Impact of Heavy Metal Pollution on the Environment

Abstract:

Pollution of the environment by the toxic heavy metals is a global issue of concern and affects the natural quality of the air, water, and soil. Anthropogenic activities are largely responsible for the widespread pollution of heavy metals in the environment, which is having a harmfulimpact on human health. Rapid urbanization, industrialization,population explosion, and use of advanced technology in developing countries have resulted in hugerise in waste production.Waste generation and disposal along with landfills is a serious global environmental threat resulting in heavy metal contamination of the soils, water, and plants. Heavy metals reaching in the atmosphere result to the deterioration of the quality, and contamination of the soil and groundwater along with damage to the living organisms.The present review describes the analysis of heavy metal pollution of the environment with respect to air, animals, aquatic ecosystem, plants, and soil. Special emphasis is provided on sources of heavy metals in the environment, harmful impacts of heavy metals on the environment and strategies to control heavy metal pollution of the environment.Present study is based on critical review and analysis of scientific information published by academic and professional researchers who studied the impact of heavy metal pollution on the environment. Research articles on impact of heavy metal pollution on the environment published in high impact factor journals were referred for collection of databases.This study notices that there is an urgent need for continuous monitoring of various environmental elements for heavy metals in different open dumpsites.It also recommendsthat nanomaterials, such as metal oxide nanoparticles, graphene and its derivatives, magnetic nanoparticles, and carbon nanotubes should be used to remove the toxic heavy metals from the air, water and soil.

Keywords:

Heavy metals, environment, toxicity, pollution,anthropogenic activities,exposure, living organisms

1. Introduction

"The pollution of ecosystems with toxic heavy metals is a major environmental concern due to their toxicity, longevity in the atmosphere, and ability to accumulate in the body of living beings via bioaccumulation" [1]. "Most heavy metals occur naturally, but a few are derived from anthropogenic sources. They are characterized with high atomic mass and toxicity to living organisms" [2]. "Toxicity of heavy metals increases by mixing with different environmental elements, such as water, soil, and air.Heavy metals cause environmental and atmospheric pollution, and living organisms are exposed to them mainly through the food chain" [3].

Vhahangwele et al [4] recorded that "population explosion, industrialisation, urbanization, and careless use of natural resources have resulted in the environmental pollution on the global scale". "Natural environment has been polluted by various pollutants such as inorganic ions, organic pollutants, organometallic compounds, radioactive isotopes, gaseous pollutants, nanoparticles, and heavy metals" [5]. "Heavy metals are the inorganic pollutants and are discarded into the natural waters, soils and the atmosphere through the rapidly growing agriculture and metal industries, improper waste disposal, fertilizers and pesticides" [6].

According to Gautam et al [7], "heavy metals are metallic chemical elements and metalloids with density being greater than 5 g/cm^3 and are toxic to the environment and

living beings”.“Heavy metals which are more common in our everyday life are:Aluminium, Arsenic,Cadmium, Chromium, Cobalt, Copper, Gold, Iron, Lead, Manganese, Mercury, Molybdenum, Nickel, Platinum, Selenium, Silver, Tin, Titanium, Vanadium, and Zinc” [8].

“Anthropogenic (metal mining, smelting, foundries, metal based industries and leaching of metals from landfills, waste dumps, excretion, livestock, chicken manure, runoffs, automobiles and road works) and agricultural (use of pesticides, insecticides, and fertilisers) activities are the major source heavy metals in the environment.Natural actionssuch asvolcanic activity, metal corrosion, metal evaporation, sediment re-suspension, soil erosion, and geological weatheringalso contributes in the environmental contamination by heavy metals” [9].

Nyiramigisha and Sajidan [10], stated that, in developing countries, a large quantity of waste is generated due to the population explosion, changing lifestyle, advanced technology, and rapid urbanization.This results in environmental pollution because disposal of untreated municipal and other waste is a serious global issue causing heavy metal pollution of soils, water, and crops. According to Aziz et al [11], “the pollution of aquatic systems by heavy metals from sources such as industrial activities, chemical manufacturing, natural sources, and household usage, is a major concern in environmental protection”.

Rajeswari and Namburu [12] reported that impact of the heavy metals on aquatic organisms is due to the movements of pollutants from point sources which pose threat to aquatic fauna. Since the metals don’t undergo biodegradation and are accumulated in the soft tissues of living organisms, the metal pollution causes various diseases and disorders even in relatively lower concentrations. Due to the contamination of the air and water with heavy metals, or their accumulation in plants and animals body, humans are exposed to heavy metals by ingestion, inhalation, or dermal contact [13].

Loredana et al [14] noted that, “heavy metals can produce side effects on soil,water,air,plants, animals and humans”. “Due to the stabilityof heavy metals in the environment, they contaminate the food chains and cause toxicity on the environment and living organisms” [15]. “Heavy metal ions are extremely harmful to both plants and animals in the soil environment, as they are absorbed by plants and eventually reach animals and people.Presence of heavy metals in the aquatic habitats producesdirect or indirect impact on living systems” [16].

According to Singh et al [17], “water sourcesgets polluted by the heavy metals and metalloids through release from the suddenly mine tailings, disposal of high metal wastes, growing industrial areas, leaded gasoline and paints, usage of fertilizers inland, animal manures, E-waste, sewage sludge, pesticides, wastewater irrigation, coal, etc”.“Heavy metals contaminate natural water bodies, sediments, soils and pose threat to aquatic and terrestrial ecosystems along with human health” [18].

Donald et al [19] stated that, “heavy metal contamination is a serious hazard to all biota in the ecosystem because of its devastating consequences and their accumulation in soil and water has significant implications for food safety and security, the growth of plants and the survival of soil microorganisms”.“Heavy metal pollution is a serious environmental issue triggered by the release of heavy metal ions into the natural environment (soil, water and air). It poses grave dangers to human health, ecosystem functioning and the global environment” [20].

Das et al [21] reported that, “heavy metals constitute a substantial threat to living entities that are not specifically targeted.Electronic wastesuch as mobile phones, tablets, computers, and smart watches are the major threat to the environment and human well-being due to presence of heavy metals like Hg, Cd, and Pb”.“The concentrations of heavy metals in

soils lead to a negative effect on human health and on all living organisms. Soil pollution by heavy metals, such as Cd, Pb, Cr and Cu etc. is a problem of health concern" [22].

"Increased urbanization and industrialization lead to increasethe heavy metal contamination of foodthrough irrigation water, agricultural soils, agricultural practices, air pollution, animal feed and packaging materials.The heavy metal contamination of agricultural crops, meat, fish, milk and egg threatens both food safety and security" [23]. "The environmental issues related to heavy metals contamination are becoming serious in developing countries due to increase in geologic and anthropogenic activities" [24].

Gautam et al [7] revealed thatthe most hazardous pollutants that are affecting the environment include heavy metals due to an increased flux of metallic substances in the aquatic and terrestrial environment [25]. The limited scientific evidence proves an escalated concern over the health burdens and effects due to heavy metals. Thecurrent situation demands identification of environmental health risks and development and adoption of preventivemeasures along with actionable policies are urgently needed [26].

The objective of this review is to provide a detailed account of heavy metal pollution of the environment with respect to soil, aquatic ecosystem, air, and living organisms. Additionally, special emphasis is provided on sources of heavy metals in the environment, harmful impacts of heavy metals on the environment and strategies to control heavy metal pollution of the environment.

1.1. Structure the Review Paper

Table1 Structure of the review paper

Section	Details
I	❖ Introduction, Definition & Structure of the review paper
II	❖ Literature Search Methods
III	❖ Sources of heavy metals in the environment • Agriculture source, Anthropogenic causes, Atmospheric source • Domestic sewage, Heavy metal intake via water, Industrial source • Mining source, Natural phenomena, Urbanization
IV	❖ Harmful impacts of heavy metals on the environment • Impacts on Air • Impacts on Animals • Impacts on the Aquatic environment • Impacts on Plants • Impacts on Soil
V	❖ Strategies to control heavy metal pollution of the environment

2. Methodology

This review summarises and analyses primary information created and provided by other academic and professional researchers who studied the impact of heavy metal pollution on the environment. Literature review was conducted using the search terms such as, heavy metals, sources, environment, and harmful effects in relevant studies on EMBASE, Google Scholar, Medline, NCBI, PubMed, Science Direct, Scopus, and Web of Science databases.This review paper analysed a total of26research articles published in reputed journals.

3. Sources of heavy metals in the environment

Mitra et al [3] noted that, heavy metals occur naturally in the environment but some are emitted into the environment from anthropogenic sources. Due to the increased use of heavy metals, quantity of metal ions has been exponentially raised in both the terrestrial

environment and the aquatic environment. Therefore, heavy metal pollution of the environment has emerged due to anthropogenic activity which is the prime cause of pollution [6].

Nyiramigisha and Sajidan [10] reported that, "heavy metals are ever-lasting environmental pollutants and enter the body through food, air, and water. Major sources of heavy metals in soil includes agricultural activities, farmland, mining activities, smoking, traffic emissions, the discharge of sewage, and building materials like paints"."The introduction of heavy metals into the environment can be attributed to both anthropogenic and natural causes" [11].

Rajeswari and Namburu [12] reported that, "Tetraethyl lead $(CH_3CH_2)_4Pb$ is probably the most significant heavy metal contaminant in recent use"."Anthropogenic processes which can release heavy metals in different environmental compartments, are industries, agriculture (insecticides, pesticides which can release As), fossil fuels combustion (Ni, V, Hg, Se, Sn), wastewater, mining, smelting (As, Cu, Zn), corrosion, metallurgical processes, residual organic matter, transportation (Pb)" [14, 17] (Table 2).

Table 2 Sources of heavy metal contamination in the environment

Major sources	Common sources	References
Agriculture source	Phosphate fertilizers, pesticides, and eroded soil. Agricultural runoff.	Rajeswari and Namburu[12], Gupta et al [26]
Anthropogenic causes	Additives of paints and petrol, aerosol precipitation, cement production, electronic switches production, fluorescent lamps, effluents, irrigation of crop fields with industrial water, landfill leachates, lead-acid batteries, metal-containing compounds, municipal wastewater, thermometers, treated woods, urban runoff, and vehicle emissions.	Gautam et al [7], Singh et al [17], Donald et al [19], Ramamoorthy [22]
Atmospheric source	Burning of fossil fuels, petroleum products.	Tchounwou et al [1], Mitra et al [3]
Domestic sewage	Untreated sewage with toxins, plastic, nitrite and nitrate anions, and toxic metals.	Nyiramigisha and Sajidan [10]
Heavy metal intake via water	Manual dressing of ores, generation of acid mine drainage (AMD).	Zhen and Liu [5], Briffa et al [6]
Industrial source	Effluent from industries, water tank leakages, dumping beside marines, radioactive waste, atmospheric deposition, and industrial processes (chemical etching, electroplating, fertilizer production, metallurgy, mining, nuclear fuel, paper manufacturing, power plant emissions, production of electronic devices, and smelting).	Loredana and Mustatea [14] Dagdag et al [20], Abdel-Rahman [23]
Mining source	Acid mine drainage (AMD), radionuclides.	Vhahangwele et al [4], Ali et al [18]
Natural phenomena	Biogenic processes, forest fires, rock abrasion, sea-salt sprays, volcanic eruptions, weathering of the sedimentary rocks such as limestone or dolomite or shale, windborne soil particles, and oxides, hydroxides, silicates, sulphates, sulphides,	Aziz et al [11], Das et al [21], Timothy and Williams [24]

	phosphates, and organic compounds found in the nature.	
Urbanization	Untreated solid waste and liquid waste, human excreta, and plastic bag and waste.	Martínez-Guijarro et al [2], Skender et al [8]

4. Harmful impacts of heavy metals on the environment

Mitra et al [3] reported that, though heavy metals are vital for the survival of living beings, they become hazardous when they accumulate in organisms. Most common heavy metals that contaminate the environment include Hg, Cd, As, Cr, Ni, and Pb. The harmful impacts caused by heavy metals are dependent on their concentrations in the medium and the length of exposure. Waste disposal is a serious global environmental threat resulting in heavy metal pollution [10].

According to Loredana and Mustatea [14], heavy metals can produce side effects on soil, on water, on air, but also on plants, animals and humans. Toxicity of heavy metals is dependent on factors such as dose, route of exposure, time of exposure, level of concentration, as well as age, gender, genetics, and nutritional status of exposed individuals. Toxic wastes, heavy metals, metalloids, and organic contaminants released due to industrialization and technological advancement can cause problems in the natural environment [19]. Detailed account of harmful impacts of heavy metals on the environment is presented in Table 3.

Table 3 Harmful impacts of heavy metals on the environment

Environmental element	Harmful impacts of heavy metals	References
Air	• Deterioration of infrastructure, formation of acid rain, corrosion, eutrophication, and haze. • Pollution due to release of particulate matters (fine particles and dust). • Precipitate severe health problems. • Pesticides, refrigerators, aerosols, radioactive pollution, internal combustion and jet engines reduces air quality.	Guijarro et al [2], Briffa et al [6], Martínez-Loredana and Mustatea [14]
Animals	• Alterations in the structure of the lungs and heart. • Anaemia, eosinophilia, lymphocytosis, bronchial, and renal injuries. • Blood vessels damage, haemorrhages, and depletion of blood cell count. • Carcinogenic, mutagenic, and teratogenic effects. • Decreased body weight, kidney damage, liver affections, shortened life span, increased oxidative stress, modifications of cells composition, and DNA damage. • Depressing influence on tissue respiration, with hypoxia and mortality. • Ecotoxic stress on aquatic organisms.	Aziz et al [11], Loredana and Mustatea [14], Khalef et al [16], Singh et al [17]

	• Impact on the death rate, reproduction, development, and physiological capacity. • Malformations, growth inhibition, chronic stress, acute and choric illnesses, and reduce the capacity to compete for food and habitat. • Neurotoxicity and cardiac illness.	
Aquatic environment	• Accumulation of heavy metals in the sediments of water bodies. • Change in the water quality. • Metal toxicity with growth inhibition in living organisms. • Water becomes very toxic to human beings and other ecosystems.	Briffa et al [6], Khalef et al [16], Singh et al [17], Ali et al [18]
Plants	• Affect seed germination and reduce the harvest production. • Affects activity of enzymes like amylase, protease, and ribonuclease. • Alter the diversity, quantity, and function of microbial populations. • Change in genetic makeup of the soil microorganisms. • Damage cell structure. • Decrease in chlorophyll content and reduction in photosynthesis. • Harmful to plant growth and cause oxidative stress. • Interfere in biochemical process (photosynthesis, alteration of minerals absorption, damage of chlorophyll, reduce the growth and development of the roots, reduction of overall growth of the plant). • Nutritional, ecological and evolutionary challenges in plants. • Produce damage of roots or leaves. • Reduced nutrients uptakes and disturbance in metabolism. • Reduction in plant height and roots length.	Nyiramigisha and Sajidan [10], Aziz et al [11], Loredana and Mustatea [14], Khalef et al [16], Singh et al [17]
Soil	• Affects the health of the living organisms. • Alteration of soil quality through modification of pH, colour, porosity and natural composition. • Alters the microbial community synthesizing enzymes. • Attenuation of mineralization and nutrient cycle. • Changes in soil quality and fertility, groundwater contamination, and damage of	Briffa et al [6], Nyiramigisha and Sajidan [10], Loredana and Mustatea [14]

	soil biota. • Contamination of vegetables and other crops. • Inhibits enzymatic activity. • Low crop production and loss of many types of normal flora and habitat.	

5. Strategies to control heavy metal pollution of the environment

Mitra et al [3] noted thatthe reduced use of heavy metals in industrial processes can control the heavy metal pollution of the environment up to certain extent. Social awareness, avoid the exposure, and minimum use of chemical products containing toxic heavy metals will also minimize the heavy metal pollution and its hazardous effects. Traditional procedures such as phytoremediation, intercropping, phytostabilisation, phytoextraction, phytodegradation, rhizofiltration, and rhizodegradation can be used for the removal of inorganic and organic compounds from the soils, sediments and waters [6].

Aziz et al [11] stated that, nanotechnology should be applied for the analysis and removal of heavy metals from the environmental elements. Nanomaterials, such as metal oxide nanoparticles, graphene and its derivatives, magnetic nanoparticles, and carbon nanotubes, should be used to remove the toxic heavy metals from the air, water and soil. Practice of organic farmingcan also be used as an alternative for reducing the entry of heavy metals into the environment. Cultivation of consumable crops should be avoided in the vicinity of dumpsites to reduce heavy mental pollutants in the soil [10].

6. Conclusions and Future Research

The present study notices that there is an urgent need for continuous monitoring of various environmental elements forheavy metals in different open dumpsites. Future research is required to fully understand the mechanism and principles of heavy metal complex decomposition and heavy metal ion recovery. It is necessary to develop cost-effective and efficient techniques for removing heavy metals from environmental elements for the better health of ecosystem and human.

7. References

1. Tchounwou Paul B, Clement G Yedjou, Anita K Patlolla, Dwayne J Sutton. Heavy Metals Toxicity and the Environment. EXS, 2012; 101: 133–164. doi:10.1007/978-3-7643-8340-4_6.
2. Martínez-Guijarro Remedios, María Paches, Inmaculada Romero, Daniel Aguado. Sources, Mobility, Reactivity, and Remediation of Heavy Metal(loid) Pollution: A Review. Adv Environ Eng Res, 2021; 2(4), doi:10.21926/aeer.2104033.
3. Mitra Saikat, Arka Jyoti Chakraborty, Abu Montakim Tareq, Talha Bin Emran, Firzan Nainu, Ameer Khusro, Abubakr M. Idris, Mayeen Uddin Khandaker, Hamid Osman, Fahad A Alhumaydhi, Jesus Simal-Gandara. Impact of heavy metals on the environment and human health: Novel therapeutic insights to counter the toxicity. Journal of King Saud University – Science, 2022; 34 101865. https://doi.org/10.1016/j.jksus.2022.101865.
4. VhahangweleMasindi, PhilaniMkhonza,MemoryTekere.Chapter 17 Sources of Heavy Metals Pollution. In: Inamuddin et al. (eds.), Remediation of Heavy Metals, Environmental Chemistry for a Sustainable World 70, 2021; https://doi.org/10.1007/978-3-030-80334-6_17. pp. 37.
5. Zhen Li, Zhi Liu. Hazards, Sources and Control Measures of Heavy Metal Pollution of Forest Soil: Taking Jin-Jing-Ji Region of China as an Example. Nature Environment and Pollution Technology, 2017; 16(4): 1141-1147.

6. Briffa Jessica, Emmanuel Sinagra, Renald Blundell. Heavy metal pollution in the environment and their toxicological effects on humans. Heliyon, 2020; 6 e04691. https://doi.org/10.1016/j.heliyon.2020.e04691.
7. Gautam Pavan Kumar, Ravindra Kumar Gautam, Sushmita Banerjee, M C Chattopadhyaya, J D Pandey. Chapter 4 Heavy Metals in the Environment: Fate, Transport, Toxicity and Remediation Technologies. In, Deepak Pathania (Eds) Heavy Metals, Nava Science Publishers, Inc., 2016; pp.30. ISBN: 978-1-63484-740-7.
8. Skender Demaku, Kaltrina Jusufi, Gani Kastrati. Contamination of Environment with the Heavy Metals Emitted from a Cement Factory, Kosovo. Journal of Ecological Engineering. 2020; 21(8): 75–83. https://doi.org/10.12911/22998993/127091.
9. Muhammad Afzaal, Saman Hameed, Iram Liaqat, Amir Amanat Ali Khan, Hafiz abdul Manan, Raja Shahid, Muhammad Altaf. Heavy metals contamination in water, sediments and fish of freshwater ecosystems in Pakistan. Water Practice & Technology, 2022; 17(5): 1253. doi: 10.2166/wpt.2022.039.
10. Nyiramigisha Philomene, Komariah, Sajidan. Harmful Impacts of Heavy Metal Contamination in the Soil and Crops Grown Around Dumpsites. Reviews in Agricultural Science, 2021; 9: 271–282, https://dx.doi.org/10.7831/ras.9.0_271.
11. Aziz Kosar Hikmat Hama, Fryad S Mustafa, Khalid M Omer, Sarkawt Hama, Rebaz Fayaq Hamarawf, Kaiwan Othman Rahman. Heavy metal pollution in the aquatic environment: efficient and low-cost removal approaches to eliminate their toxicity: a review. RSC Advances, 2023; 13, 17595. DOI: 10.1039/d3ra00723e.
12. Rajeswari T Raja, Sailaja Namburu. Impact of Heavy Metals on Environmental Pollution. Nat. Sem. on Impact of Toxic Metals, Minerals and Solvents leading to Environmental Pollution-2014 Journal of Chemical and Pharmaceutical Sciences, JCHPS 2014; Special Issue 3: 175-181.
13. Karnawat Romila. Impact of Heavy Metals on Human Health and Environment. International Journal of Innovative Research in Science, Engineering and Technology, 2018, 7(1): 549-556. DOI:10.15680/IJIRSET.2018.0701110.
14. Loredana Elena, Ungureanu, Gabriel Mustatea. Chapter Toxicity of Heavy Metals. In, Environmental Impact and Remediation of Heavy Metals. IntechOpen, 2022;1-22. DOI: http://dx.doi.org/10.5772/intechopen.102441.
15. Arora Naveen Kumar, Reshu Chauhan. Heavy metal toxicity and sustainable interventions for their decontamination. Environmental Sustainability, 2021; 4:1–3. https://doi.org/10.1007/s42398-021-00164-y.
16. Khalef Riyam N, Amal I Hassan, Hosam M Saleh. Chapter Heavy Metal's Environmental Impact. In, Environmental Impact and Remediation of Heavy Metals. IntechOpen, 2022;1-18. DOI: http://dx.doi.org/10.5772/intechopen.103907.
17. Singh Anubhav, AnujSharma, RohitK Verma, RushikeshLChopade, PritamPPandit,VaradNagar,VinayAseri,SumitKChoudhary,GarimaAwasthi, Kumud K Awasthi,MahipalSSankhla.Chapter: Heavy Metal Contamination of Water and Their Toxic Effect on Living Organisms. In: The Toxicity of Environmental Pollutants. IntechOpen. 2022; 1-20. DOI: http://dx.doi.org/10.5772/intechopen.105075.
18. Ali Hazrat, Ezzat Khan, Ikram Ilahi. Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation. Journal of Chemistry, 2019; Volume 2019, Article ID 6730305, 14 pages https://doi.org/10.1155/2019/6730305.

19. Donald Anyiam N, Pene B Raphael, Oluwole J Olumide, Okoro F Amarachukwu. The Synopsis of Environmental Heavy Metal Pollution. American Journal of Environmental Sciences, 2022; 18 (5): 125.134. DOI: 10.3844/ajessp.2022.125.134.
20. Dagdag Omar, Taiwo W Quadri, Rajesh Haldhar, Seong-Cheol Kim, Walid Daoudi, Elyor Berdimurodov, Ekemini D Akpan, Eno E Ebenso. Chapter 1 An Overview of Heavy Metal Pollution and Control. In, Verma et al.; Heavy Metals in the Environment: Management Strategies for Global Pollution ACS Symposium Series; American Chemical Society: Washington, DC, 2023; pp. 1-22.
21. Das Sumanta, Kaniz Wahida Sultana, Ashwell R Ndhlala, Moupriya Mondal, Indrani Chandra. Heavy Metal Pollution in the Environment and Its Impact on Health: Exploring Green Technology for Remediation. Environmental Health Insights, 2023; 17: 1–10. DOI: 10.1177/11786302231201259.
22. Ramamoorthy D. Assessment of heavy metal pollution and its impacts on soil physical, chemical properties and β-glucosidase activities in agricultural lands, Puducherry region. Project report submitted to Department of Science, Technology and Environment Government of Puducherry. 2015; pp. 45.
23. Abdel-Rahman, Gomaa N. Heavy metals, definition, sources of food contamination, incidence, impacts and remediation A literature review with recent updates. Egypt. J. Chem., 2022; 65(1): 419 – 437. DOI: 10.21608/EJCHEM.2021.80825.4004.
24. Timothy Nachana'a, Ezekiel Tagui Williams. Environmental Pollution by Heavy Metal: An Overview. International Journal of Environmental Chemistry, 2019; 3(2): 72-82. doi: 10.11648/j.ijec.20190302.14.
25. Shah Alkesh I. Heavy Metal Impact on Aquatic Life and Human Health – An Over View. IAIA17 Conference Proceedings | IA's Contribution in Addressing Climate Change 37th Annual Conference of the International Association for Impact Assessment 4 - 7 April 2017; | Le Centre Sheraton | Montréal | Canada | www.iaia.org. pp. 07.
26. Gupta Vidhu, Kanhaiya Lal, Mahima Uttreja. Contamination of Heavy Metals in India: Health Effects and Remediation Measures. The Energy and Resources Institute (TERI), 2019; pp. 24.