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RESEARCH ARTICLE

Assessment of cadmium and lead concentrations in different types of cosmetics products consumed in Iran

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ABSTRACT

Background: A safety assessment of cosmetic is necessary for evaluating the health risks associated with the use of these products. **Aims and Objectives:** The aim of this study is to assess the cadmium (Cd) and lead (Pb) concentrations in different types of cosmetics products consumed in Iran. **Materials and Methods:** This study was design to evaluate the content of Cd and (Pb) in 11 different types of cosmetics including lipstick, nail polish, eyeliner, eye pencil, eyeshadow, makeup cleaner, mascara, pancake, tattoo, hair dye, and hair gel belonging to German, French, Turkish, Chinese, and Iranian brands, from September 2016 to March 2017. The content of Cd and Pb were measured with a polarograph following nitric acid digestion. **Results:** Out of 264 sample, the mean and standard error level of Cd and Pb were 3.69 ± 0.72 and 9.07 ± 1.126 µg/g, respectively. The average content of Pb in lipstick, tattoo, and nail polish was higher than the permitted limit of 10 µg/g. The mean content of Cd was also at level above the permitted limit of 3 µg/g for eye pencil, lipstick, and tattoo. The statistical analysis showed a significant difference between Cd ($P = 0.038$) and Pb ($P = 0.013$) among different types of the cosmetics. **Conclusion:** Results indicated that several samples contain high levels of Cd and Pb that can be associated with health effects at sufficiently exposures. Regular monitoring of toxic metals, along with increased public awareness is necessary to provide a level of protection for women, especially for pregnant and lactating women.

KEY WORDS: Beauty; Cadmium; Cosmetics; Lead; Poisoning; Iran

INTRODUCTION

Today, a lot of peoples used cosmetics products to make one feel and appear more beautiful as well as for boosting confidence and self-esteem. Cosmetic products for human consumption is defined by the European Union's (EU) Cosmetics regulation as substances or mixtures intended to be placed in contact with the external parts of the human body (epidermis, hair system, nails, lips, etc.,) or with the teeth and the mucous membranes of the oral cavity with a view exclusively or mainly to cleaning them, perfuming them, changing their appearance, protecting them, keeping them in good condition, or correcting body odor's.[1] These substances are commonly used in all of communities with different religious and socioeconomic levels.[2] psychologists believe that many individuals, especially women tend to

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show their beauty to other people through using of cosmetics products. For this reason, it is not unusual that more women concerned about their beauty in a meeting, concourse, or procession.[3]

In recent years, there has been increasing concern about the presence of toxic substance such as Cd and Pb in cosmetic products at a levels more than suggested a safe limit of 3 μg/g for Cd[4] and 10 μg/g for Pb.[5] The research on the presence of Cd[6-9] and Pb[9-12] in cosmetic products is reported over than recommended limit in some studies. One of the main causes of this will be the use chemical substance as additive to keeping them in good condition.[5] The most Cd compound used are Cd sulfide, Cd selenide for making different colors such as yellow, orange, and black. Cd green or light green is obtained when the Cd yellow mixed with viridian (Cr (III)oxide). The Pb mainly enters to cosmetics products through compounds such as Pb chromate, Pb sulfide, Pb carbonate, and Pb acetate because they usually used as a color pigment.[4] It is obvious that Cd has adverse effects on the renal duct, glomerular, bone mineral depletion, and increase the risk of bone fractures, decreases lung function, and emphysema.[13] The agency for the registration of toxic substances and diseases and the international agency for research on cancer considered Cd as a toxic substance and human carcinogen, respectively.[13,14] The carcinogenic effects of cadmium (Cd) observed on the lung, prostate, liver, and pancreatic.[15] Pb has also acute and chronic damaging effects on various parts of the body such as the hematological, gastrointestinal, renal, cardiovascular, neurological, and reproductive systems. Furthermore, exposure to Pb through the uterus during pregnancy can delay or disrupt the development of neurological systems, intelligence quotient deficiency, weight loss, birth defects, and delay in the sexual maturity of girls.[16]

It is clear that cosmetics need more attention since these products are directly applied on the human skin and stay for a prolonged period.[4] In addition, it should be noted that this toxic substance with a prolonged half-life could be a threat to human health by biologically accumulated.[15] Beside this, increasing trend for applying cosmetics by Iranian peoples has made Iran as the seventh countries with the highest cosmetic product usage in the world, and the second in the Middle East region after Saudi Arabia. Consequently, assessment of Cd and lead (Pb) as toxic substance in cosmetics products is an essential to make ensure that these products are not threats for human health.

MATERIALS AND METHODS

Sampling

This cross-sectional study was performed from September 2016 to March 2017. In total, 264 samples from 11 cosmetic products including lipstick, nail polish, eyeliner, eye pencil, eyeshadow, mascara, eye cleanser, pancake, tattoo, hair dye, and hair gel (24 samples of each cosmetics product) purchased from different shopping in Gorgan, Iran. The proposed criteria of choice were recommendation of coworkers and friends, price range, the top accessible cosmetics of German, French, Turkish, Chinese, and Iranian brands. Sample size selected according to the equation: n=[(Z2σ)/d2]2 with an alpha of 0.05, a σ of 1.62, and a d of 0.1 from a study in Isfahan.[12] The samples were stored at the laboratory according to cosmetic labeling guide prior analyzing.

Sample Digestion

Initially, all plastic and glass containers were washed with tap water and then immersed in 10% v/v HNO3 (Sigma-Aldrich, Germany) solution for 24 h. They were then rinsed with deionized water and finally dried in clean air. For digestion, 1 g of cosmetic product transferred to a 100 ml clean Becher and then set on the water Bath (SCI FINECH-model 230 v, 50 HZ, Korea) with temperature around 80°C to run digestion process after adding 5 ml of nitric acid (70%). The procedure was repeated through addition of acid and heating continued until the evolution of white fumes (marking the end of the digestion process). The solutions were allowed to cool, filtered by Whatman no. 45 (GE Healthcare, Little Chalfont, UK) into a calibrated flask (100 ml), and diluted up to the mark with deionized water.[17] These digestion solutions transferred to plastic bottles and were kept in refrigerator until ready.

CD AND PB DETERMINATION BY THE VOLTAMMETRIC METHOD

A Metrohm 797 VA Computrace (Herisau, Switzerland) equipped to three electrode system consisting of hanging mercury drop electrode as working electrode, platinum (Pt) as auxiliary electrode, and Ag/AgCl as reference electrode was used in estimation of Cd and Pb. Analytical standard solutions get ready by proper dilution of 1000 mg/l Titrisol Merck (Germany) stock solutions [$CdCl_2$, Ni $(NO_3)_2$, and Pb $(NO_3)_2$] in a 10% (v/v) HNO_3. The calibration standards were prepared using chem lab, Zedelgem, Belgium, at 1000 ppm of Cd and Pb. The Cd and Pb concentrations were quantified using linear regression based on the height of the peaks of the voltammograms.[18]

Data Analysis

Statistical analysis data were analyzed using statistical software (IBM SPSS Statistics 20; IBM Corporation, NY, USA) at a significance level of $P < 0.05$. Descriptive statistical parameters such as mean and standard error (SE) were used to describe the Cd and Pb concentration in different cosmetic product. One-way analysis of variance (ANOVA) was used to determine the difference of Cd and Pb concentration among different types of cosmetic, brands, colors, and producer country. Pearson correlation coefficient was also used to test the relation between the Cd and Pb in cosmetics products.

RESULTS

Overall, the results show that the mean and SE (Mean ± SE) concentration of Cd and Pb were 9.07 ± 1.126 μg/g (ranged from 0.68 to 63.42) and 3.69 ± 0.72 μg/g (ranged between < 0.001 and 15.99), respectively. Table 1 shows descriptive statistics of results for Cd and Pb concentrations in 11 beauty product based on the cosmetic substance, producer country, and cosmetics brands. Comparing the mean level of Pb and Cd in various type of cosmetics product showed that the Pb level in cosmetics products of lipstick, tattoo, and nail polish was 15.39, 13.09, and 10.36 μg/g, respectively [Figure 1]. They were higher than permitted limit of 10μg/g. Moreover, the average concentration of Cd was 5.39, 5.33, and 3.97 for eye pencil, lipstick, and tattoo, respectively, that exceeded than the permitted limit of 3 μg/g [Figure 2]. Comparing the results among producer country showed that the mean concentration of Cd and Pb was only higher than the suggested value in the cosmetics produced by the China country [Figures 3 and 4].

Table 1: Descriptive statistical analysis of quantitative monitoring of Cd and Pb in different types of cosmetic products, Gorgan, Iran

Types of cosmetics	Country	Brand	Mean±SE	
			Cd (μg/g)	Pb (μg/g)
Lipstick	France	A	0.28 (0.07)	0.37 (0.8)
	Turkey	A	2.81 (0.84)	9.05 (1.05)
	Iran	A	4.76 (1.12)	18.67 (1.14)
	China	A	14.28 (2.2)	33.48 (3.52)
Nail polish	Turkey	B	2.69 (0.56)	8.36 (1.42)
	Iran	A	2.72 (0.94)	12.36 (1.04)
Eyeliner	Turkey	A	1.96 (0.88)	6.45 (0.82)
	Iran	B	3.14 (0.75)	8.57 (1.02)
Eye pencil	Turkey	C	1.05 (0.57)	6.64 (0.57)
	China	B	9.73 (0.95)	10.08 (1.03)
Eyeshadow	Turkey	A	1.24 (0.37)	3.78 (0.84)
	Iran	B	3.92 (0.51)	6.16 (1.47)
Eye makeup remover	Iran	C	1.22 (1.06)	4.38 (1.1)
	China	C	4.52 (1.14)	6.15 (2.04)
Mascara	Turkey	C	1.12 (0.84)	6.22 (1.03)
	Iran	A	3.27 (0.79)	7.09 (0.72)
Hair color	Germany	A	0.38 (0.06)	1.47 (0.55)
	Iran	D	2.81 (0.67)	7.14 (0.83)
Hair gel	France	B	0.14 (0.63)	0.23 (1.13)
	Iran	E	2.12 (0.58)	4.25 (0.12)
Pancake	Turkey	C	0.55 (1.16)	2.13 (0.59)
	Iran	A	1.12 (0.08)	4.83 (0.83)
Tattoo	Germany	B	0.65 (0.02)	1.04 (0.48)
	China	D	7.29 (0.44)	25.14 (2.89)

SE: Standard error, Cd: Cadmium, Pb: Lead

DISCUSSION

Pb level in cosmetics products of lipstick, tattoo, and nail polish was 15.39, 13.09, and 10.36 μg/g, respectively, [Figure 1]. They were higher than permitted limit of 10 μg/g. Moreover, the average concentration of Cd was 5.39, 5.33, and 3.97 for eye pencil, lipstick, and tattoo, respectively, that exceeded than the permitted limit of 3μg/g [Figure 2]. The average concentration of Cd and Pb were less than the permitted limit for other cosmetics products. With respect to

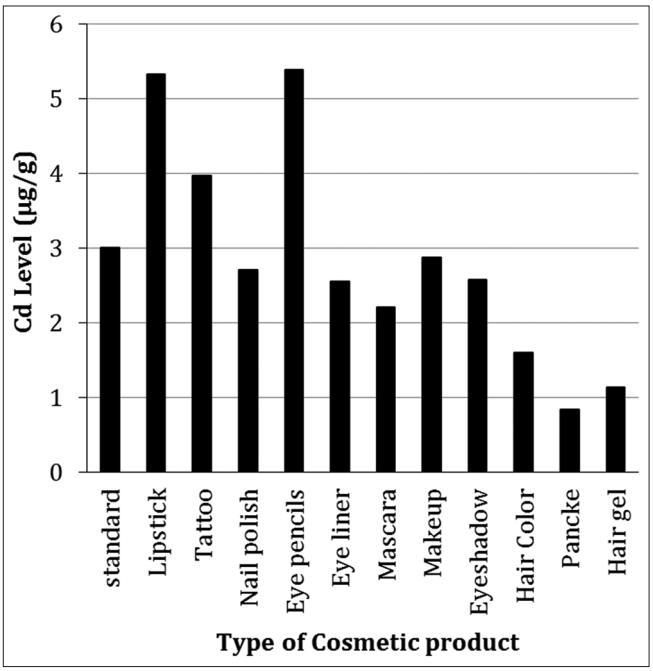

Figure 1: Comparing the mean level of cadmium in various type of cosmetics product with permitted limit

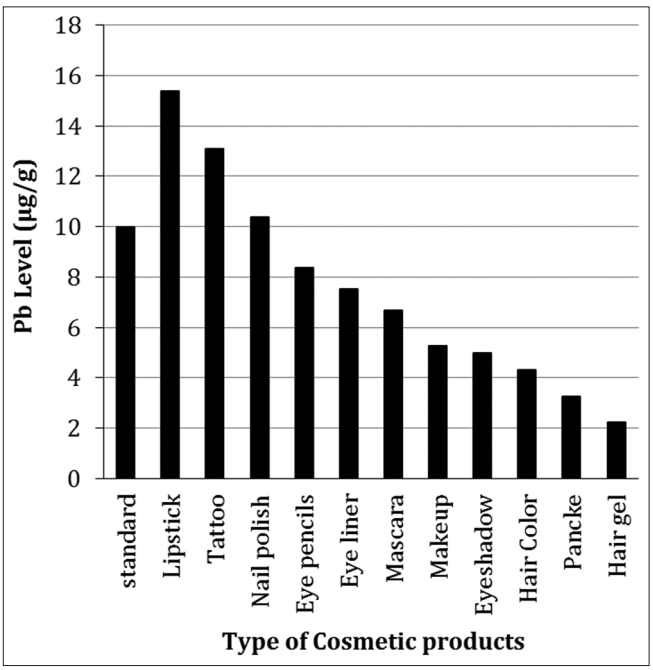

Figure 2: Comparing the mean level of lead in various type of cosmetics product with permitted limit

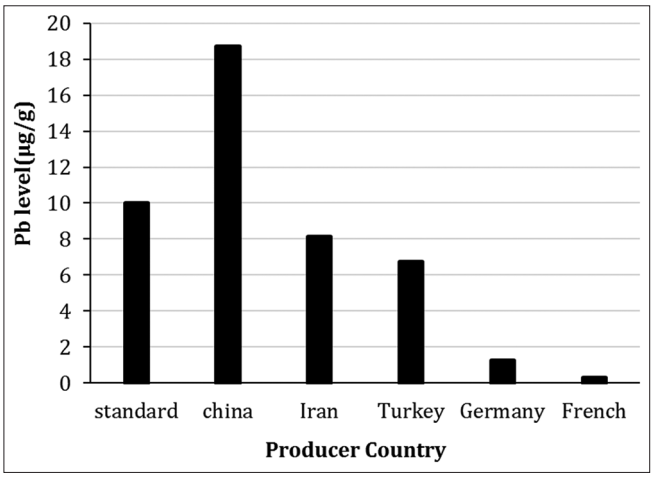

Figure 3: Comparing the mean lead level of cosmetics in producing country with permitted limit

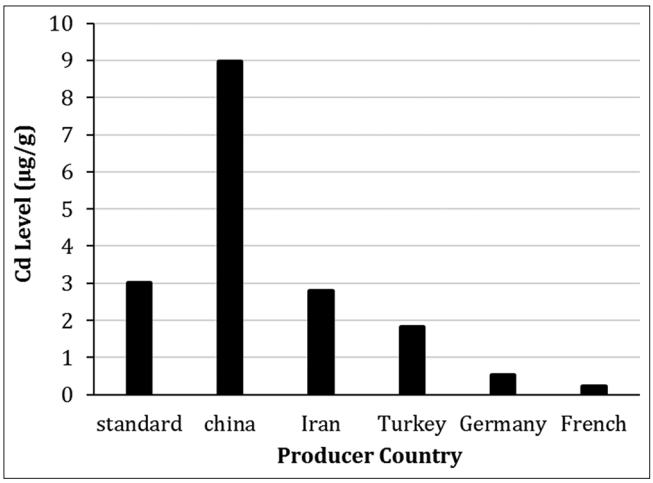

Figure 4: Comparing the mean cadmium level of cosmetics in producing country with permitted limit

type of cosmetic products, our finding revealed that 18% of lipstick, 14% of nail polish, and 13% of eye pencil had a Cd level above the suggested limit. In eye cosmetics, the highest percentage of sample above the permissible value of Cd was found in eye pencil and followed by eyeliner, mascara, and eyeshadow. In pancakes and hair gel samples, 2–4% of samples had Cd content above the recommended value that was totally related to Iranian brands. Moreover, Cd levels in pancakes and hair gel were below the permitted limit in more than 95% of the samples tested. Among the tattoo samples, concentration of Cd was exceeding than the recommended levels in one-third of samples. Furthermore, the highest Pb concentration above the permitted value was 28%, 22%, and 17% in lipstick, nail polish, and hair dye, respectively. Among the samples of pancakes, hair gel and makeup cleaner, 3%, 6%, and 7% had Pb content higher than the recommended value, as well. The one-way ANOVA analysis showed that there were statistically significant differences between mean Cd ($P = 0.038$) and Pb ($P = 0.013$) values of cosmetic products and type of brand.

Comparing the results among producer country showed that the mean concentration of Cd and Pb was only higher than the suggested value in the cosmetics produced by the China country [Figures 3 and 4]. In addition, the highest level of Cd an Pb were found in China brands, followed by Iranian and Turkish brand. In contrary, French and German products had the lowest level of Cd and Pb. It is due to this reason that the Directive 76/768/EEC banned the use of toxic metals as impurities in preparation of cosmetics products.[4]

According to one-way ANOVA, statistical significant difference was found between the mean of Cd and Pb concentration and producing country ($P < 0.001$). However, the average level of Cd in Iranian and Turkish brand was less than the recommended limit, but we found that 22–9% of cosmetics from Iranian and Turkish brands had a Cd level above the permitted limit.

As well, 27–13% of cosmetics had Pb concentration of more than recommended limit in Iranian and Turkish brand, respectively. In contrast, all the products related to Germany and France brands had Cd and Pb concentration lower than the permitted limit. The highest concentrations of Pb observed in Chinese lipsticks, Iranian nail polish, and tattoo imported from China with concentrations of 63.42, 52.19 to 48.75 µg/g, respectively. In contrary, the lowest amount of Pb was found in hair gel (French brand) and pancakes (Iranian brand) with the content of 0.68–0.94 µg/g. On the other hand, content of Pb was not found higher than the permitted limit in the samples of pancakes and hair gel imported from Turkish and French country, respectively. Similar results are found in the study of Gunduz and Akman who revealed that the highest level of Pb was found in Chinese and Taiwan cosmetics and the lowest level was found in cosmetics substance produced in USA and French.[19] Al-Saleh *et al*. and Gondal *et al*. also reported that the high level of Cd and Pb in cheap products related to China and India companies.[11,20] Among tattoo samples, all samples had concentration of Cd and Pb above permitted limit related to Chinese brand. While the highest quantity of Cd and Pb in tattoo imported from Germany was 1.83 to 7.08 µg/g, respectively, which was much less than permitted limit. Similarly, the high level of Cd and Pb was found in Iranian hair dye with golden, brown, and black colors (relatively cheap price range). According to present findings, Cd in the Iranian hair color was much higher than the German brand ($P = 0.03$). In Iranian hair dyes, two samples had a Cd concentrations of 8.16–6.46 µg/g. In Iran and other developing countries, the cheapest cosmetics related to China and India companies. While, cosmetics substance produced according to the registration, evaluation, authorization, and restriction of chemicals in EU countries are at an expensive price range. Since the low-income social group was not able to buy and use the high-quality brands, so they are likely at high risk of harmful chemicals.

Regarding cosmetics color, the current findings showed that Cd and Pb were found in all explored colors (data not

shown), but the highest concentrations of Pb observed in brown, chocolate, and dark red colors with concentration of 63.42, 52.19–47.75 μg/g, respectively. On the contrary, the lowest Pb levels were associated with colors of purple (0.68 μg/g), white (1.94 μg/g), and bright peach (2.55 μg/g). Among to tattoos dye sample, the highest and lowest level of Cd were found in products with dark brown and light blue colors, respectively, but this difference was not statistically significant ($P = 0.08$). With respect to Cd concentration, dark brown and dark red color had a high level of Cd similar to Pb. Statistical analysis revealed a significant difference between Pb concentration and color of cosmetic products ($P < 0.001$). Our results were in agreement with research conducted by Nourmoradi *et al.*, which high level of Cd and Pb in dark colors was higher than in bright colors.[12] In another study conducted in Iran, the pink and violet color had the highest and lowest concentration of Pb. Furthermore, the brown and orange color have the highest and lowest Cd concentration, respectively.[21] Nevertheless, Cd and Pb detected in all of cosmetics products, but a significant association was not found between the content of Cd and Pb in cosmetic products ($P = 0.071$).

CONCLUSION

The overall results showed that Cd and Pb content were above the permissible value in some cosmetic products which might pose health risks for human, especially pregnant and lactating women. Thus, regular monitoring of other toxic metals in cosmetics, along with increased public awareness is necessary to provide a level of protection for public health.

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