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An Update to Toxicological Profiles of Heavy Metals, Especially Lead as Hazardous Environmental Pollutant: A Review

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ABSTRACT
Globally, Environmental pollution is one of the most important issues of concern to international organizations, international scientific centers and researchers in the fields of environmental and health sciences. Heavy metals are chemical pollutants whose levels increase in water, air and soil, which leads to a threat to the stability of ecosystem and the sustainable development. Contamination of heavy metals in the environment is a major global concern. Recently, the industrial and agricultural activities have caused massive increases in human, animals and plants exposure to heavy metals. Lead (Pb) is considered one of the heavy metals and is characterized by its high risk and toxic effects on living organisms. The health problems caused by Pb have been well documented over a wide range of exposures on every continent. Pb toxicity has been recognized as a major public health risk. This article reviews recent updates regarding the toxicological profiles of heavy metals. The focus was on Pb toxicity and this review covers the range of Pb exposures and its effects on several organs of body.

Keywords: Environmental pollution, ecosystem, heavy metals, lead, toxicity.

Introduction

Environmental pollution

Environmental pollution is the primary cause of various diseases and premature deaths throughout the globe. Every year, around 9 million deaths occur because of pollution which is about 16% of the total deaths all over the world. Death with pollution is nearly three times more than that of acquired immunodeficiency syndrome (AIDS), malaria and tuberculosis combined together (Landrigan *et al.,* 2018). In certain countries, where pollution is more severe, it accounts for the death of more than one in every four people. Children are most susceptible to pollution (Suk *et al.,* 2016). As the pollutants are non-degradable, highly toxic and have a tendency to accumulate biologically, they are not only responsible for carcinogenic, toxic, mutagenic and teratogenic effects in humans or other living beings but can also cause severe risk for the sustainability of the environment (Bilal and Iqbal, 2019).

Heavy metals

The utmost harm to the environment is caused by heavy metals as they contaminate the entire food chain. Heavy metals can contaminate the soil ecosystem and the whole agricultural land which could make the crop unfit for consumption both for human beings as well as animals owing to carcinogenicity and various other serious health issues (Mao *et al.,* 2019). In many big cities, heavy metals are the reason for major and crucial contamination (Li, 2015; Nagarajan *et al.,* 2014). Heavy metals are the main environmental contaminants that are concealed, persistent and have cytotoxic as

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well as bioaccumulating properties (Zhang *et al.,* 2017). They have the potential to cause permanent damage to the entire ecosystem (Adamiec *et al.,* 2016; Khorshid and Thiele-Bruhn, 2016).

As soon as the heavy metals are released in the environment via drinking water, air, food or various other synthetic chemicals and manufactured goods, they are transported into the organism's body through ingestion, inhalation and absorption by the skin. When the rate of ingestion and accumulation is faster than the detoxification and disposal mechanism, the slow accumulation of these toxins occurs inside the body (Sardar *et al.,* 2013).

Shah, (2021) defines heavy metals as substances inherent to nature with high molecular weight, widespread and, in many cases, very useful, such as lead, which is widely used for pipes, and cadmium. Concerning pollution, heavy metals have effects on health and affect different organs. That would be a more or less general definition. The author further explains that there are several ways to define the term "heavy metal." One of them is referred to the atomic weight and would define heavy metal as a chemical element between 63.55 copper (Cu) and 200.59 mercury (Hg); another way refers to metals with a density between 4 g/ cm^3 up to 7 g/ cm^3, and there is also another classification referring to atomic number (Medfu *et al.,* 2020).

Moreover, not all high-density metals are especially toxic in normal concentrations (some are necessary for humans) (Rai *et al.,* 2019). However, there are a series of heavy metals better known for their tendency to represent serious environmental problems: mercury (Hg), lead (Pb), cadmium (Cd) and thallium (Tl), as well as Cu, zinc (Zn) and chromium (Cr). Sometimes when talking about contamination by heavy metals, other light toxic elements such as beryllium (Be) or aluminum (Al) or some semimetal such as arsenic (As) are included. They further conclude that the danger of heavy metals lies in the fact that they cannot be degraded (neither chemically nor biologically) and they tend to bioaccumulate and bio-magnify (which means that they accumulate in living organisms reaching concentrations greater than those reached in food or environment and that these concentrations increase as there is movement up the trophic chain), causing toxic effects of a very diverse nature. In humans, countless physical effects (chronic pain, blood problems, etc.) and psychic effects (anxiety, passivity, etc.) have been detected (Sall *et al.,* 2020; Ventriglio *et al.,* 2021).

Sources of heavy metals pollution

Tepanosyan *et al.* (2017) found that domestic effluents, pharmaceuticals, agricultural, industrial geogenic, and the atmospheres are major sources of heavy metal pollution. They also further state that smelter, foundries, and mining activities are prominent sources of heavy metal pollution and other metal-based industrial operations. The authors concluded that one has to follow the natural process: where they are distributed and concentrated. The most important because of its abundance is the lead present in lead pipes, which are no longer used and replaced by plastic. However, many of the city's facilities still have lead pipes, so as the water passes through the lead pipe, it releases particles, and little by little, it contaminates. Another source is lead paint used in crafts, especially kitchen utensils, so when one eats, Pb is released from the paint and enters the body. A third source is gasoline that was previously used with Lead, and now it has been eliminated (Levallois *et al.,* 2018).

The following Table shows the sources of the heavy metals and their effects (Abbas *et al.,* 2014).

Heavy Metal	Source	Effect
Pb	Mining, paint, pigments, electroplating, manufacturing of batteries, burning of coal	Anemia, brain damage, anorexia, malaise, loss of appetite, Liver, kidney, gastrointestinal damage, mental retardation in children
Cu	Plating, copper polishing, paint, printing operations	Neurotoxicity, and acute toxicity, dizziness, diarrhea
Cd	Plastic, welding, pesticide, fertilizer, mining, refining	Kidney damage, bronchitis, Gastrointestinal disorder, bone marrow, cancer, lung insufficiency, hypertension, Itai–Itai disease, weight loss
Hg	Batteries, paper industry, paint industries, mining	Damage to nervous system, protoplasm poisoning, corrosive to skin, eyes, muscles, dermatitis, kidney damage
As	Smelting, mining, rock sedimentation, pesticides,	Bronchitis, dermatitis, bone marrow depression, hemolysis, hepatomegaly,

Uptake, transport, and accumulation of heavy metals by organisms

Bioaccumulation is the major method through which the uptake, transport, and accumulation of heavy metals finds its way into living organisms. In summary, based on the Jitar *et al.,* (2015) results obtained and taking into account the habitual participation of organism in the diet, most edible species' consumption cannot be considered a health risk due to the presence of metals. However, it would be advisable not to increase the consumption of wild terrestrial micro-mycetes excessively. It is advisable to moderate the consumption of species of the genus Boletus, especially in crude oil, due to their mercury content and the specimens of macro-mycetes that develop in urban areas or close to highways due to its Pb content (Melgar *et al.,* 2009). The high Cd content in Agarics macrospores makes it advisable to reduce its consumption as much as possible or to avoid it completely. Cu and Zn do not pose a toxicological risk through the consumption of mushrooms and, on the contrary, constitute an interesting contribution of these elements to the diet (Jitar *et al.,* 2015).

Shahid *et al.* (2017) reported that the heavy metals are potentially toxic elements, whose presence in the environment has increased exponentially in recent decades, mainly due to man's action. Large amounts of these metals and other pollutants are discharged into the atmosphere, soil, water, and, finally, enter living organisms through one of the nutrient cycle pathways. Metallic contamination poses a significant environmental challenge for living things, as several metals that are essential micronutrients, such as Cu and Zn are toxic in high concentrations. In contrast, others, such as Cd, Pb, and Hg, are toxic at minimal doses. Among the organisms present in terrestrial ecosystems, the macro-mycetes are particularly noteworthy due to their ubiquity and extensive and intimate integration in the environment. The mycelium of these organism can capture and bioaccumulate heavy metals, appearing later in the carp fora or mushrooms, in concentrations sometimes much higher than those of the medium (Mao *et al.,* 2019).

Toxic Effects of heavy metals contamination on public health

Each metal and each contaminating chemical element have a mechanism of action and a preferred place of accumulation as per the findings of Mahurpawar, (2015). The best known is Pb which affects several systems. For example, in the nervous system, it damages neurons, especially those of the brain. Pb also affects the bone marrow and another place where it is frequently found in the kidney, specifically in the nephrons' tubular system. Another heavy metal is Cd that also affects the kidney. It is the as that has a direct effect on the mitochondria. The damage itself is very diverse depending on each metal, but in general, it can be said that there is cellular injury. Pb poisoning can mimic other diseases, such as sclerosis, which is an incurable disease very complicated in terms of its symptoms, and Pb poisoning can simulate and affect the nervous system with the same symptoms, such as paresthesia, paresis, fatigue, etc., and can generally produce a dysfunction. The important aspect of Pb is that it has recently been linked to the generation of antisocial behaviors. There is also a relationship with mental retardation and loss of cognitive abilities (Mumtaz *et al.,* 2020; Xu *et al.,* 2018)

Jan *et al.* (2015) stated that the heavy metal contamination is quite serious since it changes its alkalinity. It depends a lot on the concentration. They also pollute water and crops. If it is an excessive amount of lead, some alterations in the plants can occur. It also degrades the soil, which decreases its productivity. If the contamination is excessive, it can lead to desertification. At the level of rivers and lakes, it also mainly affects fauna. The problem of contamination of the environment by heavy metals is that their effect is silent, it is not seen, and by the time people realize the damage they cause, it is too late and above all that they are dangerous to health. Fortunately, measures are being taken, although some industrialized countries have taken a lot to implement these.

The concern about the impact of metal pollution was born as early as the sixties. Ghorbani and Kuan, (2017) point out that there is no reliable evaluation of the situation of contamination by chemical elements and that, in principle, there are suspicions of contamination due to the discharge of mining tailings and industrial wastes in several rivers of the country. The Instituto de Ingenieros de Chile establishes that Cu and gold (Au) mining represents the most important source of liquid effluents that are discharged into the environment, where the most common pollutants of these are arsenic, mercury, and cyanides (Cn) (Wu *et al.,* 2016) describe the presence of some heavy metals and metalloids with their respective polluting sources and affected areas at the national level.

Meza-Ramírez *et al.* (2021) carried out a study on heavy metal contamination in the Puchuncaví area (Valparaíso Province, V Region, Peru). In this study, it was found that the soils contained, in general, high levels of Cu, Pb, Zn, and Cd, not justified in the soils of the area, naturally very low in these metals. The most prominent element found in this study was Cu A similar study, developed by Wu *et al.* (2016) demonstrated an abnormal presence of Cd, Cu, Pb, and Zn, Cu being again the element most exceeded over normal levels and maintaining a proportionally inverse relationship between concentration and distance from the industrial zone.

Fierro *et al.* (2021) point out that in a systematic survey of the waters of the Aconcagua River, enrichment of molybdenum was detected in the waters of the Blanco and Juncal rivers in Chile when receiving discharges from the El Saladillo mining center. In turn, Rodríguez *et al.* (2018) in a study on trace elements in the Maipo and Mapocho valleys' surface waters, estimates that the high cupricity and acidity of the San Francisco River is the preferred product of an existing Cu extraction center above the sampled sites. However, the diversity of possible environmental conditions has limited these studies to very specific conditions and not very applicable to field conditions. These studies' conclusions vary and differ from each other depending on the particular environmental conditions and the metals under study. Notwithstanding the above, and as expected, all agree that on certain concentrations, various symptoms of toxicity are observed, including the respective losses in yields (Peña-Guerrero *et al.,* 2020).

Although the forms of contamination of the mining industry are diverse, the great final receptor of the pollutants in the soil, since it is in this substrate where these pollutants are continuously deposited, regardless of the dispersion path (air or water) (Paul, 2017). Within these, heavy metals have been the subject of innumerable investigations tending in the first place, to determine their presence and their relationship with the polluting source. This is how it has been concluded that in various localities of the soils and watercourses present concentrations of heavy metals much higher than normal, associated with polluting processes of generally mining industries and close to said localities (Bhardwaj *et al.,* 2017).

The soils irrigated by the Cachapoal River in Chile are contaminated due to the presence of heavy metal traces according to the findings of Copaja *et al.,* (2016). This contamination has produced copper toxicity in tobacco plantations, within the most polluting sector. In the surface strata, copper concentrations are higher than those defined as toxic. (Alengebawy *et al.,* 2021; Kolbas *et al.,* 2020).

Bosch *et al.* (2016) claimed that the recent experiences and research cited in the literature highlight the need to incorporate the concept of risk in production into agricultural policies, which, together with the effect that the level of inputs has on the product, allows the associated benefits to be evaluated with greater certainty to the incentive policies in the use of said inputs. The various investigations in this regard conclude that in addition to increasing production as the level of use of certain inputs increases, its variance decreases or increases depending on the input considered; that is, the variance of production is conditional on the level of use of certain factors of production. These conclusions are relevant if one wants to evaluate the real impact of polluting elements, heavy metals in this particular case, and the yield and variance of commercial crop production. Suppose a heavy metal occurs in supernormal concentrations in a given soil. In that case, the quantification of the negative externality of the associated polluting process must consider the losses in yields and the effect on production's central moments (Masindi and Muedi, 2018).

The estimation methodology allows people to conclude that Cu harms the expected total dry matter (DM) production of wheat and alfalfa in some soil series once a critical level is exceeded (Ma and Zheng, 2018). Furthermore, in some soil series and the impact on the expected DM production, it is concluded that Cu would hurt the variance of the DM production of wheat and alfalfa once a critical level is exceeded. That is, the effect of Cu would be consistent with a multiplicative specification. However, there are no significant impacts of increases in Cu concentrations in other soil series, indicating that Cu's effect would be consistent with a rather linear specification. Thus, when estimating the model corresponding to the third moment of the distribution of production for each crop, significant evidence was detected that relates to changes in the symmetry of the distribution of yields compared to increases in the concentration of copper in the soil with a level of significance of 16%, comparatively much lower significance than those that characterize the previous models. In principle, this would indicate that the effect of Cu would not be consistent with a multiplicative specification (Rezaeian *et al.,* 2020).

Tóth *et al.* (2016) claimed that if the water is contaminated, and people have to bathe, drink the water, etc., contact with heavy metals cannot be avoided. That is, there is no direct measure such as boiling water in the case of bacterial contamination, so it is impossible to take a direct measure. Still, it can be prevented by preventing metals from reaching the water and soil. It is then necessary to control contamination sources with heavy metals; prevent them from spreading into the environment by preventing waste containing heavy metals from reaching it. Specifically, sanitary measures are mainly prevention: identifying sources of contamination, controlling their diffusion, trying not to include raw material containing heavy metals in industrial processes, and other similar ones (Shahid *et al.,* 2017).

Treatment resulting from heavy metal contamination depends a lot on intoxication levels (Hassaan *et al.,* 2016). With Pb, for example, which is the most studied, its presence in hair indicates a very high degree of contamination. As it affects the nervous system, subtle changes such as behavioral changes can be attributed to other factors such as school, family environment, etc. Pb poisoning is a very difficult disease to suspect and, therefore, to diagnose. Perhaps something very important is that Pb affects the child causing poor school performance (Ijomone *et al.,* 2020). When it is consulted on this, it is thought that it is for the teacher, for nutrition, for his family environment, the environment at school, etc., but Pb will hardly be thought of.

Javed and Usmani, (2016) in support of the above sentiments, claims that there are some treatments, but it is very difficult to remove from the body. It can be treated with chelators, which are substances that go to capture Pb and then be eliminated; that's the only direct treatment. The symptoms or damage caused by heavy metals is also treated, depending on where it has been. For example, if there is severe damage to the kidney, the treatment is not to remove the Pb, but to perform a transplant depending on kidney damage. The main tests measure the concentration of the metal in blood using a chemical test. One method is the detection of Pb by atomic absorption chromatography, but it is an expensive procedure. That same detection can be done on the hair.

Lead (Pb)

Lead (Pb) is a metal that is considered as a major environmental contaminant. Various studies have suggested that Pb can trigger serious health issues and diseases (Jacobs *et al.,* 2009). Pb is naturally present inside the earth's crust and possesses several distinctive properties. It is soft, highly malleable, and ductile, it has a low melting point. Lead is regarded as a major health hazard for human beings through numerous aspects (Sachdeva *et al.,* 2018). Pb prevails as a major health problem for children as they continuously get exposed to Pb that is coming from degenerated wall paints, water supply using Pb pipes, toys, cosmetics and many other synthetic products along with the contaminated soil (Fortoul *et al.,* 2005; Klemick *et al.,* 2019). After getting in the body, Pb reaches the liver, where it causes severe damage and can disrupt its normal functioning. The histopathological tests can diagnose the damaged liver which is mostly associated with increased levels of blood enzymes and decreased protein synthesis (El-boshy *et al.,* 2017; Yuan *et al.,* 2014).

Boldyrev, (2018) defined Pb as a natural material found in the earth's crust and was discovered in 6500 BC. The industrial revolution triggered an epidemic metal poisoning and forced scientists and physicians to study the specific symptoms and organic changes associated with chronic Pb poisoning. Several hypotheses have been proposed to explain the mechanism of Pb toxicity, but no single mechanism has been defined so far. The release of Pb into the environment has decreased in recent years in developed countries due to the prohibition of lead toxicity (Bell and Deubzer, 2018).

Chemistry of lead

Poltabtim *et al.* (2018) described the chemistry of Pb extensively. Lead's clinical and chemical characteristics reflect the inhibition of the enzyme porphobilinogen synthase by Pb, which can react with the enzyme's sulfhydryl groups or displace zinc. This review reflects the adverse health effects of this metal, which is present in some occupational activities and the environment in general and is intended to update knowledge.

Some of the physical properties of Pb is that it is a bluish-gray metal, shiny on recent surfaces, very soft, so soft that it is scratched with the nail, very malleable, and is the least tenacious of all metals, it has great density and a low melting point, it crystallizes in octahedra. Kumar *et al.,* (2020) found that Pb leaves a gray stain on the paper. Further, the authors found some of the main physical parameters, such as density, 11.85. This value makes it a dense, toxic, and accumulative metal. Of the metals in everyday use, Pb is one of the metals with the highest density, except for precious metals. Its physical properties include atomic number 82 while its chemical symbol is Pb. In addition, its atomic weight is 207.21. It has a bundance of isotopes while it is slightly soluble in water.

Pb in contact with air oxidizes superficially, covered with a grey layer of lead sub oxide (Pb_2O), which removes its metallic shine and protects it from further oxidation. When freshly melted, it quickly oxidizes, forming the product PbO, which is known as masicot. Chemically pure water almost does not attack it, but as it always contains carbon dioxide and free oxygen, there is always an attack when it is in contact (Islam, 2011).

Pb oxide is also soluble in alkali hydroxide solutions to form the corresponding plumbite salt.

$$PbO + 2OH^- + H_2O \rightarrow Pb(OH)_4^{2-}$$

Chlorination of plumbite solutions causes the formation of lead's +4 oxidation state.

$$Pb(OH)_4^{2-} + Cl_2 \rightarrow PbO_2 + 2Cl^- + 2H_2O$$

Pb is altered in the presence of rainwater and CO_2 in the air, covering itself with a layer of hydrated carbonate. This salt dissolves little in the water, giving it toxic properties. For this reason, rainwater that falls on roofs covered by Pb surfaces or containers containing Pb should not be used in food (Zdeb *et al.,* 2020). The hydrocarbonate decomposes again into CO_2 and lead hydroxide, and thus the reaction continues indefinitely. The recommendation is almost extensive for the inhabitants of the mountains and jungle, areas where large amounts of rain precipitate, and therefore lead-downpour contact should be avoided (Gittleman *et al.,* 2017). On the other hand, with ordinary or distilled water, this reaction does not occur since it contains free sulphates. These react with lead, forming lead sulphate, which is insoluble and prevents the subsequent chemical attack of lead. Still, when the waters are scarce or poor in sulphates and rich in carbon dioxide, it is possible that chemical reactions can occur (Ng and Lin, 2015). Dilutes sulphuric acid does not react with it, instead of concentrated and hot generates lead sulphate II. Cold dilute hydrochloric acid also does not react but the concentrated one reacts with lead. Cold nitric acid dissolves it giving lead II nitrate and nitrous fumes, very toxic (Amrane *et al.,* 2017). The solutions of lead salts in reaction with zinc react, displacing the zinc to lead and forming lead sulphate II, a compound in a branched spongy form known as Saturn's tree. This happens because Pb has a solution of lower stress than zinc (Boldyrev, 2018).

Sources of lead pollution

Monna *et al.* (2004) in their findings, stated that the environmental contamination by Pb and its potential adverse effects have been observed. The amount of Pb released into the environment is closely related to the metal production in the last 5,000 years; approximately half of Pb produced is released as a pollutant. Thus, the estimated annual global production is about 3.4 million metric tons, of which about 1.6 million are released into the environment. Pb is indestructible and cannot be transformed into a harmless form. The dispersion of the metal knows no geographical limits and contaminates areas far from the original emission site. The authors further claim that Pb found in the atmosphere comes basically from the combustion of leaded gasoline; Other sources considered are coal, oil combustion, mining, the production of certain types of manufactures, fertilizers, incineration, the production of blocks of cement, and the combustion of wood. The historical environmental effects of these emissions on Pb levels in humans have been demonstrated by comparing the concentrations of this metal in pre-Columbian indigenous remains and modern humans so that levels between 100 and 1000 times higher have been found for the latter (Pompeani *et al.,* 2019).

Leroux *et al.* (2018) are of the view that although steps have been taken to reduce the concentration of Pb in gasoline, paint, canned food, and toys, the tradition of using glazed pottery persists today; to this is added the lead released into the environment in previous years. Low temperature glazed ceramics release substantial amounts of Pb on contact with food, especially if they have a low pH. A short time ago, using a new technology incorporating boron-derived products was approved in the glazing process, replacing the traditional method that contains Pb. However, this new technique has not yet become widespread, and its results have not been evaluated, so it is unknown if the problem can be solved in the short term (Zhang *et al.,* 2015). On the other hand, there are other measures that, although they have been put in place and for which there are regulations, their compliance is not subject to monitoring.

Accumulation of lead in organisms

According to the studies conducted by Malar *et al.,* (2016), Pb enters the body through intestinal absorption by ingestion, into the lungs by inhalation, and through the skin. Once in the body, it is transported by the bloodstream to all organs and tissues and, once absorbed, can accumulate in bones, teeth, liver, lungs, kidneys, brain, and spleen; it is also capable of crossing the blood-brain barrier, and the placenta. Pb is more easily absorbed on an empty stomach than when ingested with food (Mahurpawar, 2015).

Additionally, Kastury *et al.* (2019) suggested that 50% of Pb vapors and fumes reach the lung by absorption. The blood distributes this metal throughout the body, damaging soft organs such as the central and peripheral nervous systems. Still, the earliest and most obvious damage is caused in the blood by interfering with the synthesis of globin in the red blood cell and blocking the fixation of the iron; the result is anemia. Pb poisoning is known as Pb poisoning in the blood, which blocks the synthesis of hemoglobin and alters oxygen transport to the blood and other body organs. Besides, increased Pb exposure has been associated with many illnesses in both children and adults (Hauptman *et al.,* 2017).

Mayans (2019) concluded that concerning children's exposure they are more susceptible because, about their mass, they inhale more air and ingest more soil than adults and because of the hand-mouth interaction, so common during childhood, that it facilitates the intake of powder; Furthermore, it is necessary to consider that the gastrointestinal absorption of Pb in infants is up to five times higher than in adults. Lead's concern is especially focused on children as they are more vulnerable to the metal's adverse effects during the growth and development of the nervous system. In them, there is greater absorption by the respiratory and oral routes, especially by this last if one suffers from malnutrition, calcium, iron, phosphorus, zinc, and vitamin D deficiencies and gastrointestinal infections. The clinical manifestations are imperceptible and include periods of constipation and diarrhea with abdominal cramps and continuous headaches (or both), changes in behavior and poor school performance, intoxication is chronic and worsens after the mentioned symptoms, manifestations of encephalopathy, stupor, seizures and respiratory depression (Zeng *et al.,* 2019).

Hladun *et al.* (2015) did a study regarding the work environment. As a result of various industrial processes, workers are exposed to different compounds containing toxic metals such as Pb that cause high risks of occupational diseases and impact the ecosystem. Their findings found that the build-up of lead in the body causes long-term, low-dose exposure in the workplace to lead to chronic toxicity. Acute Pb poisoning in adults is rare but can occur after high respiratory doses by absorption through the digestive tract or percutaneously, leading to encephalopathies. Water pollution from industrial effluents puts human health at risk due to the presence of heavy metals such as Pb.

Nazir *et al.* (2015) suggested that in dealing with the topic of excess Pb tap water, many authors explain that drinking water flows out practically lead-free. Still, metal is introduced when it passes through service pipes and Pb -soldered joints or joints when it remains next to brass or bronze accessories that contain it. Another mechanism of lead toxicity is its ability to interact with metal-binding proteins and enzymes. The interaction generally includes the binding of Pb to sulfhydryl groups and, to a lesser extent, to phosphate and carboxyl groups; protein binding can cause the protein structure to undergo a conformational change and alter the protein's ability to function normally. Pb in bone tissue displaces calcium from the bones to deposit in them, increasing their brittleness.

Systems and organs affected by lead

Pb can be inhaled and absorbed through the respiratory system or ingested and absorbed through the gastrointestinal tract; percutaneous absorption of inorganic Pb is minimal, but this route well absorbs organic Pb. After Pb ingestion, it is actively absorbed, depending on the shape, size, gastrointestinal transit, nutritional status, and age; there is greater absorption of Pb if the particle is small presence of iron and calcium deficiency, incidence of a large fat or inadequate calorie intake, and when the child is a child since lead absorption in them is 30 to 50%. In comparison, in adults, it is 10%. Some of the body systems affected by Pb poisoning include the hematopoietic system, kidney, and liver (Shukla *et al.,* 2018).

Hematopoietic system

Assi *et al.* (2016) concluded that Pb is toxic to enzymes dependent on zinc. The organs most sensitive to toxicity are the hematopoietic system, the central nervous, and the kidney. The hematopoietic system interferes with the synthesis of heme, since it binds to the sulfhydryl groups of metalloenzymes such as aminolaevulinic dehydratase coproporphyrinogen oxidase, and ferro chelatase, being the result, the increase in protoporphyrin's such as zinc-protoporphyrin (ZPP) and anemia. Acute toxicity occurs after exposure to respiratory at high concentrations, with encephalopathy, kidney failure, and gastrointestinal symptoms. Chronic toxicity is the most frequent and manifests with a multisystemic compromise: hematopoietic, nervous system, gastrointestinal, and kidney.

Kidney

Boskabady *et al.* (2018) suggested that as for the kidney, heavy metals will eventually cause kidney damage that can lead to kidney failure. Then something important about Pb is that it has been linked lately with the generation of antisocial behaviors since it affects the part of the brain that codes for socialization. There is also a relationship with mental retardation and loss of cognitive abilities. As for the kidney, heavy metals will eventually cause kidney damage that can lead to kidney failure.

Ara and Usmani (2015) referred to the subject, that the highest concentrations of Pb are registered in the kidneys, especially in the proximal burial mounds. Chronic exposure can cause hypertension. On the other hand, exposure to high doses of Pb is a risk factor for kidney failure. Also, according to (Ara and Usmani, 2015) decreased spermatogenesis and menstrual disorders can be caused. When talking about sexual maturation and Pb exposure, other authors state that high levels of Pb in the blood have been associated with a delay in sexual maturation: in a study by National Health and Nutrition Examination Survey II Data (NHANES II) in 8 to 18-year-old boys and girls breast development and pubic hair, as well as age at menarche, were significantly delayed in African American and Mexican American girls who had blood Pb levels greater than 40ug / dl. Because of their knowledge of the effects of Pb, the authors of this study consider it important to make their findings known to risk personnel when considering the large number of activities in which this metal is involved in occupational and daily life (Naicker *et al.,* 2010).

Testis

Li *et al.* (2018) stated that the exposure to Pb affect testis by reduces sperm count because it is a male reproductive toxicant. In addition, they found that lead contamination has an effect on retarded the activity of spermatozoa and sperm motility. However, they also noted the effect of Pb on testis is an issue under controversy since a low dose exposure was found to not affect in some cases, but in other, it arrested spermatogenesis. Additionally, several experimental showed that Pb induced testicular injury (Sudjarwo *et al.,* 2017; Ezejiofor *et al.,* 2019; El-Khadragy *et al.,* 2020; Abdel-Emam and Ahmed, 2021).

Liver

Pb causes liver damage by increasing oxidative stress according to Teerasarntipan *et al.* (2020) a diet low in antioxidants is, therefore, one of the causes of oxidative stress. But other factors contribute significantly to its development. Environmental pollution, active and passive smoking, excessive exposure to sunlight, excessive alcohol consumption, the action of certain medications, exposure to toxic substances, or unbalanced physical activity are just some of those factors that favor the proliferation of free radicals and, therefore, oxidative stress. Therefore, the liver gets damaged through the oxidative stress mechanism. Moreover, previous investigations revealed that the exposures to Pb induced hepatotoxicity and liver dysfunction (Chen *et al.,* 2019; Albasher *et al.,* 2020; Shirazinia *et al.,* 2021; Abdel-Emam and Ali, 2022).

Conclusion

Pb is one of the heavy metals and has dangerous and toxic effects on human, animals and plants. Many scientific studies and reports indicate an increase in its rates in water, air and soil and its accumulation in body tissues, which leads to changes in the structure and functions of organs. As a result of the increasing rates of Pb concentration in the environment, effective and successful solutions must be developed to limit the increase of Pb levels in the environment and to maintain the stability of ecosystem in a way that provides survival opportunities for living organisms.

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