ORIGINAL ARTICLE

A REVIEW ON HEAVY METALS CONTAMINANT IN GROUNDWATER AND THEIR TOXIC EFFECTS ON HUMAN HEALTH & ENVIRONMENT

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ABSTRACT

Seventy percent of the Earth is covered by water in the form of oceans, lakes, rivers, etc., and only 2.5% is available for human use. However, the deteriorating quality of water by natural and anthropogenic sources has become a serious concern worldwide. Anthropogenic sources, particularly the unchecked industrial wastewater streams containing toxic metals (Cd, Hg, As,Ni, Pb, etc.) organic pollutants and bacteria are the major sources of water pollutants. Among several kinds of water pollutants, heavy metal ions are widely considered as catastrophic owing to their adverse toxic effects. Considering this, the World Health Organisation (WHO) and Bureau of Indian Standard (BIS) prescribe stringent limits of heavymetal concentration for potable purpose. This chapter focuses on the type of indulged pollutants with special attention to heavy metal pollution, describing their origin, nature, and effect on human, animal, and plant health. Moreover, various case studies on heavy metal pollution in water systems are outlined along recent with mitigating approaches and technologies, current development, and future projections.

Keywords: *Contamination, Ground water, Heavy metal, Sources, Pollution, Water Pollution.*

1. INTRODUCTION

Groundwater is one of the prime natural resources upon which the survival of mankind as well as the social and economic development of the nation are dependent. Only 2.5% of the world's water is non-saline fresh water. Since water is a universal solvent and which provides the ionic balance and nutrients, supports all forms of life [1]. It has been used for drinking for a long time and its purity has made it a well-known source of potable water. Advancement of human civilization has put serious questions to the safe use of groundwater for drinking [2]. Several factors such as climate, characteristics of soil, circulation of ground water through rock types, topography of the area, human activities on the ground etc. possess several effects on the quality of water [3]. In some coastal areas, intensive pumping of fresh ground water has caused salt water to intrude into fresh-water aquifers [1]. Heavy metal pollution represents an important environmental problem due to its toxic effects and bioaccumulation throughout the food chain. The main sources of heavy metal pollution include electroplating, painting and surface treatment industries [4]. Some transition metals at trace levels in our metabolism are important for good health. Heavy metals normally occurring in nature are not harmful to our environment, because they are only present in very small amounts.

However, if the levels of these metals are higher than the levels of healthy life, the roles of these metals change to a negative dimension. The direct sources of the heavy metal ions are food and water and, indirect sources are industrial activities and traffic [5]. Some heavy metals such as Cu, Fe, Mn, Ni and Zn are compulsory micronutrients for flora – fauna and microbes. The quantity of copper compounds in nature is minimal. Cu enters the groundwater from weathering of minerals and rocks, which contain copper.

Copper (Cu) is essential to human life and health but, like all heavy metals, is potentially toxic as well as continued inhalation of Cu containing spray is linked with an increase in lung cancer among exposed worker [6]. On the other hand, lack of copper intake causes anaemia, growth inhibition and blood circulation problems [3]. Symptoms of severe copper poisoning include extensive homolysis, hepatic necrosis, nephropathy, coma, Wilson's disease. If not treated it may lead to death. Lead poisoning has been recognized as an occupational illness for centuries and it is linked with both severe Higher concentration of lead in drinking water has adverse effect on central nervous system, blood cell and may cause brain damage [2]. Chromium is present in small quantities in nature. It is present maximum in rocks than in those of silica type. The toxicity of chromium depends on its physicochemical shape; hexavalent salts are considered the most dangerous [1]. Nickel is also non-toxic element, but it affects physiological process at very high concentration [4]. The high level of nickel in waters are due to mixing of variety of wastes including that of automobile repair shops, electroplating units, utensil manufacturing process, sewage, agricultural runoff. High heavy metal concentration is attributed to runoff into the water body. Mercury is a toxic element and serves no physiological function in man i.e., non-essential element [3]. Water containing high mercury content is not suitable for drinking. Keeping in view the hazardous nature of heavy metals contamination in water, it is imperative to initiate this study to assess the problem and suggest ways and means to decrease the risk of toxic heavy metals contamination of drinking water [7]. To know the maximum acceptable concentration of heavy metals in drinking water, guidelines have been set by different

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international organizations such as USEPA, WHO, EPA and the European Union Commission. Domestic uses of groundwater are used for agriculture and industrial determination in many parts of the world. Human Activities like swage and waste water re- lease huge number of pollutants into the water. In India surface water and ground water are used for the anthropogenic and agriculture and industrial purpose [8]. In now days the growing of many industrial development machinery, incising pollutions and water are used to improvement of the pressure upon together our water and land sources. Contamination difficulties contain sewerage leakage procedure and landfills leeching. Some seaside areas, thorough impelling of fresh bore well water has produced salt water to interrupt into fresh-water aquifers. The growth process of world contamination of water are biggest threats have become progressively apparent and have led to major environmental problems [9].

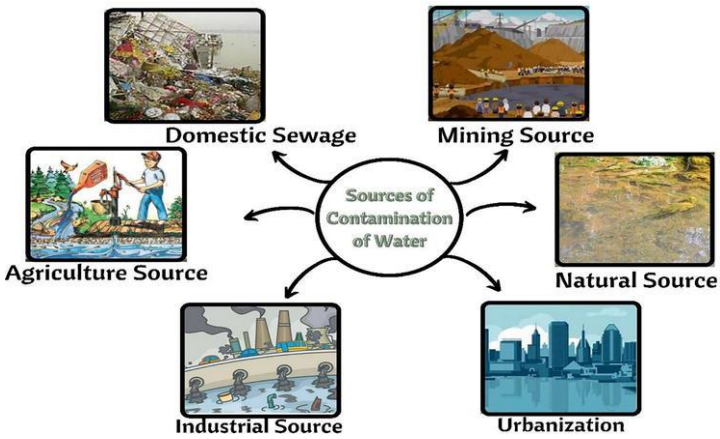


Figure 1: Heavy Metal contamination of water and their toxic effect on living organisms.

2. Sources of Contamination of Heavy Metal in Ground water

i) Natural sources

In nature are found the extreme stages of heavy metals can happen by physical condition are like withstanding of rocks, volcanic eruptions, leach out into rivers, lakes and groundwater due to stroke of water [10]. The Earth's layer, productions from volcanoes and vaporization. In natural water are found various heavy metals. Mining activity of the across of world the metal leads to direct and indirect waste into the water [11].

ii) Anthropogenic sources

Minor quantities of heavy metals are released while mining and wild producing of bulky amounts of metal, ores in open fires. With the industrial uprising, metals were mined from natural sources and treated in the industries from where heavy metals conceded on into the water. Likewise traces of heavy metals get into the environment over release of waste - both domestic, agricultural and from auto drains. Following list displays the several human activities done which heavy metals get into the water & environment. The major sources of Heavy metals are mentioned on below table no 2.

a) Smelting or treating of ores of metals.
b) Mining.
c) Burning of fossil fuels petroleum products.
d) Discharging industrial waste.
e) Discarding domestic waste.
f) Discarding from auto exhausts.
g) Using pesticides having salts of heavy metals [12].

Table 1: Major sources of some Heavy metal ions in water

Sr. No	Heavy metal ion	Common sources
1	Copper (Cu)	Fertilizers, tanning, and photovoltaic cells
2	Zinc (Zn)	Soldering, cosmetics, and pigments
3	Silver (Ag)	Refining of copper, gold, nickel, zinc, jewellery, and electroplating industries
4	Chromium (Cr)	Leather industry, tanning, and chrome plating industries
5	Arsenic (As)	Wooden electricity poles that are treated with arsenic-based preservatives, pesticides, fertilizers, the release of untreated effluents, oxidation of pyrite (FeS) and arsenopyrite (FeAsS)
6	Mercury (Hg)	Combustion of coal, municipal solid waste incineration, and volcanic emissions
7	Cadmium (Cd)	Paints, pigments, electroplated parts, batteries, plastics, synthetic rubber, photographic and engraving process, photoconductors, and photovoltaic cells
8	Lead (Pb)	PVC pipes in sanitation, agriculture, recycled PVC lead paints, jewellery, lead batteries, lunch boxes, etc.

iii) Mining activities

Heavy metals are found in the earth's physical background and consequently come in water sources concluded natural procedures. Example of the contamination of mining activity through heavy rains or fluid water can leaching heavy metals out of physical background. Such procedures are improved when this physical property is disturbance by commercial actions such as mining. These procedures representation the mined waste telling area to water can lead to significances such as acid mine drainage [13].

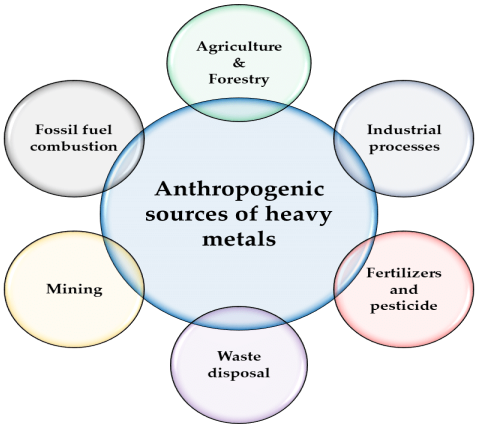


Figure 2: Anthropogenic Sources of Heavy metals.

iv) Mineral extraction

Mineral dispensation processes can also produce major heavy metal contamination, both from through removal procedures (which naturally involve size decrease - significantly accumulative the external mass area transferal - and produce wastes over leach out from ore and tailings accumulations [13]. Electronic properties Industrial Corporations essential be legitimately guaranteed to indication the discarding procedures of their product in their user guide book. Recognized major toxicity producing by E-wastes and main source of heavy metals, dangerous compounds and carcinogens, diseases connected to intestinal, immune, skin, respiratory, and endocrine CNS and cancers containing can be prohibited by appropriate management and removal of E-waste. With an estimation to association the digital distributes, there is exponential growing in the use of Electrical and electronic apparatus and so around is troubling effect on people and environment when the ICT wastes are not discarded of systematically [14].

3. Heavy Metals in Water & Effect on Human Health

i) Arsenic (As)

Arsenic toxicity also presents a syndrome, which is associated to, and frequently disorganized with Guillain-Barre disease, an anti-immune illness that occurs when the bodies resistant function incorrectly occurrences part of the PNS, resultant in nerve irritation that reasons muscle weakness. Arsenic is the most significant heavy metals affecting concern from both environmental and separate health stand points. The metallic function of arsenic and is apparently toxic and carcinogenic, and is generally obtainable in the form of oxides or sulphides or as a salt of iron, sodium, calcium, copper, etc. Arsenic are 20th most abundant metals are originating in earth its arsenic on geological and its mineral systems such as arsenate and arsenate multiplexes are fatal to the atmosphere and current people. sulfhydryl group of cells producing malfunctioning of cell breathing, mitosis and cell enzymes mostly effected by Arsenic [13]. People health outcome toxicity of arsenic happens due to consumption of as consuming dusts or solutions by mistake, homicide, suicide, or ingestion of contaminated food or drinking water. Arsenic was caused to relate to hypertension and major impacts on the cardiovascular structure, and even hepatic damaging in the extreme quantity taken [15,16]. An exploitive result release on spermatogenesis and gonadotrophin and testosterone in human [17].

ii) Lead (Pb)

Lead is a hazardous component; it is injurious even in minor quantities. Lead component comes in the Human body majorly found in water and food. It can be gasped in powder form of lead in paints, or excess gases from leaded petroleum products. It is originated in minor quantities in several water bodies & food, particularly fish, which remain seriously focus to industrialized toxic waste. Approximately old households might water pipes consume lead, which can then pollute intake water. Contact to lead is growing above period. Extreme level of lead absorptions in the human body can cause death or perpetual harm to the brain, central nervous system and kidneys [18]. The devices fundamental lead developed neurotoxicity is compound. Anxiety, membrane bio-physics modifications or cell motioning deregulation and the damage of neurotransmission are important characteristics difficult in lead neurotoxicity. It can cause toxicity by oxidative anxiety straight or ultimately by lipid peroxidation resultant in the group of sensitive oxygen types (ROS), counting hydroperoxides, singlet oxygen, hydrogen peroxide and through reduction of antioxidant investments. Lead reduces enzymes non-functional by compulsory to their sulfhydryl group's additional contribution to a damage in oxidative balance [19]. The capability of lead to permit above the barrier blood and brain is mostly due to its capability to extra for calcium ions. Major toxicity of lead causing the brain prefrontal hippocampus, cerebellum and cerebral cortex can lead to a variability of neurological dis- order, such as brain injury, psychological delay, behaviour difficulty ties, nerve injury, and probably Alzheimer's disease, Parkinson's disease and schizophrenia [20].

iii) Nickle (Ni)

Nickel is usually found in human tissues and, under situations of high exposure, these levels may rise significantly [21,22]. In the universal population, contributions to the people intake of nickel in the air and from drinking water are normally less significant than dietary intake and absorption is the most significant way of exposure. The consumption of nickel is dependent on its physicochemical procedure, with water-soluble methods (chloride, nitrate, sulphate) presence further readily consumption. In animals, 1-10% of the dietary nickel is consumption by the route of gastrointestinal. It is significant to note that the means in which nickel is absorbed may importantly affect its bioavailability [23,24]. While differences in distribution happen as a role of way of exposure, the solubility of the nickel element and period after exposure, the major target organs for nickel-induced general toxicity are the lungs and the higher respiratory tract for inhalation exposure and the kidney for oral exposure. Additional object organs contain the cardiovascular system, the immune system and blood [25,26]. Human exposure to extremely nickel-polluted in water has the probable to produce a range of pathological affects. Amongst them are skin allergies, lung fibro- sis, cancer of the respiratory tract and iatrogenic nickel toxicity [27-29]. A various research studies are shown that established the hepatic toxicity related with nickel exposure and dose related modifications in serum enzyme action were observed following animal treatment with nickel. Nephrotoxicity has been noted and aminoaciduria and proteinuria were the directories of nickel toxicity. Nickel exposure has been conveyed to produce haematological effects in both humans and animals. Although no reproductive effects have been linked with nickel exposure to humans [25,29,30].

iv) Chromium (Cr)

Chromium is a naturally arising metal existing on the geo- logical, by states corrosion ranging from chromium [31]. Chromium arrives into several environmental mediums (water, soil and air) from an extensive variability of anthropogenic and natural sources with the major discharge upcoming from industry establishing. Industry with the major involvement to discharge chromium contains metal dispensation, tannery services, chromate manufacture, welding stainless steel, and ferrochrome and chrome pigment manufacture. The growth in the environment contamination of chromium has remained associated to wastewater and air discharge of chromium, mostly from metallurgical, and biochemical productions. Contaminated chromium into the environment from major anthropogenic action happens generally in the hexavalent method. Hexavalent chromium is a poisonous industry waste contaminant that is categorized as human carcinogen by numerous controlling and non- controlling activities [32,33].

Environmental exposure of chromium is involving mixtures compound is known to produce multi organ posonousness such as asthma, allergy, renal damage and major effect cancer of the respirational tract in people [34,35]. Inhalation extreme level of chromium can origin frustration to the covering of the nose and ulcers. The major health difficulties seen in human subsequent consumption of chromium mixtures are impatience and ulcers in the small intestine and abdominal, anaemia, damage male reproductive system and sperm damage. Chromium mixtures are plentiful fewer poisonous and do not perform to origin these difficulties. Nearly persons are tremendously sensitive to chromium, allergic responses containing of severe swelling and redness of the skin have remained noted. A growth in abdominal tumours was observed in people and animals showing to chromium in water. The consumption of excessive quantity was taken of chromium complexes by humans takes resulted in plain respiratory, cardiovascular, gastrointestinal, haematological, hepatic, renal, and neurological effects as part of the sequelae important to death or in patients who persisted as per medical treatment. Though the indication of carcinogenicity of chromium in people and global living thing appears tough [36].

V) Zinc (Zn)

Zinc is an important mineral apparent by the human today as being excellent biologic and human health significance, mainly concerning prenatal and perinatal growth. Zinc deficiency effects around two billion public in the rising global and is related with several illnesses. In children its sources development delay, late sexual development, infection vulnerability, and diarrhoea. Enzymes with a zinc particle in the sensitive focus are extensive in chemistry, such as liquor dehydrogenase in people Zinc in- sufficiency is generally due to unsatisfactory dietary consumption, but can be correlated with malabsorption, Acrodermatitis enteropathy, liver damage, renal damage, sickle cell damage, diabetes, malignancy, and other chronic diseases assemblies at hazard for zinc deficiency contain the elderly, children in rising nations, and individuals with renal deficiency. Signs of mild zinc insufficiency are varied. Medical consequences contain depressed development, diarrhoea, weakness and late sexual development, alopecia, eye and skin abrasions, decreased appetite, changed perception, decreased host protection possessions, defects in carbohydrate utilization, and reproductive spermatogenesis [37].

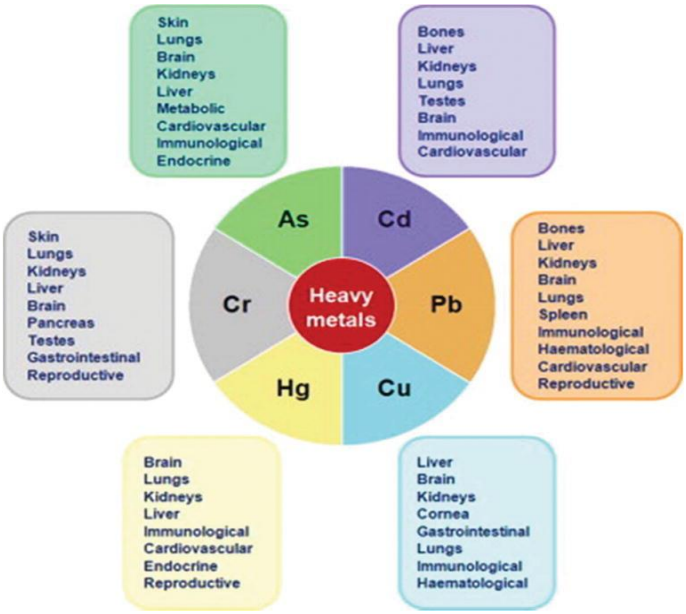


Figure 3: Impacts of Heavy metals on the Human body and their organs.

4. Conclusion and Future Aspects

Being the largest freshwater sources, groundwaters not only provide adequate supply for domestic, agricultural, and industrial activities but also ensure sustainability of the ecohydrological phenomenon. Their continuous depletion (due to overexploitation) and deterioration (due to pollution) are causing grave environmental and health consequences. Particularly, over the past few decades, release of unchecked industrial wastewaters into streams of heavy metal ions into groundwater resources has been found to be catastrophic andthe devastating impacts of the use of heavy metal contaminated groundwater can be seen across the globe despite strong and rigid legislations. Therefore, the major challenge now is to maintain the sustainability of groundwater resources in conjunction with socioeconomic- industrial development. The development of efficient methodologies that can be used to monitor groundwater sources in real time from the perspective of heavy metal pollution are highly desirable. The permissible limit of Heavy metal ions in water and WHO permissible limits are mentioned on below table no 2.

Table 2: Permissible limit of Heavy metal ions in Water.

Heavy Metals	WHO Permissible Limit (mg L^{-1})
Se	0.02
Hg	0.001
Mn	0.02
Ag	0.1
Cd	0.05
Cr	0.003
Pb	0.01
Zn	3.00
Fe	0.30
Cu	0.02
As	0.01

Further, technologically feasible and commercially viable treatment processes need to be designed and developed for the pre-treatment of industrial waste before it discharges to groundwater sources and other water bodies. Moreover, attention needs to be paid to the sustainability of new-generation advanced treatment technologies like membrane filtration and adsorption so that treatment of contaminated groundwater can be achieved on a bulk scale at the point of source prior to its consumption. These technologies not only offer purified water from contaminated water but also provide an opportunity for recovery of heavy metals as resource materials from polluted waters. The prolong research needs to be conducted in the industrial and contaminated areas in the sites. All the Industries should be followed zero liquid discharge of water and should be submitted their industrial solid waste to authorized agency the treated waste water needs to be used for gardening purpose, encourage research on remediation of ground water, soil and industrial solid waste contaminated sites in industrial areas.

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