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Water Pollution: A Menace to Mankind

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Water is the most abundant liquid on earth. In man,more than three quarter of fluid in him is water. The survival of mankind is not possible without water which is put to several uses including drinking,cooking, recreation(swimming), transportation agriculture and industrial uses. Human settlements are usually found in areas of close proximity to water. As a result of sundry uses of water, it is usually contaminated. These contaminants can be faecal/domestic wastes or industrial wastes which are often laden with microorganisms and chemicals that are harmful to man and aquatic life. Several journals and other search engines used for this review show the need for awareness information on the dangers of water pollution and the attendant health implication. It is therefore recommended that regular public enlightenment on water pollution. Polluted water should be treated before use to mitigate against various health complications for the survival of mankind'

Keywords: Domestic waste; Danger; Survival; Aquatic life.

1. Introduction

Water pollution refers to contamination of water bodies, such as lake, river, ocean and ground water with harmful substances (Xiao *et al*., 2019). These substances could be chemical, microorganisms or waste materials that can have detrimental effect on human health, animal and the environment (Chen *et al.*, 2019). Water pollution has become a significant problem in many countries around the world. It is therefore very important to understand its causes, effects and remedies in order to take effective actions to combat it (Wu *et al.*, 2020). With the increase in civilization, industrialization has increased. The advancement in technology has given rise to economic and social development but the other side is grim as it had polluted the environment and had spoiled the ecological balance to a great extent (Chowdhary *et al*., 2020). Various norms and regulations are set to arrest the problem but the unconscious and careless attitude of mankind had created a menace (Lu *et al.*, 2015). Water pollution poses a significant threat to both environmental ecosystems and public health, making it a critical issue in today's world (Xiao *et al.*, 2019). Defined as the contamination of water bodies by harmful substances, water pollution encompasses various pollutants, including chemicals, pathogens, and waste materials, which adversely affect aquatic life and human well-being (Lai, 2017). Understanding the scope and implications of water pollution is essential for devising effective strategies to mitigate its impacts and safeguarding the quality of water resources (Lu *et al.*, 2015). At its core, water pollution stems from human activities across industrial, agricultural, and urban sectors. Industrial discharges, agricultural runoff containing pesticides and fertilizers, untreated sewage, and improper waste disposal practices contribute to the degradation of water quality. As pollutants accumulate in water bodies, they disrupt aquatic ecosystems, harm wildlife, and compromise the availability of clean water for human consumption and

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recreational activities (Dwivedi *et al.*, 2018). The consequences of water pollution extend beyond ecological concerns to encompass public health risks. Contaminated water sources can harbor harmful pathogens and toxins, leading to waterborne diseases such as cholera, dysentery, and hepatitis (Ustaoğlua *et al.*, 2020). Vulnerable populations, including children, the elderly, and individuals with compromised immune systems, are particularly susceptible to these health threats. Moreover, pollutants in water can bio-accumulate in aquatic organisms, eventually reaching humans through the food chain and causing long-term health effects (Ansari and Akhmatov, 2020). Water pollution control requires a multifaceted approach that integrates regulatory measures, technological innovations, and community engagement. Efforts to reduce pollution must focus on pollution prevention, sustainable resource management, and the implementation of robust water treatment and sanitation systems (Ansari and Akhmatov, 2020). Public awareness and education initiatives play a crucial role in fostering a culture of environmental stewardship and encouraging responsible water use practices. Water pollution represents a complex and pervasive challenge with far-reaching implications for environmental sustainability and public health. By recognizing the significance of water pollution and taking proactive measures to address its root causes, societies can work towards ensuring clean and safe water resources for current and future generations (Ahmed and Ismail, 2018).

Water pollution is another significant environmental concern, resulting from the contamination of freshwater bodies such as rivers, lakes, and groundwater sources. Sources of water pollution include industrial discharges, agricultural runoff containing pesticides and fertilizers, untreated sewage, and improper waste disposal practices. Pollutants such as heavy metals, pathogens, nutrients, and synthetic chemicals can accumulate in water bodies, posing risks to aquatic ecosystems and human health (Xu *et al.*, 2019). Water pollution not only affects drinking water quality but also disrupts aquatic habitats, leading to declines in biodiversity and ecosystem services (Kaur *et al.*, 2021).

Figure-1. Type of pollution

Source: Peng *et al.*, (2017).

2. Water Pollution: A Menace to Mankind

Water pollution refers to the contamination of water bodies, including rivers, lakes, oceans, groundwater, and even drinking water sources, by various pollutants (Schullehner *et al.*, 2018). These pollutants can be of natural or human origin and may include chemicals, microorganisms, heavy metals, plastics, and other substances that degrade water quality and pose risks to human health and the environment (Tseng *et al.*, 2018). The sources of water pollution are diverse and can be categorized into point sources and non-point sources. Point sources refer to specific, identifiable locations where pollutants are discharged directly into water bodies, such as industrial facilities, wastewater treatment plants, and sewage outfalls (Tseng *et al.*, 2018). These point sources often release large quantities of pollutants, including toxic chemicals, heavy metals, and organic compounds, which can have significant impacts on aquatic ecosystems and human health if not properly managed (Xu *et al.*, 2019). Non-point sources of water pollution, on the other hand, are diffuse and arise from various activities across landscapes, including agriculture, urban development, transportation, and mining (Ebenstein, 2012). Examples of non-point source pollutants include agricultural runoff containing fertilizers and pesticides, urban storm water runoff carrying pollutants from streets and rooftops, and sedimentation from construction sites and land erosion. Unlike point sources, non-point sources are challenging to control and regulate due to their dispersed nature and the complex interactions between land, water, and natural processes (Zaveri, *et al.*, 2020). The consequences of water pollution can be severe and wide-ranging, affecting both human populations and ecosystems. One of the most significant impacts of water pollution is on human health, as contaminated water can spread diseases and infections through pathogens such as bacteria, viruses, and parasites (Zaveri, *et al.*, 2020). Waterborne diseases such as cholera, typhoid fever, dysentery, and hepatitis are common in areas with DSty, and even death, particularly among vulnerable populations such as children and the elderly (Jorgenson, 2009). In addition to human health concerns, water pollution can also have detrimental effects on aquatic ecosystems and biodiversity (Zaveri, *et al.*, 2020). Pollutants

discharged into water bodies can disrupt the balance of aquatic ecosystems, leading to declines in fish populations, loss of biodiversity, and degradation of habitats such as coral reefs, wetlands, and estuaries. Excessive nutrient runoff, for example, can cause algal blooms and eutrophication, resulting in oxygen depletion and the death of aquatic organisms. Similarly, toxic chemicals and heavy metals can accumulate in the food chain, posing risks to fish, wildlife, and humans who rely on these resources for food and livelihoods (Jorgenson, 2009). Addressing water pollution requires comprehensive and integrated management approaches that involve pollution prevention, control, and remediation measures at local, regional, and global scales (Chen *et al.*, 2019). Strategies for mitigating water pollution include improving wastewater treatment infrastructure, implementing best management practices in agriculture and industry, reducing the use of harmful chemicals, promoting sustainable land use and urban planning, and fostering public awareness and education about water conservation and pollution prevention. By working collaboratively across sectors and stakeholders, societies can protect and preserve water resources for current and future generations (Xu *et al.*, 2022a).

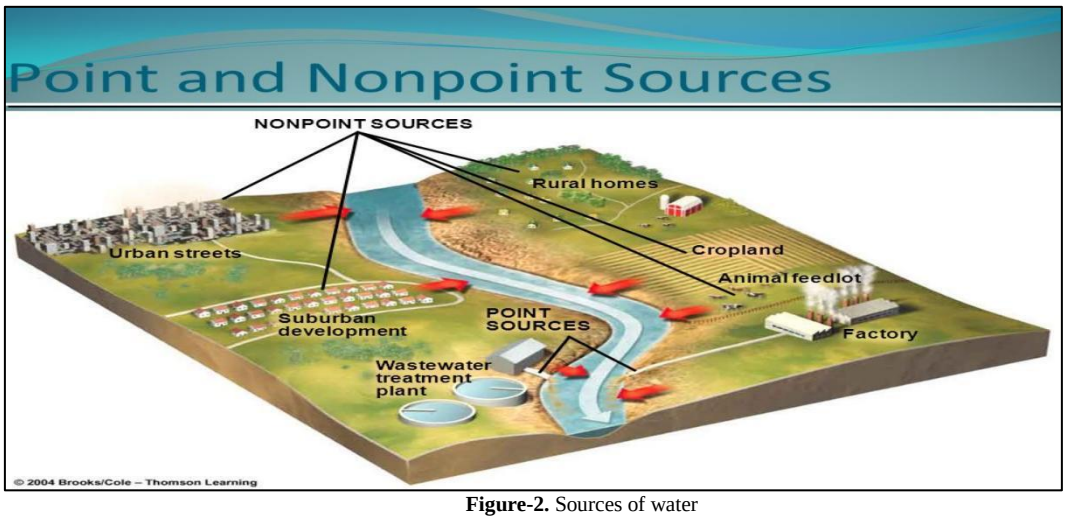

Figure-2. Sources of water

Source: Siegfried *et al.*, (2017)

3. Signs of Water Pollution

Signs of water pollution can manifest in various forms, providing visual, olfactory, and sometimes tactile cues that indicate the degradation of water quality. These signs are crucial indicators of potential environmental hazards and can help individuals and authorities identify and address sources of pollution (Dwivedi, *et al.*, 2018). Common signs of water pollution include foul odors, discoloration, and the presence of debris, each of which reflects different types and levels of contamination. One of the most noticeable signs of water pollution is the presence of foul odors emanating from water bodies (Lin *et al.*, 2013). These odors can range from unpleasant and pungent smells to distinctively chemical or sewage-like scents. Foul odors in water may result from the decomposition of organic matter, the release of gases such as hydrogen sulfide and methane, or the presence of pollutants such as industrial chemicals, sewage, or agricultural runoff (Wu *et al.*, 1999). In some cases, microbial contamination and algal blooms can also produce odors indicative of water pollution, signaling potential health risks and environmental concerns. Discoloration of water is another common sign of pollution and can manifest in various hues, including brown, green, yellow, or even red (Brown and Clasen, 2012). Discoloration may result from the presence of suspended sediments, algae, dissolved organic matter, or chemical pollutants in the water. Sediment runoff from construction sites, erosion of soil from agricultural fields, and industrial discharges can contribute to turbidity and discoloration, impairing water clarity and aesthetics (Halder and Islam, 2015). Algal blooms, fueled by nutrient pollution from sources such as fertilizers and sewage, can also cause water discoloration, posing risks to aquatic ecosystems and human health. The presence of debris, litter, and floating materials on the surface of water bodies is another visible indicator of pollution (Dwivedi *et al.*, 2018). Debris can include plastic bottles, bags, Styrofoam, tires, and other human-made materials that accumulate in rivers, lakes, streams, and oceans (Payment *et al.*, 1997). These materials not only detract from the natural beauty of waterways but also pose serious threats to wildlife, aquatic organisms, and ecosystems. Plastic pollution, in particular, has become a significant environmental concern, as plastics persist in the environment for long periods, fragmenting into smaller pieces and entering the food chain, with potential consequences for human health and marine life (Gundry *et al.*, 2004). In addition to these visual and olfactory signs, water pollution can also have broader ecological and health impacts, affecting aquatic biodiversity, ecosystem functioning, and human well-being (Ansari and Akhmatov, 2020). Contaminated water can pose risks to public health through the spread of waterborne diseases, the accumulation of toxins and pollutants in aquatic organisms, and the degradation of recreational and drinking water supplies (Clasen *et al.*, 2015). Addressing water pollution requires concerted efforts to identify pollution sources, implement effective pollution prevention and control measures, and promote sustainable water management practices to safeguard water resources for current and future generations (Fong and Lipp, 2005).

4. Causes of Water Pollution

Water pollution stems from a multitude of sources, each contributing to the degradation of water quality and posing significant environmental and public health risks (Halder and Islam, 2015). Understanding the diverse causes and sources of water pollution is crucial for implementing effective management and mitigation strategies to safeguard water resources. Some of the primary sources of water pollution include industrial waste, agricultural runoff, and sewage discharge. Industrial activities are major contributors to water pollution, releasing a wide range of contaminants into water bodies (Dwivedi *et al.*, 2018). Industrial processes generate various types of wastewater containing pollutants such as heavy metals, toxic chemicals, oils, solvents, and organic compounds (Brown and Clasen, 2012). Improper disposal of industrial wastewater, leaks, spills, and inadequate treatment facilities can result in the direct discharge of pollutants into rivers, lakes, and coastal waters. Industrial pollution poses serious threats to aquatic ecosystems, affecting water quality, biodiversity, and the health of aquatic organisms (Halder and Islam, 2015). Agricultural runoff is another significant source of water pollution, particularly in rural and agricultural areas (Dwivedi *et al.*, 2018). Runoff from agricultural lands carries sediment, nutrients, pesticides, and fertilizers into waterways, leading to nutrient enrichment, eutrophication, and contamination of surface and groundwater (Wu *et al.*, 1999). Excessive use of fertilizers and pesticides, improper land management practices, and inadequate erosion control measures exacerbate the impacts of agricultural runoff on water quality (Chen *et al.*, 2019). Nutrient pollution from agricultural runoff can stimulate algal growth, leading to algal blooms, oxygen depletion, and ecological imbalances in aquatic ecosystems. Sewage discharge, including untreated or inadequately treated wastewater from domestic, municipal, and industrial sources, is a significant contributor to water pollution worldwide. Sewage contains organic matter, pathogens, nutrients, and a variety of contaminants that can degrade water quality and pose risks to human health and the environment (Wu *et al.*, 2020). In many regions, inadequate sanitation infrastructure, combined sewer overflows, and aging wastewater treatment facilities contribute to the discharge of untreated sewage into water bodies. Pathogens such as bacteria, viruses, and parasites in sewage can spread waterborne diseases, posing public health risks and compromising access to safe drinking water and sanitation (Jorgenson, 2009). Other sources of water pollution include urban runoff, storm water runoff, construction activities, mining operations, oil and gas extraction, shipping, and atmospheric deposition of pollutants (Wu *et al.*, 2020). Urbanization and urban runoff transport pollutants such as heavy metals, petrochemicals, micro-plastics, and litter into water bodies, degrading water quality and aquatic habitats (Chen *et al.*, 2019). Construction activities, mining operations, and oil and gas extraction can introduce sediment, chemicals, and toxic substances into rivers and streams, altering aquatic ecosystems and threatening wildlife. Addressing water pollution requires integrated approaches that focus on pollution prevention, source control, and sustainable water management practices (Jorgenson, 2009). Strategies for mitigating water pollution include improving wastewater treatment infrastructure, implementing best management practices in agriculture and industry, promoting water conservation and efficiency measures, and enhancing regulatory frameworks to enforce pollution control standards (Chen *et al.*, 2019). Collaborative efforts among governments, industries, communities, and stakeholders are essential to mitigate the impacts of water pollution and protect water resources for current and future generations (Chowdhary *et al.*, 2020).

5. Types of Water Pollution

Water pollution encompasses various types of contaminants and pollutants that degrade water quality and pose risks to aquatic ecosystems, human health, and the environment. Understanding the different types of water pollution is crucial for identifying sources, assessing impacts, and implementing effective management and remediation strategies. Some of the primary types of water pollution include chemical pollution, nutrient pollution, and thermal pollution (Chowdhary *et al.*, 2020).

Chemical pollution refers to the introduction of harmful chemicals and toxic substances into water bodies, posing significant risks to aquatic life and human health (Chen *et al.*, 2019). Chemical pollutants originate from various sources, including industrial activities, agricultural practices, urban runoff, and household products (Jorgenson, 2009). Common chemical pollutants found in water bodies include heavy metals (e.g., lead, mercury, cadmium), pesticides, herbicides, industrial chemicals, pharmaceuticals, and petroleum hydrocarbons (Lai, 2017). These pollutants can accumulate in water, sediments, and aquatic organisms, leading to bio-accumulation and bio-magnification in food chains. Chemical pollution can disrupt aquatic ecosystems, impair water quality, and threaten human health through contamination of drinking water sources and consumption of contaminated fish and seafood (Xiao *et al.*, 2019).

Nutrient pollution occurs when excessive amounts of nutrients, such as nitrogen and phosphorus, enter water bodies, leading to nutrient enrichment and eutrophication. Nutrients originate from various sources, including agricultural runoff, wastewater discharge, fertilizer application, and urban storm water runoff (Brown and Clasen, 2012). Excessive nutrient loading stimulates the growth of algae and aquatic plants, leading to algal blooms, oxygen depletion, and ecological imbalances in aquatic ecosystems (Halder and Islam, 2015). Eutrophication can result in the formation of hypoxia or anorexic zones, where oxygen levels are insufficient to support aquatic life, leading to fish kills, habitat degradation, and loss of biodiversity. Nutrient pollution also poses risks to human health by contaminating drinking water sources and contributing to the proliferation of harmful algal blooms and waterborne pathogens (Dwivedi *et al.*, 2018).

Thermal pollution refers to the increase in water temperature caused by human activities, such as industrial discharges, power plant operations, and urban runoff (Ustaoğlua *et al.*, 2020). Thermal pollution alters natural temperature regimes in water bodies, disrupting aquatic habitats, and ecological processes (Yassin *et al.*, 2006). Elevated water temperatures can reduce dissolved oxygen levels, impair fish and aquatic organism metabolism, and

increase susceptibility to diseases and stress (Gundry *et al.*, 2004). Thermal pollution also alters aquatic species composition and distribution, favoring heat-tolerant species over native cold-water species. Changes in water temperature can disrupt spawning, migration, and feeding patterns of aquatic organisms, leading to population declines and shifts in ecosystem structure and function (Waddington *et al.*, 2009). Addressing different types of water pollution requires integrated approaches that focus on pollution prevention, source control, and sustainable water management practices (Ahmed and Ismail, 2018). Strategies for mitigating water pollution include improving wastewater treatment infrastructure, implementing best management practices in agriculture and industry, promoting water conservation and efficiency measures, and enhancing regulatory frameworks to enforce pollution control standards (Ansari and Akhmatov, 2020). Public awareness, education, and stakeholder engagement are essential for promoting responsible water use, reducing pollution, and protecting water resources for current and future generations (Fong and Lipp., 2005).

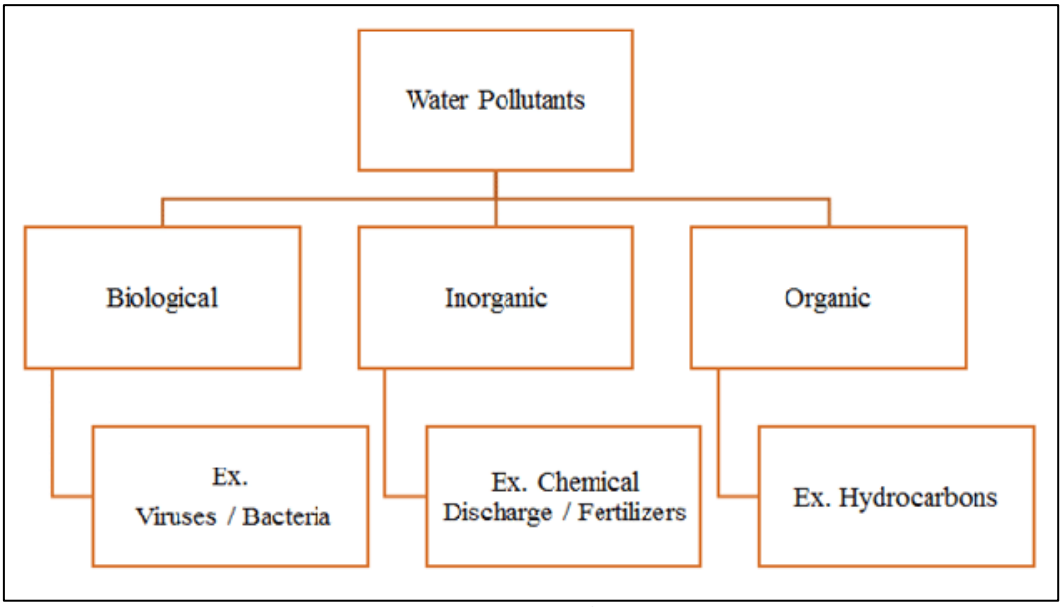

Figure-3. Types of water pollutant

Source: Van *et al.*, (2018).

6. Sources of Water Pollution

Water is sometimes referred to as the universal solvent, as it dissolves more substances than any other liquid. However, this ability means that water is easily prone to pollution (Lin *et al.*, 2013). Below are just some of the many ways that water pollution can occur.

6.1. Sewage and Wastewater

After being used, water becomes wastewater. Wastewater can be domestic, such as water from toilets, sinks, or showers, or from commercial, agricultural, or industrial use. Wastewater also refers to rainwater that washes oil, grease, road salt, debris, or chemicals from the ground into waterways (Khan *et al.*, 2013). The UN estimates that 80% of wastewater returns to the ecosystem without being treated or reused. In 2017, the UN found that 2 billion people worldwide did not have access to facilities such as toilets or latrines. The organization also discovered that 673 million people openly defecate outside (Fleisher and Kay, 2006).

6.2. Agriculture

The agriculture industry is one of the biggest consumers of fresh water. In the U.S., it is responsible for around 80% of the nation's water consumption. Agriculture is also the main source of pollution in rivers and streams in the U.S. One way that agriculture causes water pollution is through rainwater (Kazi *et al.*, 2009). When it rains, pollutants, such as fertilizers, animal waste, and pesticides get washed from farms into waterways, contaminating the water. Contaminates from agriculture usually contain high amounts of phosphorous and nitrogen, which encourage the growth of algal blooms (Yau *et al.*, 2009). These blooms produce toxins that kill fish, seabirds, and marine mammals, as well as harming humans. Additionally, when these algal blooms die, bacteria produced as the algae decompose use up oxygen in the water. This lack of oxygen causes "dead zones" in the water where fish cannot live (Yau *et al.*, 2009). The United Nations Educational, Scientific and Cultural Organization (UNESCO) estimate that there are roughly 245,000 square kilometers of dead zones globally (Arif *et al.*, 2020).

6.3. Plastics and Garbage

Due to the widespread use of plastics, experts estimate that 4.8–12.7 million tons of waste enter the ocean each year (Lin *et al.*, 2013).

Plastic and garbage can enter the water in many ways:

• Debris falling off ships

• Trash blowing into the ocean from landfills

• Garbage swept into the sea via rivers from people discarding used items such as food packages and water/other drinks cans.

• People throwing their trash on to the beach

Once in the water, plastic and garbage can harm marine life and human health. Fish may eat trash, mistaking it for food, and end up dying (Schullehner *et al.*, 2018).

As plastic slowly breaks apart, micro-plastics form. These are small fragments of plastic that are less than 5 millimeters in size. Fish may consume these micro-plastics, which may then be eaten by humans. The UN state that plastic debris in the ocean causes the deaths of over a million seabirds each year. Plastic debris is also responsible for the deaths of more than 100,000 marine mammals annually (Zhitkovich, 2011).

6.4. Oil

Oil pollution can occur when oil tankers spill their cargo. However, oil can also enter the sea via factories, farms, and cities, as well as via the shipping industry (Tseng *et al.*, 2018).

6.5. Radioactive Waste

Radioactive waste can endure in the environment for thousands of years, making safe disposal difficult. If improperly disposed of, it can enter the water, making it hazardous to humans, marine life, and the environment (Kaur *et al.*, 2021).

6.6. Fracking

Fracking is the process of extracting oil or natural gas from rock. The technique uses large amounts of water and chemicals at high pressure to crack the rock. The fluid created by fracking contains contaminants that can pollute underground water supplies (Zhang *et al.*, 2003).

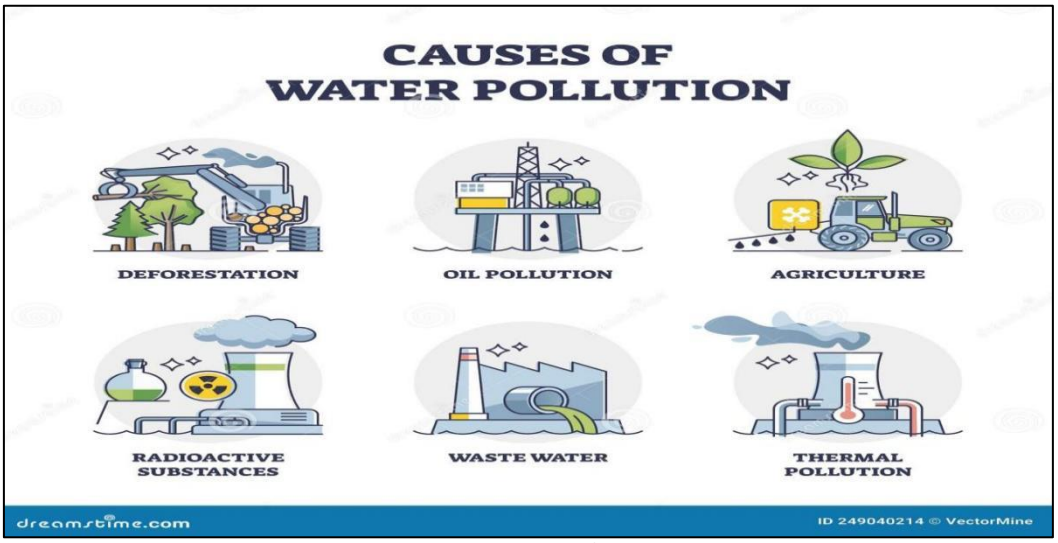

Figure-4. Causes of water pollution

Source: Wear *et al.*, (2016).

7. Menace of Water Pollution to Mankind

Water pollution poses significant adverse effects on human health, ecosystems, and economies, highlighting the urgent need for effective pollution control and management measures. Understanding these impacts is crucial for raising awareness, implementing preventive strategies, and safeguarding water resources for present and future generations (Kaur *et al.*, 2021).

7.1. Human Health Impacts:

Water pollution directly threatens human health by contaminating drinking water sources and exposing individuals to harmful substances and pathogens (Schullehner *et al.*, 2018). Contaminated water can transmit waterborne diseases, including cholera, typhoid fever, dysentery, and gastroenteritis, causing gastrointestinal illnesses, dehydration, and even death, particularly in vulnerable populations lacking access to safe drinking water and sanitation facilities (Lin *et al.*, 2013). Additionally, exposure to chemical pollutants, such as heavy metals, pesticides, and industrial chemicals, through contaminated water sources can lead to acute and chronic health problems, including neurological disorders, reproductive issues, organ damage, and cancer (Zhitkovich, 2011). The ingestion of contaminated fish and seafood containing high levels of toxins, such as mercury and polychlorinated biphenyls , which can also pose health risks to consumers (Fewtrell and Colford, 2005).

7.2. Ecosystem Impacts:

Water pollution disrupts aquatic ecosystems, impairing water quality, biodiversity, and ecological processes. Excessive nutrient pollution and algal blooms deplete oxygen levels in water bodies, leading to hypoxia or anorexic conditions that suffocate aquatic organisms and create dead zones devoid of life (Clasen *et al.,* 2015). Eutrophication alters species composition, favors the proliferation of algae and invasive species, and diminishes habitats for native flora and fauna. Chemical pollution contaminates sediments, bio accumulates in food chains, and poses risks to aquatic organisms, including fish, invertebrates, and amphibians (Arnold and Colford, 2007). Habitat destruction, loss of wetlands, and fragmentation of aquatic ecosystems further exacerbate the impacts of water pollution on biodiversity and ecosystem resilience (Ansari and Akhmatov, 2020).

7.3. Economic Impacts:

Water pollution imposes significant economic burdens on communities, industries, and governments, affecting livelihoods, economic productivity, and resource sustainability. The costs of treating polluted water for drinking, industrial, and agricultural purposes are substantial, straining public budgets and infrastructure investments (Xu *et al.,* 2022). Waterborne diseases and illnesses resulting from contaminated water sources impose healthcare costs, productivity losses, and economic hardships on affected populations, particularly in developing countries with limited access to healthcare services (Chowdhary *et al.,* 2020). Declines in fisheries, aquaculture production, and recreational opportunities due to degraded water quality undermine local economies and livelihoods dependent on healthy aquatic ecosystems. Pollution-related damages to infrastructure, property, and natural resources further exacerbate economic losses and diminish the resilience of communities and ecosystems to environmental stressors (Chen *et al.,* 2019).

Addressing the adverse effects of water pollution requires coordinated efforts at local, national, and global levels to strengthen regulatory frameworks, enforce pollution control measures, invest in wastewater treatment infrastructure, promote sustainable water management practices, and raise public awareness about the importance of clean water and environmental stewardship. Collaboration among governments, industries, communities, and stakeholders is essential for achieving water quality goals, preserving ecosystem health, and ensuring equitable access to safe and clean water resources for all (Chowdhary *et al.,* 2020).

Figure-5. Death of aquatic organisms

Source: Ajahu *et al*., 2014.

Figure-6. Contaminated River

Source: Altieri *et al*., 2017.

Figure-7. Algae bloom

Source: Meador *et al.*, 2016.

BOD Level

BOD Level *(in ppm)*	Water Quality
1 - 2	**Very Good** There will not be much organic waste present in the water supply.
3 - 5	**Fair: Moderately Clean**
6 - 9	**Poor: Somewhat Polluted** Usually indicates organic matter is present and bacteria are decomposing this waste.
100 or greater	**Very Poor: Very Polluted** Contains organic waste.

Figure-8.

8. Managing Water Pollution

Effective management and mitigation of water pollution require a multifaceted approach encompassing regulations, wastewater treatment, and pollution prevention measures. By implementing comprehensive strategies, governments, industries, and communities can address the root causes of water pollution, protect water resources, and promote environmental sustainability (Wu *et al.*, 2020).

8.1. Regulatory Frameworks:

Regulations and policies play a critical role in controlling water pollution by establishing standards, guidelines, and enforcement mechanisms to limit pollutant discharges and protect water quality (Lu *et al.*, 2015). Regulatory frameworks vary across jurisdictions but commonly include laws governing water quality standards, discharge permits, pollution monitoring, and environmental impact assessments (Lai, 2017). Regulatory agencies oversee compliance with these regulations, conduct inspections, impose penalties for violations, and work collaboratively with stakeholders to develop and implement pollution control measures. International agreements, such as the Clean Water Act in the United States and the Water Framework Directive in the European Union, provide legal frameworks for managing water pollution and promoting ecosystem health on a regional or national scale (Xiao *et al.*, 2019).

8.2. Wastewater Treatment:

Wastewater treatment is a fundamental component of managing water pollution, particularly in urban and industrial areas where wastewater discharges contribute to surface water contamination (Halder and Islam, 2015). Treatment plants employ various processes to remove pollutants, pathogens, and contaminants from wastewater before discharge into receiving water bodies or reuse for non-potable purposes. Conventional treatment methods typically involve preliminary screening, primary sedimentation, biological treatment (e.g., activated sludge, trickling filters), and secondary clarification to remove organic matter, nutrients, and suspended solids (Dwivedi *et al.*, 2018). Advanced treatment technologies, such as membrane filtration, ultraviolet disinfection, and chemical oxidation, provide additional treatment levels to address emerging contaminants and enhance effluent quality. Integrated approaches, such as decentralized treatment systems and constructed wetlands, offer sustainable solutions for

managing wastewater in decentralized or remote settings and mitigating environmental impacts (Ahmed and Ismail, 2018).

9. Pollution Prevention Measures

Pollution prevention focuses on reducing the generation and release of pollutants at the source through changes in production processes, materials management, and behavioral practices (Ansari and Akhmatov, 2020). Pollution prevention measures aim to minimize the use of hazardous substances, optimize resource efficiency, and promote environmentally friendly alternatives to conventional practices. Industries can implement pollution prevention strategies, such as cleaner production techniques, recycling and reuse programs, and spill prevention measures, to minimize pollutant discharges and environmental impacts (Ustaoğlua *et al.,* 2020). Best management practices , pollution control technologies, and pollution prevention plans help industries, municipalities, and agricultural operations identify, prioritize, and implement cost-effective measures to minimize pollution risks and improve environmental performance (Dwivedi *et al.,* 2018). Public education, outreach campaigns, and stakeholder engagement initiatives raise awareness about water pollution issues, promote responsible behavior, and empower communities to participate in pollution prevention efforts (Ansari and Akhmatov, 2020). By integrating regulatory frameworks, wastewater treatment technologies, and pollution prevention measures, stakeholders can effectively manage water pollution, protect public health, and sustainably manage water resources for present and future generations (Hanif *et al.,* 2020). Collaborative partnerships, innovation, and continuous improvement are essential for addressing emerging challenges, advancing pollution control technologies, and achieving water quality goals in a rapidly changing environment (Arif *et al.,* 2020).

10. Conclusion

Water is an important commodity for the survival of Man. Pollution of water with chemicals and microorganisms poses a great danger to life including aquatic life. Identifying the sources of pollution is necessary for prevention and control measures to be effective.

11. Recommendation

- Regular awareness campaign on the dangers of water pollution
- Strict cross-boundary policy on control and prevention measures must be in place
- Test materials of pollution should be enhanced and substained.
- Sludge from industries should be treated and converted to less hazardous materials before burial
- Legislation against dumping of wastes (treated or not treated) in water body should be enacted.

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