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Water Quality Index for Drinking Water in Amroha, Uttar Pradesh, India

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Abstract
In this study was conducted to evaluate the quality of groundwater and determine its suitability for domestic as well as irrigation use. Since water quality is directly related to human health, it remains a critical concern for society. Groundwater holds significant importance as it serves as the primary source of drinking and irrigation water across much of India. In this study, the Water Quality Index-WQI for groundwater used for drinking in Amroha was determined across ten different locations, based on measured physico-chemical parameters and WHO water quality guidelines. The results indicate that groundwater at most sites is severely polluted, with a few locations showing moderate pollution, and only one site meeting the criteria for safe human consumption. Residents relying on this water are likely exposed to serious health hazards from contamination. The findings underline the vital necessity for implementing effective groundwater management policies, routine monitoring, and public awareness initiatives to ensure a safe as well as sustainable water supply in study region.
Keywords: *WQI, underground water, quality rating*

INTRODUCTION

In many developing countries, groundwater is an essential source for domestic, agricultural, and industrial purposes. However, contamination from landfill sites has become a significant global issue, contributing to the pollution of air, water, and soil. Poorly managed landfill waste presents serious threats to human health, causing illnesses, disabilities, and even deaths, while also impeding economic growth and development across several developing nations. In numerous Asian countries, this issue is intensified by inadequate financial resources, poor administrative management, and a lack of sufficient technical expertise within municipal bodies and government authorities (Khan 2015). Contemporary waste management prioritizes the use of sanitary landfills—specially engineered sites aimed at protecting groundwater from contamination. However, in India, more than ninety percentage of municipal solid waste (MSW) continues to be dumped on land in a poorly managed and unregulated manner. The management of MSW remains a critical challenge globally, including in India, driven by increasing waste generation, rising disposal expenses, environmental and health risks, decreasing landfill space, changes in regulations, climatic conditions, and shifting public perceptions. According to data from the Central Pollution Control Board (CPCB) and the Indian Infrastructure Report (IIR), India currently generates between forty and fifty five million tons of municipal solid waste (MSW) each year. Projections indicate that this figure could escalate to approximately 270 million tons annually by the year 2047 (CGWB 2018). The quality of groundwater is just as critical as its availability. Poor water quality can negatively impact both plant growth and human health, leading to reduced agricultural productivity, a decline in the agrarian economy, and slower improvements in rural living standards. Potable water refers to water that is free from harmful chemicals and disease-causing microorganisms, yet the majority of rural populations lack access to such safe water for domestic use (Ekbal 2022). Across numerous parts of India, the quality of groundwater has declined like rapid population expansion in addition to accelerated urban development. Within rural areas, groundwater is often used directly—without adequate treatment—for drinking and agricultural purposes throughout much of the year (Rastogi 2024). Contamination can also occur through natural processes such as rock weathering, as well as from agrochemicals applied for irrigation. India possesses a wealth of diverse natural resources, with water being among the most essential. It is one of nature's most extraordinary, plentiful, and valuable substances. Of all the elements vital for the survival of humans, animals, and plants, water is of paramount importance. While humans can survive for days without food, life without water is impossible (Sinha 2006).

Environmental degradation observed today is the outcome of various factors, with human activities being the most significant contributor. It is universally recognized that clean water is crucial for sustaining good health. Every individual on Earth requires a sufficient provide of fresh, safe with uncontaminated drinking water as a essential necessity. However, issues related to drinking water contamination, conservation, and quality management have become increasingly complex. Addressing water pollution and implementing effective management strategies is now an urgent priority due to its profound and far-reaching impacts on human health (Goldman 1983).

In the present era, industrial, domestic, and agricultural waste is being discharged into groundwater reserves at an alarming pace. Once groundwater becomes contaminated, restoring it to its original quality is often highly challenging, and in many cases, nearly impossible (Herojeet 2017). As groundwater pollution is generally irreversible, it is far more effective to focus on preventing contamination in the first place rather than depending solely on technological solutions to purify water from already polluted sources (Khan 2017).

Amroha, a ‘C’ rank city located in western UP, recorded a population of over 19 lakh as 2011 Census. Geographically, the district is located west of Moradabad, sharing borders with Meerut, Hapur, Sambhal, and Bulandshahr. It comprises 1133 villages, 4 tehsils, 8 development blocks, and 11 police stations, covering an area of 2470 sq. km. The district lies between latitudes 28°54’ N and 39°6’ N, and longitudes 78°28’ E and 78°39’ E, with elevations ranging from 177 ft to 240 ft above sea level. To the north is Bijnor district, while Sambhal tehsil of Moradabad lies to the south, and Moradabad Sadar tehsil is to the east. The western boundary is shared with Meerut, Ghaziabad, and Bulandshahr districts, separated by the Ganga River. In recent decades, Amroha has experienced rapid industrialization and significant population growth. However, certain industries in the region have been contributing to groundwater pollution in study region, highlighting the urgent need for remedial measures and strict water quality management (Verma 2020).

Agriculture forms the primary livelihood for most residents of the district, supplemented by various cottage industries. Notable among these are the production of dholaks and katholis, along with traditional handloom work in Amroha. In Naugaon Sadat, beedi manufacturing is a key occupation, while cloth weaving has gained prominence in Bachraun. Additionally, dairy farming and milk-based products are drawing increasing interest in rural areas, with many villagers engaging in these activities through cooperative societies. The district’s climate resembles that of other regions in Uttar Pradesh located at the foothills of the Himalayas—hot during the summer months, and dry and cold in winter. The Ganga, Baha, and Krishna rivers serve as the major water bodies flowing through the district (Kumar 2023).

The Water Quality Index-WQI is a widely recognized as well as efficient tool for conveying information about water quality. It offers a easy, consistent, with reproducible assess that helps policymakers and concerned stakeholders understand the status of water quality (Kumar 2021). As a result, it serves as an essential factor for the estimation along with management of water. WQI is ranking system that reflects combined influence of multiple quality parameters along with indicates whether surface water is fit for human consumption. It is regarded as one of the most reliable methods for assessing overall water quality. Calculated WQIs have been extensively used to represent the quality of water from various sources. The computation of WQI is based on measured quantitative values of parameters compared with the corresponding WHO standards (Horton 1965; Tiwari 1985). The present study focuses on evaluating quality of drinking water at Amroha.

This work aims to examine the quality of drinking water in Amroha, Uttar Pradesh, by analyzing seasonal variations using mathematical and statistical methods. By employing a systematic and analytical approach, it seeks to identify the influence of monsoon rainfall on various water quality parameters, including physical, chemical, and biological properties (Kumar 2022). This assessment is vital for recognizing potential public health risks, ensuring water safety, and recommending effective water management measures for the region (Ouyang 2005). The incorporation of mathematical modeling highlights a precise, data-driven evaluation, offering evidence-based insights to help stakeholders enhance monitoring and management of water quality during monsoon-affected periods (Selvam 2014).

MATERIAL AND METHODS

Water samples were collected from IM2-India Mark-II hand pumps situated at ten locations across Amroha district for analysis. The evaluation of physico-chemical water quality parameters was conducted following standard methods and procedures (APHA 1998, Manahan 1994). Unless stated otherwise, all chemicals utilized for the examination were of Analytical Reagent (AR) mark. At each location, three individual samples were gathered and analyzed, with the arithmetic mean of the results recorded. Additionally, a blank sample was examined for completely volumetric titrations to maintain accuracy. The instruments employed included a Century CP 901 pH meter, an RI Conductivity meter, and a Hach 2010 spectrophotometer (version 6.4). The parameters measured in this study and a concise description of the sampling sites is provided in Table 1.

The concept of the general Water Quality Index (WQI) was initially introduced by Brown et al. (1970) and subsequently improved by Deininger for the Scottish Development Department in 1975. Prior to this, Horton (1965) suggested that several water quality measurements could be consolidated into a single comprehensive index. The WQI is a well-established and effective approach for expressing water quality, offering a clear, consistent, and repeatable measure that efficiently communicates water quality information to policymakers as well as the general public. This makes it a crucial tool for assessing and managing surface water resources. This index represents a combined rating that encapsulates the overall influence of multiple water quality parameters and is primarily calculated to assess the suitability of water for human consumption (WHO 1984). Based on the measured parameter values and WHO guidelines (WHO 2004), the WQI for drinking water at all sampling locations was determined using the procedure outlined by Sinha and Kumar (Kumar, 2008). The rating scales for each parameter were determined according to their ideal values, considering the significance and impact of each parameter on the overall quality of underground drinking water. Certain parameters, although present, may not play a decisive role in determining water quality; hence, they were assigned a value of zero. The WQI was assessed using following formulas:

1. The quality rating, $Qn = 100[(Vn - Vi) / (Vs - Vi)]$

Vn is actual value of n^{th} parameter, Vi is its ideal value, and Vs is its standard

2. For different parameters, the unit weight (Wn) is inversely proportional to the standard-Sn, for that parameter.

K/Sn = Wn, K is a constant, Sn is the suggested standard, and Wn is 1.

3. Water Quality Index-WQI is obtained through computing arithmetic mean of the individual sub-indices. $\text{antilog}_{10} [Wn \log_{10} Qn] = WQI$

Drinking water quality is evaluated through calculation of the WQI, which represents cumulative impact of different physico-chemical parameters on its overall condition (Kumar, 2010). To evaluate the degree of pollution or the status of underground drinking water, specific assumptions are applied, based on insights derived from various water pollution research studies (Kumar 2022). The key assumptions are as follows:

Values of WQI	Level of Contamination
0 to 50	Good Quality
51 to 80	Moderate
81 to 100	Excessive
More than 101	Severe

RESULTS AND DISCUSSION

Table-2 provides the assessed values of underground drinking water quality for each site and parameter, while Table-3 lists the corresponding W.H.O. standards along with the assigned unit weights for each one. The map of sampling sites in Figure 1-2. The final site-wise Water Quality Index values are shown in Table-4. A thorough analysis of index results in Table-4, when compared by the standard reference assumptions, reveals important observations regarding the severity and characteristics of drinking water contamination in Amroha during the assess period. During the assessment, WQI in the study region was found to range between 19 and 262. The highest WQI was recorded at site III, while the lowest was observed at site XII. Most sites exhibited severe pollution, with WQI values exceeding 100. Groundwater at site XI was identified as moderately polluted, while just one location met the criteria for safe human consumption according to its WQI value.

CONCLUSION

The findings indicate that drinking water in Amroha is heavily contaminated at most sampling sites, with only a single location exhibiting moderate pollution. In summary, the groundwater in the assessment region is significantly polluted in addition to unfit for both drinking consumption with domestic purposes. Recorded on analyzed parameters, the findings confirm that the water is significantly degraded. Residents relying on this source are likely exposed to serious health risks from contaminated water. Immediate and stringent measures for effective water quality management in Amroha are essential. This research reinforces the effectiveness of WQI as reliable technique for evaluating water quality.

The findings highlight the pressing necessity for robust water quality management measures, encompassing routine monitoring, the adoption of advanced treatment technologies, and stringent control over pollution sources. Additionally, raising public awareness through targeted campaigns is vital to encourage safe water usage practices. Swift action is imperative to mitigate health risks and guarantee a reliable supply of clean and safe drinking water for the people of Amroha.

The outcomes show that present condition of groundwater in the region poses serious health hazards for residents who depend on it for everyday needs. Pollution from both natural and human-induced sources worsens the situation, calling for immediate action to address water quality challenges. Implementing effective groundwater management strategies—such as consistent monitoring, advanced purification techniques, and public awareness programs on safe water usage—is essential to reduce risks and ensure the availability of clean, drinkable water. This study emphasizes the critical role of sustainable water resource management in protecting public health and meeting the community's long-term water demands.

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Table-1: Sampling details

Site Number	Site Number & Name	Noticed Activity	Evident Water Quality
1	Amroha Block	Drinking & Bathing	Pale yellow on standing, odourless
2	Tehsil Amroha	Drinking & Bathing	Colourless, odourless
3	Railway Station	Drinking, Washing & Bathing	Pale yellow on standing, odourless
4	Joya Chouraha	Drinking & Bathing	Pale yellow on standing, foul smell
5	Samaj Kalyan Office	Drinking, Washing & Bathing	Colourless, odourless
6	RTO Office	Drinking, Washing & Bathing	Colourless, odourless
7	District Court	Drinking & Bathing	Colourless, odourless
8	Nagar Palika Parishad	Drinking & Bathing	Pale yellow on standing, odourless
9	Collectrate Amroha	Drinking & Bathing	Colourless, odourless
10	Roadways	Drinking & Bathing	Colourless, odourless

Table-2: Estimated values for water quality parameters by site

S.No.	Parameters	Units	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
1	pH	-	7.74	7.64	7.93	7.71	7.36	8.03	7.83	7.57	7.62	7.47
2	Conductivity	μS/cm	0.783	0.793	0.972	0.534	0.504	1.012	1.011	0.641	0.545	0.440
3	Total Hardness	ppm	354	382	555	322	337	453	537	343	357	322
4	Calcium	ppm	265	290	457	285	294	415	499	257	286	268
5	Chemical Oxygen Demand	ppm	29	25	52	19	22	43	42	37	33	36
6	Biological Oxygen Demand	ppm	21	18	27	17	15	26	29	18	15	15
7	Alkalinity	ppm	236	239	301	182	226	322	283	165	187	312
8	Chloride	ppm	62	84	167	83	67	154	175	75	87	69
9	Total Dissolved Solids	ppm	714	685	797	708	694	807	794	687	677	712
10	Fluoride	ppm	0.33	0.55	0.64	0.32	0.23	0.54	0.43	0.22	0.12	0.19

Table-3: WHO standards, parameters, and unit weights (Wn)

S.No.	Parameters	WHO standard	Assigned Unit

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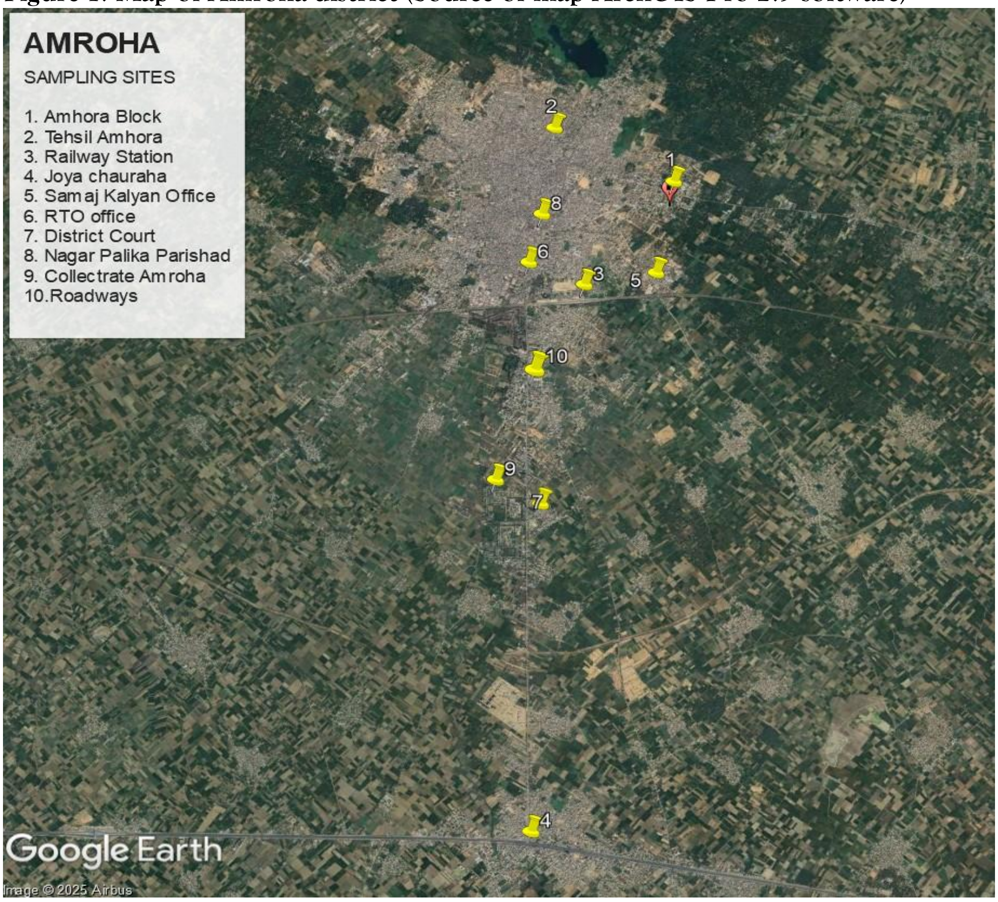
			Weights (W_n)
1	pH	7.0-8.5	0.017619
2	Conductivity(μS/cm)	0.300	0.469792
3	Total Hardness (ppm)	100	0.001408
4	Calcium (ppm)	100	0.001408
5	Chemical Oxygen Demand (ppm)	10	0.014094
6	Biological Oxygen Demand (ppm)	6	0.023486
7	Alkalinity (ppm)	100	0.001408
8	Chloride (ppm)	200	0.000703
9	Total Dissolved Solids (ppm)	500	0.000282
10	Fluoride (ppm)	1	0.469792

Table-4: Values of water quality index (WQI)

Site Number	Name of Site	Water Quality Index (WQI)
1	Amroha Block	171
2	Tehsil Amroha	209
3	Railway Station	262
4	Lakra Square	137
5	Hasanpur Bus Stop	107
6	Dhanora Bus Stop	247
7	District Court	218
8	Nagar Palika Parishad	126
9	Collectrate Amroha	83
10	Roadways	19

Figure-1: Map of Amroha district (Source of map ArchGIS Pro 2.9 software)



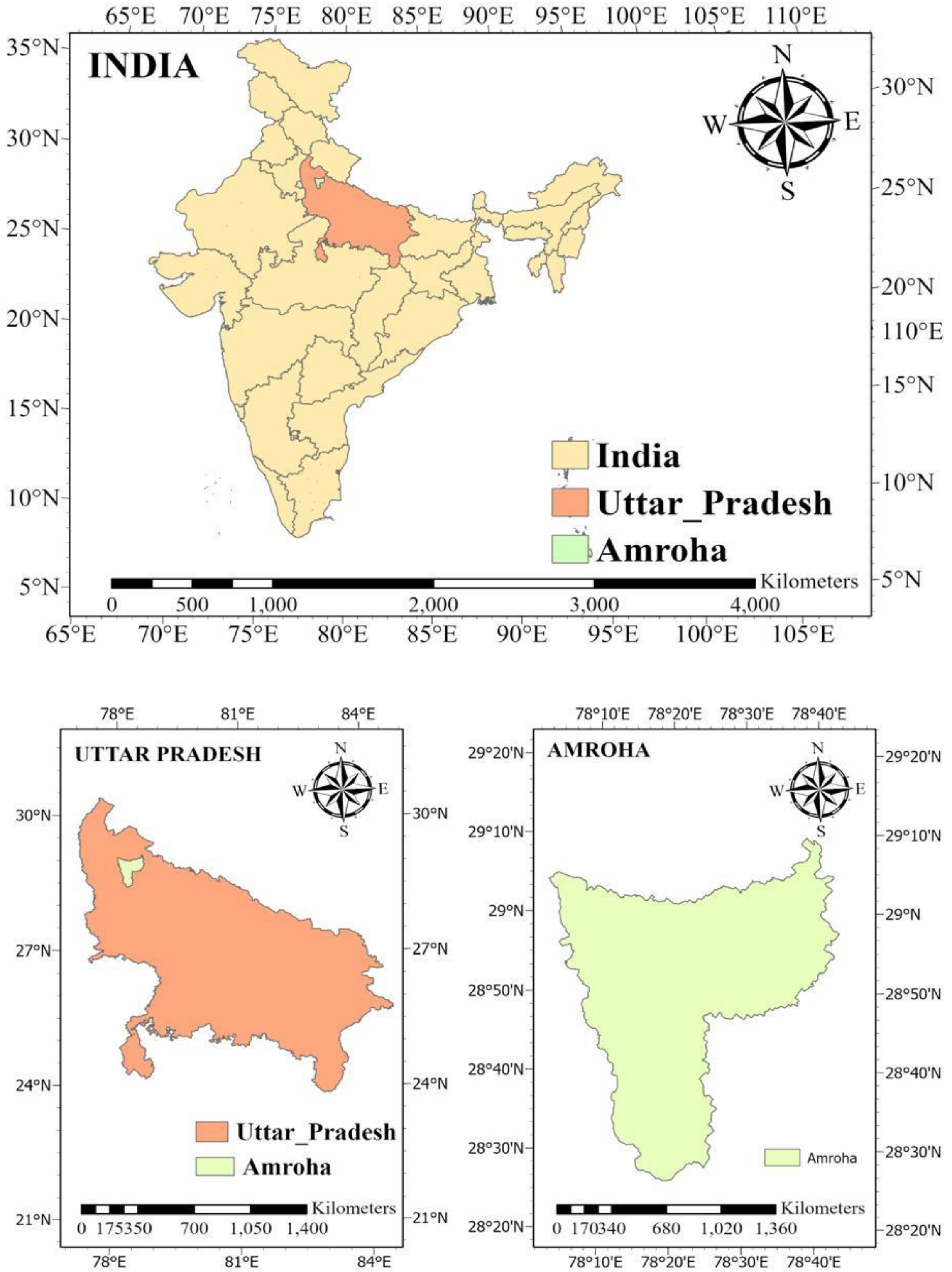


Figure-2: Map of sampling sites in Amroha district (Source of map Google Earth and ArchGIS Pro 2.9 software)