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Study of heavy metals concentration in cosmetics purchased from Jordan markets by ICP-MS and ICP-OES

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Abstract. Twenty six different cosmetic products collected from Jordanian market have been studied. The concentrations of different toxic elements were determined by two techniques. These are Inductively Coupled Plasma Mass (ICP-MS) and Optical Emission Spectrometry (ICP-OES). The trace elements (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, Sr, Ti, Tl, U, Zn, Zr, Nb, Rb, Sb, Al, Bi, Ca, Fe, K, Mg, Na, P, Si, Th, V, and Se) have been studied using these two techniques. Two brands of eye shadow with different colors have lead content higher than 10 part per million (ppm). One brand of the eye shadow has remarkable nickel concentration 28.556±2.881 to 33.663±3.650 ppm, while the highest concentration was found in one brand of mascara with 56.23±11.57 ppm. Seven samples of eye shadow had the concentration of cadmium ranging between 1.35±0.21 and 7.99±0.84 ppm. Chromium may have been used as a pigment in the cosmetic products with high concentration detected in eye shadow #5 dim gray (82.17±8.41 ppm). Copper concentration were generally low except in two brands of eye shadow with 796.08±83.55 ppm (steel blue), and 424.901±42.883 ppm (dark blue).
Key Words: toxic elements, spectroscopy, side effect of heavy metals, allergic contact, manufacture of colors.

Introduction. For many people all over the world, the use of the beauty products is part of their everyday life. There is a growing concern about the physiological and behavior effects of trace metals in human issue as they are toxic even at low concentrations (Al-Qutob et al 2013).

Acceptable limits for heavy metals vary according to the subpopulation of the interest (Adepoju-Bello et al 2012). Cosmetics commonly used by women and children have been reported to contain toxic metals (Omolaoye et al 2010).

In the manufacture of colors, toxic elements are retained in pigments. Eye shadow is a typical example of a group of cosmetic product in which the significance of pigments is great. Some toxic elements and their compounds are water soluble and moist skin can therefore promote the percutaneous absorption of elements occurring as impurities in pigments. Some elements and their compounds may cause skin allergy or even cancer (Sainio et al 2000).

Many studies have been made to determine the amount of heavy metals in cosmetics. Misra & Mittal (2004) have been measured the concentrations of various elements in lipstick of popular Indian and foreign brands using γ-ray spectrometer. Their study showed that the concentration of Br in samples of lipsticks identified lipsticks of different Indian brands. The lipsticks samples of their study were compared on the basis of concentrations of Cs, and Sc which were found to be higher in the foreign brands than of those in Indian brands.

Umar & Caleb (2013) investigated heavy metal content in 28 body creams and lotions in Nigerian markets using atomic absorption spectrometry techniques. The heavy metals which they analyzed were Pb, Cd, Ni, and Cr. The concentration of heavy metals in the samples which they analyzed was in the order Cd > Ni > Pb > Cr.

Orisakwe et al (2013) have studied the concentration of metals in cosmetics commonly used in Nigeria. They have found that the concentration of Pb in 28 creams and lotions ranged from 6.1 to 45.9 mg kg^{-1} and from 1.2 to 9.2 mg kg^{-1}, and about 61% of the body cosmetics, the lotions, and the creams contained detectable levels of Ni ranging from 1.1 to 6.4-9.2 mg kg^{-1}. Cr and Hg were detected in 100% of their cosmetic product.

Alqadami et al (2013) have been determined heavy metals in some skin whitening cosmetics creams in local market of Saudi Arabia by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). In their study the detection limits for As, Bi, Cd, Pb, Hg, and Ti were 2.4, 4.08, 0.3, 2.1, 1.8, and 1.8 ng mL^{-1} respectively.

Gondal et al (2010) determined the concentration of different toxic elements, like Pb, Cr, Cd, and Zn in four different lipstick brands sold at local markets in Saudi Arabia using Laser Induced Breakdown Spectroscopy (LIBS). They found that the concentration of some of the toxic metals like Pb, Cr, and Cd were much higher than the safe permissible limits.

Liu et al (2013) have been measured Pb and eight other metals in convenience sample of 32 products used by young Asian women in Oakland, California and assessed potential health risks related to estimated intakes of these metals using ICP-OES. In their study the tested lip products contained high concentrations of Ti and Al.

Sneyers et al (2009) have determined the trace elements in cosmetics in European market by using K_0 – instrumental neutron activation analysis (K_0 - INAA) technique.

The rare information about the trace of heavy elements in cosmetics products at the Jordan Standers Metrology Organization creates the current study. The aim of this study is to analyze the heavy metals in cosmetics products sold in Jordan. The objectives are therefore to study the concentration of different trace and heavy metals using ICP-MS and ICP-OES.

Material and Method. In this study, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-OES) were used to determine the concentration of heavy metals in different brands of cosmetics in the period between Februarys to April 2014 sold in the Jordanian markets (Jordan). Twenty three trace elements (Ag, As, Ba, Be, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, Sr, Ti, Tl, U, Zn, Zr, Nb, Rb, Sb, and Se) were studied by using ICP-MS. Twenty two elements (Al, Ba, Bi, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, Si, Sr, Th, Ti, U, and V) were studied using ICP-OES. The samples were prepared in the analytical chemistry section in Jordan Atomic Energy Commission (JAEC), and prepared according to Standard Operation Procedure (SOP3) for sample preparation as follows:

- 0.25±0.0001 g was taken from each sample;
- 2 mL concentration of hydrofluoric acid (HF), 8 mL concentration of HNO_3 and 2 mL H_2O_2 (30%) were added to the samples;
- the samples were digested using Milestone ETHOS1, microwave digestion system;
- the samples were then transferred volumetrically to 50 mL centrifuge test tube at room temperature;
- next the samples were treated with 4% boric acid to eliminate the excess of HF;
- the samples then diluted to 50 mL as a last step in the primary chemical preparation;
- the samples were diluted additionally 100 times for ICP-MS and 2 times for ICP-OES measurements.

Results and Discussion. Heavy metals were measured in five brands of eye shadow taking into account the color effect on each brand, three brands of lipstick, eyeliner, mascara, and kohl, and two brands of lip-gloss, hair color, and henna, four brands of foundation, and fairness. Results from ICPM-MS are shown in Table 1, while the results from ICPM-OES are shown in Tables 2 and 3. Ag, As, Ba, Cd, Co, Cr, Mn, Mo, Ni, Pb, Sn, Sr, Ti, Tl, U, Zn, Zr, and Se were detected. Cd was detected in all samples of eye shadow with low concentration value < 0.1 ppm except seven samples were the concentration

ranging between 1.35±0.21 and 7.99 ± 0.84 ppm. All forms of Cd are toxic (Mudgal et al 2010) and classified as a human carcinogen by National Institute for Occupational Safety and Health (NIOSH) (Eltegani et al 2013). This will knock the alarm for the users to use these products. The color effect was shown in the different concentration such that Ag, Cr, and Cu in some samples as shown in the Tables 1 and 2. Cr may had been used as a pigment in the products with high concentration such as eye shadow #2 saddle brown (37.9±3.841 ppm), eye shadow #5 dim gray (82.17±8.41 ppm). In addition Cr can be absorbed by the skin and high levels can cause unfavorable effects to the skin.

Pb was detected in all eye shadow samples with concentration between 1.35±0.21 and 153.89±17.03 ppm, the high concentration value can affect every organ and system in the body, so the users will take attention when they use the products (Martin et al 2009).

Remarkable concentration of Ni was detected in the eye shadow; 2.359±0.672 to 31.909±3.34 ppm is considered a cautionary warning of the allergic eye infection, and it is also an important cause of hand eczema (Orisakwe et al 2013). The safe permissible limits for Pb, Cd, Cr for water and other food are 15, 5, and 100 parts per billion (Gondal et al 2010) while the concentration in this study for these elements is higher than these permissible limits as shown in the Tables 1, 2, and 3 which are matter that the user will be concern especially when daily use. Bi was found in all our samples that have been detected by using ICPM-OES and its concentration varied from <10.5 to 97.36 ±9.84 ppm.

Co, Zn, and Mg were detected in all cosmetic samples in different brands with varying concentrations. Co concentration should preferably less than 170 ppm (Omolaoye et al 2010), in our samples the concentration was found between < 0.063 to 96.28±9.73 ppm which is within the allowable values. Zn with high level of concentration was found in one brand of eye shadow #2-Indigo (467.510±47.496 ppm), and in one brand of henna #2 (23,573.98±2,901.42 ppm). Remarkable Mn concentrations were found in three brands of eye shadow between 1000 and 4000 ppm, and two brands of mascara with concentration 1,583.29±313.93 and 1,503.85±209.13 ppm. Ba was detected in all samples, the highest concentrations were found in Lip stick #2 (10,200.63±1,216.28 ppm). Cu concentration were generally low except in two brands of eye shadow with 796.08±83.55 ppm (steel blue), and 424.901±42.883 ppm (dark blue), the concentration were found in khol #3 7580.82±1149.55 ppm. This shows that it has been used as a pigment in these types of cosmetics.

Table 1

Mean (±SD) heavy metal concentration in cosmetic samples using ICPM-MS (SD: standard deviation)

Cosmetic (type-color)	*Ag (ppm)*	*As (ppm)*	*Ba (ppm)*	*Cr (ppm)*	*Cu (ppm)*
Eye Shadow-1-BLACK	<2.309	<0.316	646.711±65.131	<0.113	18.899±1.976
Eye Shadow-1-BROWN	<1.663	<0.228	466.112±46.911	7.349±0.946	46.713±4.728
Eye Shadow-1-GREEN	<2.015	<0.276	488.905±49.468	<0.099	193.310±19.540
Eye-Shadow-2-IndianRed	<1.781	<0.244	539.625±54.395	<0.087	14.758±1.659
Eye-Shadow-2-slateGray	<1.940	<0.266	420.427±42.312	<0.095	80.684±8.160
Eye-Shadow-2-DarkBlue	<2.039	<0.279	521.251±52.588	<0.100	424.901±42.883
Eye-Shadow-2-DeepPink	<2.316	<0.317	484.023±49.235	<0.113	41.831±4.426
Eye-Shadow-2-HotPink	<2.028	<0.278	400.066±40.377	<0.099	23.570±2.453
Eye-Shadow-2-MediumVioletRed	2.217±0.842	<0.265	354.841±35.918	<0.095	39.081±3.973
Eye-Shadow-2-DarkGreen	<2.006	<0.275	472.796±47.721	<0.098	350.087±35.236
Eye-Shadow-2-Indigo	<1.757	<0.241	673.025±67.958	<0.086	98.854±9.983
Eye-Shadow-2-SaddleBrown	<1.666	<0.228	512.877±51.814	37.900±3.841	29.472±2.987
Eye-Shadow-2-DarkViolet	<1.942	<0.266	542.260±54.797	<0.095	27.473±2.781
Eye-Shadow-2-Tan	<2.004	<0.275	410.430±41.490	<0.098	10.110±1.042
Eye Shadow-3-RoyalBlue	<1.856	<0.254	567.085±57.103	<0.091	114.061±11.880
Eye Shadow-3-HotPink	<1.983	<0.272	1,183.146±119.257	<0.097	<0.097
Eye Shadow-3-Sienna	<1.704	<0.233	403.644±40.782	<0.083	<0.083
Eye Shadow-3-Chocolate	<1.797	<0.246	582.472±59.347	<0.088	<0.088
Eye Shadow-3-Olivedrab	<1.868	<0.256	419.352±42.547	<0.091	32.247±3.316
	Mn (ppm)	*Nb (ppm)*	*Ni (ppm)*	*Pb (ppm)*	*Se (ppm)*
Eye Shadow-1-BLACK	132.528±13.451	68.919±6.961	<0.169	11.907±1.221	4.3559±0.440
Eye Shadow-1-BROWN	207.666±21.016	60.5314±6.114	17.327±1.871	9.834±0.992	UDL*
Eye Shadow-1-GREEN	87.743±8.864	59.8322±6.043	<0.148	12.874±1.312	UDL
Eye-Shadow-2-IndianRed	413.504±41.654	68.4283±6.911	2.359±0.672	7.592±0.765	UDL
Eye-Shadow-2-slateGray	740.937±74.598	70.7906±7.150	<0.142	7.921±0.830	1.6827±0.170
Eye-Shadow-2-DarkBlue	1,433.563±144.319	53.6466±5.418	<0.150	5.880±0.594	UDL
Eye-Shadow-2-DeepPink	60.759±7.184	55.2044±5.418	<0.170	5.935±0.602	UDL
Eye-Shadow-2-HotPink	98.743±9.949	87.3966±8.827	<0.149	9.950±1.007	UDL
Eye-Shadow-2-MediumVioletRed	2,301.022±231.729	48.3996±4.888	<0.142	6.343±0.646	UDL
Eye-Shadow-2-DarkGreen	59.731±8.056	62.5353±6.316	<0.147	6.232±0.649	UDL
Eye-Shadow-2-Indigo	3,919.762±394.423	53.7518±5.429	<0.129	6.072±0.628	UDL
Eye-Shadow-2-SaddleBrown	1,002.432±101.171	60.6172±6.122	6.702±1.444	7.957±0.802	UDL
Eye-Shadow-2-DarkViolet	104.300±10.497	75.7562±7.651	<0.143	9.084±0.924	UDL
Eye-Shadow-2-Tan	83.721±8.431	63.773±6.441	<0.147	6.659±0.673	1.4428±0.146
Eye Shadow-3-RoyalBlue	95.197±9.599	67.4188±6.809	28.556±2.881	9.889±1.001	UDL
Eye Shadow-3-HotPink	88.656±8.962	56.2306±5.680	33.663±3.650	6.876±0.696	UDL

Eye Shadow-3-Sienna	85.573±8.814	48.191±4.867	21.980±2.283	4.319±0.455	UDL
Eye Shadow-3-Chocolate	85.225±8.664	75.7513±7.650	31.810±3.465	7.120±0.799	0.0074±0.001
Eye Shadow-3-Olivedrab	75.335±7.597	52.6336±5.316	31.909±3.340	5.994±0.631	UDL
	Zn (ppm)	*Co (ppm)*	*Cd (ppm)*	*Mo (ppm)*	*Rb (ppm)*
Eye Shadow-1-BLACK	311.214±31.407	<0.087	<0.121	6.372±0.724	216.154±21.832
Eye Shadow-1-BROWN	296.620±30.227	<0.062	<0.087	1.209±0.184	214.4789±21.662
Eye Shadow-1-GREEN	408.015±41.382	<0.076	<0.105	0.894±0.202	149.3197±15.081
Eye-Shadow-2-IndianRed	247.038±24.894	<0.067	<0.093	4.931±0.521	258.9092±26.150
Eye-Shadow-2-slateGray	325.967±33.589	<0.073	<0.101	0.422±0.062	159.5241±16.112
Eye-Shadow-2-DarkBlue	333.288±33.572	<0.077	<0.106	0.865±0.120	133.7925±13.513
Eye-Shadow-2-DeepPink	385.137±39.154	<0.087	<0.121	0.303±0.038	129.0693±13.036
Eye-Shadow-2-HotPink	277.391±28.442	<0.076	<0.106	0.424±0.046	149.7323±15.123
Eye-Shadow-2-MediumVioletRed	306.257±30.975	<0.073	<0.101	<0.208	126.0054±12.727
Eye-Shadow-2-DarkGreen	426.343±43.042	<0.075	<0.105	1.087±0.173	121.4856±12.270
Eye-Shadow-2-Indigo	467.510±47.496	<0.066	<0.092	50.362±5.188	68.8916±6.960
Eye-Shadow-2-SaddleBrown	297.422±29.972	<0.063	<0.087	4.137±0.510	134.6257±13.597
Eye-Shadow-2-DarkViolet	409.841±41.902	<0.073	<0.101	0.256±0.028	176.5691±17.833
Eye-Shadow-2-Tan	284.677±28.801	<0.075	<0.105	0.251±0.046	170.5032±17.220
Eye Shadow-3-RoyalBlue	238.239±24.328	<0.070	<0.097	0.298±0.084	238.3062±24.069
Eye Shadow-3-HotPink	165.644±16.808	<0.074	<0.104	<0.214	203.0518±20.508
Eye Shadow-3-Sienna	137.169±13.969	<0.064	<0.089	<0.183	152.1837±15.371
Eye Shadow-3-Chocolate	215.803±23.735	<0.067	<0.094	2.048±0.251	280.812±28.362
Eye Shadow-3-Olivedrab	145.661±14.882	<0.070	<0.098	0.511±0.052	225.0405±22.729
	Sb (ppm)	*Zr (ppm)*	*Be (ppm)*	*Sn (ppm)*	*Sr (ppm)*
Eye Shadow-1-BLACK	12.7413±1.287	26.460±2.674	<0.267	608.343±61.374	26.244±2.714
Eye Shadow-1-BROWN	8.4187±0.850	16.835±1.740	<0.193	1,176.545±118.546	19.481±1.966
Eye Shadow-1-GREEN	10.9384±1.105	21.036±2.137	<0.233	2,766.590±278.862	16.245±1.643
Eye-Shadow-2-IndianRed	11.4447±1.156	17.943±2.179	<0.206	243.179±24.476	12.860±1.310
Eye-Shadow-2-slateGray	10.4892±1.059	52.520±5.342	<0.225	533.623±53.705	9.271±0.948
Eye-Shadow-2-DarkBlue	11.1917±1.130	19.800±2.051	<0.236	3,851.731±387.651	12.716±1.284
Eye-Shadow-2-DeepPink	11.9292±1.205	13.331±1.346	<0.268	3,427.484±346.584	11.409±1.170
Eye-Shadow-2-HotPink	10.928±1.104	12.889±1.338	<0.235	190.389±19.796	8.343±0.903
Eye-Shadow-2-MediumVioletRed	9.8217±0.992	10.910±1.129	<0.224	4,275.252±430.382	110.628±11.132
Eye-Shadow-2-DarkGreen	10.5654±1.067	13.934±1.487	<0.232	3,665.543±369.050	11.252±1.216
Eye-Shadow-2-Indigo	9.6576±0.975	29.290±2.988	<0.203	6,114.457±615.405	12.106±1.220
Eye-Shadow-2-SaddleBrown	8.473±0.856	30.557±3.108	<0.193	513.232±53.251	12.568±1.271
Eye-Shadow-2-DarkViolet	10.0801±1.018	11.100±1.121	<0.225	1,549.857±155.977	9.743±1.013
Eye-Shadow-2-Tan	9.9568±1.006	10.247±1.037	<0.232	174.538±17.899	7.652±0.772
Eye Shadow-3-RoyalBlue	9.1228±0.921	19.134±1.999	<0.215	409.593±41.332	17.528±1.789
Eye Shadow-3-HotPink	9.2913±0.938	17.414±1.764	<0.230	243.631±24.842	24.656±2.494
Eye Shadow-3-Sienna	7.8773±0.796	5.675±0.594	<0.197	339.093±34.175	5.168±0.522

Eye Shadow-3-Chocolate	10.6124±1.072	24.823±2.753	<0.208	536.184±54.183	18.217±1.842
Eye Shadow-3-Olivedrab	9.2799±0.937	10.060±1.027	<0.216	443.212±45.015	10.014±1.020
	Ti (ppm)		*Tl (ppm)*		*U (ppm)*
Eye Shadow #1-BLACK	40,468.690±4,076.926		6.014±0.606		<0.075
Eye Shadow #1-BROWN	43,490.470±4,385.853		4.484±0.452		<0.054
Eye Shadow #1-GREEN	108017±10923		5.113±0.518		<0.066
Eye-Shadow #2-IndianRed	31,740.610±3,200.305		7.464±0.922		0.125±0.268
Eye-Shadow #2-slateGray	48,622.040±4,892.674		5.026±0.510		<0.063
Eye-Shadow #2-DarkBlue	54,742.500±5,509.263		4.869±0.500		<0.067
Eye-Shadow #2-DeepPink	75,725.210±7,630.699		5.492±0.553		<0.076
Eye-Shadow #2-HotPink	42,068.160±4,235.321		5.584±0.573		<0.066
Eye-Shadow #2-MediumVioletRed	62,419.190±6,284.635		4.553±0.459		<0.063
Eye-Shadow #2-DarkGreen	65,618.730±6,603.620		4.828±0.486		<0.065
Eye-Shadow #2-Indigo	108017±10923		4.133±0.418		<0.057
Eye-Shadow #2-SaddleBrown	23,056.290±2,326.612		4.237±0.429		<0.054
Eye-Shadow #2-DarkViolet	53,877.930±5,421.838		5.020±0.508		<0.063
Eye-Shadow #2-Tan	36,087.720±3,631.990		5.367±0.540		<0.065
Eye Shadow #3-RoyalBlue	20,293.490±2,042.366		5.071±0.514		<0.061
Eye Shadow #3-HotPink	10,586.110±1,066.860		5.029±0.507		<0.065
Eye Shadow #3-Sienna	9,625.895±968.940		4.293±0.437		<0.056
Eye Shadow #3-Chocolate	16,795.220±1,692.336		7.956±1.161		0.642±0.739
Eye Shadow #3-Olivedrab	15,102.160±1,521.019		5.187±0.527		<0.061

Table 2

Mean (±SD) heavy metal concentration in cosmetic samples using ICPM-OES

Cosmetic type	*Al (%)*	*Ba (ppm)*	*Bi (ppm)*	*Ca (%)*	*Cd (ppm)*
Lip stick # 1	0.517±0.025	1,765.87±314.73	<10.55	0.064±0.004	<0.13
Lip stick # 2	0.056±0.019	10,200.63±1,216.28	<10.55	0.052±0.022	<0.13
Lip stick # 3	0.570±0.031	1,806.97±257.85	<10.55	<0.000	<0.13
Lip gloos # 1	0.029±0.014	176.33±20.26	<10.55	<0.000	<0.13
Lip gloos # 2	0.014±0.024	<0.13	<10.55	<0.000	<0.13
Eye liner # 1	0.218±0.046	2,820.65±577.08	<10.55	0.387±0.067	<0.13
Eye liner # 2	0.024±0.002	212.23±36.30	<10.55	0.013±0.001	<0.13
Eye liner # 3	0.013±0.003	338.75±35.18	<10.55	0.042±0.006	<0.13
Mascara # 1	0.114±0.014	708.01±75.23	<10.55	<0.000	<0.13
Mascara # 2	0.017±0.009	131.17±14.24	<10.55	<0.000	<0.13
Mascara # 3	<0.010	119.26±13.45	<10.55	<0.000	<0.13
Kohl #1	0.036±0.011	770.30±93.88	<10.55	0.021±0.005	<0.13
Kohl #2	0.010±0.014	60.90±12.89	<10.55	<0.000	<0.13
Kohl #3	2.225±0.093	446.52±63.74	<10.55	1.103±0.035	<0.13
Fairnees # 1	<0.010	1.37±0.28	<10.55	0.008±0.001	<0.13
Fairnees # 2	0.021±0.007	1.08±0.20	<10.55	<0.000	<0.13
Fairnees # 3	<0.010	1.05±0.19	<10.55	0.010±0.000	<0.13
Fairnees # 4	0.054±0.001	5.49±0.56	<10.55	0.095±0.003	<0.13
Hair colour # 1	0.012±0.004	1.64±0.17	<10.55	0.012±0.001	<0.13
Hair colour # 2	<0.010	1.19±0.48	<10.55	0.019±0.003	<0.13
	Co (ppm)	*Cr (ppm)*	*Cu (ppm)*	*Fe (%)*	*Pb (ppm)*
Lip stick # 1	6.35±1.49	<0.16	21.55±2.59	0.691±0.049	<1.82
Lip stick # 2	17.83±3.05	<0.16	164.80±29.36	0.167±0.018	<1.82
Lip stick # 3	26.48±4.66	<0.16	201.73±21.22	2.773±0.092	<1.82
Lip gloos # 1	8.19±0.93	<0.16	75.05±7.56	0.003±0.000	<1.82
Lip gloos # 2	21.37±3.11	<0.16	254.47±27.42	0.000±0.001	<1.82
Eye liner # 1	28.16±8.47	<0.16	178.17±37.05	0.016±0.001	<1.82
Eye liner # 2	3.89±0.54	2.93±0.74	66.18±11.47	0.002±0.000	<1.82
Eye liner # 3	10.26±2.25	<0.16	34.07±3.78	<0.000	<1.82
Mascara # 1	36.69±17.34	5.28±11.09	258.76±30.82	5.541±0.168	<1.82
Mascara # 2	14.75±5.44	<0.16	133.80±13.84	0.017±0.002	<1.82
Mascara # 3	28.28±10.55	<0.16	325.21±41.24	2.696±0.231	<1.82
Kohl #1	7.27±1.73	<0.16	78.21±10.75	0.007±0.002	<1.82
Kohl #2	9.88±3.20	<0.16	76.30±11.71	0.006±0.004	<1.82
Kohl #3	10.19±9.07	<0.16	7,580.82±1,149.55	0.165±0.008	<1.82
Fairnees # 1	3.47±0.54	<0.16	7.10±0.75	0.000±0.000	<1.82
Fairnees # 2	2.38±1.51	2.22±0.67	4.21±1.10	<0.000	<1.82
Fairnees # 3	3.10±0.35	<0.16	2.21±0.96	<0.000	<1.82
Fairnees # 4	4.61±1.14	<0.16	8.49±0.97	0.041±0.003	<1.82

Hair colour # 1	4.25±0.51	<0.16	8.25±1.05	0.015±0.001	<1.82
Hair colour # 2	4.50±0.95	1.34±0.26	10.84±1.99	0.002±0.000	<1.82
	Si (%)	*P (%)*	*K (%)*	*Mg (%)*	*Mn (ppm)*
Lip stick # 1	0.287±0.011	0.069±0.005	0.290±0.050	0.036±0.001	683.53±70.36
Lip stick # 2	<0.000	0.039±0.004	<0.002	<0.001	16.98±1.79
Lip stick # 3	<0.000	0.045±0.010	0.146±0.005	0.191±0.013	97.23±10.39
Lip gloos # 1	<0.000	0.022±0.005	0.033±0.007	0.149±0.006	6.67±0.68
Lip gloos # 2	<0.000	0.031±0.025	<0.002	<0.001	17.54±1.93
Eye liner # 1	1.287±0.187	0.022±0.005	0.108±0.021	0.025±0.004	24.90±4.45
Eye liner # 2	0.261±0.011	0.024±0.001	0.055±0.003	0.013±0.001	3.46±0.35
Eye liner # 3	0.167±0.014	0.047±0.003	0.031±0.003	0.013±0.000	7.56±0.79
Mascara # 1	<0.000	0.039±0.009	<0.002	<0.001	1,583.29±313.93
Mascara # 2	<0.000	0.025±0.006	<0.002	0.023±0.002	10.97±1.16
Mascara # 3	<0.000	0.046±0.009	<0.002	<0.001	1,503.85±209.13
Kohl #1	0.170±0.030	0.033±0.005	<0.002	0.008±0.003	8.35±1.01
Kohl #2	<0.000	0.025±0.006	<0.002	0.017±0.002	6.76±0.90
Kohl #3	0.824±0.069	0.037±0.006	1.161±0.036	0.073±0.001	37.16±3.83
Fairnees # 1	0.094±0.006	0.017±0.001	<0.002	0.009±0.000	2.66±0.27
Fairnees # 2	0.072±0.006	0.163±0.016	0.148±0.007	0.010±0.004	2.61±0.27
Fairnees # 3	0.088±0.004	0.020±0.001	0.004±0.000	0.008±0.001	2.41±0.26
Fairnees # 4	0.033±0.004	0.038±0.001	0.331±0.007	0.024±0.000	3.44±0.35
Hair colour # 1	0.391±0.041	0.023±0.001	0.006±0.000	0.008±0.000	3.96±0.40
Hair colour # 2	0.301±0.033	0.024±0.002	0.009±0.002	0.008±0.000	4.03±0.42
	Na (%)	*Ni (ppm)*	*V (ppm)*	*Sr (ppm)*	*Th (ppm)*
Lip stick # 1	<0.001	<1.15	24.71±3.06	216.74±35.82	7.75±8.40
Lip stick # 2	<0.001	17.26±18.02	178.17±21.83	147.80±18.26	117.50±20.28
Lip stick # 3	<0.001	36.58±25.29	221.98±23.91	9.68±1.12	119.23±22.14
Lip gloos # 1	<0.001	10.06±7.40	80.53±8.37	3.31±0.50	58.91±16.01
Lip gloos # 2	<0.001	54.48±46.14	243.32±28.13	<0.04	141.73±33.53
Eye liner # 1	<0.001	16.86±22.01	150.38±32.15	34.26±6.79	103.91±32.65
Eye liner # 2	0.360±0.016	<1.15	5.23±0.55	3.70±0.42	<3.07
Eye liner # 3	<0.001	11.47±5.30	40.60±4.32	2.57±0.35	15.11±4.09
Mascara # 1	<0.001	56.23±11.57	236.51±28.10	<0.04	120.35±23.76
Mascara # 2	<0.001	29.13±22.83	125.85±13.33	6.94±0.72	92.74±16.44
Mascara # 3	<0.001	48.42±28.70	249.29±27.36	<0.04	145.61±42.55
Kohl #1	<0.001	6.53±3.19	77.43±10.49	2.57±0.64	52.85±9.05
Kohl #2	<0.001	19.01±22.37	83.02±11.73	0.26±0.39	47.64±6.27
Kohl #3	<0.001	24.04±23.17	127.85±15.10	27.92±3.32	56.60±15.01
Fairnees # 1	<0.001	4.21±2.90	8.85±1.11	1.41±0.14	<3.07
Fairnees # 2	0.096±0.009	<1.15	9.65±1.33	0.85±0.14	<3.07
Fairnees # 3	<0.001	3.01±1.86	5.05±1.09	0.56±0.10	<3.07
Fairnees # 4	<0.001	<1.15	11.09±1.40	2.94±0.30	<3.07
Hair colour # 1	0.650±0.036	<1.15	9.48±1.62	0.38±0.05	<3.07

Hair colour # 2	0.279±0.007	43.54±5.58	13.74±1.76	0.40±0.13	<3.07
	Ti (ppm)		*U (ppm)*		*Zn (ppm)*
Lip stick # 1	2,402.00±584.58		11.97±12.76		1.22±1.70
Lip stick # 2	2,605.04±291.71		86.07±61.26		<0.47
Lip stick # 3	16,322.18±1,933.94		127.18±60.49		<0.47
Lip gloos # 1	607.48±105.70		34.91±12.72		41.38±5.69
Lip gloos # 2	11.44±11.43		48.02±19.04		<0.47
Eye liner # 1	68.51±10.63		33.32±175.21		2,095.41±329.26
Eye liner # 2	2.03±0.78		<11.00		333.40±35.64
Eye liner # 3	6.38±1.10		<11.00		218.11±25.41
Mascara # 1	129.01±13.95		34.67±54.50		405.84±64.46
Mascara # 2	4.73±5.39		67.24±88.91		73.69±7.46
Mascara # 3	354.00±40.89		108.59±79.60		336.00±40.31
Kohl #1	11.12±3.15		24.11±32.96		236,158.65±30,264.70
Kohl #2	1.70±2.74		17.12±10.96		394.04±113.41
Kohl #3	28,519.24±5,761.09		89.37±37.54		401.23±49.80
Fairnees # 1	6.08±0.72		<11.00		10.20±1.15
Fairnees # 2	1,504.70±682.66		<11.00		<0.47
Fairnees # 3	0.69±0.20		<11.00		1.05±0.25
Fairnees # 4	5,515.41±580.25		<11.00		0.64±0.56
Hair colour # 1	117.23±12.46		<11.00		0.62±0.40
Hair colour # 2	868.45±94.92		<11.00		1.89±0.28
Cosmetic (type-color)	*Al (%)*	*Ba (ppm)*	*Bi (ppm)*	*Ca (%)*	*Cd (ppm)*
Foundation # 1	2.111±0.136	497.29±53.62	75.14±8.23	1.540±0.045	2.69±0.41
Foundation # 2	2.866±0.096	251.67±25.76	<10.55	0.295±0.010	1.53±0.87
Foundation # 3	0.082±0.011	1.47±0.19	<10.55	0.016±0.007	<0.13
Foundation # 4	1.343±0.042	4,724.62±714.81	<10.55	0.018±0.002	<0.13
Eye shadow # 4-light gray	3.654±0.102	140.93±14.52	26.66±5.61	1.580±0.047	1.35±0.21
Eye shadow #5-tan	7.305±0.315	679.53±74.74	97.36±9.84	0.274±0.008	4.62±0.72
Eye shadow #5-slate gray	8.693±0.231	402.25±42.33	80.68±9.43	0.346±0.011	3.53±0.40
Eye shadow #5- dim gray	6.916±0.342	909.77±104.68	45.77±5.32	0.434±0.022	7.99±0.84
Eye shadow #5- brown bisque	5.725±0.260	410.06±43.01	23.50±3.44	0.794±0.033	1.94±0.40
Eye shadow #5-hot pink	4.851±0.045	745.95±75.25	19.87±2.09	0.754±0.013	2.03±0.41
Eye shadow #5-steel blue	7.285±0.114	1,413.01±145.53	87.65±9.33	0.490±0.008	4.11±0.61
Henna # 1	0.212±0.001	<0.13	<10.55	0.731±0.020	<0.13
Henna # 2	<0.010	567.70±99.21	<10.55	0.023±0.007	<0.13
Henna # 3	0.057±0.005	153.85±28.55	<10.55	0.895±0.057	<0.13
	K (%)	*Mg (%)*	*Mn (ppm)*	*Na (%)*	*Ni (ppm)*
Foundation # 1	0.270±0.018	11.107±0.537	105.12±11.33	0.222±0.013	5.21±0.74
Foundation # 2	1.012±0.048	12.665±0.328	70.11±7.06	0.220±0.009	7.08±0.72
Foundation # 3	<0.002	0.126±0.007	6.80±0.72	<0.001	<1.15
Foundation # 4	1.534±0.045	0.065±0.003	28.20±2.93	0.078±0.003	<1.15
Eye shadow # 4-light gray	2.315±0.116	9.260±0.201	88.31±9.30	0.150±0.008	2.53±0.83

Eye shadow #5-tan	4.531±0.199	1.757±0.057	168.00±17.40	0.421±0.013	<1.15
Eye shadow #5-slate gray	4.673±0.226	2.232±0.044	166.08±16.72	0.241±0.002	<1.15
Eye shadow #5- dim gray	3.853±0.206	2.516±0.085	446.27±47.12	0.242±0.013	17.87±2.31
Eye shadow #5- brown bisque	3.605±0.265	8.275±0.276	186.65±19.31	0.243±0.006	4.09±3.37
Eye shadow #5-hot pink	3.194±0.067	7.437±0.105	127.45±12.99	0.281±0.005	5.12±0.95
Eye shadow #5-steel blue	4.750±0.240	1.608±0.033	159.45±16.65	0.398±0.021	<1.15
Henna # 1	0.780±0.032	1.107±0.016	109.08±11.39	0.863±0.054	10.22±1.19
Henna # 2	0.008±0.000	0.048±0.002	3.12±0.88	13.719±0.454	11.59±5.21
Henna # 3	1.130±0.045	0.804±0.040	43.23±5.02	0.254±0.009	18.19±2.51

	Pb (ppm)	*Si (%)*	*Sr (ppm)*	*Ti (ppm)*	*V (ppm)*
Foundation # 1	17.12±2.37	5.049±0.214	44.20±5.88	45,465.43±4,864.09	10.66±1.09
Foundation # 2	12.57±1.48	5.027±0.163	43.40±4.60	604.55±62.97	3.82±0.60
Foundation # 3	<1.82	0.298±0.049	0.43±0.07	29,676.03±3,207.64	25.51±3.41
Foundation # 4	<1.82	2.477±0.040	55.19±5.74	28,928.87±4,099.44	16.98±1.95
Eye shadow # 4-light gray	18.45±1.97	0.760±0.041	13.75±1.46	14,808.74±1,659.38	6.47±0.89
Eye shadow #5-tan	39.38±4.07	4.764±0.221	15.52±1.79	61,693.23±6,521.97	9.27±1.46
Eye shadow #5-slate gray	32.97±3.98	1.301±0.024	17.19±1.85	48,066.45±4,987.28	9.25±0.93
Eye shadow #5- dim gray	143.56±15.68	1.005±0.049	37.75±4.02	24,760.67±2,720.23	11.07±1.44
Eye shadow #5- brown bisque	153.89±17.03	0.293±0.020	23.49±2.57	9,827.77±1,036.18	4.53±0.82
Eye shadow #5-hot pink	54.15±6.08	7.331±0.061	19.17±1.94	10,569.90±1,064.92	4.22±0.49
Eye shadow #5-steel blue	37.83±4.34	7.177±0.239	15.63±1.64	64,015.56±6,482.89	10.10±1.49
Henna # 1	70.11±7.18	1.424±0.017	254.46±26.81	131.27±14.37	2.81±0.36
Henna # 2	<1.82	UDL	0.21±0.37	2.53±0.58	0.87±0.45
Henna # 3	2.01±0.27	0.123±0.016	335.38±44.40	40.98±5.52	UND

	Co (ppm)	*Cr (ppm)*	*Cu (ppm)*	*P (%)*	*Fe (%)*	*Zn (ppm)*
Foundation # 1	64.97±6.74	19.42±2.34	22.05±2.41	0.034±0.002	0.798±0.032	362.46±39.80
Foundation # 2	2.84±0.48	8.41±0.91	0.57±0.32	0.022±0.002	1.436±0.045	140.33±14.60
Foundation # 3	3.47±7.20	4.25±0.66	17.75±2.37	0.031±0.001	0.195±0.019	400.41±66.63
Foundation # 4	2.32±3.40	1.81±0.29	3.15±0.89	0.028±0.001	0.782±0.030	3,205.41±326.17
Eye shadow # 4-light gray	21.72±2.35	9.30±1.54	5.09±0.61	0.015±0.001	0.653±0.025	30.36±3.49
Eye shadow #5-tan	93.58±9.72	15.22±1.78	27.13±3.06	0.014±0.000	1.411±0.070	289.08±30.54
Eye shadow #5-slate gray	71.00±7.17	11.14±1.16	76.57±7.87	0.012±0.001	0.965±0.021	44.65±4.76
Eye shadow #5- dim gray	39.82±4.33	82.17±8.41	82.18±9.10	0.012±0.002	7.234±0.336	142.69±15.00
Eye shadow #5- brown bisque	16.27±1.74	44.09±4.70	3.89±0.41	0.016±0.001	1.232±0.052	76.95±8.28
Eye shadow #5-hot pink	16.89±1.79	14.89±1.50	4.48±0.52	0.015±0.000	0.823±0.008	382.52±38.57
Eye shadow #5-steel blue	96.28±9.73	14.06±1.42	796.08±83.55	0.015±0.001	1.034±0.008	358.01±36.06
Henna # 1	19.48±2.08	90.62±9.21	8.35±0.85	0.079±0.001	0.152±0.008	132.35±13.67
Henna # 2	0.39±0.35	16.62±5.89	7.39±1.53	0.017±0.001	0.014±0.001	23,573.98±2,901.42
Henna # 3	1.03±0.24	15.80±1.96	4.54±0.55	0.136±0.011	0.072±0.006	0.92±0.62

Conclusions. The application of ICP-MS and ICP-OES techniques allowed us to determine the concentration of heavy metals in different kinds of cosmetics. All brands of eye shadow in the current study had high Pb concentration, some had Se, Ni, Cr, Co and Cd with high concentrations. Some of the foundations studied had also high concentration of Pb, Ba, Cd and Cr. Some of mascara, lip stick and gloos had also high concentration of Ni. So, daily and continuous uses of these cosmetics could result in increase in toxic metal levels in human body beyond permissible limits, and thus causing harmful effects to consumers over time. Based on the study results there must be a regular testing program to check the toxic heavy metals in cosmetic products imported to Jordan in order to protect consumer health.

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