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Assessment of Groundwater Quality at Kanpur City

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***Abstract* - This research evaluates groundwater quality in Kanpur City by analyzing test data from manual pumping stations in various places. Groundwater quality must be evaluated as it affects its suitability for human consumption. The Quality of groundwater can be assessed in terms of the Water Quality Index (WQI) and used to assess the acceptability of groundwater for drinking and other applications. The goal of this study was to determine the water quality in the designated areas of Kanpur to address the physicochemical properties of groundwater and evaluate its appropriateness for drinking. Throughout the summer and winter of 2023–2024, water samples from handpumps will be gathered and examined at specified sampling locations. Comparing the parameter concentrations in a few chosen places to the Bureau of Indian Standards (BIS), it was discovered that they were within an acceptable range. To calculate WQI, a variety of physicochemical parameters were tested, including pH, total decomposed solids (TDS), chloride, hardness, and nitrate levels. Using BIS 10500: 2012 Techniques, the calculated WQI values for Azad Nagar, Gurudev, Bithoor Road, and Vishnupuri are 35, 33, 38, and 50 correspondingly, suggesting that the groundwater quality falls within the range of appropriate for drinking. The analysis's result is that all of the chosen places' groundwater quality falls into the "good" category. The results demonstrate that groundwater quality varies greatly among selected locations, with some regions having water that is safe to drink and use.**

Keywords: Groundwater quality, Water Quality Index (WQI), Handpump, Physicochemical parameters, Kanpur City.

1. INTRODUCTION

Groundwater is extremely crucial for the lives and associated functions of the earth. About 70% surface of the Earth is covered by water, with 97% as salt water and the remaining 3% as fresh water (Gupta, R., et. al., 2019). Groundwater is natural source of our life support system. Groundwater is stored in subsurface geological formations and it occurs in the zone of saturation and it takes part in the global or basin hydrological cycle. In India there has been a tremendous increase in the demand for groundwater due to rapid growth of population, accelerated pace of industrialization and urbanization. The groundwater quality also varies with depth of water, seasonal changes, leached dissolved salts and subsurface environment (Ram, A., Tiwari, 2020).

According to the World Health Organization (WHO 2017), about 80% of all the diseases in human beings are water-borne. Once the groundwater is contaminated, it is difficult to ensure its restoration and proper quality by preventing the pollutants. It, therefore, becomes imperative to monitor the quality of groundwater regularly, and to device ways and means to protect it from contamination (Arjun Ram et al., 2021). The quality of groundwater is deciphered using various physical, chemical and biological characteristics of water. It is a measure of health and hygiene of groundwater concerning the need and purpose of human consumption.

In this study, the physicochemical properties of four groundwater samples collected from hand pumps were determined and compared with national standards of BIS for drinking and domestic uses based on Water Quality Index (WQI). Water has been playing a major role in development of human civilization, Industrialization and urbanization. Over 97% of all the water an earth is salty and most of the remaining 3% is frozen in the polar ice caps (Gupta, R., et. al., 2019).

Groundwater is an important natural resource. It is the largest reservoir of fresh water available on earth which is being continuously exploited due to increase in population especially in developing countries. Ground water is used for domestic, agriculture and industrial purposes in most of the part of the world (Karunakaran et al., 2009). Keeping in view of the pollution effects and its risk management to the ecosystem, it is very essential to monitor the impact of industrial effluents on ground water quality (Agrawal et al., 2016). Groundwater is the major source of drinking water in both urban and rural areas. Ground water has become a scarce commodity due to over exploitation and pollution of water. Groundwater provides drinking water for more than 80 cities(Agrawal et al., 2016). It is also used to irrigate crops, provide drinking water for stock and to support industry. Contamination of drinking water has become a major concern to the Environmentalist in the developing countries. Due to this pollution load sustained over long periods. Water is drawn from the ground for a variety of uses, principally community water supply, farming (both livestock and irrigated cultivation) and industrial processes (Chilton, 1996).

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Groundwater contamination can be classified as having either natural or anthropogenic sources. Natural groundwater contamination is mainly due to geological formation with shallow groundwater mass (water–rock interaction in cold waters), infiltration from low-quality surface water bodies (streams, rivers, lakes), seawater intrusion, or due to the effect of geothermal fluids (water– rock interaction in hot waters). Anthropogenic groundwater contamination is generally ascribed to extreme use of agricultural pesticides and fertilizers, mining wastes, disposal of industrial wastes, waste disposal sites, and imperfect well construction (Alper and Gokmen, 2011). Ground water quality has become an important water resource issue due to rapid increase of population, rapid industrialization, unplanned urbanization, flow of pollution from upland to lowland, and too much use of fertilizers, pesticides in agriculture (Joarder et al., 2008). Human and ecological use of ground water depends upon ambient water quality. In India, most of the population is dependent on ground water as the only source of drinking water supply (Murhekar and Krushna 2011). India accounts for 2.2% of the global land and 4% of the world water resources and 16% of the world population. It is estimated that one third of the world's population use groundwater for drinking (Pawari and Sagar 2015). Now days, the expanding danger to groundwater quality because of human action has turned into the matter of great concern. Presently a day the ground water potential and its Quality level in significant urban communities and urban focuses is getting crumbled because of the blast of population, urbanization, industrialization, disappointment of storm and inappropriate administration of rain water. Not just ground water, soil is additionally sullied by human and industrial activities due to dumping of solid waste and industrial effluent. Waste water is being used for the irrigation of edible plants and is a matter of concern due to the presence of pollutants particularly toxic metals (Barman et al., 2000). The over exploitation of groundwater in some parts of the country induces water quality degradation (Mondal et al., 2005). Contamination of drinking water may occur by percolation of toxics through the soil to ground water (Khan and Shivastava, 2012). Pollutant discharge causes widespread organic pollution, toxic pollution, and eutrophication, along with severe ecological destruction (Miao et al., 2012). Approximately 190 million people fall ill and 60,000 people die from a range of other diseases and injuries associated with water pollution each year (Tao and Xin, 2014). Urbanization and industrialization in India have resulted in deep increase of generation of waste. Due to improper treatment and lack of awareness, waste water is not properly treated and disposed. Most of the industries discharge their effluent without proper treatment into nearby open pits or pass them through unlined channels resulting in the contamination of groundwater (Jinwal and Dixit, (2008). The problem is more crucial in rural cities due to cluster of industries. The strong waste produced from enterprises is being dumped close to the industrial facilities, is subjected to response with permeating precipitation water, and achieves the ground water level. Which make the issue of ground water contamination in a few pieces of the nation. Both surface and subsurface water sources are getting polluted due to developmental activities (Chandra et al., 2014). Industries are responsible for water pollution. Pollution in the soil and water has a lot of adverse effects and thus is of great concern to the public health agricultural production and environment health (Sinha et al., 2006). Treated Industrial and domestic waste water is being used for the irrigation of the agricultural land which contributes significantly towards the contamination of the soil in wastewater receiving area (Sinha et al., 2006). In India, the province of Uttar Pradesh alone in charge of more than half of poisons entering in the river stream because of partially treated effluent drained into river and also used for irrigation. In Uttar Pradesh, Kanpur is biggest mechanical and business focus. Kanpur is one of the important industrial centers in northern India, where more than 800 industries are involved in manufacturing. Kanpur is most contaminated city as a result of huge number of tannery businesses is built up. It is otherwise called Leather city. Pollution becomes acute when tanneries are concentrated in clusters in small area like Kanpur, India (Beg and Ali, 2008). The large number of industries has clearly contributed to the economic growth of Kanpur.

The scope of our study is meticulously designed to investigate the groundwater quality in the urban areas of Kanpur city over a period. Our primary objectives include identifying the presence and concentrations of organic pollutants, and microbial contaminants in selected wells and handpumps (Ramakrishnaiah, C. R., 2009). The geographical focus will be on four locations within Kanpur, chosen for their varying land use patterns and demographic characteristics. We will employ a combination of quantitative and qualitative research methods, incorporating water sampling, laboratory analyses, and interviews with local residents and authorities. The study will exclude industrial areas due to access limitations and will concentrate on residential and agricultural zones. The study's findings are anticipated to contribute valuable insights into the current state of groundwater quality in the selected region, aiding in the formulation of targeted interventions and sustainable water management strategies. Ethical considerations, including participant confidentiality and informed consent, will be rigorously adhered to throughout the research process. The study's significance lies in its potential to inform local authorities, community members, and environmental policymakers about the factors influencing groundwater quality and the necessity for proactive measures to safeguard this vital resource (Ram, A., Tiwari, 2020). The following Objectives were accomplished in this study:

a) To assess the Physico-chemical parameters of ground water of selected location in Kanpur city and to compare them with BIS (10500: 2012) for drinking water purposes.

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b) To calculate the Water Quality Index (WQI) value.

2. STUDY AREA

Kanpur district is a large industrial city located in the central-western part of the Uttar Pradesh in the north. It lies between 25°55' and 27° North latitude and 79°30' and 80°35' East. The major part of the area is almost a flat plain with some minor undulations. The river Ganga and Yamuna with their tributaries form the drainage system. The Kanpur Nagar district is part of Indo Gangetic Plain. The clay, silt, gravel and sands of different grades are main sedimentary constituents.

2.1 Sampling Locations

The present study was carried out at the different locations of area of Kanpur city. The site for the sampling was identified which are mainly used for domestic purposes.

The sampling locations for groundwater quality assessment were strategically selected across the study area to capture variability in hydrogeological conditions and potential sources of contamination. A total of 4 sampling locations were distributed systematically as shown in Figure1, taking into account factors such as proximity to industrial facilities, agricultural areas, and urban centers and the source of sampling was handpump. A total stretch of 11.43 km was found between first and last station. Additionally, existing monitoring wells and boreholes were utilized where available to augment the sampling network. Field observations were conducted at each sampling location to document any relevant land use activities or environmental factors that could influence groundwater quality. Coordinates (latitude and longitude) were recorded using GPS devices to ensure accurate spatial referencing. Accessibility and logistical considerations were taken into account during the sampling process to facilitate safe and efficient data collection. A map illustrating the spatial distribution of sampling locations within the study area is provided for reference. Overall, the sampling strategy employed aimed to provide comprehensive coverage and representative sampling of groundwater quality across different hydrogeological settings and land uses within the study area. The details of sampling location is shown in table1.

Figure 1: sampling locations.

Table 1: Details of Sampling Locations

S.NO.	LOCATION	LONGITUDE	LATITUDE
1	AZAD NAGAR, KANPUR	80.304001	26.501784
2	GURUDEV, KANPUR	80.279638	26.498305
3	BITHOOR ROAD, KANPUR	80.273271	26.525557
4	VISHNUPURI, KANPUR	80.309447	26.502989

3. METHODOLOGY

3.1 Sampling Procedure: -

The ground water samples were collected from handpump within the study area. The method described by (APHA 22nd Edn 2012) were followed during field and laboratory work. Ground water samples were collected in polyethylene bottles. All the sampling bottles were cleaned with diluted HNO_3 then rinsed with tripple distilled water and also rinsed with ground water to be sampled. After collection of samples, some parameters like Temperature, Assessment of ground water quality and its suitability for drinking, pH, Electrical conductivity was determined immediately on sampling site by portable digital meter. After that sampled were preserved in ice box and transported to the laboratory for further analysis (Gupta, R., 2019). Labels were used to prevent sample misidentification. Sample preservation was done in tune with Ground Water Board guidelines with minimum possible time lapse between collection and analysis (UGC Minor Research Project, Dr. P. Sarada). In ground water, Parameters were Total Dissolved Solids, Total Hardness (as CaCO3), Calcium (Ca), Magnesium (as Mg), Total Alkalinity (as $CaCO_3$), Chloride (as Cl), Turbidity and DO. The drinking water quality depends on many physicochemical parameters and their concentrations, which are derived from laboratory tests of water samples. The samples were analyzed for different physicochemical properties as per the Standards methods outlined in (APHA 22nd 2012). The method of parameter analysis and abbreviation as shown in Table 2.

Table 2: Parameter and method of analysis (Nayak et al., 2024 a,b)

S.No.	Parameter	Shorthand	Method of analysis
1	Temperature	Temp.	Thermometer
2	pH	pH	pH meter
3	Conductivity	EC	Conductivity meter
4	Dissolved oxygen	D.O	D.O meter
5	Hardness	TH	Titrimetric
6	Alkalinity	Alkal.	Titrimetric
7	Turbidity	Turb.	Turbidity Meter
8	Chloride	Cl	Titrimetric

APHA (2012) was followed for the analysis of selected parameters for groundwater in the laboratory for the selected locations.

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3.2 WATER QUALITY INDEX

The Water Quality Index (WQI) assesses overall groundwater quality based on multiple parameters. Water Quality Index (WQI) is a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption (Wagh, V. M., et al., 2019). Here, WQI is calculated using weighted arithmetic index method. Assigning weightage to each parameter, it computes a composite score. Parameters include physical, chemical, and biological indicators. The formula involves normalizing individual parameter scores, summing them, and then transforming the sum into an index value. WQI facilitates a comprehensive understanding of groundwater quality, aiding decision-makers in resource management and ensuring water safety for various uses (Ram, A., Tiwari et al., 2020). Weighted Arithmetic water Quality Index wax used for determining the WQI (Brown et.al., 1972, Chandra, D. S. et al., 2017).

Formulae and Steps for Calculating WQI:
Step 1 : Calculate the unit weight (W_n) factors for each parameter by using the formula:

where,

$$W_n = \frac{K}{S_n} \quad (1)$$

$$K = \frac{1}{\frac{1}{S_1} + \frac{1}{S_2} + \frac{1}{S_3} + \cdots \ldots + \frac{1}{S_n}} \quad (2)$$

where,
S_n = standard desirable value for n^{th} parameter.
Step 2: Calculate the Sub-index (Q_n) by using the formula:

$$Q_n = \frac{[V_n - V_0]}{[S_n - V_0]} \times 100 \quad (3)$$

where,
V_n = mean concentration of n^{th} parameter
V_o = actual values of parameter in pure water (generally zero)
but in case of pH = 7 and in case of D.O = 14.6 mg/l
Step 3 : Combining step 1 and step 2, WQI is calculated as ;

$$\text{Overall WQI} = \frac{\sum W_n Q_n}{\sum W_n} \quad (4)$$

Table 3: Standard WQI value and water quality status by (Chandra, D. S. et al., 2017; Nayak et al., 2024a)

WQI Value	Water Quality Status
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
>100	Unfit for consumption

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4. RESULT AND DISCUSSION

To assess the Physico-chemical parameters of ground water of selected location in Kanpur city and to compare them with BIS (10500: 2012) for drinking water purposes**.** The average experimental results derived from the experiments are described in the below tables, namely from Table 4 respectively.

The analyzed water sample of Azad Nagar has an average pH of 6.97 as shown in table 4, suggesting a slightly acidic nature. The average turbidity value is 1.2 NTU of similar location, which does not exceed the recommended value of 5 NTU. The measured EC of groundwater of Azad Nagar in this study area has an average value of 826.56 (µs/cm@20), exceeding the permissible limit. Hence, the concentration of total dissolved solids (TDS) in the groundwater of the area averages 536.90 mg/l (Table 5.1). The average alkalinity of this location is 190.76 mg/l, slightly less than the permissible limit. Total hardness (TH) of the sample is 285.62 mg/l, within the permissible range. The average value of chloride in this station is 27.38 mg/l, indicating a very low concentration of chloride in the sample. The dissolved oxygen (D.O) of the sample is 8.8 mg/l, which exceeds the permissible limit.

The analyzed water sample of Gurudev has an average pH of 6.87 as shown in table 4, suggesting it is more acidic than the Azad Nagar site. The average turbidity value is 0.9 NTU of similar location, and the average concentration of total dissolved solids (TDS) in the groundwater of the location averages 536.90 mg/l, indicating lesser suspended solids in the sample. The measured EC of groundwater in this study area has an average value of 875.72 (µs/cm@20), which exceeds the permissible limit. The average alkalinity of Gurudev area is 241.39 mg/l. Total hardness (TH) of the sample is 296.50 mg/l in this location, which falls within the permissible range. The average value of chloride in this location, which is 27.38 mg/l, indicates a very low concentration of chloride in the sample. The dissolved oxygen (D.O) of the sample is 8.5 mg/l, exceeding the permissible limit.

The analyzed water sample of Bithoor road has an average pH of 7.05 as shown in table 4, suggesting a slightly basic nature. The average turbidity value is 1.10 NTU of same location, which is normal and does not exceed the recommended value of 5 NTU. The measured EC of groundwater in this study area has an average value of 823.36 (µs/cm@20), which exceeds the permissible limit. Hence, the concentration of total dissolved solids (TDS) in the groundwater of the Bithoor road averages 536.90 mg/l (Table 4). The average alkalinity of this area is 276.45 mg/l. Total hardness (TH) of the sample is 259.30 mg/l, which falls within the permissible range. The average value of chloride in Bithoor road, which is 29.72 mg/l, indicates a very low concentration of chloride in the sample. The dissolved oxygen (D.O.) of the sample is 8.4 mg/l, exceeding the permissible limit.

The analyzed water sample of Vishnupuri has an average pH of 7.10 as shown in table 4, suggesting a slightly basic nature. The average turbidity value is 1.2 NTU of Vishnupuri, the same as in the first sample, and does not exceed the recommended value of 5 NTU. The measured EC of groundwater in this study area has an average value of 785.92 (µs/cm@20), which exceeds the permissible limit. Hence, the concentration of total dissolved solids (TDS) in the groundwater of the Vishnupuri area averages 510.90 mg/l (Table 4). The average alkalinity of this area is 263.35 mg/l, slightly less than the permissible limit. Total hardness (TH) of the sample is 290.87 mg/l, which falls within the permissible range. The average value of chloride in Vishnupuri is 30.65 mg/l, indicating a very low concentration of chloride in the sample. The dissolved oxygen (D.O.) of the sample is 8.9 mg/l, which exceeds the permissible limit and is the highest among all samples.

Table 4: Average Analytical values obtained for selected locations

S.No.	Parameter	Average Analytical value				IS (10500: 2012)
		Azad Nagar	Gurudev	Bithoor road	Vishnupuri	
1	pH	6.97	6.87	7.05	7.10	6.5-8.5
2	EC(µs/cm@20)	826.56	875.72	823.36	785.92	300
3	Turbidity (NTU)	1.20	0.90	1.10	1.20	1-5
4	TDS (mg/l)	536.90	568.75	535.18	510.90	500-2000
5	Alkalinity (mg/l)	190.76	241.39	276.45	263.35	200-600
6	Total Hardness (mg/l)	285.62	296.50	259.30	290.87	300-600
7	Chlorides (mg/l)	27.38	31.52	29.72	30.65	250-1000
8	D.O. (mg/l)	8.80	8.50	8.40	8.90	5

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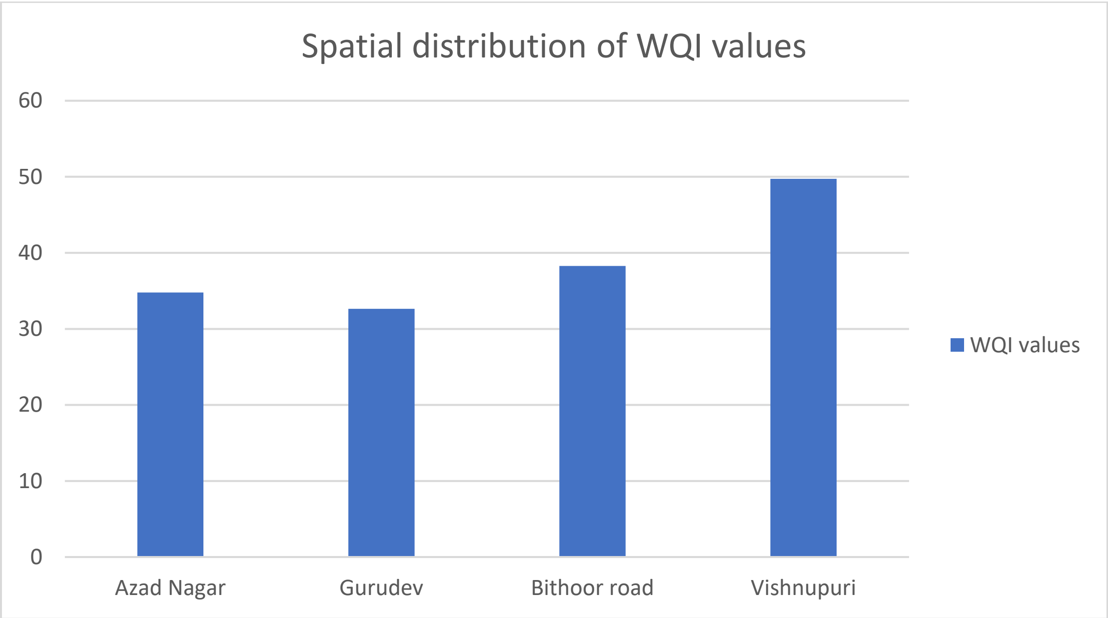
Spatial distribution of WQI values :

The groundwater quality of selected locations of Kanpur for drinking purpose was evaluated through water quality index method. The computed WQI value in the selected locations of groundwater approximately ranges from 33 to 50. The Gurudev area suggesting best quality water whereas the Vishnupuri area having worse quality of water among the selected locations as described in table 5. WQI values of selected locations as shown in Figure 2.

Table 5: Water Quality Index

Sampling Location	**WQI values**	**Water Quality Status**
Azad Nagar, Kanpur	35	Good
Gurudev, Kanpur	33	Good
Bithoor road, Kanpur	38	Good
Vishnu Puri, Kanpur	50	Good

Figure 2: WQI values of selected locations



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