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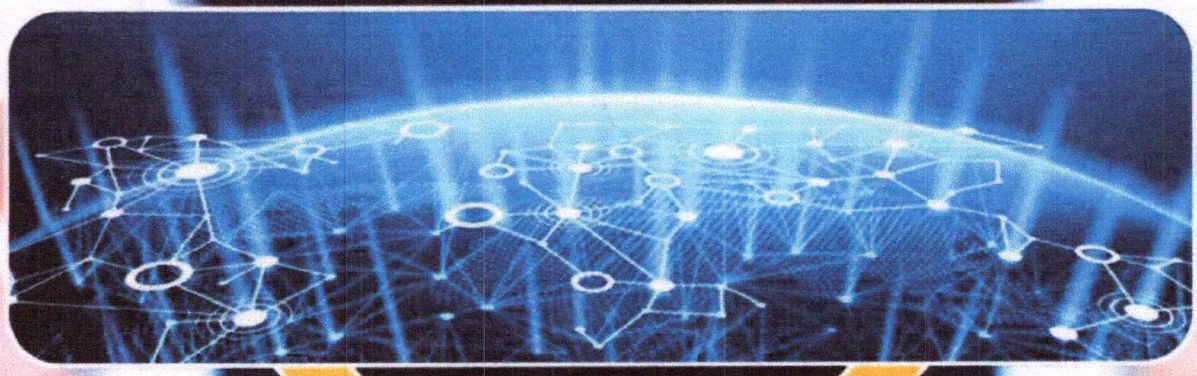

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Advances in Multidisciplinary Research and Development

Chief Editor
Dr. Dhondiram Tukaram Sakhare

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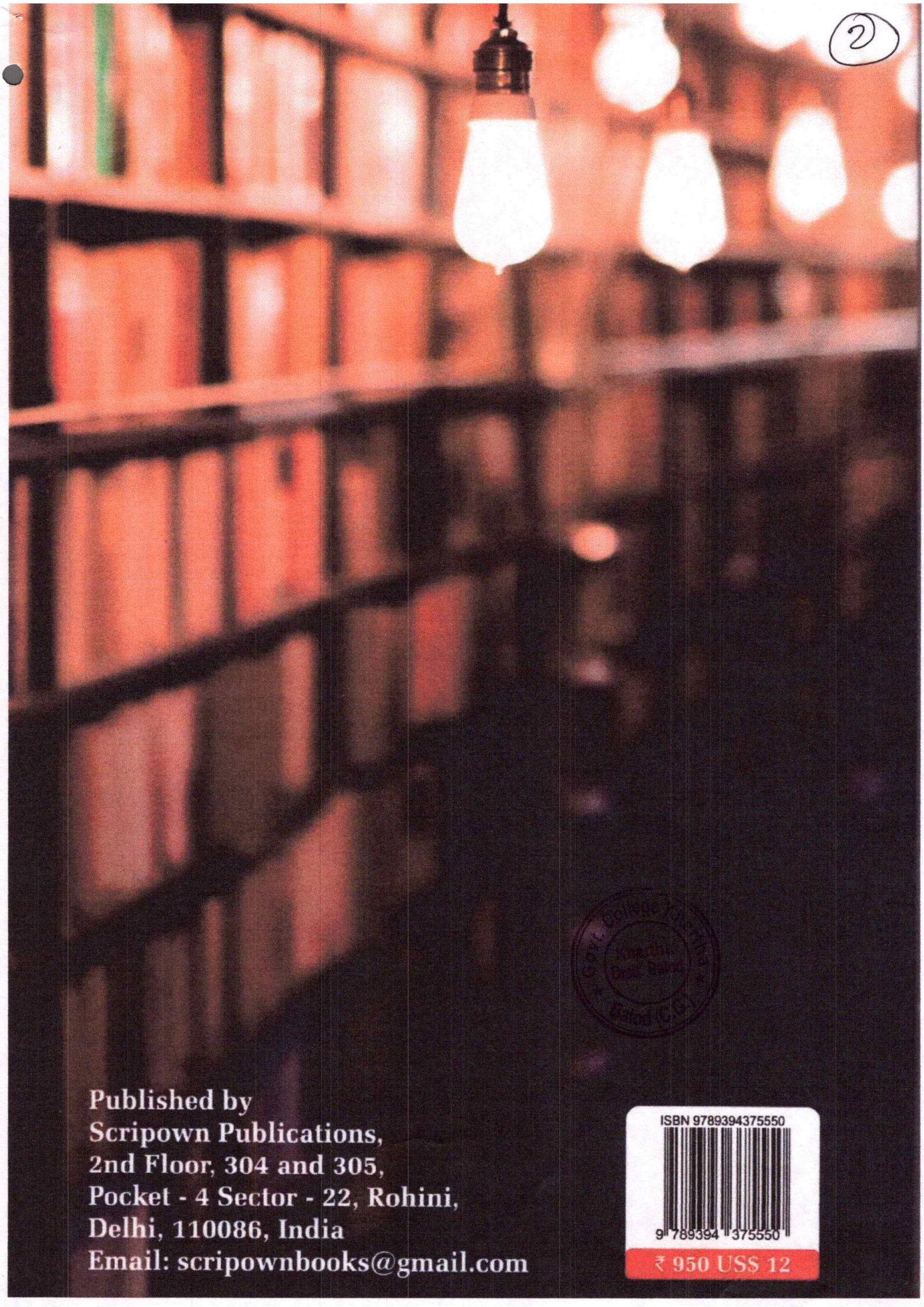

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Advances in Multidisciplinary Research and Development

(Volume – 9)

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Chapter - 6

Heavy Metal Pollution: Great Concern for Human Health

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Abstract

Heavy metal pollution is one of the major threats to human life. There are many heavy metals found in our surroundings. When they enter the animal body they can produce many types of problems. Mercury, cadmium, lead, chromium, and iron are examples of heavy metals which are affecting human life. heavy metals are harmful due to their tendency to bioaccumulation and biomagnification. these metals can accumulate in different parts of the human body and cause problems like kidney damage, brain deformities, respiratory problems, and genetic aberration. Heavy metal pollution can pose a significant health concern to humans and the environment. Heavy metals can accumulate in the soil, water, and air, and can eventually enter the food chain, causing harm to human health It is important to implement effective measures to reduce heavy metal pollution and protect public health.

Keywords: heavy metals, bioaccumulation, biomagnification

Introduction

The term "heavy metals" denotes elements with an atomic density of more than 4 g./c.m.^{3}. Some metals and metalloids come under this category (Nriagu, 1988). The term is generally used to refer to metals like mercury (Hg), Cadmium (Cd), Silver (Ag), Iron (Fe), Chromium (Cr), Lead (Pb), and Copper (Cu).

On the opposite end of the spectrum, the international union of pure and applied chemistry calls 'heavy metals' a meaningless term (Duffus, 2002).

Heavy metals are considered pollutants of concern in freshwater bodies due to their cancer-causing effect, mutagenic activity, and noxious impact. They are found in every ecosystem of the world. The most threatening effect of them is their ability to bioaccumulation and bioconcentration in living systems. They are also called trace metals because of their lower quantity requirement by different flora and fauna.

Heavy metals can be categorized into two main groups – essential and non-essential heavy metals. Some heavy metals like iron, zinc, chromium, copper, and manganese play a vital role in the proper functioning of body organs because of their role in metabolism. If their concentration exceeds an optimum level, they pose health risks to the body (Unger, 2002).

Heavy metals pollution is one of the highly discussed environmental problems for its harmful effects on different living beings. One of the biggest threats due to heavy metals is their tendency to bioaccumulate/bioconcentrate. Once they enter the food chain, they are transferred to the upper trophic level with higher concentration, so their effect of bioaccumulation is seen easily in the food chain at the topmost trophic levels (Kalay, 2000).

Some heavy metals like iron, magnesium, copper, and zinc play an important role in the metabolic activities of the body. Some heavy metals like chromium and nickel are needed in small quantities; other heavy metals like mercury, cadmium, lead, and arsenic have no role in the metabolism and physiology of the human body. Consumption of these metals even at a very low amount could be lethal. Different world authorities like European Union and the United States Environmental Protection Agency have set permissible limits for the presence of these heavy metals in food products; above that permissible limit, they are considered toxic (Young, 2005).

Mercury (Hg):

Mercury is one of the peculiar pollutants due to its indestructibility and persistent nature. Its horrific effects came into the limelight when the tragedy occurred in the year 1952 in the vicinity of the Japanese coast of minimata. Victims of this area suffered disorders related to the nervous system commonly called "Minimata disease" A previously unknown disease "Minimata" erupted and spread rapidly and became an epidemic. It was caused due to consuming fish and shellfish contaminated with mercury compounds (Takeuchi, 1968; Vandecasteele and Block, 1991).

Mercury is the only common metal that is liquid at ordinary temperatures. It rarely occurs free in nature and is found mainly in cinnabar ore (HgS) in Spain and Italy.

Effects of Mercury on Health

- Disruption of the nervous system and excretory system.
- Damages brain activities.
- DNA damage and chromosomal aberrations.
- Allergic reactions, result in skin rashes, tiredness, and headaches.

- Negative effects on the reproductive system, such as sperm damage, birth defects, and miscarriages (Valek, 1965; De, 2014).

Lead (Pb):

Lead is a bluish-white, highly shiny, malleable, and ductile metal. It is one of the most poisonous Heavy metals. A large portion of the lead fixations found on the earth is an after-effect of human exercises like the burning of petroleum products and industrial activities. Lead emission from consumed petroleum in the engine has chlorides, bromides, and oxides of lead which enter the environment into the air. The bigger particles drop to the earth quickly and pollute soil and water.

"Lead is a delicate metal and is generally utilized as a part of metal items, pipelines, paints, and pesticides. It can spread in water and soil through the corrosion of pipelines and leaded paints. Lead can accumulate significantly well in the water and soil flora and fauna. It can enter the human body through the uptake of food, water, and air." (Jarup, 2003)

Vegetables, agricultural produce, poultry products, fish, meat, sea products, and liquor may contain some amount of lead. Lead is one out of four metals that have the most harmful impacts on human well-being. Lead has the capacity for trans-placental penetration and can damage the nervous system of the unborn baby.

Effects of Lead on Health

- Disruption of the biosynthesis of hemoglobin and anemia.
- Elevated blood pressure.
- Kidney failure.
- Miscarriage.
- Disruption of the nervous system.
- Brain damage.
- Infertility of men through sperm damage.
- Low learning abilities of children.
- Behavioral changes in children, such as aggression, impulsive behavior, and hyperactivity (Jarup, 2003; Duruibe et al., 2007).

Cadmium (Cd):

Cadmium is not essential for human beings. It does not have any metabolic role in the human body. It is a byproduct of zinc production and is mostly found in the earth's crust with zinc. It is one of the most toxic elements

to which humanity is exposed. Once absorbed, Cadmium is retained in the human body and accumulates up to the lifetime of the topmost trophic level animal. Most cadmium is incorporated into the environment by weathering of rock and through human activities. It is mostly generated as industrial waste.

The Itai-Itai bone disease reported from Japan in 1960 was caused by Cadmium that had been discharged into the environment by different sources. After the outbreak of Itai-Itai disease, different studies were carried out worldwide to characterize the toxicity of Cadmium (Hagino, 1961). Cadmium uptake in humans generally takes place through food products and cigarette smoking. Fishes, shellfish, and sea products may also contain Cadmium (Bernard, 1986). Cadmium is used in nickel-cadmium batteries, electroplating, pigments, and paints (Nordberg et al., 2007).

Effects on Health

- Diarrhea, stomach spasms, and vomiting.
- Bone fracture.
- Reproductive dysfunction and infertility.
- Damage to the central nervous system.
- Damage to the immune system.
- Psychological disorders.
- DNA damage or cancer (Jarup, 1998; Sethi et al., 2006).

Chromium (Cr): Chromium is radiant, brittle, dim color metal. The human body requires it to perform certain vital functions like catabolism of fat and carbohydrate and to control the optimum level of glucose and blood pressure (Anderson, 1989).

Chromium is found in two types - trivalent and hexavalent. Hexavalent chromium is not found naturally, it is produced by different industrial activities. Hexavalent chromium is loosely dissolved in water and leached into underground water. Sometimes underground water may contain a higher level of chromium (Sullivan, 1969; Towill, 1978).

Some industries are directly responsible for releasing chromium into the environment. Industrial establishments like steel, leather tanneries, textile dyeing, printing, photography, and chrome electroplating are mainly responsible for this. Chromium accumulates in aquatic flora and fauna and can be seen at many folds above the higher level of the food chain (Hantson, 2005; Adeniyi and Yusuf, 2007; Gupta et al., 2009; Raphael et al., 2011).

Effects on Health

- Allergic reactions, such as skin rashes.
- After breathing it can cause nose irritations and nosebleeding.
- Stomach disorders and ulcers.
- Respiratory complications.
- Weakened immunity.
- Nephrological and liver damage.
- Genetic aberrations.
- Lung cancer (Braver, 1985; Cohen, 1993; Geller, 2001).

Iron (Fe):

Sources of iron in freshwater are related to mining activities. Iron pyrites (FeS_2) found in the coalfield release iron by weathering and bacterial action. Mining and oxidation of iron pyrite results in the production of sulphuric acid and the formation of Ferrous iron (Fe^{2+}) (Smith et al., 1973).

Different types of iron ores like hematite and magnetite when comes in contact with acidic water releases ferrous and ferric ion. Iron is a common element of industrial and mining output that is often discharged into aquatic environments. Ferrous ion (Fe^{2+}) is considered more toxic to fish than the ferric ion (Fe^{3+}) (Decker et al., 1978).

Iron plays a vital role as a part of enzymes such as catalase and cytochrome, and most importantly, as a part of hemoglobin and myoglobin. It is commonly found in all freshwater environments (Livingstone, 1963; Forstner et al., 1979). High iron content in water causes corrosion and rust formation of pipelines and results in a metallic taste of water (Theis et al., 1974).

Iron can be toxic at high concentrations, Iron's ability to transfer electrons means that it can form free radicals; it can convert hydrogen peroxide into free radicals. Free radicals can damage the structure of the cell and ultimately kill the cell (Crichton et al., 2002).

Heavy metals released in the aquatic system by natural or manmade sources are deposited and distributed in different parts of the ecosystem like water, sediment, flora, and fauna (Moore et al., 1984). Fishes can be considered the best indicator of metal pollution due to their ability to acquire these metals from the surrounding environment (Kitchell et al., 1975).

Fishes have different feeding patterns, some are herbivorous, and

omnivorous, while others are detritivores. They are in direct contact with water; there is continuous water flow inside their body, so if any change in water quality occurs it can be observed in fish. So, we can monitor the environmental condition of any area by monitoring fish habitats of the specific water source. A large population depends on fish so if any pollutant enters fish, it may be harmful to the health of humans too (Rashed, 2001).

Accumulation of heavy metals in fish depends on different parameters like water hardness, pH, salinity, and the metabolism of the fish. As we know, fish are generally at the top of the food chain, they may concentrate a greater number of Heavy metals from lower-level animals in the food chain. This may result in the phenomenon of biomagnification of Heavy metals. As man is a fish consumer, biomagnified Heavy metals in fish may transfer to humans and can produce different types of ailments (Mance, 1987; Begum et al., 2005; Fernandes et al., 2008; Praveena et al., 2008).

Health Risks for Children and Adults associated with the Consumption of Fishes contaminated with Heavy Metals :

Food consumption is a major way through which humans, as well as other animals, are exposed to toxic heavy metals. Many reported studies have confirmed that contamination of heavy metals via the food chain can cause human health risks because of their toxicity, long persistence, bioaccumulation, and biomagnification. Heavy metals disrupt cellular events including growth, proliferation, differentiation, damage-repairing processes, and apoptosis. A comparison of the mechanisms of action reveals similar pathways for these metals to induce toxicity including reactive oxygen species (ROS) generation, weakening of the antioxidant defense, enzyme inactivation, and oxidative stress. On the other hand, some of them have selective binding to specific macromolecules. The interaction of lead with aminolevulinic acid dehydratase and ferrochelatase is within this context. Some toxic metals including chromium and cadmium cause genomic instability. Defects in DNA repair following

the induction of oxidative stress and DNA damage by cadmium and chromium have been considered the cause of their carcinogenicity. Mercury and lead, on the other hand, disrupt the functioning of the human body in other ways. Mercury could cause thiol binding, inhibit glutathione peroxidase and enzymes, reduce aquaporins mRNA, and affect ROS production. Lead causes increased serum and inflammatory cytokines and a reduction in Glutathione (GSH), Superoxide (SOD), and Glutathione peroxidase (GPx) levels. Even with the current knowledge of the hazards of heavy metals, the incidence of