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Impact of Heavy Metal Pollution on the Environment: A Short Review

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Abstract: Heavy metals are naturally considered to be compounds but they are added in vast numbers in many biological boxes by anthropological behaviour. This adds to the environment's failure to nurture life as humans, animals and plants are threatened. Bioaccumulation is caused by the oxidation of heavy metals in food systems. Significant attention has to be paid to the solution of heavy metals for protection of soil quality, atmospheric quality, water quality, human health and animal health in all regions. Advanced heavy metal physical and chemical systems are non-practical and time intensive innovations that require extra toxic emissions.

Keywords: Heavy metals, Chromium, Copper, Cobalt, Zinc, Antimony, Environmental pollution

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Introduction

Heavy metal contamination, as well as accumulating over the food chain and, consequently, in the human body, poses a significant environmental issue. The natural world becomes harmful due to metals like cadmium, chromium, nickel, copper, piping, arsenic, cobalt, platinum, uranium and zinc. The heavy metals in water penetrate the human body and impact the human food chain which induces diseases. Heavy metals are more toxic when accumulates in soft tissue (Mishra *et al.*, 2019). Toxicity of heavy metals can lead to damage to the core nerve function, decreased energy levels, and damage to lungs, kidneys, liver, and other essential organs. Exposure to heavy metals may cause Alzheimer's diseases, allergies, muscular dystrophy, and multiple sclerosis. Allergies not cured at an early stage and prolonged exposures with metals that may cause cancer often arise. Evaporation, absorption, membrane separations, adsorption and ion exchange procedures are the primary disposal processes used to remove copper (II) ions from waste water and are also used to remove ions. These methods are ideally suited where there is a relatively high concentration of heavy metal ions (Tóth *et al*., 2016). In low concentrations, heavy metals are either inactive or expensive in the wastewater. Techniques for metal separation from industrial wastewater include filtration, chemical precipitation, ion exchange, adsorption, electrical deposition, and membrane systems. Owing to the resistance and accumulation in the environment, the handling of heavy metals is a particular concern (Peng and Guo, 2020).

Different methods for heavy metal removal have been widely researched in recent years. This paper discusses and reviews the latest approaches used to treat heavy metal waste water (Fu and Wang, 2011) that includes additives, ion exchanges, adsorption, membrane filters, coagulation-flocculation, flotation, electrochemical processes and other technologies. The literature survey revealed that the most widely researched treatment of heavy-metal wastewater is ion exchange, adsorption and membrane filtration (Yong *et al*., 2017).

Chromium is a significant precursor to surface water heavy metal emissions. Owing to their involvement with diverse health conditions, heavy metal care and elimination has gained significant attention (Rehman *et al*., 2021). It is a well-known fact that environmental regulations are being tightened up and that heavy metals are now being rigorously regulated into marine bodies and supplies of potable water. Industries commonly use chromium for electroplating, tanning, metal finishing and preparation of chromate (Vaiopoulou and Gikas, 2020).

The tanning industry uses massive quantities of chemical agents and creates vast numbers of residual water and solid wastes, leading to the difficulty of turning the animal hide (or skins) into leather. In industrial and military facilities, they are also important groundwater pollutants. Industrial effluents contain chromium at 10 to 100 mg/l level (Feng *et al*., 2022).

The IARC views chromium as a powerful carcinogenic agent which modifies the process of transcription of DNA causing significant aberrations. The accumulation of chromium in water causes big environmental issues, on the other hand. The National Institute of Occupational Safety and Health (NIOSH) suggests lowering water chromium levels to 10-3 mg/m^3. This is recommended by the. Chromium is known to be carcinogenic and harmful to animals and humans (Jiang *et al*., 2017). Compounds of chromium (III) are water insoluble since they are largely bound to floating matter of water. The two water-soluble compounds are chromium (III) oxide and chromium (III) hydroxide. Oxide of chromium (VI) is an example of chromium compounds and is excellently water soluble, soluble = 1680 g/l. In nature, chromium is not readily available (Hildebrand, 1983).

Chromite is the largest chromium mineral. As previously described, only small quantities of chromium can be present in water. The compounds and the elements may be emitted by different factories into surface water. It is used in metal surface refineries and alloys for instance. Stainless steel is made of chromium 12-15%. Chromium metal is used about 20,000 tonnes per annum worldwide. It can be polished and not oxidised if it is taken in by air (Fu *et al*., 2018).

Trivalent chromium is mostly released by the metal industry. Hexavalent chromium comes primarily from tanning and painting of agricultural wastewaters (Saha and Orvig, 2010). Chromium compounds are used as pigments and 90% of the leather is chromium tanned. Wastewater typically has about 5 ppm of chromium. The chromium is used as a catalyst, for timber impregnation, audio, video and laser processing. Inflammable substance and chemical processing is based on chromite. Chrome from different synthetic materials can be found in household waste (Meche *et al*., 2010).

Oxides of chromium (IIT) are water soluble only marginally and thus natural water concentrations are reduced. At pH values above 5, Cr^{3+} ions are seldom present, as hydrated chromium oxide ($Cr(OH)_3$) is water-soluble with little water. Compounds of chromium (VI) are soluble under aerobic conditions whereas chromium (III) under anaerobic conditions. In an oxidising climate, the reverse process is another option. Chromium is largely associated with water-floating particles. The LC_{50} is between 7 and 400 ppm for marine organisms, 0.01- 0.26 ppm for daphnia and 0.032-6.4 ppm for algae and for marine fish. Chromium (VI) was listed as extremely harmful to the atmosphere and grouped into water-hazard groups (Abdullah *et al*., 2015).

The phytototoxicity of chromium is unknown. Plants were not affected at concentrations ranging from 500 to 6000 ppm in soil. Lime or phosphate can further reduce the resistance of chromium to soils. Generally, air-dried soil contains from 2-100 ppm of chromium. In soil water, chromium solubility is smaller than other highly harmful metals. This is why the plant intake is comparatively poor. Plants contain roughly 0.02 - 1 ppm (dry mass) of chromium under standard conditions, but can grow to 14 ppm. Relatively high levels of chromium can be present in mosses and lichens (Chary *et al*., 2008).

Compounds of chromium (VI) are poisonous to both plants and animals at a low concentration. The toxicity process depends on the pH level. These compounds are moving further in the soil than compounds of chromium (III), but typically reduce their mobility to chromium (III) in the short term (Kimbrough *et al*., 1999). The supply of soluble chromates for plants reduces. This system defends the food chain from chromium in large concentrations. Both soil pH and soil sorption capability and temperature depend on chromate mobility in soils. The chromium guideline is about 100 ppm in agricultural soils. Of course, there are four stable isotopes of chromium. The isotopes are unstable. Cr has an average degree of radiation, and is used for medical purposes (Yoshimoto *et al*., 2016).

The harmful environmental effects and extreme toxicity of hexavalent chromium are known. It is allergic, asthmatic, carcinogenic and 1000 times more toxic than the trivalent chromium. Heavy chromium toxicity symptoms include diarrhoea, blood pressure, cramps, liver and kidney injury and stomach bleeding. The placenta can transfer toxic effects to infants. Oxide is a potent oxidant, called chromium (VI). When chromium acid is dissolved, the organ is corroded. Cramping and paralysis may occur. The fatal dosage is around 1-2 g. The legal limit in drinking water for most countries is 50 ppb of chromium. Chromium sores in skin contact with chromatoes are a professional condition in the chromium industry. The ingestion of chromium trioxide dust at work will cause cancer and affect the respiratory tract (Zeitoun and Mehana, 2014).

The consistency of drinking water is impaired by chromium. Normally it cannot be present in large quantities in ground water and surface water. Therefore, it is rare to explicitly exclude sewage water treatment (Zulkifli *et al*., 2010). The precipitation of chromium (III) can be hydroxide. Clotting is not a particularly efficient chromium (VI) removal mechanism. As chromium iron sulphate (VI) is used, the iron ions can decrease to chromium (III) and remove it (Liang *et al*., 2021).

Cobalt is abundant in the environment, including flora, soils, rocks, and water, and is used to manufacture alloys. Although its discharge rate is minimal, it is extremely hazardous to people. Cobalt has both positive and negative effects on the human body. Small levels of cobalt have no harmful repercussions in most cases, but huge releases into the environment can be lethal (Domingo, 1989).

Nickel is a naturally plentiful element with several industrial applications. It is released into the atmosphere by both natural and manmade sources (Li *et al.,* 2016). It has several negative effects on people and causes allergies, nose and lung cancer, renal and cardiovascular illness as a result of inhaling polluted air (Genchi *et al.,* 2020). Copper is widely acknowledged as an essential micronutrient for all living creatures. It participates in typical physiological activities of plants such as chlorophyll production, photosynthesis, and carbohydrate and protein metabolism. Copper shortage changes critical metabolic processes, and excessive exposure is hazardous (Schwartz *et al.,* 2003).

Zinc is a fundamental and ubiquitous metal. It is involved in a variety of enzymatic activities by functioning as a cofactor. Zinc toxicity is determined by the method and amount of exposure. Zinc is mostly obtained through smelting and mining. Mineral processing operations release a considerable quantity of zinc into the environment, which has an impact on ecosystems as well as living species (Zhang *et al.,* 2012).

Antimony is a toxic element that may be found at nanogram concentrations in the atmosphere. Emissions into the atmosphere are caused by natural phenomena such as volcanic activity and weathering, as well as artificial activities (He *et al.,* 2019). Inhalation causes antimony poisoning in persons working in industrial locations. Antimony poisoning produces physiological deficiencies such as pancreatitis, cardiotoxicity, and breathing issues (pleural adhesions, chronic emphysema, chronic bronchitis, respiratory irritation, and inactive tuberculosis). It is also carcinogenic and has an impact on reproduction (Sundar and Chakravarty, 2010).

Thallium may be found in numerous forms in the environment and is toxic to living creatures. Thallium is the most poisonous heavy metal. Monovalent thallium ions form in natural water and are released into the atmosphere via the aqueous pathway (Peter and Viraraghavan, 2005). Furthermore, industrial emissions constitute a key contribution to the rise in thallium levels in the atmosphere. Exposure to thallium is exceedingly hazardous to people (Kazantzis, 2000).

The majority of heavy metals are naturally present in the environment. Anthropogenic sources release certain hazardous heavy metals into the environment. The human body is exposed to heavy metals through either environmental means (because the metal already exists in nature) or through external sources. Different methods of intake are possible. It is critical to comprehend how heavy metals enter the body, as well as the degree of toxicity and the rate of mortality. Following our thorough analysis, we find that the oral route is a prevalent method of heavy metal intake. Excessive amounts harm every organ in the body, including neurological abnormalities, respiratory diseases, carcinogenicity, GI blockage, and osteoporosis (Mitra *et al.,* 2021).

To combat the toxicity, several nanotechnology and natural product-based treatments have been created. Some social prevention techniques should also be considered. First and foremost, to reduce heavy metal toxicity, remove sufferers from the source of exposure. Furthermore, the usage of heavy metals should be decreased in industrial operations. People should avoid using harmful heavy metals in chemical goods. Regardless, self-awareness may assist everyone in reducing their reliance on heavy metals. Chronic low-dose exposure to several elements poses a significant risk to public health in many metal-polluted areas, particularly in areas where metal pollution is prevalent. Understanding the molecular basis of heavy metal, interactions is crucial for assessing and managing the health hazards associated with chemical combinations. As a result, further research is needed to better understand the molecular mechanism and public health effects of human exposure to hazardous metal combinations.

Conclusion

Due to man's reliance on industry, the environmental poisoning by heavy metals has grown to a significant public health hazard globally. In addition to other anthropogenic activities and natural phenomena, heavy metal pollution of land and water bodies has also been caused by mining, burning fossil fuels, smelting, irrigation of wastewater, dumping of sewage sludge, corrosion, weathering, volcanic eruption, and atmospheric deposition. The pollution of heavy metals is also a result of anthropogenic activities like driving and mixed industrial activity. According to specialists and researchers in several study and review articles, these metals enter the human system through contaminated foods and water and are nephrotoxic, carcinogenic, immunotoxic, genotoxic, and reproductive organ disruptors. Due to their chemical stability, biomagnification propensity, enormous production, and high intake, heavy metals are considered persistent pollutants because they continue to be discovered in many living forms, in addition to being present in every segment of the environment, including foods. However, the global absence of integrated analysis hinders research on the risk assessment of micropollutants, particularly heavy metals, in all environmental systems. Sometimes, residue analysis just looks at a particular molecule and ignores associated matrices, such as aquatic ecosystem elements. Another concern is the prohibition on doing a rapid examination of a single drug under controlled conditions. As a result, the following data gaps should be considered in order to conduct a thorough risk assessment of heavy metals: (i) the human accumulation parameters for heavy metals, particularly in groups with high exposure rates, such as young women of reproductive age, residents of coastal cities, who consume crops that may have accumulated these metals, and people who live close to chemical process industries; (ii) heavy metal contamination screening for edible goods and the environment; and (iii) heavy metal contamination screening for the environment. To maintain the earth's ecological balance, it is critical to enhance scientific research on the impacts of heavy metal toxicity on various life forms. Furthermore, it is critical to focus on risk assessment and study on the amounts and distribution of these persistent environmental toxins in the environment.

References

Abdullah MZ, Abd Manap N R, Saat A, Hamzah Z and Abas MT. (2015) Evaluation of heavy metal contamination levels of Balok River sediments in Pahang, Malaysia based on geoaccumulation index and supported with enrichment factor. Malaysian J Analytical Sci. 19(4): 707-714.

Chary NS, Kamala CT and Raj DSS. (2008) Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. Ecotoxicol Environ Saf. 69(3): 513-524.

Domingo JL. (1989) Cobalt in the environment and its toxicological implications. Rev Environ Contam Toxicol. 108: 105-132.

Feng X, Long R, Wang L, Liu C, Bai Z and Liu X. (2022) A review on heavy metal ions adsorption from water by layered double hydroxide and its composites. Separation Purification Technol. 284: 120099.

Fu F and Wang Q. (2011) Removal of heavy metal ions from wastewaters: a review. J Environ Managem. 92(3): 407-418.

Fu X, Liang Y, Qin L, Zeng H, Mo L, Wang D and Qin L. (2018) Distribution of organochlorine pesticides (OCPs) in the water body of Huixian Karst wetland of Guilin and environmental risk assessment of OCP mixtures. J Agro-Environment Sci. 37(5): 974-983.

Genchi G, Carocci A, Lauria G, Sinicropi MS and Catalano A. (2020) Nickel: Human health and environmental toxicology. Int J Environ Res Public Hlth. 17(3): 679.

He M, Wang N, Long X, Zhang C, Ma C, Zhong, Q, Wang A, Wang Y, Pervaiz A and Shan J. (2019) Antimony speciation in the environment: Recent advances in understanding the biogeochemical processes and ecological effects. J Environ Sci. 75: 14-39.

Hildebrand WL. (1983) Environmental Medicine. In: Family Medicine, Springer, New York, NY, pp. 1332-1358.

Jiang X, Xiong Z, Liu H, Liu G and Liu W. (2017) Distribution, source identification, and ecological risk assessment of heavy metals in wetland soils of a river–reservoir system. Environ Sci Pollut Res. 24(1): 436-444.

Kazantzis G. (2000) Thallium in the environment and health effects. Environ Geochem Hlth. 22(4): 275-280.

Kimbrough DE, Cohen Y, Winer AM, Creelman L and Mabuni C. (1999) A critical assessment of chromium in the environment. Crit Rev Environ Sci Technol. *29*(1): 1-46.

Li SG, Xu SZ, Niu Q, Ding YS, Pang LJ, Ma RL, Jing MX, Wang K, Ma XM, Feng GL, Liu JM, Zhang XF, Xiang HL and Li F. (2016) Lutein alleviates arsenic-induced reproductive toxicity in male mice via Nrf2 signaling. Hum Exp Toxicol. 35(5): 491-500.

Liang YH, Liu QC, Li YK and Liu F. (2021) Speciation analysis and ecological risk assessment of antimony in Xikuangshan, Hunan Province. Polish J Environ Stud. 30(2): 1289-1296.

Meche A, Martins MC, Lofrano BE, Hardaway CJ, Merchant M and Verdade L. (2010) Determination of heavy metals by inductively coupled plasma-optical emission spectrometry in fish from the Piracicaba River in Southern Brazil. Microchem J. 94(2): 171-174.

Mishra S, Bharagava RN, More N, Yadav A, Zainith S, Mani S and Chowdhary P. (2019) Heavy metal contamination: an alarming threat to environment and human health. In: Environmental Biotechnology: For Sustainable Future, (eds.) Sobti R., Arora N., Kothari R., Springer, Singapore, 103-125.

Mitra S, Prova SR, Sultana SA, Das R, Nainu F, Emran TB, Tareq AM, Uddin MS, Alqahtani AM, Dhama K and Simal-Gandara J. (2021) Therapeutic potential of indole alkaloids in respiratory diseases: A comprehensive review. Phytomedicine. 90: 153649.

Peng H and Guo J. (2020) Removal of chromium from wastewater by membrane filtration, chemical precipitation, ion exchange, adsorption electrocoagulation, electrochemical reduction, electrodialysis, electrodeionization, photocatalysis and nanotechnology: a review. Environ Chem Lett. 18(6) 2055-2068.

Peter AJ and Viraraghavan T. (2005) Thallium: a review of public health and environmental concerns. Environ int. 31(4): 493-501.

Rehman AU, Nazir S, Irshad R, Tahir K, ur Rehman K, Islam RU and Wahab Z. (2021) Toxicity of heavy metals in plants and animals and their uptake by magnetic iron oxide nanoparticles. J Molec Liquids 321: 114455.

Saha B and Orvig C. (2010) Biosorbents for hexavalent chromium elimination from industrial and municipal effluents. Coordination Chem Rev. 254(23-24): 2959-2972.

Schwartz GG, Il'yasova D and Ivanova A. (2003) Urinary cadmium, impaired fasting glucose, and diabetes in the NHANES III. Diabetes Care 26(2): 468-470.

Sundar S and Chakravarty J. (2010) Antimony toxicity. Int J Environ Res Public Hlth. 7(12): 4267-4277.

Tóth G, Hermann T, Szatmári G and Pásztor L. (2016) Maps of heavy metals in the soils of the European Union and proposed priority areas for detailed assessment. Sci Total Environ. 565: 1054-1062.

Vaiopoulou E and Gikas P. (2020) Regulations for chromium emissions to the aquatic environment in Europe and elsewhere. Chemosphere 254: 126876.

Yong J, Jie Z, Liwei Z, Xiaoli L, Dingding W, Jiali L and Jing L. (2017) Analysis of heavy metals in the surface sediments of shallow lakes in Nanjishan (Poyang Lake) Natural Wetland in China. J Environ Biol. 38(4): 561.

Yoshimoto N, Takaoka M, Fujimori T, Oshita K, Sakai N and AbdKdir SAS. (2016) Substance flow analysis of mercury in Malaysia. Atmospheric Pollut Res. 7(5): 799-807.

Zeitoun MM and Mehana EE. (2014) Impact of water pollution with heavy metals on fish health: overview and updates. Global Veterinaria 12(2): 219-231.

Zhang X, Yang L, Li Y, Li H, Wang W and Ye B. (2012) Impacts of lead/zinc mining and smelting on the environment and human health in China. Environ Monitoring Assessm. 184(4): 2261-2273.

Zulkifli SZ, Ismail A, Mohamat-Yusuff F, Arai T and Miyazaki N. (2010) Johor Strait as a hotspot for trace elements contamination in Peninsular Malaysia. Bullf Environ Contam Toxicol. 84(5): 568-573.