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Review Article

WATER QUALITY OF RIVERS OF DEORIA (U.P.) AND NEIGHBOURING DISTRICTS IN BIHAR - A REVIEW

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ABSTRACT

Water is one of the most important natural resources on Earth. It plays a critical role in supporting all living organisms, sustaining ecological systems, protecting human health, and enabling food production and economic development. Water quality generally refers to the composition of water at levels optimal for the healthy growth of plants and animals. The safety of drinking water is affected by various contaminants, including physical, chemical, and microbiological agents, which can cause serious health problems. Due to the growing human population, industrialisation, the use of fertilisers, and other anthropogenic activities, water bodies are becoming increasingly polluted with harmful contaminants. There is therefore an urgent need to protect and conserve water resources. Accordingly, it is essential to understand the physico-chemical parameters of water, such as colour, temperature, acidity, hardness, pH, sulphate, chloride, DO, BOD, COD, and alkalinity. Accurate assessment of these parameters is crucial for evaluating the condition of water sources and ensuring that they remain safe and sustainable for both ecological and human use. This study evaluates the physico-chemical characteristics and contaminant levels of groundwater and surface water sources in Deoria district (Uttar Pradesh) and selected neighbouring districts of Uttar Pradesh and Bihar.

Keywords: Physico-Chemical Parameters, Seasonal Variations, Water Pollution, Freshwater, Temperature, Acidity, Hardness, ph, Sulphate, Chloride, DO, BOD, COD, Conductivity, Health, Etc.

INTRODUCTION

India has been classified as 'water stressed' since 2004, with projections indicating a critical phase by 2050. The World Bank has warned of a severe water crisis in India due to poor groundwater management and climate change. Groundwater is crucial for drinking supplies, meeting 85% of the population's needs, while also supporting over 70% of irrigated agriculture and 95% of industrial water demand. Uncontrolled abstraction has led to critical scarcity in many areas, necessitating better management practices. Rapid urbanization has accelerated groundwater depletion and created a state of 'hydrological poverty' in many cities, with adverse effects on hydrogeological conditions and long-term resource sustainability. Uttar Pradesh faces significant groundwater management challenges, with slow reform implementation, and requires comprehensive management interventions Sinha (2021). In Bihar, widespread arsenic, fluoride, and iron contamination has also been reported across multiple districts, posing serious public health risks.

Access to safe and clean water is fundamental for human well-being and development and is recognized as a basic human right United Nations General Assembly (2010), Abegaz and Midekssa (2021). Contaminated water exposes populations to a range of

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waterborne diseases, and the unchecked, unregulated use of chemical pesticides can compound these risks within communities. India is the sixth-largest producer and tenth-largest consumer of pesticides Pretty and Bharucha (2015). Most pesticides applied to agricultural land accumulate in the soil, from where they leach out and eventually enter nearby ponds, rivers, and other water sources, adversely affecting aquatic life. The direct effects of pesticides vary from ecosystem to ecosystem depending on differences in physico-chemical and biological characteristics Liess (2008). Ecological effects such as bio-concentration and bio-magnification can adversely affect human health and contribute to diseases such as cancer, asthma, and diabetes. Because increasing population, industrialization, fertilizer use, and other anthropogenic activities continue to pollute water with harmful contaminants, it is necessary to monitor water quality at regular intervals. Highly impure water bodies may contain bacteria and heavy metals that affect humans and animals and give rise to physiological disorders. Hard water is unsuitable for domestic uses such as washing, bathing, and cooking, and is equally unsuitable for industrial and agricultural use, as it damages delicate machinery and affects the quality, stability, and glossiness of the final product.

Contamination of household and drinking water resources with heavy elements, metal ions, and harmful microorganisms remains one of the most serious public health problems. Recent research indicates that the deterioration of groundwater quality is largely driven by rates of extraction exceeding natural recharge, inappropriate disposal of solid and liquid wastes, weak enforcement of laws, and poor governance Gupta (2009). Monitoring contamination is therefore fundamental to assessing water quality, and the ultimate goal of such assessment is to establish standards that can be used to compare pollution levels across sources Barrie et al. (2023).

Water quality monitoring is of great importance for the conservation of water resources used in fisheries, water supply, and other activities, and involves the assessment of the physico-chemical parameters of water bodies. Changes in water quality are reflected in the structure of biotic communities, where vulnerable species decline while the most sensitive species act as indicators of water quality Tiwari (2023).

Natural water contains various impurities that enter the aquatic system through processes such as the weathering of rocks, leaching of soils, dissolution of atmospheric aerosol particles, and numerous human activities. Large fluctuations in these parameters across seasons indicate the intensity of pollution, and microorganisms also serve as indicators of contamination. Evaluating water quality is essential for ensuring safe drinking water and protecting aquatic ecosystems, making it crucial to establish stricter regulations and effective waste management practices to prevent contamination. Rivers in eastern Uttar Pradesh and western Bihar are lifelines for millions of people, supporting drinking water supply, agriculture, fisheries, and cultural practices. However, rapid population growth, urban expansion, inadequate wastewater infrastructure, and agricultural runoff have degraded river water quality across the Indo-Gangetic Plain. This paper reviews the quality of groundwater and of major rivers flowing through Deoria district (Uttar Pradesh) and neighbouring districts of Uttar Pradesh and Bihar.

REVIEW OF RESEARCH LITERATURE

Studies on the water quality of the Rapti River reveal significant pollution from industrial waste, sewage, and urbanization, with high levels of pH, BOD, TDS, and metals rendering the water unfit for drinking. These studies typically analyse physico-chemical parameters using Water Quality Indices (WQI) and report declining trends, particularly downstream of cities such as Gorakhpur, highlighting severe ecological stress. In one such study, the water quality of the Rapti River and Suvaw Nala was assessed and compared, revealing that Suvaw Nala is heavily polluted due to the absence of treatment facilities, causing significant deterioration in the Rapti River's water quality. The untreated effluents from Suvaw Nala considerably degrade the water quality of the Rapti River, with pronounced seasonal effects and serious implications for aquatic life and aquaculture suitability (Vivek Mani Tripathi, 2008).

Pollution in the Ami River significantly deteriorates the water quality of the Rapti River from the Sohgaura confluence downstream to Kaparwar Ghat, as indicated by DO, COD, and TDS levels. COD levels at Jarlahi in the Ami River were found to resemble those of wastewater, reflecting heavy pollution from industrial effluents (Rudhauli, Sant Kabir Nagar, GIDA) and municipal discharges (Khalilabad, Maghar). The study accordingly recommended that adequate treatment facilities be established and operated in line with regulatory norms, and that the discharge of treated or untreated wastewater be prohibited. It was also found that the Rapti River recovers only slowly from this pollution load until it meets the Ghaghara at Kaparwar Ghat, suggesting a potential gradual deterioration of Ghaghara River water quality over time Pandey (2023).

A recent study on the Rapti, Rohin, and Ami rivers in Gorakhpur observes that the Rapti River is crucial to the city for drinking water, farming, and industry, but faces severe pollution from industrial waste, sewage, and agricultural runoff. High BOD and COD levels across all three rivers indicate the need for effective wastewater treatment, as this degradation harms ecosystems, public health, agriculture, and local livelihoods. Although some government and community efforts exist, stronger and more integrated action is needed, including improved wastewater treatment, stricter enforcement of environmental laws, promotion of sustainable practices, and greater involvement of local communities in restoring river ecosystems. Effective implementation of such measures could revive the Rapti River, protect biodiversity, enhance quality of life, and support Gorakhpur's long-term development Gupta (2025).

A study evaluating the impact of sugar mill effluents on regional water quality in Kushinagar during the pre- and post-rainy seasons, using physico-chemical parameters and GIS mapping, indicates widespread degradation of water quality in both seasons, with greater deterioration after the monsoon. High organic pollution was particularly evident after the rainy season, and overall, more than one-third of the region's water resources were found unsuitable for drinking, highlighting the substantial adverse impact of sugar effluent discharge, especially in the post-rainy period Gyanendra Awasthi (2006).

A study examining the water of the Ghaghara River from Katerniaghat (Bahraich, Uttar Pradesh) to Chhapra (Bihar) found that industrial activity in the area was low and that overall water quality supported a healthy plant community. Algae showed greater variation than higher plants, while plankton diversity was lower in the middle and lower stretches, likely due to human-induced degradation. Land-use analysis indicated agriculture as the dominant category, and high numbers of macrophytes were found where pH was alkaline and DO levels were good. However, heavy water abstraction reduced macrophyte presence, and sites with low nitrate and phosphate levels showed fewer species. Overall, changes in water quality and nutrient availability, especially around water-intake points, directly affected macrophyte diversity and, in turn, the broader aquatic flora and fauna of the Ghaghara and Gandak rivers Harendra Singh (2017). Water quality data for the Ghaghara River showed poorer conditions at Muktidham (a cremation site) compared with Kaparwar Ghat and Barhaj, and the completion of a biomass-gasifier-based cremation system was suggested to improve conditions at Muktidham Sandeep Vishen (2014).

The Chhoti Gandak, a meandering river, serves as a lifeline for the people of Deoria district, Uttar Pradesh. Its principal water-quality components are governed by lithology, a gentle slope gradient, poor drainage, long water residence time, ion exchange, mineral weathering, heavy fertilizer use, and domestic waste. At some stations, the water is hard with excess alkalinity and is unsuitable for drinking and irrigation due to anthropogenic activities, whereas at most stations, the water is of good quality for irrigation and can be used for agricultural production. The impact of land use on water quality is an important consideration in developing suitable policy and regulatory mechanisms, and the absence of such efforts results in the deterioration of water quality, which causes health problems and damages the industrial sector Vikram Bhardwaj (2010).

Industrial activities, particularly from the sugarcane industry, and agricultural practices in the Chhoti Gandak river basin have significantly contaminated the soil and groundwater. Heavy metals such as Pb, Cu, and Zn occur at much higher concentrations in soils near industrial sites, while Fe and Mn in groundwater exceed WHO and BIS drinking-water limits. The alkaline nature of nearby swamps and groundwater results from industrial waste, agricultural runoff, processed waste, and atmospheric deposition. Both anthropogenic sources (industrial effluents, agrochemicals, and leaching) and natural processes (ion exchange, weathering, and clay mineral–water interactions) contribute to metal concentration, although human-induced contamination is dominant, and elevated trace metal levels pose serious health risks to local populations Vikram Bhardwaj (2010).

A study of the Chhoti Gandak between Kushinagar and Deoria emphasizes the need for a comprehensive hydrogeochemical assessment and the sustainable implementation of an integrated waste and wastewater management plan to protect soil and water resources and improve environmental and human health conditions in the industrial area Vikram Bhardwaj (2009).

The Ganga River at Varanasi shows high coliform concentrations, altered pH, and elevated dissolved oxygen, biochemical oxygen demand, and chemical oxygen demand values. A study revealed that water quality is poor for bathing and drinking at most sites throughout the year, and that upstream water quality is considerably better than in the heavily contaminated downstream region. Such findings can be useful for environmentalists, policymakers, and water resource managers in developing strategic plans to preserve the cultural and aesthetic value of the Ganga River Gurudatta Singh (2024).

Another study examined seasonal variations in the physico-chemical parameters of the Ganga River at various ghats in Varanasi, including Santravidas, Assi, Harish Chandra, Dasawamedha, Lalita, Mannmandir, and Namo Ghats, and compared these with World Health Organization and standard water quality guidelines. The findings indicate that the river water is polluted, posing potential risks to aquatic life and human health Yadav et al. (2025).

The water quality of the Varuna River (Varanasi) is moderately polluted due to sewage, industrial waste, excessive fertilizer use, and religious ritual activities, among other factors. The permeability index indicates that the groundwater samples are suitable for irrigation, and although the general quality of groundwater in the lower Varuna basin is suitable for irrigation purposes, the sewage discharged into the river still requires treatment Agrawal (2025).

A study conducted along the stretch from Nepal to Chhapra (Bihar), including Gorakhpur and Deoria, evaluated the eutrophication risk associated with nutrient flux in the Ghaghara River and found that nutrient concentrations in the river are contributed by both allochthonous and autochthonous sources. Nitrate constitutes a major share of the dissolved inorganic nitrogen (DIN) load in the river, with significant seasonal variation in nutrient concentrations, while phosphate limits primary productivity. The Ghaghara's water is alkaline, with pH increasing downstream and dropping during the monsoon due to rainfall dilution. BOD levels (2.47–3.53 mg/L) place the river in the clean to moderately polluted category, though they still exceed CPCB limits, with higher BOD downstream driven by dense population and agricultural runoff. A 50-km stretch near Gorakhpur–Deoria is critically polluted due to untreated sewage, and BOD shows clear spatial and seasonal variation Ravi et al. (2021).

In Chhapra district, the water quality of the Ghaghara River is generally suitable; however, during the post-monsoon season, turbidity and iron levels exceed the permissible limits set by BIS and WHO, indicating areas of concern. TDS values suggest that the dissolved solids present are largely anthropogenic, highlighting the need for improved water management, although most other physico-chemical parameters, including calcium, magnesium, total hardness, alkalinity, fluoride, chloride, nitrate, and sulphate, remain within safe limits. This underscores the need for targeted management to control elevated iron levels in the river water Sarvesh Kumar Diwakar (2022).

Another study of the Ghaghara River evaluated its suitability for drinking and irrigation, finding that most water quality parameters were within WHO (2017) drinking-water limits, though major cations and anions showed significant seasonal variation due to changes in river discharge and human inputs. Calcium (Ca^{2+}) and bicarbonate (HCO_3^-) were the dominant ions, and the Water Quality Index (WQI) ranged from excellent to unsuitable, with the poorest quality recorded in the post-monsoon season. This study highlights the urgent need to prevent further degradation by expanding sewage and effluent treatment facilities, tapping drains, and stopping the discharge of untreated waste. Additionally, reducing fertilizer and pesticide use and adopting measures such as buffer strips, retention ponds, constructed wetlands, and sediment fences can help control non-point-source pollution Nirdesh Kumar Ravi (2023).

Research on the Gandak River's water quality reveals significant seasonal variation and pollution impacts from urbanization and industries such as sugar mills, with elevated TDS, BOD, COD, and heavy metals recorded in many areas, especially near Samastipur and Khagaria in Bihar, rendering the water unfit for drinking. The Water Quality Index (WQI) often varies from 'good' to 'poor', highlighting the need for closer supervision of water quality in rivers near cities and towns, along with the human activities occurring there Akash Priyadarshee (2024). Domestic and industrial wastewater are persistent pollutant sources, while cultural and religious tourism also contribute to water quality degradation in the Ganga River Farooquee et al. (2008).

Apart from pesticides, industrial effluents and domestic waste also contribute significantly to the degradation of water quality. Rivers and lakes that receive factory discharges often show high levels of contaminants such as heavy metals (e.g., cadmium, lead, and chromium), organic pollutants, and suspended solids. These pollutants not only affect water quality but also harm aquatic life, disrupt ecosystems, and pose long-term health risks to humans. For example, industrial effluents from sugar mills in Muzaffarpur (Bihar), such as those at Sugauli and Lauria, have been found to introduce organic matter and chemicals into the Budhi Gandak River, significantly affecting water quality during their operational season (November to March). Despite the presence of effluent treatment plants, water quality deteriorates when these industries are operational, adding to the overall pollution load of the river system. Urbanization, domestic sewage, agricultural runoff, land-use change, and deforestation further contribute to the deterioration of water quality, while seasonal variations, such as increased turbidity during the monsoon or elevated sulphate concentrations in winter, further complicate water quality monitoring Kumar (2015).

Organic impurities in water originate from both natural sources, such as decaying plant and animal matter, and human activities, such as industrial discharge and agricultural runoff. These impurities encompass a wide range of organic compounds, including hydrocarbons, alcohols, aldehydes, ketones, and substances such as humic and fulvic acids, tannins, and lignin. They can affect water quality by altering taste, odour, and colour, and can also serve as a breeding ground for harmful microorganisms Danka Barloková (2023).

GROUND WATER QUALITY

Arsenic contamination in groundwater, and its effect on human life, is currently one of the most serious problems worldwide. Deoria and its surrounding districts show moderate to high arsenic levels in groundwater at several sites, placing them in medium-to high-risk categories with respect to human consumption. A study of arsenic contamination in Deoria district (Uttar Pradesh) found elevated arsenic concentrations in both shallow and deep borewell water samples within high-risk regions, and further found that the groundwater of Bankata, Barhaj, Bhaluani, Bhatpar Rani, Rudrapur, Salempur, and Tarkulwa is unfit for drinking without treatment Mishra (2020).

Another study of groundwater and surface water in Deoria district (Ganga Plain) assessed its suitability for drinking, farming, and industrial use, finding that groundwater is generally fine for drinking, although high levels of EC, TDS, bicarbonate, magnesium, sodium, and iron render the water unsafe in some locations. Both groundwater and river water were found to be generally safe for livestock, though the water is supersaturated with minerals such as dolomite, calcite, and aragonite, making it unsuitable for industrial purposes. Changes in downstream river-water chemistry were attributed mainly to land use, natural processes, and human activities near the river Researcher (2009). Similarly, water in Deoria district was found to be generally suitable for domestic and irrigation use, though certain locations showed unsafe levels of salts and metals such as Mg, Na, and Fe, warranting further investigation. Surface and groundwater were deemed acceptable for livestock, but a high magnesium hazard at some sites may restrict irrigation, and mineral supersaturation renders the water unsuitable for industrial use, with downstream variations again attributed to land-use patterns and combined natural and human activities Vikram Bhardwaj (2011).

Forty districts in the state are exposed to high concentrations of arsenic in groundwater. The worst-affected areas lie in the floodplains of the Ganga, Rapti, and Ghaghara rivers, such as Gorakhpur, Ghazipur, and Ballia, while districts such as Deoria, Kushinagar, and Varanasi face a moderate risk of arsenic contamination Mishra (2019).

Broader regional data reveal similar issues across eastern Uttar Pradesh, including bacteriological contamination and chemical pollutants such as nitrate and salinity in some areas. Such changes in water quality are reflected in the structure of biotic communities, with vulnerable species declining while the most sensitive species act as indicators of water quality (Tiwari, 2023).

CONCLUSION

Ensuring safe water is a shared responsibility that requires cooperation among governments, industries, and individuals. Clean water is not a luxury but a basic human right, yet several groundwater sources, including open wells, hand pumps, and public water supply schemes, fail to meet WHO standards for drinking water. In essence, water bodies in Purvanchal are under severe stress from rapid development, leading to widespread contamination, though local efforts and monitoring by bodies such as the CPCB continue to track these critical issues.

Groundwater, which supports most drinking water, agriculture, and industry, is depleting rapidly, while states such as Uttar Pradesh and Bihar face overuse and serious groundwater contamination. Rivers in eastern Uttar Pradesh and western Bihar, vital to local livelihoods, are increasingly polluted by sewage, agricultural runoff, and inadequate infrastructure. Water quality assessments reveal significant contamination, posing risks to public health, ecosystems, and agriculture. This situation highlights the urgent need for continuous monitoring, stronger regulation, effective pollution control, and integrated water resource management to ensure sustainable water security. Public awareness campaigns, coupled with scientific research and policy enforcement, can help mitigate the adverse effects of water pollution and ensure the sustainability of water resources for future generations. Concerned authorities should also take all necessary measures to address water pollution and eliminate potential risks to local inhabitants. For the Rapti River in particular, establishing sewage treatment systems and biomass-gasifier or electric cremation facilities in Gorakhpur would help improve water quality.

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