International Journal of Research and Review
Vol. 10; Issue: 10; October 2023
Website: www.ijrrjournal.com
Review Paper *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Impact of Heavy Metals on the Climate Change

Hassan Alzain

Environmental Protection Organization, Saudi Aramco, Al-Midra Tower, Dhahran 31311, Kingdom of Saudi Arabia

DOI: https://doi.org/10.52403/ijrr.20231032

ABSTRACT

One of the most significant issues facing decision-makers who are committed to achieving the Sustainable Development Goals as outlined in the 2030 Agenda for Sustainable Development is climate change. The effects of climate change are already being seen, including rising temperatures, altered precipitation patterns, changes in ocean currents, melting of ice sheets, rising sea levels, and an increase in the frequency and severity of sea level events. Other effects include melting permafrost, retreating glaciers and ice sheets, an increase in fire-friendly weather, and an increase in the frequency and severity of extreme weather events. This has caused the climate change, including an increase in atmospheric carbon dioxide, along with other climate gasses. Increased frequency and severity of extreme weather events, such as hurricanes, cyclones, and heavy rain, which may affect water quantity and quality, are among them. The primary releases of hazardous chemicals like heavy elements have increased, and this has had an impact on the climate.

Key Words: *Heavy metals; climate change, Air pollution, water pollution, soil pollution, sediment pollution, measure control pollution.*

INTRODUCTION

According to general definitions, heavy metals are defined as those metals that have a specific density of more than 5 g/cm3 and have a negative impact on both the environment and living things [1]. The exposure to heavy metals in the environment has significantly increased as a result of industrial activity over the past century. The most frequent heavy metals to cause human poisonings have been mercury, lead, chromium, cadmium, and arsenic. Environmental contamination by these metals has recently been linked to rising ecological and global public health concerns [2].

Various geogenic, industrial, agricultural, pharmaceutical, domestic effluent, and atmospheric sources have been identified as heavy metals' sources in the environment [3]. Their toxicity is affected by a number of variables, such as the dose, the exposure route, and the chemical species [4]. Even at low exposure levels, these metallic elements are known to cause multiple organ damage and are regarded as systemic toxicants. Additionally, they are categorized as human carcinogens. And directly have negative impact on environment.

An overview of the main effects of climate change in various regions with potential connections to hazardous chemical and waste management is given in Table 1 [5]. Table 2[6] lists the main toxic metals found in industrial effluents. This review's goal is to draw attention to heavy metal pollution, its detrimental effects on climate change, and methods for reducing potential pollution.

Table 1: Toxic Metal in manufacturing effluents

Metal	Sources
Arsenic	Phosphate and Fertilizer, Metal Hardening, Paints and Textile
cadmium	Phosphate Fertilizer, Electronics, Pigments and Paints
chromium	Metal Plating, Tanning, Rubber and Photography
copper	Plating, Rayon And Electrical
Lead	Paints, Battery
Nickel	Electroplating, Iron Steel
Zinc	Galvanizing, Plating Iron and Steel
Mercury	Alkali, Scientific Instruments, Chemicals

SOURCE: Physical climate risks from (IPCC, 2013b, 2014b, 2018a, 2019b). Potential links to hazardous chemicals and waste management synthesized by the authors of this document.

Table 2. Overview of major impacts climate change with potential Links to hazardous chemicals and waste management

Region	Climate change impacts	Potential links to hazardous chemicals and waste management
Arctic	Melting of sea Ice and permafrost Increased precipitation	Local contamination due to disruptions of pipelines and storage facilities, for example, leading to oil and chemical spills Unintentional releases and increased movement of POPs, mercury and other chemicals
Africa	Reduced water availability and increased droughts reduced crop productivity Changes in the incidence and geographic range of vector and water borne diseases Increased wildfires	Increased fertilizer and pesticide use Increased use of insecticides Increased use of agricultural plastics Unintentional releases and increased movement of POPs, mercury and other chemicals
Australia	Increased intensity and frequency of flooding	Increases in releases from waste disposal sites
North America	Increased wildfires Urban floods in coastal and riverine areas Increased cyclones	Unintentional releases and increased movement of POPs, mercury and other chemicals Increases in releases from waste disposal sites and other disrupted infrastructure
Central and South America	Reduced water availability in semi-arid regions Increased flooding and landslides in urban areas in other regions. Decreased food production and quality Increased spread of vector-borne diseases Increased wildfires	Unintentional releases and increased movement of POPs, mercury and other chemicals Increased releases from waste disposal sites and other disrupted infrastructure Increased fertilizer and pesticide use Increased use of insecticides Increased use of agricultural plastics
Europe	Increased impacts flooding in river basins and coasts. Reduced water availability Increased wildfires	Unintentional releases and increased movement of POPs, mercury and other chemicals Increased releases from waste disposal sites and other disputed infrastructure Increased fertilizer and pesticide use Increased use of agricultural plastics
Asia	Increased flooding in some areas, including that linked to sea level rise Increased droughts in others Increased wildfires	Unintentional releases and increased movement of POPs, mercury and other Chemicals Increased releases from waste disposal sites and other disrupted Infrastructure Increased fertilizer and pesticide use increased use of agricultural plastics

SOURCE: Physical climate risks from (IPCC, 2013b, 2014b, 2018a, 2019b). Potential links to hazardous chemicals and waste management synthesized by the authors of this document

Contamination of Natural Waters, Sediments, and Soils by Heavy Metals

The effects of heavy metal contamination on climate change have been discussed [7]. Climate change may increase the risk of flooding, which has implications for the flooding of contaminated land and the risk of contaminated sediment and water reaching freshwater and marine environments as well as the risk of contaminants being remobilized in floodwater. One mechanism by which climate change may affect the release of heavy metal contamination is the temperature dependence of arsenic release from flooded contaminated soils. [8]

Additionally, heavy metal contamination frequently builds up in the topsoil; as a result, the location of the water table controls the leaching of contaminants. As a result, periods with high groundwater levels and high discharge rates are frequently when high concentrations of heavy metals in surface water are discovered [9]. Due to the increased resuspension of contaminated suspended sediment, total concentrations of heavy metals with high adsorption capacities to suspended solids also rise [10–13].

1.1. Air pollution

Climate change and air pollution are closely related. It mostly happens because of wasteful exhaust gases from different industries. Air pollution is significantly influenced by greenhouse gases [14]. It is causally proven that an abundance of these gases in the atmosphere causes air pollution. They tend to contribute to global warming when they interact with other gases or molecules in the environment, which has an impact on all living things either directly or indirectly. [15-17]. Due to the species that went extinct, these effects have a tendency to reduce biodiversity. A rise in temperature causes the summer season to last longer and the winter season to last less time.

Additionally listed as air pollutants are some particulate matter and dust. They were affected by anthropogenic activities in transportation and industry as well as natural processes like soil erosion, rock weathering, dust storms, and volcanic eruptions. [18, 19]

Depending on where they come from, there are two significant groups of air pollutants. Carbon monoxide and sulfur dioxide are examples of primary pollutants that are released into the atmosphere directly, whereas ozone and other secondary pollutants are created as a result of chemical reactions between primary pollutants and atmospheric gases [20]. When addressing the issue of air pollution, it is crucial to differentiate between the different types of pollutants in order to select the best course of action because a decrease in some of the responsible emissions may result in an increase in its concentrations.

For instance, a decrease in nitrogen oxide emissions may result in a rise in the amount of ozone in a given area.The World Health Organization [21] states that particulate matter (PM), ozone (O3), nitrogen dioxide (NO2), sulfur dioxide (SO2), and carbon monoxide (CO) are the air pollutants that have the greatest impact on human health. In comparison to other air pollutants, particulate matter is thought to be the most significant [22]. PM stands for dangerous, airborne, multi-element particles.

Ozone at ground level is a secondary pollutant because it is created by chemical reactions in the presence of sunlight rather than being directly released into the atmosphere. According to the substances present and the intensity of the sun, ozone formation mechanisms may differ depending on the region [23]. This pollutant is to blame for a number of respiratory illnesses and breathing difficulties. Ozone harms materials and plants while functioning as a "greenhouse gas" that adds to the greenhouse effect. Its high levels are frequently linked to issues with visibility as well [24]. Nitrogen dioxide is a crucial component of both ozone and particulate matter. It is released into the atmosphere as a result of the burning of fuel [25].

NO2 can harm lakes, forests, natural parks, and coastal waters when it interacts with water, oxygen, and other chemicals to produce acid rain and hazy air [26]. According to some studies, this pollutant may cause wheezing and asthma symptoms [27]. When sulfur-containing fuels are burned, sulfur dioxide is produced [28]. The human respiratory system may be harmed by this substance. Additionally, the production of SO2 causes acid deposition, which can harm lakes, forests, and vegetation by affecting the quality of the soil and water. Another precursor to PM is sulfur dioxide [29] Colorless, odorless, tasteless, non-corrosive, and extremely poisonous gas with a density similar to air is carbon monoxide [30]. CO is released during combustion and is highly flammable [31]. Very high CO levels are uncommon to find outside, but when they do, people with heart conditions should be especially cautious because there isn't much oxygen getting to their hearts [32, 33].

Control measure of air pollution

The following items are frequently used by industry or transportation equipment as pollution control devices. Prior to being released into the atmosphere, they can either eliminate contaminants or remove them from an exhaust stream.

- Mechanical collectors, such as multi-cyclones and dust cyclones • Electrostatic precipitators: An electrostatic precipitator (ESP), also known as an electrostatic air cleaner, is a device for collecting particulates that uses the force of an induced electrostatic charge to remove particles from a flowing gas (such as air).
- Electrostatic precipitators are extremely effective filtration systems that only slightly obstruct gas flow while effectively removing fine particulates from the air stream, including smoke and dust.
- Bag residences: A blower, dust filter, filter-cleaning system, and dust receptacle or dust removal system make up a dust collector, which is intended to handle heavy dust loads (as opposed to air cleaners, which use disposable filters to remove the dust).
- Particulate scrubbers: A type of pollution control technology is the wet scrubber. The term refers to a wide range of devices that use pollutants from other gas streams or from the flue gas from a furnace. In a wet scrubber, the polluted gas stream is forced through a pool of liquid, sprayed with the liquid, or exposed to another method of contact to the liquid in order to remove the pollutants. [34-38]

1.2. Water pollution.

Government agencies and scientists have focused their research on water pollution. Additionally, increased evaporation, geographical changes in precipitation intensity, duration, and frequency (affecting average runoff, soil moisture, and the frequency and severity of droughts and floods) are all effects of global warming that have an effect on water resources. Due to the rapid population growth and the accelerated rate of industrialization, the demand for freshwater has significantly increased over the last few decades. The majority of agricultural development activities endanger human health, especially when they involve the overuse of fertilizers and unsanitary conditions. [39, 40]

Water dissolves various organic and inorganic chemicals as well as environmental pollutants because it is a universal solvent. Freshwater and marine aquatic ecosystems are both susceptible to pollution. Heavy metal contamination of water resources is a serious environmental problem that has a negative impact on plants, animals, and human health [41]. Even at very low concentrations, heavy metals are extremely toxic to aquatic organisms [42]. These substances have been shown to significantly alter the histopathology of fish tissues [43]. Heavy metal contamination of aquatic ecosystems comes from a variety of sources. Effluents from mining operations are a source of heavy metals in aquatic ecosystems [44].

Different industrial effluents, domestic sewage, and agricultural run-off are additional sources of heavy metal water contamination. One of the main causes of surface and groundwater pollution is the untreated discharge of industrial effluents into aquatic environments [45]. Due to their toxicity, environmental persistence, bioaccumulation, and biomagnification in food chains, heavy metal pollution of water bodies is a global issue [46].

Control Measures of Water Pollution

Given that we now understand what water pollution is, let's examine some of the steps taken to reduce it. There are numerous ways to prevent and reduce water pollution. The first step is to increase tree planting around water bodies because trees naturally help to absorb and recycle pollutants. The following is a summary of some key points. Water hyacinth is a plant that actively removes pollutants from water by absorbing toxic chemicals like cadmium and mercury that are dissolved in water. It's crucial to properly dispose of waste and avoid dumping it into water bodies without first treating it.

Before directly disposing of chemicals and other materials into water bodies, industries should treat their wastes carefully. Industries build sewage treatment and wastewater treatment facilities to clean the used water before mixing it safely with river streams. It also makes water recycling possible. It is beneficial for plants and water to use natural pesticides and fertilizers in place of chemical ones. Water pollution will be significantly reduced by chemical procedures like ion exchange, reverse osmosis, and others. In order to lower the overall level of pollution, it is preferable to use less water during daily activities and to reuse water whenever possible.

1.3 Soil pollution

Leaded paint, pesticides, animal manures, fertilizers, sewage sludge, spills of petroleum distillates, coal combustion residues, waste dumping, and wastewater irrigation are all examples of intentional pollution. Untreated sewage and wastewater use has increased the number of heavy metals in our agricultural lands, which have then been absorbed by the crops that are typically consumed by people [47]. Non-intentional pollution can be caused by flooding of seas and rivers, which brings sewage and contaminated water to the land, as well as collisions involving vehicles carrying toxic chemicals [48]. Heavy metals stay in the soil for a very long time because they are not degradable by microbial or chemical processes.

Because heavy metals are getting into the food chain, the ecosystem is being destroyed. Additionally, heavy metals reduce the biodegradability of organic pollutants, which has the effect of polluting the environment twice. [49] These metals in the soil pose risks to the entire biosphere and are ingested directly by plants, which can be dangerous for both the plant and the food chain that consumes the plant. They also change the soil's properties, such as pH, color, porosity, and natural chemistry, which lowers the soil's quality and contaminates the water.

Control measure of soil pollution

The rate of pollution has been suggested to be reduced in a number of ways[50]. Environmental cleanup initiatives demand a lot of time and money. Some actions to lessen soil pollution include:

- The use of plastic bags thinner than 20 microns is prohibited.
- Reusing waste plastics.
- Prohibition of deforestation.
- Supporting agroforestry and plantation programs. Lowering the use of pesticides and chemical Fertilizers.
- Recycling materials like paper and plastic. • Prohibit the use of plastic bags, a major source of Pollution.
- Material reuse.
- Keeping forests intact and encouraging their growth.
- Appropriate and secure disposal of wastes, such as nuclear waste.
- Organic fertilizers and pesticides ought to take the place of chemical ones.
- Supporting agroforestry and social programs.
- Executing numerous pollution awareness campaigns.

1.4. Sediment Pollution.

Heavy metal contamination of sediments is a significant environmental problem with effects on aquatic life and public health. In the aquatic environment, sediments serve as the primary repository for metals [51]. Sediment is the most prevalent type of water pollution, according to the Environmental Protection Agency (EPA). Sediment pollution is the harmful deposition of an excessive amount of sediment into new areas by wind and water. Drilling for land development, stormwater runoff from farms and residential areas, and hard coastal protection structures (like seawalls) that reroute sand movement are all sources of sediment pollution.1

Sediment pollution affects a wide range of factors, including infrastructure degradation, ecological disruption, and the creation of unfavorable environmental conditions for human health and the economy [52]. Heavy

metals are absorbed by sediments and released into the water column.
Groundwater contamination can result from the continued deposition of heavy metals in sediments [53]. Numerous physicochemical factors, such as temperature, hydrodynamic conditions, redox state, content of organic matter and microbes, salinity, and particle size, influence the adsorption, desorption, and subsequent concentrations of heavy metals in sediments [54]. The chemical make-up of the sediments, the size of the grains, and the amount of total organic matter (TOM) all have an impact on the distribution of heavy metals in sediments [55].
pH is a significant factor in determining the bioavailability of metals in sediments. A decrease in pH makes metal ions and H+ more competitive for binding sites in sediments and may cause metal complexes to dissolve, releasing free metal ions into the water column [56]. Higher levels of hazardous heavy metals in riverine sediments may put benthos (bottom-dwelling organisms) at ecological risk [57].

Control measure of sediment pollution

The proper methods and equipment are needed to stop sediment pollution. By using a weed-free mulch in your garden or lawn, observing sediment dispersion from construction sites, and washing your vehicle on a water-absorbent surface, you can lessen the amount of sediment pollution you release into the environment. Storm drain filters are also excellent tools and controls for sediment pollution. Construction sites that are prone to losing control of significant amounts of sediment will benefit from the use of turbidity curtains and sediment barrier perimeter control fences [58–60].

Author's Contribution

The author designed the study along with writing the article in line with the Journal's requirements.
The author of this article review is solely responsible for the content thereof. Data, ideas and opinions presented herein do not necessarily represent the corporate views of the Saudi Arabian Oil Company.

Declaration by Authors

Acknowledgement: None
Source of Funding: The author received no financial support for the research, authorship, and/or publication of this research paper.
Conflict of Interest: None

REFERENCES

1. Fergusson, JE., editor. The Heavy Elements: Chemistry, Environmental Impact and Health Effects. Oxford: Pergamon Press; 1990
2. Bradl, H., editor. Heavy Metals in the Environment: Origin, Interaction and Remediation Volume 6. London: Academic Press; 2002
3. He ZL, Yang XE, Stoffella PJ. Trace elements in agroecosystems and impacts on the environment. J Trace Elem Med Biol. 2005; 19(2–3):125–140. [PubMed: 16325528] P 3
4. Goyer, RA. Toxic effects of metals. In: Klaassen, CD., editor. Cassarett and Doull's Toxicology: The Basic Science of Poisons. New York: McGraw-Hill Publisher; 2001. p. 811-867
5. CHEMICALS, WASTES AND CLIMATE CHANGE INTERLINKAGES AND POTENTIAL FOR COORDINATED ACTION, Basel, Rotterdam, Stockholm Conventions (BRS), and the Minamata Convention on Mercury (MC), May 2021UN environment programme
6. International Journal of Research – GRANTHAALAYAH Manju Mahurpawar ISSN- 2350-0530(O) ISSN- 2394-3629(P), 2022
7. Schiedek, D., Sundelin, B., Readman, J.W., Macdonald, R.W., 2007. Interactions between climate change and contaminants. Marine Pollution Bulletin 54 (12), 1845–1856
8. Weber, F.A., Hofacker, A.F., Voegelin, A., Kretzschmar, R., 2010. Temperature dependence and coupling of iron and arsenic reduction and release during flooding of a contaminated soil. Environmental Science & Technology 44 (1), 116–122
9. Rozemeijer, J.C., Broers, H.P., 2007. The groundwater contribution to surface water

contamination in a region with intensive agricultural land use (Noord-Brabant, The Netherlands). Environmental Pollution 148 (3), 695.
10. De Weert, J., Streminska, M., Hua, D., Grotenhuis, T., Langenhoff, A., Rijnaarts, H., 2010. Nonylphenol mass transfer from field-aged sediments and subsequent biodegradation in reactors mimicking different river conditions. Journal of Soils and Sediments 10 (1), 77–88.
11. Jacoby, H.D., 1990. Water quality. In: Waggoner, P.E. (Ed.), Climate Change and U.S. Water Resources. John Wiley and Sons, New York, pp. 307–328
12. Mulholland, P.J., Best, G.R., Coutant, C.C., Hornberger, G.M., Meyer, J.L., Robinson, P.J., Stenberg, J.R., Turner, R.E., Vera-Herrera, F., Wetzel, R.G., 1997. Effects of climate change on freshwater ecosystems of the southeastern United States and the Gulf Coast of Mexico. Hydrological Processes 11 (8), 949–970
13. A. Visser et al. Journal of Contaminant Hydrology 127 (2012) 47–64
14. U.S. Energy Information Administration, Annual Energy Outlook 1999, Washington, D.C., December 1998
15. F. B. Wood, Climatic Change 12, 297 (1988); T. M. L. Wigley and P. D. Jones, ibid., p. 313; T. R. Karl, ibid., p. 179.
16. B. Bolin, B. R. Doos, J. Jaeger, R A. Warrick, Eds., The Greenhouse Effect, Climatic Change and Ecosystems (Wiley, New York, 1986)
17. M. Schlesinger and J. F. B. Mitchell [Rev. Geophys. 25, 760 (1987)] review the responses of different climate model to CO2 increases
18. Yu M-H, Tsunoda H, Tsunoda M. Environmental toxicology. Biological and Health Effects of Pollutants. Third Edition. Boca Raton, London, New York: Taylor & Francis Group, CRC Press; 2011.
19. Tchounwou PB, Yedjou CG, Patlolla AK, Sutton DJ. Heavy metal toxicity and the environment. Exp Suppl. 2012; 101:133-64.
20. Holman C (1999) Sources of air pollution. Air pollution and health, Academic Press, London, pp 115–148
21. World Health Organisation (2017a) Ambient air pollution: pollutants. http://www.who.int/airpollution/ambient/ pollutants/en/. Accessed Dec 2017
22. UN Environment Annual Report 2017 - United Nations …*https://www.unep.org/annualreport/2017/ index.php*
23. T. Sivasakthivel, K. K. Reddy Published 2011, Ozone Layer Depletion and Its Effects: A Review Environmental Science International journal of environmental science and development
24. Håkan Pleijel,Johanna Gelang,Ebe Sild,Helena Danielsson,Suhaila Younis,Per-Erik Karlsson,Göran Wallin,Lena Skärby,Gun Selldén Volume108, Issue1January 2000Pages 61-7
25. “Production, Sales, and Atmospheric Release of Fluorocarbons,” Alternative Fluorocarbons Environmental Acceptability Study (AFEAS), Washington, DC 1996.
26. Anderson, James G. “The Measurement of Trace Reactive Species in the Stratosphere: An Overview.” In Causes and Effects of Stratospheric Ozone Depletion: An Update, Washington, DC: National Academy Press, 2008.
27. Angell, J. K. “The Variations in Global Total Ozone and North Temperate Layer Mean Ozone.” Journal of Applied Meteorology, vol. 27, no. 1, pp. 91–97, 2007.
28. International Journal of Science and Research (IJSR) ISSN: 2319-7064 SJIF (2020): 7.803 Volume 11 Issue 1, January 2022 www.ijsr.net Licensed Under Creative Commons Attribution CC BY Ozone Layer Depletion - Causes and Effects: A Review Aarati Sao
29. “Environmental Effects of Ozone Depletion. “AMBIO24 May (1995): 137-196.
30. Cook, Elizabeth, ed. Ozone Protection in the United State: Elements of Success. Washington, D. C.: World Resources Institute, 1996.
31. UNEP Ozone Depletion Report 1994/98 http: //www.gcrio. org/UNEP1998
32. Analyses of CO2, CH4, and other atmospheric constituents have been made in Greenland [A Neftel, H. Oeschger, J. Schwander, B. Stouffer, R Zumbrunn, Nature 295, 220 (1982); J. Beer et al., Ann. Glaciol. 5, 16 (1984)] and in Antarctica [J. M. Barnola et al. (15); J. Jouzel, C. Lorius, J. Petit, C. Genthon, N. Barkhoff, V. Karolyoff, V. Petrov, Nature 329, 403 (1987)

33. W. C. Clark, Ed., Carbon Dioxide Review 1982 (Oxford Univ. Press, New York, 1982); G. I. Pearman, Ed., Greenhouse: Planning for Climate Change (Brill, Leiden, The Netherlands 1987), National Research Council Current Issues in Atmospheric Change (National Academy Press, Washington, DC, 1987)
34. V. Masindi, K.L. Muedi, Environmental contamination by heavy metals, in: Heavy Metals, InTech, 2018. [2] C.H. Walker, R.M. Sibly, S.P. Hopkin, D.B.P., in: Principles of Ecotoxicology; Group, T. And F., Ed.; 4th Edition, CRC Press, 2012.
35. P.K. Gautam, R.K. Gautam, M.C. Chattopadhyaya, S. Banerjee, M.C. Chattopadhyaya, J.D. Pandey, Heavy metals in the environment: fate, transport, toxicity and remediation technologies Thermodynamic profiling of pollutants View project Materials for Solid oxide fuel cells View project Heavy Metals in the Environment: Fate, Transport, Toxicity And Rem, 2016.
36. P.B. Tchounwou, C.G. Yedjou, A.K. Patlolla, D.J. Sutton, Heavy metal toxicity and the environment, In EXS 101 (2012) 133–164.
37. L.K. Wang, Heavy Metals in the Environment, CRC Press, 2009.
38. Z.L. He, X.E. Yang, P.J. Stoffella, Trace elements in agroecosystems and impacts on the environment, J. Trace Elem. Med. Biol. 19 (2005) 125–140.
39. OWA, F.D,"Water pollution: sources, effects, control and management" MCSER, volume 4,no 8; Sept-2013 ISSN 2039-2117
40. Joshua Nizel Halder and M Nazmul Islam (2015)," Water pollution and its impact on human health", Volume -2, No-1,ISSN 2373-8324
41. S. Rezania, S. M. Taib, M. F. Md Din, F. A. Dahalan, and H. Kamyab, "Comprehensive review on phytotechnology: heavy metals removal by diverse aquatic plants species from wastewater," Journal of Hazardous Materials, vol. 318, pp. 587–599, 2016.
42. M. Akif, A. R. Khan, K. Sok et al., "Textile effluents and their contribution towards aquatic pollution in the Kabul River (Pakistan)," Journal of the Chemical Society of Pakistan, vol. 24, no. 2, pp. 106–111, 2002.
43. M. K. Ahmed, E. Parvin, M. M. Islam, M. S. Akter, S. Khan, and M. H. Al-Mamun, "Lead- and cadmium-induced histopathological changes in gill, kidney and liver tissue of freshwater climbing perch Anabas testudineus (Bloch, 1792)," Chemistry and Ecology, vol. 30, no. 6, pp. 532–540, 2014.
44. P. Zhuang, Z.-a. Li, M. B. McBride, B. Zou, and G. Wang, "Health risk assessment for consumption of fish originating from ponds near Dabaoshan mine, South China," Environmental Science and Pollution Research, vol. 20, no. 8, pp. 5844–5854, 2013.
45. M. S. Afzal, A. Ashraf, and M. Nabeel, "Characterization of industrial effluents and groundwater of Hattar industrial estate, Haripur," Advances in Agriculture and Environmental Science: Open Access (AAEOA), vol. 1, no. 2, pp. 70–77, 2018.
46. G. Rajaei, B. Mansouri, H. Jahantigh, and A. H. Hamidian, "Metal concentrations in the water of Chah nimeh reservoirs in Zabol, Iran," Bulletin of Environmental Contamination and Toxicology, vol. 89, no. 3, pp. 495–500, 2012
47. V. Masindi, K.L. Muedi, Environmental contamination by heavy metals, in: Heavy Metals, InTech, 2018.
48. C.H. Walker, R.M. Sibly, S.P. Hopkin, D.B.P., in: Principles of Ecotoxicology; Group, T. And F., Ed.; 4th Edition, CRC Press, 2012
49. P. Aronsson, K. Perttu, Willow vegetation filters for wastewater treatment and soil remediation combined with biomass production, For. Chron. 77 (2001) 293–299. J. Briffa et al. Heliyon 6 (2020) e04691 25
50. A.P. Jackson, B.J. Alloway, The transfer of cadmium from sewage-sludge amended soils into the edible components of food crops, Water. Air. Soil Pollut. 57–58 (1991) 873–881.
51. M. Muchuweti, J.W. Birkett, E. Chinyanga, R. Zvauya, M.D. Scrimshaw, J.N. Lester, Heavy metal content of vegetables irrigated with mixtures of wastewater and sewage sludge in Zimbabwe: implications for human health, Agric. Ecosyst. Environ. 112 (2006) 41–48.
52. Pierzynski, G.M.; Sims, J.T.; and Vance, G.F. (2000). Soils and Environmental Quality, 2nd edition. Boca Raton, FL: CRC Press. http://biology.tutorvista.com/environmenta

53. Saeid Mahdeloei et al Annals of Biological Research, 2012, 3 (7):3101-3109
54. Goldman, Marshall I., Environmental Disruption in the Soviet Union, New York, McGraw-Hill, 1971.
55. Hazardous Waste "Soil Treatment" Reference Library Peroxide Application, 1998. [11] Pfife, Daniel. Killing the Goose, Environment, 13, 3, 1971.
56. Erfan-Manesh, Majid & Afyouni, Majid, Environment, Water, Soil and Air Pollution, Publications of Arkan Danesh, 2008.
57. A. Zahra, M. Z. Hashmi, R. N. Malik, and Z. Ahmed, "Enrichment and geo-accumulation of heavy metals and risk assessment of sediments of the Kurang Nallah-Feeding tributary of the Rawal Lake Reservoir, Pakistan," Science of the Total Environment, vol. 470-471, pp. 925–933, 2014.
58. L. L. Fernandes and G. N. Nayak, "Heavy metals contamination in mudflat and mangrove sediments (Mumbai, India)," Chemistry and Ecology, vol. 28, no. 5, pp. 435–455, 2012.
59. T. Sanyal, A. Kaviraj, and S. Saha, "Deposition of chromium in aquatic ecosystem from effluents of handloom textile industries in Ranaghat-Fulia region of West Bengal, India," Journal of Advanced Research, vol. 6, no. 6, pp. 995–1002, 2015.
60. S. Zhao, X. Shi, C. Li, H. Zhang, and Y. Wu, "Seasonal variation of heavy metals in sediment of Lake Ulansuhai, China," Chemistry and Ecology, vol. 30, no. 1, pp. 1–14, 2014.
61. N. Ali Azadi, B. Mansouri, L. Spada, M. H. Sinkakarimi, Y. Hamesadeghi, and A. Mansouri, "Contamination of lead (Pb) in the coastal sediments of north and south of Iran: a review study," Chemistry and Ecology, vol. 34, no. 9, pp. 884–900, 2018.
62. M. Nowrouzi, B. Mansouri, S. Nabizadeh, and A. Pourkhabbaz, "Analysis of heavy metals concentration in water and sediment in the Hara biosphere reserve, southern Iran," Toxicology and Industrial Health, vol. 30, no. 1, pp. 64–72, 2014.
63. S. C. Decena, M. Arguilles, and L. Robel, "Assessing heavy metal contamination in surface sediments in an urban river in the Philippines," Polish Journal of Environmental Studies, vol. 27, no. 5, pp. 1983–1995, 2018.
64. Yuri N. Skiba1, David Parra-Guevara International Journal of Applied Mathematics Volume 25 No. 5 2012, 673-708
65. Christensen. T.H. (1989) Cadmium soil sorption at low concentrations: VIII. Correlation with soil parameters. Water, Air and Soil Pollution. 44: 71-82
66. Karickhoff S.W.• Brown D.S. and Scott T.A. (1978) Sorption of hydrophobic pollutants on natural sediments. Wat. Res. 13: 241- 247

How to cite this article: Hassan Alzain. Impact of heavy metals on the climate change. *International Journal of Research and Review*. 2023; 10(10): 245-253.
DOI: *https://doi.org/10.52403/ijrr.20231032*

******