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Urban Water, Urban Illness: Assessing the Health Impacts of Water Pollution in Lucknow, India

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ABSTRACT

Background: Rapid urbanization and population growth in Indian cities have increased pressure on water resources, causing widespread pollution and public health risks. Lucknow, the capital of Uttar Pradesh, has experienced significant deterioration in surface and groundwater quality due to untreated sewage discharge, aging infrastructure, and inadequate wastewater management. Contaminated drinking water has become a critical environmental health concern, contributing to rising waterborne and water-related diseases.

Methods: A mixed-methods approach was used to examine the link between water pollution and health outcomes in Lucknow. Water quality data from selected wards were analyzed using the Weighted Arithmetic Water Quality Index (WQI), incorporating physicochemical and microbiological parameters. Data on waterborne disease incidence were collected from secondary health records and household surveys. Pearson's correlation analysis assessed the association between WQI values and disease rates across wards.

Results: WQI values ranged from good to very poor, showing substantial spatial variation. Over half of the wards were classified as poor to very poor. Higher disease incidence was observed in wards with lower water quality. Correlation analysis indicated a strong positive relationship between deteriorating water quality and increased disease incidence, highlighting the direct health impact of polluted water.

Conclusion: Water pollution is a major determinant of public health in Lucknow. Enhancing wastewater treatment, upgrading water infrastructure, and integrating water quality monitoring with health surveillance are essential. Sustainable urban water management policies are urgently needed to reduce disease burden in growing cities.

Key-words: Water Pollution, Water Quality Index (WQI), Waterborne Diseases, Urbanization, Lucknow

INTRODUCTION

Safe drinking water is widely acknowledged as a primary determinant of human health. However, rapid urbanization, population growth, and inadequate environmental management have significantly compromised water quality in many Indian cities.

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Lucknow, the capital city of Uttar Pradesh, exemplifies these challenges [1]. In recent decades, unchecked urban expansion, growing industrial activity, and mounting infrastructural stress have resulted in escalating water contamination and consequent threats to human health. Contaminated surface water, deteriorating groundwater quality, and aging water distribution systems have collectively intensified exposure to biological and chemical pollutants among the city's residents [2].

The Gomti River, the principal surface water source for Lucknow, has been substantially degraded due to the persistent discharge of untreated and partially treated sewage, solid waste dumping, and urban runoff [3]. Studies conducted in the last decade report elevated biochemical oxygen demand (BOD), reduced dissolved oxygen (DO), and high concentrations of faecal coliforms in the river, particularly within urban stretches [4]. Such conditions make the river water unsuitable for domestic use without extensive treatment and increase the risk of microbial contamination in municipal supplies. In addition to surface water pollution, groundwater—widely used for drinking in peri-urban and low-income areas—has been polluted by nitrates, heavy metals, and pathogens due to leaching from sewage lines, septic tanks, and waste disposal sites [5].

The health implications of polluted water in Lucknow are both acute and chronic. Microbiologically contaminated water is a major cause of waterborne diseases such as diarrhoea, typhoid, cholera, hepatitis A, and dysentery. According to the World Health Organization, unsafe drinking water remains a leading contributor to communicable diseases in urban India, disproportionately affecting children, the elderly, and economically marginalized populations [6]. Recurrent outbreaks of gastrointestinal illnesses reported in several localities of Lucknow reflect the persistent vulnerability created by compromised water quality and inadequate sanitation infrastructure.

Beyond infectious diseases, chemical contamination of water presents long-term health risks. Research conducted in urban regions of northern India, including Lucknow, has identified elevated levels of arsenic, iron, fluoride, and other heavy metals in groundwater sources. Prolonged exposure to these contaminants is associated with neurological disorders, renal impairment, skeletal fluorosis, cardiovascular diseases, and developmental effects in children [7]. Such long-term health consequences are often insufficiently diagnosed, which further amplifies the hidden disease burden linked to water pollution.

Government bodies have acknowledged these challenges and initiated programs such as the Jal Jeevan Mission, Swachh Bharat Mission, and continuous water quality monitoring by the Central and State Pollution Control Boards. While these initiatives have improved access to piped water and sanitation, significant gaps persist in wastewater treatment capacity, infrastructure maintenance, and enforcement of environmental regulations in Lucknow [8]. As a result, the health impacts of water pollution continue to undermine urban sustainability and quality of life.

MATERIALS AND METHODS

Study Area- The study was conducted in Lucknow city, the capital of Uttar Pradesh. The city was divided into 5 zones, and data was collected from each. This study adopted a mixed-methods research design.

Data Sources- Both primary and secondary data were utilized. Primary data were collected through structured household surveys in wards categorized into high-, medium-, and low-exposure zones based on their proximity to polluted water sources. A structured questionnaire was used to collect information on drinking water sources, water treatment practices, frequency of water supply interruptions. Informal interviews with local healthcare workers and municipal officials provided contextual insights into disease patterns and water management challenges. Secondary data was obtained from reports published by the Uttar Pradesh Pollution Control Board (UPPCB) and Central Pollution Control Board (CPCB), including parameters such as pH, turbidity, total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), faecal coliform, and selected heavy metals. Health data related to waterborne diseases (e.g., diarrhoea, typhoid, hepatitis A) were collected from district health records, National Health Mission (NHM) reports, and peer-reviewed journal articles. Census data and municipal records were used to analyze demographic and socio-economic characteristics. A stratified random sampling method was employed to ensure representative coverage of different socio-economic and environmental conditions.

Water Quality Assessment- Water quality indicators were analyzed using secondary monitoring data and compared with Bureau of Indian Standards (BIS 10500:2012) and World Health Organization (WHO) drinking water guidelines. A Water Quality Index (WQI) was calculated to classify water sources as excellent, good, poor, and unfit for drinking. This index facilitated spatial comparison of water quality across different zones of the city.

Health Impact Assessment- Health impacts were assessed by correlating water quality parameters with the prevalence of waterborne and water-related diseases. Descriptive statistics were used to identify disease patterns, while correlation analysis helped examine associations between contaminated water exposure and reported health outcomes.

Ethical Considerations- Informed consent was obtained from all survey participants, and confidentiality of personal health information was strictly maintained. The study adhered to ethical guidelines for social and public health research, ensuring voluntary participation and anonymity.

Data Analysis- Quantitative data were analyzed using statistical software to generate frequencies, percentages, and correlation coefficients. Qualitative interview responses were analyzed to identify recurring issues related to water access, perceptions of water quality, and health risks. Geographic variation in water quality and disease prevalence was examined using ward-level comparisons.

Level of Significance- Statistical significance was tested at $p<0.05$, ensuring that observed associations were unlikely to have occurred by chance.

WQI Classification- The Water Quality Index (WQI) values were classified into different categories to assess the suitability of drinking water (Table 1). Lower WQI values represent better water quality, while higher values indicate increasing levels of contamination. Based on the calculated WQI, water quality was categorized as excellent, good, poor, very poor, and unsuitable for drinking, facilitating comparison of water quality status across different wards of Lucknow.

Table 1: Interpretation of calculated WQI values

WQI Range	Water Quality Status
0–25	Excellent
26–50	Good
51–75	Poor
76–100	Very Poor
>100	Unsuitable for Drinking

RESULTS

The Water Quality Index (WQI) was calculated for selected wards of Lucknow to assess the suitability of drinking water. The computed WQI values ranged from 33 to 91, indicating considerable spatial variation in water quality across the city. Wards located near the Gomti River and major sewage drains recorded comparatively higher WQI values, reflecting poor to very poor water quality. In contrast, wards with relatively better infrastructure showed lower WQI values.

Table 2 presents ward-wise WQI values and corresponding water quality categories. Nearly 50% of the sampled wards fell under the poor or very poor water quality categories, indicating that a significant proportion of the population is exposed to unsafe water conditions.

Table 2: Ward-wise Water Quality Index (WQI) in Lucknow

Ward	WQI Value	Water Quality Category
Alambagh	86	Very Poor
Chowk	78	Very Poor
Gomti Nagar	41	Good
Indira Nagar	58	Poor
Aminabad	91	Very Poor
Rajajipuram	65	Poor
Hazratganj	49	Good
Jankipuram	36	Good

Fig. 1 shows ward-wise variation in Water Quality Index (WQI) across Lucknow. Higher WQI values, indicating poor to very poor water quality, are observed in older and densely populated wards, while planned residential areas exhibit comparatively better water quality.

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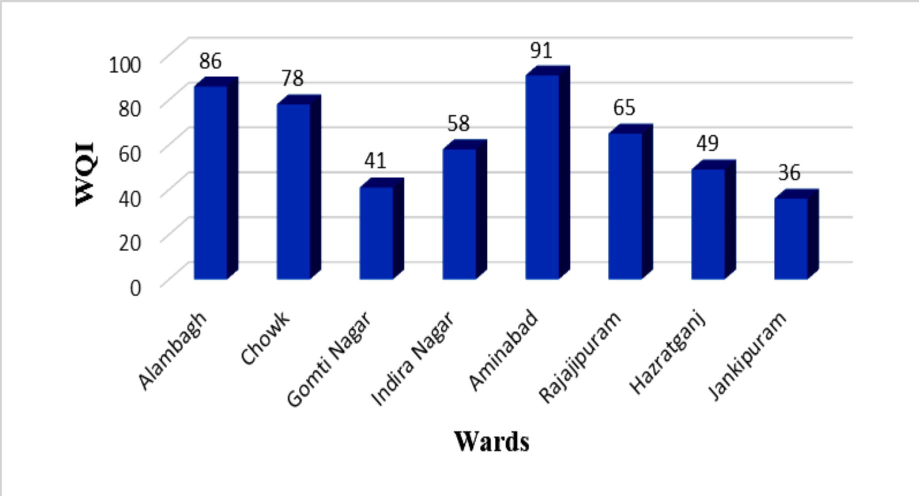

Fig. 1: Ward-wise Water Quality Index in Lucknow

Ward-wise analysis of health data revealed that the incidence of waterborne diseases varied from 14 to 52 cases per 1,000 population. Higher disease incidence was recorded in wards with poor water quality, particularly Aminabad and Alambagh, where frequent cases of diarrhoea, typhoid, and gastroenteritis were reported. In contrast, wards with better WQI values showed comparatively lower disease incidence (Table 3).

Table 3: Ward-wise Disease Incidence

Ward	Disease Incidence (per 1,000 population)
Alambagh	49
Chowk	41
Gomti Nagar	19
Indira Nagar	27
Aminabad	52
Rajajipuram	33
Hazratganj	22
Jankipuram	14

Fig. 2 depicts the relationship between Water Quality Index (WQI) values and the incidence of waterborne diseases across selected wards of Lucknow. The figure shows that wards with higher WQI values, indicating poorer water quality, report a greater incidence of waterborne diseases such as diarrhoea and typhoid. This trend highlights a clear positive association between deteriorating water quality and increasing health risks among the urban population.

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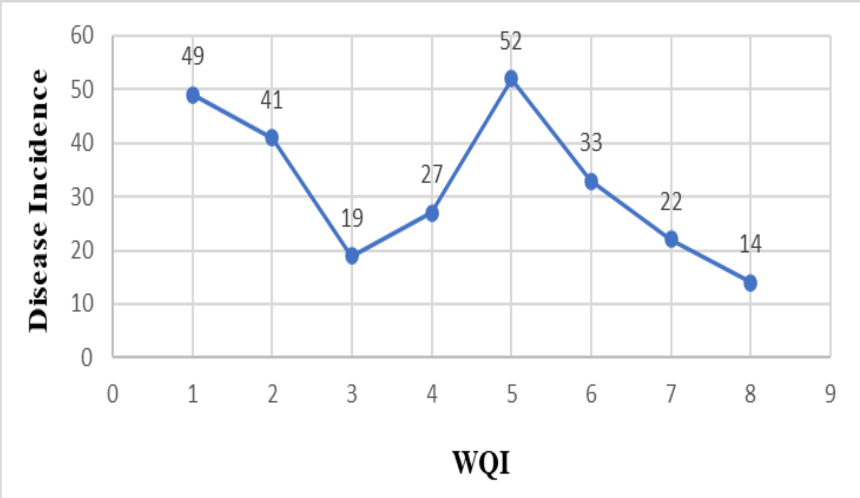

Fig. 2: Relationship between Water Quality Index and Disease Incidence in Lucknow

DISCUSSION

The present study's findings align with a growing body of evidence indicating that urban water pollution significantly undermines public health [9]. The high-Water Quality Index (WQI) values recorded in multiple wards of Lucknow indicate persistent contamination resulting from untreated sewage, industrial effluents, and deficient wastewater management [10-12]. Physical and chemical analyses of the Gomti reveal critically low dissolved oxygen and high biochemical oxygen demand, indicating degraded water quality unsuitable for human use and favorable for pathogen proliferation [13,14].

Such degraded water quality facilitates the transmission of waterborne pathogens, contributing to both acute and chronic health outcomes [15,16]. Global assessments show that over 80% of untreated sewage entering surface waters is linked to more than fifty diseases, including diarrhoea, typhoid, and skin infections, disproportionately affecting children and vulnerable populations [17,18]. In India, research from the Gomti Basin indicates substantial microbial contamination alongside elevated heavy metal levels, collectively contributing to non-carcinogenic health risks above permissible standards [19,20].

The strong positive correlation between deteriorating WQI and disease incidence observed in this study corroborates these findings, reinforcing poor water quality as a key determinant of urban health burdens in Lucknow [21,22]. Rapid urban expansion often outpaces infrastructure development, leading to leakage and cross-contamination between sewage and drinking water systems, a vulnerability also reported in other Indian cities [23].

Interventions such as improving sewage treatment, enforcing water quality standards, and community-based monitoring are essential to mitigate public health risks. Integrated management combining water quality monitoring with health surveillance can further enhance early detection and prevention of waterborne diseases [24].

CONCLUSIONS

This study demonstrates that water pollution in Lucknow, driven by untreated sewage discharge, aging distribution systems, and inadequate wastewater treatment, poses a serious threat to public health. Elevated exposure to microbial and chemical contaminants increases the risk of waterborne and chronic diseases among urban residents. Strengthening sewage treatment infrastructure under national initiatives such as the Namami Gange Programme and ensuring that all major drains are connected to functional treatment plants are critical. Regular water quality monitoring, transparent public reporting, and integration of water surveillance with health data are essential to reduce disease burden and support sustainable urban water management. Future research should adopt longitudinal designs and high-resolution spatial mapping to identify emerging contamination hotspots and vulnerable populations.

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Final approval- Dr. Baldeep Singh, Dr. Shubhra Chowdhry

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