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Chapter
[11]

An overview on enormous effect of hazardous wastes on water components and their management

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Abstract

Hazardous waste substances are reaching an alarming level with the increasing pace of development, thus posing a severe threat to different segments of the environment. There are different sources from where hazardous substances are getting into the system such as electronics, thermal and nuclear power plants, mining practices, metallurgical departments, weapons, biomedical, etc. The waste generated by the above said activities enter into the water system, they start deteriorating the quality consequently bringing about the greater extent of change. Therefore, proper management practices should be adopted for storage, segregation, transportation, and disposal. In today's scenario, few land-spill sites for the disposal of hazardous waste are available in-country, rest all the wastes dumped into the nearby water bodies. Certain rules and regulations are mentioned by the central governing bodies in India, to reduce the hazardous waste generation and minimizing the effect of waste on which are still present and not handled properly. Thus, keeping the perspective on seriousness, in this chapter we reviewed and discussed various sources of hazardous waste and their impact on water bodies. Also, we mentioned about the remedial measures and conservation practices to be adopted.

Keywords Hazardous waste, Human health, Waste management, Water pollution

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Introduction

For the progress of any country, development is a key step, but the thing is that it must not affect the livelihood of the future generation. Due to the increased human populace and greater consumption of energy, lack of alertness is taking place. People are not focusing on the adverse effects of the deteriorating environmental conditions and expelling harmful substances into the environment to a greater amount (Li *et al.*, 2019). When anything jumps above the required limit or the permissible limit, it gets blasted up and the good material started being called as "waste". There are different types of wastes depending upon their sources and origin and every waste has specific properties (Leelavathy *et al.*, 2018). The material that banishes from the household and non-household area including harmful materials that affects the surrounding, can be called as "hazardous" (Fazzo *et al.*, 2017). It may include substances like industrial solvents, extracts from thermal and nuclear plants, electronic waste, sludge from industries, chemical waste, batteries, electrical equipment, metallurgical extracts and medical equipment etc. There are various factors on which the degree of threat of hazardous waste depends such as complexity, corrosiveness, reactivity, quantity, mobility, persistence, toxicity, availability and local environmental conditions, etc. depicted in Table 1 (Misra and Pandey, 2005).

The sources are categorized into the following two categories one is point source that are the contaminants enter to the water body through the single or identifiable route which may be a pipe or ditch and other is non-point source that are multiple routes for the entrance to the water body or small amount of pollutants assembled from a huge area for e.g. leaching out of nitrogen compound from the fertilized land (Li *et al.*, 2011). Whatever the source will be, once the hazardous waste enters the water body, it will alter the quality thus harming the life living under. Besides this, if human consume the water containing the contaminants in any form, will suffer from various health issues. Sometimes fatal conditions can also happen. Proper management techniques should be adopted before disposing the waste into open space or the aquatic system to limit the impact on ecosystem. Since hazardous waste poses a greater threat to the receiving body, so keeping this in mind we have studied and conferred about various sources of hazardous waste and their impact on water bodies. Also, we have mentioned the curative measures and conservation practices to be adopted.

Sources of hazardous waste

There are several sources by which hazardous wastes are being liberated into the environment including different water bodies. Some of them are listed below, which proves to be the major topic of concern illustrated in Table 2 and Figure 1. They are as follows:

Electronics sector

The electronic segment is one of the fastest-growing markets in the world. The rate at which the genera-

Table 1. Characteristic of hazardous waste and their effect on the environment and living beings.

Characteristics of hazardous waste	Hazards they convey to the environment and living beings
Corrosive	The liquid which has a pH of less than or almost 2 and more than or almost 12.5 can be called as corrosive liquid hazardous waste. Sodium hydroxide and Hydrochloric acid use to clean and degrease the metals before painting in many industries. When these liquids are disposed of, affect the receiving water bodies. The plants and animals also get affected severely when comes into direct contact. Rust removers, battery acids, acid or alkaline cleaning solvents, etc.
Infectious substances	The microorganism in hazardous waste and the toxins they contain are answerable for initiating various diseases in living beings. Sharps, cadavers, swabs, bandages etc.
Noxious	The wastes can cause death, severe damage to health if swallowed, taken inside through the pores of the skin and by direct contact. Besides this, it brings about the lethal conditions to the aquatic biota.
Combustible	The substances that bring about change in the surrounding by release of harmful gases at elevated temperature and pressure thereby causing fire hazards. The combustible hazardous waste substances according to EPA are coded as D001. Petroleum parts washer solvents, solvent-based paint waste, waste kerosene or gasoline, spent paint booth exhaust filters.
Oxidizing	The substances that liberate oxygen and are responsible for the combustion of other materials Chromate, bromate, hypochlorite, etc.
Eco-toxic	On the accumulation, these substances have direct or delayed impact on the environment and aquatic biota. Petrol, diesel, oils, paints etc.
Organic peroxide	The waste that contains –O-O- bond structure and can undergo a self-accelerating exothermic reaction. Butanone peroxide, ethyl methyl ketone peroxide etc.
Reactivity	Waste reacts with water and forms toxic substances that are explosively dangerous. It contains cyanides, sulfides that are released to the when exposed to alkaline or acidic medium. cyanide plating waste, waste concentrated bleaches, pressurized aerosol cans, metallic sodium, and potassium.

tion of electronic gadgets is increasing, with the same ratio of waste generation, is also hiking. In informal terms, electronic wastes are called the "e-waste" (Radha, 2002). E-waste can be defined as the materials that are being discarded after the utmost use or the gadgets that get broken up and thrown away directly without getting segregated and recycling. This may include laptops, computers, cellphones, printers, LEDs, LCDs, etc. that are made up of complicated mixtures of plastics, metals and other alloys (Osibanjo *et al.,* 2008). These are very complex with non-biodegradable properties and are dumped into the ground after being discarded. As time passes by, they appear as mountain heaps creating a burden to the mother earth. The electronic gadgets contain small amount of toxic substances such as BFRs, PCBs, Lead, Cadmium, Plastics, *etc.* that affect the soil quality when gets infiltrate thereby polluting the underground water. This, in turn, harm human life and environment as well

Table 2. Impact of hazardous waste from different source on water and human.

Source	Major contributors	Process that generates hazardous wastes	Effect on water bodies	Effect on human health	References
Electronic sector	Cathode ray tube, Circuit boards, Chips and gold-plated components, plastics from computer accessories, Secondary steels and copper from smelting unit, refrigerator, Television, mobile phones	Dumping, Breaking and removal of copper, open burning, chemical stripping along river banks.	Leaching of heavy metals contaminating the groundwater bodies, discharge of hydrocarbon ash in surface water bodies.	Silicosis, respiratory irritation, pulmonary edema, circulatory failure and death	Kumar and Tripathi, (2007); Dwivedy *et al.* (2010); Gupta *et al.* (2011) .
Nuclear power plant	Nuclear reactors, Nuclear fuel reprocessing	Near surface disposal and deep surface disposal, aqueous waste sorption, precipitation, evaporation etc.	The aquatic biota gets destroyed due to radiation	Mental retardation, mutation, cancer, fetus gets destroyed before birth, reduced fertility	Islam *et al.* (2014)
Mining practice	River beds, Dunes, Coal, Gold, and other activities	Underground mining of coal, acid mines, and sometimes river bed	Disturbed the water quality with higher turbidity, and also the effect on distribution and abundances of the aquatic organisms	In river bed mining the major caused socio-economically impacts, Acid drainage mine caused skin irritation kidney damage and neurological disease	Garland (2012); Kamboj *et al.* (2017); Kamboj and Kamboj (2019, 2020)

Table 2. *Continued...*

Source	Major contributors	Process that generates hazardous wastes	Effect on water bodies	Effect on human health	References
Agriculture hazardous waste	Pesticides, fertilizers, other chemicals like phosphate, nitrates, sulphides.	Runoff, direct consumption of crops that are growing using pesticides	Bioaccumulation, Eutrophication	Cancer, neurological disorder	Kumar *et al.* (2020a, b)
Hazardous heavy metals	Sewage and untreated waste water	Directly dumping or adding the untreated waste water in water resources	Contaminates the water quality, eutrophication condition, and affect on the food chain cycle of the water source	By bioaccumulation process, it can be affected by various diseases such as Diarrhea, Cancer	Lee *et al.* (2002); Musilova *et al.* (2016)
Thermal power plants	Spent catalyst, waste mineral oil, waste resin, lead-acid battery, waste asbestos, waste chemical, terminal concentrated brine, wastewater crystalline salt, and fly-ash.	Direct landfill, melting, solidification, crushing, separation, pressure filtration, distillation.	Leaching of heavy metals, Contamination in the nearby water bodies, bioaccumulation	Brittle hair, deformation of nails, neurological damage, cancer, lung and heart disease.	Vasistha (2014); Shao and Li (2019)
Biomedical waste	Syringes, medical sharps, vials, ampules, tubing, gloves and gowns, wasted drug, PPE kit.	By collection, segregation and transportation	Dumping of these wastes directly affect the water quality by increase the number of pathogens and bioindicator species	Hepatitis B and C, HIV	Sharma and Chauhan (2008); Rajor *et al.* (2012)

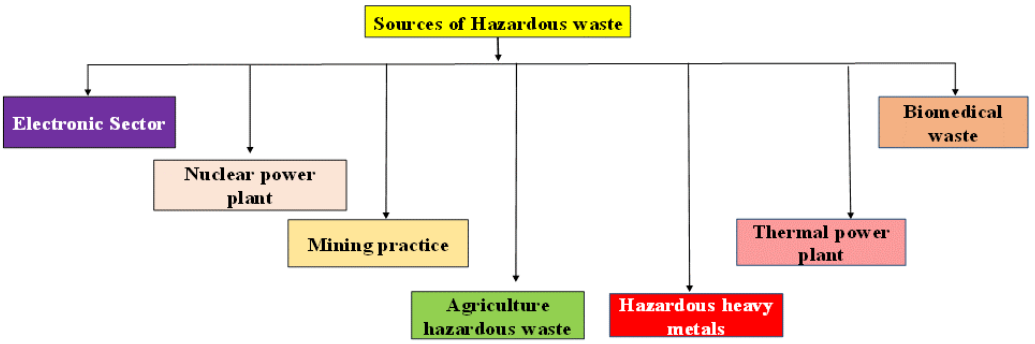

Figure 1. Sources of hazardous waste.

(Otache *et al.,* 2012). The rate of increase in the generation of e-waste is three times greater than that of municipal solid waste (DIT, 2003). It is estimated that every year 2.7 million tons of e-waste is generated in India. Since the disposal of e-waste is a big problem in India and becomes the 5th largest producer of this type of waste. In India, the proper disposable site for hazardous electronic waste are not up-to-date. The landfill sites are found to contain a prominent amount of heavy metals that get leached out in the ground, thereby contaminating the groundwater quality. The e-waste is not handled properly as municipal solid waste landfills have a linear system and sometimes fails to collect and remove the leachate ejected out. While in the developed country the e-waste is managed by inappropriate routes including open dumps, unsanitary landfills, recovery of the material, backyard recycling etc. (Osibanjo *et al.,* 2008). Figure 2 shows different stages of e-waste. We are moving toward the development and updating ourselves with new technologies. After the primary use the electronic gadgets are being disposed of into the landfill areas. When this waste comes in contact with rainfall, leaching process starts taking place. The leachate from the landfill areas starts moving below the ground and contaminates the groundwater quality. When the land gets irrigated using the ground water source get enriched with greater amount of nutrients. In some way it is good for the growth and yield of crops but on the other hand if the limit exceeds various nutrient related problem starts. And, when human consume the crops contaminated with heavy amount of nutrients, also get suffered from various diseases.

Nuclear power plants

The extra material after the utilization of the radioactive materials in the atomic reactor during the creation of atomic weapons is called as radioactive waste (Khelurkar *et al.,* 2015). The radioactive waste

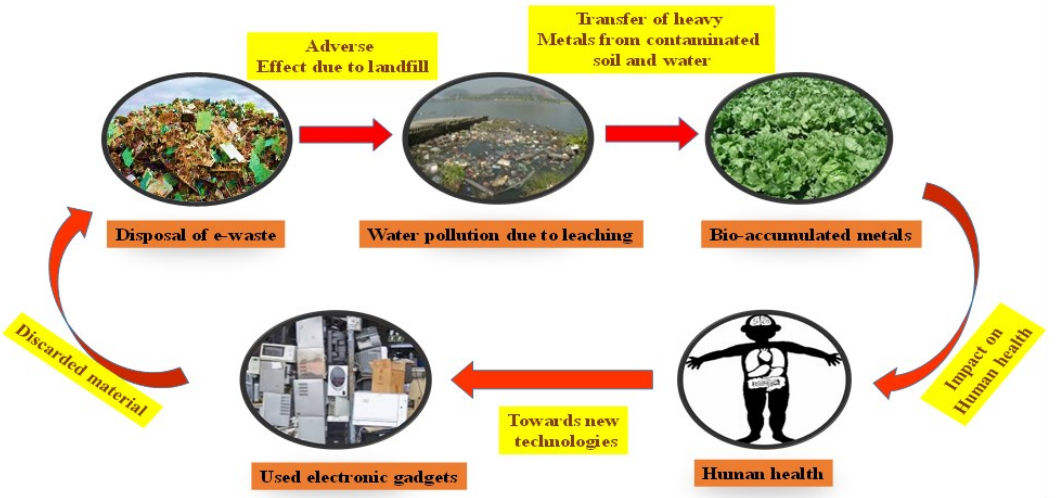

Figure 2. Different stages of hazardous e-waste formation.

a huge amount of radiation in the form of rays such as alpha, beta, gama and neutron radiation which directly affected the environment. If these are handled properly, have lesser harm but if not can destroy the whole population within a short span of time (Islam *et al.*, 2014). Mostly, the nuclear waste is disposed into the oceans and seas. When they are dumped, they release harmful rays which directly affect the reproduction and growth of the aquatic organisms (Khelurkar *et al.*, 2015).

Mining

The extraction of metals and other mineral substances from the earth is called mining (Hudson, 2012). In developing countries, mining is one of the most vital sources of the economy and employs many laborers working in the field (Sumi and Thomsen, 2001; Jhariya and Chaurasia, 2010). Mining whether on a small scale or at a larger scale extremely affects the environment by producing prominent amount of wastes that affect the environment for many years (Sumi *et al.*, 2001; Kitula, 2005). Mining results in the degradation of land and forest, loss of flora and fauna, soil erosion, breakdown of water channel, contamination of surface and groundwater (Kamboj *et al*. 2017). Due to the mining practice, surface and groundwater pollution takes place (Kamboj and Kamboj, 2019). In mining activity, huge amount of water is being used for extracting the material. Some of them reuse the water intake, while some dispose of the, left out water after the use of the nearby areas (Sumi *et al.*, 2001). Mainly the sulfides containing minerals are being thrown out into the air whereon reacting with water and form sulphuric acid (Sumi 2012; Hudson, 2012). The surface and groundwater greatly affected by the elevated concentration of hazardous chemicals like arsenic sulphuric acid and mercury (Kamakar *et al.*, 2012). The impact of adulteration in the mining area is due to the substances used in the mining process and

the metals which are been extracted from the raw material (Hudson, 2012). A huge quantity of water obtained after the process of mine drainage, mine cooling, aqueous extraction and other such processes, contains massive amount of chemicals that contaminate the surface and groundwater (Dasgupta, 2012).

Agriculture hazardous wastes

With the increase in agriculture practices, the rate of use of fertilizers and pesticides, and other livestock products is increasing day-by-day, to enhance the yield. These products have a serious impact on the water bodies if discharged loosely without prior treatment. The water from the agrarian practices contains constituents such as nitrates, phosphates, sulfates, pesticides, etc. When the nitrate content reaches high above the permissible limit, it starts hindering the normal activities of water thus degrading the quality. Besides, these pesticides directly or indirectly emit harmful substances to the water bodies. The intensified level of both the substances directly affects the aquatic flora and fauna and life living on land that are plants and animals (Bharti and Kamboj, 2019; Kumar *et al.* 2020a). The pollution of land takes over a wider area, so it's difficult to define their source and identification becomes a tedious task. On the other hand, control of agriculture water pollution also becomes difficult. Predicting the degree of pollution in agriculture water varies with different parameters such as a pattern of rainfall, slope of the land, the chemical supplements used in the field, the features of soil, the type of crop used, production methods used, etc. Utilization of the fertilizers in the agrarian system and dumping of the animal and human waste into the land results in leaching of nitrate in high amounts, thus the groundwater quality gets changed. Overburden of the nutrients directly affects the surface water quality when water and soil containing nitrogen and phosphorus streams alongside overflow into close by waters Kumar *et al.* (2020b). In the modern trend of agriculture, farmers start using waste water for irrigation purposes. The water contains higher concentration of salts, nutrients and heavy metals too. Due to the increased concentration of these constituents, limitation of water uptake by plants takes place resulting in high-stress conditions and low crop yield. Further when the consumer consumes the food grown by contaminated water, suffers from high health risk.

Hazardous heavy metals

Aggregation of heavy metals in the biological system over an extensive period compared with the chemical concentration in the environment ends up being dangerous for water and human health (Verma and Dwivedi, 2013). Various sources are responsibly contaminating the water bodies like industrialization and urbanization that increases the heavy metal concentration. These heavy metals are migrated through the industries, municipalities and urban areas through runoff and get accumulated in the soil and sediments of the water bodies (Musilova *et al.*, 2016). Many of the heavy metals are found in water body in a very trace amount that is very toxic. This is because the toxicity level of a metal depends on factors such as the organisms which are exposed to it, its nature, its biological role and the

period at which the organisms are exposed to the metal. Food chains and food webs symbolize the relationships amongst organisms. Therefore, the contamination of water by heavy metals affects all organisms. Humans, an example of organisms feeding at the highest level, are more prone to serious health problems because the concentrations of heavy metals increase in the food chain (Lee *et al*., 2002).

Thermal power plants

Thermal power plants are the conventional means, used for the generation of electricity using coal as a raw material. In the whole process of electricity generation, various hazardous waste is being generated that proves to be harmful to water and human life. According to national hazardous waste list different hazardous waste materials such as spent catalyst i.e. Vanadium-titanium catalyst used for denitration, waste mineral oil used for rotating instrument and resin used to purify demineralized water, waste from lead-acid battery, asbestos waste pipe, tanks. towers etc. on the outer surface of power plants, needs to be covered by asbestos, different harmful chemicals, fatal concentrated saline water, wastewater, slats in crystalline form salts from desulfurization wastewater are being generated (Shao and Li, 2019). Huge amount of fly ash is generated near the thermal power plants. It contains heavy metals like lead, mercury, arsenic and chromium which depends upon the type of the coal used. The fly ash ejected from the plants are either use in building structures or are directly dumped into the ash pond. Ash ponds are small lake like structure which are present behind the brick wall. The affect of fly ash is on water bodies is that it spread over the water body and creates a thin layer of ash that hindered the passing of sunlight. If a proper sunlight is not entering in the water bodies such as ponds and lake. The less amount of sun light penetration increases the biochemical oxygen demand and affected the food chain process of that water body (Shao and Li, 2019).

Biomedical wastes

Biomedical wastes are those waste that incorporates different discarded materials from the clinics, nursing homes, hospitals, medical shops, etc. have variable physiognomies and composition. They are harmful to the environment if not managed properly and exposed directly to the populace (Manzoor and Sharma, 2019). The waste generated in these sectors contains 85%-90% of hazardous waste (i.e., the waste almost similar to domestic waste, free from body fluids) and 10%-20% of hazardous waste. These 10-20 % of wastes are a greater matter of concern as they are harmful and infectious depicted in figure 3 (Rajor *et al*., 2012). Biomedical waste is either generated from the primary source or the secondary sources depending upon the amount of the waste generated. The major source sectors of biomedical waste include hospitals, labs, research centers, blood banks, animal research and nursing generate. While, the minor source sectors of biomedical wastes include dental clinics, vaccination centers, funeral services, cosmetic piercing and ambulance services (Sharma and Chauhan, 2008). Different medical representatives such as doctors, nurses, ward boys, workers in additional services, patients, visitors,

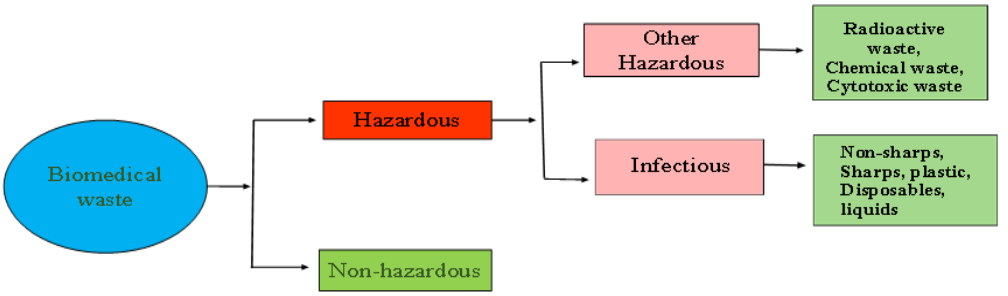

Figure 3. Types of hazardous wastes generated from biomedical practices.

workers dealing with waste disposal and treatment are very prone to have health-related issues. The three main infections commonly transmitted amongst the workers are hepatitis B, Hepatitis C, and HIV. It was estimated that out of 35 million health workers throughout the world, 3 million suffers from the greater exposure to blood-borne pathogens, 2 million affected by Hepatitis B and 0.9 million people from Hepatitis C whereas 1.7 million people from HIV. The workers involved in the collection, segregation, transportation also have a high risk of exposure (Blenkharn, 2006). When these wastes are dumped into the adjoining water bodies such as surface water bodies or in the lowland areas affects severely the water bodies either due to chemical, radioactive or biological materials respectively. Dumping of these waste results in the enrichment of the nutrients in the form of heavy metals and other nutrients thus causing the bioaccumulation and eutrophication (Sharma and Mathur, 2002). Due to which the dissolved oxygen in the water bodies gets hindered and the number of bio-indicator organisms such as *Euglena, Volvox, Vaucheria, Paramecium* etc. are high and the fresh water organisms such as *Spirogyra, Closterium, Cladophera, Daphnia* and *Diatoms* are found in fewer number thus resulting in the loss of aquatic life (Kamboj and Kamboj, 2020).

Impact of hazardous waste on water and human health

Due to the fast-moving rate of industries establishment together with the changing pattern of lifestyle, huge damage to the environment is taking place with the release of hazardous wastes. Many of the chemicals released from the anthropogenic activities such as the metals, metalloids, non-metallic substance, and wastes both organic and inorganic, our ecosystem sometimes fails to biodegrade and mineralized them. So, they remain unattended and gets accumulated in either water bodies both surface and ground or other components of the ecosystem. When the effluents containing the hazardous substances are released from different sources including industries, agrochemicals,

biomedical unit, leachates from e-waste, etc. immensely pollutes the surface and groundwater bodies. In agriculture practice, the use of various organic substrates i.e., pesticides, fertilizers, fungicide, rodenticides, weedicides, herbicides, weedicides, bactericides, etc. brings about acute water pollution. These chemicals reach the nearby water bodies through the run-off from the fields. There are several chemicals such as DDT, BHC, Aldrin, Dialdrin, Chlordane, Endosulphan, etc. when get assimilated with the water bodies, brings about drastic chemical changes. Thus, resulting in severe health issues for men and animals. These chemicals have mutagenic properties and may bring about cancer-like disease.

Management of hazardous waste

Management of hazardous waste substances is a very tedious task that involves intensive labor and subsequently a larger area for the setup. Depending upon the origin and the source of the hazardous waste outlet, different managing techniques and conservation methods are being adopted. Some of them are list below:

Bioremediation

Deterioration of harmful toxic substances by changing them into harmless substances like carbon dioxide and water under the presence of certain micro-organisms is called bioremediation. It very well may be performed either on location (in-situ) in the existence of microorganisms or expansion of bacterial or fungal strains to the bioreactors (ex-situ) to detoxify the hazardous substances present. In other words, we can say that bioremediation is the process in which native microbial population, with or without any nutrient supplements are added or injection of exogenous substances into the site. When the microorganism is added by the external source, the process is known as "bio-augmentation". In both cases the harmful substances are being removed without the formation of any new toxin (Bennett *et al*., 2002). Microorganisms assume a significant function in bioremediation as their metabolic rate is high and can degrade the polluted sample rapidly. It can be possible for them as they use energy for their development utilizing aerobic and anaerobic respiration, fermentation and co-metabolism under the presence of degradation inducing enzymes (Rose, 2002). The breakdown of chemical compounds under the presence of microbial colony is called as "biodegradation". When biodegradation process gets complete, "bio-mineralization" starts i.e. the breakdown of the complex chemical substances into simpler forms such as water, carbon dioxide and other inorganic end products. Biotransformation is frequently used as a synonym for bioconversion, in which one molecule (the predecessor) gets converted into another molecule (the products) catalytically through a single step biochemical way. When the breakdown of the chemical substances is done for the economical purpose, it will be called "bio-deterioration". It sometimes used for the substances that are resistant toward degradation such as plastics materials, metals substances, drugs, electrical gadgets, fuel and oil and

other alike products (Rose, 1981, Bennett *et al.,* 2002). There are several bioremediation techniques have can be adapted to detoxify the harmful hazardous waste from water and other components of the ecosystem but it is broadly divided into two main categories: microbial bioremediation and phytoremediation. In microbial bioremediation the bacterial colony such as *Bacillus, Pseudomonas, Arthrobacteria, Flavobacterium, Deinococcus radiodurans* are used to convert harmful substances into mild byproducts through cellular metabolism. Besides, in phytoremediation the aquatic plants such as *Lemna, Pistia, Nelumbo, Eichornnea*, are used to remediate the heavy metals from the polluted wastewater (Thakur, 2006).

Mycoremediation

When fungi are used as a raw material for the remediation of a contaminated water system, then this type of remediation is known as mycoremediation. The extracellular cellular enzymes are secreted from the fungal cell which thereby helps to destroy the complex hazardous substances. They derive the energy for their growth and development through it. The extracellular enzymes have the potential to degrade the non-cellulosic substances such as plastics, hydrocarbon pollutants, various dyes, the agriculture supplements such as pesticides and fertilizers and the nutritional wastes (Singh *et al.,* 2008). In the whole process several fungal species are used such as *Phanerochaete chrysosporium*, *Pleurotus flordia*, *Trametes hirsute*, *Ceriporiopsis subermispora* etc, in order to degrade the hazardous wastes. The enzyme secreted by *Pleurotus* species are used mainly to use degrade the chemically derived dyes. It is due to their adaptable enzymatic framework (Benette *et al.,* 2002). A large number of fungal species have the ability to absorb the heavy metals such as Cd (Cadmium), Cu (Copper), Pb (Lead), Hg (Mercury), Zn (Zinc), etc. into their mycelium and spore chamber. It was seen sometimes that the dead mycelium stores quite large amount of these heavy metals than the living form. The system developed by using *Rhizopus arrhizus*, used for the treatment of U (Uranium) and Th (Thorium) (Treen-Seares *et al.,* 1984).

Phytoremediation

It is the process in which plants are used to remediate partly or considerably the specific contaminants from the surface, sub-surface water, soil, sludge, sediments, wastewater, etc. The plants used for the process may be aquatic, semiaquatic and terrestrial. The phytoremediation process is illustrated in the Table 3 (Kumar *et al*., 2019).

Bio-sorption

Expulsion of toxins from the water system by the utilization of the biological materials with the involvement of absorption, adsorption, and exchange of ions, surface complexation and precipitation are known as bio-sorption. The bio-sorbents have a benefit that their efficiency rate is high, easily

Table 3. Different types of phytoremediation used for hazardous waste treatment (Ghosh and Singh, 2005).

Method	Explanation	Media	Contaminants	Plants involved
Rhizodegradation/ phytodegradation	The microbial degradation stimulated by plants in the rhizosphere	Sediments, soils, sludge's	Aliphatic and aromatic petroleum hydrocarbons (Organic), pesticides, solvents containing chlorine	*Jatropha, Brassica,* S everal grasses, *Alfa alfa, Cassia.*
Phytostabilization	The contaminants gets stabilized through binding and complexation	Sediments, soils, sludge's	Heavy metals (Inorganic): Arsenic (As), Cd (Cadmium), Cr (Chromium), Cu (Copper), Pb (Lead), Zn (Zinc)	*Helianthus, Chenopodium.*
Phytoextraction	Accumulation of contaminants in the soil/ water bodies that roots uptake or the harvestable shoot	Sediments, soils, sludge's	Heavy metals (Inorganic): Arsenic (As), Cd (Cadmium), Cr (Chromium), Cu (Copper), Pb (Lead), Zn (Zinc) and radio-nuclides	*Helianthus, Brassca, Alyssum, Thlaspi*
Rhizofilteration	Contaminants are removed by the roots	Surface-water, groundwater and wastewater	Inorganic Metal and radionuclides (^{137}Cs, ^{230}Pb, ^{238}U)	*Eichhornia, Lemna*
Phytovolatilization	Contaminants gets volatilized from the leaves	Sediments and soil	Organic/inorganic Se (Selenium), Mercury (Hg), Arsenic (As)	*Scirpus, Poplar, Phragmites*

accessible and have capability of bind the heavy metals on its surface. They are most favorable option for removal of contaminants as they have high regeneration properties. In any case, at the point when the centralization of the feed solution is exceptionally high, the cycle effectively arrives at an advancement, consequently restricting further pollutant evacuation (Silvas *et al.*, 2011; Adelodun *et al.*, 2020).

Conclusion

The present book chapter discussed about the various sources and process of hazardous waste and their impact on water bodies and human health also. Due to the increasing population, the

consumption of energy is hiking day-by-day and these energies are generated from various sources. In the whole process starting from harvesting up to generation, liberates prominent amount of wastes in different forms. The disposal of these waste is very difficult. If a proper management technique not used than it affects the local environment. In this chapter, we discussed about the various effects of these waste on water bodies and humans. Whenever this waste comes in contact with the water bodies than it affects the water quality by increasing the nutrient amount and increase the level of heavy metals. Also, it affects the aquatic organisms such as plankton species, benthic fauna and flora and also the fish diversity directly or indirectly. The consumption of these affected fishes is affecting the human health and cause diseases such as cancer. However, in this chapter, we reviewed and discussed about the management techniques to control and use of hazardous waste in sustainable way.

Conflict of interest: The author declares that there is no conflict of interest.

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