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Bioaccumulation of Heavy metals and chemical Toxicants from industries, a serious threat to environment and human

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ABSTRACT
Environmental Pollution due to heavy metals and toxicants is a direct consequence of their extensive utilization in various industrial processes. The persistence and nondegradability of heavy metals cause them to bioaccumulate in nature, and when they come in direct contact with our environment, these hazardous toxicants not only contaminate it severely but also cause serious threats to human health and agriculture. Therefore, their concentration sometimes increases in feeds, fodders, water bodies, and tissues of livestock in the vicinity of the industrial areas, leading to metabolic, structural, and functional changes of different organs of all animals and plants due to their bioaccumulation in several organs mainly in the liver, kidney, lung, and reproductive organs. Due to increased oxidative stress at cellular levels led by over-production of reactive oxygen species, exhausts antioxidant defense mechanisms leading to disruption of biologically relevant molecules, viz.nucleic acid, protein, lipid, and subsequently apoptosis, cell damage, and necrotic cell death. These toxicants can affect human as well as aquatic biota and also affecting soil productivity, therefore their accumulation cannot be ignored. Hence there is need to monitor their concentration at every level from time to time and also to generate awareness among people to combat this serious problem. Formulation of policy guidelines and regulations for the management of toxicants containing groundwater and routine risk assessment of toxicant-contaminated soils is needed with proper. Further, advanced approaches such as biotechnology could facilitate in developing microbial genotypes to reduce deleterious impact of toxicants on environment and public health.
Key Words: *Environmental pollution, Toxicants, Bioaccumulation, Public health, Management.*

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INTRODUCTION

Problems related to environment have always remained as the major concern for the scientists across the world. Toxicants pollution is a critical environmental concern that has posed serious threats to human health and agricultural production Enormous economic development and rapid growth in many fields, such as agriculture and industry has led more environmental pollution [1]. Environmental pollutants are toxic substances which enter the environment from both anthropogenic and natural sources. Certain processes that are used in certain industries such as synthetic industries, coal conversion, and waste burning, result in hazardous problems for abiotic elements (water, air, and soil) and biotic communities (animals, plants, and humans) [2]. Heavy metals and pesticides are the major toxicants of the environmental endangering nature. These environmental toxicants threaten the entire ecosystem, seriously damaging its function and structure [3].

Heavy metals emission from various sources can contaminate groundwater and surface water, agricultural soils, and food crops; [2, 43]. Number of scientific study based reports indicated that water, soil, vegetables and dust have been heavily polluted by lead (Pb), arsenic (As), copper (Cu), chromium (Cr), zinc (Zn) and cadmium (Cd) near the mining areas Pb, As [4-7] Cu, Cr and Cd are important toxic heavy metals, and have also been identified as health risks by World Health Organization (WHO) [44, 59, 60].

In many countries of the world, currently waste water is used for agricultural purposes. At least 20 million hectares of land are irrigated with untreated or partially treated wastewater that poses the highest risk to the environment and human health [9, 10]. However, the problem is more severe in developing countries like India where reusing waste water for agricultural purposes is increasing from time to time [Raschid-Sally L *etal* 2009]. This leads to the uptake and accumulation of various metals in foods and potential risks to human health [11, 35, 62].

Consumption of unsafe concentrations of heavy metals in food may lead to the disruption of biological and biochemical processes in the human body [12]. These disorders are characterized by gastrointestinal disorders, stomatitis, tremors, diarrhea, hemoglobinuria, paralysis, vomiting, convulsions, and depression [39, 13]. Similarly, heavy metals have the ability to disrupt metabolic activity and genetic makeup, or to affect embryonic or fetal development [14].

Therefore, food safety is an important public health issue, and is necessary to maintain food quality and to ensure that human beings are safe from food related health hazards [15]. In many urban areas of India, a large volume of untreated waste water is released into water bodies that are used for irrigation or agricultural purposes and has significant negative impacts on human health and the environment [50, 16]. Besides these problems, there is no adequate country-wide knowledge base of the public health implications of heavy metals in foods and drinking water in India.

Thus, this review aimed to determine the public health implications of heavy metals in foods and drinking water in India that can be crucial to understand its implications, to take the appropriate measures by the concerned organizations, and to protect the public health and environment.

VARIOUS EFFECTS OF HEAVY METALS

Heavy metals Impacting Human Health

Arsenic (As), cadmium (Cd), chromium (Cr), and nickel (Ni) have all been categorised as group 1 carcinogens by the International Agency for Research on Cancer (IARC) (2012) [26] because long-term exposure increases the risk of developing various cancers and disrupts the expression of tumour suppressor genes, damage repair mechanisms, and enzymatic activities that are involved in metabolism through oxidative damage. [3].

Heavy metals are toxic, persistent, and harmful to human health even at low concentrations of metallic chemicals with a comparatively high density [19]. Some of these are mercury (Hg), lead (Pb), copper (Cu), cadmium (Cd), arsenic (As), chromium (Cr), thallium (TI), manganese (Mn), zinc (Zn), and nickel (Ni) [20]. In their lower amounts, some of these metals—Fe, Mn, Cu, and Zn—are necessary for metabolism [21]. The most frequently encountered heavy metals that have the ability to have harmful effects on human health are As, Cd, Cr, Co, Pb, Ni, and Zn [22]. However, due to their ease of availability through the food chain, cadmium and lead have more detrimental side effects on human health [23, 24].

Due to their propensity to damage DNA and membranes, as well as to interfere with protein and enzyme action, toxic metals have been shown to pose a serious risk to human health., [56-62]. Consumption of unsafe levels of heavy metals in food may disrupt biological and biochemical processes in the body [25], leading to a variety of disorders like gastrointestinal disorders, stomatitis, tremors, diarrhoea, hemoglobinuria, paralysis, vomiting, convulsions, and depression [26]. Additionally, heavy metals have the capacity to interfere with genetic composition, metabolic function, and foetal or embryonic development. [27].

Heavy metal effects on cellular mechanism

To comprehend the molecular mechanisms of metal effects, numerous studies have been conducted. The findings showed a correlation between the biological system and the individual metal characteristics, dose, and exposure duration. In addition to the oxidative stress that metals cause, they may also have additional impacts on cellular signalling pathways. They have an immediate impact on a cell's biology through a variety of mechanisms, such as binding to and activating cell surface transporters and receptors [29, 30], modulating specific intracellular kinases and phosphatases [31], activating metallothioneins [32, 5] and specific enzymes [33]; and (d) inducing DNA damage or affecting DNA repair systems [34].

Adverse effects of Industrial toxicants on Agriculture and Soil

Heavy metals can be divided into two categories based on their natural makeup: organic and artificial [34]. For instance, inorganic As is more dangerous than its organic form because its pentavalent inorganic compound solubilizes in water to create arsenate [6], which causes ground water contamination and has an impact on people [13]. Heavy metal contamination of the environment has resulted from intensive anthropogenic activities, including agriculture, and has presented serious issues for the safe use of agricultural land [Fytianos K., etal 2001]. As a result of mechanical cultivation and the arbitrary use of agrochemicals like pesticides and fertilisers, farmland soils may become contaminated with both necessary and unnecessary heavy metals health [18, 24].

Therefore, the safety of food is an important public health concern, and is essential to maintain food quality and to ensure the safety of human beings from food related health hazards [1, 56] worldwide, namely,in many urban areas of Ethiopia, a large volume of untreated waste water is released into water bodies that are used for irrigation or agricultural purposes and has significant negative impacts on human health and the environment [35].

Hazardous effects of Bioaccumulation of Toxicants In food chain

A thorough analysis of the soil-rice system in rural and peri-urban regions of the lower Brahamputra valley in northeastern India for heavy metal pollution and health risks revealed that the paddy soil was acidic, ranging from strongly acidic to weakly acidic. The Nemerow pollution indicator indicated moderate to severe pollution. Correlations were found between the Cd and Fe concentrations in rice grains and the associated soil. Therefore, it was determined that heavy metal pollution in rice poses a threat to customers' health. [3]

Another study conducted in the Jhansi area identified seasonal variations in the accumulation of heavy metals in various vegetables and linked these variations to a significant health risk for adult humans. More than 25 composite samples of soil and vegetables (fenugreek, spinach, eggplant, and chilli) that were gathered from various agricultural areas were analyzed for their total concentrations of zinc (Zn), lead (Pb), nickel (Ni), manganese (Mn), copper (Cu), cobalt (Co), and cadmium (Cd). Significant non-carcinogenic health risks due to exposure to analyzed heavy metals through intake of these veggies were computed, as well as the transfer factor of heavy metals from soil to analyzed vegetables. According to the statistics, anthropogenic actions were a significant source of heavy metals in the environment. [19], 23]

It was necessary to look into soil-borne organic contaminants because agricultural areas were transformed into an industrial corridor under the State Industries Promotion Corporation of Tamil Nadu Limited (SIPCOT). This research is the first to assess the presence of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and organochlorine pesticides (OCPs) in soils from the Mambakkam and Cheyyar SIPCOT belt along residential, industrial, and agricultural transects. 28 PCBs, 16 PAHs, and OCPs were all present in concentrations between 0.3 and 9 ng/g, 33 to 2934 ng/g, and nd-81.4 ng/g, respectively. The frequent use of residential areas in vector control programmes may have contributed to residential areas showing greater OCP concentrations than other site types. Low concentrations of DDT isomers and the -isomer of endosulfan were found, suggesting previous use of these OCPs. High-temperature combustion and industrial processes may be the main sources of high molecular weight PAHs, according to principal component analysis, whereas low-temperature combustion processes may be the cause of low molecular weight PAHs. PCBs in the soil were most likely caused by unreported e-waste combustion operations in the area. The concentrations of 28PCB and carcinogenic PAHs were higher in industrial locations. Mean 28PCBs in Mambakkam were considerably higher (p 0.05) than those in Cheyyar, an emerging industrial corridor (2.7 ng/g). In 75% of the locations, lower chlorinated PCBs (3-Cl and 4-Cl) made up more than half of the 28PCBs. In industrial areas, PAH total toxic equivalents (TEQs) (total BaPeq) were discovered to be at their highest levels. PCB-157 made the largest addition to TEQs caused by dioxin-like-PCBs, followed by PCB-189. [36]

As a connecting connection between biotic and abiotic elements of the terrestrial ecosystem, soil is exposed to a variety of point and nonpoint sources of pollutants. Irrigation water contamination is one of the most significant causes of soil pollution, affecting soils all over the world. Due to numerous anthropogenic activities, irrigation water (both surface and groundwater) is becoming more and more contaminated with pollutants like metal(loids).Using wavelength-dispersive X-ray fluorescence (WDXRF) spectroscopy, a study was performed to examine the metal(loid) contents in agricultural soil samples collected from fields along the banks of rivers Beas and Sutlej flowing through Punjab state of India. Using the *Allium cepa* root chromosomal aberration test, the soil samples were also examined for their potential for genotoxicity. Different regions of Punjab have municipal and industrial effluent contamination of the Beas and Sutlej waterways. Comparing the soil samples to the reference values provided by various international organisations, it was discovered that the soil samples had greater concentrations of arsenic, cobalt, and chromium. The soil samples were found to be heavily contaminated with cobalt and arsenic after pollution evaluation using various indices, including the index of geo-accumulation, enrichment factor, and contamination factor. The Allium cepa assay showed that soil samples with greater As and Co contents had the highest levels of genotoxicity. Strong positive correlations between the various metal(loid)s were found through analysis, pointing to shared origins for these metal(loid)s. It is necessary to make efforts to lower the concentrations of these metal(loid)s in these agricultural soils.[37]

The disposal of municipal solid waste (MSW) near to a Ramsar site in Assam, India, may cause ecological and health risks that need to be evaluated, as well as the degree of soil contamination. Three heavy metals (HMs), chromium (Cr), manganese (Mn), and zinc, were detected in soil samples (Zn). Different indices were used to assess the HM pollution amounts and its sources. The findings showed that Cr contamination was particularly high close to the metal scrap segregation unit within the dump site, but that the ecological dangers posed by Zn and Mn were generally minimal. While Mn (52.55%) was associated with the exchangeable fraction, the speciation of Cr and Zn (44.23% and 30.68%, respectively) were associated with the Fe-Mn oxide bound (F4) fraction (F2). Significant enrichment for Zn and minimal to modest enrichment for Mn, respectively, were only found in a small number of sites. The results of the health risk assessment showed that consuming Cr presented a greater threat to human health.[38]

Genotoxic and mutagenic effects of toxicants

Hazardous substances found in industrial effluents pose a severe risk to both human health and agriculture. A study on the cytotoxic and genotoxic effects of agricultural soil enriched with hazardous industrial effluent in Dera Bassi, Punjab, India, found defects in DNA repair in K-12 mutants of Escherichia coli and chromosomal aberrations as a result of acute toxicity and chromosomal mutagenesis, respectively. High amounts of organic compounds and heavy metals were found in the soil, respectively, according to GC-MS analysis and atomic absorption spectrometry. Dichloromethane was discovered to cause DNA damage at these locations, and mutants lexA and recA had survival rates of 38 and 49%. In the A. cepa assay, a negative correlation between the mitotic index and soil extract concentration was seen. Growing A. cepa roots exposed to soil extracts experienced chromosomal abnormalities and changes to the mitotic phases. The research found that genotoxic and mutagenic substances were present at agricultural sites close to the industrial area. In order to lessen the toxicity of industrial effluents discharged onto agricultural areas, appropriate measures should be taken. [35, 45].

Persistent organic chemicals include phenolic compounds (PCs), organochlorine pesticides (OCPs), and polycyclic aromatic hydrocarbons (PAHs). The most researched environmental compartments involve contamination of these possibly toxic organic pollutants in soils and sediments. Recent studies on PAHs, OCPs, and PCs in different soils and sediments in India have been conducted. Similar research was conducted on these contaminants in soils and sediments from a river flood plain in Delhi, India. Thirteen prioritised PAHs, four OCPs, and six PCs were examined in a total of fifty-four samples, including twenty-seven each of soil and sediment. The amounts of PAHs, OCPs, and PCs that were found in soil varied from 473 to 1132, 13 to 41, and 639 to 2112 g/kg, respectively, while their levels in sediments were lower.[39, 50]

Heavy metals and other toxicants impact on Food Industries globally

Chemical exposure levels above the maximum allowable amounts have historically had disastrous effects on developing nations. Toxic chemical substances are mainly affecting the global food industry due to anthropogenic and natural factors. As a result of chemical contamination at different stages of food production, food safety is at risk. Pesticides and other chemicals, such as Polychlorinated Biphenyls (PCBs), are examples of persistent organic pollutants (POPs), which have a long-lasting negative influence on the environment. The pathways for chemical contamination along the different stages of food production up until the food enters the consumer are the main focus of the current review. Food contamination can come from a variety of sources, including the agricultural industry and industrialized areas' pollution of the air, water, and soil.[30, 31]

An essential minor element for human health and wellbeing is chromium (Cr). As a consequence of numerous anthropogenic activities over the past few decades, the contamination of both terrestrial and aquatic ecosystems, particularly with hexavalent chromium [Cr (VI)] form, has increased. Our environment and natural resources, particularly water and soil, are badly impacted by chromium pollution, which is a serious danger to the environment. Increased amounts of accumulation in human and animal tissues could result from excessive exposure, which would be harmful to health. According to numerous studies, chromium is a toxic element that impairs plant metabolic processes, hinders crop development and yield, and lowers the quality of vegetables and grains. As a result, the crop producing system, soil, and water must all be monitored. Chromium in water, soil, and other resources has been under control thanks to the development of a number of helpful and practical remediation technologies. To maintain a balance between the environment and wildlife, a sustainable remediation strategy must be used [40-49].

Effects of Heavy metals on cellular organelles

Osteochilus vittatus fish from the Nam Kok river near the Sepon gold-copper mine in the Lao People's Democratic Republic were studied to determine the concentrations of heavy metals and metalloids in water, sediment, and fish, as well as to assess chromosome aberrations, serum biochemical changes, and histopathological alterations in *O. vittatus.* Results showed that Fe, Mn, and Ni in water, As, and Cd in sediment, In addition, seven different kinds of chromosome aberrations were found in *O. vittatus*, with a centromere gap having the most overall aberrations. the overall number of chromosome aberrations, the number of cells with aberrant chromosomes, and the percentage of aberrant chromosomes. Fish living close to a gold-copper mine had liver histopathological changes that showed aberrant cytoplasmic mitochondria, rough endoplasmic reticulum disintegration, and nuclear membrane degeneration. The findings of this research indicated that *O. vittatus* fish were adversely affected by heavy metal and metalloid contaminations from the Sepon gold-copper mine region in terms of chromosomal defects, serum biochemical changes, and liver histopathological appearances. [52]

Global agricultural output is constrained by soil arsenic (As) contamination. CO2 amounts in the atmosphere are rising as a result of anthropogenic emissions. Plant development is accelerated by elevated CO2 (eCO2) in both ideal and unfavourable growth environments. The effects of eCO2 (620 ppm) and soil exposure to arsenic were evaluated in a study to reveal crop-specific interactions, and the effects were examined at the physiological and biochemical levels. Effects of as exposure (mild and intense treatments, 25 and 100 mg As/Kg soil) on barley (C3) and corn growth, photosynthesis, and redox homeostasis (C4). At ambient CO2 values, barley was more vulnerable to soil As exposure than maize. More As was accumulated by barley plants, especially in the roots. Buildup hampered plant development and brought on oxidative damage in a species-specific manner. As-exposed barley experienced severe oxidative stress as illustrated by high H2O2 and protein oxidation levels. Interestingly, eCO2 differentially mitigated As-induced stress in barley and maize. In barley, eCO2 exposure reduced photorespiration, H2O2 production, and lipid/protein oxidation. In maize eCO2 exposure led to an up regulation of the ascorbate-glutathione (ASC/GSH)-mediated antioxidative defense system. Combined, this work highlights how ambient and future eCO^2 levels differentially affect the growth, physiology and biochemistry of barley and maize crops exposed to soil As pollution.[2]

In a different study, soil and crop samples were taken from 17 locations along the Kali River and the results showed that the concentrations, distribution, and bioaccumulation of heavy metals in these sources were Fe > Zn > Mn > Cu > Ni > Pb > Cr > Cd and Mn > Fe > Zn > Mn > Cu > Ni > Pb > Cd, respectively. Except for Cd, Mn, and Zn, the bioaccumulation factor was 1, which denotes a lower accumulation of metals in plants. Consumption of agricultural produce may have negative health impacts as a result of low to moderate heavy metal pollution in Kali River irrigated areas, according to this research. [47]

Due to their prevalence, persistence, and toxicity, heavy metals (HMs) contamination in agricultural soil areas has caught the attention of the environmental community. Using the geo-accumulation index (Igeo), pollution index (PI), pollution load index (PLI), enrichment factor (EF), statistical analysis, as well as the spatial distribution of 15 surface agricultural soil samples, a study was conducted to assess the degree of HM contamination in the agricultural soils of northern Telangana. The results showed that the concentration of HMs, including Cr, Cu, Co, Ba, V, As, Ni, Pb, and Zn, had average values that ranged from Ba, V, Zn, and Cu concentrations were discovered to be significantly above their recommended values, while the levels of Co, Ni, Pb, Zn, and As are within the predetermined limits According to Canadian soil quality standards. The greatest Igeo (1.04) showed a severe level of Cu contamination. While the EF indicated moderate soil pollution from Cr, Co, V, Zn, and As, the calculated PI and PLI indicated low to moderate soil pollution. Principal component analysis with eigenvalue shows that more than one account for 53.020% of the total variance, suggesting that anthropogenic activity is the main source of the variance. Four extremely polluted zones were visible on the spatial distribution maps of HMs in the northern Telangana agricultural sites of Oni, Yamcha, Bederelli, and Mudhol..[Adimalla N etal 2019]

A study was conducted to evaluate the health risks connected with the presence of heavy metals in the soil and food crops (wheat, rice, maize, and mustard seeds) for the inhabitants of Ropar Wetland and its surroundings. All sediment samples contained significant amounts of cadmium and cobalt, whereas all crop samples contained significant amounts of cobalt and lead. According to bioconcentration factor (BCF) analysis, maize cereals are copper hyper-accumulators (BCF = 30.43), whereas maize grains are hyper-accumulators of chromium (BCF = 17.98) and copper (BCF = 10.91). According to a one-way ANOVA, the concentration of heavy metals in food crops varied significantly at p 0.05 for various sites, showing that heavy metals from anthropogenic sources were present in agricultural fields. Cobalt consumption through all agricultural crops increased non-cancer health risks. In comparison to other heavy metals, cobalt exposure through all food crops presented a greater risk to residents' non-cancer health. Wheat is the main food source in the study region, and consumption of wheat grains presented the highest cancer risk due to chromium. [47]

This research identified the accumulation of heavy metals (HMs) in various vegetables over time and concluded that eating such vegetables in Jhansi posed a significant health risk to adults. 28 composite samples of soil and vegetables (fenugreek, spinach, eggplant, and chilli) gathered from seven agricultural areas were analyzed for their total concentrations of zinc (Zn), lead (Pb), nickel (Ni), manganese (Mn), copper (Cu), cobalt (Co), and cadmium (Cd). Significant non-carcinogenic health risks resulting from exposure to analysed heavy metals through intake of these veggies were computed, and the transfer factor (TF) of HMs from soil to analysed vegetables was determined. Principal Component Analysis (PCA) and Pearson's correlation matrix statistical analysis indicated that anthropogenic actions were a significant source of HMs. The target hazard quotient of Cd, Mn, and Pb for spinach (3.697, 3.509, and 5.539) and fenugreek (2.161, 2.143, and 2.228, respectively) exceeded unity, showing the high likelihood of non-carcinogenic health risks if consumed frequently by people. This research strongly recommends ongoing soil, irrigation water, and vegetable monitoring to prevent unwarranted buildup in the food chain.[19]

By using Vicia faba L to analyze the physico-chemical properties and phyto-genotoxicity of arsenic (As) contaminated soil collected from various sites in Lakhimpur, Uttar Pradesh (UP), India, it was discovered that the soil's pH was slightly acidic to neutral in nature and that it also affected the bulk density (1.18-1.23 gcm-3), particle density (2.51-2.59 gcm-3), and porosity (44-53%). Additionally, it was discovered that the levels of the minerals nitrogen, phosphorus, and potassium varied from 124 to 165 mgkg-1, 173 to 186 mgkg-1, and 48 to 98 mgkg-1, respectively. In comparison to the water samples of these sites, the soil samples contained the highest amounts of arsenic. Significant rises in stress metabolites like hydrogen peroxide (H2O2), malondialdehyde (MDA), and carbonyl groups in root and shoot of plants made it clear that soil-borne As was toxic to plants. Reduced mitotic index (MI), higher mitotic depression (MD), relative abnormality rate (RAR), other chromosomal abnormalities, and micronuclei were also signs of cyto-genotoxic effects in the root meristematic cells of V. faba. The evaluation of phytotoxicity and cyto-genotoxicity points out potentially harmful soil characteristics that could impact biota. [20].

In an attempt to assess the contamination status, human health risk, and spatial distribution of heavy metals in the urban soils from the Medak province in India, results of the study showed that the concentration of Cr (81-751 mg/kg), Cu (2-180 mg/kg), Zn (25-108 mg/kg), Pb (5-77 mg/kg), Ni (1-50 mg/kg), As (0.4-14 mg/kg), and Cd (0.1-4.2 mg/kg), respectively, was found above their natural background values. Except for Zn, all other tested heavy metals had a range of moderately to highly polluted/contaminated in the study area, according to the geo-accumulation index analysis. An analysis of the spatial distribution pattern suggested that the western regions of Medak had significantly higher soil heavy metal (Cu, Cr, Zn, and Ni) pollution levels than the central and eastern regions. Because the hazard index (HI) values for Cu, Cd, Zn, As, Pb, and Ni were below 1, it was concluded that neither children nor adults in the study area were exposed to any non-carcinogenic risks from these heavy metals in soil. Children, however, had HI values for Cr that ranged from 3.08E-01 to 2.86E+00, suggesting that they were a more vulnerable group than adults. Comparatively, the overall carcinogenic risks for Cr are 67.5% and 100%, respectively. [2]

The Sutlej river in Indian Punjab is contaminated by industrial refuse, sewage, and agricultural runoff. A small section of the river is where the majority of earlier research on metal contamination of water was conducted. In order to evaluate the spatial and temporal variability of metal contamination in water from the Sutlej River's entry site in the Indian Punjab to its exit point, a systematic research was conducted. Through the evaluation of human health risks, the chance of developing cancer was also estimated. Ten metals (Zn, Cu, Fe, Mn, Ni, Cd, Pb, Co, Cr, and As) were examined in the water samples (between 76 and 91) taken from the Sutlej River during the pre- (April) and post-monsoon (September-October) seasons of the years 2017 and 2018. [46]

Conclusion

Since heavy metals and other toxicants are nonbiodegradable and thus persist in the environment, the aforementioned review research primarily shows various types of industries as sources of various types of heavy metals and other toxicants and their hazardous effects on environment. Additionally, the buildup of these toxins in the ecosystem causes them to become biologically more potent in plants and other living things. Due to the persistent increased oxidative stress caused by the overproduction of reactive oxygen species at the cellular level and the exhaustion of antioxidant defense mechanisms, bioaccumulation of these dangerous toxicants occurs in a variety of organs, primarily the liver, kidney, lung, and reproductive organs. This disruption of biologically relevant molecules, such as nucleic acid, protein, and lipid, results in apoptosis, cell damage, and necrotic cell death. These toxins can have an impact on human health, aquatic life, and soil output. In order to combat this serious issue, it is necessary to periodically monitor the concentration of these toxicants at every stage of the food chain and to raise public awareness about their presence.

While regulations are present in the majority of established nations, they are absent in developing nations like India. The permissible level of heavy metals is strictly regulated in the majority of the nations for which these legal regulations have been found. In the industrial sector, there is a need for strict evaluation of the efficacy of these regulations as well as enforcement of the currently in place rules. Therefore, this study sought to ascertain the public health effects of heavy metals in foods and drinking water in India, which can be crucial to understanding its effects, enabling the concerned organizations to take the proper action, and safeguarding the public health.

Further Bioremediation represents an emerging technology through which plants and microbes can be used to remove pollution from soil, water, and other environments. Bioremediation is of very less effort, less labor intensive, cheap, ecofriendly, sustainable, and relatively easy to implement. Most of the disadvantages of bioremediation relate to the slowness and time-consumption; furthermore, the products of biodegradation sometimes become more toxic than the original compound.

Further A new technique called bioremediation uses plants and microbes to clean up contaminated soil, water, and other environments. Bioremediation requires very little work, requires less labor, is affordable, environmentally friendly, sustainable, and generally simple to execute. The majority of bioremediation's drawbacks are related to its slowness and time requirement. In addition, sometimes the biodegradation's byproducts become more toxic than the initial compound. Bioremediation may be hampered by irregularity and incompleteness doubt. Additionally, because there is no measurable endpoint for bioremediation, performance assessment may be challenging. In order to find more biological solutions for the bioremediation of metals and other toxicant contamination from various environmental systems, more research is required to create bioremediation technologies. Furthermore, cutting-edge methods like biotechnology could make it easier to create microbial genotypes that can biologically use environmental toxins, lowering their concentration and lessening their harmful effects on the environment

Conflict of Interest

There is no conflict of interest.

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