Heavy Metal Toxicity and its Effect on Living Organisms: A Review in Toxicology Study

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ABSTRACT

The pollution chain of heavy metals, such as industry, climate, soil, water, food and humans, nearly always assumes cyclical order in the climate. It is clear that the harmful consequences are caused by prolonged exposure to metalloids and heavy metals at minimum doses. It has been proven that heavy metals are harmful for environmental and human. Strong toxicity of a metal is recognized with a significant hazard and it is associated with many health hazards. They also antagonism component of the body, but metabolic activities can interact with metabolic processes at some times. By reduction exercises, few metals, such as aluminum, can be eliminated.

Kewords: Free radicals, Metal toxicity, Heavy metals, Oxidative stress.

1. Introduction

Metals comprise a significant class of radioactive compounds found in working and environmental environments on a regular basis. Due to the ubiquity of its exposure, the influence of such toxic agents on human health is currently an area of passionate concern by growing the use of large truth of metals in industry and in everyday life job hoods [1, 2, 3]. Heavy metals are important environmental contaminants, their toxicity is a significant environmental issue [4].

The heavy metals widely present in waste water which cause undesirable effects to health and environmental through entering the atmosphere by human activities [5]. Also erosion of soil, natural weathering of the earth's crust, industrial effluents, mining, urban runoff, sewage discharge, insect or disease controlling agents, which are applied to crops [6].

2. Toxicity mechanisms of heavy metals and their effects on humans

Thirty five metals, most of which belong to heavy metals (arsenic,bismuth, antimony, cerium, cadmium, chromium, cobalt, copper, gold, gallium, iron, manganese, lead, mercury, nickel, platinum, silver, tellurium, thallium, tin, plutonium, vanadium, and zinc), are of interest to us because of residential or industrial exposure [7]. Fig. 1 shows the effect of some heavy metals.

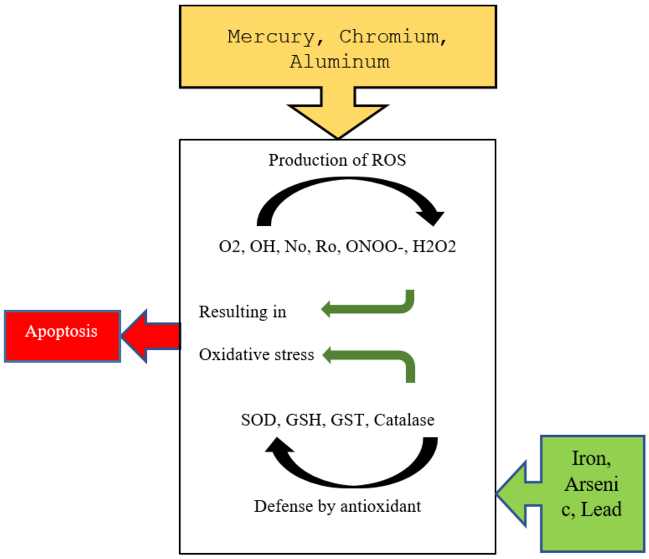

Fig.1: Effect of some heavy metals.

2.1. Arsenic

Arsenic is semi-metallic in nature and is one of the most common heavy metals, triggering ecological and personal health warning because it is prominently poisonous and carcinogenic, because it is the twentieth most abundant element on earth, in inorganic forms such as arsenite and arsenate derivatives, it is toxic to both the atmosphere and living organisms [8, 9]. Via natural supplies, industrial sources, or from accidental sources, humans may come across arsenic. The utilizing of arsenic pesticides, common mineral deposits or the unequal transfer of arsenic chemicals can pollute drinking water [10, 11]. The intentional use of this metal in cases of suicide or unintended ingestion in children will cause extreme damage and its protoplasmic poison nature ultimately affects the selection of sulfhydryl cells that cause malfunction of cell enzymes, cell respiration, and mitosis [12].

2.1.1 Effects of Arsenic on humans.

As a result of normal geological phenomena and manmade procedures, arsenic pollution happens on earth. The ancient and modern methods of smelting will cause leaking of arsenic to the air and soil [13]. The use of groundwater ejection and drainage can influence on the consistency of water surface [14]. Arsenic is contained in many soaps, dyes, paints, metals and medicines. Arsenic is also emitted in higher concentrations to the atmosphere by some fertilizers, chemicals and animal feeding operations [15].

2.2. Lead

Storage batteries, ammunition, cable coverings, pipes, nuclear power plants, tetraethyl Pb paints and manufacturing, and radiation shields around X-ray equipment are all made of lead (Pb). Lead oxide is used to make fine crystal and flint glass, as well as soldering and pesticides. Lead, in particular, is a volatile substance that has resulted in unnecessary environmental emissions and health risks in several regions of the world. Agricultural activities, smoking, drinking water, and home sources such as gasoline and paints, pewter pitchers, plumbing tubes, toys, storage batteries, and faucets are the main sources of lead pollution. [16], see Fig. 2.

Fig.2: Different sources of Lead

2.2.1 Mechanisms of lead toxicity

In living cells, lead toxicity is activated by ionic and oxidative stress pathways. Oxidative stress of living cells occurs because of the irregularity in the development of free radicals. The antioxidants creation detoxifies the intermediates reactive. The presence of antioxidants like glutathione prevent formation of free radicals in living cells (e.g., H_2O_2). Owing to the effect of lead, the amount of reactive oxygen species (ROS) rises and the level of antioxidants declines.

2.2.2 Effects of Lead on humans

Lead is a particularly poisonous substance to living organisms, but its use of different goods (paints, oil, etc.) has now been greatly limited. Yet logging, fossil fuel combustion, lead-based paints, gasoline, cosmetics, ammunition, soldering, polluted dirt, factory pollution are the major causes of lead contamination [17, 18]. The lead toxicity is nowadays known as a conventional illness and symptoms that are exhibit in adults and children is basically linked to the gastrointestinal tract and nervous system [19]. Lead contamination by drinking of water often takes place if lead compounds present in water-carrying vessels [20].

The lead Poisoning may be acute or chronic, the acute exposure cause hypertension, loss of appetite, stomach pain, headache, kidney failure, exhaustion, arthritis and sleeplessness. Sever lead exposure happens mostly in some workplace Fig. 3. Chronic lead exposure may lead to birth defects, mental retardation, paranoia, autism, hyperactivity, dyslexia, asthma, paralysis, weight loss, muscle failure, kidney injury, brain damage due to this chronic lead exposure and can also lead to death [21].

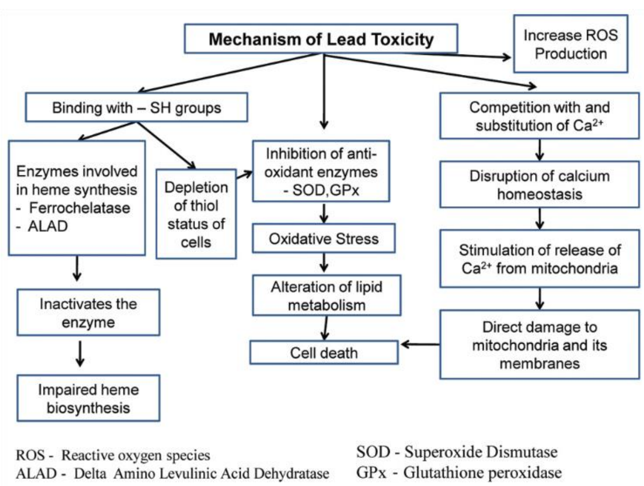

Fig.3: Toxicity Effect of lead

2.3. Mercury

Mercury (Hg) is an omnipresent, very permanent product that can practically be found anywhere. It is a naturally occurring metal, polished silver-white, odorless liquid on earth, and on heating it becomes colorless and odorless gas. It is particularly poisonous and highly bio accumulative in nature [22]. There are adverse effects of mercury on the aquatic ecosystem therefore many new research programs in global studies are therefore targeted at the distribution of mercury in the water environment. Anthropogenic interventions, including irrigation, urban wastewater discharges, mining, commercial wastewater discharges and incineration are a primary cause of mercury emissions. Mercury occurs principally as metallic components, inorganic salts and organic compounds; each has distinct toxicity and bioavailability [23]. The mercury available in water resources such as oceans, lakes and rivers may converted by some microorganisms into methyl-mercury, ultimately experiencing biomagnifications causing major disruption to aquatic lives that therefore causes imbalance in the aquatic setting. The use of this type of marine animal by humans is the primary path to formation of methyl mercury [24].

2.3.1 Mechanism of mercury toxicity

Mercury is a well-known dangerous metal on earth. It is one of the neurotoxic compounds responsible for the degradation of microtubules, lipid peroxidation, mitochondrial damage and the aggregation of neurotoxic molecules (serotonin, aspartate, and glutamate). The estimated production of mercury in the atmosphere has been measured at 2,200 metric tons per year [25]. Mercury may also impair the potential of the membrane and disturb calcium intracellular homeostasis [26]. Asthma, bronchitis and occasionally temporary respiratory issues may be caused by mercury vapors [27]. Mercury interfere with the processes of transcription and translation for ribosomes, thereby stopping functioning of natural killer cells and therefore leading to the eradication of the endoplasmic reticulum. [28].

2.3.2 Effects of Mercury on humans

Mercury is introduced into the world by the operations of different sectors. It is considered one of the environment's most dangerous heavy metals. Mercury has the potential to mix and shape organic and inorganic mercury with the other elements. Organic and inorganic mercury will affect the kidneys, brain and fetus growth [29, 30]. Mercury is found within the range of < 1 to 50 pg/kg in virtually all foods and drinks, though mercury is typically seen at higher concentrations in aquatic foods [31]. Methylmercury, one of the mercury compounds, is principally responsible for the neurological changes seen in humans and experimental animals. The mechanisms are thought to be linked to a hazardous increase in reactive oxygen species (ROS). The genesis of neurodegenerative illnesses such as amyotrophic lateral sclerosis, Parkinson's disease, and Alzheimer's disease is linked to oxidative stress, but the mechanisms are yet unknown [32].

2.4. Cadmium

It is the seventh most toxic heavy metal in the world, according to the Agency for toxic Substances and Disease List (ATSDR).

Cadmium is the produced as result of zinc production. During working hours or in the atmosphere, humans or animals may be exposed to this metal and it may accumulate within the human body during life until it has been consumed by it [33]. In the First World War, cadmium was first used as a substitute for tin and also as a dye in the art industry. It is now used every day in rechargeable batteries for the manufacture of special alloys and is even found in cigarette smoke. Human beings can be mainly exposed by inhalation and ingestion of this poisonous heavy metal and can cause acute and chronic toxicity [34]. For decades, cadmium dispersed throughout the atmosphere will linger in the soils and sediments, plants steadily pick-up and accumulated in the food chain and finally enter the human body because cadmium is primarily present plant [35].

2.4.1 Mechanism of cadmium toxicity

Its toxicity function is not yet well understood, but its effects on cells are documented in several research papers [36]. It can form complex of cystein-metallothionein induces liver hepatotoxicity and circulates to the kidney if nephrotoxicity is induced by it following aggregation in renal tissue [37]. The tendency of cadmium to bind to cysteine, aspartate, histidine and glutamate ligands can contribute to iron deficiency [38]. Cd is thought to cause dispositional tolerance via attaching to the protein metallothionein (MT). By reducing Cd distribution to sensitive cellular macromolecules, MT induction protects the liver. However, extremely high amounts of cadmium result in unbound and free Cd, resulting in hazardous effects. [39]. The kidneys may easily absorb Cd bounded to MT. The compound is extremely toxic to the kidneys and is thought to play a role in Cd nephrotoxicity. Cadmium can imitate the function and behavior of other metals. Cd, for example, attaches to albumin in plasma in the same way as zinc does. As a result, calcium, zinc, and iron homoeostasis are disrupted [40].

2.4.2 Effects of Cadmium on humans

Cadmium metal from the 20th century has many uses in numerous types of batteries, plastics, pigments, metal coatings and is commonly used in electroplating [41]. A certain amount of cadmium is found in coal and mineral fertilizers in soils and rocks. Latest studies of International Organization for Research on Cancer are considered cadmium and its derivatives have been listed as category 1 of human carcinogens [42]. Weathering, water transportation, volcanic eruptions and other human activity inject cadmium into the atmosphere [42]. Kidneys are the most damaged organ if exposed to cadmium toxicity since it accumulates in higher concentrations in the proximal tubular cells of kidney and in the bone causes bone mineralization.

2.5. Chromium

In multiple oxidation states, chromium available as Cr2+ to Cr6+ in the atmosphere. Trivalent Cr+3 and hexavalent Cr+6 are the most common types of Cr, all of which are toxic to wildlife, humans and plants [43, 44]. Naturally, chromium production happens by the combustion of oil and tar, ferrochromate refractory petroleum, pigment oxidants, catalysts, fertilizers, chromium glass, oil well drilling and tannery metal plating [45]. Chromium is released anthropogenically by waste and fertilizers in the setting. It is immobile and insoluble in water in the reduced Cr(III) form, while it is mobile and strongly soluble in water in the oxidized Cr(VI) state [46].

2.5.1 Effects of Chromium on humans

In nature, chromium is found as solid, liquid, gas and preent in minerals, soil, animals and plants [47]. The most reliable chromium III and VI have the high important relation to human.

2.6. Iron

The second metal within metals in earth crust is iron; it holds the 26th elementary position in the periodic table and is the most crucial part of nearly all living species for development and life [43]. Iron is one of the most essential components of some protein-carrying species (algae) and some enzymes (cytochromes and catalase). The origins of iron in surface water is anthropogenic and connected to mining [48].

2.6.1. Mechanism of iron toxicity

In mammalian cells (especially the gastrointestinal tract) and biological fluids, various dangerous free radicals are produced due to the lack of absorbed iron binding with the proteins. The rate limiting absorption stage becomes saturated after entering extreme amounts of iron into the bloodstream. Free iron may result in lipid peroxidation, causing severe damage to microsomes of the cells, mitochondria and other organelles of the cells [49].

2.6.2. Effects of Iron on humans

The respiration of aerobic organisms during the process is stimulated by several iron-mediated reactions. This could speed up the creation of internal radicals, which can damage molecules, cells, tissues, and the whole body if iron is not adequately used. For pediatricians, iron poising has long been of concern because babies are especially vulnerable to iron poisoning because they are more prone to iron-containing items [50]. Iron toxicosis occurs after 6 hours of iron overdose in four phases I. Iron toxicosis is characterized by gastrointestinal symptoms (gastro intestinal bleeding, vomiting and diarrhea). (ii): iron toxicosis is recognized within 6-24 hours of the iron dosage as an apparent medical healing moment (latent period). (iii): iron toxicosis symptoms are tachycardia, shocks, lethargy, metabolic acidosis, hypotension, hepatic necrosis, and sometimes by iron-dose mortality within 12-96 hours. (iv): iron toxicosis is characterized by the formation, within 2-6 weeks of the iron dosage, the ulcerations of gastrointestinal and the development of strictures [51, 52].

2.7. Conclusion

Heavy metals in industry, climate, soil, water, food and humans, needs always considered cyclical order in the climate. It is clear that the harmful consequences of metalloids and heavy metals are caused by prolonged exposure to minimum doses. It has been proven that heavy metals are harmful for environment and human.

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