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The cities most affected worldwide by water pollution

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Abstract

Water pollution is one of the most severe environmental problems for communities all across the globe, especially in town regions where population growth, industry expansion, and waste disposal are the main causes for the gradual deterioration of water quality. Surface water and groundwater quality standards are frequently broken, making wastewater a serious environmental concern. The amount of municipal wastewater produced worldwide is 380 billion m3, and it is predicted to rise by 24% by 2030 and 51% by 2050. Every day, most developing nations release 30-70 mm^3 of wastewater per person. Rapid urbanization, industrialization, population increase, the use of pesticides and insecticides, inadequate waste treatment systems, and a lack of water management regulations are some of the factors causing this problem. Water bodies can get contaminated by organic debris, inorganic pollutants, nitrates, phosphate, fluoride, oil spills, heavy metals, and radioactive materials. The disposal of untreated trash has both ecological and economic consequences. In this respect, ten of the worst cities that are discussed in this article include New Delhi, Dhaka, Jakarta, Karachi, Cairo, Beijing, Mexico City, Lagos, Manila and Flint, Michigan all has grim situations concerning the influx of industrial pollution, domestic sewage, agricultural runoff and plastic wastes found in them. The prime consequences of having the water supplies contaminated include an increase in the number of waters borne diseases, a decrease in the biodiversity levels and a change to normal day to day activities. Aspects concerning the socio-economic burden posed by the lack and the contamination of water are touched upon stressing on the existence of policies and practices that are effective as well as sustainable. The response includes advanced existing water treatment technologies in addition to local activity-based initiatives. The experiences of these cities amplify how important an integrated approach combining civil authorities, industries and communities is in prevention of ocean pollution. This review targets contributing toward the already existing engagements directed at solving the water crisis and emphasizes the need for both short-term measures and long-term strategies that will provide clean and potable urban water for different cities around the world.

Keywords: Most affected cities, water pollution, water treatment, heavy metals, wstewater

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1. Introduction

For many uses, such as life, food production, economic growth, and overall well-being, water is an essential renewable resource. Agriculture, hydropower production, cattle production, industrial operations, forestry, fisheries, navigation, and leisure activities all depend on India's surface and groundwater resources. However, the fast industrialization and population expansion have raised the demand for freshwater. Agricultural development activities pose a hazard to human health, especially when it comes to excessive fertilizer use and unhygienic circumstances [1]. Worldwide, water pollution is a serious issue, and in the next 20 years, many nations may have freshwater shortages. This problem is exacerbated by inadequate management, a lack of qualified personnel, and budgetary difficulties. The deliberate and unintentional disposal of hazardous substances, pollutants, and toxic chemicals into various bodies of water are major sources of contamination [2]. Around 380 billion m3 of municipal wastewater is produced annually worldwide, according to the European Investment Bank. This amount is expected to rise by 24% by 2030 and 51% by 2050. Water contamination accounts for 80% of disease transmission, making it a significant source of illness. Numerous nations' drinking water does not adhere to WHO standards, unhygienic circumstances and low water quality fuel spread of infectious diseases including cholera and typhoid fever. The poorest areas of nations like Afghanistan, India, and the Democratic Republic of the Congo have greatest rates of diarrheal child mortality. Numerous significant challenges pertaining to water quantity and quality are existing in the twenty-first century, and climate change is predicted to make them worse [3]. More than one-third of the world's population suffers from inadequate sanitation and unsafe drinking water, which has the greatest negative impact on human health. With more than one-third of planet's accessible renewable freshwater being consumptively consumed for

home, industrial, & agricultural uses, this analysis focuses on pollution of freshwater resources, such as lakes, rivers, and groundwater [4].

2. Sources of Water Pollution

There are two types of sources of water pollution: point sources and non-point sources. Point sources, such as factories, oil spills, and industrial effluents, are easily identified. Conversely, non-point sources originate from diverse sources and have the potential to impact surface or groundwater in a variety of ways. There are two examples of urban garbage and runoff from agricultural areas. When pollutants from one location have impact hundreds or thousands of miles elsewhere, this is known as trans-boundary pollution. Both organic and inorganic substances can contaminate water. Chemicals, germs, food processing waste, pathogens, and volatile organic compounds are examples of organic pollutants. Heavy metals from acid mine drainage, silt from surface runoff, fertilizers from agricultural runoff, and chemical waste from industrial effluents are examples of inorganic pollutants [5].

❖ ***Urbanization***

Because of increased indestructibility, runoff from urbanized surfaces, and increased municipal and industrial discharges, urbanization raises the concentrations of phosphorus in urban catchments. Accordingly, the primary source of stream damage is urbanization, which is surpassed only by agriculture. In cities, pollutants such as pesticides, oil, filth, and lawn fertilizers are transported straight to rivers and streams. While these contaminants are held in soil pores in natural landscapes, they are washed away into water bodies in urban areas, resulting in water contamination. Storm water's rapid flow also erodes sediment from bodies of water, which adds to the pollution of the water [6].

❖ ***Industrial Wastes***

Water pollution is caused by industrial waste from companies like steel and paper that are located near riverbanks. This trash includes chemicals, acids, alkalis, and dyes. As effluents, fluoride, ammonia, cyanide, and chromium salts are released into water bodies by chemical firms that produce aluminum. These dangerous substances have corrosive, ignitable, poisonous, and reactive properties. They might be solid, liquid, or gaseous. Unlike sewage treatment plants, they can only be treated by specialized waste treatment plants [7].

❖ ***Agro-chemical Wastes***

Water logging and wasteful flood irrigation are caused by the agricultural sector's frequent subsidies of electricity and water for irrigation. Water loss from seepage and breaches is another way that poor agricultural practices contribute to water pollution. Pesticides and fertilizers are examples of agro-chemical wastes that contribute to pollution by direct spraying, drifting, and surface runoff. Through t food chain, these substances can also get to people, causing bio magnification. Fertilizers, pesticides, and degraded soil are common in rural regions and contribute to eutrophication in freshwater bodies. Oceanic wildlife suffers from dissolved oxygen deprivation brought on by nitrogen-rich fertilizer chemicals. Furthermore, irrigation practices cause heavy metals like selenium to build up in soil, which can be harmful to both humans and animals [8].

❖ ***Nutrient enrichment***

Both natural and man-made sources of nutrients can be found in surface water. Because production and consumption are balanced, natural resources help to reduce pollution. Waste from homes, businesses, and agriculture are examples of anthropogenic sources. There is a substantial correlation between human land use & disturbance gradients and concentration of nutrients in streams and rivers. The primary source of nitrogen in rivers and streams is nitrogen fertilizer. There is greater regional and temporal diversity in nonpoint sources such urban runoff, livestock, & crop fertilizers [9].

❖ ***Bacteria and Pesticides***

Bacteria and pesticides are examples of pathogens that contaminate drinking water and cause sickness. Water contamination is detected by coliform bacteria. Water contamination is also a result of herbicides and insecticides used to eradicate weeds and other pests. Ground water and natural water bodies are contaminated by leaching from these materials, which is impacted by soil texture, pesticide characteristics, irrigation, and precipitation [10].

3. 10 Most Affected Cities Worldwide of Water Pollution

3.1. Dhaka-Bangladesh

Over 180 million people live in Bangladesh, a South Asian country that is experiencing environmental problems because of fast urbanization, industrialization, and digitization. The arsenopyrite mineral, which is 70 times greater than the permissible limit, is the main source of arsenic contamination in the nation's water bodies. 60% of rural residents lack access to sanitary facilities, making sanitation problems a significant contributor to water contamination [11]. Only 15% to 20% of the city's population is served by the Dhaka Water and Sewerage Authority, and solid waste management systems are unable to cope with the enormous amount of trash produced in urban areas. Surface water is being contaminated by industrial pollution, especially from Dhaka, Chittagong, Khulna, and Bogra. Dhaka and adjacent districts have biggest victims of unregulated industrialization, resulting in serious water quality problems [12]. Illegal discharge of unprocessed effluents from several industrial sectors around those rivers contaminates the water.

Many textile manufacturing and dyeing sectors dump huge amounts of industrial effluents into several waterways, which eventually reach the Shitalakshya River. Nearly 80% of overall industries lack treatment plants, dumping untreated harmful effluents into water ways. Increased industrialization, unsustainable farming methods, ongoing urban wastewater dumping, and needless traffic are all contributing factors to heavy-metal contamination, which is a major worldwide concern [13]. Because of aquaculture, this pollution significantly jeopardizes human health, the environment, and water quality. By lowering pollution, banning dumping, minimizing the release of hazardous chemicals and materials, cutting the percentage of untreated wastewater in half, and significantly increasing recycling and safe reuse worldwide, the Sustainable Development Goals

(SDGs) and UN Agenda 2030 seek to improve water quality.

Since 2017, tanneries in Bangladesh have been compelled to relocate to leather industry estates in Savar, with the Buriganga and Turag rivers serving as the primary recipients of industrial wastewater [14]. Only one-third of the tanneries have relocated, though, and wastewater is still being dumped into these waterways. Persistence, accumulation, and bioaccumulation of heavy metals make them toxic to living things. For evaluating general condition of the aquatic ecosystem, sediment analysis is crucial. Seasonal variations in heavy-metal concentrations are caused by physiological factors such temperature, precipitation, runoff, and flush out. Crops cultivated along riverbanks may be seriously threatened by irrigation with tainted water. In order to better understand correlation between contamination and health risks, study examined the seasonal variability of heavy metals in aquatic environment and comparative assessment of heavy metal concentrations that leached out into nearby rivers from Dhaka city's textile and leather industrial areas.

3.2. New Delhi-India

Seventy percent of the surface water in India, the second most populous country in the world, is unfit for human use due to severe water pollution. Domestic, agricultural, and industrial wastes are the main causes of the excessive pollution found in about 80% of India's water bodies. 229 million people lack proper sanitation, and about 91 million people lack access to clean water [15]. Only 10% of wastewater in India is treated, and 70% is left untreated, contributing to the country's poisonous water due to urbanization. Leaching fluoride, arsenic, nitrates, iron, heavy metals, and residues from fertilizers and pesticides severely contaminate groundwater supplies. Burning coal and open stools are two factors that pollute water [16]. In India, the Ganges River is a significant source of pollution, producing 33% of the nation's wastewater. The most polluting cities include Kolkata, Patna, Bhagalpur, and Kanpur; industrial centers like Kanpur are accountable for 18% of all water pollution. Water hyacinths, weeds, and inadequate sewage treatment systems have blocked Delhi's Yamuna River. Around 80% of total water pollution is in Delhi.

Over 70% of Delhi's water supply comes from the Yamuna River, which bears 80% of the pollution load [17]. Heavy metals like lead, chromium, arsenic, and cadmium are a serious problem due to their toxicity, endurance, and bioaccumulation. Only a few criteria have been identified for assessing contamination in the Delhi stretch, and the distribution of heavy metals in relation to nutrients, main ion concentrations, and other physicochemical characteristics has not been systematically studied in the area [18]. To protect water resources and avoid overexploitation, contamination from point sources, such as wastewater, must be avoided. 72% of India's urban population lives in class I and class II cities, and 70-80% of the water supplied for domestic use ends up as wastewater. Delhi is home to 36 sewage treatment plants, but less than half of the total sewage is being collected and cleaned. The two most popular technologies in Class I and Class II cities are the activated sludge process (ASP) and up-flow anaerobic sludge blanket (UASB).

Waste stabilization ponds (WSP) have a total capacity of 5.6%, but only 28% of these plants use waste stabilization ponds. Delhi's wastewater is extremely contaminated, containing biological, inorganic, organic pollutants and colorful materials. To solve these problems, an effective mix of primary, secondary, and tertiary treatment solutions is required. Marine pollution, a major global environmental concern, impacts rivers, coastal areas, and marine habitats by fertilizer input, oil spills, toxic contaminants, and untreated urban and industrial effluent [19]. Understanding origin, distribution, fate, and behavior of pollutants is crucial for developing a workable management plan for preservation of aquatic resources. In recent decades, industrial processing facilities have provided a significant number of hazardous compounds to untreated municipal and industrial wastewater received by Karachi Coast, especially Manora Channel. Controlling marine pollution is essential to prevent ocean extinctions, depletion of current fisheries and marine resources [20].

3.3. Karachi-Pakistan

With a population of 243 million, Pakistan is a South Asian nation that is experiencing water pollution as a result of poor management systems, fast urbanization and industry, domestic sewage, and population increase [21]. With a projected 275 million people living there by 2050, the country's urbanization has increased domestic water consumption. Microbes, inorganic materials, cations and anions, radioactive materials that dissolve in water, oil, insecticides, and pesticides are examples of pollutants found in water [22]. About 87,000 tons of solid garbage is produced daily in urban areas, and there are serious issues with water contamination in major cities including Karachi, Lahore, Faisalabad, Rawalpindi, Peshawar, Gujarat, and Sialkot. The largest cities in the country are primary producers of industrial effluent, and the extensive use of agrochemicals in agriculture is another important cause of water contamination. The main causes of Pakistan's many water pollution-related public health problems are microbial and chemical pollution [23].

About 70 thousand tons of pesticides are produced in the nation each year, and this amount is rising at a rate of roughly 6% per year. In order to maintain safe conditions for cooking, bathing, and drinking, water sanitation is essential. Approximately one in four people on the planet do not have access to drinkable water as of 2020. 70% of Pakistani homes consume tainted water, with rural & urban areas experiencing different levels of contamination. Up to 91% of the drinking water in Karachi is hazardous to drink, compared to 62% in 29 other major Pakistani cities that were tested. In Pakistan, 40% of fatalities and 50% of all infections caused by poor water sanitation, which is concerning for a number of reasons [24]. The most common cause of death for infants and children is diarrhea, a watery illness. Water contaminated by industrial and municipal sewage at different water distribution networks is the main source of waterborne illnesses. High rates of water pollution are a result of treatment plants' ineffective and occasionally nonexistent water disinfection and quality monitoring.

Pre-existing health burdens in Karachi are predicted to worsen due to the city’s administrative dysfunction and the expanding population needs. Raising awareness of Karachi, Pakistan's inadequate sanitation standards and practices, as well as ongoing initiatives to improve water sanitation, is goal. Inadequate water sanitation in Karachi is the result of several causes, such as inadequate infrastructure management and inept municipal officials. Significant obstacles to

Karachi's water sanitation services include inadequate infrastructure, population growth, government corruption, leaks, poor management, and a lack of long-term planning [25]. An increasing population and poor sanitation have resulted in negative health effects, including a rise in spread of rotavirus, malaria, and typhoid fever. To solve these problems and protect health of its residents, Karachi's sanitation services urgently need to be improved [26].

3.4. Jarakata-Indonesia

A country's health and the sustainability of its environment depend heavily on its access to water and sanitation. The management of water and sanitation is a major concern for Indonesia because of its varied terrain and expanding population. Peri-urban, rural, and isolated areas frequently struggle to find supplies of safe drinking water and sanitary facilities, and access to clean water is still a major problem. Rapid urbanization, population expansion, and climate change are changing way water resources managed, making sewage systems, sanitation services, and wastewater management more important than ever. Inadequate sanitation facilities and contamination of water sources can affect aquatic ecosystems and public health. Although there have been notable improvements in water and sanitation conditions in Indonesia since 2000, issues including access to drinking water and poor sanitation persist. Demands for equitable and sustainable water solutions. Urban water pollution is a serious problem, especially in places with inadequate wastewater treatment. The rapidly expanding megacity of Jakarta, Indonesia, has poor water quality as a result of pollution and inadequate wastewater treatment [27].

With the overall goal of providing resources to improve water quality through the designation of water usage, the establishment of criteria to protect water resources, and the development of water quality management plans, this study employs spatiotemporal trend analysis of water quality to generate an overview of water quality for Jakarta [28]. Data on urban growth, statistical analysis to spot trends in urban water quality and conditions, evaluation of assessments to comprehend the urban water environment and pinpoint the causes of water pollution issues, and recommendations for sustainable water and environmental management are all part of research process for Jakarta's urban water quality assessment. The Ministry of Public Works, the Local Government of Jakarta Province, the Ministry of Environment and Forestry, and government of DKI Jakarta Province provided secondary data on water quality [29]. The Indonesian Institute of Sciences (LIPI) and Statistics Indonesia provided the socioeconomic statistics. Three water quality metrics are examined in this study: total suspended solids (TSS), dissolved oxygen (DO), and biochemical oxygen demand (BOD). Strategies will result from an understanding of Jakarta's water conditions. Strategies for future urban water management in Jakarta and elsewhere will result from an understanding of the city's water conditions.

3.5. Cairo-Egypt

Egypt is facing an increasing problem of water pollution as a result of home waste, industrial effluents, and overuse of pesticides and fertilizers in agriculture. One of the main causes of this issue is Egypt's primary water source, the Nile River. Because of their toxicity, abundance, ubiquity, ability for bioaccumulation, and resistance to breakdown, heavy metals build up in sediments, water, and biotic elements like fish and aquatic plants. The health of people, plants, animals, and ecosystems are all seriously threatened by these toxins [30]. River sediments may be cause of metal buildup in aquatic food chain as a result of bio magnification process. For a brief time, these metals can be retained in sediment before being released into water and harming aquatic life. Through processes of sorption, precipitation, and dissolution, variables including temperature, pH, and dissolved oxygen levels regulate the destiny of metals. Because of their quick development and large biomass output, aquatic plants are essential for removing metals and nutrients from the environment. They also have a high potential for remediation. Comparing concentrations b/w plants and environment is challenging, though, because exposure to metals in both water and sediments may cause bio concentration of metals in macrophytes.

Because of worries about their buildup and harmful effects on aquatic life and humans, research on heavy metals in aquatic environments is essential. Concerns over freshwater quality are widespread, especially in Egypt's Nile River, which serves as the main source of freshwater for agriculture and drinking. Over time, anthropogenic inputs and untreated effluents have caused the water quality of the Nile River to decline [31]. The physical, chemical, and biological characteristics of the downstream Nile water have been profoundly altered by the construction of the Aswan High Dam (AHD). Poor drainage and sewerage systems, as well as the growth of industrial, agricultural, and recreational activities, have all led to the deterioration of Nile water. Until it reaches the Delta, the water quality released from AHD deteriorates, although it stays comparatively clean. Untreated sewage from open sewers carrying sewage, industrial wastewater, and agricultural return flows are major causes of contamination. The primary contaminants in Nile River are heavy metals, which are mostly produced by human activity. Evaluating the water quality is essential to determining whether using Nile water for drinking and aquatic life is feasible [32]. Using indicators of water quality (WQI), heavy metal pollution (HPI), and contamination (Cd), this study sought to assess the present state of the Nile River's water quality from Aswan to Cairo.

3.6. Mexico City-Mexico

Mexico City, a megacity with a population of 9 million, is located in the Basin of Mexico and has a population of 22 million. It was self-sufficient in water in the past but now extracts 70% from regional aquifers and imports 30%. Groundwater is the main water source for Mexico City, but its quality is increasingly threatened. This study aimed to determine water quality in areas related to seismic fractures, which may increase vulnerability of water provision and identify specific zones that could be affected. Official water quality data from 2002 to 2017 was analyzed and compared to recent data taken in wells in the city after the September 2017 earthquake. The results showed that free chlorine was below the limits according to the Mexican regulatory framework, while the presence of fecal coliforms, aluminum, ammonia, iron, and manganese exceeded the standards [33]. Clusters show specific parameters that increase with time: turbidity, sulfates, nitrates, arsenic, manganese, lead, and iron. These tendencies could imply the deterioration of

groundwater quality and a potential effect on the health of the exposed population.

Spatially, vulnerability was observed in Iztapalapa, Tláhuac, Xochimilco, and Coyoacán. Wells coincide spatially with some of the geologically damaged areas from the earthquakes in Iztapalapa and Xochimilco. Water quality represents a challenge for the urban future, as water disinfection systems are limited to treating the diversity of compounds detected. According to the Mexican regulatory framework, the results indicated that free chlorine was below the requirements, but fecal coliforms, aluminum, ammonia, iron, and manganese levels were higher than required. Turbidity, sulfates, nitrates, arsenic, manganese, lead, and iron are among the factors that clusters display and that rise over time. These patterns can indicate that the quality of the groundwater is declining, and that exposed population's health may be impacted. Vulnerability noted geographically in Coyoacán, Xochimilco, Tláhuac, & Iztapalapa. In Iztapalapa and Xochimilco, wells are located near some geologically damaged places caused by earthquakes. Since water disinfection technologies can only handle a variety of compounds found, water quality poses a problem for future urban areas. A strategic plan for groundwater system proposed to improve conditions toward a more equitable and sustainable pathway for Mexico City [34].

3.7. Beijing-China

Due to economic growth, urbanization, and industrialization, China—the most populous nation in the world—faces serious environmental degradation. With 40% of China's rivers classified as severely dirty and 80% of its lakes deemed eutrophic, the country experiences an average of 40 billion tons of water shortages per year. Untreated wastewater disposal is causing China's surface and groundwater to deteriorate, which is causing ecological degradation and a decrease in the efficiency of water sources [35]. The primary sources of water contamination are household garbage and industrial effluents. According to the Ministry of Water Resources, 73.1 billion tons of wastewater were released throughout China in 2006. Class V is the lowest class of China's National Water Quality Standard, and the water quality in 81.6% of rivers, 25% of lakes, 87.3% of reservoirs, and 23.9% of shallow groundwater is below it. China's capital, Beijing, has serious water problems, including land subsidence, groundwater depletion, droughts, floods, and water pollution.

Sources of drinking water for the city include surface water, ground water, reclaimed water, and South-to-North Transferred water. With almost 40% of surface water classified as Grade IV or worse, water quality is the most concerning issue. Beijing's groundwater quality is either very bad or poor, and organic and nitrate pollutants are frequently found. Although 22% of the residential water supply comes from the South-North Water Transfer Project, the main sources of drinking water are groundwater and surface water from the Guanting and Miyun Aquifers. The low rates of tap water use are caused by issues with programming, technology, and legislation. Centuries-old distribution pipelines, a lack of legally binding regulations, and a dearth of programming initiatives aimed at informing the public about the true cost of the water system or fostering confidence in the purity of tap water are examples of technical obstacles. Three interconnected approaches are suggested to remedy Beijing's tap water quality problem: 1) rising tap water use overall, and 2) rising proportion of households that consume unfiltered water straight from the faucet.

Only three presumptions would make these tactics possible: a centralized government with dispersed responsibilities; financial limitations on local governments; infrastructure upgrade investments; and the ability of the treatment plant to treat water of standard quality. Because of excessive groundwater use and decreasing rainfall, Beijing, the capital of China, has acute water scarcity and flooding. Because of pollution, the Yongding watercourse, the city's principal watercourse, has been abandoned. In an attempt to reduce domestic water demand, water charges have risen, but results have been mixed. The city is encouraging water reclamation and using new water sources, including 300 small decentralized plants and 15 central municipal wastewater treatment plants [36].

3.8. Lagos-Nigeria

The most populous country in Africa, Nigeria, is home to several bodies of water that are used for domestic, agricultural, recreational, transit, and industrial reasons. However, approximately 66.3 million people lack access to clean drinking water due to the unrestricted disposal of untreated effluents into these bodies, which is seriously polluting the water supply. Heavy metals, phosphates, oil and grease, nitrates, and chlorides are among the pollutants found in untreated effluents. Numerous locations have been impacted by this poor water quality, endangering public health. While rural regions continue to have poor water quality, metro politan areas have seen improvements. Water contamination is caused by industrial operations including mining, oil drilling, home and agricultural activities, and commercial slaughterhouses and abattoirs. The primary source of surface water contamination is the direct and indirect release of industrial effluents from tanneries.

Industrial effluents from tanneries, textile mills, breweries, oil refineries, and gas companies are the primary source of surface water contamination, both directly and indirectly [37]. Nigeria's abundant mineral resources have also contaminated waterways; the Oika, Eriper, and Justice Ibidapo rivers in Osun state have high levels of heavy metals as a result of gold mining operations. Since most communities have an abattoir, slaughterhouse effluents also have an impact on water quality. When municipal waste with a high microbiological load is occasionally thrown into water bodies in urban areas, domestic sewage and effluents contribute to the decline of water quality. In Nigeria, open defecation of municipal waste is still widespread, and the widespread use of tainted water as a result of inadequate funding for proper treatment is predicted to raise the rates of environmental degradation and water-borne illnesses. Although groundwater is becoming a more valuable resource globally, it is less vulnerable to pollution and contamination than surface water sources.

Additionally, naturally existing sources including soil and geologic formations with significant concentrations of heavy metals can contaminate it. Because it is difficult to clean up groundwater pollution from industrial effluents, municipal wastewater, and industrial clusters in Nigeria, prevention is essential. There are ponds, marshes, and a large river spread across 1.71 km2 of dry and wet ground at the Majidun Community in Ikorodu, Lagos State [38]. Even for

summer living, the quality of surface and groundwater is insufficient, and it is deteriorating as a result of careless water resource use, dehumanizing organizations, industrialization, and other advanced activities. The uncontrolled release of solid debris and untreated wastewater into the Ibese River in Lagos State, Nigeria, is posing serious ecological and environmental problems. According to research, aquatic ecology, downstream user groups' health, and their cultural, religious, and aesthetic values are all impacted regionally by declining water quality [39].

3.9. Manila-Philippines

The goal of this study is to comprehend the intricacies of urban environmental and water challenges in a densely populated region such as Metro Manila, Philippines. Metro Manila, which is home to more than 11.8 million people, has environmental challenges including flooding, solid waste management, air and water pollution, and climate change. By creating databases, policy tools, and modeling the impact of optimal land use and water treatment facilities, the Water and Urban Initiative (WUI) Project, a research program of the United Nations-Institute for Advanced Study of Sustainability (UNU-IAS) with funding from the Japanese Ministry of Environment, seeks to improve urban water environments in developing Asian cities. Study focuses on reducing the risk to human health, protecting ecosystems, and reducing likelihood of environmental disasters, especially floods [40]. Metro Manila is one of four emerging Asian cities where the project is being carried out. The study's main objectives are data collecting, literature research, and data analysis for the creation of databases, models, & policy tools.

The Marikina, San Juan, Parañaque, and Pasig rivers are the four river systems that define Metro Manila's water condition. These systems are categorized as Class C water bodies, which are used for manufacturing, fishing, and non-contact recreation. Their water quality is severely contaminated, nevertheless, as evidenced by higher-than-normal dissolved oxygen levels and biochemical oxygen demand. With elevated levels of heavy metals and other contaminants, Manila Bay, a Class SB body of water, is likewise severely contaminated. The area gets its water from Bulacan's Angat Dam, and two water concessionaires transport the raw water to homes after filtering it at La Mesa Dam. Air pollution, flooding, and solid waste concerns are some of the environmental challenges caused by urbanization and the existence of informal settlements. Poor ambient air quality has also been caused by the area's rapid growth and growing population; in 2013, total suspended particles exceeded the recommended amount of 90 ug/Ncm.

In the Philippines, more than 20 agencies carry out development and regulatory tasks, making the management and preservation of water resources and the environment complicated. The Pasig River Rehabilitation and Development Program, Manila Bay Coastal Strategy, Adopt-an-Estero Program, Flood Management Master Plan for Metro Manila and Surrounding Areas, Adopt-A-River Project, Environmental Management and Pollution Control, and Water Resources Regulation Program are just a few of the initiatives the government is working on to manage and safeguard the water and urban environment. Relocating households who are informal settlers along the Pasig River, enhancing water quality, and creating linear parks and environmental preservation zones are the goals of these projects. The government also carries out the Adopt-A-River Project, Environmental Management and Pollution Control, Water Resources, and Flood Management Master Plan for Metro Manila and the Surrounding Areas [41].

3.10. Flint, Michigan, USA

The construction of engineering infrastructure has been a hallmark of prosperous cultures throughout history, providing societies with drinkable water. In the United States, community water systems supply tap water to over 286 million people, but only 8% of these systems supply 82% of the population. Flint, Michigan experienced one of the largest public water supply failures in recent history on April 10, 2014. Lead is well-known environmental pollutant associated with lead, which can cause anemia, kidney damage, colic, muscle weakness, and brain damage in children. Exposure to lead during pregnancy can also cause low birth weight, early delivery, fetal mortality, and later-life cognitive decline [42]. Adults working in environments with high levels of lead are more likely to develop peripheral neuropathy, high blood pressure, and cardiovascular death. In November 2011, Michigan replaced Flint's government with an Emergency Manager, but this took away elected officials' sense of accountability, leading to economic-driven decisions that fell short of safeguarding public health and electorate interests. The House Committee on Oversight and Government Reform examined the federal administration of the Safe Drinking Water Act (SDWA) in Flint, Michigan, and concluded that there were failures at all levels of government. The Lead and Copper Rule (LCR) requires first-draw samples taken by community water supply systems for residences with high risk of lead and/or copper contamination. However, Flint's citizens were let down by the government on all fronts, with its ethnic and economic makeup contributing to the crisis's onset, poor response, and disdain for public health. Anecdotes from various cities demonstrate how drinking water rules were not properly implemented and enforced, resulting in drinking water contamination [43].

4. Comparative Analysis of Affected Cities

4.1. Industrialization and Urbanization

Majority of affected cities have experienced speedy ‘industrialization’ and ‘urbanization’ processes, surpassing construction of needed environmental infrastructure. This allowed for large volumes of industrial waste, biological waste, and solid waste to be dumped into rivers, lakes and the seas without being treated. Cities of Dhaka, New Delhi, Karachi, and Beijing suffer because of solid wastes and effluents from textile, chemical & other industries [44].

4.2. Toxic Waste Discharge

In places like Dhaka and Karachi, industries do not go through the required processes to treat toxic waste, and instead discharge it directly into the water resources. These pollutants include metal cadmium, chemical messengers and other organic compounds; all of which contaminate water sources and get biomagnified [45].

4.3. Corruption and Poor Regulation

Water pollution is exacerbated by weak governance, corruption and poor legal enforcement. In many of the affected cities, have legal frameworks for environmental protection but remain largely ineffective. Systems of

corruption governing management of water, lack of political willpower to act and red tape in bureaucracy allow industries and municipalities to act lawlessly. Karachi, Lagos are examples in which, despite existence of regulations skilled at banning dumping of industrial wastes or improper disposal of sewage, there is insufficient implementation of such regulations create conditions for chronic pollution of water sources [46].

4.4. Lack of Infrastructure Development

Inadequate water treatment and waste disposal facilities are not a new thing in most cities. On other hand, there has been a tremendous increase in the production of industrial and domestic wastes while construction of sewage treatment plants and garbage recycling plants has remained stagnant.

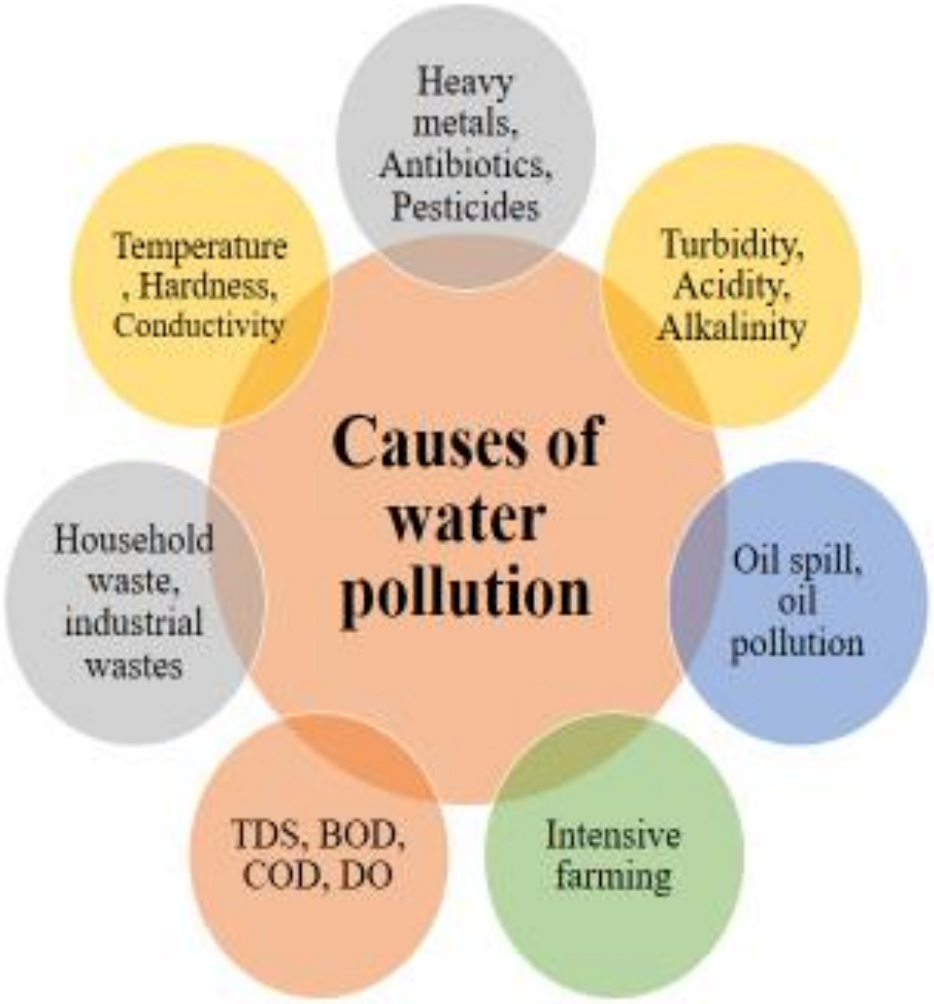

Figure 1: Causes of water pollution

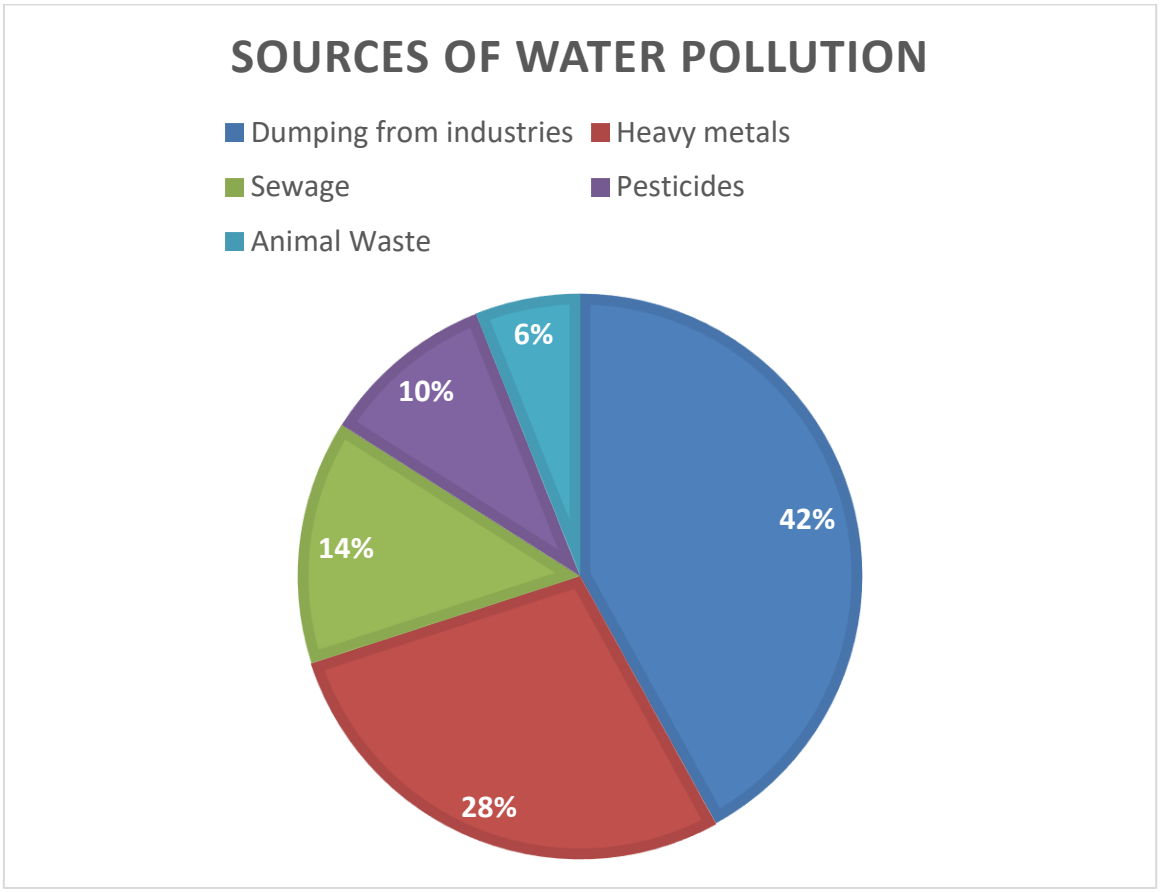

Figure 2: Sources of Water Pollution

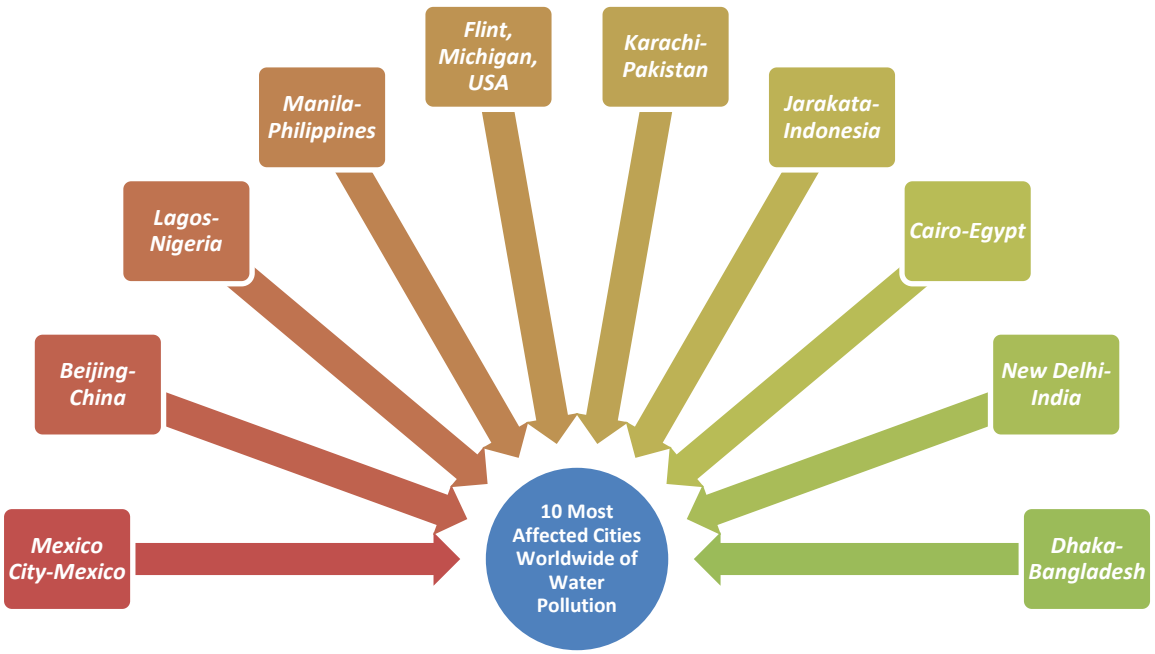

Figure 3: Most Affected Cities Worldwide of Water Pollution

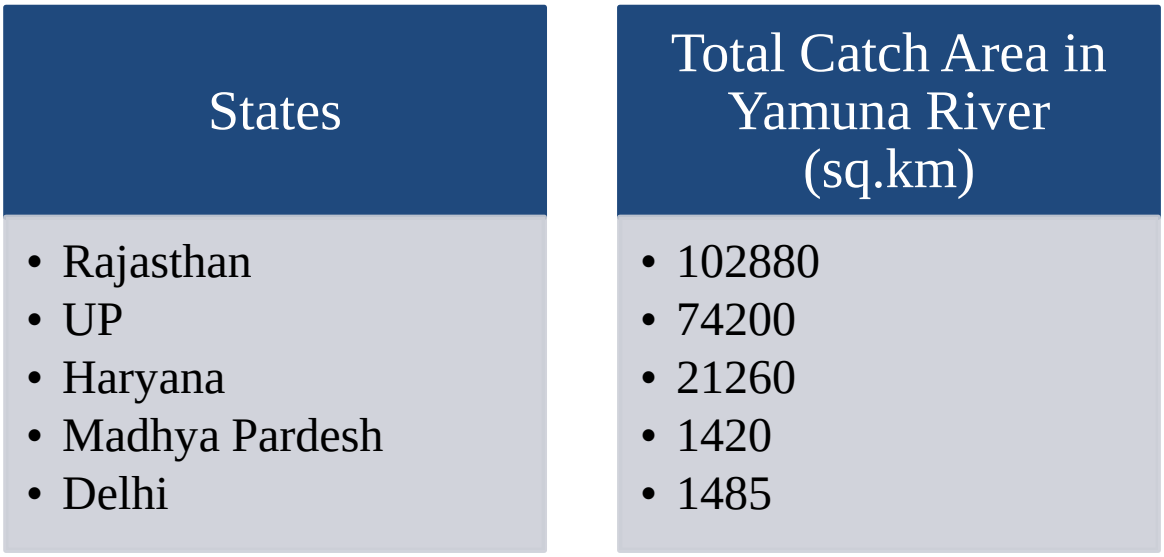

Figure 4. Total Catch Area in Yamuna River (sq.km)

Table 1: Water pollution sources in Bangladesh

Industry	**Water Pollution**
Sugar	Excessive
Leather	Excessive
Paper	Very Large
Textile	Large
Agriculture	Average
Transport	Minor

Table 2. Water Quality parameters according to WHO 2004 Guidelines in Karachi

Water Quality Parameters	**WHO 2004 Guidelines**
pH	6.5-8.5
Color	Colorless
Odor	Odorless
Turbidity	5NTU
Hardness	500

4.5. Coastal Pollution

Due to proximity to ocean and other water bodies, Coastal Cities like Lagos, Jakarta and Karachi have unique problems. In such cities, industrial effluents and unprocessed sewage find a route into the oceans, thereby aggravating pollution in these coastal cities and damaging oceanic resources. Oil slicks and industrial wastes are disposed of in large quantities in Lagos' lakes and rivers, which merge into the Atlantic Ocean. This disadvantage of a coastal location also means that flooding occurs, which carries pollution further towards the land and makes water sources contact the pollution. Another concern is the oil dumped in the Arabian Sea by Karachi's coastal areas which gets exacerbated by shipping operations [47].

4.6. Groundwater Depletion and Contamination

Southern cities including Mexico City, New Delhi, and Cairo suffer from extreme depletion of groundwater resources combined with pollution of those resources as well. Such cities use abundant wells for their water needs as surface resources are inadequate, but not all such extraction is sustainable, which results in depletion of aquifers and most resources being groundwater which is adversely affected by chemicals and biological waste. With development of ground water wells in Mexico City, the city was observed to be subsiding in specific regions while there is over pollution from the untreated domestic sewage water and other industrial effluents making the available water undrinkable [48].

4.7. Flooding and Waterlogging

Flood-prone cities including Jakarta, Dhaka and Manila deal with flooding beyond their typical scales; waterlogging complicates matters because it is an agent of pollution and serves to worsen the pollution of both surface and underground sources. Floods provide a natural pathway for wastage and pollutants to infiltrate and reside within the residential section of the population and the drinking water sources, leading to greater chronic stress index on the population health. 17 million people in Jakarta are the most affected because of the low-lying areas of land as well as the regular flooding within the region during the monsoon period. The heavy rains pose a problem as water rises above the drainage systems and spreads across the city.

4.8. Infrastructure Collapse and Lead Contamination

A distinct concern of lead contamination based on the perforated water management system was experienced in Flint, Michigan. In direct contrast to the other cities that are battling with pollution from industries and sewage, Flint's crisis depends on corruption on the management angle which lead to the intake of an already polluted river as a source of water, and leaching of lead from rusted pipes that were used for water. Flint's population was not prepared for the shift; their water supply system was not designed for such standstill or incapacity so people had to deal with a monumental level of pollution, strain, and health risks for years to come [49].

5. Consequences

5.1. Public Health Crisis

In developed cases, for instance in Karachi, such a scenario as combining industrial waste with non-hygienic drain water untreated has contributed. People residing in New Delhi have serious health implications due to the pollution of the Yamuna River which is the main source of drinking water in many areas of this city. Awfully, Dhaka suffers the same menace with the presence of these toxic and pathogenic elements in the Buriganga River and people suffering from gastrointestinal diseases in high numbers as a result.

5.2. Environmental Degradation

The ecological devastation caused by the pollution of rivers, lakes, and seas is catastrophic. Not only are aquatic ecosystems destroyed, but biodiversity is severely hurt as well. The quality of water bodies is impaired by toxic compounds and heavy metals which sanitized waste only comes to parent which in turn triggers destruction to river-based fisheries and loses of habitation – spaces for marine life like corals. Rivers in Beijing are too polluted and therefore lifeless, whereas fishermen in Cairo are in danger due to the polluted Nile River giving way to agricultural and fishing businesses that are dependent on it. Water pollution of Manila Bay in Manila has decimated a lot of aquatic fauna which hurt their lifestyle as well as the tourism industry as well.

5.3. Economic Costs

Costly economic losses can be traced back to water pollution which includes healthcare expenditures that treat waterborne diseases, low agricultural productivity, destruction of marine habitats and fisheries, and adverse impacts on tourism. Water pollution is a problem that weighs strongly on local councils, the governments and the individuals who often uncontrollably pour money into the bottled water.

6. Prospects

The reduction of water pollution in these cities necessitates the implementation of stringent laws, sophisticated wastewater treatment, efficient waste management, international cooperation, community awareness, technological advancements, and sustained investment in water infrastructure. Techniques including continuous fermentation, cooling water recycling, reducing the dilution of spent wash during anaerobic digestion, and improving boiler efficiency are suggested to reduce water use. In order to protect the environment and promote sustainable development, a program for the monitoring and remediation of these pollutants at the regional and national levels should be started.

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