [39]. The difference in Pb concentration discovered in these goods, according to Al-Saleh et al. [39], might be related to the quantity of specific cosmetic dyes and pigments used in lipsticks against lip glosses. Colorants used in the cosmetic industry, which mostly comprise metal oxides, were shown to be possible sources of hazardous metals. Only light orange lip gloss samples may be regarded as possibly hazardous to human health in the group of lip gloss since the Pb concentration is higher than the permissible limit. Eye shadows showed Pb concentrations ranging from 26.43 to 95.55 g/g. The Pb content of pearlescent eyeshadow (53.19 to 95.55 g/g) is higher than that of unadded eyeshadow (26.43 to 50.41 g/g). Al-Ashban et al. [4] highlighted that eye shadows containing iron oxide and zinc oxide record high concentrations of Pb ranging from 0.42 to 58.7 g/g. All of the eye shadow samples examined in this investigation might be potentially hazardous. A study by Kaličanin and Velimirović [6] on the possible harmful effects of cosmetic beauty products on human health reported high Pb levels in selected lipsticks and lip glosses (Figs. 5 and 6). According to

Soares and Nascentes [41] and Sharafi et al. [42], cream dye has 19.9 g/g and 187 g/g, dust dye has 14.0 g/g and 100 g/g, liquid dye has 1.00 g/g and 11.3 g/g, and hair dye has 55.3 g/g and 72.2 g/g.

Henna hair dyes have been enhanced in recent years by combining other plants and other chemicals to make the final product darker and minimize the application time. Mineral products with added materials may be rich in metals such as Pb [2, 5]. The Pb level in henna hair dye samples ranged from 8.52 to 19.61 g/g, as per this study. The Pb level in red henna dye is greater than the levels in brown henna dye. Metal salts, which are used widely to achieve varied henna hues, are the cause of the variation in Pb content in henna hair dye samples. The Pb concentration of henna hair dye varies between 2.2 and 19.9 g/g [43]. However, Jallad and Espada-Jallad [44] found that Pb levels in the henna samples tested in their study were between 2.29 and 65.98 g/g, indicating that the henna samples tested in their study may be harmful to human health influences. The findings of Łodyga-Chruścińska et al. [45] highlight those two out of the twelve brands studied surpassed US FDA restrictions, while all the twelve surpassed European standards. Parry and Eaton [46] found that out of 22 kohl samples tested, 7 had excess Pb levels of 50%, 5 had 20%, 1 had 3.31%, and 9 had less than 0.6%. Pb characteristics in cosmetics were 0.11 to 4.48 ng mg1 in 25 lipstick samples evaluated by Gunduz and Akman [47], which were not substantially different from those reported by FDA for about 400 samples (0.026–7.19 ng mg/1). In a study of lipsticks from 15 EU countries, the majority of lip products (78%) contained a Pb content of less than 1 mg/kg (only 4% had a Pb content of more than 2 mg/kg). Lipstick samples had almost double the amount of Pb as lip gloss samples (0.75 and 0.38 mg/kg, respectively). Pb values in Bulgarian lipsticks ranged from 0.286 to 6.234 g/g, according to Lu et al. [48]. In Pakistan, Khalid et al. (2013) and Nourmoradi et al. [35] reported Cd levels in lipstick and eye shadow samples ranging from 87 to 123 g/g, 4.08 to 60.20 g/g, and 1.54 to 55.59 g/g, respectively.

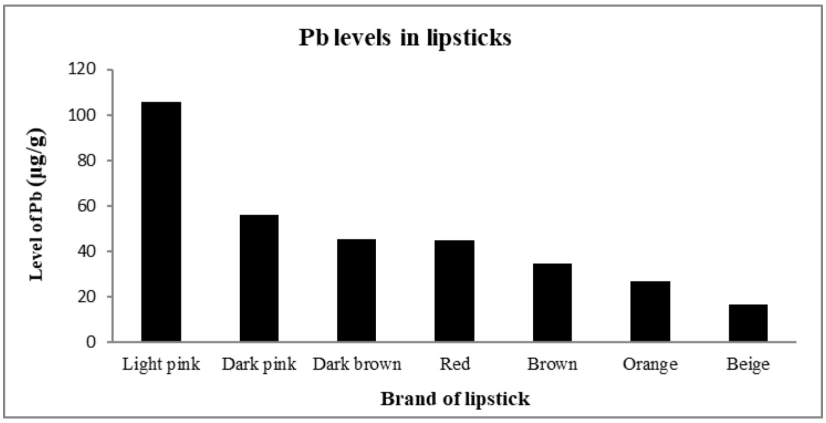

Figure 5 Pb content in selected lipsticks [6]

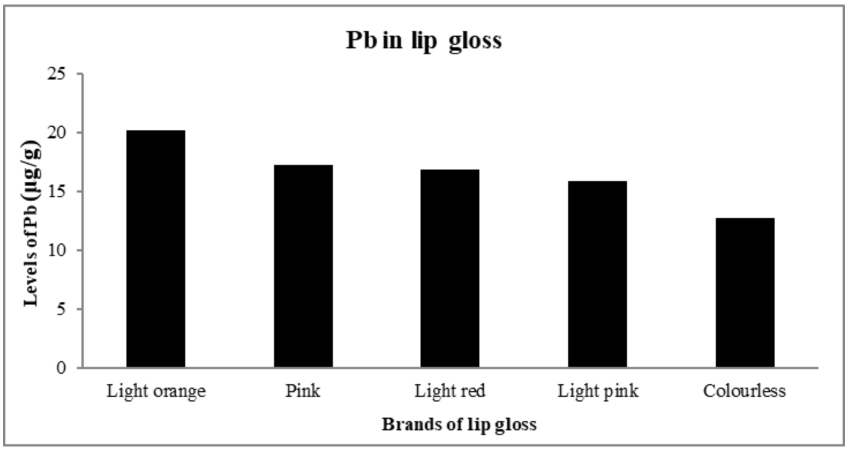

Figure 6 Pb content in selected lip glosses [6]

Alam et al. [37] discovered Pb values ranging from 14.38 g/g to 50.39 g/g in a study of heavy metals in cosmetic items in Bangladesh. According to Sainio et al. [93], in 25 brands of 298 eye shadows, the Pb content reached up to 16.8 g/g.

According to Liu et al. [57], Pb was found in 75% of cosmetics tested in California, with an average value of 0.40 mg/kg. An assessment of the Pb content in imported lipsticks and nail polish in Ghana showed levels between 10.9 mg/kg and 15.25 mg/kg, and 4.15 mg/kg and 8.55 mg/kg [95]. Ziarati et al. [50] found that the mean concentration of Pb in 95.91% of Chinese lipsticks was greater than 20 g/g and all of the Iranian lipsticks were lower than 10 g/g in a risk assessment of Pb and Cd. According to the data, the concentration of Pb in cosmetics varies by nation. Cosmetics with high levels of Pb, whether used once or several times a day, may cause human harm [51].

3.2.3. Cadmium (Cd)

Cadmium is a very poisonous metal ion that may be found in the air, food, and water. Most bodily tissues absorb cadmium ions, which are concentrated mostly in the liver and kidneys. Health Canada, EU, and WHO recommend permissible levels of 3 µg/g, 0.5 µg/g, and 0.3 µg/g in cosmetics for Cd [37, 52]. Both unbranded (cheap samples) and branded lipsticks contain large amounts of Cd (5-10 g/g) [53]. The amounts of Cd in eyeshadows ranged from minimal (0.0006 g/g) to high quantities (8.89 g/g) as indicated by Volpe et al. [54] in a comparative study in China, Italy, and the USA and Omolaoye et al. [55] in Nigeria. A similar study by Funtua and Oyewale [56] discussed 14.30 µg/g in graphite-based kwali. Liu et al. [57] in the United States and Kaličanin and Velimirović [6] in Serbia, on the other hand, found no Cd in tested samples of lipsticks and lip glosses. Nnorom et al. [30] reported Cd levels in eyeliners, eye pencils, and lipsticks ranging between 0.3 µg/g and 1.8 µg/g, 0.5 µg/g and 1.1 µg/g, and 0.5 µg/g and 2.4 µg/g respectively in Nigeria. A previous study by Funtua and Oyewale [56] presented Cd (14 µg/g - 30 µg/g) in graphite-based kwali. Still in Nigeria, Orisakwe and Otaraku [58] identified Pb levels in creams and lotions between 6.1 mg/kg and 45.9 mg/kg. A similar study by Chauhan et al. [59] in India discussed Cd levels ranging from 0.037-0.4 µg/g in soap, 0.026-0.03 µg/g in face creams, 0.033-0.042 µg/g in shampoos, 0.012-0.02 µg/g in shaving creams, and 0.01-0.02 µg/g in talcum powder. As reported by Nourmoradi et al. [35], concentrations of Cd exceeding 20 µg/g were detected in 29.4% of lipstick samples and 66.7% of eye shadow samples. Al-Saleh et al. [39] noted that eye shadows containing darker color pigments tend to exhibit elevated levels of heavy metals. Additionally, Khalid et al. [49] identified that dark brown lipsticks with shocking pink colors displayed the highest heavy metal concentrations, while cosmetics with a pink coloration had lower metal content. The mean concentration of Cd presented by Ziarati et al. [50] in 120 lipstick samples from Iran and China was lower than 1.2 mg/kg. However, samples from China had elevated concentrations than those produced in Iran. In the determination of selected heavy metal levels in cosmetics sold in the Kano Metropolis in northern Nigeria, the content of Cd in skin lightening creams, face powders and lipsticks were 0.14–1.32, 0.07– 1.74, and 0.07–1.67 (mg/kg) respectively [82]. The study further showed that these products were imported from Cote d'Ivoire, Nigeria, Italy, the USA, Canada, China, Mexico, France, and unknown countries.

An analysis of henna by Alwakeel [60] revealed Cd levels between 0.017 µg/g and 0.019 µg/g. Similarly, hair dyes samples tested in Baghdad; blonde, black, brown, and red had Cd concentrations of 0.011-0.017 µg/g, 0.013-0.016 µg/g, 0.012-0.016 µg/g, and 0.015 µg/g respectively [61]. Liu et al. [57] in an inspection of lipsticks showed that the Cd concentrations in lipsticks in California were between 0.002 mg/kg and 3.48 mg/kg. In Bangladesh, Alam et al. [37] discussed Cd concentration in cosmetics to range between 2.40 and 6.27 µg/g, signifying a total exceedance of Cd beyond the WHO limit of 0.3 µg/g. Ackah [95] reported Cd levels in nail polish and lipstick between 1.4 mg/kg and 2.8 mg/kg, and 0.8 mg/kg and 1.65 mg/kg. In a study conducted in Palestine, Al-Qutob et al. [62] discovered high levels of Cd in 81% of cosmetic items tested. High heavy metal contents were identified in cheap lipstick, compact face powder, and kohl brands. A study in Malaysia by Zakaria and Ho [63] on imported lipsticks showed Cd concentrations for pink (0.33 ± 0.05 mg/kg), pink (0.27 ± 0.01 mg/kg and 0.08 ± 0.05 mg/kg) lipsticks produced in Malaysia, pink lipstick (0.09 ± 0.07 mg/kg) from Korea, pink lipstick (0.19 ± 0.09 mg/kg and 0.07 ± 0.01 mg/kg) from France, brown lipstick (0.09 ± 0.05 mg/kg) and pink lipstick (0.06 ± 0.05 mg/kg) from USA, and pink lipstick (0.07 ± 0.04 mg/kg) from the UK.

Cd possesses a particularly hazardous characteristic in its propensity to accumulate within the body over time. Prolonged exposure to Cd in humans has been associated with a range of severe health issues, including renal failure, anaemia, liver dysfunction, and the development of cancer in various organs, notably the kidneys [2, 64]. Its well-established carcinogenic properties position Cd as the top-rated human carcinogen within its category [65]. Even low levels of Cd exposure can lead to adverse health effects such as heart disease, hypertension, kidney and liver impairments, and a compromised immune system [59]. Furthermore, Cd has been linked to conditions such as osteoporosis, non-hypertrophic emphysema, irreversible damage to renal tubules, eosinophilia, anosmia, and chronic rhinitis [66].

3.2.4. Iron (Fe)

Much like Zn, Fe is generally considered a metal with minimal toxicological effects; however, prolonged exposure to cosmetics containing Fe can lead to cell damage or even colorectal cancer, as the consequences tend to accumulate over time [67]. Fe compounds play a prominent role as colourants in a wide range of cosmetic products.

Table 1 Summary of potentially harmful elements in cosmetic products

Element	Product (Treatment)	Major producer	Concentration	Source
Antimony	Make-up powder (solid)	Japan	0.46	Sneyers et al. [68]
		Egypt	0.76–5.36	El-Shazly et al. [69]
	Soap (solid)	Japan	0.177	Sneyers et al. [68]
	Body lotion	South Korea	N.D.	
	Hair conditioner		N.D.	
	Makeup remover		N.D.	
	Face cream		0.001	
	Shampoo		N.D.	
	Shower gel		N.D.	
	Sun cream		N.D.	
	Lipstick		0.005	
	Lipstick (wet)	Canada, USA, France, Italy, Korea, China	0.008–0.39	Al-Saleh and Al-Enazi [70]
	Eye shadow (solid)	UK, Germany, The Netherlands	0.157–0.76	Sneyers et al. [68]
Arsenic	Soap (solid)	Japan	< 4	Sneyers et al. [68]
	Lipstick	Canada, China, France	0.17–6.52	Al-Saleh and Al-Enazi [70]
	Eye shadow (solid)	Germany, The Netherlands, UK	0.181–1.58	Sneyers et al. [68]
	Make-up powder (solid)	Egypt	1.86–3.40	El-Shazly et al. [69]
	Skin cream (solid)	France, Japan, Monaco	0.027–0.444	Sneyers et al. [68]
Cadmium	Eye shadow	China, Italy, USA	0.0006–0.033	Volpe et al. [54]
	Hair conditioner (microwave)	N. D	<0.002	Lavilla et al. [71]
	Eyeliner (wet)	N. D	0.3–1.8	Nnorom et al. [30]
	Shampoo (wet)	N. D	0.033–0.042	Chauhan et al. [59]
	Shower body oil (microwave)	N. D	<0.002	Lavilla et al. [71]

	Skin cream (microwave)	France, Italy, Switzerland, USA	0.00012–0.00511	Bocca et al. [72]
	Shower body milk (microwave)	N. D	<0.002	Lavilla et al. [71]
	Talcum powder (wet)	N. D	0.01–0.02	Chauhan et al. [59]
Chromium	Nail polish (microwave)	N. D	0.800–10.9	Grosser et al. [73]
	Lipstick (wet)	N. D	20.5–58.8	Nnorom et al. [30]
	Lip gloss (wet)	N. D	<0.005–7.84	Liu et al. [57]
	Hair cream (wet)	N. D	0.013–0.426	Ayenimo et al. [74]
	Skin cream	France, Italy, Switzerland, USA	0.0168–0.303	Bocca et al. [72]
	Skin emulsions (creams, lotion, jelly) (wet)	Africa, Asia, Europe, Nigeria, USA	0.097 mg/L	Oyedeji et al. [75]
Cobalt	Eye shadow (microwave)	China, Italy, USA	0.00015–0.3037	Volpe et al. [54]
	Face paint (wet)	China, Spain, UK, USA	4.8–5.5	Campaign for Safe Cosmetics (CSF) [76]
	Lipstick (solid)	China, France	0.055–0.105	Sneyers et al. [68]
	Skin cream (microwave)	France, Italy, Switzerland, USA	0.00013–0.222	Bocca et al. [72]
	Soap (solid)	Japan	0.36	Sneyers et al. [68]
	Nail polish (microwave)	N. D	<1	Corazza et al. [77]
	Eye pencil (solid)	N. D	< 0.27	El-Shazly et al. [69]
Lead	Lip gloss (microwave)	Canada, Japan, EU countries, USA	0.04–2.12	Piccinini et al. [78]
	Eye shadow (wet)	China, France, USA	0.42–58.7	Al-Saleh et al. [39]
	Kohl	India, Iran, Pakistan, Saudi Arabia	0.006%-52.4%	Al-Ashban et al. [4]
	Face paint (dry)	China, Spain, UK, USA	0.074–0.65	CSF [76]
	Nail polish (microwave)	N. D	0.204–6.03	Grosser et al. [73]
	Skin cream (microwave)	France, Italy, Switzerland, USA	<0.0002-0.00867	
	Foundation (microwave)	Canada, Europe, Korea, USA	<LoD-110	Environmental Defence Canada [79]
	Lipstick (wet)	Canada, China, France, Italy, Korea, UK, USA	0.0002–0.01	Al-Saleh and Al-Enazi [70]

Mercury	Skin cream (microwave)	Asia, Africa, Europe, North, and South America	<0.07–1325	Uram et al. [80]
	Shower body milk (microwave)	N. D	<0.0055	Lavilla et al. [71]
	Hair gel (microwave)	N. D	<0.0055	
	Nail polish (microwave)	N. D	<0.0055	
Nickel	Hair dyes	Turkey	0.030-0.37	Ozbek and Akman [81]
	Hennas	Turkey	0.49-1.06	
	Skin lightening cream	Nigeria	3.68–11.03	Sani et al. [82]
	Eye shadow (microwave)	China, Italy, USA	0.0218–4.148	Volpe et al. [54]
	Lip pencil	Germany	1.8	Jäger and Jappe [83]
	Lipstick	Nigeria	0–11.03	Sani et al. [82]
	Face paint (wet)	China, Spain, UK, USA	2.1–5.9	CSF [76]
	Hair conditioner (microwave)	N. D	0.012	Lavilla et al. [71]
	Lip gloss (wet)	N. D	0.013–9.73	Liu et al. [57]
	Lipstick (adults)	Brazil, China, USA	< LOQ–1.4	Batista et al. [84]
	Lipstick (children)	China	< LOQ–3.0	
	Face powder	Nigeria	3.68–11.03	Sani et al. [82]
	Shampoo	N. D	12	Lavilla et al. [71]

Note: N. D means country/location was not stated

Particularly, they are employed in dyes for mineral cosmetics, especially those aiming to replicate flesh tones [51]. In the study conducted by Bellinger [51], the Fe concentrations within face powders were observed to range between 4183.18 mg/kg and 12,168.57 mg/kg, while lipsticks displayed concentrations ranging from 8.00 mg/kg to 8046.42 mg/kg. It is noteworthy that these Fe concentrations in cosmetic products were found to surpass those of Zn, Cd, and Pd [51]. A similar study by Nnorom et al. [30] in Nigeria discussed Fe levels in eyeliners, eye pencils and lipsticks as 78.0 – 325.2 μg/g (avg. 169.2 μg/g), 17.0 – 288.3 μg/g (avg. 97.2 μg/g) and 92.2 – 632.0 μg/g (avg. 256.1 μg/g). Alike with the findings of Bellinger [51], the concentration of Fe in the studied cosmetic products exceeded the obtained levels of Ni, Pb, Zn, Cr, and Cd. In a comparative study between third and first-world countries including Mauritania, Britain, Bulgaria, Morocco, Pakistan, USA, Saudi Arabia, and India, Parry and Eaton [46] in Nnorom et al. [30] revealed that 46% of analysed kohl samples had high Fe contents. Ajayi et al. [31] also showed that 6.15% of local eye shadows had high concentrations of Fe. Funtua and Oyewale [56] also presented an exceedance of Fe 0.98% – 1.2% and 0.43% – 0.46% in eye makeup; galena-based kwali and graphite-based kwali in Nigeria. These claims suggest that using most cosmetics may pose short and long-term iron-related complications.

3.3. Elemental relationship and controls in cosmetics

In cosmetic products, the Principal Component Analysis (PCA) results (Table 2) revealed the variability of different elements. The first principal component (PC1) was positively correlated with Cd, Cr, Pb, and Ni, suggesting that these elements tended to co-occur together in the samples. PC1 also showed a negative correlation with Antimony, As, and Hg. The second principal component (PC2) was positively associated with Hg, indicating a potential link between Hg levels and the samples. PC2 was negatively correlated with Cu, Pb, and Antimony. The third principal component (PC3) was positively correlated with Antimony, As, and Cd, suggesting their potential association in the samples. Overall, these PCA results provided insights into the interrelationships and variability of various elements in cosmetic products, which aided in understanding their compositions and potential implications for consumer health.

The correlation matrix for the cosmetic products' elemental composition revealed interesting relationships between different elements. The correlation coefficient (r) values indicated the strength and direction of these relationships (Fig. 7). Sb had a weak positive correlation with As (r = 0.12), while Cd showed weak negative correlations with Sb (r = -0.29) and As (r = -0.01). Cr exhibited a weak negative correlation with Sb (r = -0.3) and a weak positive correlation with As (r = 0.31). Cu displayed a moderate positive correlation with Cd (r = 0.85) and Ni (r = 0.2). Pb showed weak positive correlations with Cd (r = 0.92) and weak negative correlations with Sb (r = -0.15) and As (r = -0.12). Ni demonstrated strong positive correlations with Cd (r = 0.95) and moderate positive correlations with Cr (r = 0.94), while it had a weak negative correlation with Cu (r = -0.21). Hg showed moderate positive correlations with Sb (r = 0.55) and As (r = 0.23), weak negative correlations with Cd (r = -0.14) and Cr (r = 0.26), and weak positive correlations with Cu (r = 0.55) and Ni (r = 0.03). These correlations provided valuable insights into the potential associations and sources of different elements in the cosmetic products and were crucial for assessing their safety and potential health implications for consumers.

Some possible harmful interactions could be the formation of toxic compounds or complexes between these elements. For example, Cd and Cr can react to form cadmium chromate ($CdCrO_4$), a highly toxic and carcinogenic compound. The reaction can be represented as follows:

$$Cd + Cr \rightarrow CdCrO_4 \qquad (4)$$

Similarly, Cd and Ni can react to form cadmium nickelate (CdNiO3), another potentially harmful compound. The reaction can be expressed as:

$$Cd + Ni \rightarrow CdNiO_3 \qquad (5)$$

Cu and Pb have a strong positive correlation with a coefficient of 0.92. Cu and Pb can react to form copper lead oxide (Cu_2PbO_3), which is a toxic compound. The reaction can be represented as:

$$2Cu + Pb \rightarrow Cu_2PbO_3 \qquad (6)$$

Cd and Cu also have a strong positive correlation with a coefficient of 0.85. Cd and Cu can react to form cadmium copper alloy (Cd-Cu), which may release toxic cadmium ions when in contact with the skin.

$$Cd + Cu \rightarrow Cd\text{-}Cu \qquad (7)$$

Cr and Ni have a strong positive correlation with a coefficient of 0.94. Cr and Ni can react to form chromium nickel alloy (Cr-Ni), which may release toxic chromium compounds. The reaction can be represented as:

$$Cr + Ni \rightarrow Cr\text{-}Ni \quad (8)$$

Hg and Cd have a moderate positive correlation with a coefficient of 0.55. Hg and Cd can react to form mercury cadmium alloy (Hg-Cd), which is hazardous to human health. This presented as:

$$Hg + Cd \rightarrow Hg\text{-}Cd \quad (9)$$

The formation of these toxic compounds may lead to skin irritation, allergic reactions, and long-term health effects such as organ damage and carcinogenicity. These potential reactions highlight the importance of closely monitoring the presence and concentrations of heavy metals in cosmetic products. Strict regulatory measures and thorough testing are essential to ensure the safety of consumers and prevent any harmful interactions that may occur when using these products. Cosmetic manufacturers should adhere to established safety guidelines and standards to minimize the risk of adverse health effects related to the presence of these elements in their products.

Table 2 PCA of elemental constituents in cosmetic products

Variable	PC1	PC2	PC3
Sb	-0.379	-0.047	0.791
As	-0.216	-0.014	0.592
Cd	0.906	-0.064	0.248
Cr	0.503	-0.081	0.259
Cu	0.021	-0.665	-0.089
Pb	0.734	-0.595	-0.315
Ni	0.539	0.005	0.072
Hg	0.018	0.638	-0.409

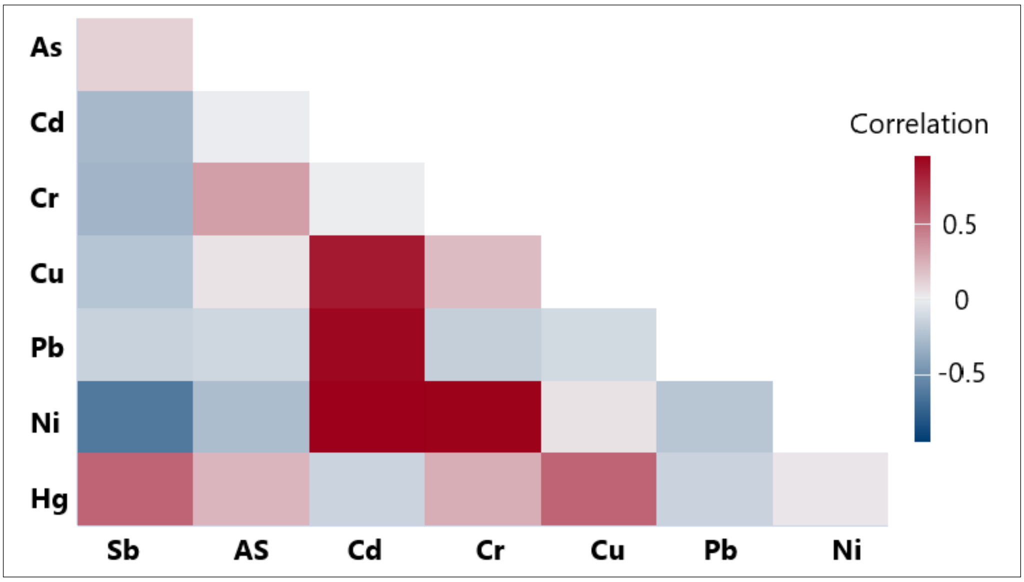

Figure 7 Variance-Covariance of elemental constituent of cosmetic products

3.4. Health effects of hairsprays

Hairsprays incorporate a range of active components, including various polymers and solvents. According to the National Library of Medicine [98], hairsprays feature potentially harmful elements such as polyvinylpyrrolidone, hydrofluorocarbon, carboxymethylcellulose, denatured and polyvinyl alcohols, as well as propylene glycol. These ingredients can trigger allergic reactions, manifesting as symptoms like sneezing, red eyes, rashes, and irritation of the eyes, nose, throat, and skin. Frequent usage of hairspray has been associated with breathing difficulties, low blood pressure, and respiratory disorders. Many hairsprays contain propylene glycol, which, when inhaled consistently, can lead to cancer [85]. Morrocco Method [7] further outlines various health concerns related to cosmetics and hairspray, including hair breakage, loss, thinning, dry hair and skin, organ damage (particularly to the kidneys and lungs), pneumonia, irritation of mucous membranes, toxin accumulation in organs and tissues (including the brain), hair shaft damage, skin issues like hives, allergies, eczema, asphyxiation, blackheads, and other skin impurities. Ingesting cosmetics can potentially deplete essential nutrients in the body. In rare instances where the aerosol nozzle is in close proximity to the eyes during application, there is a risk of injury. Briefly inhaling a small quantity of hairspray might result in coughing, choking, or temporary breathing difficulties [86].

3.4.1. Case analysis of selected cosmetic related health implications

Case 1: Reports submitted to the United States of America Food and Drugs Authority (U.S.F.D.A.) from 2004 to 2016 concerning makeup, sunscreen, tattoos, hair color, perfume, shaving creams, and baby care products raised nearly 5,144 adverse cases, averaging 396 cases per year. Notably, 2015 saw a spike with 706 reported cases [87].

Case 2: A total of 4,427 cancer-related adverse cases were documented in the FDA database related to cosmetics. Most cancer reports were associated with products whose names were withheld in the Center for Food Safety and Applied Nutrition (CFSAN) Adverse Event Reporting System (CAERS) (n = 4,210, constituting 95.1% of all cancer reports) [88].

Case 3: A mother contacted Poison Control after her two sons, aged 2 and 4, playfully sprayed each other with hairspray. While the younger child did not experience any adverse health effects, the older child developed red eyes and skin swelling around his eyes [86].

Case 4: Among the non-redacted reports (n = 218), talc powders were linked to the occurrence of cancer, comprising 70% of all reported cancer cases (n = 153). Notably, ovarian cancer constituted the majority of these cases, accounting for 92%, including specific subtypes such as clear cell, serous cystadenocarcinoma, epithelial, and granulosa. Other observed cancers included skin cancer (1%), malignant (2.1%) and neoplasm (1.1%) mesothelioma, and uterine cancer (0.01%) [88].

Case 5: In 2014, the U.S.F.D.A. launched an investigation into Chaz Dean Cleansing Conditioners following 127 reports from consumers. The investigation revealed that the company had already received approximately 21,000 complaints related to scalp irritation, alopecia, and hair loss [87].

3.5. Environmental and ecological impacts of cosmetics

The cosmetics industry has been described to focus on a green economy, resource utilization, and efficiency and significantly reduce the sector's impacts on the environment. Meanwhile, footprints of the production and consumption of cosmetics have been widely identified [89]. UK Essays [94] mentioned that the known environmental impacts emanating from cosmetic waste vary based on the products used. For instance, cosmetic packages are mostly non-biodegradable and thus may take decades to disintegrate fully. Toxic elements in cosmetics could be deposited into oceans. These pollute the oceanic ecosystem and cause increased mortality of aquatic life. In addition, cattle exposed to toxins from cosmetics residues in the soil may have reproductive, genetic, and developmental abnormalities, as well as malignancies. Toxic components in cosmetics are quickly destroying natural ecosystems and resources, according to Ecovia Intelligence [89].

Similarly, cosmetics with palm oil are causing rapid deforestation and climate change, changing the behavior of aquatic lives and aquatic species mortality, and reducing animal plankton population [90]. Cosmetic preservatives like beta hydroxy acid (BHA) and butylated hydroxytoluene (BHT) have been found to have severe ecological consequences. They can lead to the death of aquatic life and cause genetic mutations in amphibians [91]. Sodium laureth sulfate disrupts fish behavior and increases mortality, while dioxane is lethal to insects. Diethanolamine (DEA) accumulates in the environment and reacts with nitrates to form highly carcinogenic nitrosamines, which can harm fish, amphibians, animal plankton, humans, flatworms, and crustaceans. Flatworms, amphibians, nematodes, animal plankton, fish, and crustaceans are especially vulnerable to its toxicity. Many cosmetic chemicals are non-biodegradable and tend to accumulate in ecosystems. These toxic substances may eventually find their way into lakes, oceans, water supplies, rivers, and streams, posing reproductive challenges and cancer risks to exposed animals, particularly in soil environments [90].

Mademoiselle Organic's findings [91] indicated that P-phenylenediamine in dark hair coloring and lipsticks contributes to the mortality of aquatic life. Similarly, dibutyl phthalate (DBP) found in nail polishes has been associated with the mortality of plant plankton and aquatic species. Triclosan, used in skin cleansers and deodorants, can have detrimental effects on aquatic plants, fishes, and amphibians by altering their biochemistry.

Chemical elements from cosmetics that are deposited in water systems can vaporize with water, form part of condensed water, and fall alongside rain. This poses debilitating impacts on all spectrums of the environment. Since these elements are mostly non-biodegradable, they may persist in the food and water chains [94]. The presence and persistence of cosmetics-related chemicals in the environment including triclosan do not only pose direct impacts on populations but have indirect-negative impacts on apex predators. Similar to microbeads, triclosan accumulates in a population of prey. Predators, by consuming multiple contaminated prey, accumulate these toxins at an exponential rate. The introduction of oxybenzone in sunscreens has a significant impact on tropical waterways, leading to severe consequences for young coral. This includes endocrine disruption, DNA damage, and ultimately death [94].

3.6. Safe usage of cosmetics products

To ensure the safe and responsible use of cosmetics, this study recommends implementing several measures to minimize potential risks and protect consumers' well-being. It is advisable to apply hair products, such as hairspray, from a distance of at least 12 inches to reduce direct exposure and inhalation of volatile components. Also, maintaining proper hygiene by regularly cleaning makeup brushes and sponges helps prevent the accumulation of harmful bacteria and contaminants, ensuring safe application on the skin.

Furthermore, caution should be exercised when using glittery cosmetics, especially near delicate organs like the eyes, as these products may contain ingredients that can potentially cause eye irritation or damage. When applying hairspray, it is crucial to do so in well-ventilated spaces to minimize the chances of inhaling aerosols and potentially harmful chemicals. Moreover, the use of hairspray should be strictly avoided in the presence of open flames or sources of ignition to prevent fire hazards [85].

Reading and comprehending the user guidelines provided on cosmetic products is essential to understand their proper application and any specific safety precautions indicated by the manufacturer. Consumers should also be vigilant in scrutinizing the ingredient lists of cosmetics to identify any allergens or potentially harmful substances, especially if they have known sensitivities or allergies.

Cosmetic manufacturers should adhere to stringent quality control measures and regulatory guidelines to ensure the absence of hazardous substances in their products. Comprehensive product testing, continuous monitoring, and compliance with safety standards are crucial to mitigate potential risks associated with the use of cosmetics.

Finally, raising awareness among consumers about the importance of responsible cosmetic usage and potential risks associated with certain ingredients is vital. Empowering individuals with knowledge about safe practices and informed decision-making when choosing cosmetics can contribute to a safer and more enjoyable experience with cosmetic products. By adopting these precautions and recommendations, consumers can enjoy the benefits of cosmetics without compromising their well-being.

4. Conclusion

This study reviewed the elemental concentrations of cosmetic products and the extent to which these products affect public health and the environment. Cosmetic products such as lipsticks, lip glosses, eye shadows, henna hair dyes, and hairsprays pose adverse effects on human health and deleterious impacts on the environment due to their high metal contents. Elements including Cd, Pb, Zn, and Fe in their toxic levels have been detected in some studied cosmetic samples globally. Some of these elements pose carcinogenic health implications for consumers. The study showed that though international and national regulations on the production, delivery, use, and disposal of cosmetics are available, these are violated following the presence of toxic-bearing cosmetics on the market.

Recommendation

The study recommends

- Manufacturers of cosmetics invest in non-toxic materials that pose no or fewer impacts on public health and the environment
- Cosmetic users reduce the use of cosmetics that contain highly toxic elements;
- Recycling of cosmetic containers;
- Education on the environmental and health implications of cosmetics;
- Manufacturers of cosmetics to comply with international and national regulations on cosmetics;
- Regulatory bodies of cosmetics must ensure that proper regulations are formulated and implemented;
- Cosmetic users to report any health complications arising from the use of any cosmetic product to the regulatory body in charge of handling cosmetics and their related products; and
- Environmental and health risk studies related to cosmetics and their related products.

Compliance with ethical standards

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