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Determination of Heavy Metals in Selected Cosmetic Products sold in Nepal

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ABSTRACT

Introduction: Cosmetics are a significant source of heavy metals, as they contain various chemicals as ingredients and additives. There are concerns about the presence of hazardous chemicals in cosmetics, including heavy metals. The objective of this study was to assess the levels of heavy metals, specifically lead (Pb), Cadmium (Cd), and Arsenic (As), in bathing soaps, shampoos, face creams, and bulk powders sold in Nepal.

Methods: Fourteen different brands of bathing soaps, shampoos, face creams and bulk powders were purchased from local markets of major cities of seven provinces of Nepal to determine the concentrations of three metals (Pb, Cd and As) by using Atomic Absorption Spectrophotometry (AAS).

Results: The results showed that lead was detected in four samples, and all of them exceeded the permissible limit. Arsenic was detected in only one sample, which also exceeded the limit.

Conclusion: This study demonstrates that some cosmetic products in Nepal contain heavy metals, such as Pb, Cd, and As, above the permissible limits. The continuous use of such products may result in harmful effects, and consumers should exercise caution. Manufacturers must be informed of their products' status to eliminate these heavy metals, and regulatory guidelines should be strictly enforced, accompanied by routine analytical checks, to ensure that cosmetics are safe for human use.

Keywords: *Arsenic, Atomic absorption spectrophotometer, Cadmium, Cosmetics, Lead.*

INTRODUCTION

The use of cosmetic products has become increasingly popular due to the desire for individual beautification and the rise of advertisements in electronic media.[1] Although the skin provides a great protective barrier, some of the ingredients in cosmetic products are able to penetrate the skin and reach vital internal organs via systemic circulation. This is especially hazardous when it comes to cosmetic products that are applied to mucous membranes, such as lip products like lipsticks, which have a higher risk of direct oral ingestion and can result in negative effects of its chemicals.[2]

Heavy metal poisoning has been a recognized health hazard for more than 2,000 years. There have been a number of reports in the media and on the internet about the presence of different heavy metals in branded cosmetic products.[3] There is no exact guideline for heavy metals in cosmetics. However, some comparative guidelines are used to limit the heavy metals in cosmetic items. U.S. Food and Drug Administration (USFDA), has set up 0.1 ppm limit for lead in candy- to protect people from directly ingesting the lead which is used for cosmetic products as well. The Campaign for Safe Cosmetics (CSC) has set 0.1 ppm for lead in cosmetics. This rule has been assigned on the basis of the maximum allowable lead concentration in candy, because it has been assumed that lipstick may be directly taken in via the mouth.[4]

USFDA has suggested that the concentration of some heavy metals such as nickel, cobalt, and chromium in color additive cosmetics should be less than 170 ppm and that of lead should be less than 20 ppm.[4] Similarly, Health Canada Product Safety Laboratory while reviewing and analyzing the results of heavy metal testing on a number of cosmetics sold in Canada determines the limit for heavy metal impurities. According to this, a lead level exceeding 10 ppm is considered technically avoidable. For cadmium, the oral limit value ranges from 0.9 to 3 ppm for nutritional

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supplements.[5] The Guidelines for Canadian Drinking Water Quality recommend a maximum acceptable concentration (MAC) of 0.005 mg/L (0.005 ppm) for cadmium, while the United States Environmental Protection Agency (US EPA) has an oral reference dose of 0.5 µg/kg bw/day for cadmium.[6]

Arsenic is one of the 10 chemicals of major public health concern according to the World Health Organization (WHO). WHO publishes a guideline value for arsenic in its Guidelines for Drinking-water Quality to be not more than 10 µg/L (0.01 ppm). The recommended MAC for arsenic in drinking water is 0.01 mg/L (0.01 ppm) in Canada. The USFDA limit for arsenic in certain colorants is < 3 ppm.[6]

However, Nepal does not have any standards, guidelines, or legislation regarding the limits of heavy metals in cosmetic products. There are no government agencies responsible for regulating heavy metals in cosmetics, and neither government agencies nor private sectors monitor the heavy metal impurities in cosmetics imported, produced, marketed, distributed, and used in Nepal. There is an absolute lack of awareness among the users and consumers of such products, and no one pays attention to the content, labelling, or expiry dates of products. This study aims to assess the levels of heavy metals, specifically Pb, Cd, and As, in bathing soaps, shampoos, face creams, and bulk powders sold in Nepal.

METHODS

Sampling Method

Fourteen different brands of each cosmetic item; a total of four cosmetic items were taken for study from each major city of each province of Nepal. In this way a total of 56 samples were collected separately in a polythene bag. All the collected cosmetic items were then coded so that brand identity is not revealed.

After the collection of cosmetic items, sample preparation was done in the Laboratory of CiST College, Kathmandu, Nepal. The prepared samples were then sent to ZEST Laboratories (ISO/IEC 17025: laboratory), Bhaktapur, Nepal for determination of Lead, Cadmium and Arsenic in an Atomic absorption spectrophotometer (AAS). The standard solutions for each metal were used as per the Association of Official Analytical Collaboration (AOAC) official method of analysis.

Table 1: Preparation of metal standards (Adapted from AOAC official method of analysis).[7]

Metals	Weight (gm.)	Compound	Dissolving medium (1L in total)
Cd	1.142	CdO	5 ml HNO_3 + water
Pb	1.599	$Pb(NO_3)_2$	10 ml HNO_3 + water
As	1.000	As_2O_3	25 ml of 20% NaOH + water

Sample Preparation and Heavy Metal Determination

The sample was incinerated in a muffle furnace at approximately 450˚C for 8 hours to remove any organic matter. Following incineration, 5 ml of a 1:1 mixture solution of hydrochloric acid (HCl) was added to the residue obtained, and the mixture was heated on a hot plate until it was dried. The residue was then dissolved in 0.5% nitric acid (HNO_3), and if it did not dissolve completely, the sample was again incinerated in the muffle furnace. Once dissolved, the residue was further dissolved in 0.5% HNO_3, and the volume was maintained up to 100 ml. This process ensured that the sample was free from any contaminants and was in a suitable form for AAS analysis. The AAS was used to analyze the samples that were prepared. The AOAC guidelines were followed carefully to prevent any potential contamination of the samples. To reduce matrix effects, relevant calibration curves were established from metal standards in aqueous solutions with the same acid concentration, and quantification was accomplished by interpolation.

RESULTS

Calibration Curve for Standards

Standards for each metal to be determined i.e., lead, cadmium and arsenic were used as per AOAC official method of analysis. The data and calibration curve obtained for each metal were as follows:

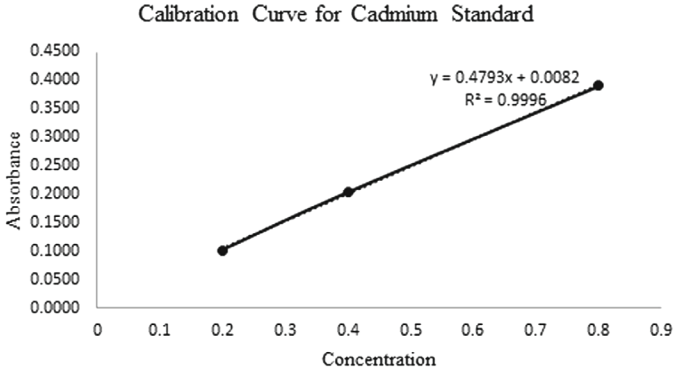

Figure 1: Graph Showing Calibration Curve of Cd Standard

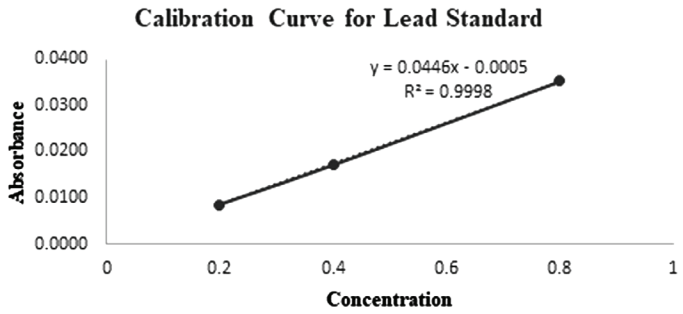

Figure 2: Graph Showing Calibration Curve of Pb Standard

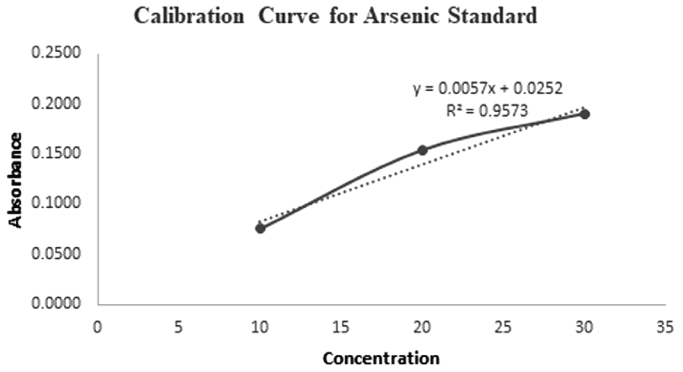

Figure 3: Graph Showing Calibration Curve of As Standard

The correlation coefficient for calibration curve of each metal standards were above 0.9 (0.9996 for Cd, 0.9998 for Pb and 0.9573 for As). Hence, these calibration curves were used to estimate the amount of corresponding metals present in the samples.

Estimation of Metal Concentration

Flame AAS was used to determine Cd and lead whereas hydride generator AAS was used for the determination of As in the cosmetic samples. As there are no any standard guidelines for permissible limits of heavy metals in cosmetics, reference was taken from the permissible heavy metal limits in food products, USFDA has set up a 0.1 ppm limit for lead in candy, and USP for nutritional supplements recommends oral limited value for Cd to be 0.9 to 3 ppm.[4] Similarly, WHO has published a guideline value for arsenic in drinking water quality to be not more than 0.01 ppm.[6]

Considering these limits as standard limits, the results were interpreted. The amount of metals detected in the cosmetic samples is tabulated in Table 2.

Table 2: Metal Concentration (Pb, Cd and As) Detected in Different Cosmetic Items

Soap				Shampoo				Face cream				Bulk powder			
Conc in mg/kg				Conc in mg/kg				Conc in mg/kg				Conc in mg/kg			
Code	Pb	Cd	As	Code	Pb	Cd	As	Code	Pb	Cd	As	Code	Pb	Cd	As
SO1	0.6	ND	ND	SH1	ND	ND	ND	FC1	ND	ND	ND	BP1	ND	ND	0.482
SO2	0.2	ND	ND	SH2	ND	ND	ND	FC2	ND	ND	ND	BP2	ND	ND	ND
SO3	0.4	ND	ND	SH3	ND	ND	ND	FC3	ND	ND	ND	BP3	0.2	0.4	ND
SO4	ND	ND	ND	SH4	ND	ND	ND	FC4	ND	ND	ND	BP4	ND	ND	ND
SO5	ND	ND	ND	SH5	ND	ND	ND	FC5	ND	ND	ND	BP5	ND	ND	ND
SO6	ND	ND	ND	SH6	ND	ND	ND	FC6	ND	ND	ND	BP6	ND	ND	ND
SO7	ND	ND	ND	SH7	ND	ND	ND	FC7	ND	ND	ND	BP7	ND	ND	ND
SO8	ND	ND	ND	SH8	ND	ND	ND	FC8	ND	ND	ND	BP8	ND	ND	ND
SO9	1	ND	ND	SH9	ND	ND	ND	FC9	ND	ND	ND	BP9	ND	ND	ND
SO10	ND	ND	ND	SH10	ND	ND	ND	FC10	ND	ND	ND	BP10	ND	ND	ND
SO11	ND	ND	ND	SH11	ND	ND	ND	FC11	ND	ND	ND	BP11	ND	ND	ND
SO12	ND	ND	ND	SH12	ND	ND	ND	FC12	ND	ND	ND	BP12	ND	ND	ND
SO13	ND	ND	ND	SH13	ND	ND	ND	FC13	ND	ND	ND	BP13	ND	ND	ND
SO14	ND	ND	ND	SH14	ND	ND	ND	FC14	ND	ND	ND	BP14	ND	ND	ND

ND= not detected

Among 14 soap samples collected from different cities, lead was detected in four samples (SO1, SO2, SO3 and SO9) and the amount was excess than the limit. Cd and As were not detected in any of the samples. Among 14 shampoo samples, Pb, Cd and As were not detected in any of the samples. Among 14 Face cream samples, lead, Cd and As were not detected in any of the samples. Among 14 Bulk powder samples, lead was detected in one sample (BP3) and the amount was excess than the limit. Cd was detected in one sample (BP3) but the amount was lower than the limit and As was detected in one sample (BP1) with an amount higher than the permissible limit.

Comparison of Heavy Metals

It is clear that Pb concentrations in the samples under investigation are higher. The overall concentration of heavy metals analyzed was: lowest in Bulk Powder (BP3) for Pb; Maximum of 0.4 ppm with the highest concentration in Bulk Powder (BP3) for Cd. Only one item, Bulk powder (BP1) have shown the presence of arsenic with 0.48 ppm.

Table 3: Comparison of Cosmetic Items for Pb, Cd and As

S.N.	Cosmetic items	Lead (mg/kg)	Cadmium (mg/kg)	Arsenic (mg/kg)
1	Soap	0.2 - 1.0	ND	ND
2	Shampoo	ND	ND	ND
3	Face Cream	ND	ND	ND
4	Bulk Powder	0.00-0.16	0.00-0.04	0.00-0.48

DISCUSSION

The concentration of metals in cosmetics varies depending on the metal and the type of product analyzed. Even within the same class of cosmetics, the concentration of the metal can vary significantly due to various factors such as the state of purchase, the manufacturing process, the shade, and the brand. Furthermore, the presence of multiple metals in one cosmetic product is quite common. One concerning issue is the presence of lead (Pb) in soap, as shown in Table 2. The high lead values found can be due to the use of lead chromate, which provides the pigment in colored soaps. Lead may also be found as lead sulfide or lead acetate. The lead contamination of soaps may also originate from leaded paint in production equipment or from Pb-contaminated dust and water. High lead content was seen in soaps SO1, SO2, SO3, and SO9 in the range of 0.2 to 1 ppm, which is more than the standard limit. The Pb contained in soaps may be dermally absorbed, which can create the basis for aggregate risks. Although there is less chance of ingestion of soaps, the risk of dermal absorption cannot be neglected. Lead is highly toxic for fetuses, babies, and children whose nervous systems are still developing.[8]

According to the research carried out by Forte et al. in 2008, it should be considered that the concomitant presence of more than one allergenic metal or minimal amounts of toxic metals could trigger a pre-existing allergy and reaction.[9] Therefore, even though Cd was determined to be present in minimal amounts in some of the samples of bulk powders, it is essential to be cautious before use.

Face creams are widely available in pharmacies, beauty aid, health stores, and local marketplaces. In most cases, no label warning is present on the products, so the consumer does not have any choice in selecting suitable products.[10] These creams are commonly used in Nepal due to the mass distribution of products. Even though none of the heavy metals (Pb, Cd, and As) were detected in this research due to the limited number of products, there is a high chance of exposure to other heavy metals like mercury (Hg), which is used as a skin whitener. Hence, low quality skin creams may be a global health problem.

There is also a reason to be concerned about As and Cd. Arsenic and its inorganic compounds, and Cd and its compounds are considered human carcinogens and are also considered substances "for which there is believed to be some chance of adverse health effects at any level of exposure" in Canada.[11,12]

The data obtained from this research has revealed three key findings. Firstly, heavy metals were present in cosmetics at concentrations above the set standard limits, as shown in Table 2. This indicates that many cosmetics are not compliant with the set limits. Secondly, heavy metals, particularly Cd, were detected in some cosmetic items in lower amounts that were within the set limits. However, it should be considered that the presence of even minimal amounts of toxic metals could trigger a pre-existing allergy and reaction, as per Forte et al., 2008.[9] Lower Cd levels are not necessarily safe, as the Centre for Disease Control and Prevention (CDC) has stated that even low levels of exposure in children are associated with neurodevelopmental deficits and that there is no known safe blood Cd level.[8] Furthermore, it is noteworthy that Canada's 2009 draft impurity limits for Pb, As, Cd, and antimony (Sb) are more stringent than Germany's limits, which were established in 1985. This suggests that manufacturers' ability to technically reduce impurities has changed over time.

Thirdly, heavy metals were not detected in most of the cosmetic items, which may be due to the low sensitivity of the AAS instrument, inappropriate sample preparation methods, or errors during analysis. However, there

may be traces of heavy metals in the products that were undetermined. The trace amounts applied to the skin, lips, or any parts of the body each day might be small, but exposure to these cosmetic items can accumulate over time and be toxic. Additionally, the number of cosmetic items available in the market is unlimited, and many cosmetics are used in combination, which can result in different exposure patterns and health effects. Therefore, further research on the safety of cosmetics is mandatory to reduce unnecessary exposure to toxic metals.

CONCLUSION

The result of the study showed that Pb, Cd and As levels in some of the cosmetic products (especially soaps and bulk powders) were above the permissible limits. Continuous and frequent use of these items, though unintended, either through the mouth, skin or eyes as the case may be, should be discouraged as it could enhance the absorption of these heavy metals thereby triggering harmful effects in the body. Efforts could however still be made to eliminate these heavy metals from our cosmetics either by warning the consumers or by notifying the manufacturers of their product status. Based on the research findings, we recommend that concerned authorities establish legal provisions for continuous monitoring of heavy metals in all cosmetic products. This will ensure that manufacturers comply with the permissible limits and produce safe products for consumers. Furthermore, regulatory guidelines regarding quality control of cosmetic products should be formulated and enforced by the regulatory authority. This will help to ensure that low-quality products are not produced and marketed to consumers.

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CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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