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Water Pollution due to Population and Its Impact on Environment

Prem Prabhakar
Department of Chemistry, Paliwal P G College Shikohabad Firozabad Uttar Pradesh
Email: drpremprabhakr34@gmail.com

Abstract: *Approximately 70% of the Earth's surface is covered by water. Ensuring access to safe drinking water is a fundamental necessity for all individuals. Human activities have significantly shaped global water resources in recent years, leading to a pressing global challenge concerning water availability and the quality of drinking water. In numerous regions worldwide, concentrations of heavy metals (HM) in drinking water exceed established international guidelines. The intersection of "Population and Pollution" is a paramount concern in environmental and public health. The World Health Organization (WHO) reports that 80% of diseases are transmitted through waterborne routes. Factors such as industrialization, discharge of domestic and radioactive waste, excessive use of pesticides and fertilizers, and water tank leakages are prominent contributors to water pollution, exacerbated by rapid population growth, particularly in megacities. These contaminants have adverse effects on human well-being. Various chemicals have varying impacts, contingent upon their locations and types. Polluted water serves as a vector for the spread of bacterial, viral, and parasitic diseases, including typhoid, cholera, encephalitis, poliomyelitis, hepatitis, skin infections, and gastrointestinal disorders. Heavy metal pollution in drinking water, its integration into the food chain, and the associated risks to global human health have garnered significant attention. Alarmingly, millions of individuals suffer from chronic heavy metal poisoning, constituting a pressing worldwide public health concern, with an annual toll of 1.6 million children succumbing to diseases linked to contaminated drinking water. Additionally, there is compelling evidence of heavy metals in drinking water adversely affecting human health through contamination of the food chain. Regular monitoring of water quality is strongly recommended to avert its deleterious impacts on human health. Proper treatment should be administered to both domestic and agricultural waste to prevent haphazard disposal.*

Keywords: *Critical, Heavy Metal, Radioactive Waste, Gastrointestinal.*

1. INTRODUCTION :

The fundamental elements essential for the survival of humanity on our planet are water, air, and soil. Water, accounting for 71% of the Earth's surface, primarily exists in oceans and other expansive bodies of water. According to biologists, all life forms originated from the sea, underscoring the pivotal role of water in the emergence of life. Our existence on this planet is intricately linked to the benevolence of water. Throughout the course of civilization, spanning from ancient cave dwellers to modern city residents, humans have harnessed water for a multitude of vital purposes, including drinking, bathing, providing for animals, and irrigating lands. However, the contamination of water poses a significant threat when unwanted substances infiltrate this precious resource, altering its quality and endangering both the environment and human well-being. Water, as a critical natural resource, plays a central role in sustaining our lives, particularly in providing safe drinking water that is indispensable for human health across the globe. Water, known as a universal solvent, is also a primary vector for infections. The World Health Organization (WHO) reports that a staggering 80% of diseases are transmitted through waterborne pathways. Regrettably, in many countries, drinking water falls short of meeting WHO standards, leading to 3.1% of deaths resulting from unhygienic and poor-quality water. It's worth noting that despite the vast coverage of water on Earth's surface, a mere 2.5% of this abundant resource can be categorized as freshwater, as per Shiklomanov (1993).

Currently, a significant challenge is the fact that 1.6 billion people are confronting economic water shortages, and a staggering two-thirds of the world's population experiences water scarcity for at least one month each year. Recent scientific findings reveal a concerning trend: 21 out of the world's 37 largest aquifers have surpassed their sustainability thresholds (Richey et al., 2015). This alarming situation is poised to deteriorate further. It is anticipated that nearly 1.8 billion individuals residing in various regions across the globe could confront absolute water scarcity by the year 2025 (WWAP, 2012). Regrettably, these limited water resources are under grave threat due to pollution, primarily stemming from human activities. Agriculture, industrial processes, mining, power generation, and various human-induced factors contribute significantly to the contamination of water bodies. This pollution, in turn, poses a direct and growing risk to humanity as a whole (UN-Water, 2001). Numerous diseases, including cholera, diarrhea, dysentery, and hepatitis A, are intricately linked to the consumption of unclean and contaminated drinking water. Shockingly, it is estimated that over 842,000 individuals succumb to diarrhea annually on a global scale (WHO, 2017). Notably, arsenic pollution is a substantial concern in groundwater contamination, affecting approximately 70 million people worldwide (UNESCO, 2009). This underscores the urgent need for concerted efforts to safeguard our precious water resources and protect human health.

The global burden of disease associated with environmental pollution hazards is a complex issue encompassing various aspects, including infectious diseases linked to drinking water, sanitation, and food hygiene, as well as vectorborne diseases like malaria, which have a significant environmental component. Each type of pollutant presents its own distinct health risk profile, making it challenging to summarize all relevant information concisely. Nevertheless, it is crucial for public health practitioners and decision makers in developing countries to be cognizant of the potential health risks stemming from water pollution and to have access to comprehensive information to address specific situations effectively.

While there is no universally accepted definition of what constitutes a heavy metal (HM), density is typically considered the defining factor. HMs are commonly defined as elements with a specific density exceeding 5 g cm-3. The principal threats to human health from HMs are often associated with exposure to cadmium, lead, mercury, and arsenic (with arsenic, classified as a metalloid, commonly treated as a heavy metal). Additionally, there are 19 other elements classified as HMs: antimony, bismuth, cerium, chromium, cobalt, copper, gallium, gold, iron, manganese, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc. Notably, trace amounts of HMs are naturally present in our environment and diet, with some being essential for good health. Living organisms, including humans, require varying quantities of certain HMs like iron, cobalt, copper, manganese, molybdenum, and zinc. However, excessive exposure to any of these elements can result in acute or chronic toxicity, posing health risks (Kabata-Pendias and Mukherjee, 2007). Soil serves as a significant reservoir for HM ions, which can enter the food chain through various pathways, including water, plants, and leaching into groundwater. HM toxicity can lead to adverse effects such as brain damage, impaired mental functions, reduced energy levels, DNA damage, alterations in gene expression, and harm to vital organs in both humans and other living organisms (Bouchard et al., 2011; Salgado-Bustamante et al., 2010). The pollution of water is primarily driven by the discharge of domestic and industrial effluents, leakage from water tanks, marine dumping, radioactive waste, and atmospheric deposition. Improper disposal of heavy metals and industrial waste can result in the accumulation of pollutants in lakes and rivers, posing hazards to human and animal health. The direct damage to plant and animal life, which form part of the human food chain, is also a concern. Water pollutants have adverse effects on seaweeds, mollusks, marine birds, fishes, crustaceans, and other marine organisms that serve as food sources for humans. Moreover, the concentration of insecticides like DDT tends to increase along the food chain, posing risks to human health. Additionally, large quantities of untreated domestic sewage are discharged into rivers, compounding the problem of water pollution.

Domestic sewage is a significant contributor to water pollution, as it contains toxic substances, solid waste, plastic debris, and bacterial contaminants. These harmful materials adversely affect water quality. Furthermore, the discharge of various industrial effluents into rivers without proper treatment constitutes a major source of water pollution. Industries often release hazardous materials that contaminate both surface water and groundwater, with the specific contaminants depending on the nature of the industry. Toxic metals are among the pollutants that enter the water, further degrading its quality. Approximately 25% of water pollution is attributed to industrial activities, making it particularly detrimental to the environment. The growing global population exacerbates many environmental issues, including water pollution. An increase in population leads to a rise in the generation of solid waste, both in urban and rural areas. Unfortunately, solid and liquid waste often find their way into rivers and water bodies, contributing to contamination. Human excreta is another source of water pollution, introducing a large number of harmful bacteria into water sources, which pose risks to human health.

Governments often face challenges in providing essential services to citizens due to the rapid growth in population. Consequently, sanitation facilities tend to be more accessible in urban areas compared to rural regions. Plastic waste, including polythene bags, is a major source of pollution as they are frequently used for waste disposal. In urban areas, the process of urbanization can lead to the spread of infectious diseases due to factors such as overcrowding, unhygienic conditions, and the availability of unsafe drinking water. As a result, a significant portion of the urban population is susceptible to diseases linked to these issues. Addressing these challenges requires comprehensive strategies for waste management, sanitation, and water quality improvement, particularly in densely populated urban areas. It is essential to promote responsible waste disposal practices, reduce plastic waste, and ensure access to clean and safe drinking water for all, irrespective of their place of residence.

2. POLLUTION DUE TO HEAVY METALS :

The increased toxicity of heavy metals often results from their localized accumulation. In some regions, tall chimneys have been constructed to disperse metal emissions over a larger area, preventing them from settling in concentrated spots. However, this approach may have unintended consequences, such as making the emissions more susceptible to contributing to acid rain. Despite viewing the Earth as a single entity, it can be subdivided into various compartments, including organisms and individual cells. Potential toxins within organisms can be sequestered into insoluble deposits, preventing them from interacting with vital biochemical processes occurring in the cytoplasm. Heavy metals, being non-biodegradable, persist in the environment for extended periods without degradation. They remain in soils and sediments until they are transported to other compartments. Heavy metals in these environments can also undergo reactions with other elements, potentially forming more toxic compounds or degrading into less harmful forms. One example of this is the conversion of inorganic mercury to the poisonous methyl mercury due to the activity of bacteria found in water, sediment, and soil. Human activities have led to the accumulation of high concentrations of heavy metals in contaminated sites, such as abandoned mining areas or locations previously exposed to metal-containing pesticides. In these areas, vegetation often struggles to grow, and only metal-tolerant strains can thrive. To mitigate the environmental impact, techniques like capping are employed. Capping involves placing an impermeable layer on top of the contaminated site and adding new soil on top of it. This strategy helps prevent vegetation from absorbing heavy metals and minimizes the leaching of these metals into groundwater.

Metal-containing pesticides, which often include elements like arsenic, copper, lead, and chromium, may still persist in certain areas where they were previously used. In agriculture, some farmers use sewage sludge as a soil amendment, but this sludge can potentially contain heavy metals, particularly if it originated from industrial sources. Consequently, agricultural lands amended with sewage sludge may exhibit elevated concentrations of heavy metals such as copper, zinc, lead, cadmium, and chromium in the soil. Smelting processes can lead to localized pollution through the release of airborne pollutants that eventually settle onto the soil. Areas near smelting facilities may exhibit signs of environmental stress, including dead vegetation and a lack of essential decomposers like earthworms and woodlice.

Historically, lead contamination in the environment has been linked to the use of lead-containing gasoline, lead shotgun pellets, and lead fishing weights. Some of these practices have been banned in certain parts of the world. Lead pellets, for instance, have been ingested by birds, entering the food chain. Lead weights have also contributed to lead contamination in wetlands. The binding of metals to soil is influenced by factors such as clay content, organic matter, and pH. Higher clay content, more organic matter, and higher pH levels tend to promote stronger binding of metals to soil particles. Conversely, acidic soils are less effective at retaining elemental elements, as they become more soluble and can leach deeper into the ground, beyond the reach of plant roots, leading to nutrient deficiencies in plants. In the water sector, many rivers are contaminated, particularly those passing near industrial and mining areas. These polluted waters eventually flow into the sea, where they often settle at the seabed due to reduced current speed. The solubility of metals in water largely depends on the water's pH. When streams containing heavy metals flow into the sea, the pH tends to increase, causing the solubility of the metals to decrease, leading to their precipitation and accumulation on the seabed.

3. POLLUTION OF RIVERS DUE TO INDUSTRIALISATION :

Rivers have played a pivotal role in human civilization by providing various ecological benefits. They recharge groundwater, regulate floods, support wildlife habitats, and facilitate adaptation to climatic changes. However, many industrial cities located along the banks of rivers have seen the proliferation of chemical plants, textile mills, distilleries, and hospitals. Unfortunately, these industries often contribute to pollution by discharging untreated waste into the rivers.

The Ganges, often considered the lifeline of millions of Indians living along its course, has suffered significant pollution due to industrialization. This pollution has led to numerous hormonal and physiological diseases among the people who depend on the river for their daily needs. For instance, around 210,000 tons of fly ash, containing toxic heavy metals like lead and copper, were dumped into the Pandu River, a tributary of the Ganges, from a coal-based power plant in Kanpur. Industrial effluents account for approximately 12% of the total effluent volume discharged into the Ganges. Although this proportion may seem relatively small, it is a matter of major concern because of the toxic and non-biodegradable nature of these industrial pollutants.

Industrial discharges are primary sources of aquatic pollution. Depending on the type of industry, various pollutants are released into the environment either directly through industrial outlets or indirectly through domestic sewage, as a result of various human activities. These pollutants can pose serious threats to human health and the environment. Wastewater from various industries often contains high concentrations of organic pollutants and toxic components such as heavy metals, pesticides, polychlorinated biphenyls (PCBs), dioxins, poly-aromatic hydrocarbons (PAHs), petrochemicals, and phenolic compounds. These substances are harmful to surrounding water bodies, human health, and aquatic life if discharged directly into aquatic ecosystems. When industrial effluents containing heavy metals (such as chromium, lead, mercury, nickel, copper, zinc, arsenic, and cadmium) enter aquatic ecosystems, biomagnification can occur through the food chain. Advances in toxicology have provided insights into the excessive accumulation of heavy metals and their adverse effects on human health. These effects include developmental retardation, cancer, kidney damage, endocrine disruption, immunological disorders (autoimmunity), and even fatalities. Addressing industrial pollution and its consequences is critical for protecting both the environment and human well-being.

4. POLLUTION DUE TO AGRICULTURAL SECTOR :

Each year, a substantial quantity of chemicals is employed to sustain crop production and boost agricultural yields. Additionally, several tons of pesticides are utilized to combat pests, weeds, insects, and microorganisms in agricultural practices. These pesticides and other chemical agents often contain hundreds of distinct active ingredients that have direct toxicity not only to humans but also to various forms of life in ecosystems. The consequences of using these chemicals extend beyond just polluting the soil and water resources; they also have far-reaching impacts on ecosystems, biota, farmers, and consumers. Continuous exposure to these chemicals poses a significant concern for living organisms. In some cases, remarkably high concentrations of pesticides and their byproducts, such as triazines and chloroacetanilides, have been detected in rivers in the United States. Due to their relatively high allowable limits, these chemicals can affect non-target organisms within soils and entire aquatic systems, compromising the quality of surface and groundwater (Gilliom 2007).

Organochlorine pesticides like dichlorodiphenyltrichloroethane (DDT), hexachlorocyclohexane (HCH), aldrin, and dieldrin are commonly used in developing countries like India due to their cost-effectiveness. These pesticides find application in crops such as cotton, vegetables, sugarcane, and rice in regions like Punjab, Maharashtra, Karnataka, Gujarat, and Andhra Pradesh (Abhilash and Singh 2009). Efficient mitigation measures are imperative to prevent pesticides and other chemicals from contaminating surface and groundwater. Pesticide runoff is influenced by various soil hydrological properties, including water flow patterns, permeability, topography, meteorological conditions, and the absorption behavior of the chemical components (Leu et al. 2004). Addressing these factors is crucial to safeguard both environmental health and human well-being.

Pesticides applied to crops initially undergo degradation processes facilitated by soil microbes and chemical reactions. Additionally, they can become absorbed into the organic matter present in the soil. While these transformations result in the conversion of pesticides into various metabolites, complete degradation is often not achieved. The ultimate fate of pesticides in the environment involves several pathways, including volatilization into the atmosphere, runoff in dissolved and particulate forms into surface water bodies like rivers, and mixing with groundwater through the leaching process. Water contamination can occur through various means, such as the runoff of pesticides carried by rainwater from urban areas, including rooftops and roads, ultimately leading to pollution in drainage and sewer systems. The application of pesticides in agricultural practices poses a direct exposure and health risk to workers, and extensive pesticide use can result in water and soil pollution. In areas where pesticide concentrations are notably high, effective mitigation measures are essential, which may involve replacing or restricting the extensive use of pesticides. To maintain ecological balance and biodiversity, it is crucial to control the extensive use of pesticides in agricultural lands and regulate direct exposure of pesticide chemicals to workers and farmers.

Reports indicate that accidental pesticide exposure results in the poisoning of approximately 3 million people and 20,000 accidental deaths per year in developing countries. The primary role of agricultural practices in most developing countries is to address and sustain food security concerns for growing populations. This must be done while considering the types of agricultural practices employed, the usage of pesticides and agrochemicals, and their effects on humans and other living beings. As urbanization and industrialization continue to expand, developments in agricultural practices lead to increased water usage and quality issues. Due to the extensive usage of pesticides per hectare of agricultural land in developing countries, monitoring their concentrations and assessing their effects on human and plant health are often limited. The implementation of regulations to maintain pesticide concentrations is also frequently lacking. Addressing these challenges is crucial for sustainable agriculture and the well-being of both the environment and human populations.

5. SURFACE WATER CONTAMINATION FROM MINING OPERATIONS :

Mining activities around the world have significant environmental and social impacts, resulting in large waste deposits that can lead to pollution of water resources. Various types of mining, including coal, lignite, building materials, iron, and the extraction of rare metals like copper, nickel, or gold, generate substantial waste materials, which can be accompanied by problematic geochemical reactions and pollutant releases. In many ores, especially those containing sulfide materials, exposure to air and water can lead to the release of sulfuric acid, a phenomenon known as "acid mine drainage." This acidic effluent can seriously damage water bodies, with an estimated 20,000 river kilometers and 70,000 hectares of lake and reservoir area worldwide being affected. Precious metal extraction, such as gold production, involves the use of chemicals, energy, and water, posing significant pollution hazards and environmental risks. For example, the extraction of gold may involve the use of toxic chemicals like mercury or cyanide. Artisanal gold mining, practiced by millions of miners in various countries, often employs mercury amalgamation to extract gold. This process is highly toxic to humans and the environment, with mercury contamination of water resources and the atmosphere being a major concern.

In industrial-scale gold extraction, cyanide is frequently used to facilitate the leaching of gold into aqueous solutions. This process, while effective, requires large volumes of water and cyanide, which can have devastating ecological consequences if not properly managed. Cyanide is highly toxic to humans and aquatic organisms, often resulting in fish kills and other environmental damage. Efforts to make mining more sustainable include measures to address existing tailings, improved processes, safety procedures, and the replacement of highly toxic extraction agents like cyanide and mercury with less harmful alternatives. International regulations and corporate social responsibility in the mining industry also play crucial roles in protecting water quality and mitigating environmental impacts. Clear international standards and agreements, along with open information policies, can provide benchmarks for safeguarding water quality. However, strong enforcement of environmental regulations by developing countries remains essential to address the environmental challenges associated with mining activities.

6. CONCLUSION :

The increasing stress on our water environment due to industrialization and urbanization is a matter of serious concern. This stress is diminishing the availability of clean water, and polluted water poses significant threats to aquatic organisms, plants, humans, and the overall climate, ultimately disrupting ecosystems. Preserving our water environment is an integral part of sustainable development and should be a priority across all sectors. Effective wastewater treatment plays a critical role in mitigating the adverse impacts of water pollution. Furthermore, integrating environmental policies into the core objectives of businesses and organizations, coupled with continuous education on the present and future consequences of environmental and water pollution, is essential for the conservation of the water environment. Water is fundamental to the existence of all life forms, including humans, and its preservation and sustainable availability are paramount. The presence of clean water is under threat due to various human activities, particularly pollution, which not only affects ecosystems but also contributes to various climatic changes. While there are ongoing efforts to explore different wastewater treatment methods by industries and treatment plants, the issue persists as some industries continue to discharge untreated wastewater into water bodies. Therefore, a strong commitment to compliance with environmental protection policies is essential. These policies should be integrated into the goals and objectives of all entities involved in activities that contribute to environmental deterioration. Taking these environmental protection policies into account and making them an integral part of the strategies of various stakeholders will contribute to the effective reduction of water pollution. This, in turn, will represent a significant step toward safeguarding our water environment and ensuring a sustainable and healthy future for all.

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