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RESEARCH ARTICLE
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ASSESSMENT OF THE PRESENCE OF LEAD IN VARIOUS HERBAL COSMETIC PRODUCTS, AND THEIR ASSOCIATED HEALTH RISKS IN POPULATION

Aqsa Noreen[1], Saif Ahmed[2], Shafia Arshad[3*], Faiza Irshad[1], Amina Riaz[4], Rehan Latif[5], Reehan Ullah[6], Muhammad Zakaria[2], Sabahat Abbas[6]

[1,3*]University College of Conventional Medicine, Faculty of Medicine and Allied Health Sciences, The Islamia University Bahawalpur, Pakistan
[2]Department of Eastern Medicine, University of Balochistan, Quetta, Pakistan
[4]Department of Pharmacy, The Women University Multan, Pakistan
[5]Institute of Molecular Biology and Biotechnology, University of Lahore.
[6]Department of Eastern Medicine, Government College University of Faisalabad, Pakistan

***Corresponding author:** Shafia Arshad
* Email: shafia.arshad@iub.edu.pk

ABSTRACT
Herbal skincare products are widely used in Pakistan, but may be contaminated with the toxic metal lead. This study aimed to assess the presence and prevalence of lead contamination in different herbal skincare products accessible in the Pakistani market, with a specific emphasis on Bahawalpur, Punjab, using an atomic absorption spectrophotometer. A total of 28 samples, including 7 facial cleansers and 19 face masks from 19 different brands, were purchased from the local market in Bahawalpur, Pakistan. The brands represented a mix of local, national, and international companies. Each 1-gram cosmetic sample was digested with a mixture of Nitric Acid (60%) and Perchloric Acid (72%) in a 3:1 ratio on a hot plate at 90-110 degrees Celsius for 1 hour using the open vessel wet digestion method. The digested samples were then analyzed using Atomic Absorption Spectrophotometer to quantify lead concentrations. The results of the analysis revealed concerning findings: detectable lead levels were found in all products, with several exceeding permissible limits set by international safety standards. The study compared the observed lead levels with established benchmarks and typical concentrations found in previous research, highlighting the gravity of contamination. Additionally, the study delved into the health implications arising from lead exposure, not only addressing general health concerns but also emphasizing the vulnerabilities of specific subgroups within the population. The primary objective of this research was to provide valuable information for stakeholders and raise awareness among the general public about the use of these non-regulated personal-care cosmetic products.

Key words: Skin care products, Heavy metals, Cosmetics, Environmental aspects

1. Introduction:

The use of various compounds for skincare purposes may be traced back to ancient civilizations, when the quest of beauty, hygiene, and overall well-being spurred the use of various substances for skincare reasons. The word "cosmetic" originates from the Greek word "kosmetikos," meaning "decorated skillfully." People of all races, genders, and ages have used cosmetics to improve, change, or alter their physical features since the beginning of civilization [18]. The modern herbal cosmetic industry represents a convergence of traditional wisdom, scientific innovation, and consumer demand for natural alternatives [6]. In Pakistan, where herbal traditions thrive, there has been a resurgence of interest in herbal skincare products, drawing inspiration from historic knowledge and formulas [23]. However, the surge in popularity raises questions about quality control, safety, and efficacy, especially given the complex nature of botanical extracts [6]. Many studies have been conducted to investigate the content of heavy metals in personal care and cosmetic products such as eye pencils, eyeliner, lipstick, skin whitening creams, mascara, body cream, face cream, powder, hairspray, liquid, spray perfumes, body wash, shampoo, and foundation [19,2]. Generally heavy metals are those whose density is five times greater than the density of water [3]. Even the essential metals when present in higher concentration become toxic. Because of the industrial manufacturing process, one of the biggest concerns in the application of cosmetic products is their high level of heavy metals contamination [27]. Cross-contamination during manufacturing, packing, and storage can result in the presence of lead in finished products inadvertently [25]. Pb (lead) containing cosmetics was used in Europe for the duration of the archaic period. At that time, the Greek women used white lead in face creams as they clear-up the skin tone [10]. Too much use of this Pb type of cosmetics greatly effects the health. Lead is a very toxic heavy metal that, even at low levels of exposure, offers considerable health concerns to humans [20]. Lead may be taken into the circulation and disseminated to many organs and tissues when it enters the body. The nervous system is one of the principal targets of lead intoxication. Lead disrupts the proper functioning of neurons, which can result in cognitive deficits, learning difficulties, and behavioral issues, particularly in children [4]. Lead exposure has also been associated to an increased risk of neurological illnesses in adults, such as Alzheimer's and Parkinson's [14]. Furthermore, lead can harm the cardiovascular system, contributing to hypertension, heart disease, and stroke [22]. Lead exposure can also impair kidney function, increasing the risk of chronic renal disease and causing kidney damage [12]. The reproductive system is not immune to lead's ill effects, since lead exposure has been linked to decreased fertility and poor pregnancy outcomes [5]. Lead can pass the placental barrier in pregnant women, disrupting fetal development and resulting to developmental delays and other birth abnormalities [26]. Preparation of cosmetic samples for analysis is a critical step to ensure accurate and reliable results. The diacid digestion technique is widely used for sample preparation in the analysis of various matrices, including cosmetics. This technique involves the use of strong acid combinations to decompose the complex matrix and release the target analyte, such as lead ions, for subsequent analysis. Different acid combinations and ratios are employed to achieve efficient digestion and minimize potential matrix interference. A study by Rahman et al. (2019) evaluated different acid combinations, including nitric acid (HNO3), hydrochloric acid (HCl), and perchloric acid (HClO4), for the digestion of cosmetic samples [24].. The researchers found that a mixture of concentrated HNO3 and HClO4 provided optimal results in terms of complete digestion and minimal interference. The ratio of acids used in the digestion process is crucial to achieving efficient decomposition. The use of concentrated acids or mixtures with high acid-to-sample ratios ensures complete digestion and minimizes the loss of analytes during the process. For instance, Silva et al. (2017) investigated the performance of various acid-to-sample ratios for the digestion of cosmetic samples. The researchers concluded that a higher acid-to-sample ratio, such as 3:1 or 4:1, produced better results in terms of lead recovery and accuracy. Atomic Absorption Spectrophotometry (AAS) is a widely used analytical technique for the quantification of metals, including lead. AAS measures the absorption of light by metal ions in a sample, allowing for the determination of their concentration [29]. Chaudhary et al. (2018) utilized AAS to analyze lead content in cosmetic products. The study demonstrated the sensitivity and specificity of AAS in quantifying lead levels and highlighted its suitability for routine quality control of cosmetic products [8]. Cosmetics, especially herbal skin care products, are regulated in Pakistan by the Drug Regulatory Authority of Pakistan (DRAP), which is controlled by the Drug Act of 1976. DRAP is in charge of guaranteeing the safety, effectiveness, and quality of the country's medicines and cosmetics. However, in the case of heavy metal content, such as lead, the regulatory framework may lack clear rules and allowable limits for cosmetics, including herbal skin care products [36]. The regulatory landscape, overseen by the Pakistan Standards and Quality Control Authority (PSQCA), presents challenges in enforcing quality standards for herbal products [30]. This regulatory context underscores the need for meticulous research and assessment, especially concerning potential contaminants such as lead. Despite regulatory efforts, the presence of lead in cosmetics remains a concern, necessitating continuous assessment and oversight [2]. The permissible levels of lead in skincare products vary globally, emphasizing the importance of understanding and adhering to regional regulations [31]. The U.S. Food and Drug Administration (FDA) has established regulations regarding lead content in cosmetics. According to FDA regulations, the maximum allowable level of lead as a contaminant in cosmetic lip products and externally applied cosmetics marketed in the United States is 10 parts per million (ppm). Color additives used in cosmetics may also contain lead as an impurity, typically permitted within the range of 10 to 20 ppm [31]. The European Union (EU) has prohibited the use of lead and its compounds in cosmetics since 1976 [9]. However, trace levels of lead may still be unavoidable under good manufacturing practice [3]. The WHO has not specified a specific permissible level of lead in cosmetics. However, the WHO classifies lead as one of the substances of serious public health concern that require protective measures to ensure the health of workers, children, and women of reproductive age [35]. It's important to note that these permissible levels are subject to change and may vary based on the latest scientific evidence and regulatory updates. Cosmetic manufacturers and regulatory agencies are responsible for ensuring that products meet these guidelines to ensure consumer safety. This research, contextualized in the rich landscape of herbal skincare products in Pakistan, aims to address the significant gap in assessing lead contamination. The study's objectives are rooted in the recognition of the potential health risks associated with lead exposure through cosmetic use. Limited studies have investigated the presence of lead in skincare products in Pakistan, indicating a research gap that needs to be addressed. The significance of this study lies in its potential to fill the research gap concerning lead contamination in herbal skincare products especially face masks in different forms in Pakistan. As the market witnesses a surge in new products, the need for continuous assessment and awareness about potential health risks becomes paramount.

Tabel 1 Sample Purchased from Local Market of Bahawalpur

Sample Code	Brand name	Manufactured By	Natural/Herbal Ingredients and extracts*	Brands Approach
S-01	Skin Glow	Skin glow cosmetics	Multani mitti1	Local
S-02	AQUA skin care	Medhouse Nutraceuticals Ltd Pakistan	Cucumber extract	National
S-03	Blesso	Blesso cosmetics	Peach extract	National
S-04	AQUA skin care	Medhouse Nutraceuticals Ltd Pakistan	Aleovera	National
S-05	Golden Pearl	Golden pearl cosmetics	Aleo vera, olive oil, walnut shell	National
S-06	Mehrun Nisa	Mehrun Nisa	Multani mitti	Local
S-07	AQUA skin care	Medhouse Nutraceuticals Ltd Pakistan	Clay/mud	Local
S-08	AQUA skin care	Medhouse Nutraceuticals Ltd Pakistan	Cucumber	Local
S-09	Golden pearl	Golden pearl cosmetics	Grape extract and peppermint	National
S-10	HB-11	HB-11 Cosmetics	Blend of herbs	Local
S-11	Glamza	Glamza	Blend of herbs	Local
S-12	Golden Pearl	Golden pearl cosmetics	Clay, aleo vera with shea butter	National
S-13	Derma shine	Lipcara	Clay, cucumber	National
S-14	Saffron	Saffron skin care	Mulberry extract	National
S-15	Soft touch	So Golden Girl Cosmetics	Minerals, red sea weed nutrients	National

S-16	Soft touch	Golden Girl Cosmetics		National
S-17	Derma shine	Lipcara	Lemon	National
S-18	Derma clean	Skin Beauty Cosmetics (SMC) PVT LTD	Aleo vera	National
S-19	Soft touch	Golden Girl Cosmetics	Lavender extract	National
S-20	Olivia	Olivia Cosmetics	Aleo vera	National
S-21	Derma shine	Lipcara	Minerals	National
S-22	Tree City	Yiwu Yijie e-commerce Co., Ltd	Olive	International
S-23	Wokali	Fruit of Wokali	Broccoli & sunflower oil	International
S-24	Glamourous face	Glamourous face	Fruit extracts including pineapple, mango, strawberry, avocado, apricot	International
S-25	Disa	Disa skin care	Goqi berry	International
S-26	Garnier	L'Oréal S.A	Charcoal, black tea	International
S-27	Rivaj UK	SJS International (SJS Intl)	Rose extract	National
S-28	Saeed Ghani	Saeed ghani	Orange	National

* These are the claimed herbal/natural Ingredients present in these products along with other ingredients i.e sulfates, artificial fragrances, and paraben

Table: 2 Samples Description

Sample Code	Brand	Product name	Remarks
S-01	Skin glow	Multani mitti (clay enriched)	Face mask (powder)
S-02	AQUA skin care	Whitening cleanser	Cleanser
S-03	Blesso	Peach Whitening Cleanser/ makeup remover	Cleanser
S-04	Aqua skin care	Double action cleanser	Cleanser
S-05	Golden pearl	Whitening face mask	Face mask
S-06	Mehrun Nisa	Multani matti (mud mask)	Face mask (powder)
S-07	Aqua skin care	Whitening purifying mud mask	Face mask
S-08	Aqua skin care	Cucumber peel off mask	Peel off mask
S-09	Golden pearl	Organic clay mask	Face mask
S-10	HB-11	Ubtan facial	Face mask
S-11	Glamza	Fairness glow ubtan	Face mask
S-12	Golden pearl	Moisturizing mud mask	Face mask (Cream based)
S-13	Derma shine	Brightening facial clay mask	Face mask
S-14	Saffron	Whitening face cleanser	Cleanser
S-15	Soft touch	Clarifying mineral mask	Face mask
S-16	Soft touch	Triple action cleanser	Cleanser
S-17	Derma shine	Soothing and moisturizing peel off mask	Face mask
S-18	Derma clean	Aleo vera whitening brightening mask	Face mask
S-19	Soft touch	Double action cleanser	Cleanser
S-20	Olivia	Moisturizing cleansing milk	Cleanser
S-21	Derma shine	Lightening mask	Mask
S-22	Tree City	Olive Facial mask	Facial Sheet mask
S-23	Fruit of Wokali	Broccoli & sunflower oil Sheet mask	Facial Sheet mask
S-24	Glamourous face	Fruit facial mask	Facial sheet mask
S-25	Disa	Goqi berry facial mask	Facial sheet mask
S-26	Garnier	Pure charcoal black tissue mask	Facial tissue mask
S-27	Rivaj uk	Brightening serum sheet mask	Facial sheet mask
S-28	Usman ghani	Orange peel powder	Orange Peel powder

2. Material and Methodology:

2.1 Materials & Methods

Traditional cosmetics, predominantly of herbal origin, enjoy global popularity. However, these products often face contamination by heavy metals, posing significant health risks upon accumulation in the human body. Accurate detection of such pollutants becomes imperative for ensuring consumer safety. In spectroscopic analysis, sample preparation plays a crucial role in obtaining reliable results. Wet digestion methods are commonly employed to dissolve herbal product samples before elemental analysis.

2.2 Experimental Site and sample collection

Sample preparation occurred at the Quality Control and Instrumental Laboratory at Khawaja Fareed Campus, Islamia University Bahawalpur. Subsequent lead concentration analysis took place at the Nutrient Analytical Laboratory, MNS University of Agriculture Multan, Pakistan. Samples were transported from Bahawalpur to Multan through a courier company and stored in a dark, dry, and cool environment. The sampling methodology aimed at comprehensive representation, ensuring randomness in product selection and inclusion of various brands and types. Products were randomly purchased from commercial establishments at Fareed Gate and Bahawalpur Trade Centre. The sampled items included seven facial cleansers and twenty-one face masks from 19 different brands, ranging from local to international. Various product formats were considered, such as powders, creams, and sheet masks, ensuring a diverse examination of lead occurrence in herbal skincare products. In conclusion, the sampling methodology ensured unbiased representation, capturing the diversity of the local market.

2.3 Equipment, Reagents, Chemicals and Apparatus

Analytical Balance Scale with a precision of +0.001g, Pipettes (50ml, Pyrex, USA), Measuring Cylinders (100ml, Pyrex, USA), Beakers (50ml, 100ml, 500ml, Pyrex, USA), HSC Ceramic Hot Plate Stirrer (VELP, Scientifica), Falcon Tubes (50ml), Whatman Filter Paper No 42, Atomic Absorption Spectrophotometer (AnalytikJena, Model no: VAA 400P), Analytical grade 60% Nitric acid HNO_3 (DAEJUNG), 70% Perchloric acid $HClO_4$ (DAEJUNG), Distilled water.

All equipment and instruments underwent calibration to ensure accurate operation. Glass materials were cleansed with a solution of 60% Nitric Acid diluted with distilled water to eliminate any heavy metal residues. Prior to each digestion process, glass apparatuses like beakers, funnels, volumetric flasks, and measuring cylinders were washed with detergent, soaked in the acid solution for 24 hours, rinsed with distilled water, and deemed ready for digestion. The following details specific equipment and materials.

2.4 Methods and Procedure

2.4.1 Reagents and Sample Preparation

Samples underwent Diacid open vessel wet digestion. A solution of Nitric Acid (60%) and Perchloric Acid (70%) was prepared (3:1 ratio). One gram of the sample was soaked in 5ml of the acid mixture for 24 hours at room temperature. After 24 hours, the sample-soaked solution underwent digestion on a magnetic stirrer hot plate at 90-110 degrees Celsius for 1 hour. When the brown fumes appeared, the same procedure was again repeated by adding the 3ml mixture solution of per choleric acid and concentrated HNO3 and the samples were continuously heated and further digested for 45 minutes at 90 degrees until the white fumes appeared then the samples were allowed to cool at room temperature. Following digestion, samples were allowed to cool at room temperature for one hour. After this cooling period, samples were diluted to approximately 50 ml with distilled water. Post-dilution, samples were filtered through Whatman filter paper No 42 and stored in 50 ml Falcon tubes in a cool and dry environment.

2.4.2 Samples analysis

Since there is very little variation between the appropriate quantity and the toxic dose, accurate heavy metal measurement in personal care cosmetic goods is crucial. Prior to analysis, materials were thoroughly mixed to obtain homogeneous and representative samples. The lead concentration of the samples was analyzed by running the samples in atomic absorption spectrometer (The AnalytikJena VAA 400P) at a specific wavelength. Using the same method used for the samples, calibration standards and blank solutions were examined. Six standard solutions were used to create calibration curves for the lead absorbance. The conventional process in quantitative analysis is to generate a set of standard solutions with concentration ranges appropriate for the sample being analyzed, i.e., so that the expected sample concentrations are within the range established by the standard. The following standard solutions were prepared by dilution from a 1000ppm stock solution: Lead concentrations are 0.25ppm, 0.5ppm, 1.0ppm, 2.0ppm, 4.0 and 8.0ppm. Calibration curves for Pb were created by graphing absorbance against metal ion concentration. Metal concentration was determined by comparing the observed absorbance to the relevant standard (calibration curve).

2.5 Statistical Analysis

Statistical software, SPSS, was used to assess the research results for statistical significance. All samples were analyzed in triplicate, and mean (m) and standard deviation (SD) were calculated for lead in each sample and collectively and shown as mean± SD. An analysis of this research was done in triplicates. The statistical analysis of our skincare product study revealed a detailed portrayal of lead content. The estimated mean of 14.5954 parts per million (ppm), indicating the average lead concentration throughout the 28 samples, revealed the study's central tendency. In addition, the median, at 13.2900 ppm, revealed the midpoint, providing vital insights into the data's distribution. The significant standard deviation of 12.75569 ppm highlighted the strong variability, indicating a wide range of lead levels in these products. Furthermore, the mode, an intriguing 1.38 ppm, revealed a predominant concentration.

2.6 Health Risk Assessment

2.6.1 Margin of safety (MoS)

The potential health hazards for individuals due to exposure to heavy metal impurities in cosmetics can be assessed by computing the Margin of Safety (MoS). This calculation involves determining the ratio of the No Observed Adverse Effect Level (NOAEL) of the specific product being analyzed to its systemic exposure dosage (SED), as previously documented [28].

$$\text{MoS} = \frac{\text{NOAEL}}{\text{SED}}$$

The Systemic Exposure Dosage (SED) anticipates the quantity of chemicals entering the human body through different exposure pathways. This calculation considers factors such as the concentration of metals in the product under examination, the daily application amount of the product, application frequency, the skin surface area where the product is applied, and the average body weight [28]. The SED value was determined through an expression.

$$\text{SED (mg/kg/d)} = \frac{CS \times AA \times SSA \times F \times RF \times BF}{BW} \times 10^{-3}$$

Where CS is the metal concentration in the sample under study (mg/kg), AA is the amount of the product applied per day (g/cm^{2}), SSA is the surface area of the skin on which the product is applied (cm^{2}) F is the frequency of application (Product/day), RF is the retention factor, BF is the bioavailability factor (10^{-3} mg/kg) and BW is the average body weight (60 kg) [13,28]. This study utilized standard values for AA (amount of the product applied per day), SSA (surface area of skin for product application), and RF (application rate factor), as established by the Scientific Committee on Consumer Safety (SCCS).

For the investigated metal, the calculation of NOAEL value involved the formula: NOAEL= RFD×UF×MF

where RFD is Dermal reference dose, UF (uncertainty factor) and MF (modifying factor) represent factors reflecting overall confidence in various data sets and scientific judgment, respectively. In this instance, default values of 100 for UF and 1 for MF were applied According to USA risk-based concentration table, dermal reference doses Rfd for Pb is 0.42 mg/kg/d [1,13]. The assessment of the risk to human health from exposure to metallic impurities in cosmetic products utilized the Margin of Safety (MoS).

The World Health Organization (WHO) recommends a minimum value of 100, and it is widely acknowledged that a Margin of Safety (MoS) of at least 100 is necessary to establish the safety of a substance for usage [28].

2.6.2 Hazardous quotient (HQ)

The Hazard Quotient (HQ) is determined by comparing the Systemic Exposure Dosage (SED) of a substance to the dermal reference dose (Rfd) for each metal [32,17]. A Hazard Quotient value <1 is deemed safe, whereas a value exceeding 1 is considered unsafe for human health. The calculation of HQ follows a specified formula.

HQ=SED / Rfd

2.6.3 Lifetime cancer risk (LCR)

Lifetime cancer risk is commonly explored for metals with carcinogenic properties. In this study, the determination of Lifetime Cancer Risk (LCR) was carried out utilizing the following relationship [13]. LCR =SED/ SF

In this context, SF denotes the carcinogenicity slope factor $(mg/kg/d)^{-1}$ representing the approximation of cancer risk per unit intake dose of an agent, capable of causing cancer over an average lifetime. The slope factor reported for lead (Pb) is 0.0085 $(mg/kg/d)^{-1}$ [16,32,34].

3. RESULT AND DISCUSSION

3.1 Cleansers/Makeup removers:

The results of analyzing the lead levels in several cleansers show a large variation between brands. Notably, the lead levels in AQUA skin care's Whitening Cleanser (S-02) and Blesso's Peach Whitening Cleanser/Makeup Remover (S-03) were higher, measuring 19.755 ppm and 20.17 ppm, respectively. These findings are significant since they surpass allowable levels, indicating that these items may pose health concerns. Olivia's Moisturizing Cleansing Milk (S-20), on the other hand, has a significantly lower lead concentration of 1.45 ppm. However, even relatively lower quantities are not fully risk-free, emphasizing the importance of tight rules and frequent monitoring. Furthermore, Soft Touch's Triple Action Cleanser (S-16) and Double Action Cleanser (S-19) measured 5.165 ppm and 3.6 ppm, respectively. While these are in a lower range, they nonetheless indicate potential lead exposure, emphasizing the necessity for rigorous quality control measures across all market products.

3.2 Cream Based Face Masks

The investigation of various brands' cream-based face masks revealed a disturbing rise in lead contamination. The lead concentration in Golden Pearl's Whitening Face Mask was 11.705 ppm, suggesting a considerable divergence from safe values. The lead levels in Aqua Skin Care's Whitening Purifying Mud Mask and Cucumber Peel Off Mask were significantly higher, at 12.44 ppm and 12.955 ppm, suggesting major health concerns. The Organic Clay Mask from Golden Pearl has a lead concentration of 6.435 ppm, which was still above the allowable limit.

Tabel: 4 Lead (P)b levels in samples

Sample ID	Sample Brand Name	Parameters	Mean pb (mean ± SD) Ppm	SE
S-01	Skin glow	Pb	29.485 ± 1.092 [b]	0.631
S-02	Aqua skin care	Pb	19.755 ± 0.602 [cde]	0.348
S-03	Blesso	Pb	20.17 ± 0.497 [c]	0.287
S-04	Aqua skin care	Pb	15.37 ± 0.306 [cde]	0.177
S-05	Golden pearl	Pb	11.705 ± 0.361 [efgh]	0.209
S-06	Mehrun Nisa	Pb	15.105 ± 0.589 [a]	0.340
S-07	Aqua skin care	Pb	12.44 ± 0.349 [a]	0.202
S-08	Aqua skin care	Pb	12.955 ± 0.715 [a]	0.413
S-09	Golden pearl	Pb	6.435 ± 0.766 [a]	0.443
S-10	HB-11	Pb	13.14 ± 0.304 [defg]	0.176
S-11	Glamza	Pb	11.22 ± 0.500 [defgh]	0.289
S-12	Golden pearl	Pb	14.405 ± 0.363[efgh]	0.210
S-13	Derma shine	Pb	15.82 ± 0.544 [gh]	0.315
S-14	Saffron	Pb	16.43 ± 0.720 [cd]	0.416
S-15	Soft touch	Pb	17.26 ± 0.362 [a]	0.209
S-16	Soft touch	Pb	5.165 ± 0.495 [fgh]	0.286
S-17	Derma shine	Pb	7.685 ± 0.565 [gh]	0.326
S-18	Derma clean	Pb	5.18 ± 0.495 [hi]	0.286
S-19	Soft touch	Pb	3.6 ± 0.252 [a]	0.145
S-20	Olivia	Pb	1.45 ± 0.335 [a]	0.194
S-21	Derma shine	Pb	1.375 ± 0.263 [a]	0.152
S-22	Tree City	Pb	11.185 ± 0.462 [a]	0.267
S-23	Fruit of Wokali	Pb	13.145 ± 0.551[a]	0.318
S-24	Glamourous face	Pb	72 ± 0.092 [a]	0.631
S-25	Disa	Pb	14.33 ± 0.376[cde]	0.218
S-26	Garnier	Pb	13.71 ± 0.480[a]	0.277
S-27	Rivaj uk	Pb	14.715 ± 0.538[cde]	0.311
S-28	Usman ghani	Pb	13.435 ± 0.327[def]	0.189

N = 28 Pb-lead, Alphabetical letters represents significant differences at at $p < 0.05$.
Max. 72 ppm
Min. 1.375 ppm

Furthermore, the lead levels in HB-11's Ubtan Facial, Glamza's Fairness Glow Ubtan, and Golden Pearl's Moisturising Mud Mask were 13.14 ppm, 11.22 ppm, and 14.405 ppm, respectively, demonstrating the pervasive problem. Derma Shine's Brightening Facial Clay Mask, Soft Touch's Clarifying Mineral Mask, Derma Shine's Soothing and Moisturizing Peel Off Mask, Derma Clean's Aleo Vera Whitening Brightening Mask, and Derma Shine's Lightening Mask exhibited lead concentrations of 15.82 ppm, 17.26 ppm, 7.685 ppm, 5.18 ppm, and 1.375 ppm, respectively. These findings highlight a serious gap in quality control and regulatory oversight within the cosmetic sector, requiring immediate intervention to protect consumers from potentially dangerous exposure. The persistent presence of lead in these commonly used face masks highlights the importance of strong regulations and open communication between makers and consumers to maintain product safety and public health.

3.3 Powder based face masks

The examination of market powder-based face masks indicates significant differences in lead amounts. Skin Glow's Multani Mitti (clay-enriched) Face Mask had a surprisingly high lead content of 29.485 ppm, indicating a significant divergence from safe values. Although powder-based, Mehrun Nisa's Multani Matti (mud mask) Face Mask had alarming lead levels of 15.105 ppm. Usman Ghani's

Orange Peel Powder contains lead, although at a lower concentration of 3.435 ppm. Multani Mitti, which has traditionally been used for medicinal purposes, has recently come under attention due to heavy metal pollution. Clay-based goods, notably Multani Mitti, have been found in studies to absorb heavy metals from the environment during their creation. As a result of the lead poisoning, these masks, which are commonly marketed for their natural constituents, pose unforeseen health hazards. The presence of lead in these ostensibly natural goods is concerning, emphasizing the significance of strong quality control methods.

3.4 Facial Sheet masks

Sheet masks, which are made of a thin fiber soaked in nutrient-rich serum, are popular due to their ease of application and effectiveness in providing skincare advantages. When applied to the face, these masks provide hydration, brightness, and anti-aging benefits. However, as this study found, assuring the safety of sheet masks is critical due to potential pollutants such as lead, emphasizing the importance of tight standards and consumer knowledge. The examination of market-purchased sheet masks revealed a disturbing pattern of lead contamination, indicating possible health hazards to consumers. The Olive Facial Sheet Mask from Tree City contained 11.185 ppm of lead, whereas the Broccoli & Sunflower Oil Sheet Mask from Fruit of Wokali contained 13.145 ppm. The most concerning discovery was in Glamourous Face's Fruit Facial Mask, which had a lead content of 72 ppm. Lead levels were 14.33 ppm in Disa's Goji Berry Facial Mask, 13.71 ppm in Garnier's Pure Charcoal Black Tissue Mask, and 14.715 ppm in Rivaj UK's Brightening Serum Sheet Mask, respectively. The presence of lead in these sheet masks raises serious concerns about contamination sources. While the specific source of lead in sheet masks is unknown, probable explanations include contaminated raw materials used in mask formulations, such as clays or herbal extracts. Furthermore, the manufacturing process, including equipment and packing, may incorporate lead into the product. Cross-contamination during manufacture, processing, or storage may also contribute to high lead levels.

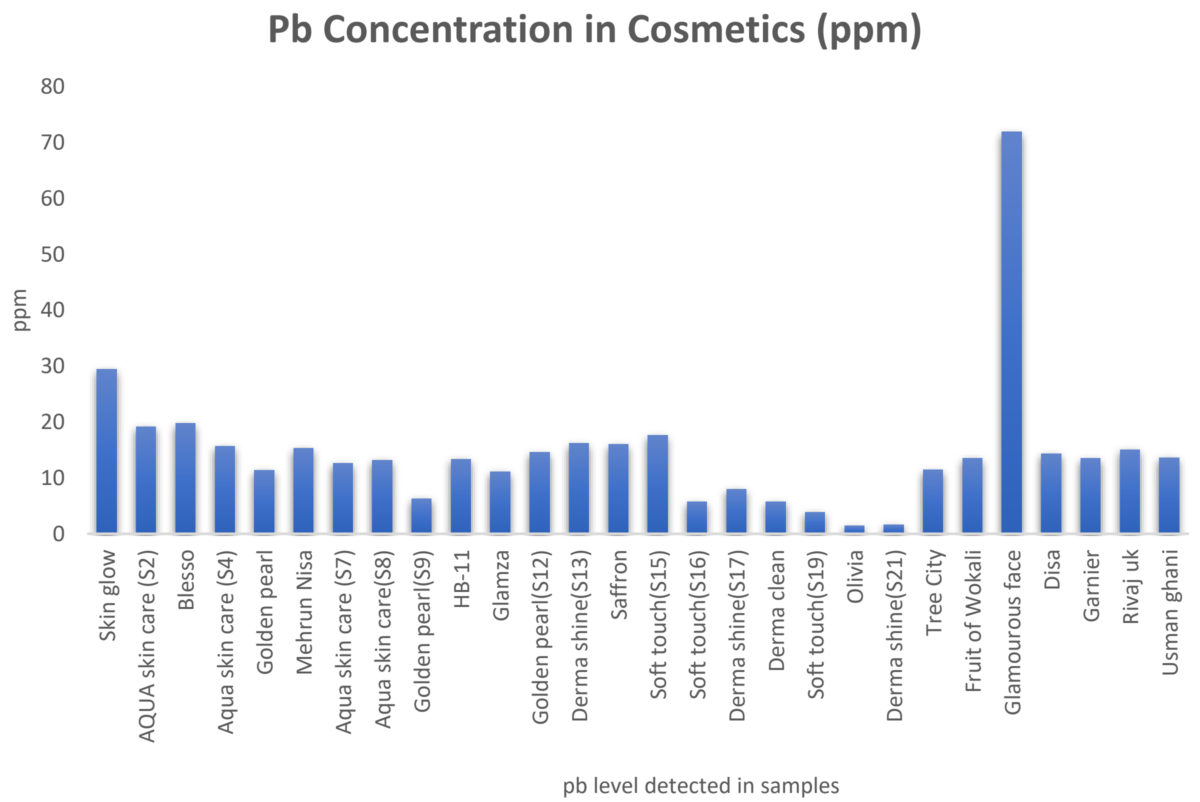

Fig 1. Pb conc. in samples

3.5 Health Risk Assessment:

Systemic exposure to cosmetic products anticipates the quantity of chemicals entering the human body through diverse exposure pathways. The computed values of Systemic Exposure Dosage (SED) for selected heavy metals at 50% and 100% bio-accessibility in various cosmetic products are presented in the table 5.

It was noted that at 50% bio-accessibility, SED values for Cleanser/ makeup removers, Cream face masks, Powder Face masks, Sheet Face masks $2.35.10^{-2}$, $3.22.10^{-2}$, $7.1.10^{-2}$ and $1.18.10^{-1}$ respectively, while at 100% bio-accessibility SED values were $4.7.10^{-2}$, $6.44.10^{-2,}$ $1.42.10^{-1}$ and $2.36.10^{-1}$ respectively. The evaluation of the risk to human health from exposure to lead (Pb) in cosmetic products was conducted through the application of the Margin of Safety (MoS). The calculated MoS levels for heavy metals in cosmetic products, considering both 50% and 100% bio-accessibility, are detailed in the table 6. MOS greater than 100 indicates that the products are safe to use according to SCCS

3.5.1Hazardous quotient (HQ)

The HQ values of the products at 50% and 100% bio-accessibility levels are presented in Fig 2 & 2.1. At 50% bio accessibility, HQ values were found considerably <1 elucidating the potential safety of samples. Despite the HQ values being below 1, indicating potential safety, the concurrently high LCR and lead levels signal a potential risk, suggesting that the HQ value alone may not accurately reflect the overall safety of the samples.

3.5.2Lifetime cancer risk (LCR)

Hazardous metals (HMs) are persistent in the body due to their non-biodegradable nature, accumulating over an extended period. Lead is a well-known carcinogen with negative health consequences, and skin absorption is a primary conduit for its entry into the human body. Numerous studies have linked lead's carcinogenic potential to a variety of malignancies, including but not limited to kidney, lung, and bladder cancers. Lead compounds are classified as Group 2A by the International Agency for Research on Cancer (IARC), indicating that they are likely carcinogenic to humans [15]. According to the U.S. Environmental Protection Agency (USEPA), the acceptable range for Lifetime Cancer Risk (LCR) falls between 1×10^{-6} to 1×10^{-4}. In the analysis of lead (Pb) with 50% and 100% bio-accessibility, as depicted in figures 3.A and 3.1.B, the estimated lifetime cancer risk for almost all examined samples surpasses the permissible limit. This suggests that cosmetic products may pose a lifetime cancer risk.

Table: 5 SED values (mg/kg/d) of Lead (pb) in the cosmetic products

Sample	pb
At 50 % Bio-accessibility	
Cleanser/makeup removers	2.35×10^{-2}
Cream based face masks	3.22×10−2
Powder Based Face masks	7.1×10−2
Sheet Based Face masks	1.18×10−1
At 100% Bio-accessibility	
Cleanser/makeup removers	4.7×10^{-2}
Cream based face masks	6.44×10−2
Powder Based Face masks	1.42×10−1
Sheet Based Face masks	2.36×10−1

Table: 6 Margin of Safety (MoS) for Lead (pb) in the cosmetic products

Sample	pb
At 50 % Bio-accessibility	
Cleanser/makeup removers	1.78723×10^3
Cream based face masks	1.30435×10^3
Powder Based Face masks	5.9155×10^2
Sheet Based Face masks	3.5593×10^2
At 100% Bio-accessibility	
Cleanser/makeup removers	8.9362×10^2
Cream based face masks	6.5217×10^2
Powder Based Face masks	2.9577×10^2
Sheet Based Face masks	1.7797×10^2

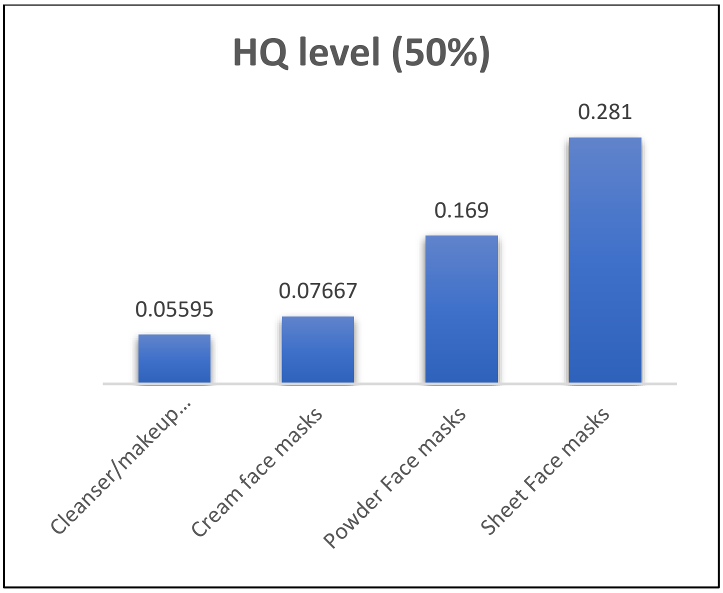

Fig 2 (A) HQ values of samples at 50% (A) and 100% (B) bio accessibility levels.

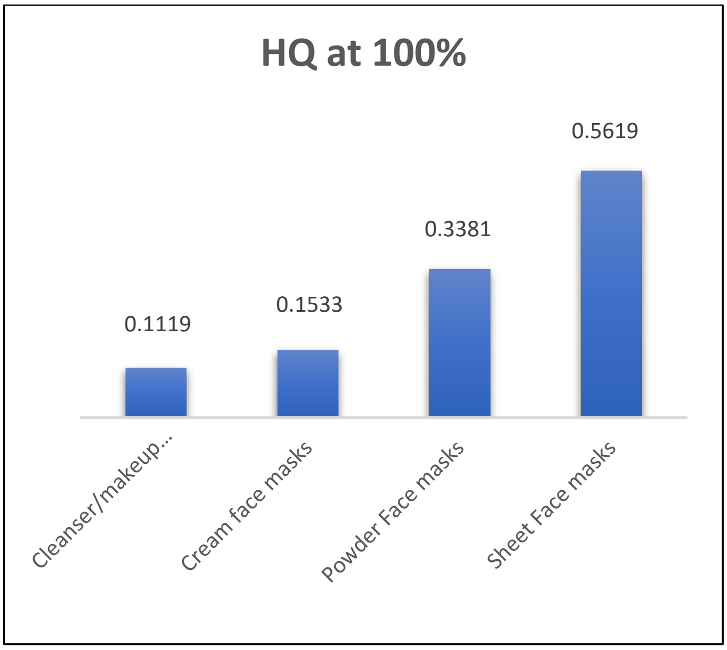

Fig 2.1 (B)

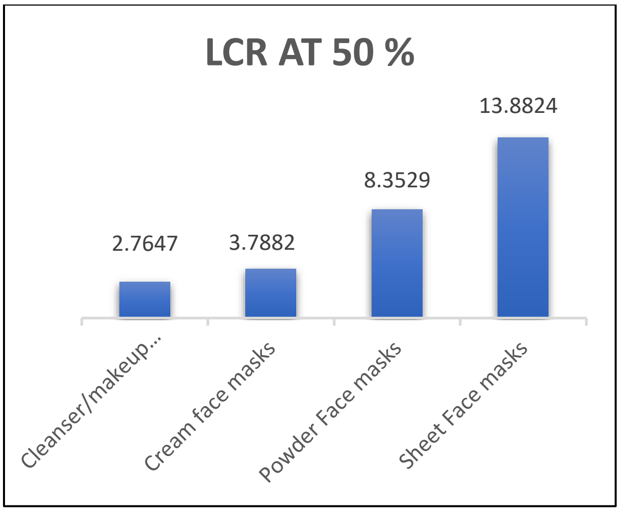

Fig 3 (A)

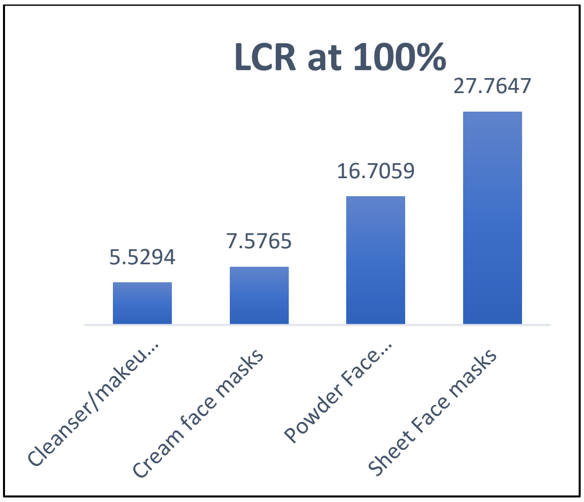

Fig 3.1 (B)LCR values of samples at 50% (A) and 100% (B) bio accessibility levels

4. Conclusion

The wide range of heavy metal concentrations found in the samples emphasizes the importance of mineral components used during formulation and production. While the FDA's established limit of 10 ppm for lead (Pb) in externally used cosmetics serves as a benchmark, our study found several products that exceeded this limit, indicating potential health risks upon usage. However, it is widely acknowledged that there is no level of lead (Pb) intake or applied considered safe [7]. Prolonged exposure to these cosmetics may intensify lead's toxic effects, negatively impacting various bodily systems such as the reproductive, neurological, and renal systems. Lead is listed as carcinogenic heavy metal by international agency of research on cancer [15]. The constraints of this study, such as the small sample size and the necessity to ship samples for analysis due to a lack of AAS equipment nearby, emphasize the difficulties encountered during the research. Future study conducted on-site with greater sample sizes and using cutting-edge analytical instruments will improve the accuracy and dependability of outcomes. Because there are no effective safety laws in Pakistan, it would be presumptuous to assess the fate of these products based on heavy metal concentration. This comprehensive approach will greatly contribute to a better knowledge of heavy metal concentrations in cosmetics, allowing for more effective regulatory actions and improved consumer safety. Pakistan needs strict quality control laws because the general public is still surprisingly unaware of product labels and their specified components. As a signatory to the Minamata Convention on Mercury, Pakistan is attempting to build a clean cosmetic supply chain with an emphasis on decreasing heavy metals levels. If items fail to meet lead content regulations, licenses should get cancelled and manufacturing units sealed. These targeted actions are critical stages in Pakistan's journey towards comprehensive and standardized lead regulations [21]. This study emphasizes the need for swift regulatory changes and increased awareness initiatives, which are essential first steps toward a Pakistani cosmetics market that is safer and more uniform.

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