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Research Article

Evaluation of Lead and Cadmium Levels in Lipsticks Sold in Kathmandu, Nepal, and Their Potential Health Risk Assessment

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Abstract

The study aimed to assess the levels of Lead (Pb) and Cadmium (Cd) in lipsticks and theirs associated health hazards to consumers. 13 lipsticks and 7 lipglosses were selected randomly from various shopping centers in Kathmandu, Nepal. The lipstick sample was chemically digested and analyzed using flame atomic absorption spectroscopy (FAAS). The concentration range of Pb and Cd in lipsticks was from 0.02±0.009 to 30.97±0.014 mg kg^{-1} and 0.01±0.014 to 0.92±0.009 mg kg^{-1} respectively. The hazard quotient for Pb was found greater than 1 in 15 samples showing detrimental carcinogenic health risk through lipstick consumption. So, these lipstick brands are prone to hamper human health. Accordingly, regular monitoring of the lipsticks before importing them is highly recommended.

Introduction

Cosmetics constitute an integral part of routine body care by all strata of people from ancient times (Chauhan *et al*., 2010). Cosmetic refers to the substance used in contact with the skin, hair, nails, lips, extragenital organs, etc. to clean, protect, and change the overall appearance promoting attractiveness (Belurkar and Yadawe, 2017). Cosmetics include creams, beauty soaps, talcum, face powder, lotions, shampoo, hair oils, hair dyes, mouth wash, eyeshadow, perfumes, lipsticks, shaving cream, nail polish, etc (Ackah *et al*., 2015). Cosmetic safety concerns broadened during the 1960s and 1970s along with the development of various tools concerning sensitization, photo-toxicity, and clinical tests. This attracted health professionals and researchers to investigate the reasons behind the side effects of cosmetics (Bocca *et al*., 2014; Chauhan *et al*., 2010). Above 10,000 cosmetic components are related to various diseases like cancer, congenital anomaly, developmental and reproductive harm (Ullah *et al*., 2013). Lipstick is an intricate matrix combining an organic part and an inorganic part contributing to a variety of colors (Lemaire *et al*., 2013). The organic part includes different waxes and oils responsible for the crystalline structure of stick, shine, and easy application quality. The inorganic part includes pigments and pearls (Volpe *et al*., 2012). Human exposure to the organic and inorganic particles in lipsticks occurs via ingestion and absorption leading to non-carcinogenic risks (Liu *et al*., 2013). Lipstick is found in different forms as solid (stick), semi-solid (jars), and liquid (tube). The different types of lipsticks are Sheer and Satin, Moisturizing, Matte, Glossy, Frosted, and Cream (Mailgyurai *et al*., 2015; Resano *et al*., 2016). A woman is suspected to ingest 1.8 kg of lipstick in her lifetime (Soares and Nascentes, 2013). Heavy metal contamination is one of the major reasons behind the negative impacts of lipsticks. It is believed to occur due to the use of metallic devices during the manufacturing process, metal-based dyes, and different pigments used as ingredients (Mailgyurai *et al*., 2015; Al-Saleh *et al*., 2009; Volpe *et al*., 2012, Soares and Nascentes, 2013).

Metals with density five times the density of water are termed heavy metals (Al-Trabulsy *et al*., 2013). Some heavy metals are essential in a trace amount to maintain normal human body functions known as trace elements. However, lead, cadmium, mercury, etc. are some known toxic heavy metals capable of bioaccumulation in the human body leading to multiple organ failure (Helaluddin *et al*., 2016). The different routes of heavy metal exposure to humans are ingestion through eating, or inhalation through breathing, or absorption through the skin (Amartey *et al*., 2011). The heavy metal ions are found to interact and damage cell components and cell organelles resulting in carcinogenesis (Wang and Shi, 2001). The major toxic effect of heavy metals in the human body includes the denaturation of proteins eliminating its bio-catalytic activity (Horvath, 2011). About 12,500 industrial chemicals used as cosmetic ingredients were found to include carcinogens, plasticizers, degreasers, pesticides, endocrine disruptors, reproductive toxins, and surfactants (Mohiuddin, 2019).

Lead is toxic to the foetus causing a high risk of premature delivery, reduced physical and mental growth in babies, and responsible for schizophrenia and dementia in adults (Schwalfenberg *et al*., 2018). Lead is absorbed very slowly in human bodies, and its excretion is even slower. So, the continuous exposure of lead results in its absorption in blood and circulation throughout the body resulting in its concentrated accumulation in soft tissues like the liver and kidneys (Naalbandi *et al*., 2016). Lead poisoning causes anemia and acts as a selective blocker of voltage-dependent calcium channels. Lead may harm the nervous system with permanent neurological and behavioral damage and also damage the protective blood-brain barrier cells responsible to protect the brain from many harmful chemicals (Wani *et al*., 2015; Wang *et al*., 2000). It hampers the central nervous system of children and the peripheral nervous system of adults (Seikh, 2018). The utmost reproductive effects of lead include decreased prolificacy, miscarriage, and infant mortality. Excessive lead reduces the secretion of pituitary gonadotropin. Lead decreases the re-absorption of tiny organic molecules on renal mitochondria (Navid, 2014). Cadmium, due to its characteristic color pigments, is used in cosmetics. Its exposure even in low concentrations is harmful (Ackah *et al*., 2015; Wang *et al*., 2016). Cadmium is mostly related to cardiovascular diseases like hypertension, atherosclerosis, endothelial dysfunction, peripheral artery disease, cancer, stroke, and heart failure. Most of these diseases occur because of the increased oxidative stress and specific biochemical changes initiated by cadmium. It also accumulates in the kidney cortex (Oliveira *et al*., 2018). Severe cadmium ingestion is symptomatized by nausea, vomiting, abdominal cramps and pain, and diarrhea. Chronic cadmium exposure results in adverse effects on kidneys, liver, pancreas, testes, and placenta. It is also responsible for bone degradation as it affects calcium metabolism (Theresa *et al*., 2011; Al-Saleh *et al*., 2009). Observing the harmful impacts, the Health Canada, the World Health Organization (WHO), and Nepal Standard (NS) has set the permissible limit of Pb at 10 mg kg^{-1}; 2.0 mg kg^{-1} by European Union (EU), and 20 mg kg^{-1}according to the United States Food and Drug Administration (USFDA). Similarly, the Cd concentration is limited to 3 mg kg^{-1} by USFDA, Health Canada, and NS, 0.1 mg kg^{-1} by EU, and 0.3 mg $kg^{-1}$by WHO (Ackah *et al*., 2015; Health Canada, 2012; NBSM, 2019).

Belurkar and Yadawe, 2017 evaluated the levels of lead, cadmium, and nickel in 18 lipsticks traded in Goa Metropolis using AAS. Nkansah *et al*. (2018) evaluated Pb and Cd and their health impacts in 15 lipsticks sold in the Ghanaian market. Similarly, Ernest *et al*. (2019) analyzed heavy metals in different lipstick brands sold in Enugu Metropolis, Nigeria, and their probable health risks to the consumers. To the best of our knowledge, no reports are available in the literature on the evaluation of heavy metals levels in lipsticks sold in Nepal, and their potential health risk assessment. The objective of this study was to evaluate Pb and Cd levels in lipsticks sold in Kathmandu and determine their potential health risks to the consumers. So, this research finding intends to aware people and the government about the toxicity of lipstick brands and their possible health impacts.

Material and Methods

Sample Collection

The sampling area was chosen very carefully to obtain the data that speak for background levels. For this, the area with a high percentage of lipstick users was chosen. The sampling was carried out in Kathmandu, Nepal. Divergent sets of lipsticks are found here, which help people to buy them according to their price, quality, type, and trademark. 20 distinct lipsticks sold in Kathmandu were purchased. The purchased lipsticks were found to be imported from six different nations according to their provided information. Most of them were imported from China while the rest were from India, the US, Turkey, France, and Canada. The detail of the collected lipstick samples is presented in Table 1.

Chemicals and Reagents

In this experimental process, the reagents, and chemicals of analytical grade, manufactured by Merck were used. The chemicals included concentrated nitric acid (69%, v/v), perchloric acid (70%), and distilled deionized water. Standard stock solutions (1000 mg L^{-1}) of lead and cadmium were purchased from Standards, Metrology, Testing and Quality (SMTQ) Forum Nepal. These standard solutions were diluted with deionized water to desired concentration to prepare the calibration solutions.

Sample Preparation

The lipstick samples were digested and analyzed according to the procedure given by Oklo *et al*., 2020. 1.0 g of lipstick was weighed in a conical flask. 10 mL of a mixed acid solution of concentrated HNO_3 and $HClO_4$ in 3:1 was added. The mixture was then heated on a hot plate for 3 hours at 90˚C. 5 mL of the acid mixture was again added and further heated for 2 hours for complete digestion. It was then left to cool. The cooled mixture was then filtered using Whatman no. 41 filter paper and diluted up to the mark with deionized water in a 25 mL volumetric flask. The clear solution was kept at room temperature and subjected to metal quantification analysis.

Sample Analysis

The digested samples were analyzed by Flame Atomic Absorption Spectrophotometer (nov AA 350, Analytikjena, Germany) for the determination of lead and cadmium. The device was standardized with both elements via a ten-point calibration curve. The calculated correlation constant (R^2) demonstrated the linearity of the calibration curve for both elements. To maintain the precision of the procedure, samples were analyzed in triplicates. The operating parameter of FAAS includes a wavelength of Pb and Cd as 217 nm and 228.8 nm respectively, slit width as 1.4 nm in both, and cathode lamp current as 4.0 (milliampere) mA for Pb and 3.0 mA for Cd.

Table 1: detail of the collected lipstick samples

Sample Code	Name of Brand	Lipstick Type	Color	Price (NRs)	Country of origin
L1	LA girl matte velvet lipstick	Solid	Crimson red	1200	USA
L2	Loreal	Solid	Dark red	1200	France
L3	Nude edition	Liquid	Lip color	1000	China
L4	Kate	Solid	Brown	1100	China
L5	Lac matte lipstick	Solid	Maroon red	1000	China
L6	Farmasi	Solid	Red	350	Turkey
L7	Mac	Solid	Orange red	400	Canada
L8	Kylie	Liquid	Brown	400	China
L9	Sonata butter Lip balm	Solid	Red	150	India
L10	Baby lips	Solid	Colorless	50	India
L11	Huxiabeauty matte lipstick	Solid	Orange	150	China
L12	Romantic bird velvet matte	Solid	Brownish Red	200	China
L13	Romantic bird vivid lipgloss	Liquid	Red	250	China
L14	Huda beauty	Solid	Chocolate-brown	150	China
L15	Sonata	Solid	Pink	150	India
L16	Comforbeauty	Solid	Lip color	150	China
L17	Kiss beauty	Liquid	Light pink	250	China
L18	Huda beauty	Liquid	Light orange	200	China
L19	LA girl matte	Liquid	Pink	220	China
L20	Ever beauty	Liquid	Dark brown	200	China

Quality Control

All apparatus including all the plastic and glassware like beakers, funnels, conical flask, etc. were washed properly with soap and water followed by distilled water and dissolved in 10% nitric acid solution for 24 hours. Then, they were dried and forwarded for the experimental process. The values of the standard deviation of the respective blank solutions were multiplied by 3 and 10 to evaluate the limit of detection (LOD) and limit of quantification (LOQ) respectively (Khan *et al*., 2013). The obtained LOD, LOQ, and R^2 values of Pb and Cd are 0.001, 0.003 and 0.996, and 0.022, 0.073, and 0.997 respectively.

Health Risk Assessment

One of the ways of an inlet of heavy metals in the human body is lipstick ingestion. The amount acquired via ingestion was calculated as per Eqn. 1 as described by (Ernest *et al*., 2019).

$$ADD_{ing} = \frac{C \times IR \times EF \times ED}{BW \times AT} \times CF \quad \text{(Eqn. 1)}$$

Where, ADD_{ing} = average daily dose of ingestion (mg kg^{-1} day^{-1}), C = concentrations of heavy metals (mg kg^{-1}), IR = intake rate of the lipstick (40 mg day^{-1}), EF = the exposure frequency (260 days $year^{-1}$), ED = exposure duration (35 years), BW = the bodyweight of the exposed population (57.9 kg), AT = averaging time (365 days$year^{-1}$), CF = conversion factor (10^{-3}).

Using the value of ADD_{ing}, the Hazard Quotient (HQ) for the non-malignant threat was evaluated using Eqn. 2.

$$HQ = \frac{ADD_{ing}}{RfD} \quad \text{(Eqn. 2)}$$

Where, RfD = reference oral dose (for Pb = 0.0004 and Cd = 0.001 mg kg^{-1} day^{-1}) (Ernest *et al*., 2019).

When ADD_{ing} > RfD and HQ > 1 then, it indicates adverse effects on human health. The health risk generated due to heavy metals was estimated by calculating hazard index (HI) using Eq.3.

$$HI = \sum HQ = HQ_{Pb} + HQ_{Cd} \quad \text{(Eqn. 3)}$$

Result and Discussion

Twenty different brands of lipsticks were collected and analyzed under FAAS for the determination of lead and cadmium. Every sample was examined in triplet and the mean value and standard deviation (sd) were evaluated. The evaluated levels of Pb and Cd in different samples are listed in Table 2.

The highest concentration of Pb and Cd is observed in L8 and L17 respectively. Similarly, L9 contains the lowest Pb while L3 is the least Cd-containing sample. Here, samples L8 and L12 contain Pb above the limits set by USFDA, Health Canada, WHO, and NS while eight samples (L2, L4, L5, L6, L7, L9, L10, L13) were found safe as per the EU. Similarly, all the samples contained a safe limit of Cd as per the USFDA, Health Canada, and NS, ten samples were below the mark of tolerance limits set by WHO, and a single sample (L3) was found to be the safest one below EU.

Table 2: The amount of Pb and Cd in lipstick samples

Sample Code	**Lead (Pb) Mean ± sd**	**Cadmium (Cd) Mean ± sd**
L1	3.53±0.014	0.29±0.021
L2	1.59±0.024	0.50±0.014
L3	6.61±0.012	0.01±0.014
L4	1.15±0.014	0.38±0.014
L5	0.87±0.016	0.28±0.009
L6	0.64±0.009	0.41±0.021
L7	0.43±0.014	0.21±0.016
L8	30.97±0.014	0.30±0.021
L9	0.02±0.009	0.32±0.024
L10	0.41±0.014	0.22±0.014
L11	8.71±0.009	0.31±0.016
L12	20.99±0.008	0.18±0.021
L13	0.20±0.012	0.38±0.014
L14	3.12±0.009	0.10±0.016
L15	2.79±0.02	0.22±0.009
L16	7.81±0.024	0.33±0.016
L17	1.38±0.014	0.92±0.009
L18	7.11±0.016	0.63±0.016
L19	7.87±0.009	0.50±0.009
L20	3.44±0.02	0.18±0.009

Health Risk Assessment

The concentration of heavy metals and their health effects in cosmetics appear significantly low compared to that in food, water, and air. Yet, their harmful upshots should not be ignored, due to their continuous usage in delicate human body parts. Lead and Cadmium stand high as possible malignant metals. To sum up, the health risks caused, the daily intake rate, and hazard index was evaluated and presented in Table 3.

With daily usage of lipstick, the average daily intake value and HQ for lead in all lipstick samples ranged from 0.01×10^{-3} to 15.12×10^{-3} mg day^{-1} and 0.03 to 37.80 respectively where the 15 samples crossed the recommended reference dose 4×10^{-4} mg day^{-1} with HQ > 1. Similarly, the average daily intake and HQ of cadmium were found from 0.17×10^{-3} to 15.85×10^{-3} mg day^{-1} and 0.01 to 0.45 respectively. All the samples were found below the recommended reference dose and HQ < 1 indicating samples to be safe with L3 and L4 being the safest ones. The hazard indices (HI) were calculated by the summation of respective HQ data. The HI for 15 samples was above 1 with L8 (37.95) at the highest and L9 (0.19) at the lowest. Thus, the non-malignant health risk from ingestion of lipstick was observed. The results obtained in this study compare well with previously reported results found in literature, which are listed in Table 4.

Table 3: health risk assessment of Pb and Cd in lipsticks

Lipstick Sample	Lead (Pb)		Cadmium (Cd)		Hazard index (HI)
	ADD_{ing} (10^{-3})	HQ	ADD_{ing} (10^{-3})	HQ	
L1	1.73	4.33	0.14	0.14	4.47
L2	0.78	1.95	0.24	0.24	2.19
L3	3.23	8.08	0.01	0.01	8.09
L4	0.56	1.40	0.01	0.01	1.41
L5	0.43	1.08	0.13	0.13	1.21
L6	0.31	0.78	0.20	0.20	0.98
L7	0.21	0.53	0.24	0.24	0.77
L8	15.12	37.80	0.15	0.15	37.95
L9	0.01	0.03	0.16	0.16	0.19
L10	0.20	0.50	0.10	0.10	0.60
L11	4.26	10.65	0.15	0.15	10.80
L12	10.26	25.65	0.09	0.09	25.74
L13	0.09	0.23	0.19	0.19	0.42
L14	1.53	3.83	0.05	0.05	3.88
L15	1.36	3.40	0.10	0.10	3.50
L16	3.82	9.55	0.16	0.16	9.71
L17	0.67	1.68	0.45	0.45	2.13
L18	3.48	8.70	0.30	0.30	9.00
L19	3.85	9.63	0.24	0.24	9.87
L20	1.68	4.20	0.09	0.09	4.29

Table 4: comparison of concentration range and HQ of Pb and Cd reported in the literature with the present study.

Heavy metal	Concentration range (mg kg^{-1})	Hazard quotient (HQ) range	Reference
Pb	0.20-36.70	ND-45.23	Oklo *et al.*, 2020
Cd	1.83-412.23	0.90-203.21	
Pb	ND-92.07	ND-43.08	Khan *et al.*, 2013
Cd	-	-	
Pb	0.4-5.89	4.38-120	Arshad *et al.*, 2020
Cd	0.05-0.20	5.85-22.10	
Pb	ND-40.9	ND-0.56	Alidadi *et al.*, 2019
Cd	ND-0.52	ND	
Pb	0.02-30.97	0.23-37.80	Present study
Cd	0.01-0.92	0.01-0.45	

(ND= Not detected)

Conclusions

The present study incorporates the concentration of lead and cadmium in the lipsticks marketed in Kathmandu and their possible health hazards. The data tells that the concentrations of Pb and Cd in lipsticks varied from 0.02±0.009 to 30.97±0.014 mg kg^{-1} and 0.01±0.014 to 0.92±0.009 mg kg^{-1} correspondingly. The concentration of Pb in L8 and L12 was found above the permissible limit of US-FDA (20 mg kg^{-1}), Health Canada (10 mg kg^{-1}), WHO (10 mg kg^{-1}), and Nepal Standard Authority (10 mg kg^{-1}). The gross outcome shows that Cd concentrations in 19 samples were above the EU limit (0.1 mg kg^{-1}) and that of 11 samples were above the WHO limit (0.3 mg kg^{-1}). This work provides innate and worthwhile information for future toxicological studies on the assimilation of harmful materials in lipsticks. The findings herein call for instant compulsory assessment of cosmetics imported in Nepal to halt their approach and protect the customers. Furthermore, consistent observation of harmful chemicals potential enough to hamper the health of individuals should be spotlighted.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors' Contribution

S. Aryal: Data acquisition, Analysis & interpretation of data, Drafting of manuscript, Critical revision of manuscript as for important intellectual content, Final approval of the manuscript; **N. Bashyal:** Analysis & interpretation of data, Critical revision of manuscript as for important intellectual content, Final approval of the manuscript; **S. K. Gautam :** Analysis & interpretation of data, Critical revision of manuscript as for important intellectual content, Final approval of the manuscript; **M. R. Pokhrel:** Analysis & interpretation of data, Critical revision of manuscript as for important intellectual content, Final approval of the manuscript; **B. R. Poudel:** Conception & design, Analysis & interpretation of data, Critical revision of manuscript as for important intellectual content, Final approval of the manuscript. All authors have read and agreed to the final version of the manuscript.

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References

Ackah M, Osei J, Anim AK, Zakaria N, Nyarko ES, Gyamfi ET, Enti-Brown S, Hanson JEK, Bentil NO and Tulasi D (2015) Status of some metals contained in nail polish and lipsticks on the Ghanaian market. *Proc Int Acad Ecol Environ Sci* **5**: 142-147.

Alidadi H, Zamand S, Najafpoor A, Heidarian H, Dehghan A, Sarkosh M and Taghavimanesh V (2019) Health impacts of exposure to heavy metals in some selected lipstick products available in Mashhad, Iran. *Avicenna J Environ Health Eng* **6(2)**: 113-118. DOI: 10.34172/ajehe.2019.15

Al-Saleh I, Al-Enazi S and Shinwari N (2009) Assessment of lead in cosmetic products. *Regul Toxicol Pharmacol* **54**: 105-113. DOI: 10.1016/j.yrtph.2009.02.005

Al-Trabulsy HAM, Khater AEM and Habani FI (2013) Heavy elements concentrations, physicochemical characteristics, and natural radionuclides levels along the Saudi coastline of the Gulf of Aqaba. *Arab J Chem* **6**: 183-189. DOI: 10.1016/j.arabjc.2010.10.001

Amartey EO, Asumadu-Sakyi AB, Adjei CA, Quashie FK, Duodu GO and Bentil NO (2011) Determination of heavy metals concentration in hair pomades on the Ghanaian market using atomic absorption spectrometry technique. *Br J Pharmacol Toxicol* **2(4)**: 192-198.

Arshad H, Mehboob MZ, Shah MH and Abbasi AM (2020) Evaluation of heavy metals in cosmetic products and their health risk assessment. *SPJ* **28**: 779-790. DOI: 10.1016/j.jsps.2020.05.006

Belurkar RS and Yadawe MS (2017) Analysis of heavy metals in lipstick by the various Physico-chemical methods. *IOSR J Appl Chem* **10:** 1-6. DOI: 10.9790/5736-1007010106

Bocca B, Pino A, Alimonti A and Forte G (2014) Toxic metals contained in cosmetics: A status report. *Regul Toxicol Pharmacol* **68(3)**: 447-467. DOI: 10.1016/j.yrtph.2014.02.003

Chauhan AS, Bhadauria R, Singh AK, Lodhi SS, Chaturvedi DK and Tomar VS (2010) Determination of lead and cadmium in cosmetic products. *J Chem Pharm Res* **2(6)**: 92-97.

Ernest E, Onyeka O, Aniobi CC, Ikedinobi CS and Alieze AB (2019) Analysis of heavy metals in different brands of lipsticks sold in Enugu Metropolis, Nigeria, and their potential health risks to users *J Chem Biol* **9(4)**: 402-411. DOI: 10.24214/jcbps.D.9.4.40211

Health Canada. Guidance on heavy metal impurities in cosmetics (2012) *Sparkle* 632. Available https://www.intertek.co.th/uploadedFiles/Intertek/Divisions/Consumer_Goods/Media/PDFs/Sparkles/2012/sparkle632.pdf

Helaluddin ABM, Khalid RS, Alaama M and Abbas SA (2016) Main analytical techniques used for elemental analysis in various matrices. *Trop J Pharm Res* **15(2)**: 427-434. DOI: 10.4314/tjpr.v15i2.29

Horváth E (2011). *Neurotoxicity of a modeled complex environmental heavy metal exposure in rats* (Doctoral dissertation, Ph. D. thesis. University of Szeged, Szeged).

Khan N, Jeong IS, Hwang IM, Kim JS, Choi SH, Nho EY, Choi JY, Kwak BM, Ahn JH, Yoon T and Kim KS (2013) Method validation for simultaneous determination of chromium, molybdenum, and selenium in infant formulas by ICP-OES and ICP-MS. *Food Chem.* **141**: 3566-3570. DOI: 10.1016/j.foodchem.2013.06.034

Lemaire R, Bianco DD, Garnier L and Beltramo JL (2013) Determination of lead in lipstick by direct solid sampling high-resolution continuum source graphite furnace atomic absorption spectrometry: comparison of two digestion methods. *Anal Lett* **46(14)**: 2265-2278. DOI: 10.1080/00032719.2013.787430

Liu S, Hammond SK and Rojas-Cheatham A (2013). Concentrations and potential health risks of metals in lip products *Environ Health Perspective* **121**: 705-710. DOI: 10.1289/ehp.1205518

Mailgyurai R, Ramasubbu A and Velmani N (2015). ICP-OES investigations of heavy metal contents in cosmetic products. *J Pharm Res* **9(1)**: 27-30.

Mohiuddin AK (2019) Heavy metals: The notorious daredevils of daily personal care products. *Am Research J Dermatol* **2(1)**: 8-18. DOI: 10.21694/2642-2980.19008

Naalbandi H, Saeedi M, Moharrami-Moghanlou O, Akbari J, Morteza-Semnani K, Alizadeh R, Esfahani-Zadeh MH and Tajbakhsh M (2016) Evaluation of heavy metal content of some lipsticks in Iran market. *Pharm. Biomed Res* **2(3)**: 31-37. DOI: 10.18869/acadpub.pbr.2.3.31

Navid N (2014) The perils of cosmetics. *J Pharm Sci. & Res* **6(10)**: 338-341.

NBSM (Nepal Bureau of Standards and Metrology), Balaju (2019) NS Lipstick Specification**.** NBSM 565.

Nkansah MA, Owusu-Afriyie E and Opoku F (2018) Determination of lead and cadmium contents in lipstick and their potential health risks to consumers. *JCF 13***(4)**: 367-373. DOI: 10.1007/s00003-018-1180-y

Oklo AD, Enenche DE and Aondoakaa MAM (2020) Heavy metals in some lipstick products marketed in Makurdi metropolis, Benue state Nigeria. *Int J Environ 5***(2)**. DOI: 10.22161/ijeab.52.8

Oliveira TF, Batista PR, Leal MA, Campagnaro BP, Nogueira BV, Vassallo DV and Meyrelles SS (2018). Chronic cadmium exposure accelerates the development of atherosclerosis and induces vascular dysfunction in the aorta of $ApoE^{-/-}$ mice. *Biol Trace Elem Res* **187(1)**: 163-171. DOI: 10.1007/s12011-018-1359-1

Resano M, Garcia-Ruiz E and Garde R (2016) High-resolution continuum source graphite furnace atomic absorption spectrometry: is it as good as it sounds? A critical review. *Anal Bioanal Chem* **399(1)**: 323-330. DOI: 10.1039/C6JA00280C

Schwalfenberg G, Rodushkin I and Genius SJ (2018) Heavy metal contamination of prenatal vitamins. *Toxicol Rep* **5**: 390-395. DOI: 10.1016/j.toxrep.2018.02.015

Seikh AG (2018) Harmful effects of beauty care products on human health. *Int J Med Sci Public Health* **7(1)**: 1-8. DOI: 10.5455/ijmsph.2018.1130118112017

Soares AR and Nascentes CC (2013) Development of a simple method for the determination of lead in lipstick using alkaline solubilization and graphite furnace atomic absorption spectrometry. *Talanta* **105**: 272-277. DOI: 10.1016/j.talanta.2012.09.021

Theresa OC, Onebunne OC, Dorcas WA and Ajani OI (2011) Potentially toxic metals exposure from body creams sold in Lagos, Nigeria. *Researcher* **3(1)**: 30-37.

Ullah H, Noreen S, Fozia, Rehman A, Waseem A, Zubair S, Adnan M and Ahmad I (2013) Comparitive study of heavy metals content in cosmetic products of different countries marketed in Khyber Pakhtunkhwa, Pakistan. *Arab J Chem* **10**: 10-18. DOI: 10.1016/j.arabic.2013.09.021

Volpe MG, Nazzaro M, Coppola R, Rapuano F and Aquino R (2012) Determination and assessments of selected heavy metals in eye shadow cosmetics from China, Italy, and USA. *Michrochem J* **101**: 65-69. DOI: 10.1016/j.microc.2011.10.008

Wang J, Kay AB, Fletcher TE and McAlindon T (2000) Is lipstick associated with the development of systemic lupus erythematosus (SLE)? *Clinical Rheum* **27**: 1183-1187. DOI: 10.1007/s10067-008-0937-6

Wang S and Shi X (2001) Molecular mechanisms of metal toxicity and carcinogenesis. *Mol Cell Biochem* **222**: 3–9. DOI: 10.1023/A:1017918013293

Wang Y, Chen L, Gao Y, Zhang Y, Wang C, Zhou Y, Hu Y, Shi R and Tian Y (2016) Effects of prenatal exposure to cadmium on the neurodevelopment of infants in Shandong, China. *J Environ Pollut* **211**: 67-73. DOI: 10.1016/j.envpol.2015.12.038

Wani AL, Ara A and Usmani JA (2015) Lead toxicity: a review. *Interdiscip Toxicol* **8(2)** 55-64. DOI: 10.1515/intox-2015-0009