
Water Pollution Control Measures: A Review of Policies and Practices

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Abstract

This review discusses the water pollution in India with reference to its causes, impact and control measures in the form of policies and practices. Rapid urbanization and industrialization, agricultural runoff and poor wastewater treatment have seriously impaired groundwater and surface water quality, threatens to public health and ecosystems and economic development. The study reviews some of the major sources of water pollution and highlights some of the key legislative frameworks (Water Act, Environment Protection Act, and recent policy reforms). It also talks about practical interventions such as effluent treatment, sewage management, monitoring systems and community participation, which emphasizes the need for integrated and sustainable approaches to water pollution control.

Keywords; Contamination, Health Problems, Agricultural and Industrial Wastes, Wastewater, Industrial Effluent Management, Wastewater Treatment

1 INTRODUCTION

In India, rivers are much more than simply waterways. Most Hindus believe that Indian rivers are holy, have the power to atone for sins, and help people become closer to God. Despite their apparent purity, the rivers are contaminated because they are used as disposal sites for solid, industrial, and sewage waste. Every day, more than 10.5 million gallons of wastewater find their

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way into India's rivers and other waterways. Water poisoning has posed a major danger to India's economy and society. Recent research suggests that in developing countries like India, pollution upstream might slow economic growth downstream by more than half a percentage point [1]. Numerous reasons have been identified as the cause of water pollution in India. Income, population, urbanization, illiteracy, lack of democracy, and corruption are socioeconomic variables that are typically thought to have an influence on water pollution in India [2].

Degraded water that is hazardous to humans or the environment is known as water pollution. It occurs when dangerous synthetic substances, bacteria, or occasionally just garbage or a lot of residue contaminate a lake, stream, river, wetland, groundwater spring, sea, or any other type of waterway [3]. Because it lowers oxygen levels and changes the species that can survive there, often welcoming non-local species attack, altering the natural pecking order, and consistently reducing species biodiversity, anthropogenic warm contrasts caused by the direct release of high temperature water from power plants and industrial facilities into an untamed water source are also considered water contamination [4]. With its sewage, trash, animal corpses, and discarded food, the holy Ganges River is the most polluted river in the world. Unchecked urbanization is the primary cause of water contamination in India. In this context, wastewater treatment and disposal have also been significant problems. Numerous villages and cities have emerged in the vicinity of rivers, which has further increased the severity of the issues [5]. Sewage water production has also resulted from unchecked urbanization in certain locations. Urban waterbodies including rivers, lakes, streams, wells, and ponds provide water for both residential and commercial uses. Even worse, 80% of the water we consume at home ends up as effluent. The majority of the time, this water is improperly handled, which severely contaminates freshwater at the surface [6].

Impacts of Water Pollution

One element that is commonly available and essential to existence is water. People greatly benefit from groundwater, which is a highly important resource. However, the previous year's high levels of ground water contamination were caused by hazardous compounds emitted from landfills, industry, and non-point sources of pollution including fertilizer and pesticides [7]. Therefore, it is crucial to evaluate the water quality for both its present use and its potential to become a sustainable supply of water for human use. In urban areas, population growth exacerbates water pollution. Waste from homes, farms, and industries is the primary source of toxins in aquatic ecosystems. Sewage is the biggest contaminant when it is disposed of in freshwater bodies. The biggest and greatest source of water pollution in civilization is sewage, and the amount of untreated sewage that is dumped into rivers is enormous [8]. Serious health

issues such as bronchiectasis, arsenicosis, hyperkeratosis, skin, lung, kidney, and bladder cancer are brought on by prolonged exposure to groundwater tainted with arsenic. Since the main source of arsenic in groundwater is geogenic processes, the geometry and properties of the local aquifer are closely related to the level of contamination [9], [10]. Cadmium and arsenic can enter the human food chain through fish tissues that have accumulated from tainted river water. Regular water quality monitoring is necessary to find an efficient, reasonably priced, and ecologically acceptable solution to heavy metal pollution. Assessing the risks to human health in areas with high uranium prevalence, creating efficient remediation technologies, and—above all—implementing preventative management techniques are all necessary to address this problem [11].

Causes of Water Pollution

- **Agriculture and Nutrient Pollution:** Globally, agriculture is the primary driver of water degradation. Rainfall brings nutrients and diseases like bacteria and viruses into our rivers, along with pesticides, fertilizers, and animal waste from livestock and agricultural operations. Globally, the most significant threat to water quality is nutrient pollution, primarily resulting from excessive nitrogen and phosphorus levels in the environment. Algal blooms, toxic soups of blue-green algae, can arise from this and pose a threat to wildlife and people alike. High concentrations of nutrients can be found in certain sewage, fertilizers, and waste water. They may clog filters and make the water unsuitable for human consumption if they end up in water bodies because they encourage the growth of weeds and algae. Additionally, too much algae will consume all the oxygen [12].
- **Sewage and Wastewater:** Used water is known as wastewater. It comes from "our sinks, showers, and toilets (think sewage) as well as from commercial, industrial, and agricultural processes (think metals, solvents, and toxic sludge)". The term also describes storm water runoff, which occurs when precipitation carries pollutants, trash, oil, grease, and road salts into our rivers from impermeable surfaces [13].
- **Surface Water Pollution:** Natural water found on the surface of the planet, such as rivers, lakes, lagoons, and seas, is referred to as surface water. Surface water pollution is the term used to describe dangerous materials that come into touch with this water and dissolve or physically mix with the water. One major contribution is the discharge of chemical waste and oil spills into water bodies by industry [14].

- **Oxygen Depletion:** Microorganisms can be found in water bodies. These include both aerobic and anaerobic creatures; an excess of biodegradable materials (those that decompose readily) in water promotes the growth of additional microbes, which in turn depletes the water's oxygen supply. When oxygen levels drop, aerobic species perish and anaerobic organisms proliferate to create toxic substances like sulfides and ammonia [15].
- **Ground Water Pollution:** Rainwater carries chemicals and pesticides that people apply to soils well below the surface. This contaminates subterranean water. This implies that water must be treated before being extracted from underground through wells and bore holes [15].
- **Oil Pollution by Oil Industries:** Every day, regular shipping, runoff, and oil spills occur on the ocean's surface. Fish, birds, sea otters, and other aquatic species in the area might suffer greatly from oil spills, which also pose serious issues. Oil suffocates fish since it does not dissolve and remains on the water's surface. Additionally, oil becomes trapped in sea birds' feathers, which hinders their ability to fly. As a result, some animals perish.

Policies for Water Pollution Control in India

India has a comprehensive policy and legal framework to prevent and control water pollution with a focus on the protection of surface water and groundwater resources.

- **The Water (Prevention and Control of Pollution) Act, 1974:** This is the main law which deals with control of water pollution in India. It aims to maintain or restore the water's wholesomeness as well as prevent and regulate water pollution. The Act establishes "the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs)", which are in charge of establishing water quality standards, controlling effluent discharge, and ensuring compliance.
- **The Water (Prevention and Control of Pollution) Cess Act, 1977:** This Act was proposed to impose and collect a cess on the amount of water used by local governments and businesses. The goal was to encourage water conservation and create resources for pollution control activities. Though this is subsumed under the GST regime, the principles governing it still have an impact on the industrial use of water.
- **Environment (Protection) Act, 1986:** An all-encompassing law for environmental protection in India is the Environment (Protection) Act. It empowers the central government to provide effluent discharge standards, regulate hazardous substances and issue directions for the closure or regulation of polluting industries.

- **Water (Prevention & Control of Pollution) Amendment Bill, 2024:** The Water (Prevention and Control of Pollution) Amendment Bill, 2024 had been enacted to modernize the Water Act, 1974 by changing the mode of regulation from the criminal prosecution to monetary fine for minor and procedural violation. It makes some offences decriminal and brings in penalties from one lakh to Rs 15 lakh and helps speed up adjudication through designated authorities. The amendment also provides for limited exemption in respect of certain categories of industrial units and seeks to bring uniformity in the consent process keeping in view the better compliance, regulatory efficiency and ease of doing business while preserving environmental safeguards.
- **National Water Policy:** The National Water Policy prioritizes pollution avoidance, water ecosystem preservation, and sustainable water management. It promotes integrated water resources management (IWRM), reuse of treated wastewater and stakeholder participation to reduce pollution of water resources.
- **National Mission for Clean Ganga (NMCG):** The NMCG is concerned with the reduction of pollution in the Ganga River by regulatory measures, wastewater treatment infrastructure, public participation etc. It advocates for tight monitoring of industrial effluents and discharging of municipal sewage.
- **Coastal Regulation Zone (CRZ) Notifications:** CRZ regulations are aimed at protection of coastal water bodies by limiting industrial and developmental activities close to coastal zones. These policies are useful to control the marine and estuarine pollution.

Practices for Water Pollution Control in India

Water pollution control practices in India are implemented through regulatory enforcement, technological interventions, and community participation.

- **Industrial Effluent Management:** Industries are made to set up Effluent Treatment Plants (ETPs) to treat waste water prior to discharging it. Many industries that are highly polluting have adopted Zero Liquid Discharge (ZLD) systems to get rid of the discharge of wastewater into natural water bodies. Regular monitoring and online effluent monitoring systems are being practiced more often [16].
- **Municipal Wastewater Treatment:** Urban areas are dependent on Sewage Treatment Plants (STPs) to treat domestic wastewater. Recent practices have covered upgrading of existing STPs, use of decentralized wastewater treatment systems, reuse of treated wastewater for irrigation and construction and industrial use [4].

- **River and Lake Rejuvenation Programs:** Programmes like Namami Gange and the National Lake Conservation Plan, aimed at mitigating the pollution loads in rivers and lakes with various measures such as sewage interception, solid waste management and ecological restoration.
- **Agricultural Pollution Control Practices:** To reduce the non-point source pollution, some practices such as controlled use of fertilizer, promotion of organic agricultural practices, drip irrigation, and establishment of buffer zones near water bodies are encouraged. Soil health card schemes are a step towards rational use of agrochemicals [17].
- **Monitoring and Compliance Mechanisms:** CPCB and SPCBs are engaged in regular water quality monitoring systems through national and state level networks. Online Continuous Effluent Monitoring Systems (OCEMS) Are Used For Compliance Tracking in Major Industries.
- **Public Participation and Awareness:** Community-based monitoring, public awareness campaigns and citizen participation in water conservation schemes play an important role in pollution control. Educational programs promote local level responsible use of water and pollution prevention.

2 LITERATURE REVIEW

(S. Singh & Goyal, 2025) [18] examines India's changing water supply policies in chronological order, evaluating their effects, spotting implementation gaps, and attempting to offer guidance for the nation's future development of equitable and sustainable water access. In this regard, incorporating artificial intelligence (AI), especially into smart water management systems, holds promise for enhancing the effectiveness of water supplies and streamlining service delivery procedures. It will be crucial in tackling water-related issues, especially in areas like India. It might identify and reduce water loss in distribution networks, offering workable options for distribution, purification, and conservation. This review paper also covered "the Practical Integrated Water Resource Management approach", which stresses decentralized management of water resources and encourages more efficient, context-specific, and locally tailored solutions for assessing the water resource system in order to implement water policy. This strategy also helps to lessen the issue of water shortage in a certain location.

(Y. Singh & Chaudhary, 2024) [19] examines the creative approaches to managing sustainable water pollution, which is becoming essential as water bodies are affected daily due to the effects of urbanization, industrialization, and agricultural practices. It critiques the conventional

approach for failing to take sustainability into account while providing thorough descriptions of the many kinds and origins of water pollution. Because particular solutions and stakeholder participation are highly valued, case studies have shown how innovations have been successfully implemented in various locations. These technical advancements are further developed in relation to scalability, cost, and regulatory obstacles that impede their application. Lastly, suggestions have been made for more study and development of the aforementioned technologies, suitable water management regulations, and civic engagement that would contribute to the creation of responsible, healthy, and environmentally friendly settings for both health care systems and the environment.

(Yadav, 2024) [20] Over a third of the world's groundwater resources are used by India, the second most populated country in the world, with over 90% of those resources being used for agriculture. Many developing nations, like India, must immediately concentrate on sustainable river management in order to prevent the degradation of water quality and maintain the aesthetic value of rivers for future generations. Urbanization and industrialization have led to the production of large amounts of residential and industrial sewage, which has deteriorated the quality of the river water. Finding the main causes and the effects of the current comprehensive water quality is essential for improving the precision and applicability of water quality management, which will significantly affect the ecological system and the water environment's quality.

(Pooja & Arul, 2020) [21] discover the gaps in Indian law about the perspective of water-polluting companies. A red category industry in Cuddalore, namely in the SIPCOT institutional region, is chosen for a case study. The engagement of all relevant stakeholders in obtaining approval at the early stage of industrial creation at any location is required, which is the strength of the NGOs and the students. Since every solution is different for every situation, a proactive step was taken to establish a rationalist model, specifically to manage these kinds of uncertain eventualities with relation to "government regulations on Water Pollution Laws towards red category business". Proposals for the formation of industries may be approved based on the situational model.

(Sarubala et al., 2020) [15] The constant degradation of water bodies by human activity is known as water pollution. It happens when contaminants are dumped straight into bodies of water without being sufficiently treated to remove dangerous substances. The primary source of pollutants entering water is human activity. One of India's most pressing problems at the moment is water pollution. Untreated sewage is clearly India's largest source of this type of pollution. Other sources of contamination include uncontrolled small-scale industry units and runoff from the agricultural sector. The problem is so bad that it's possible that every body of

water in India is contaminated in some way. Nearly 80% of India's waterbodies are reportedly extremely polluted. The most contaminated rivers in India are the Yamuna and Ganga.

(Ahmed & Araral, 2019) [22] The purpose of this study is to ascertain if the sustainability of water governance in eight Indian states has improved after the UN announced "the Sustainable Development Goals (SDGs)". We make use of Saleth and Dinar's "Institutional Decomposition and Analysis (IDA)" approach. Between the first and second surveys, we discovered that average ratings on water legislation, policy, and administration had risen. We explained this development by pointing out that since the SDGs were announced, the Indian government has given the supply of safe drinking water particular priority. We also calculated the weighted and nominal "water governance indices (WGIs)" for eight Indian states. This study made a substantial contribution to the current literature on water governance by showing improvements in the water governance ratings of eight Indian states after the SDGs were released.

(Gupta et al., 2018) [23] Groundwater serves as the main source of water for residential, commercial, and agricultural use in many countries. Human activities and industry have contaminated the ground water. These days, this is a major issue. Leaching processes from "industrial, municipal, and agricultural waste containing insecticides, pesticides, fertilizer residues, and heavy metals" have polluted groundwater. Groundwater contamination has a wide range of impacts. The pollution of ground water by industrial and human activities is summarized in this paper. Both point and nonpoint sources of pollution affect water quality. These encompass runoff originating from agricultural regions, effluent discharge from sewage systems, industrial effluent discharge, and urban stormwater runoff. To maintain and improve the natural ecosystem, water quality analysis is crucial. To safeguard the water resources, many technologies have been created for groundwater evaluation, and management procedures should be implemented on a regular basis.

(Talukdar, 2017) [24] In emerging nations like India, industrialization is essential for creating jobs, lowering regional economic disparities, and enabling the eradication of poverty. In order to achieve this, Goal 9 of the Sustainable Development Goals emphasizes the development of resilient infrastructure, innovation, and inclusive and sustainable industrialization. For the industrially advanced but naturally water-scarce and drought-prone state of Gujarat in western India, this has far-reaching consequences for ensuring water security. This paper's goal is to examine the methods used by the state of Gujarat to reduce water pollution through various legislation. In the context of federal water legislation and laws to safeguard water resources, this has been undertaken. The problem of irreversibility in the state's surface and ground water resources, which have already been deteriorated by water pollution, has been addressed.

3 CONCLUSION

This review highlights the fact that water pollution is one of the most significant environmental challenges in India, caused by untreated sewage, industrial wastes, agricultural runoff and uncontrolled urban growth. The effects on human population, biodiversity and economic growth highlight the need for effective intervention. India has developed a comprehensive policy framework, such as the Water (Prevention and Control of Pollution) Act and Environment Protection Act and recent amendments on regulatory efficiency and compliance. Alongside policy measures, the practical measures like effluent and sewage treatment plants, river rejuvenation programmes, agricultural best practices, and real-time monitoring systems have an important role in pollution control. However, there are still gaps in implementation, infrastructure and public awareness. Strengthening the institutional capacity, adopting advanced technologies, strict enforcement and community participation are very necessary for sustainable results. An integrated approach with appropriate sound governance, technological innovation and stakeholder participation will play an important role to restore and protect the water resources in India for both present and future generations.

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