Jurnal Penelitian dan Kajian Ilmiah Kesehatan
Politeknik Medica Farma Husada Mataram
Volume 10 Issue 2 2024
DOI : 10.33651/jpkik.v10i2.582
Website : https://jurnal.poltekmfh.ac.id/index.php/JPKIK
© 2024 by author. This is an open access article under the CC BY-NC-SA license

Review: Analysis of Lead Metal Contents (Pb) in Various Cosmetic Dosage Forms Using the Atomic Absorption Spectrophotometry (AAS) Method

Amelia Dyah Permatasari, Dewi Musnifatus Syifa, Leilani Zabrina, Naura Artanti, Novia Sari, Syifa Desnita
Pharmacy Study Program, Faculty of Medicine, Universitas Negeri Semarang
Email : ameliadyah1016@students.unnes.ac.id

ARTICLE INFO

Article History:
Received
Accepted
Published online

Keywords:
Cosmetics;
Heavy metals;
Lead;
Health risk;
Atomic Absorption Spectrophotometry.

ABSTRACT
Cosmetics are the preparations whose products are most widely used by people in all circles, from babies to adults. However, it is not uncommon to find dangerous substances contained in cosmetics, one of which is lead contamination, so it is necessary to test the dangerous substances in them. This review aims to provide information regarding the presence and levels of the heavy metal lead in various cosmetic samples using the atomic absorption spectrophotometry method and to analyze the dangers it causes. The method used is a literature review of articles with the keywords "cosmetics", "heavy metals", "lead pollution", "health risks" and "atomic absorption spectrophotometer" between 2019-2023. The results of the review that has been carried out are that the majority of cosmetics contain the heavy metal lead (Pb), either within the required limits or exceeding the required limits. The dangers posed by lead contamination in cosmetics used over a long period of time can be similar to acute or chronic toxic diseases, and can result in pathological changes in body organs such as the cardiovascular system, kidneys, bones, liver, potentially causing cancer and genetic changes. and the most fatal form of lead poisoning can cause death.

INTRODUCTION

Federal Food, Drug, and Cosmetic Act (FD&C Act) defines cosmetics based on their intended use, cosmetics are preparations or materials used on the outside of the body as items intended to be rubbed, poured, sprinkled, or sprayed, or applied to the human body for cleansing, beautifying, promoting attractiveness, or changing appearance is not for treating and improving and does not include claims as a medicine[1]. The use of cosmetics in Indonesia is increasing. The use of cosmetic preparations for the purpose of beautifying oneself becomes more attractive and covers up existing deficiencies. Among the products included in this definition are skin moisturizers, perfumes, lipsticks, nail polishes, eye and facial make-up preparations, cleansing shampoos, hair dyes, and deodorants, as well as any substance intended for use as a component of cosmetic products[2].

Cosmetics that are indicated for treatment fall into the drug category, so their use must be under special supervision under the supervision of a doctor. However, there are also cosmetics that contain drugs that have two purposes of use. This can be determined by looking at the active substance content in the cosmetic which has evidence that the active substance is effective for use. Examples of cosmetics that contain drugs include anti-dandruff, antiperspirants, deodorants, sunscreen and fluoride toothpaste[3].

Unfortunately, the use of cosmetics is often associated with side effects caused by the presence of chemicals that are often used in the formulation, the most frequently used being dangerous substances such as metals. Metals in cosmetics can be obtained from various sources, including: raw materials used in manufacturing, use of metal-coated devices in production, pigments or intentional use for filters[4].

Heavy metals can pose a health threat if they accumulate in the body for long periods of time. The impact can be similar to acute or chronic toxic diseases, and can cause pathological changes in body organs such as the cardiovascular system, kidneys, bones, liver, and can potentially cause cancer. In addition, the use of cosmetics containing heavy metals can cause reduced fertility in men and women. In fact, the lead contained in cosmetics has the potential to enter the fetus through the placenta and cause miscarriage. So you need to be careful in choosing cosmetics and ensure that the cosmetics used do not contain dangerous heavy metals[5]. Therefore, cosmetics are very vulnerable to use because many cosmetics still contain heavy metals and dangerous substances such as lead (Pb).

Cosmetic preparations can be said to be safe if they meet the maximum lead content requirements issued by BPOM. Based on monitoring results from the Food and Drug Supervisory Agency (BPOM) throughout Indonesia from early 2012 to October 2012, 48 cosmetic products were found to contain dangerous and prohibited chemicals. BPOM issued a public warning intended to prevent people from using these cosmetics because they can pose health risks. In accordance with BPOM RI regulations number HK. 03.1.23.07.11.6662 of 2011 that lead is a prohibited ingredient in cosmetics. Therefore, the safe limit for heavy metal lead contamination is 20 g/g[6].

The maximum amount set is <20 ppm for Pb and is not specific for other heavy metals. This is also confirmed by the FDA and Euro Commission regarding the threshold for heavy metal contamination, especially Pb, in cosmetics[7]. Lead is a group of heavy metals which are usually found in the basic ingredients for making cosmetics. Coloring materials such as iron dioxide contain < 10 ppm Pb[8]. Lead can enter by penetrating membranes or skin tissue. Skin absorption can occur because lead is soluble in oil/fat. Long-term exposure to lead can damage several body organs[5].

The large number of uses of hazardous substances in cosmetics, which are widely used in society, requires the use of analytical methods to identify and prevent the presence of hazardous substances in cosmetics that will be or have been marketed to ensure consumer safety. Methods for analyzing metal elements have evolved along with technological developments. Previously, many studies were carried out using polyographic methods and later with UV-VIS spectrophotometric procedures. Although classical test methods such as qualitative tests and quantitative tests with precipitation techniques are used to identify the content of metal elements in cosmetics, these procedures have weaknesses in their accuracy and sensitivity. Therefore, currently the Atomic Absorption Spectrophotometry (SSA) procedure is more widely used in the analysis of metal elements.[5].

The aim of writing this review article is to provide information regarding the presence and levels of the heavy metal lead in various cosmetic samples using the atomic absorption spectrophotometry method and to analyze the dangers posed by the heavy metal lead in amounts exceeding the required levels and used over a long period of time.

METHOD

The method for writing review articles is carried out by searching via the internet starting on December 8 2023. Searches are carried out using Google Scholar, Science Direct, MDPI Journal, Springer Journal, Elsevier and other journals with the keywords "cosmetic", "heavy metals", “lead contamination”, “health risks” and “atomic absorption spectrophotometer”. Then the search filter is set with a year range starting from 2013 to 2023. From these results, screening is carried out to select appropriate journals or articles. These results cannot yet be taken completely, the journals used are both national and international journals with a year range starting from 2019 to 2023, both in English and Indonesian which analyze levels of the heavy metal lead in various cosmetic preparations using the atomic absorption spectrophotometer method and the

toxicological effects of lead on the body in the long term.

RESULTS

The heavy metal lead content in cosmetics has certain characteristics, so it is necessary to identify it using the most appropriate analytical method to obtain the most optimal results. Apart from the characterization of the compound to be identified, the determination of the analytical method can be determined based on the weaknesses and strengths of the analytical method itself, it can also be determined based on the form of the sample to be used, whether it is a solid, liquid or volatile substance.[9].

Atomic absorption spectrophotometry (AAS) is an analytical method for determining the concentration of a sample which is based on the principle of absorption of radiant energy by atoms that are in a ground state, after absorption the absorbing atoms are excited, so that the electrons in the atomic shell will jump to a higher energy state (excited-state). The amount of energy absorbed will be proportional to the number of atoms at the basic energy level that absorb the radiation energy. By measuring the amount of transmitted energy absorbed (transmit) the concentration of the sample will be known. The process of energy absorption by atoms occurs at specific wavelengths according to the characteristics of each element[10].

From the various considerations that have been mentioned, the following is a research article that has been obtained regarding the analysis of heavy metal lead levels in various cosmetic preparations using the atomic absorption spectrophotometer method that has been determined and is listed in Table 1.

Table 1. Results of Analysis of Lead (Pb) Contamination from Various Cosmetic Preparations Using the Atomic Absorption Spectrophotometry Method

Types of cosmetics	Lead Contamination Level (ppm)	Remarks (Requirements <20 ppm)	References
Powder	1. 0,7831 2. 1,5216 3. 0,6001 4. 2,5674 5. 0,7635	Qualify	(Yugatama *et al*, 2019) [11]
Eyeliner pencil	1. 0,6263 2. 1,1165 3. 0,9726 4. 0,7373 5. 0,698	Qualify	
Lipstick	1. 9,3780 2. 0,7633 3. 0,8353	Qualify	
	4. 22,430 5. 23,168	Not Qualified	
Mascara	1. 7,1729	Qualify	(Fatmawati *et al*, 2019) [12]
	2. 149,77	Not Qualified	
	3. - 4. 15,612 5. 9,283 6. -	Qualify	
Soap	1. 22,4	Not Qualified	(Endah & Surantaatmadja, 2019) [10]
	2. 6,4 3. 10,4 4. 8,4 5. 18,4 6. 14,4 7. 10,4 8. 16,4 9. 18,4 10. 6,4	Qualify	
Powder	1. 18,90 2. 19,10	Qualify	(Dewi *et al*, 2019) [13]
	3. 23,47 4. 28,90	Not Qualified	
Eye shadow	1. 25,67 2. 34,23 3. 45,30 4. 45,90	Not Qualified	
Lipstick	1. 6,83 2. 0,12 3. 0,72 4. 2,99 5. 1,2	Qualify	(Fauziah *et al*, 2020) [14]
Shampoo (different brands, one color)	1. 0,4840 2. 0,6291 3. 0,7976 4. 0,9516	Qualify	(Jaya *et al*, 2021) [15]
Shampoo (one brand with different colors)	1. 0,5428 2. 0,3606 3. 0,4385 4. 0,1427	Qualify	
Eye shadow	1. - 2. 3,788	Qualify	(Farida *et al*, 2022)

Types of cosmetics	Lead Contamination Level (ppm)	Remarks (Requirements <20 ppm)	References
(oxidizing HNO3+HClO4)	3. 35,048	Not Qualified	[16]
Eye shadow (oxidizing HNO3+H2SO4)	1. - 2. - 3. 1,228	Qualify	
Liptint	1. 0,004 2. 0,002	Qualify	(Fauziyah *et al*, 2023) [5]

Based on research by Yugatama et al, (2019) which analyzed the content of lead contamination in powder preparations, eyeliner pencil and lipstick using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm, the levels of 5 powder samples, 5 eyeliner pencil samples were produced. and 3 lipstick samples still met the requirements while 2 lipstick samples did not meet the requirements (<20 ppm). The results of the lead calibration curve measurements are shown in Figure 1.

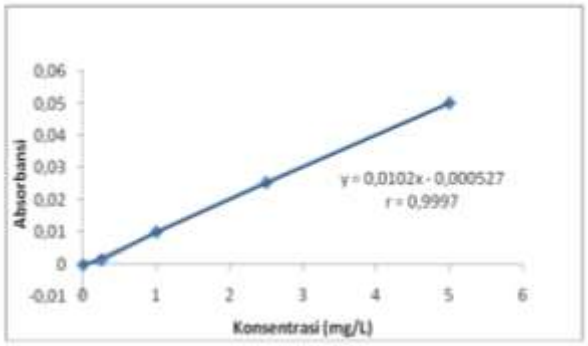

Figure 1. AAS method lead calibration standard curve

Based on research by Fatmawati et al, (2019) who analyzed the content of lead contamination in mascara preparations using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm, 4 out of 6 samples of mascara contained lead with 3 samples still meeting the requirements while 1 sample did not meet the requirements (<20 ppm). The results of the lead calibration curve measurements are shown in Figure 2.

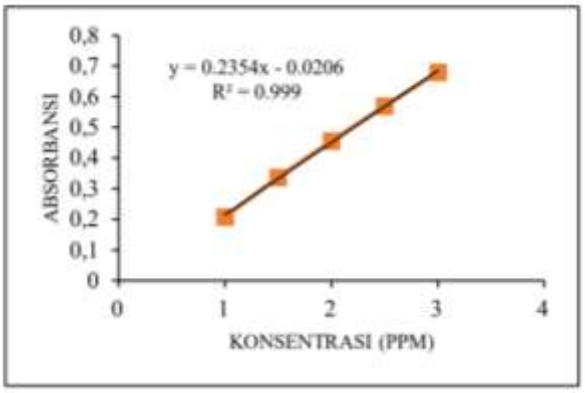

Figure 2. AAS method lead calibration standard curve

Based on research by Endah & Surantaatmadja (2019) who analyzed the content of lead contamination in soap preparations using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm, the levels of 9 soap samples still met the requirements while 1 soap did not meet the requirements (< 20 ppm). The results of the lead calibration curve measurements are shown in Figure 3.

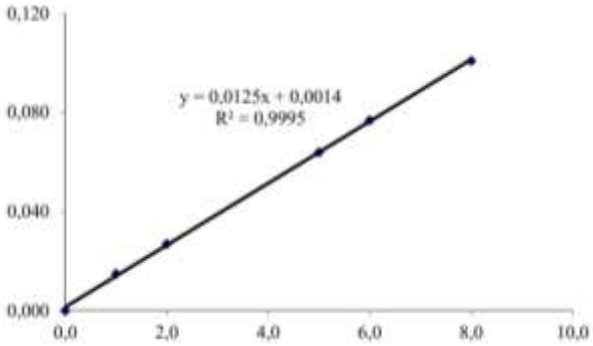

Figure 3. AAS method lead calibration standard curve

Based on research by Dewi et al (2019) which analyzed the content of lead contamination in loose powder and eye shadow preparations using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm, the levels of 2 loose powder samples still met the requirements, while 2 samples loose powder and 4 eye shadows do not meet the requirements (<20 ppm). The results of the lead calibration curve measurements are shown in Figure 4.

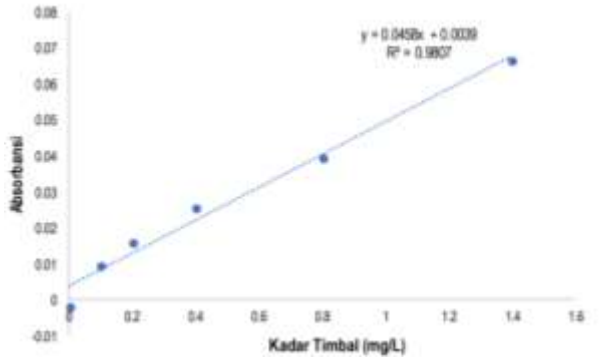

Figure 4. AAS method lead calibration standard curve

Based on research by Fauziah et al (2020) which analyzed the lead contamination content in lipstick preparations using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm, the levels of 5 lipstick samples met the requirements (<20 ppm). The results of the lead calibration curve measurements are shown in Figure 5.

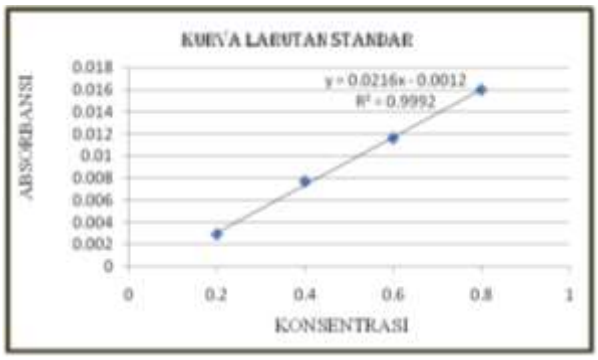

Figure 5. AAS method lead calibration standard curve

Based on research by Jaya et al, (2021) who analyzed the content of lead contamination in shampoo preparations using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm, levels were produced in 4 samples of shampoo from different brands of one color and 4 samples of shampoo from the same brand. different colors meet the requirements (<20 ppm). The results of the lead calibration curve measurements are shown in Figure 6.

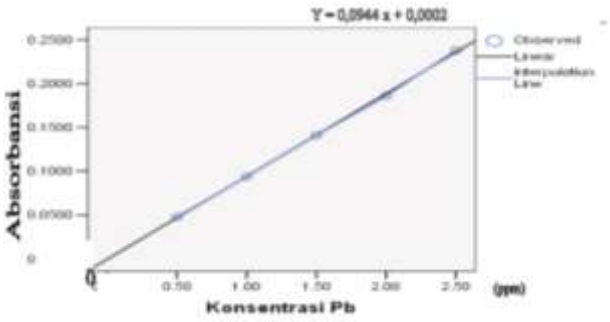

Figure 6. AAS method lead calibration standard curve

Based on research by Farida et al (2022) who analyzed the lead contamination content in eye shadow preparations using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm in HNO_3+$HClO_4$ oxidizing eye shadow, the result was that 1 sample did not contain lead contamination, 1 sample contained lead contamination at levels that still met the requirements and 1 sample did not meet the requirements, whereas in the eye shadow sample with HNO_3+H_2SO_4 oxidizer, 2 samples did not contain lead contamination and 1 sample contained lead contamination at levels that still met the requirements (<20 ppm).

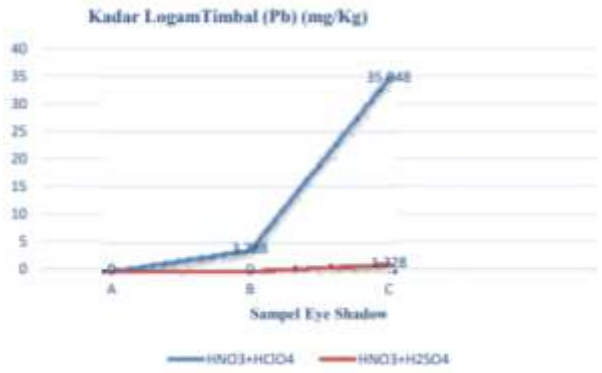

Figure 7. Graph of lead (Pb) metal content in eye shadow samples

Based on research by Fauziyah et al (2023) which analyzed the lead contamination content in liptint preparations using the flame atomic absorption spectrophotometry method using a lead cathode lamp at a wavelength of 283.3 nm, the levels of 2 liptint samples met the requirements (<20 ppm). The results of the lead calibration curve measurements are shown in Table 2.

Table 2. AAS method lead calibration standard curve

Konsentrasi (ppm)	Absorbansi
0,000	0,000
0,200	0,003
0,400	0,005
0,800	0,006
2,000	0,010
5,000	0,27
10,000	0,045

Based on these data, it shows that the majority of cosmetics contain the heavy metal lead (Pb), either within the required threshold or exceeding the requirements. Cosmetics containing lead contamination of less than 20 ppm still meet the requirements so they are considered safe to use, while cosmetics containing lead contamination of more than 20 ppm do not meet the requirements so they are not safe to use.

DISCUSSION

Nowadays, cosmetics are widely used to improve appearance. One of the substances contained in cosmetics is the heavy metal Pb which is used as a dye. The addition of the heavy metal lead can provide an attractive color to cosmetic products. The compound added to the powder is usually yellow, namely PbCrO4[17]. With increasingly advanced developments, many cosmetics are circulating that contain heavy metals such as lead (Pb), which is thought to exceed the microbial contamination threshold for cosmetic heavy metals from BPOM. In this case, if the use of cosmetic powder containing lead exceeds the threshold requirements from BPOM continuously, poisoning will occur. Poisoning caused by Lead (Pb) can penetrate the membranes or layers of the skin. Absorption through the skin can dissolve in oil and fat[18].

The presence of heavy metal compounds (Pb) in cosmetics is thought to originate from the manufacture of cosmetics with ingredients contaminated by heavy metals and their compounds. Lead (Pb) metal contamination in cosmetics can come from the basic dyes used, such as iron oxide. Apart from that, lead (Pb) contamination can also come from tin equipment that contains lead or the use of paint containing lead red and lead chromate on equipment for the lipstick production process.[14]. Lipstick must be safe from dangerous contamination, not exceeding the limits set by the Food and Drug Supervisory Agency (BPOM) of the Republic of Indonesia through BPOM head regulation Number Hk.03.1.23.07.11.6662 of 2011 and amendments to BPOM RI Regulation Number 17 of 2014 Number Hk .03.1.23.07.11.6662 Concerning Heavy Metal Contamination Requirements. The safe threshold value for lead (Pb) heavy metal contamination in cosmetic preparations is that it does not exceed 20 mg/kg or 20 ppm[19].

As stated by Farida et al (2022), heavy metals are found naturally in the environment in rocks, soil and water. Therefore, heavy metals continue to appear in pigments and other materials in all industries including the cosmetics industry. The presence of heavy metal contamination in cosmetics is caused by the low quality of the ingredients used to make these cosmetics and the cosmetic factories' indifference to removing heavy metals from the final product of the cosmetics produced. This will be very detrimental to consumers, even though the amount of this heavy metal is small, if it accumulates over a long time it can harm the body's systems[20].

Lead (Pb) is a group of heavy metals with first level danger if exposed continuously and bioaccumulation occurs in the human body or living creatures. Bioaccumulation in body tissues can cause bad effects on health, such as causing skin irritation, kidney damage, stomach ache, problems with children's intelligence, anemia, accumulation in bones, blood, soft tissue (kidneys, bone marrow, liver, brain) will cause disease. cancer and genetic changes as well as the most fatal lead poisoning can cause death. The content of heavy metals in cosmetics is not justified because the heavy metals contained in cosmetics can come into direct contact with the skin, then the heavy metals will be absorbed, then enter the bloodstream, and in the end some will be excreted and some will accumulate in the tissue. If you use it for a long time, the amount that will accumulate will increase over time[21].

Lead will become very dangerous for health if lead levels exceed the predetermined threshold. One of the disorders caused by Pb poisoning and its inorganic compounds is disruption of the hematopoietic system, namely

the inhibition of the activity of the aminolevulinic acid dehydrogenase (ALAD) enzyme in bone marrow erythroblasts and erythrocytes in heme synthesis. This will result in a decrease in ALAD levels in the blood and an increase in amino levulinic acid (ALA) levels in serum and urine[22].

Lead in all forms is toxic and dangerous for body health. Poisoning caused by Pb metal compounds can occur due to the entry of these Pb metal compounds into the body. The entry of Pb into the body is absorbed very slowly, so that it builds up and becomes the basis for poisoning. The process of Pb entering the body can be done through several routes, namely through food and drink, air and seepage or penetration into the membranes or layers of the skin.[23].

Lead poisoning can be divided into two, namely acute poisoning and chronic poisoning. First, acute poisoning is characterized by levels of more than 0.72 ppm in the blood. Poisoning that occurs is usually caused by the entry of Pb compounds that dissolve in acid or inhalation of Pb vapor. The astringent effect causes thirst and a metallic taste. Other symptoms that often arise are nausea, vomiting with vomit resembling milk due to Pb chloride, and severe stomach pain, black stools due to Pb sulfide, which can be accompanied by diarrhea or constipation. Rapidly absorbed lead can cause shock syndrome which is also caused by fluid loss through the gastrointestinal tract. In relation to the nervous system, inorganic Pb causes paresthesia, muscle pain and weakness, severe anemia and hemoglobinuria occurs because death can occur within 1-2 days.[24].

Second, chronic poisoning. This poisoning is divided into six types of syndrome, namely abdominal, neuromuscular, CNS, hematological, renal and other syndromes (gray face and pale lips, retinal spots, signs of premature aging, etc.). These symptoms can appear some or all at once. Neuromuscular syndrome and CNS syndrome occur with great strain, while abdominal syndrome is a manifestation that occurs slowly. In the United States, CNS syndrome is more often found in children and abdominal syndrome is more often found in adults[24].

The data from FDA-funded experiments showed that Pb was present in lip cosmetics including lipstick and lip gloss at levels below the inductively coupled plasma (ICP) detection limit of 7 ppm. However, the level of Pb below the detection-limit was found to be 14 ppm in the ICP analysis of hundreds of other externally used cosmetics, including blushes, shampoos, eye shadows, and body lotions. In 1980, lead acetate was listed as a color additive in hair dyes. However, on October 30, 2018, the FDA banned the use of lead acetate in hair dyes under the amended "color additive regulations" due to numerous reports on the toxicity of lead acetate in hair dyes. Lead was also included in hair dyes in the form of lead acetate for progressive coloring effects. The principal cause of lead's extended persistence in the environment and in biological organisms is its non-biodegradable nature and reactivity[25].

Thiol-containing antioxidants, heme production enzymes, and a range of enzymes, such as glutathione peroxidase and catalase, as well as antioxidant molecules including superoxide dismutase, glutathione peroxidase, and glucose 6-phosphate dehydrogenase are the main targets of Pb-toxicity. Low blood lead levels can also reduce the action of certain enzymes that speed up the production of reactive oxygen species (ROS) and exacerbate oxidative stress, therefore a high Pb accumulation is not necessary to inhibit the activity of all these enzymes. The main route that leads to the pathophysiology of lead toxicity is oxidative stress. The body uses a variety of cellular, intracellular, and molecular mechanisms to cause lead toxicity, with the central nervous system being the main target. These mechanisms include oxidative stress induction, increased neurocite apoptosis, and interference with Ca(2+) dependent enzymes like nitric oxide synthase[25].

The development of autoimmunity, in which the immune system attacks its own cells, hearing problems, mental retardation and learning disabilities, and intrauterine fatality are the other severe effects of lead poisoning. Furthermore, published population studies show a clear connection between Pb exposure and the development of cardiovascular disease and hypertension later on. According to reports, the primary target for Pb-induced toxicity is vascular endothelium[25].

CONCLUSION

One of the dangerous substances contained in cosmetics is heavy metal lead contamination.

Lead in cosmetic preparations is usually used as a dye, but in large quantities or exceeding the required limit (<20 ppm) it can be dangerous for health. Lead contamination can pose a health threat if it accumulates in the body for a long period of time. The impact can be similar to acute or chronic toxic diseases, and can cause pathological changes in body organs such as the cardiovascular system, kidneys, bones, liver, and can potentially cause cancer. This lead metal contamination can be identified using various analytical methods, one of which is the atomic absorption spectrophotometry (AAS) method. AAS is one of the most sensitive techniques and is very tolerant of complex matrices. Based on several studies, analysis of the lead levels of several cosmetics shows that the majority of cosmetics contain the heavy metal lead (Pb), whether they still meet the requirements or exceed the requirements. Cosmetics containing lead contamination of less than 20 ppm still meet the requirements so they are considered safe to use, while cosmetics containing lead contamination of more than 20 ppm do not meet the requirements so they are not safe to use.

ACKNOWLEDGMENTS

Thank you to the parties who contributed to the writing of this review article, especially to the Medica Farma Husada Mataram Polytechnic who provided suggestions and input on this review article.

REFERENCES

[1] N. L. O. Medicine, "Cosmetics," U.S: https://medlineplus.gov/cosmetics.html.

[2] R. N. Aulia and A. Zuhrotun, "Review Artikel: Penggunaan Metode Analisa Dalam Pengujian Kandungan Zat Berbahaya Dalam Kosmetika," *Farmaka*, vol. 19, no. 3, pp. 109–118, 2021.

[3] F. and D. Administration, "Istilah-istilah dasar dalam toefl," U.S: https://www.fda.gov/cosmetics/cosmetics-guidance-regulation/cosmetics-laws-regulations.

[4] E. Marguí, R. Dalipi, L. Borgese, L. E. Depero, and I. Queralt, "Possibilities and drawbacks of total reflection X-ray fluorescence spectrometry as a fast, simple and cost-effective technique for multielement analyses of cosmetics," *Anal. Chim. Acta*, pp. 27–37, 2019, doi: 10.1016/j.aca.2019.05.005.

[5] N. F. Fauziyah, L. Nurlaeli, R. B. Nian, and F. I. Kesehatan, "Analisis Cemaran Logam Berat Kadmium Dan Timbal Pada Liptint Merek Peiyen Unicorn Yang Dijual Di Toko Online Menggunakan Spektrofotometri Serapan Atom," *JIFIN J. Ilm. Farm. Indones.*, vol. 01, no. 01, pp. 39–49, 2023.

[6] BPOM RI, *Peraturan BPOM No. HK.03.1.23.07.11.6662 Tahun 2011 Tentang Persyaratan Cemaran Mikroba Dan Logam Berat Dalam Kosmetika*. 2011.

[7] S. A. Azis, M. Irham, S. Sugianto, I. Setiawan, and A. Adnan, "Analysis of research methodology on the content of heavy metals in sediments on the Indonesian coastal," *Depik J. Ilmu-Ilmu Perairan, Pesisir dan Perikan.*, vol. 10, no. 3, pp. 260–266, 2021, doi: 10.13170/depik.10.3.21275.

[8] D. Sylvia, D. L. Sari, and N. Rusdiana, "Heavy Metal Analysis on Blush on Online Selling by Atomic Absorption Spectrophotometry Method (AAS)," *Proc. 4th Int. Conf. Sustain. Innov. 2020–Health Sci. Nurs. (ICoSIHSN 2020)*, vol. 33, pp. 343–347, 2021, doi: 10.2991/ahsr.k.210115.072.

[9] A. A. Alqadami *et al.*, "Determination of heavy metals in skin-whitening cosmetics using microwave digestion and inductively coupled plasma atomic emission spectrometry," *IET Nanobiotechnology*, vol. 11, no. 5, pp. 597–603, 2022, doi: 10.1049/iet-nbt.2016.0212.

[10] S. R. N Endah and S. I. Surantaatmadja, "The Determination of Heavy Metals Level : Lead in Cosmetic Soap Preparation by Atomic Absorption Spectrophotometer (AAS)," *J. Phys. Conf. Ser.*, vol. 1179, no. 1, 2019, doi: 10.1088/1742-6596/1179/1/012178.

[11] A. Yugatama, A. K. Mawarni, H. Fadillah, and S. N. Zulaikha, "Analisis Kandungan Timbal dalam Beberapa Sediaan Kosmetik yang Beredar di Kota Surakarta," *JPSCR J. Pharm. Sci. Clin. Res.*, vol. 4, no. 1, pp. 52–59, 2019, doi: 10.20961/jpscr.v4i1.28948.

[12] F. Fatmawati, A. Asnawi, and S. Erawan, "Analisis Kadar Timbal pada Sediaan Maskara dari Pasar Lokal di Bandung," *al-Kimiya*, vol. 6, no. 1, pp. 28–31, 2019, doi: 10.15575/ak.v6i1.4454.

[13] D. C. Dewi, Ri. Mahmudah, O. R. Kumalawati, and D. Amalullia, "Analisis Kadar Timbal (Pb) pada Bedak Tabur dan Eyeshadow dengan Variasi Metode Destruksi dan Zat Pengoksidasi dengan Spektroskopi Serapan Atom," *Alchemy J. Chem.*, vol. 7, no. 1, pp. 1–6, 2019, doi: 10.18860/al.v7i1.7016.

[14] F. Fauziah, A. Maulinda, and A. Adriani, "Analysis Of Heavy Metal Pollution (Pb) In Lipstick Are For Sale In The City Of Banda Aceh By Using Atom Absorption Spectrophotometry," *J. Pharm. Sci.*, vol. 3, no. 2, pp. 77–84, 2020, doi: 10.36490/journal-jps.com.v3i2.47.

[15] F. Jaya, A. Guntarti, and Z. Kamal, "Determination Of Pb Levels In Various Shampoo Brands By Atomic Adsorption Spectrophotometry Methods," *Pharmaciana*, vol. 3, no. 2, pp. 9–14, 2021, doi: 10.12928/pharmaciana.v3i2.425.

[16] M. Farida, R. Kurniaty, and A. Thahirah, "Analisis Logam Timbal (Pb) Dalam Eye Shadow Menggunakan Atomic Absorption Spectrophotometry (AAS)," *Serambi Konstr.*, vol. 4, no. 2, pp. 383–387, 2022.

[17] D. Arifiyana and V. A. Devianti, "Analisis Cemaran Logam Berat Timbal (Pb) Dalam Sampel Bedak Menggunakan Spektrofotometer Serapan Atom (SSA)," *J. Farm.*, vol. 7, no. 1, pp. 1–5, 2021, [Online]. Available: http://repository.akfarsurabaya.ac.id/id/eprint/5%0Ahttp://repository.akfarsurabaya.ac.id/5/1/AERTIKEL ILMIAH_13515112_ERMAYULIS.pdf

[18] H. Arshad, M. Z. Mehmood, M. H. Shah, and A. M. Abbasi, "Evaluation of heavy metals in cosmetic products and their health risk assessment," *Saudi Pharm. J.*, vol. 28, no. 7, pp. 779–790, 2020, doi: 10.1016/j.jsps.2020.05.006.

[19] BPOM RI, *Peraturan Kepala Badan Pengawas Obat dan Makanan Republik Indonesia Nomor 17 Tahun 2014 tentang Perubahan atas Peraturan Peraturan Kepala Badan Pengawas Obat dan Makanan Nomor HK 03.1.23.07.11.6662 Tahun 2011 Tentang Persyaratan Cemaran Mikroba dan Logam* . 2014.

[20] F. Febriatama, E. Endrinaldi, and Z. D. Rofinda, "Analisis Kandungan Timbal pada Lipstik yang Terdaftar dan Tidak Terdaftar di Badan Pengawas Obat dan Makanan yang Dijual di Pasar Raya Kota Padang," *J. Kesehat. Andalas*, vol. 7, no. 4, pp. 475–479, 2019, doi: 10.25077/jka.v7i4.904.

[21] D. Arifiyana, "Analisis Kandungan Logam Timbal pada Sediaan Kosmetik Bedak yang Beredar di Pasar Pengampon Surabaya," *J. Pharm. Sci.*, vol. 4, no. 2, pp. 111–114, 2019.

[22] E. F. Yanti and Z. Laili, "Analisis Logam Berat Timbal (Pb) Dalam Body Lotion Yang Beredar di Pasar Jember," *J. Islam. Pharm.*, vol. 7, no. 2, pp. 94–99, 2022, doi: 10.18860/jip.v7i2.17448.

[23] T. Alawiyah and R. Herowati, "Detection Of Heavy Metal Pb In Cosmetics At Banjarmasin Traditional Market," *J. Pharmasci (Journal Pharm. Sci.*, vol. 6, no. 2, pp. 99–102, 2021.

[24] P. Dinake, O. Motswetla, T. T. Kereeditse, and R. Kelebemang, "Assessment of level of heavy metals in cosmetics," *Toxicol. Res. Appl.*, vol. 7, pp. 1–8, 2023, doi: 10.1177/23978473231156620.

[25] S. Ali *et al.*, "Toxicology of heavy metals used in cosmetics," *J. Chil. Chem. Soc*, vol. 67, no. 3, 2022.