Heliyon 7 (2021) e07067

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Alpha particle rates and heavy metal concentrations in cosmetics available in the Najaf markets

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ARTICLE INFO

Keywords:
Environmental pollution
Alpha particles
CR39 detectors
Atomic absorption spectrometry

ABSTRACT

This study focuses to measure the emission of alpha particle rates (EAPR) and heavy metal concentrations (Cd, Pb, Zn, Cr, and Co) (HMC) in some cosmetics (kohl eye, compact powder, and lipsticks) from Najaf markets using CR39 Detectors and Spectrophotometry, respectively. The EAPR range from 0.0068 to 0.0499 mBq cm^{-2}. The mean concentration of HMC in cosmetics ranged from 0.0007 to 0.0339 ppm (Cd), 0.0002–0.0986 ppm (Pb), 0.0350–9.7786 ppm (Zn), 0.0001–0.0058 ppm (Cr), 0.0011–0.1510 ppm (Co). The concentrations of Cr and Co were below the recommended limit for skin protection (1 ppm), whereas Cd and Pb were below the Canadian recommended limit. This study concludes that the HMC and EAPR in the cosmetics were within the recommended limits. The mean HMC contents were arranged in the order: Zn > Pb > Cd > Co > Cr for lipsticks; Zn > Co > Pb > Cd > Cr for powder; Zn > Co > Pb > Cd > Cr for Kohl. A statistically significant correlation (SSC) between HMC and EAPR in cosmetics was found at the 0.05 level. All the various cosmetics brands that contained HMC levels were lower than EPA limits (1 ppm and 0.3ppm, respectively), except the Zn. The cumulative exposure to HMC in cosmetics because of prolonged use is a possible source of HMC toxicity.

1. Introduction

Cosmetics are known as make-up beauty and maquillage [1]. They are also known as care products used to improve the appearance or smell of the human body and are made up of a mixture of natural or industrial chemicals [2]. The US Agency for Medicine and Food defined cosmetics as substances applied to the human body for cleansing, beautifying or enhancing the attractiveness of the body or changing its appearance without affecting the structure or functions of the body [3]. HM are two types essential and non-essential metals. It is beneficial to human health and living organisms. It can be toxic to organisms when their concentration exceeds the recommended limit. HMs can be toxic to body cells even at low concentrations [4]. Lead is considered a hazardous element that pollutes the environment [5] and cadmium used in various industries. The appearance of poisoning and disease depends on how much the person responds to this compound and how long it is absorbed and removed. When absorption is slow and continuous for a long time, the lead in the bones and tissues is deposited as insoluble lead triphosphate [6]. The recommended lead limit in cosmetics is 20 ppm, while the recommended limit to drinking water in accordance with Iraqi Standards No. 417 is about 0.02 ppm [7]. Some studies also report that there is no blood-lead ratio that is harmless to the body [8]. The nervous system and kidneys are the primary targets of lead toxicity, as toxicity increases in the nervous system [9]. Cadmium was, until the beginning of the 20th century, something new, but today it is used in many industries and its waste or residue is a major source of environmental pollution and causes lung problems [10]. Cadmium can induce miscarriage during the development of the fetus [11]. The recommended limit for cadmium in cosmetics has not been specified for all Iraqi specifications [12]. Chromium is a fragile white metal and uses about 45% of its global production in the alloy industry, 40% in structural processes with 15% for chemical. It causes inflammation of the skin in the hands, arms, face, and chest. These infections begin abruptly and the limit is not defined in the cosmetic specifications [12]. Few people know that cosmetics are absorbed through the skin [13] and whether the dose absorbed from the skin is sufficient to cause the risk. There are no reports to determine the levels of some heavy elements such as Ca, Cr, Zn, and Co in cosmetic products that cause vital effects [14]. Many cosmetic compounds are not listed under the Food and Drug Administration (FDA) where they have not been tested. Therefore, the recommended concentration is not specified. Many cosmetic companies do not write cosmetics compounds and details on the product. Heavy metals (Pb, Sb, Hg, Al, Zn, Cr, and Fe)

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https://doi.org/10.1016/j.heliyon.2021.e07067
Received 20 October 2020; Received in revised form 31 January 2021; Accepted 11 May 2021

Figure 1. Cosmetics collected from Najaf markers in Iraq.

are found in various care products including lipstick, whitening toothpaste, kohl, and nail color. Some HMs are intentionally added as ingredients, while others are contaminants. Alpha particles, called alpha radiation or alpha rays, consist of two neutrons and two protons bound together into a particle identical to a ^{4}He nucleus. The symbol for the alpha particle is α or α^{2+}. Because they are identical to helium nuclei, they are also written as He^{2+} or $^{4}He^{2+}$ indicating a helium ion with a +2 charge. Once the ion gains electrons from its environment, the alpha particle becomes a normal ^{4}He. The major types of ionizing radiation emitted are gamma rays and beta particles, alpha particles. Cosmetics play an important role in human external appearance. The products are used to alter or enhance the facial appearance or the body and skincare. The worldwide use of cosmetics in the present day world increases the human body exposure to the various chemical elements including radioactive substances. Radium contamination was found in products of London-based Radior company in 1917 when it began marketing the cosmetics, including a compact powder, rouge, hair tonic, night cream, skin soap, talcum powder, vanishing cream, and face powder. The radioactive substance causes health risks, so measuring their concentration is highly essential to ensure they are at permissible levels. This research determines alpha particles and HM in cosmetics available in Iraqi markets and a comparison of the results with the literature an appropriate conclusions and recommendations have been made. The importance of the study is to determine hazards from some cosmetics materials. The cosmetics are imported from different countries, where it is a new contribution in the scientific field.

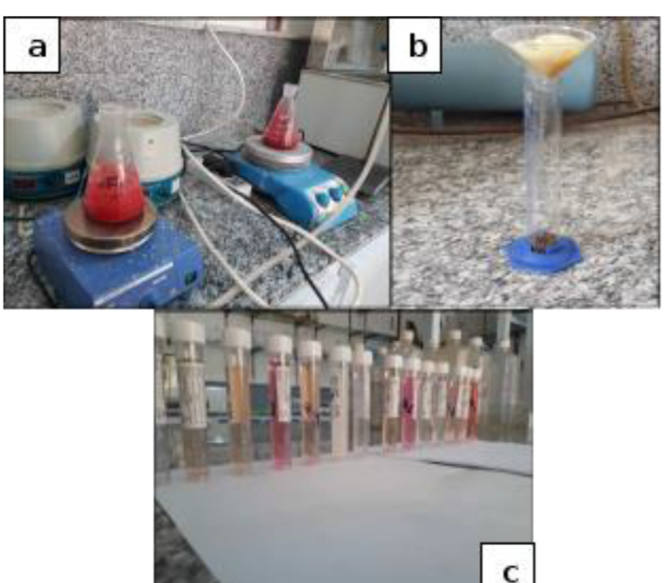

Figure 2. Preparing the samples: a. Heater b. Filtration c. Test tubes.

2. Materials and method

Twenty cosmetic samples (kohl eye, compact powder, and lipsticks) were collected from Najaf markets in Iraq, as shown in Figure 1.

2.1. Alpha particle analyses

The cosmetics were cut into small pieces and kept in the Petri dishes. The name and details of each sample were recorded. The samples were dried using oven (MEMMERT, Germany) at 90 °C for 1 h. After drying, the sample was grinded by a ceramic mortar. The sample was weighed using a sensitive scale with an error rate of about 0.0001 g. The homogeneous samples were contacted using the CR39 detector (Track Analysis Systems, UK, 25 mm × 25 mm × 1.5 mm) to detect alpha particles. The calibration of the CR39 detector has been done using RAD7 system [15]. Both were kept in a vacuum polyethylene bags and sealed to prevent the air. It was then placed inside the freezer at −20 ^{O}C for a period from 126 to 328 days. Then, the samples were removed from the detectors and are placed in NaOH solution with a 6.25 M for the etching of the CR39 to calculate the tracks of alpha particles obtained from samples. These tracks were counted using a microscope (A. KRUSS, Germany) along with

Table 1. Information and E_{α} about the cosmetics.

SC	Tracks $cm^{-2}d^{-1}$	E_{α} (mBq cm^{-2})
191	1.254	0.01254
168	0.880	0.00880
217	0.677	0.00677
265	0.823	0.00823
149	1.652	0.01652
212	0.730	0.00730
261	3.770	0.03770
256	4.331	0.04331
237	0.892	0.00892
146	1.408	0.01408
281	1.388	0.01388
202	1.307	0.01307
220	4.579	0.04579
203	2.150	0.02150
239	4.990	0.04990
165	3.539	0.03539
276	3.275	0.03275
263	2.650	0.02650
173	4.492	0.04492
177	4.410	0.04410
Average		**0.0246**

SC: Sample Code.
Tracks: Tracks of Alpha particles at CR39.
E_{α}: Alpha Emission Rate.

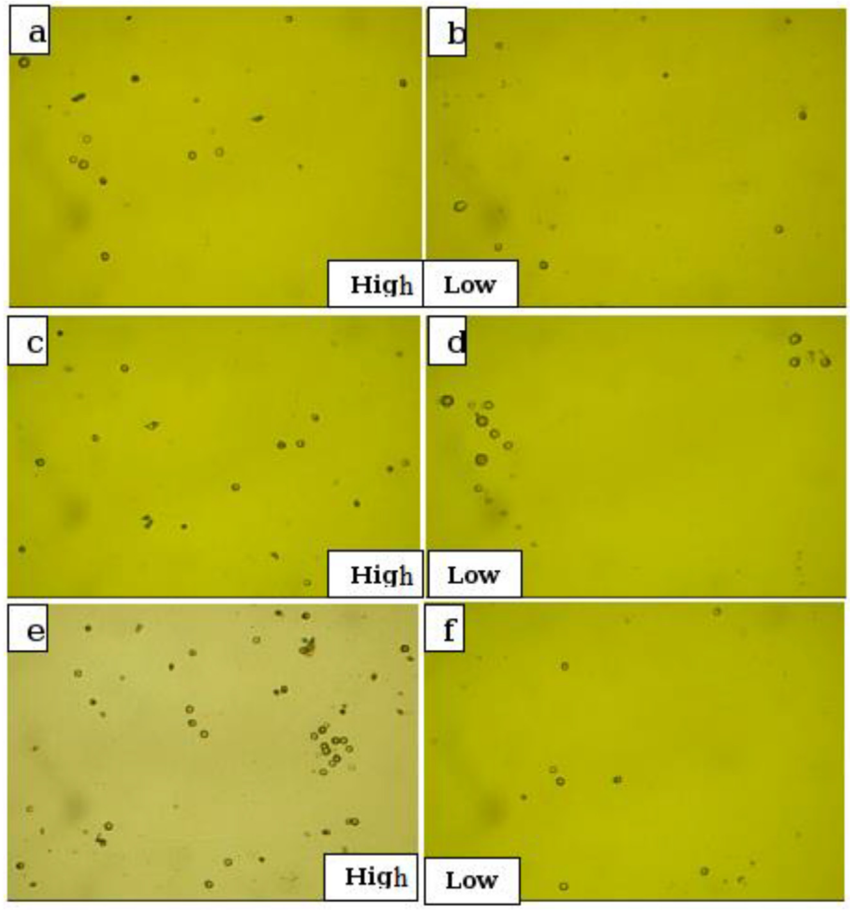

Figure 3. Tracks in the typical cosmetic samples, a, b. Kohl Eye c, d. Lipsticks, and e, f. Compact Powder.

the MDCE-5C camera at 10 × magnification. 100 ml (distilled water) was added to 2 mg and then heated using the hitter with a magnetic field (Velp Scientifica, Italy) of about half an hour, as shown in Figure 2a.

2.2. HMC analysis

The samples were filtered using a filter as shown in Figure 2b. Then, it was placed in a test tube for measuring heavy metals as shown in Figure 2c. Sample analysis was done using an atomic absorption spectrophotometer (Shimadzo 6300, Japan) to investigate the heavy metals [15]. The atomic absorption spectrophotometer was calibrated using standard elements of Cd, Pb, Zn, Cr, and Co. The linearity of the calibration curves was evaluated based on the correlation coefficient. Functions of this type can approximate the flame emission calibration curves for elements and check carefully to be sure that the curve is adequate for needs, since flame emission curves have a different shape.

2.3. Statistical analysis

The results were analysed using statistical ways. The SPSS program was used to calculate the average values, maximum and minimum values, standard deviation (SD). Pearson correlation and ANOVA test (One–way) were used to compare the average of HMs and alpha particles. $p < 0.05$ was considered a statistical significance.

3. Results

The ERAP (0.04990 mBq cm^{-2}) was found to be the highest in lipsticks 2 (MISS WENDY® Company), while the lowest rate (0.00677 mBq cm^{-2}) was found in Kohl Eye 3 (MILAI®Company) as shown in Table 1. Figure 3 shows the tracks of samples of the cosmetics. The alpha particle emission rates in this study are approximately compatible with values for Iraq and Malaysia [27, 28, 29, 30, 31]. The cosmetics in this present work are free of environmental pollution of APs and HMs.

The cosmetics in this study were free of radioactive contamination. The highest HMC for Cd was found to be (0.0339 ppm) in Kohl Eye 6 (MILAI company), while the lowest HMC (0.0007 ppm) was found in compact powder 1 (EVER bilENA Company) (Table 2). The HMC for Pb was found to be (0.0986 ppm) in Kohl Eye 5 (Rotana Company), whereas the lowest HMC (0.0002 ppm) was found in Compact powder 7, (Kokuryu supER Company). HMC for Zn was found to be (9.7786 ppm) in compact powder 3 (MAC Company), while the lowest HMC (0.0350 ppm) was found in compact powder 1 (EVER bilENA Company). The highest HMC for Cr was found to be (0.0058 ppm) in Kohl Eye 1 (Kohel Maka company), while the lowest HMC (0.0001 ppm) was found in compact powder 1 (EVER bilENA Company). The highest HMC for Co was found to be (0.1510 ppm) in Kohl Eye 1 (Kohel Maka company), while the lowest HMC (0.0011 ppm) was found in compact powder 7 (Kokuryu supER Company) as shown in Table 2. Cd, Pb, Zn, Cr, and Co vary according to the following order: Zn > Co > Pb > Cd > Cr. Mean levels of heavy metals were 0.0090 (Cd), 1.0647 (Zn), 0.0279 (Co), and 0.0148 (Pb), and 0.0017 (Cr). The mean HMs were arranged in the order: Zn > Pb > Cd > Co > Cr for lipsticks ($n = 7$); Zn > Co > Pb > Cd > Cr for powder ($n = 7$); Zn > Co > Pb > Cd > Cr for Kohl ($n = 6$).

The results show statistically significant differences (SSCDs) between HMC of Cd, Pb, Zn, Cr, and Co ($p > 0.05$). However, investigation of cadmium, lead, zinc, chromo, and cobalt in cosmetics varies from country to country.

Table 2. Heavy metals concentrati0n (ppm) in the cosmetics.

SC		Cd	Pb	Zn	Cr	Co
Kohl Eye						
191	K1	0.0169	0.0020	0.1179	0.0058	0.1510
168	K2	0.0242	0.0551	0.1020	0.0055	0.0503
217	K3	0.0169	0.0339	0.0850	0.0044	0.0824
265	K4	0.0097	0.0313	0.2438	0.0043	0.1190
149	K5	0.0145	0.0986	0.1224	0.0042	0.0641
212	K6	0.0339	0.0410	0.1009	0.0046	0.0412
Average		**0.0193**	**0.0437**	**0.1287**	**0.0048**	**0.0847**
Compact Powder						
261	C1	0.0007	0.0008	0.0350	0.0001	0.0027
256	C2	0.0012	0.0010	0.1180	0.0007	0.0022
237	C3	0.0049	0.0014	0.9778	0.0002	0.0046
146	C4	0.0036	0.0006	0.5158	0.0004	0.0038
281	C5	0.0025	0.0025	0.0481	0.0008	0.0046
202	C6	0.0009	0.0012	0.4179	0.0005	0.0032
220	C7	0.0010	0.0002	0.1421	0.0007	0.0011
Average		**0.0024**	**0.0012**	**2.2547**	**0.0006**	**0.0033**
Lipsticks						
203	L1	0.0246	0.0006	0.0525	0.0004	0.0076
239	L2	0.0099	0.0049	0.0612	0.0005	0.0035
165	L3	0.0050	0.0035	0.2208	0.0004	0.0046
276	L4	0.0039	0.0045	0.1574	0.0003	0.0017
263	L5	0.0031	0.0049	0.1617	0.0001	0.0033
173	L6	0.0017	0.0041	0.1814	0.0003	0.0030
177	L7	0.0018	0.0037	0.2273	0.0002	0.0036
Average		**0.0042**	**0.0043**	**0.1683**	**0.0003**	**0.0039**
Total Average		**0.0086**	**0.0492**	**0.8505**	**0.0019**	**0.0306**

Table 3. Comparison of HMCs (ppm) in cosmetics of this study compare with some previous studies.

Cosmetics (Ref.)	Country	Cd	Pb	Zn	Cr	Co
Kohl Eye [16]	Pakistan	0.422	692.9	254.55	0.026	0.561
Compact Powder [16]	Pakistan	0.314	3.135	….	0.131	0.968
Lipsticks [16]	Pakistan	0.280	8.371	2.405	0.258	0.565
Compact Powder [17]	Nigeria	0.96	0.170	…	0.012	…
Lipsticks [17]	Nigeria	0.89	0.106	…	0.016	…
Kohl Eye [18]	Nigeria	1.000	120.0	91.5	37.6	…
Lipsticks [18]	Nigeria	0.9	87.3	88.0	30.4	…
Cosmetics [19]	Saudi Arabia	5	20	…	…	…
Cosmetics [20]	Canada	3	10	…	…	…
Kohl Eye [21]	China, Italy, and USA	0.0006–0.003	0.25–81.50	…	0.015–0.287	0.00015–0.304
Lipsticks [22]	Saudi Arabia	4.9–10.6	6.4–9.9	…	9.3–40.8	…
Lipsticks [23]	Republic Srpska	0.00595–0.139	6.4–9.9	…	9.3–40.8	…
Lipsticks [24]	USA	<0.002–2.16	<0.025–1.25	…	<0.005–9.72	<0.005–1.30
Compact Powder [25]	India	0.01–0.02	3.8–4.63	…	…	…
Kohl Eye [26]	Nigeria	0.7–5.2	3.3–33.8	107–456.2	10.5–45.1	1.4–43.6
Compact Powder [26]	Nigeria	2.1–5.0	5.9–3399.9	8.0–3300	4.6–232.5	5.2–15.2
Lipsticks [26]	Nigeria	3.0–37.3	11.6–18.0	9.2–33.0	17.1–115.8	4.5–19.9
Present Study	Iraq					
Kohl Eye		0.0193	0.0437	0.1287	0.0048	0.0847
Compact Powder		0.0024	0.0012	2.2547	0.0006	0.0033
Lipsticks		0.0042	0.0043	0.1683	0.0003	0.0036

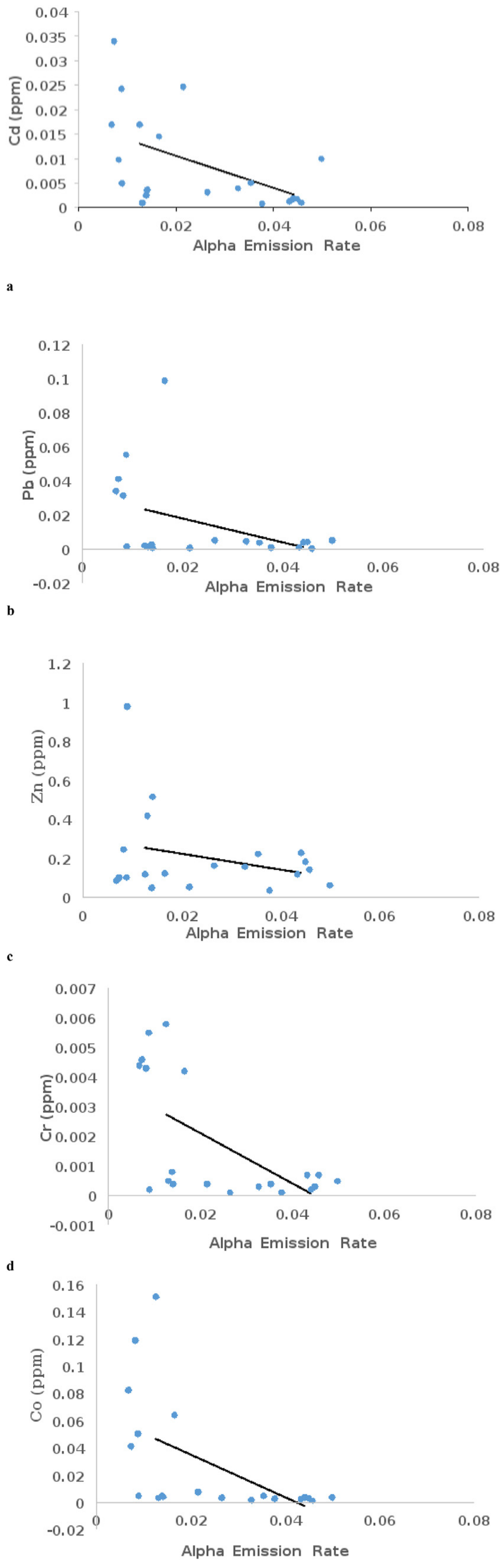

Figure 4. (a–e) Correlation between alpha emission rate and levels of: a: Cd, b: Pb, c: Zn, d: Cr and e: Co in the cosmetics.

However, cosmetics E_α is negatively correlated with Fe, Cd, and Pb (Figure 4 (a-e)). A SSC between EAPR and HMC in examining cosmetics at $p > 0.05$.

Comparison of HMCs in cosmetics and that of some previous studies is shown in Table 3. Heavy metal concentrations were found to be within the literature reviews. These data suggested that the HMs present in cosmetics do not pose a serious risk to health.

4. Discussion

Cd, Pb, Zn, Cr, and Co that were measured in some cosmetics (kohl eye, compact powder, and lipsticks) were collected from Iraqi markets. The lowest and highest cadmium were found in compact powder 1 (EVER bilENA) and kohl Eye 6 (MILAI), respectively. Whereas, the lowest and highest lead were found in compact powder 7 (Kokuryu supER) and Kohl Eye 5 (Rotana), respectively. The lowest and highest zinc were found in compact powder 1 (EVER bilENA) and compact powder 3 (MAC). The lowest and highest chrome were found in compact powder 1, (EVER bilENA) and Kohl Eye 1 (Kohel Maka), respectively. The lowest and highest cobalt were found in compact powder 7 (Kokuryu supER) and Kohl Eye 1 (Kohel Maka), respectively. Cd, Pb, Zn, Cr, and Co have the following order: Zn > Co > Pb > Cd > Cr. The lowest and highest alpha particle emission rates were found in Kohl Eye 3, (MILAI) and lipsticks 2, respectively. APs do not cause cancer, which has no evident increase in these measurements in comparison by global research. So the cosmetics is free of radioactive contamination. Overall investigation of the Cd, Pb, Zn, Cr, and Co in cosmetics from various countries revealed a range between 0.0006 ppm to 37.3 ppm, 0.025 ppm–692.9 ppm, 2.405 ppm–254.55 ppm, 0.005 ppm–232.5 ppm, 0.00015 ppm–43.6 ppm, respectively. The FAO and WHO organizations provided a guideline on the intake of the heavy elements of the human body. The HMCs in cosmetics varied depending on the country of origin. Many worldwide national and international organizations set tolerable dietary intakes limit for HMs depending on body weight and age of the cosmetics. However, cosmetics EAPR is negatively correlated with HMC. It was found that there is a SSC between EAPR and HMC in examining cosmetics.

5. Conclusions

Cd, Pb, Zn, Cr, and Co have the following order: Zn > Co > Pb > Cd > Cr. Mean heavy metals are 0.0090 (Cd), 0.1683 (Zn), 0.0279 (Co), and 0.0148 (Pb), and 0.0017 (Cr). The mean HM contents were varied according to the following order: Zn > Pb > Cd > Co > Cr for lipsticks; Zn > Co > Pb > Cd > Cr for powder; Zn > Co > Pb > Cd > Cr for Kohl. The present work showed that ERAP are a regular rate of radioactivity present in cosmetics. Therefore, the data shows that α activities of cosmetics are low and do not have any dangerous effects on human beings. This means that the cosmetics in this work were free of environmental pollution of the APs. According to the correlations between HMs and APs, it can be concluded that this work stands as a real marker of environmental pollution in cosmetics. Furthermore, there is a need for appropriate regulatory agencies to monitor the levels of these metals in the products and ensure compliance with acceptable safe limits.

Declarations

Author contribution statement

Basim Almayahi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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