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# Environment and Heavy Metal Toxicity

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**ABSTRACT:** The environment and its compartments have been severely polluted by heavy metals. This has compromised the ability of the environment to foster life and render its intrinsic values. Heavy metals are known to be naturally occurring compounds, but anthropogenic activities introduce them in large quantities in different environmental compartments. This leads to the environment's ability to foster life being reduced as human, animal, and plant health become threatened. This occurs due to bioaccumulation in the food chains as a result of the nondegradable state of the heavy metals. Remediation of heavy metals requires special attention to protect soil quality, air quality, water quality, human health, animal health, and all spheres as a collection. Developed physical and chemical heavy metal remediation technologies are demanding costs which are not feasible, time-consuming, and release additional waste to the environment. Heavy metals are naturally occurring elements that have a high atomic weight and a density at least five times greater than that of water. Their multiple industrial, domestic, agricultural, medical, and technological applications have led to their wide distribution in the environment, raising concerns over their potential effects on human health and the environment. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals. Because of their high degree of toxicity, arsenic, cadmium, chromium, lead, and mercury rank among the priority metals that are of public health significance. These metallic elements are considered systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure. They are also classified as human carcinogens (known or probable) according to the US Environmental Protection Agency and the International Agency for Research on Cancer.

## I. INTRODUCTION

Contamination of aquatic and terrestrial ecosystems with toxic heavy metals is an environmental problem of public health concern. Being persistent pollutants, heavy metals accumulate in the environment and consequently contaminate the food chains. Accumulation of potentially toxic heavy metals in biota causes a potential health threat to their consumers including humans. This article comprehensively reviews the different aspects of heavy metals as hazardous materials with special focus on their environmental persistence, toxicity for living organisms, and bioaccumulative potential. The bioaccumulation of these elements and its implications for human health are discussed with a special coverage on fish, rice, and tobacco. The article will serve as a valuable educational resource for both undergraduate and graduate students and for researchers in environmental sciences.[1] Environmentally relevant most hazardous heavy metals and metalloids include Cr, Ni, Cu, Zn, Cd, Pb, Hg, and As. The trophic transfer of these elements in aquatic and terrestrial food chains/webs has important implications for wildlife and human health. It is very important to assess and monitor the concentrations of potentially toxic heavy metals and metalloids in different environmental segments and in the resident biota. A comprehensive study of the environmental chemistry and ecotoxicology of hazardous heavy metals and metalloids shows that steps should be taken to minimize the impact of these elements on human health and the environment. During the last hundred years, industrialisation has grown at a fast rate. It has thus increased the demand for exploitation of the Earth's natural resources at a careless rate, which has exacerbated the world's problem of environmental pollution [4]. The environment has been seriously polluted by several pollutants such as inorganic ions, organic pollutants, organometallic compounds, radioactive isotopes, gaseous pollutants and nanoparticles [2]. They are defined as heavy metals either due to their high atomic weight or because of their high density. Nowadays, the word 'heavy metal' has been used to describe metallic chemical elements and metalloids which are toxic to the environment and humans. Some metalloids and also lighter metals such as selenium, arsenic and aluminium are toxic. They have been termed heavy metals while some heavy metals are typically not toxic such as the element gold [5, 6, 7, 8].

A list of heavy metals according to their density of being greater than 5 g/cm<sup>3</sup> and which are more common in our everyday life are: Titanium, Vanadium, Chromium, Manganese, Iron, Cobalt, Nickel, Copper, Zinc, Arsenic, Molybdenum, Silver, Cadmium, Tin, Platinum, Gold, Mercury, Lead

Metalloids tend to form covalent bonds, making them show toxicological properties. The two most important consequences of this property are that they can bind covalently with organic groups. Hence they form lipophilic ions

and compounds, and they can generate toxic effects when they bind to nonmetallic elements of cellular macromolecules. Due to becoming lipophilic, the metalloids distribution within the biosphere and their toxic response vary from the action of simple ionic forms of the same element. Examples of lyophilic compounds are tributyltin oxide and methylated forms of arsenic which are highly toxic. Examples of binding to nonmetallic elements are the binding of lead and mercury to sulphhydryl groups of the protein. Heavy metals may enter a human in four ways from; ingestion of contaminated food; inhalation from the atmosphere, drinking contaminated water; and due to skin contact from agriculture, pharmaceutical, manufacturing, residential and industrial areas[2,3]

## II. DISCUSSION

Motivations for controlling heavy metal concentrations in gas streams are diverse. Some of them are dangerous to health or to the environment (e.g. Hg, Cd, As, Pb, Cr), some may cause corrosion (e.g. Zn, Pb), some are harmful in other ways (e.g. arsenic may pollute catalysts). Within the European community, the 13 elements of highest concern are As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Sn, and Ti, the emissions of which are regulated in waste incinerators. Some of these elements are actually necessary for humans in minute amounts (Co, Cu, Cr, Ni) while others are carcinogenic or toxic, affecting, among others, the central nervous system (Hg, Pb, As), the kidneys or liver (Hg, Pb, Cd, Cu) or skin, bones, or teeth (Ni, Cd, Cu, Cr).[3] Heavy metal pollution can arise from many sources but most commonly arises from the purification of metals, e.g., the smelting of copper and the preparation of nuclear fuels. Electroplating is the primary source of chromium and cadmium. Through precipitation of their compounds or by ion exchange into soils and mud, heavy metal pollutants can localize and lay dormant. Unlike organic pollutants, heavy metals do not decay and thus pose a different kind of challenge for remediation. Currently, plants or microorganisms are tentatively used to remove some heavy metals such as mercury. Plants which exhibit hyper accumulation can be used to remove heavy metals from soils by concentrating them in their bio matter. Some treatment of mining tailings has occurred where the vegetation is then incinerated to recover the heavy metals. In medical usage, heavy metals are loosely defined and include all toxic metals irrespective of their atomic weight: "heavy metal poisoning" can possibly include excessive amounts of iron, manganese, aluminum, mercury, or beryllium (the fourth lightest element) or such a semimetal as arsenic. This definition excludes bismuth, the heaviest of approximately stable elements, because of its low toxicity.[4,5]

Food processors and ingredient manufacturers need to stay ahead of quickly growing global contaminant regulations. Governments classify and regulate contaminants differently for heavy metals, aflatoxins, natural toxicants, dioxins, PCBs, and other regulated substances. New standards are being developed, while other standards are changing quickly. Unless these regulatory changes are monitored, shipments can quickly be out of compliance with new regulations, resulting in rejected loads and financial loss. BCGlobal's database of global contaminant limits provides you with the information you need to ensure your exports comply with foreign standards.[6,7]

## III. RESULTS

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed. To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (e.g. copper, selenium, zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metal poisoning could result, for instance, from drinking-water contamination (e.g. lead pipes), high ambient air concentrations near emission sources, or intake via the food chain.

Heavy metals are dangerous because they tend to **bioaccumulate**. Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Compounds accumulate in living things any time they are taken up and stored faster than they are broken down (metabolized) or excreted.

Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater.

### Effects of Antimony on the environment

Antimony is a metal used in the compound antimony trioxide, a flame retardant. It can also be found in batteries, pigments, and ceramics and glass. Exposure to high levels of antimony for short periods of time causes nausea, vomiting, and diarrhea. There is little information on the effects of long-term antimony exposure, but it is a suspected human carcinogen. Most antimony compounds do not bioaccumulate in aquatic life.

#### **Effects of Cadmium on the environment**

Cadmium derives its toxicological properties from its chemical similarity to zinc an essential micronutrient for plants, animals and humans. Cadmium is biopersistent and, once absorbed by an organism, remains resident for many years (over decades for humans) although it is eventually excreted.

In humans, long-term exposure is associated with renal dysfunction. High exposure can lead to obstructive lung disease and has been linked to lung cancer, although data concerning the latter are difficult to interpret due to compounding factors. Cadmium may also produce bone defects (osteomalacia, osteoporosis) in humans and animals. In addition, the metal can be linked to increased blood pressure and effects on the myocardium in animals, although most human data do not support these findings.[8]

The average daily intake for humans is estimated as 0.15 $\mu$ g from air and 1 $\mu$ g from water. Smoking a packet of 20 cigarettes can lead to the inhalation of around 2-4 $\mu$ g of cadmium, but levels may vary widely.

#### **Effects of Chromium on the environment**

Chromium is used in metal alloys and pigments for paints, cement, paper, rubber, and other materials. Low-level exposure can irritate the skin and cause ulceration. Long-term exposure can cause kidney and liver damage, and damage to circulatory and nerve tissue. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium.

#### **Effects of Copper on the environment**

Copper is an essential substance to human life, but in high doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation. People with Wilson's disease are at greater risk for health effects from overexposure to copper. Copper normally occurs in drinking water from copper pipes, as well as from additives designed to control algal growth.

#### **Effects of Lead on the environment**

In humans exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses, with the developing foetus and infant being more sensitive than the adult. High levels of exposure may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system.[9]

Lead poisoning, which is so severe as to cause evident illness, is now very rare indeed. At intermediate concentrations, however, there is persuasive evidence that lead can have small, subtle, subclinical effects, particularly on neuropsychological developments in children. Some studies suggest that there may be a loss of up to 2 IQ points for a rise in blood lead levels from 10 to 20 $\mu$ g/dl in young children.

Average daily lead intake for adults in the UK is estimated at 1.6 $\mu$ g from air, 20 $\mu$ g from drinking water and 28 $\mu$ g from food. Although most people receive the bulk of their lead intake from food, in specific populations other sources may be more important, such as water in areas with lead piping and plumbosolvent water, air near point of source emissions, soil, dust, paint flakes in old houses or contaminated land. Lead in the air contributes to lead levels in food through deposition of dust and rain containing the metal, on crops and the soil. For the majority of people in the UK, however, dietary lead exposure is well below the provisional tolerable weekly intake recommended by the UN Food and Agriculture Organisation and the World Health Organisation.

#### **Effects of Mercury on the environment**

Mercury is a toxic substance which has no known function in human biochemistry or physiology and does not occur naturally in living organisms. Inorganic mercury poisoning is associated with tremors, gingivitis and/or minor psychological changes, together with spontaneous abortion and congenital malformation.

Monomethylmercury causes damage to the brain and the central nervous system, while foetal and postnatal exposure have given rise to abortion, congenital malformation and development changes in young children.

#### **Effects of Nickel on the environment**

Small amounts of Nickel are needed by the human body to produce red blood cells, however, in excessive amounts, can become mildly toxic. Short-term overexposure to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation. The EPA does not currently regulate nickel levels in drinking water. Nickel can accumulate in aquatic life, but its presence is not magnified along food chains.

### Effects of Selenium on the environment

Selenium is needed by humans and other animals in small amounts, but in larger amounts can cause damage to the nervous system, fatigue, and irritability. Selenium accumulates in living tissue, causing high selenium content in fish and other organisms, and causing greater health problems in human over a lifetime of overexposure. These health problems include hair and fingernail loss, damage to kidney and liver tissue, damage to circulatory tissue, and more severe damage to the nervous system.[10]

## IV. CONCLUSION AND FUTURE SCOPE

However, a complete background knowledge on the sources of heavy metal, their chemistry, and potential risks posed to environment and humans are needed to select an appropriate remedial option. In this regard, many research investigations of various integrated options that are available for heavy metal removal/recovery from the contaminated environment are systematically summarized in this review. Based on our reviewed literature, processes with an integrated approaches were found to a serve as an effective alternative for removal of toxic heavy metals and recovery of valuable metals from highly contaminated industrial sites. Therefore, we conclude that the integrated processes involving EK processes and phyto-remediation had shown astonishing results of considerable reduction in the level and toxicity of heavy metals, with minimal disturbance to the natural environment. We also believe that these integrated technologies can be highly applicable for *in situ* operations in both developed and developing countries where, urbanization, agriculture, and industrialization are leaving an inheritance of environmental degradation.

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