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Water's Vital Role: Challenges and Consequences of Pollution: A Review

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ABSTRACT

Most of the evolutionary theories suggest that life originated within the water. From origination to now, water has played an important role in living organisms. Earth's 71% of the surface is covered with water. Of the total water present, 97% of the world's water is salty or undrinkable. Water available for drinking is valuable. Freshwater can be reachable for use from rivers, lakes, and groundwater. Water availability per capita is dependent on the population of a country, and it reduces due to an increase in population. Nearly, 163 million Indians don't have access to clean drinking water, and 21% of the communicable diseases are linked to unsafe drinking water. In India, 500 youngsters lose their lives to diarrhea every day. The average annual water availability of any land or country mostly depends on hydro-meteorological and geological aspects.

The increasing population led to an increase in the demand for goods which caused rapid industrialization and is the reason for the production of industrial wastes. This hazardous waste discharge in water bodies without any treatment and management poses a harmful environment to living beings. Hospital waste water mainly contains infectious microbes and pharmaceutical drugs and it is released to municipal wastewater treatment plants without any pre-treatment further, this discharging of the wastewater into water bodies imposes a significant threat to the environment.

These industrial wastes destroy the environment by polluting water, air, and soil. The quantity and quality of wastewater depends on the type of industry, it can contain biodegradable waste such as paper, wool, leather, etc., and non-biodegradable waste such as heavy metals, pesticides, and plastic. Hazardous such as reactive, carcinogenic, and ignitable also releases.

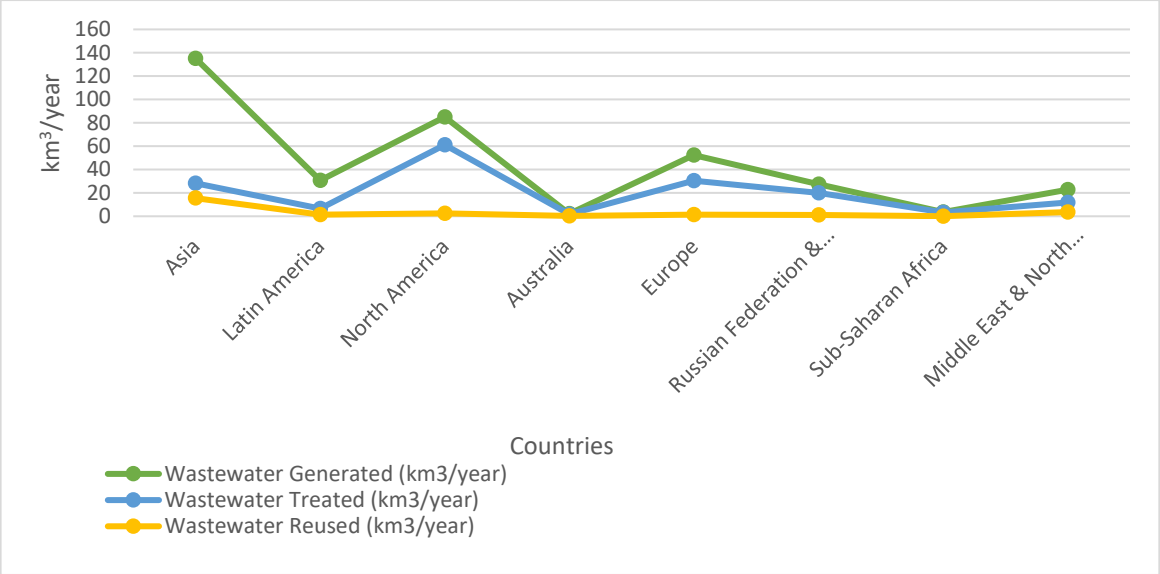
Keywords: environment; water source; census; population; hazardous chemical.

INTRODUCTION

Water is the biggest source of life. The current population of India in 2023 is 1,428,627,663, a 0.81% increase from 2022. According to the Ministry of Jal Shakti, PIB Delhi, the average annual per capita water availability in the years 2001 and 2011 was assessed to be 1486 cubic meters and 1545 cubic meters respectively which would further reduce to 1486 cubic meters in the year 2021 as per projected population projects. Per individual uses about 27% of water for bathing and toilet use. Approximately, a leaking tap can waste 4,000 drops of water, which is equal to a liter of water. A flush of the toilet uses six and a half gallons of water. On average one person wastes about 0-45 liters of water per day. It is 30% of the water requirement per person per day, which means 125 million liters of water are wasted daily. The availability of drinking water in rural areas is also affected by many factors which include, depletion of groundwater lever,

drying up of ponds and wells, deficient rainfall leading to insufficient recharge of water bodies, etc.

Figure 1.: Country-wise statistics of wastewater generated, treated and reused.



Methods and Preliminary results

This systematic review has been carried out through various studies and statistical analysis using various journal databases. The search returned 326 research articles. The data was taken from different literature.

The implication of this study is that water-relevant issues such as scarcity, contamination, and waterborne disease are not just due to increasing population but also an issue of overuse of water, hydro-meteorological and geological factors, failure to properly process the industrial, hospital and domestic wastes contaminate before discharged in water bodies.

Causes of Water pollution

Environmental pollution is one of the foremost problems worldwide. The increasing population increases industrialization. These industrial wastes cause major environmental damage, and pollutants harm the aquatic organisms that live within water bodies. Wastewater is released from various sectors such as hospital wastewater, domestic wastewater, storm run-off, industrial wastewater, and agricultural wastewater. The pollutant released mostly come from industrial dumps, heavy metals, fertilizers, herbicides, chemical waste, and disease-causing bacteria. Due to climatic changes, the incident of floods and droughts has become frequent in many regions of the world. Additionally, a major factor in the reduction of both the amount and quality of drinkable water is the growing contamination of the water caused by different industrial sectors.

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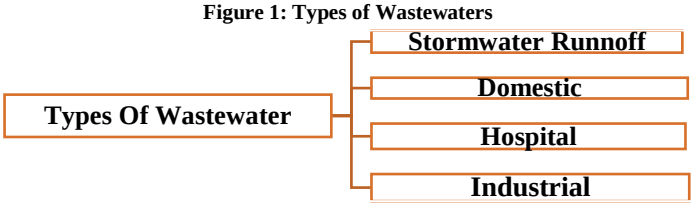
Figure 1: Types of Wastewaters



Types of Wastewaters

Stormwater runoff wastewater

It is one of the leading sources of pollution, which is any natural precipitation that is not absorbed into the ground where it falls. Toxic contaminants like pesticides, plastics, herbicides, chemicals, oils, heavy metals, domestic sewage line overflows, and pathogens get washed off on the streets. Stormwater runoff flows directly or through channeled drains and at last meets the nearby natural waterbodies like ponds, rivers, and streams without any pre-treatment. This contaminated water harms aquatic life as well as is a threat to the environment and all life forms because all are directly or indirectly connected to the natural waterbody for survival.

Domestic wastewater

The wastewater produced by residential settlements such as houses which originated predominantly from toilets, bathrooms, and kitchens known as domestic wastewater. It is the most contaminated water discharged from toilets, baths, washing areas, kitchen dishwashers, and sinks containing urine fecal matter, toilet paper, soaps, and various cleansing chemicals. It is polluted wastewater has a risk of causing diseases and infection.

Hospital wastewater

Water plays a vital role in infection transmission to humans and animals. A diverse mixture of bacteria and active medicinal compounds can be found in hospital effluent. This wastewater is frequently sent untreated to municipal wastewater treatment plants (WWTPs). WWTPs are not able to completely remove persistent pharmaceuticals. Additionally, when there is flooding or a combined sewer overflow, the dangerous wastewater may spread. The possible environmental consequences of medications in water settings are gaining attention on a global scale. Viruses, Antibiotic Resistance Bacteria (ARB), and ARG continue to survive even after the treatment of HWW, and their release to the aquatic ecosystem imposes a significant threat to the environment.

Table 1: Physico-Chemical Parameter of Hospital Wastewater

Sr. No.	Test Parameter	Result	References
1	pH	7.0	(Sackaria& Elango, 2020)
2	TSS	340mg/L	(Nasr &Yazdanbakhsh, 2008)
3	TDS	1970mg/L	(Oliveira, 2018)
4	COD	300mg/L	(Orias & Perrodin, 2013)
5	BOD	85mg/L	(Oliveira, 2018)
6	Fluoride	<0.1mg/L	(Chavhan, 2012)
7	Conductivity	2850µS/cm	(Mubedi et al., 2013)
8	Chloride	240mg/L	(Mazzitelli et al., 2018)
9	DO	6.2mg/L	(Lin et al., 2010)
10	Alkalinity	1194mg/L	(Oliveira, 2018)
11	Hardness (Total)	495mg/L	(Mazzitelli et al., 2018)

Industrial Wastewater:

It is an aqueous discard with dissolved and suspended substances that results from the industrial manufacturing process. The toxicity of discard depends on the type of industry mining industry, steel production, power plants, oil gas fracking plants, food/beverage industry, etc., This discard is contaminated with heavy metals, oil, pesticides, silt, pharmaceutical, and other industrial by-products. It is difficult to treat industrial wastewater as it has toxic chemicals and specific treatment plants are required. It needs to be installed to decontaminate the effluent released from the industry.

As reported by the Ministry of Water Resources about 40 billion cubic meters of water is used in industrial areas of the country which is about 6 percent of the total availability of water. The report from the Central Pollution Control Board (CPCB) of India, about 500 billion cubic meter waters

out of the total available fresh water is used in industries annually.

Table 2: Industrial sectors and their major pollutants

Industry	Major Water Pollutants
Dye Manufacturing	Copper, Colour, Salt, Sulfides, Formaldehydes
Paint Manufacturing	Chromium, Zinc, Lead, Volatile Organic Compounds
Textile	Iron, Chromium, Chlorinated Compounds, Urea, Salts, Hydrogen Peroxide, High Ph NaOH, Surfactants
Pharmaceutical	Cadmium, Nickel, Phenolic Compounds
Petrochemical	Petroleum Hydrocarbons, Phenolic Compounds, Nitrobenzene, Alkanes, Chloro Alkanes, High Salt, *etc.*
Paper And Pulp	Organic And Chlorophenolic Compounds, Suspended Solids, AOX, Lignin, Tannins, Sterols, Colours, Biocides, e*tc.*
Metal Working	PerfluorooctaneSulfonate (PFOS), Ammonium Nitrogen, Cyanide, Phenol, Oil And Grease
Plastic	Perfluorooctanoic Acid (PFOA), Lead, Mercury, Cadmium, Diethylhexyl Phthalate
Agriculture	Fertilizers, Pesticides, Insecticides

Consequences of Water Scarcity

1. Uneven Distribution: India's water resources are unevenly distributed across different regions and seasons. Some areas experience abundant rainfall, while others face prolonged periods of drought. The northern and north-eastern regions generally receive higher rainfall compared to the western and southern parts of the country.
2. Groundwater Depletion: Excessive extraction of groundwater for irrigation, domestic use, and industrial purposes has led to the depletion of groundwater levels in many parts of India. Over-dependence on groundwater, especially in agricultural areas, has contributed to the declining water table.
3. Inadequate Water Infrastructure: The existing water infrastructure in India, including dams, reservoirs, canals, and pipelines, often faces challenges in terms of maintenance, efficiency, and equitable distribution. Insufficient storage capacity, leakages, and inefficient water management systems exacerbate water scarcity issues.
4. Agricultural Water Demand: Agriculture is the largest consumer of water in India, accounting for approximately 80% of total water consumption. Traditional irrigation methods, such as flood irrigation, result in substantial water wastage. Promoting efficient irrigation techniques like drip irrigation can help conserve water in agriculture.
5. Rapid Urbanization: Urban areas in India are experiencing rapid population growth and urbanization, leading to increased water demand. Inadequate infrastructure, including water supply networks, sewage systems, and wastewater treatment plants, often fails to keep up with the growing urban population.
6. Climate Change Impacts: Climate change has further aggravated water scarcity issues in India. Erratic rainfall patterns, extended droughts, and increased frequency of extreme weather events like floods and cyclones disrupt the availability and distribution of water resources.
7. Water Quality Challenges: In addition to water scarcity, India also faces water quality challenges. Polluted water sources, including rivers and groundwater, pose significant health risks to the population. Lack of proper sanitation and inadequate wastewater treatment exacerbate water pollution concerns.

Water Management and Policies

1. Water Conservation: Promote water conservation practices at individual, community, and institutional levels. This can include measures such as fixing leakages, using water-efficient appliances, promoting rainwater harvesting, and implementing water reuse and recycling systems.
2. Efficient Irrigation Techniques: Encourage the adoption of efficient irrigation techniques such as drip irrigation, sprinkler irrigation, and precision farming. These methods reduce water wastage and improve

irrigation efficiency, allowing farmers to achieve higher crop yields with less water.

3. Modernize Water Infrastructure: Invest in upgrading and modernizing water infrastructure, including storage facilities, canals, pipelines, and treatment plants. This will help improve water distribution and reduce losses due to leakage and evaporation.
4. Groundwater Management: Implement effective groundwater management practices to prevent over-extraction and depletion. This can include measures like regulating the drilling of bore wells, promoting artificial recharge of aquifers, and encouraging farmers to shift to less water-intensive crops.
5. Rainwater Harvesting: Promote rainwater harvesting techniques on a larger scale. Encourage the construction of rainwater harvesting structures in urban areas, such as rooftop harvesting systems, and promote community-based rainwater harvesting in rural areas.
6. Watershed Management: Implement integrated watershed management programs that focus on conserving and rejuvenating natural water bodies, restoring and maintaining the ecological balance, and promoting sustainable agricultural practices within the watershed.
7. Public Awareness and Education: Conduct public awareness campaigns to educate people about the importance of water conservation, efficient water use, and the impact of their actions on water resources. Encourage schools, colleges, and community organizations to include water conservation in their curriculum and activities.
8. Policy and Governance: Strengthen water governance and policy frameworks to ensure efficient and equitable water allocation, monitoring, and regulation. Encourage the participation of local communities and stakeholders in decision-making processes related to water management.
9. Climate Change Adaptation: Develop and implement climate change adaptation strategies to mitigate the impacts of changing rainfall patterns and extreme weather events. This can include promoting climate-resilient agriculture, implementing water-efficient technologies, and integrating climate change considerations into water management plans.
10. Industry and Wastewater Management: Encourage industries to adopt water-efficient technologies and implement proper wastewater treatment and recycling systems. This will help reduce water pollution and ensure the efficient use of water resources.

Case Studies

Watershed Management in Ralegan Siddhi

Ralegan Siddhi's watershed development project has turned the village from a water-stressed, economically backward region to a sustainable and thriving community. The initiative has not only improved the villagers' quality of life through effective water conservation methods, afforestation, and agricultural developments, but it has also acted as a model for other places suffering similar issues. The project's success emphasizes the necessity of community involvement, innovative solutions, and long-term planning in attaining sustainable development [5].

Tarun Bharat Sangh's Water Harvesting Structures in Alwar

India is dealing with a volatile water situation. Already, 15% of aquifers are in critical condition, with that figure expected to rise to a scary 60% by 2030. Climate change appears to be increasing the variability of already extremely variable rainfall patterns, necessitating efforts to manage both scarcity and floods. People who live in areas with varying rainfall will continue to benefit from integrated water resource management. The planned, coordinated, and sustainable use of water

resources, agricultural resources, grazing pastures, and forests constitutes integrated natural resource management. Assured water supply leads to enhanced crop productivity, which leads to food security and poverty alleviation. In Alwar district, Rajasthan, India, 8600 small water harvesting johads in 1086 villages have been established [11].

SujalamSufalam Water Conservation Scheme in Gujarat

The goal of the SujalamSufalam Jal Sanchay Scheme was to conserve traditional water resources, deepen around 13,000 ponds, and check dams. This SujalamSufalam Water Yojana aimed to increase rainwater storage capacity by 11,000 lakh square feet. More than 4000 JCB Hitachi machines were to be used for soil excavation for the SujlamSuflam Jal Sanchay Abhiyan. In addition, around 8,000 additional tractors and dumpers were to be used for this purpose. All of the fertile soil that resulted from the deepening of ponds and check dams was to be distributed to the common population for free. The major goal of this effort was to revitalize 32 rivers totaling 340 kilometers in 30 day (Pattan AD, 2022) s.

Traditional Water Management Systems in Kuttanad, Kerala

Kerala receives a lot of rain, with an average annual rainfall of 3000 mm obtained throughout the northeast and southwest monsoon seasons spread out across 106 wet days. Due to Kerala's physiographic configuration and very little recharge, the state is experiencing significant water scarcity during the lean season (March to May). Other prevalent difficulties in Kerala State include a decrease in the depth of the water level, the drying up of dug wells, and water salinity in the coastal areas due to the tidal effect. Due to the steep slope towards the Laccadive Sea in the western section of this little state, salt water has not been observed in any of the locations in Kerala State. People in Kerala State have increasingly adopted various sorts of artificial recharge methods, traditional rainwater collection, and water conservation techniques for the sustainability of water resources in order to circumvent the numerous challenges faced by the people in the water sector. The current concept paper also briefly examines tanks and ponds, particularly temple ponds, holy groves, and surangams, the significance of coconut and areca nut bases in water conservation and the simplest traditional rainwater collection systems [12].

CONCLUSION

It has been observed that decreasing water availability is inversely proportional to increasing population. A viable solution to the problem is to practice water conservation and wastewater management. This would definitely decrease the use of natural water resources and maintain the natural availability of naturally available water.

Table 3.: Articles and Findings

Sr. no.	Articles	Findings
1.	Efficient Wastewater Management for Sustainable Development: Challenges and Prospects an Indian Scenario	Better wastewater treatment technology, as proposed in this review, might provide a solution for developing nations with poor economies; the treatment methods are both cost-effective and effective. A feasible solution to this problem would be to improve wastewater management systems, which would allow treated wastewater to be used for irrigation, gardening, and other industrial applications.
2.	Anthropogenic impacts on lake and stream ecosystems, and approaches to restoration	The works in this profile highlight Ormerod's (2003) conclusion in an earlier special profile in the Journal of Applied Ecology that "restoration ecology is emerging as one of the most important disciplines in the entire field of environmental science". Freshwater ecosystem management has several obstacles, and applied freshwater ecology research will continue to be a hot issue in the future.
3.	Review on Waste Water Treatment Technologies	This study provides an overview of the many methods for wastewater treatment, recovery, and reuse. Environmental managers are showing a lot of interest in natural treatment solutions. Natural treatment technologies are considered viable due to their low capital costs, ease of maintenance, potential longer life cycles, and ability to recover a variety of resources such as treated effluent for irrigation, organic humus for soil amendment, and energy in the form of biogas.

4.	Drought in India: Its impact and mitigation strategies – A review	Drought is defined as a region with annual average rainfall that is less than 50-75% of the usual south-west (S-W) monsoon rains. The main occurrence of agricultural drought in India is the delayed onset of S-W monsoon rains or early retreating of monsoon rains towards half-way through the season or extended intervals between two heavy and effective rains during the rainy season. The India Meteorological Department (IMD) forecasts the monsoon status (poor or normal) for each state/region three to four months in advance. The nature, consequences, and mitigation techniques of recent agricultural droughts in India are discussed in this article.
5.	Perspectives on a Water Resource Policy for India	Water legislation in India remains non-uniform, inconsistent, and insufficient to deal with today's complicated water situation, which is characterized by scarcity and depletion of this renewable but limited resource, as well as growing demand. A business-as-usual (BAU) strategy will not be able to bridge the supply-demand imbalance.
6.	Impending water crisis in India and comparing clean water standards among developing and developed nations	This essay provides a general overview of the problems related to India's water scarcity as well as a comparison of rich and developing countries' standards for safe drinking water.

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