Chapter

Heavy Metal's Environmental Impact

Riyam N. Khalef, Amal I. Hassan and Hosam M. Saleh

Abstract

Heavy metals are inorganic elements with something like a density of more than 5 g/cm^3. Essential and non-essential heavy metals were divided into two groups based on their toxicity. Heavy metals, unlike organic pollutants, are non-biodegradable and tend to accumulate in living things. Many heavy metal ions are hazardous or carcinogenic. The majority of heavy metals, such as cadmium, copper, and zinc, are linked to pollution and hazardous concerns. There are more than 50 elements categorized as heavy metals, with 17 of them being extremely hazardous and easily accessible. Metal pollutants are often non-degradable and have no recognized homeostasis mechanism. Their mere presence in aquatic habitats is enough to have a direct or indirect impact on living systems. The anthropogenic pollution of heavy metals in ancient mining regions refers to areas where the concentration of one or more heavy metals exceeds normal values. Heavy metals disrupt cellular organelles and components in biological systems. Nanoscale zero-valent iron is a promising alternative for heavy metal cleanup. Heavy metal ions are poisonous, non-degradable, and tend to bioaccumulate and biomagnify. The purpose of this chapter is to display some heavy metals and the environmental impact of these minerals, which includes soil, plants, and humans.

Keywords: heavy metals, chromium, lead, cadmium, mercury, copper, zinc, toxicity of heavy metals, remediation of heavy metals

1. Introduction

Heavy metals are metallic elements with a higher density than water [1]. Heavy metals also include metalloids, such as arsenic, that can cause toxicity at low levels of exposure, based on the notion that heaviness and toxicity are linked. Because of its physical and chemical features, this group comprises arsenic (As), cobalt (Co), Iron (Fe), and manganese (Mn) are less common heavy metals (Mn) [1]. Essential and non-essential heavy metals were divided into two groups based on their toxicity [1]. At low concentrations, heavy metals essential are either nontoxic or considerably less harmful (Zn, Cu, Co, and Fe). Even at low concentrations, non-essential metals are very hazardous (such as Cd, Hg, Cr, and As) [2]. Apart from a few emissions into the atmosphere in the form of dust particles or vapors, these heavy metals are mostly found in the planet's aquatic and soil phases [3]. Because of their toxicity, persistence, and non-degradability, arsenic (As), cadmium (Cd), and lead (Pb) are considered primary hazardous elements [4]. Researchers devised this study to detect the presence or absence of these fatal heavy metals in samples obtained of infant formula milk using Atomic Absorption Spectrophotometry (AAS) since lead, mercury, and arsenic were named as the top three most harmful chemicals on the priority list. The quantity of these heavy metals is measured in parts per million (ppm) [5]. Because, lead, mercury and arsenic were listed as the top three most dangerous compounds on the priority list, researchers devised this study to detect the presence or absence of these deadly heavy metals in chosen samples of infant formula milk using Atomic Absorption Spectrophotometry (AAS). These heavy metals' presence is measured in parts per million (ppm) [5]. Heavy metals are non-biodegradable, poisonous, and easy to accumulate in living creatures in general, and the human body in particular, in low quantities [6]. Heavy metal bioaccumulation in humans, such as cadmium and copper, can lead to cancer, nerve damage, failure of the liver and kidneys, as well as death [7]. Some heavy metals, such as Cd, Pb, and Cr, have no known biological purpose, whereas others, such as Cu, Zn, and Mn, are required in small amounts for normal plant growth and development but are severely poisonous to plants and animals when concentrations are somewhat higher than those required [8]. Heavy metal toxicity is still a hot topic in science, and more research is required to better to recognize the effects of the damaging mechanism and how to control them to lessen medical problems [9]. Due to rapid development, heavy metals wastewaters are increasingly discharged into the environment, mainly in developing nations, due to the rapid development of businesses such as metal plating facilities, mining operations, fertilizer industries, tanneries, batteries, paper industries, and pesticides, among others. Heavy metals, unlike organic pollutants, are non-biodegradable and tend to accumulate in living things. Many heavy metal ions are hazardous or carcinogenic [10]. The majority of heavy metals, such as cadmium, copper, and zinc, are linked to pollution and hazardous concerns, particularly when they are dissolved. Because of their toxicity and mobility, the presence of any of these heavy metals at high levels is dangerous to individuals and can interfere with a variety of environmental benefits [11]. Heavy metals' capacity to penetrate membranes until cells is a key role in many of their harmful effects. Furthermore, metals' transmembrane transfer may be implicated in their absorption, distribution in the body, and excretion, hence transmembrane transfer aids in the determination of metal toxic kinetics. Because cell membranes are so important in metal toxicity [12]. Toxic metals are commonly found in industrial, municipal, and urban runoff, and they can affect humans and other living things. Rising levels of trace metals, particularly heavy metals, in our rivers are due to increased urbanization and industry. Many hazardous chemical components accumulate in the soil and sediments of water bodies after being released into the environment. There are more than 50 elements categorized as heavy metals, with 17 of them being extremely hazardous and easily accessible. Anions play a significant role in drinking water, and the outcomes have been shown to have an impact on people's health [13]. China was close to the city streets. The residents are exposed to street dust regularly. Metal pollutants are often non-degradable and have no recognized homeostasis mechanism. As a result, any large concentration of heavy metals poses a threat to biological life [14]. An increase in anthropogenic activity has resulted in the release of numerous dangerous compounds into water resources, endangering aquatic ecosystems and the environment. Because heavy metal ions are very poisonous, non-degradable, and tend to bioaccumulate and biomagnify as a result of the food chain, they are the most serious contributors to water pollution. Their mere presence in aquatic habitats is enough to have a direct or indirect impact on living systems.

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Heavy metal ions are extremely harmful to both plants and animals in the soil environment, as they are absorbed by plants and eventually reach animals and people [15]. A set of metals and metalloids having an atomic density larger than 4000 kg/m^3 is referred to as "heavy metal" (four times the density of water). Heavy metals are present in rocks, soil, plants, and animals and occur naturally in the environment. Metals can be found in a variety of forms, including dissolved ions in water or vapor, as well as minerals in rocks, sand, and soil. These materials can also form bonds with organic and inorganic molecules, as well as cling to airborne particles. Metals are released into the air and water by both natural and manmade mechanisms [16]. The vast range of issues surrounding the presence of HMs in the food chain and their effects on human health necessitates more research in this area as part of a holistic approach to the environment in which humans live. The anthropogenic pollution of heavy metals in ancient mining regions refers to areas where the concentration of one or more heavy metals exceeds normal values in most soils, as well as some agricultural products used as plant food, such as vegetables and fruit, and even animal products (meat, eggs, and milk) [17]. It's also crucial to identify the various sources of heavy metals in the environment and establish their total concentration. Element speciation, profile distribution, and spatial distribution are common methods for distinguishing between anthropogenic and geogenic sources of potentially toxic elements, but they are insufficiently reliable to distinguish between sources of element concentration on their own and should be combined with additional information such as parent rock composition or known anthropogenic sources [18]. Heavy metals have been found to disrupt cellular organelles and components in biological systems, including the cell membrane, mitochondria, lysosomes, endoplasmic reticulum, nuclei, and several enzymes involved in metabolism, detoxification, and damage repair [19]. Nanoscale

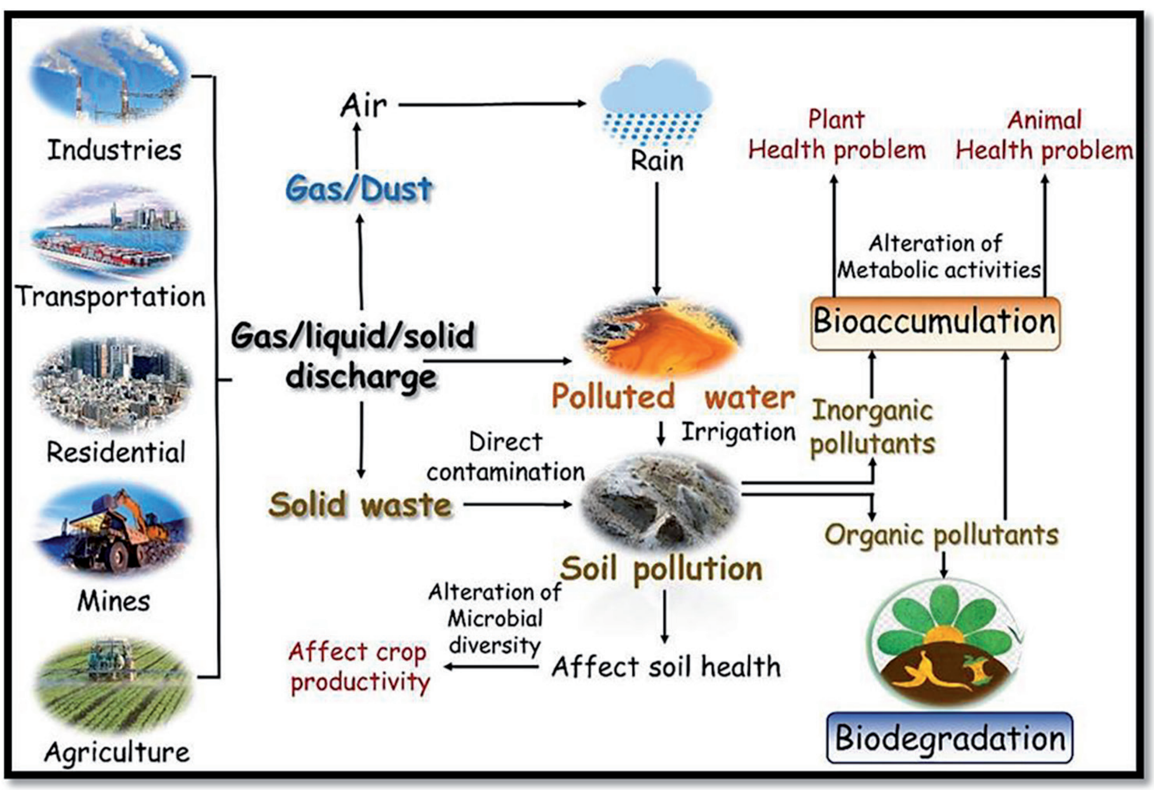

Figure 1.
Sources, migration and toxicity of heavy metals [23].

zero-valent iron is a promising alternative for heavy metal cleanup, with high efficiency and low economic costs [20]. It has a bigger specific surface area, reduction reactivity, and high surface energy. Such dangerous forms of heavy metals may survive in our environment for longer periods, and once they come into touch with the land, water, and soil, they may pose harm to living things [21].

Currently, the study region is endowed with significant mineral resources that span the whole state. Illegal mining of these minerals has resulted in the occurrence of HMs in soil and water supplies. Land application of fertilizers, animal manures, sewage sludge, pesticides, mining tailings, mechanic wastes, and disposal of heavy metal wastes are further sources of HMs [22]. Heavy metals are thought to arise from two basic sources: natural inputs (such as parent material weathering) and human inputs (such as metalliferous industries and mining, automobile emissions, agricultural practices, and so on) [23]. As a result, identifying metal sources is critical before implementing various pollution cleanup measures. The majority of current research is done on mid-to large-scale (for example, mining areas, industrial areas, large cities, etc.) as shown in **Figure 1** [23].

2. Some of the heavy metals

2.1 Mercury

Mercury is a naturally occurring metal that comes in a variety of shapes and sizes. Metallic mercury is a lustrous, silver-white liquid with no odor. Mercury forms inorganic mercury compounds or salts, which are usually white powders or crystals when it reacts with other elements like chlorine, sulfur, or oxygen [24]. Mercury enters the brain quickly, causing tremors, sadness, and behavioral issues [25]. Thousands of years have passed since the beginning of time. It's mostly used for precious metal extraction. Mercury (Hg) is used in thermometers, barometers, manometers, sphygmomanometers, float valves, mercury switches, mercury relays, and fluorescent lights, as well as in the paint industry [26]. In New Jersey, USA, levels of mercury above 0.5 ppm were found, a level of human health concern for those who consume fish regularly. 48.8% of the sampled population of 36,422 lakes in the USA had mercury tissue concentrations that exceeded 0.3 ppm [27]. For many years, mercury, which is on the US EPA's priority pollutants list, has received a lot of attention [28].

Among the various methods developed over the years for mercury removal, adsorption has substantial promise due to its simplicity and low cost, as well as the adsorption method's efficacy in purifying water [29]. We have observed substantial progress in Hg removal in adsorptive separation technology and materials science over the last 4 years [30]. The Hg(II) removal efficiencies increased in the order of ACCl impregnated ACBr-impregnated ACI-impregnated AC, indicating that the introduced functional groups' electron-donating ability may help increase the adsorption capacities of the adsorbents [30]. There are several promising advantages for the removal of aqueous Hg(II), such as rapid separation, easy elution of analytes, and reusable adsorbent [31]. Existing adsorbent materials have largely been limited in their effectiveness and efficiency for the removal of Hg(II) from aqueous solutions due to challenges such as low surface area and improper distribution of thio/thiol groups, resulting in low capacity and moderate affinity for Hg(II), sulfur leaching, and poor stability over a wide pH range [31].

2.2 Cadmium

Cadmium is a silver-white metal with a density of 8.7 g/mL and an atomic weight of 112.41 g/mol. Its main industrial applications are governed by its strong electrical conductivity, good chemical resistance, and low melting point [32]. Cadmium is released from a wide range of sources, including galvanized pipeline corrosion, erosion of natural deposits, discharge from metal refineries, runoff from waste batteries, and mining, smelting, and refining of nonferrous metals [33]. Cd impacts the brain by disrupting particular membrane function, primarily in the hippocampus, according to reports. Neurotoxicity is known to be higher in newborns than in adults, which could be owing to the absence of blood-brain barrier maturation in newborns. Cd accumulates greater in the choroid's plexus region of the brain in newborns. In prenatal exposure to Cd inhibits the acetylcholine esterase (AchE), Na^+/K^+-ATPase pump, which lowers neuronal activity in pups, according to in-vivo investigations [34]. Cadmium is one of the most toxic heavy metals, and this has piqued the attention of environmentalists. The primary sources of cadmium discharge into the environment through waste streams include electroplating, smelting, alloy production, pigments, plastic, battery, mining, and refining activities [35].

Compared to virgin biochar, biochar treated with MnO_2 has more hydroxyl groups, a bigger surface area, and a higher pore volume. They also verified that Cd(II) complexation with hydroxyl groups produces Cd–O or Cd–OH species, which is the major mechanism for Cd elimination [24]. The batch and column desorption experiments were carried out under the same conditions. One gram of adsorbent was used to treat 50 milliliters of sample water containing 20 mg of Cd(II). It was left in contact with the adsorbent for 24 hours. Then, as detailed in a previous paper [36] investigated the effects of pyrolysis temperature on biochar Pb removal ability [24].

2.3 Chromium

Chromium is an element that can be found as a liquid, solid, or gas in rocks, animals, plants, and soil. Chromium(VI) compounds are carcinogens and toxins, but chromium(III) is a required vitamin. Long-term exposure can affect the liver, kidneys, circulatory system, and nerves, as well as cause skin irritation. High levels of breathing can cause nasal irritation, nose ulcers, runny nose, and breathing problems such as asthma, cough, shortness of breath, or wheezing [37]. The use of cellulose ion exchangers for water and wastewater treatment was investigated. The ability of three cellulose ion exchangers to remove proteins, azo dyes, chromate, and heavy metal ions was investigated [38].

As a result, the elimination of Pb(II) and Cr(VI) has been recognized as a crucial environmental issue. To remediate Pb(II) and Cr(VI), mineral adsorption, coagulation, chemical precipitation, ion exchange, biosorption, chemical reduction, and membrane separation have all been developed [20].

2.4 Lead

Pb(II) ion has been discovered to be one of the most dangerous heavy metals, with the ability to cause harmful consequences in animals and plants. Drinking water is the primary route for Pb(II) ions to enter the food chain, and aquatic creatures' bioaccumulate them [39]. Lead poisoning and chelation therapy: The general public is exposed and its compounds through industries like automobile and battery manufacture, refining, and smelting. Lead disrupts several biological processes and is toxic to the nervous system, heart, kidneys, and gastrointestinal tract, with the neurological system being the most vulnerable. Lead also causes cognitive issues in children by interfering with brain growth [40]. Heavy metals, including Pb, are produced by the combustion of fossil fuels in automobiles. Pollution is also thought to be caused by the wear of motor tires and the corrosion of parts. As a result, heavy metal pollution caused by automobiles continues to be a severe problem around the world [41].

Many strategies have been used to remove heavy metals from contaminated liquid effluents to reduce the negative impact. Chemical precipitation is a popular industrial procedure that takes multiple phases before the water can be considered drinkable [42]. The majority of adsorption research was done in a batch setting. Various low-cost adsorbents, such as bagasse pith sulphurised activated carbon, blast furnace sludge, biogas residual slurry, olive mill products, and peanut shell carbon, have been used in the search for effective and cheap removal of Pb(II) from wastewater [43].

2.5 Copper

Copper is common metal contamination that, by definition, is essential for organism functioning, but it is also potentially dangerous copper may in the soil be either static or migratory. Immobile copper that is not bioavailable can be absorbed or precipitated into the soil matrix. Because copper is usually cationic, it forms complexes with negatively charged clay minerals, anionic salts, organic materials, hydroxides, phosphorus, and sulfate [44]. Copper is a versatile metal with many uses due to its excellent qualities. It's utilized in electronics, as well as the manufacture of wires, sheets, and tubes, as well as the formation of alloys. Copper is resistant to the effects of the atmosphere and many chemicals; yet, it is known that metal is prone to corrosion in aggressive media. Copper corrosion inhibitors are required in such situations since no protective passive layer may be envisaged. Copper corrosion is a possibility [45]. Even though copper is required for human metabolism, it is hardly used. Excessive copper use, on the other hand, can cause major health problems including high cholesterol, rapid breathing, kidney and liver damage, convulsions, cramps, vomiting, and even death [46].

The disposal of precipitated cupric hydroxide is a major issue with this form of treatment. Ion exchange treatment, which is the second most extensively used approach for copper removal, does not have a sludge disposal issue and has the advantage of Cu(II) reclamation [47].

2.6 Zinc

Zinc belongs to the periodic table's group IIB and is a beautiful bluish-white metal. When heated between 110°C and 150°C, it transforms from brittle and crystalline to ductile and pliable. It's a moderately reactive metal that reacts with oxygen and other non-metals to form hydrogen, as well as dilute acids. The majority of zinc is added through industrial processes such as mining, coal and waste combustion, and steel processing [48]. Zinc is an important trace element for human health. It regulates various metabolic processes and is necessary for the physiological functioning of living tissue. Too much zinc, on the other hand, can cause serious health problems such as stomach pains, rashes, vomiting, nausea, and anemia [10]. Vomiting, diarrhea, bloody urine, icterus (yellow mucus membrane), liver failure, renal failure, and anemia have all been documented as symptoms of zinc toxicosis [49]. Zinc is widely used in various industries such as galvanization, paint, batteries, smelting, fertilizers and pesticides, fossil fuel combustion, pigment, polymer stabilizers, and so on, and zinc is present in large amounts in effluent from these industries [50].

The process is affected by a variety of factors. Adsorption (chemisorption), complexation on the surface and pores, ion exchange, microprecipitation, heavy metal hydroxide condensation onto the biosurface, and surface adsorption are some of the processes involved in the biosorption process [51].

3. Effect of heavy metals on water

An increase in anthropogenic activity has resulted in the release of numerous dangerous compounds into water resources, endangering aquatic ecosystems and the environment. Heavy metal ions, which are very poisonous, non-degradable, and tend to bioaccumulate and biomagnify, are the most serious contributors to water pollution [15]. Toxic contaminants from anthropogenic businesses, such as mining or agricultural operations that do not use environmentally friendly procedures, or natural phenomena, such as volcanoes, earthquakes, or storms, are virtually always present in wastewaters [52]. Heavy metals are now one of the most important environmental hazards. To safeguard people and the environment, hazardous heavy metals should be eliminated from wastewater. Chemical precipitation, ion exchange, adsorption membrane filtration, electrochemical treatment procedures, and other ways are utilized to remove heavy metal ions [53]. It is regarded as one of the most hazardous to human health among heavy metals. Precipitation, coagulation/flocculation, ion exchange, reverse osmosis, complexation/sequestration, and electrochemical processes are all common ways of removing heavy metal ions from wastewater. These technologies are not commercially viable, and they may result in the production of harmful by-products [54]. As a result, removing unwanted metals from water systems effectively and thoroughly remains critical yet difficult work for environmental engineers. Several strategies for removing heavy metals from water have been presented in recent years [55].

3.1 Treatment of water contaminated with heavy metals

Because the composition of wastewater is exceedingly intricate, and the characterization of target species will be severely influenced by the many coexisting compounds, current technologies will have a difficult time recognizing the detailed composition. Physicochemical tests such as complexometric titration, ion exchange, and stripping voltammetry were used to evaluate the complexation features in early investigations, making it difficult to obtain the exact coordination condition of heavy metals [56]. Micellar-enhanced ultrafiltration (MEUF) is a newly discovered water treatment technique that has been proved to be an effective technology for removing heavy metals even at low concentrations [7].

4. Effect of heavy metals on plant

Soil heavy metal pollution would result in two major issues: loss of soil value and increased health risks for persons living near affected areas. Soil that has been poisoned by heavy metals will lose at least some of its function. When heavy metal concentrations are within legal limits, soils may be able to continue to function. However, more attention should be made to soil heavy metal intervention and goal values [57]. In light of the phytotoxicity and biological relevance of the metal species that control various plant processes, the term “heavy metal” is coined. Few metals, such as Zn, Fe, Cu, Mn, Ni, and Co, are important micronutrients for plants, but others, such as Hg, Al, Cd, Pb, As, Ga, Ag, and Cr, are non-essential for plants and have no recognized physiological function. The HMs’ critical limit thresholds and reactions at the cellular and whole-plant levels are summarized [58]. The overall visual toxic reaction differs between heavy metals due to their varied locations of action inside the plant. The most common visual indication of heavy metal toxicity is a reduction in plant development, which includes leaf chlorosis, necrosis, turgor loss, a drop-in seed germination rate, and crippled photosynthetic machinery, which is commonly linked to senescence or plant mortality [59]. The concentration of this element in food varies depending on where it comes from, how it’s stored, and how it’s processed. These metals have several peculiar characteristics, including the fact that (1) they do not degrade over time (2) they can be necessary or beneficial to plants at certain levels but can be toxic when levels exceed specific thresholds, (3) they are always present at a background level of non-anthropogenic origin, with their input in soils being related to weathering of parent rocks and paedogenesis, and (4) heavy metals in soils can become mobile as a result of changing environmental conditions because they frequently appear as cations that interact strongly with the soil matrix [5]. Multiple studies have found that anthropogenic sources are the principal contributors of heavy metal contamination in the environment. Traffic emission (vehicle exhaust particles, tire wear particles, weathered street surface particles, brake lining wear particles, etc.), industrial emission (power plants, coal combustion, metallurgical industry, auto repair shop, chemical plant, etc.), domestic emission, building and pavement surface weathering, and atmospheric deposited heavy metals are all anthropogenic sources of heavy metals in urban soils and urban road dust [60]. Soil bacteria have been shown to alter heavy metal mobility and bioavailability by solubilizing metal phosphates, releasing chelating agents, producing redox changes, and acidification [61]. Due to the textural composition of distinct soil strata, heavy metals differ in different soil horizons. Different remediation strategies have been developed to avoid metal deposition and movement within the soil profile. Those based on the addition of materials capable of immobilizing mobile forms of metals, such as compost and biosolid, are sufficient. Another approach is phytoremediation, which is based on heavy metal absorption by various plant species [62]. pH, organic matter, and redox conditions are all factors that affect the chemistry of metals in soil and their intake by organisms; of these, pH is the most important and easiest controllable. Soil pH influences the availability and plant uptake of micronutrients [63].

4.1 Treatment of soil contaminated with heavy metals

Soil washing, which comprises pretreatment, separation, coarse-grained treatment, fine-grained treatment, water treatment, and residual management, can reduce heavy metal concentrations in soils by physical/chemical desorption, chelation, dissolution, and oxidation processes. The distribution of heavy metal compounds between soil and washing solution impacts soil cleaning performance. The efficacy of treatment varies depending on the washing technique and solution agents utilized [57]. Heavy metals and metalloids can accumulate in soils due to emissions from rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, fertilizer application, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, petrochemical spillage, and atmospheric deposition [64]. Minerals are dissolved in most cases by reacting with carbonic acid and water. Insoluble minerals are distributed into fine particles. Metals and metalloids from metal wastes, gasoline, animal feces, sludge, wastewater irrigation, and atmospheric deposition contaminate soils. Heavy metals can be removed from soil and water via phytobiological remediation, which is a cost-effective and environmentally benign method. Heavy metals are removed from soil and water through phytobial remediation, which incorporates plants and bacteria. Plants are used to ingest heavy metals, and microbes aid in the breakdown of those metallic elements in phytobial-based remediation [65]. Integrating an appropriate bacteria that can release numerous plant growth-promoting substances can improve these mechanisms [66]. Phytobial remediation, in contrast to other invasive technologies, is widely considered the safest and most cost-effective option. It's in situ treatment method has also been demonstrated to reduce heavy metal distribution in soil and aid in topsoil preservation. Phytoremediation is aided by the mobilization and volatilization of free-living microorganisms. Metals are mobilized through a variety of processes, including volatilization, redox transformation, leaching, and chelation. Endophytes are bacteria and fungus that dwell on the inside of plants. They spend at least part of their life cycle inside the plant without harming it. They are found in almost every plant, with certain of them having the ability to encourage plant development [67]. Secondary metabolites are produced by a few fungal endophytes. Heavy metal tolerance has been discovered in Methylobacterium strains from the *Pteris vittata* plant [68]. Algae are considered an essential constituent of the aquatic system, playing a significant role in the biogeochemical cycle. Because of its exceptional absorption and sequestration capability, it has piqued the interest of researchers all over the world [69]. Though several integrated techniques, recombinant genetic engineering of bacteria and plants has also proven to be worthwhile in terms of heavy metal removal applications. If microbes are genetically modified, they can perform better than the natural variety, which has enormous remedial potential. Similarly, genetic engineering can be used to stimulate phytoremediation to increase heavy metal accumulation and absorption [70].

5. Effect of heavy metals on human

These do not degrade and accumulate in live beings, resulting in a variety of illnesses and disorders of the neurological, immunological, reproductive, and gastrointestinal systems. Because these heavy metal ions (HMI) are non-biodegradable, they can last for decades or even centuries once released into the environment. Lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr), and arsenic (As) are among the most poisonous heavy metals [71]. Melanin may protect tissue by filtering or detoxicating heavy metals from the surrounding neuronal retina and photoreceptor cells. The choroid plexus of the brain, like the retinal pigment epithelium, sequesters lead and acts as a protective barrier against harmful materials entering the brain [72]. During pregnancy, potentially dangerous contaminants circulating in a pregnant woman's blood might reach the fetus, posing a risk to the child's health. Because of their ubiquitous exposure, cadmium (Cd), lead (Pb), manganese (Mn), and mercury (Hg) have gotten a lot of attention [73]. Exposure to heavy metals and other contaminants has resulted in a variety of problems in humans and wildlife, including carcinogenic, mutagenic, and teratogenic effects. Structure anomalies, nutritional imbalance, metabolic disruption, and low have all been observed in plants cultivated in contaminated areas [74]. Furthermore, exposure to these hazardous metals has been linked to several serious disorders, including Alzheimer's disease [75]. Due to the difficulty of completely avoiding heavy metal exposure, chemoprevention is a prominent technique for shielding humans and animals from the risk of major health problems caused by toxic metal exposure. The usefulness of many antioxidants, including vitamins taurine, in reducing heavy metal-induced oxidative DNA damage was investigated [75]. Liquid pollutants can hurt human health as well as the environment. Landfill leachate and mine drainage, among other sources of these toxins, cause serious health and environmental hazards [76]. Lead (Pb), cadmium (Cd), mercury (Hg), and arsenic are the most prevalent heavy metals that can cause health concerns when taken in contaminated foods (As). For thousands of years, heavy metals have been employed in a variety of situations throughout human culture. Even though the severe health consequences of heavy metals have long been known, heavy metal exposure persists and, in certain countries, is even rising. Unfortunately, food and food containers are one of the most prevalent causes of heavy metal contamination in the general population [77].

Cadmium-rich foods can significantly increase the amount of cadmium in people's bodies. Liver, mushrooms, prawns, mussels, cocoa powder, and dried seaweed are just a few examples. The circulatory system is a significant route of exposure, and blood vessels are thought to be the main organs of cadmium poisoning. Chronic inhalation exposure to cadmium particles is linked to pulmonary function abnormalities and chest radiographs that are suggestive of emphysema [78]. Cigarette smokers have greater blood and urine cadmium levels, while former smokers have intermediate levels and nonsmokers have lower levels [79]. High quantities of chromium(VI) in the air might irritate the lining of the nose and cause ulcers. Irritation and ulcers in the stomach and small intestine, anemia, and sperm impairment are the most common health concerns found in animals after consuming chromium(VI) compounds [80]. Lead is the most systemic toxin, affecting the kidneys, liver, central nervous system, hematopoietic system, endocrine system, and reproductive system among other organs [81]. Mercury has an extremely low excretion rate once absorbed. The kidneys, neurological tissue, and the liver store a large part of what is absorbed. Mercury is harmful in all forms, with gastrointestinal toxicity, neurotoxicity, and nephrotoxicity among the side effects [82]. Several additional critical elements, like copper, are required for biological function; nevertheless, excessive amounts of these metals cause cellular and tissue damage, resulting in a range of negative impacts and human diseases. There is a relatively limited range of concentrations between helpful and hazardous effects for several elements, such as chromium and copper [82].

6. Conclusion and recommendations

Heavy metals are found naturally throughout the earth's crust, anthropogenic activities such as mining and smelting, industrial production and use, and domestic and agricultural use of metals and metal-containing compounds cause environmental contamination and human exposure. Physical parameters such as temperature, phase association, adsorption, and sequestration influence their bioavailability. Metals such as Co, Cu, Cr, Fe, Mg, Mn, and Zn have been identified as crucial nutrients necessary for a variety of biochemical and physiological functions. A lack of certain micronutrients leads to several deficient illnesses or syndromes.

The most important steps taken to protect the environment are the establishment of natural reserves that ensure that one element is not tyrannized over another, by placing endangered animals and rare plants in an ideal environment suitable for them to grow and reproduce without imbalance or imbalance. It decreases because the environment is safe in our necks to maintain it well and use modern methods or environmentally friendly materials for the treatment process. Remediation of heavy metal-contaminated soil is required to eliminate the related dangers, make the land resource available for agricultural development, improve food security, and reduce land tenure issues. In the future, more emphasis should be placed on assessment methodologies for measuring remediation efficacy while creating new remediation technologies.

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