ORIGINAL PAPER

Health risk assessment of the concentration of trace elements in cosmetic products in Sanandaj, Iran

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ABSTRACT

This study was conducted to determine the concentrations of Ag, Cd, Cr, Cu, Fe, Ni, Pb, and Zn in the commonly used cosmetic products such as eyeshadows, eyeliners, and skin whitening creams in markets of Sanandaj city, Iran in 2014. In this study, 60 samples comprising of three different types of eyeshadows, eyeliners, and skin whitening creams were purchased randomly from different cosmetic shops in Sanandaj city. The cosmetic product samples were digested using wet digestion method. Trace elements were assayed using an ICP-OES. According to the results, Ag and Fe were the trace elements with the lowest and highest concentration in the three brands, respectively. Moreover, the results indicated that eyeshadow contains the highest (except Ag and Cd) concentrations of trace elements. On the other hand, the levels of HQ for trace elements in the cosmetic products decreased in the following order: Zn > Cr > Cd > Fe > Cu > Ag > Ni > Pb. The trace element concentrations in the three brands of cosmetic products in our research were lower than the international standards and similar to those reported from researchers in different parts of Iran, but according to the accumulation and toxicity of these trace elements in the human body, they require periodic monitoring.

Keywords: Cd, Pb, Toxicity, Cosmetic products, Health risk

Introduction

Heavy metal contamination is one of the main problems in the environment because long-term exposure to toxic metals causes neurotoxic, carcinogenic, mutagenic, and teratogenic damages, and damage to blood composition, lungs, kidneys, liver, and other vital organs.[1] Among metals, cadmium and lead are very toxic and common pollutants in the environment that have led to considerable concern.[2,3] For example, Cd is one of the major metals found in lipsticks and face powders. The use of Cd in cosmetic products is due to its coloring property since it is used as a color pigment in many industries.[4] Cd poisoning causes bone degradation, renal dysfunction, and obstructive lung disease, and Cd pneumonitis results from inhaled dusts and fumes.[5] Exposure to Pb leads to inhibition of hemoglobin synthesis, kidney dysfunction, and reproductive and cardiovascular system dysfunction.[6] So, it is important to conduct a study to assess the levels of trace elements in cosmetic products so as to know the potential consumption risk to consumers.

Among the cosmetic products, eyeshadows, eyeliners, lipsticks, skin whitening creams, and hair colors have been the most widely used worldwide, especially in the Middle East.[7] Iranians are one of the highest consumers of cosmetics in the Middle East and are the seventh largest consumers of cosmetics in the world.[1] According to studies conducted, 14 million Iranian women use cosmetic products in a way that this accounts for 29 percent of cosmetic product consumption in the Middle

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East. Moreover, Iranian women use cosmetics worth about 2.1 billion dollars in the Middle East cosmetic market. Lipstick and eyeshadow, as common cosmetic products, have various components including antioxidants, pigments, waxes, oils, and inorganics such as silica, TiO_2, copper powder, aluminum powder, and bronze powder.[7] Numerous studies have evaluated levels of trace metals in cosmetic products. Ajayi et al.[8] reported that high levels of trace metals were detected in the locally produced facial makeup in Nigeria. In addition, Nourmoradi *et al.* who assessed concentrations of Cd and Pb in commonly used cosmetic products in Isfahan city reported that the continuous use of these cosmetics could increase the accumulation of metals such as Cd and Pb in the human body due to swallowing lipsticks or through dermal cosmetic absorption.[7]

Monitoring the trace metal levels in consumer products and providing a suitable solution for the material used is essential.[9] One of the most suitable methods for determining risk indicators and permissible use limits (their risk assessment) is target hazard quotients (THQ). In fact, THQ represents the relative ratio of the amount of inhibitory substances and dose required to express the abnormal effects. If the THQ value is lower than one, it indicates that the exposed population has not experienced any evident adverse effects, but if this ratio is equal to or greater than one, it is dangerous for the consumers. After performing the risk assessment, the potential risk associated with the use of any cosmetics can be considered.[10,11] Therefore, this research aimed to investigate the concentration of Ag, Cd, Cr, Cu, Fe, Ni, Pb, and Zn in the most frequently used brands of eyeshadows, eyeliners, skin whitening creams, and hair colors in Sanandaj city.

Materials and Methods

A total of 60 samples including three brands of eyeshadows, eyeliners, and skin whitening creams were purchased randomly from different cosmetic shops in Sanandaj city in 2014. These brands are very popular, and most of them are imported. The cosmetic products were mostly imported from three different countries (French, China, and Turkey), and they are compared with Iranian cosmetic products.

The samples were digested using wet digestion method. Ten milliliters of concentrated nitric acid (65%) and 5 ml of perchloric acid (70%) mixture (2:1 ratio) was added to 1g of each sample in 150 ml Erlenmeyer flasks and allowed to stand in a bain-marie (water bath) at 100 ºC until the solutions were clear. Afterward, the digested samples were allowed to cool to room temperature before diluting with 25 ml deionized water. In the end, the levels of Ag, Cd, Cr, Cu, Fe, Ni, Pb, and Zn were assayed using an ICP-OES. The detection limits for Ag, Cd, Cr, Cu, Fe, Ni, Pb, and Zn were 0.0001, 0.00004, 0.00009, 0.0003, 0.0001, 0.0002, 0.002, and 0.0002 mg/l respectively. The results for all the trace elements gave a mean recovery from 97% to 100%.

To assess the risk, the daily exposure dose of cosmetic contaminants via dermal absorption pathway (carcinogenic and non-carcinogenic) was determined using the following formula:[9]

$$CDI_{dermal} = CS \times SA \times AF \times ABS \times EF \times ED \times CF/ BW \times AT$$

CDI: chronic daily intake; CS: exposure-point concentration: mg/kg (mg/l); EF: exposure frequency (350 days/year); ED: exposure duration (30 years); AT: averaging time for non-carcinogens (365 days/year ED); BW: body weight (70 kg for adult); SA: exposed skin area (0.53 m^2/day); AF: adherence factor (0.07 mg/cm^2); ABS: dermal absorption fraction 0.001(other metals); CF: unit conversion factor (10^{-6} kg/mg^1).[10] The non-carcinogenic risk from each of the trace elements can be expressed as the hazard quotient:

$$HQ = CDI/RFD$$

Where the non-cancer hazard quotient (HQ), the ratio of exposure to hazardous substances and RFD (10, 3, 3, 300, 20, 20, 3, and 360 µg/kg for Cd, Pb, Cr, Zn, Cu, Ni, Cr, and Fe, respectively), is the chronic reference dose of the toxicant (mg/kg/day). Statistical analyses were performed using SPSS statistical package (version 16; SPSS, Chicago, IL). The one-way analysis of variance (ANOVA) was used to verify significant differences in trace element concentrations among the three brands of cosmetics. The trace element concentrations in the cosmetic products were expressed as microgram per gram wet weight (w/w). Values are given in means ± standard deviation.

Results and Discution

The amounts of trace elements found in the three brands of cosmetic products are shown in Table 1. The findings of this research indicated that Fe and Ag were the trace elements with the highest and the lowest concentrations in the three brands, respectively. According to our findings in this research, most of the cosmetic products were found to contain high levels of trace elements, particularly, Cu, Cr, Fe, and Zn, with a wide variation among the samples (Table 1). The highest levels of trace elements in eyeshadows and skin whitening creams were detected in Chinese brand. The ANOVA showed that there was no significant difference in the concentration of metals among the three brands of cosmetic products (except for Cr and Fe). The non-carcinogenic HQ and daily oral intake of the trace elements present in each cosmetic product are shown in Tables 2 and 3. Among the metals, Fe and Zn presented relatively higher potential health risks followed by Cr and Ni. In addition, the non-carcinogenic risks of Fe and Zn in some cosmetic products such eyeshadows and eyeliners were higher than those evaluated in other cosmetic products. According to our findings, the HQ of the trace elements decreased in the following order: Zn > Cr > Cd > Fe > Cu > Ag > Ni > Pb.

Table 1. Concentration of trace elements (μg/g) in different brands of cosmetic products in Sanandaj City

Different brands	Trace elements						
	Ag	Cd	Cr	Cu	Fe	Ni	Pb
Eye shadows							
Mean	0.006	0.009	0.566	0.592	108.44	0.207	0.053
SD	0.001	0.01	0.04	0.13	0.01	0.152	0.01
Eyeliners							
Mean	0.011	0.023	0.138	0.295	92.04	0.160	0.342
SD	0.002	0.003	14.4	0.05	7.16	0.21	0.84
Skin whitening creams							
Mean	0.009	0.214	0.222	0.336	70.33	0.366	0.499
SD	0.002	0.06	0.03	0.07	0.59	0.11	0.02
p -value	0.57	0.48	0.001	0.45	0.01	0.45	0.35

Table 2. Chronic daily intake (CDI) for individual trace elements detected in cosmetic products in Sanandaj city, Iran

Different brands	Trace elements							
	Ag	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Eye shadows	1.6E-11	2.6E-10	1.5E-08	1.6E-08	2.9E-06	5.7E-09	1.4E-09	1.7E-07
Eyeliners	7.1E-10	6.4E-10	3.7E-09	8.1E-09	2.5E-06	4.3E-09	9.3E-09	4.8E-07
Skin whitening creams	2.4E-11	5.8E-09	6.1E-09	9.2E-09	1.9E-06	1.0E-08	1.3E-09	4.0E-08

Table 3. Non-carcinogenic risk (HQ) for individual trace elements detected in cosmetic products in Sanandaj City, Iran

	Trace elements							
	Ag	Cd	Cr	Cu	Fe	Ni	Pb	Zn
HQ	3.8E-08	1.4E-06	5.0E-06	1.8E-07	5.8E-07	2.5E-08	1.0E-08	8.4E-06

Cosmetics are considered as a source of trace elements in humans which can influence health. Daily consumption of these substances in the Middle East, especially in Iran, is on the rise. Unfortunately, there are no current international standards for impurities like trace metals in cosmetics except 20 μg/g for lead and 5 μg/g for cadmium.[11] The acceptable limits for certain metals in cosmetics are 10 μg/g for Pb and 3 μg/g for Cd as per the Canadian health guidelines.[12] According to our results, the concentrations of lead and cadmium were lower than the FDA limit,[13] and there was no significant difference in the lead and cadmium concentrations among the three brands of cosmetic products. In a similar study in Iran, Nourmoradi et al.[7] reported that the lead levels in the lipsticks and eyeshadows (range of 0.08–6.9 μg/g) was lower than that of FDA standards, and the cadmium levels in the samples (range of 1.54–60.20 μg/g) were relatively high. The results of the findings of Mousavi et al.[14] illustrated that 95.91% of Chinese lipstick bought from Tehran market in Iran contained higher than 20 µg/g of Pb. In a similar study in another country, Al-Saleh et al.[15] illustrated that the median Pb level in 72 lipsticks samples was 0.73 µg/g (0.49–1.793 µg/g) and was below the FDA lead limit. Moreover, Volpe et al.[16] found a lead concentration range of 9.53–81.50 µg/g in Chinese samples compared with a range of 0.25–7.64 µg/g in Italian and US samples. The concentrations of lead and cadmium according to their type, country of production, and the location of use can vary. Although the amount of lead and cadmium in the samples studied was below the international standard, but considering the bioaccumulation and toxicity of these metals, they require periodic monitoring.

According to our findings, among the three brands of cosmetic products, eye shadow contained the highest concentration of trace metals (except Ag and Cd). Sainio et al.[17] determined the levels of trace metals in various brands of eyeshadows and reported that the levels of lead and arsenic were less than 20 µg/g, but higher levels of cobalt and nickel were detected. Since various colors are used in manufacturing eyeshadows, eye cosmetics can be considered as one of the most important sources of trace elements. However, the US FDA has allowed the use of some natural colors or inorganic pigments such as iron oxide, carmine, mica, titanium dioxide, copper powder, bronze powder, aluminum powder, and manganese.[18] Moreover, there have been numerous researches on the presence of Pb and other trace elements in customary eye cosmetics,[19-22] and the results of these studies show that eyeshadow has the highest use, and this also raises the likelihood of skin uptake; however, previous studies reported insignificant skin absorption of metals.[23,24] Some of the allergic responses in humans are caused by trace metals, and the metals such as nickel, chromium, and cadmium in cosmetic products can cause dermatitis and allergies in humans.[25,26] Nickel allergy is considered to be the leading cause of allergic contact dermatitis, but small amounts of other toxic elements may sensitize the immune system and trigger an allergic reaction.[27] In this study, levels of nickel and chromium metals were less than 1 µg/g, in order to minimize the risk of allergic reactions or eczema of the eyelids. All the cosmetic products analyzed in this study had levels of nickel and chromium widely below this limit; so, we can consider them as harmless with regard to the health risks, and the risk of allergic contact dermatitis might increase over time.

During the last decade, cosmetic usage has had a growing trend in Iran, which can be a health risk for consumers. In this regard, it is important to calculate the daily exposure dose of metals via consumption of cosmetic products. Chronic daily intake (CDI) for individual metals detected in cosmetic products in this study was lower than that reported in other studies.[28,7] Moreover, the results of non-carcinogenic risk (HQ) for an individual metal detected in the cosmetic products in Sanandaj city was lower than one. Liu et al.[29] reported that HQ values higher than one shows that there is a chance that non-carcinogenic risk may occur, and when HQ is lower than one, the reverse applies. However, trace metals have the potential to accumulate in the body of consumers, and proper use of cosmetic products requires appropriate education.

Conclusion

According to the results of this study, the trace metals Fe and Ag showed the highest and the lowest concentrations in the three cosmetic brands, respectively. Also, the results indicated that eyeshadow has the highest concentration of trace metals. The levels of trace elements in the three brands of cosmetic products were lower than the international standards and other studies in different parts of Iran. Considering the bioaccumulation and toxicity of these metals in the human body, they require periodic monitoring.

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