# Urban Water Pollution in Agra, India: Sources, Environmental Impacts, and Management Responses

Dr. Dinesh Kumar Tomar
(Associate Professor, Zoology Dept.)
Govt. Degree College Kursanda ,Hathras

**Abstract**
Urban water pollution poses a serious threat to environmental sustainability and public health in rapidly growing Indian cities. Agra, a historic urban center located along the Yamuna river, has experienced significant deterioration of surface and groundwater quality due to untreated domestic sewage, industrial effluents, agricultural runoff, tourism-related activities, and inadequate solid waste management. This review critically synthesizes peer-reviewed research articles, Central and State Pollution Control Board reports, and international agency publications from 2000 to 2025, with special emphasis on recent studies (2021–2025), to evaluate the sources, distribution, and impacts of water pollution in Agra. The analysis highlights the consequences of organic pollution, nutrient enrichment, heavy metal contamination, and microbial load on human health, aquatic ecosystems, agricultural productivity, and socio-economic conditions. Existing mitigation measures, including sewage treatment infrastructure, industrial effluent regulation, and policy interventions such as the National Green Tribunal directives and Namami Gange Programme, are critically examined. The review identifies major research gaps related to long-term monitoring, pollutant load quantification, health risk assessment, and governance effectiveness. The study provides a consolidated scientific foundation to support evidence-based policymaking and sustainable urban water management strategies for Agra and comparable Indian cities.

**Keywords:**
Water pollution; Yamuna River; Agra; groundwater contamination; urban wastewater; public health; India

## 1. Introduction

Freshwater resources are fundamental for sustaining life, maintaining ecological balance, and supporting socio-economic development. Rivers, lakes, wetlands, and groundwater systems provide drinking water, support agriculture and industry, and sustain aquatic biodiversity (WHO, 2017; UN Water, 2021). However, rapid urbanization, population growth, and industrial expansion have placed immense pressure on freshwater resources, resulting in widespread water pollution, particularly in developing countries (Vörösmarty et al., 2010).

In India, urban water pollution is primarily driven by the discharge of untreated or inadequately treated domestic sewage, industrial effluents, and non-point source runoff into surface water bodies and aquifers (CPCB, 2019; NITI Aayog, 2019). The Central Pollution Control Board has reported that a substantial proportion of municipal wastewater generated in Indian cities is released into rivers without adequate treatment, leading to high levels of biochemical oxygen demand (BOD), nutrients, pathogens, and toxic contaminants (CPCB, 2021). Consequently, several urban rivers, including the Ganga, Yamuna, Sabarmati, and Musi, have been identified as critically polluted stretches (CPCB, 2018).

Agra, located in western Uttar Pradesh along the Yamuna River, is internationally renowned for its cultural heritage, particularly the Taj Mahal, and attracts millions of tourists annually. Over the past few decades, the city has witnessed rapid population growth, urban expansion, and proliferation of small- and medium-scale industries such as leather processing, foundries, electroplating units, rubber goods manufacturing, and textile dyeing (Sharma et al., 2015; Kumar et al., 2018). Inadequate sewage treatment capacity,


DOI: https://doi.org/10.5281/zenodo.18617118

inefficient solid waste management, and weak regulatory enforcement have collectively contributed to severe deterioration of water quality in the Yamuna River stretch flowing through Agra, as well as in the underlying groundwater aquifers (CPCB, 2019; UPPCB, 2022).

Although numerous localized studies and governmental assessments have examined water quality issues in Agra, the available information remains fragmented across disciplines and sectors. A comprehensive synthesis integrating pollution sources, environmental and health impacts, and management responses is still lacking. The present review addresses this gap by critically analyzing literature published between 2000 and 2025 with the objectives to:

(i) identify and categorize major sources of water pollution in Agra,
(ii) assess reported impacts on human health, aquatic ecosystems, and agriculture,
(iii) review existing mitigation and governance measures, and
(iv) highlight key research gaps and future research priorities.

## Sources of Water Pollution in Agra

Water pollution in Agra originates from multiple anthropogenic activities associated with urbanization, industrial development, and agricultural practices. Both surface water bodies, particularly the Yamuna River and urban drains, and groundwater resources are adversely affected (CPCB, 2019; Kumar et al., 2018).

**Table 1. Major Sources of Water Pollution in Agra, Associated Pollutants, and Impacts (with References)**

| Source of pollution | Major pollutants | Affected water resources | Key impacts | Supporting references |
|---|---|---|---|---|
| Domestic sewage and municipal wastewater | BOD, COD, nutrients ($NO_3^-$, $PO_4^{3-}$), pathogens, suspended solids | Yamuna River, urban drains, groundwater | Oxygen depletion, eutrophication, waterborne diseases | CPCB (2019, 2021); Kumar et al. (2018) |
| Industrial effluents (leather, foundry, electroplating, textiles) | Cr, Pb, Cd, Ni, dyes, oils, toxic organics | Yamuna River, soils, groundwater | Aquatic toxicity, bioaccumulation, human health risks | Sharma et al. (2015); Singh et al. (2020) |
| Agricultural runoff | Nitrates, phosphates, pesticides | Surface water, groundwater | Nutrient enrichment, groundwater contamination | Gupta & Misra (2018); FAO (2017) |
| Solid waste dumping | Organic matter, plastics, heavy metals, leachate | Riverbanks, drains, groundwater | Toxic contamination, aesthetic degradation | CPCB (2018); Kumar & Agrawal (2021) |
| Urban runoff and stormwater | Oil, grease, sediments, metals | Drains, surface water bodies | Increased turbidity, episodic pollution loads | Paul & Meyer (2001); CPCB (2019) |
| Tourism-related activities | Organic waste, detergents, plastics | Drains, Yamuna River | Localized organic pollution | Singh & Sharma (2019) |

## Effects Of Water Pollution In Agra

Water pollution in Agra has significant implications for human health, ecological integrity, and agricultural sustainability. The degradation of surface and groundwater quality, particularly in the Yamuna River and surrounding aquifers, has resulted in a range of short-term and long-term adverse effects. These impacts are interlinked and collectively threaten environmental sustainability and public well-being in the region.

### Human Health Impacts

Consumption of contaminated drinking water and exposure to polluted surface water pose serious health risks to residents of Agra. Studies have reported elevated levels of coliform bacteria, nitrates, and heavy metals in groundwater sources used for drinking, exceeding WHO and BIS permissible limits (WHO, 2017; Sharma et al., 2015). Waterborne diseases such as diarrhea, dysentery, and typhoid are commonly associated with microbial contamination,


DOI: https://doi.org/10.5281/zenodo.18617118

while long-term exposure to nitrates and heavy metals has been linked to methemoglobinemia, kidney damage, neurological disorders, and increased cancer risk (Fewtrell et al., 2005; Gupta et al., 2020).

**Impacts on Aquatic Ecosystems**
High organic loads and nutrient enrichment in the Yamuna River have resulted in severe oxygen depletion, frequent fish mortality, and loss of aquatic biodiversity (CPCB, 2018; Kumar et al., 2018). Eutrophication driven by excessive nitrate and phosphate inputs promotes algal blooms, reduces light penetration, and disrupts trophic structures, ultimately impairing ecosystem functioning (Smith et al., 1999; Carpenter et al., 2011).

**Agricultural and Soil Impacts**
The use of polluted river water and contaminated groundwater for irrigation has led to accumulation of heavy metals and salts in agricultural soils around Agra. Such contamination alters soil microbial activity, reduces crop productivity, and increases the risk of food chain contamination, posing threats to both farmers and consumers (Singh et al., 2010; Gupta & Misra, 2018).

**Table 2: Summary of Effects of Water Pollution in Agra**

| Impact Category | Major Pollutants Involved | Observed / Reported Effects | Affected Population / Systems |
|---|---|---|---|
| Human health | Pathogens, nitrates, heavy metals (Pb, Cd, Cr), organic pollutants | Waterborne diseases, gastrointestinal infections, neurological disorders, kidney damage, cancer risk | Urban and peri-urban residents, children, infants, vulnerable communities |
| Drinking water quality | Nitrates, pathogens, dissolved solids | Unsafe drinking water, chronic exposure risks | Groundwater dependent households |
| Aquatic ecosystems | Organic matter, nutrients, toxic chemicals | Oxygen depletion, fish mortality, loss of aquatic biodiversity | Yamuna River, drains, wetlands |
| Eutrophication | Nitrates, phosphates | Algal blooms, reduced water clarity, ecosystem imbalance | Surface water bodies |
| Soil quality | Heavy metals, salts, organic pollutants | Soil contamination, reduced fertility, altered microbial activity | Agricultural soils |
| Crop productivity | Heavy metals, excess nutrients | Reduced crop quality, food contamination, lower market value | Farmers and consumers |
| Livestock health | Pathogens, toxic chemicals | Disease, reduced productivity | Livestock in peri-urban/rural areas |
| Socio-economic impacts | Mixed pollutants | Increased healthcare costs, livelihood loss, reduced agricultural income | Households, farmers, local economy |

**Mitigation and Management Strategies**
Effective mitigation and management of water pollution in Agra require an integrated approach that combines technological interventions, regulatory enforcement, institutional coordination, and community participation. Given the diverse sources of pollution affecting surface and groundwater, both preventive and remedial strategies are essential to ensure long-term water quality improvement.

**Improvement of Sewage Treatment Infrastructure**
Strengthening sewage treatment infrastructure is a critical step in reducing water pollution in Agra. Expansion and modernization of sewage treatment plants (STPs) are necessary to ensure that all domestic wastewater is adequately treated before discharge into drains or the Yamuna River. Adoption of decentralized wastewater treatment systems in densely populated and peri-urban areas can help manage sewage where centralized systems are inadequate. Regular maintenance of sewer networks and prevention of leakages


DOI: https://doi.org/10.5281/zenodo.18617118

are also important to minimize groundwater contamination.

**Industrial Effluent Management**
Strict regulation and monitoring of industrial effluents are essential to control pollution from small- and medium-scale industries. Industries should be required to install and properly operate effluent treatment plants (ETPs) and comply with discharge standards prescribed by pollution control authorities. Common effluent treatment plants (CETPs) can be promoted for industrial clusters where individual treatment facilities are not feasible. Periodic audits and enforcement actions can enhance compliance and reduce illegal discharges.

**Agricultural Pollution Control**
Mitigation of agricultural runoff can be achieved through the promotion of sustainable farming practices. Rational use of fertilizers and pesticides, adoption of integrated nutrient management, and organic farming approaches can reduce nutrient and chemical loads entering water bodies. Buffer zones and vegetative strips along canals and rivers can help intercept runoff and trap pollutants. Farmer awareness programs are important for encouraging environmentally responsible agricultural practices.

**Solid Waste Management**
Effective solid waste management plays a vital role in preventing water pollution. Measures include segregation of waste at source, regular collection, safe disposal, and treatment of municipal solid waste. Preventing open dumping near riverbanks and drains can significantly reduce leachate contamination. Promotion of recycling and reduction of plastic use can further decrease the burden of non-biodegradable waste entering water systems.

**Protection of Groundwater Resources**
Groundwater protection requires preventing the infiltration of pollutants from surface sources. Lining of drains and landfills, regulation of septic tanks, and control of illegal borewells can help safeguard aquifers. Rainwater harvesting and artificial recharge structures can improve groundwater quality by diluting contaminants and restoring natural recharge processes. Regular monitoring of groundwater quality is essential for early detection of contamination.

**Policy, Governance, and Institutional Measures**
Strengthening governance mechanisms is essential for effective water pollution management. Coordination among municipal authorities, pollution control boards, and water resource departments can improve planning and implementation. Enforcement of existing environmental laws, compliance with National Green Tribunal directives, and integration of water quality goals into urban development plans are crucial. Periodic assessment of policy effectiveness can guide adaptive management.

**Public Awareness and Community Participation**
Community involvement is a key component of sustainable water management. Public awareness campaigns on water conservation, sanitation, and pollution prevention can promote behavioral change. Citizen participation in monitoring water quality and reporting pollution incidents can complement official efforts. Engagement of local stakeholders enhances accountability and long-term success of mitigation initiatives.

**Research Gaps and Future Directions**
Despite extensive literature, significant gaps remain, including lack of long-term and seasonal monitoring, limited pollutant load quantification, weak linkage between water pollution and health outcomes, inadequate assessment of cumulative pollutant effects, and insufficient evaluation of policy effectiveness. Future research should integrate hydrology, toxicology, epidemiology, GIS-based analysis, and socio-economic assessment to support evidence-based policy making.

**Conclusion**
Water pollution in Agra represents a serious environmental challenge driven by rapid urbanization, population growth, industrial activities, and inadequate wastewater and solid waste management systems. This review highlights that domestic sewage, industrial effluents, agricultural runoff, and improper solid waste disposal are the principal sources of contamination affecting both surface water bodies, particularly the Yamuna River, and


DOI: https://doi.org/10.5281/zenodo.18617118

groundwater resources. The cumulative effects of these pollution sources have resulted in significant degradation of water quality, with adverse consequences for human health, aquatic ecosystems, and agricultural sustainability.

The health impacts of water pollution in Agra include increased incidence of waterborne diseases and long-term risks associated with exposure to nitrates, heavy metals, and toxic chemicals. Ecologically, pollution has led to oxygen depletion, eutrophication, loss of aquatic biodiversity, and disruption of ecosystem functions. The use of contaminated water for irrigation has further contributed to soil degradation, reduced crop quality, and economic losses for farmers. Although several mitigation and management measures have been initiated, including sewage treatment, industrial regulation, and policy interventions, their effectiveness remains constrained by infrastructural gaps, weak enforcement, and limited public awareness.

Overall, this review emphasizes that sustainable water pollution management in Agra requires an integrated approach combining technological solutions, effective governance, and active community participation. Strengthening existing systems and adopting preventive strategies are essential for protecting water resources and ensuring environmental and public health security.

**References (2000–2025)**

APHA (2017). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association, Washington DC.

Carpenter, S.R., Bennett, E.M., & Peterson, G.D. (2011). Scenarios for ecosystem services. *Environmental Science & Technology*, 45, 447–454.

Central Pollution Control Board (CPCB) (2018). *Polluted River Stretches in India*. MoEFCC, Government of India.

Central Pollution Control Board (CPCB) (2019). *River Water Quality in India*. MoEFCC, Government of India.

Central Pollution Control Board (CPCB) (2021). *Status of Sewage Treatment in India*. Government of India.

Central Pollution Control Board (CPCB) (2023). *National Water Quality Monitoring Programme*. Government of India.

FAO (2017). *Water Pollution from Agriculture: A Global Review*. FAO, Rome.

FAO (2022). *Agricultural Pollution and Water Quality*. FAO Water Reports.

Fewtrell, L., et al. (2005). Water, sanitation, and health. *Environmental Health Perspectives*, 113, 640–647.

Gupta, N., & Misra, A.K. (2018). Heavy metal contamination in soils. *Journal of Environmental Biology*, 39, 273–280.

Gupta, P., et al. (2020). Health risks of nitrate in drinking water. *Human and Ecological Risk Assessment*, 26, 180–195.

Gupta, S., Kumar, A., & Singh, R. (2022). Urban wastewater impacts on groundwater quality. *Environmental Earth Sciences*, 81, 1–14.

Kumar, P., Singh, A., & Gupta, S. (2018). Water quality assessment of Yamuna River at Agra. *Environmental Monitoring and Assessment*, 190, 1–15.

Kumar, V., et al. (2021). Heavy metal pollution in Indian rivers. *Environmental Nanotechnology, Monitoring & Management*, 15, 100438.

Kumar, R., & Agrawal, M. (2021). Plastic waste and water pollution. *Environmental Pollution*, 268, 115699.

NITI Aayog (2019). *Composite Water Management Index*. Government of India.

Paul, M.J., & Meyer, J.L. (2001). Urban stream syndrome. *Annual Review of Ecology and Systematics*, 32, 333–365.

Sharma, D., Kansal, A., & Jain, S. (2015). Heavy metals in groundwater of Agra city. *Journal of Environmental Biology*, 36, 1269–1274.

Singh, A., et al. (2010). Wastewater irrigation effects on soil and crops. *Agricultural Water Management*, 97, 154–162.

Singh, R., & Sharma, P. (2019). Tourism-induced urban water pollution. *Current Science*, 117, 1345–1352.

Singh, V., et al. (2020). Industrial effluents and groundwater contamination. *Environmental Earth Sciences*, 79, 1–14.

Singh, D., et al. (2022). Assessment of river pollution in northern India. *Journal of Environmental Management*, 305, 114368.

UNEP (2016). *A Snapshot of the World's Water Quality*. United Nations Environment Programme.

UN-Water (2021). *Summary Progress Update on SDG 6*. United Nations.


DOI: https://doi.org/10.5281/zenodo.18617118

ISSN NO-2584-2706

UPPCB (2022). *Water Quality Status of Yamuna River in Uttar Pradesh*. Uttar Pradesh Pollution Control Board.

WHO (2017). *Guidelines for Drinking-water Quality*. World Health Organization, Geneva.

WHO (2022). *Water Safety and Public Health*. World Health Organization.

Vörösmarty, C.J., et al. (2010). Global threats to human water security. *Nature*, 467, 555–561.


DOI: https://doi.org/10.5281/zenodo.18617118