# Arsenic, Lead and Cadmium contamination and pH analysis of skincare cosmetics found in Nepalese market

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**Abstract:** Cosmetics are skin and hair care materials used to beautify and enhance appearance, and the demand for cosmetics is increasing rapidly. The increased consumption of cosmetic products to nurture skin poses a problem due to the presence of excessive heavy metals and their impact on consumers. This research aimed to assess the levels of arsenic (As), lead (Pb), cadmium (Cd), and pH in five different popular cosmetic creams currently available in the Nepalese market. The lead and cadmium concentrations were determined by Atomic Absorption Spectroscopy (AAS), while the continuous hydride generation method determined the arsenic concentration, pH of the products was measured using a digital pH meter. The analysis indicated that lead concentrations ranged from 8.93±0.027 to 27.18±0.030 ppm, among which just one sample (PDS-04) concentration was within the acceptable level of 10 ppm which is recommended by ISO/TR 17276. Cadmium concentration varied between non-detectable to 1.22±0.010 ppm, within the permissible limits. The arsenic contamination was not detectable. The pH was found highest at 8.7 in FH-01 and lowest at 7.4 in samples HM-03 and PDS-04.

**Keywords**: Atomic absorption spectroscopy; Cadmium toxicity; Lead contamination; pH analysis.

## Introduction

The demand for cosmetics increases rapidly, these are skin and hair care materials used to beautify and enhance the attractive appearance or odor of the human body, the choice of cosmetic product selection depends on the consumer behavior, brand, price and quality to fulfill their desire to be attractive, and well-groomed[1]. Recent trends in the usage of cosmetic products have elicited some serious health implications because of possible heavy metal content. Lead (Pb), Cadmium (Cd) and Arsenic (As) are the most hazardous elements that are bio-accumulative and have toxicological impacts on the human body. Lead poisoning has adverse effects on the human brain; such effects are worse in children and can cause cardiovascular disease in adults. Cadmium is toxic to the kidneys and is a carcinogen[2]. Arsenic affects the skin and leads to cancer and cardiovascular disease[3]. Another parameter that defines the compatibility of skin and leads to cancer and cardiovascular disease[3]. Another parameter that defines the compatibility of cosmetic products with the skin is their pH level. Human skin has an optimal pH level of 4.5 to 5.5 and this makes it to provide checkpoints against microbes and other pollutants. Cosmetic products with pH levels outside this range affect the skin's protectant shield thus causing skin irritation, dryness, and susceptibility to infections. Regular use of lead-containing cosmetics accumulates cumulatively and can add up significant levels of exposure, especially in the case of pregnant and lactating mothers because lead passes through milk feeding and the placenta which may affect infants and fetus development[4]. Though these health risks are well understood internationally, research pointed out that some cosmetics available in the Nepalese market contain high concentrations of heavy metals such as Pb, Cd, and As

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In a study, 85.35% of respondents know the preventive measures of the adverse effects of cosmetic products. However, due to their habit of using cosmetic products use of such products cannot be avoided[6]. In cosmetic products, the presence of heavy metals as contaminants can occur during the manufacturing process due to improper handling of raw materials, inadequate sanitation practices, and lack of proper quality control[7].

Globally, several organizations have set acceptable levels of heavy metals in cosmetics products. The Government of Canada specifies that lead concentrations of more than 10 ppm in cosmetics are prohibited[8]. Likewise, the US FDA has given the permissible limit for lead as an impurity in cosmetic lip products and externally applied cosmetics not more than 10 ppm[9]. Since heavy metals pose a serious health hazard[10] Nepal Standards-2019 for cosmetics recommends a limit for lead 10 ppm, arsenic 3 ppm and cadmium 3 ppm in skin cream, lotion and lipstick[11]. Research is required to determine the concentration of these hazardous contaminants in cosmetics available in the Nepalese market. Also, the pH characteristics of these products are crucial to understand their compatibility with human skin. The study aims to measure the concentrations of lead (Pb), cadmium (Cd), arsenic (As), and pH in the selected cosmetic products available in the Nepalese market.

## Materials and Methods

### Collection of samples

Cosmetics samples were collected from the local markets of Kathmandu, Nepal. Five different samples FH-01 (Radiance Cream), VC-02 (Moisturizing Cream), HM-03 (Brightening Cream), PDS-04 (Nourishing Cream), and ASTBY-05 (Sun Protection Cream) were selected based on product category, popularity and market availability. The samples were checked for the expiration date and defects to avoid any errors. Before the laboratory analysis, the samples were stored in their original packaging and handled carefully to prevent contamination.

### Determination of lead and cadmium in cosmetic samples

For the determination of Lead and cadmium, Atomic Absorption Spectroscopy (GBC SAVANTAA) was used. Each sample (0.5 g) was accurately weighed and placed into the digestion vessels. A digestion process was done using a mixture of concentrated nitric acid ($HNO_3$), perchloric acid ($HClO_4$) and sulfuric acid ($H_2SO_4$) in a proportion of 9:4:1, respectively, on a hot plate under controlled conditions to ensure that the organic matter was completely digested[12]. The solutions were then filtered using Whatman filter paper No. 41 and diluted to 100 mL with distilled water.

The AAS was calibrated using standard solutions of lead and cadmium (0–5 ppm). Detection wavelengths were set at 283.3 nm for lead (Pb) and 228.8 nm for cadmium (Cd)[13]. The absorbance values were noted, and the concentrations were displayed in the computer-operated GBC SAVANTAA Ver 3.11a software. All the experimentations were done in triplicate to ensure the accuracy and reproducibility of the results.

### Determination of arsenic in cosmetic samples

Arsenic concentration was determined by using the continuous hydride generation technique[14] using a spectrophotometer (CECIL CE2041). Each 0.5 g sample was digested in concentrated nitric acid ($HNO_3$) and sulfuric acid ($H_2SO_4$) until clear white fumes appeared to show that the sample was fully solubilized. Potassium iodide was used to reduce arsenic to its trivalent state ($As^{3+}$) to facilitate hydride generation.

For spectrophotometric analysis, sodium tetrahydroborate ($NaBH_4$) was used to generate arsine gas ($AsH_3$), it was then passed through a heated quartz absorption cell in the CECIL CE2041 spectrophotometer. The absorbance was measured at 540 nm and the concentration of arsenic was calculated. The experiment was repeated thrice to check for consistency.

### Determination of pH

The pH value of each cosmetic sample was measured using a pH meter (HI2213), which was calibrated with standard buffer solutions. The sample preparation method depended on the type of emulsion. For oil-in-water emulsions, 5 g of cream was dispersed in 45 mL of deionized water, while for water-in-oil emulsions, 10 g of cream was mixed with 90 mL of rectified spirit, maintaining a pH range between 6.5 and 7[15].

The prepared solutions were equilibrated for some time at a temperature 27°C ± 0.5°C. The pH electrode was placed into the solution, and the measurements were taken after 5 minutes to allow for equilibration. All measurements were done 3 times to increase the reliability of the results obtained.

## Results and Discussion

### Lead contamination

The absorbance of the standard Pb solution in the range of 0.0 - 5.0 ppm was measured and plotted against the concentration shown in Figure 1:

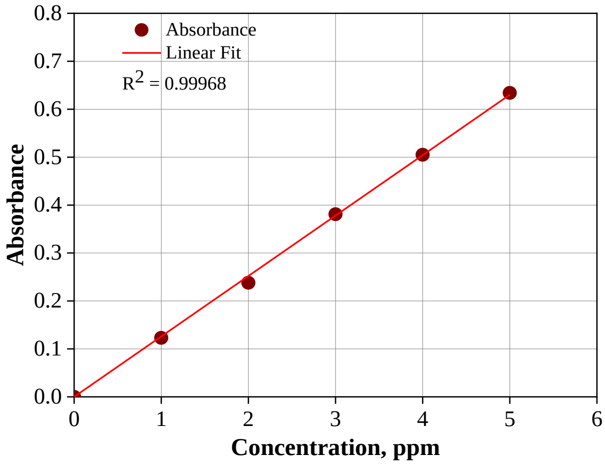


**Figure 1: Plot of Lead concentration against absorbance.**

### Cadmium contamination

The absorbance of the standard Cd solution 0.0 - 5.0 ppm was measured and plotted against the concentration shown in Figure 2.

### Arsenic contamination

The absorbance of the standard As solution 0.0 - 8.0 ppm was measured and are plotted against the concentration shown in Figure 3.

The amount of metal ions and pH detected in the cosmetic samples is tabulated in Table 1. Lead content in the cosmetic samples FH-01, VC-02, HM-03, PDS-04, and ASTBY-05 were found to be 23.05±0.031, 27.18±0.030, 12.79±0.036, 8.93±0.027, and 21.32±0.020 ppm respectively. As per WHO, the permissible limit of 10 ppm for cosmetics[16].

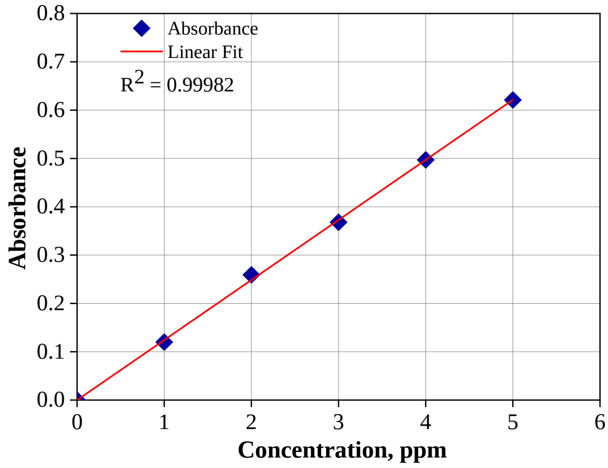


**Figure 2: Plot of Cadmium concentration against absorbance.**

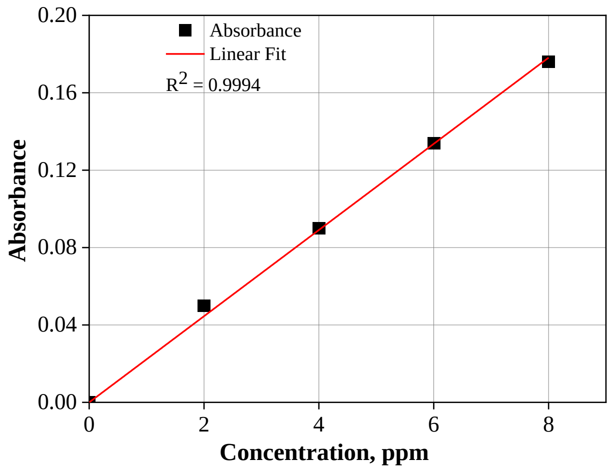


**Figure 3: Plot of Arsenic concentration against absorbance.**

**Table 1: Concentration of Pb, Cd and As and pH in different cosmetic samples.**

| Cosmetic samples | Pb | Cd | As | pH |
|---|---|---|---|---|
| | ppm | | | |
| Radiance Cream (FH-01) | 23.05±0.031 | ND | ND | 8.3 |
| Moisturizing Cream (VC-02) | 27.18±0.030 | 1.22±0.010 | ND | 7.5 |
| Brightening Cream (HM-03) | 12.79±0.036 | 1.09±0.006 | ND | 7.4 |
| Nourishing Cream (PDS-04) | 8.93±0.027 | ND | ND | 7.4 |
| Sun Protection Cream (ASTBY-05) | 21.32±0.020 | ND | ND | 8.7 |

Regulatory standards set by the USFDA and Health Canada restrict lead levels in cosmetics to 10 ppm, while ISO/TR 17276 sets a limit of 10 mg/kg[17].

These results show that the samples FH-01, VC-02, HM-03, and ASTBY-05 exceed the permissible limits, raising concerns about potential neurological toxicity, cognitive impairment, and cardiovascular risks[18]. Studies in India and Pakistan have also reported excessive lead content in cosmetics such as lipsticks and fairness creams[19]. Al-Saleh et al. had reported Lead content in some cosmetic products above 20 ppm[4].

Cadmium content in the cosmetic samples ranged from non-detectable to 1.22±0.010 ppm. VC-02 and PDS-04 exhibited a Cd concentration of 1.22±0.010 and 1.09±0.006 ppm respectively, while no detectable cadmium was found in the samples FH-01, HM-03, and ASTBY-05.

According to ISO/TR 17276, the allowable limit for cadmium in cosmetics is 3–5 ppm[20]. These results show that Cd content in all the cosmetic samples was found within the prescribed limits. However, even at low concentrations, cadmium exposure poses significant health risks, cadmium is classified as a Group 1 carcinogen by the International Agency for Research on Cancer and is known to cause renal toxicity, osteoporosis, and systemic bioaccumulation[21].

Arsenic content in all the cosmetic samples was not detected. These results comply with the USFDA regulations, which set the maximum allowable arsenic concentration in cosmetics at 3 ppm[22]. However, even at low concentrations, the toxic effects of arsenic include carcinogenicity, cardiovascular diseases, and skin lesions[23].

**Determination of pH in cosmetic samples**

The pH values of the cosmetic samples was measured at25 ºC, ranged from 7.4 to 8.7 shown in Table 1. Sample HM-03 and PDS-04 exhibited the lowest pH 7.4, which is closest to the natural skin pH, followed by VC-02 7.5, FH-01 8.3 and ASTBY-05 8.7 were found to be more alkaline.

The skin's natural acid mantle, with an optimal pH of 4.5–6.0, plays a crucial role in barrier function, enzymatic activity, and microbiome stability. Alkaline pH levels above 7 can disrupt the epidermal barrier, leading to dryness, irritation, and increased microbial colonization. Products with a pH closer to 5.5 will have less tendency to disrupt skin health and enzymatic functions necessary to the skin's defense[22]. While all tested products fell within a moderate range, FH-01 and ASTBY-05 may pose a greater risk of skin barrier disruption, particularly for sensitive individuals[24].

## Conclusions

- This study highlights significant heavy metal contamination in cosmetic products, with lead (Pb) concentrations in FH-01, VC-02, HM-03, and ASTBY-05 exceeding WHO, USFDA, and ISO/TR 17276 limits, posing potential neurological and cardiovascular health risks. PDS-04 was the only sample within safe limits.
- Cadmium (Cd) was detected in VC-02 and PDS-04 within the permissible limits, but its carcinogenic and bio-accumulative nature necessitates continuous monitoring.
- Arsenic (As) was non-detectable in all samples, complying with USFDA regulations.
- The pH analysis revealed that FH-01 and ASTBY-05 had high alkalinity (8.3 and 8.7, respectively), which may disrupt the skin barrier and cause irritation.
- These findings underscore the need for stringent regulatory enforcement, mandatory heavy metal screening, and improved formulation standards in the cosmetic industry to ensure consumer safety.

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