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Original Article

Assessment of Groundwater Quality in Amravati District: Identification of Contaminants, Sources, and Physicochemical parameter Analysis

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Abstract

Groundwater contamination has become a growing concern in the Amravati district, Maharashtra, owing to various anthropogenic activities and natural factors. This study investigated the physicochemical parameters of the groundwater in the region to assess the extent of contamination. The parameters analyzed included pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, nitrate, chloride, fluoride, and heavy metals, such as arsenic, lead, Cobalt, Zinc, and cadmium. A series of groundwater samples was collected from different locations across the Amravati district, representing rural and urban areas. The results revealed that certain areas exhibit contamination above permissible limits for several parameters, particularly nitrate and fluoride, potentially posing health risks to the local population. High TDS and Hardness levels were also observed in some regions, indicating intrusion of poor-quality water. These findings suggest that agricultural practices, industrial discharges, and inadequate waste management systems are significant contributors to groundwater pollution in the region. This study highlights the urgent need for effective water quality monitoring, proper waste disposal practices, and implementation of sustainable agricultural techniques to safeguard groundwater resources in the Amravati district.

Keywords: *Physicochemical, contamination, anthropogenic, intrusion, monitoring*

Introduction

Groundwater is a key source of freshwater for drinking, irrigation, and industries worldwide, especially in developing countries; however, it is regularly challenged by environmental conditions and human activity (1). Almost one-third of the population around the earth drinks from freshwater sources (2). Groundwater is a critical resource in the Amravati district, where agriculture, domestic use, and industrial processes rely heavily rely on it. Over the years, the increasing demand for water, along with improper waste management practices and agricultural runoff, has contributed to groundwater contamination of groundwater. Contaminants such as nitrates, fluoride, heavy metals, and total dissolved solids have been detected in groundwater sources across the district, affecting both the water quality and public health (3).

The primary aim of this research was to evaluate the physicochemical parameters of groundwater in the Amravati district, identify the potential sources of contamination, and determine the impact of these contaminants on human health and the environment. This study paper further explored the relationship between various contaminants and the quality of life in the district (4).

Study Area

The Amravati district, located in the Vidarbha region of Maharashtra, is characterized by an agro-based economy and a rapidly growing urban population.(5) The district is largely dependent on groundwater for irrigation, drinking, and other industrial processes. This research focused on multiple sampling sites across rural and urban areas, ensuring a comprehensive analysis of the groundwater in the region (3). The Wardha River forms the eastern boundary of this district (12). For administrative suitability, The district is divided into 13 talukas:, namely, Amravati,

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Warud, Morshi, Chandur Railway, Tiwsa, Nandgaon, Bhatkuli, Daryapur, Anjangaon, Dharni, Achalpur, Chikhaldara, and Chandur Bazar. It has a total population of 4,014,939 (estimated as per January 2023 data from adharuidai.gov.in). (12)

Data Collection

Groundwater samples were collected from five different locations across Amravati, including wells, boreholes, and hand pumps. The samples were collected during both the pre-monsoon seasons to account for seasonal variations in water quality. Table 1. (Name of Sampling Spot and Code).

Physicochemical Analysis

The physicochemical parameters measured include:
Physical parameters

1. Colour
2. Taste and odour
3. Temperature (Table 2. Physical parameters)

Physicochemical Analysis

1. pH: Indicates the acidity or alkalinity of water.
2. Electrical Conductivity (EC): Reflects the ionic concentration in water.
3. Total Dissolved Solids (TDS): Measures the concentration of dissolved solids.
4. Hardness: Indicates the presence of calcium and magnesium ions.
5. Alkalinity: Alkalinity is a measure of a water body's ability to resist changes in pH
6. Nitrates (NO_3^-): Used as an indicator of contamination from agricultural runoff or sewage.
7. Fluoride (F^-): Elevated fluoride levels can lead to dental and skeletal fluorosis.
8. Phosphate: to help diagnose and evaluate the severity of conditions and diseases that affect the digestive system and interfere with the absorption of phosphate.
9. Chloride: Chloride levels in groundwater are determined to assess water quality, identify potential contamination sources
10. Sulphate: Sulfate was determined in groundwater samples to assess water quality and identify potential problems related to sulfate reduction.
11. Dissolve Oxygen (DO): is the amount of oxygen that is present in water.
12. Biochemical Oxygen Demand (BOD) measures the amount of oxygen consumed by microorganisms as they decompose organic matter in water, indicating the level of organic pollution.
13. Chemical Oxygen Demand (COD) measures the amount of oxygen required to chemically oxidize organic and inorganic compounds, indicating the potential for oxygen depletion and pollution levels.
14. **Heavy Metals**: Arsenic (As), lead (Pb), and cadmium (Cd) were measured because of their toxic effects on human health.

Results and Discussion

Physicochemical Parameters

(Table-5 parameters -hardness, Chloride alkalinity nitrate fluoride phosphate sulphate)

- **pH:** The pH levels ranged from 6.8 to 8.5, which is within the permissible limit for drinking water. However, all the samples were within the permissible limit.
- **Electrical Conductivity (EC):** EC values ranged from 250 to 1,500 µS/cm; all the samples were within the permissible limits.
- **Total Dissolved Solids (TDS):** The TDS levels in the groundwater ranged from 300 to 1,500 mg/L. Some areas showed low TDS levels, indicating salt depletion. (Table-3 pH, E.C., and T.D.S.)
- **Hardness:** Groundwater in Amravati exhibited hardness levels ranging from 56 to 300 mg/L, suggesting low to moderate hardness owing to the presence of calcium and magnesium ions.
- **Alkalinity:** The minimum value of alkalinity was recorded on AD1 (72 mg/L) and the maximum value of alkalinity was recorded on AD 4 (376 mg/L), while the standard values of BIS and WHO were 300–400 mg/L and 200–600 mg/L, respectively.
- **Nitrates:** The minimum value of nitrate was recorded on AD 1 (3 mg/L) and the maximum value was recorded on AD 4(41 mg/L); the standard prescription values of BIS and WHO are 45 and 50 mg/L, respectively, and all the samples were found to be within the permissible limit.
- **Fluoride:** Fluoride concentrations were found to ranged from 1.0 to 2.5 mg/L, with all areas within the permissible limit of 1.5 mg/L, and there were no concerns about dental and skeletal fluorosis.
- **Phosphate:** The sample AD 5 observed value of phosphate below the detection limit, while the other samples observed value was found to be above the standard value of BIS and WHO is 0.1 and 0.1 mg /L respectively
- **Chloride:** The minimum value of chloride was found in the AD 21(16 mg/L) sample, and the maximum was found in the AD4(60 mg/L) sample, all of which were within the permissible limit, while the standard values of BIS were 200–1000 and 200–1000 mg/ L respectively.
- **Sulphate:** The minimum value of sulfate was noted on AD2(8 mg/L), and the maximum value of sulfate was noted on AD4(129 mg/L), while all the water samples were found to be within the limit, the standard value of BIS and WHO was 200.000 mg/L.
- **Dissolve Oxygen (DO):** The minimum value of DO was observed in sample AD5(7 mg/L) and the maximum value was found to be in sample AD1(7 .9 mg/L). The standard value of BIS and WHO is 5.0 to 6.0 mg/, all of whichthe groundwater simple DO was found to be exceed the permissible limit.
- **Biochemical Oxygen Demand (BOD):** The minimum value of **BOD** was calculated in sample AD3(4 mg/L)

and the maximum was found in sample AD2(9 mg/L)), all of whichthe sample exceeded the permissible limit except for sample AD3, which is within the limit of 5 mg/L prescribed by the WHO and BIS.

- **Chemical Oxygen Demand (COD):** All the COD values calculated for the samples exceeded the permissible limit given by WHO and BIS (10 mg /L, indicating that the chemical oxygen demand for all groundwater samples was high. (Table-4 D.O., C.O.D., and B.O.D.).
- **Heavy Metals**: The minimum and maximum trace metal concentrations of Al, As, Ba, Cd, Cr, Cu, Fe, Mn, and Pb in different areas ranged between 0.001 ppm and 0.445 ppm. The chromium concentration level was exceeded in all water samples. The iron limits were even exceeded in the two samples.

Sources of Contamination

The primary sources of groundwater contamination in Amravati district were identified as:

Agricultural Activities: Excessive use of chemical fertilizers and pesticides contributes to high nitrate concentrations.

- Industrial Effluents: Some industrial zones near the district discharge untreated waste into nearby water bodies, which ultimately infiltrates the groundwater.
- Sewage Disposal: Poor sanitation and the disposal of untreated sewage into open drains leads to bacterial contamination and an increase in TDS and nitrate levels.

Health Implications

The presence of Elevated levels of nitrate, fluoride, and heavy metals pose significant health risks. Nitrate contamination can cause methemoglobinemia, particularly in infants. High fluoride levels can cause dental and skeletal fluorosis. Long-term exposure to arsenic and lead is associated with cancer, developmental disorders, and neurological damage.

Conclusion and Recommendations

This study underscores the urgent need for groundwater quality management in the Amravati district. This analysis revealed significant contamination from agricultural runoff, industrial discharge, and inadequate waste management. The following recommendations were made.

1. Sustainable Agriculture: Farmers should be encouraged to adopt organic farming techniques and reduce the use of chemical fertilizers and pesticides.
2. Regular Monitoring: A robust groundwater quality monitoring system should be implemented to track changes in physicochemical parameters over time.
3. Waste Treatment: Proper treatment of industrial and sewage effluents is necessary to prevent contamination of groundwater resources.
4. Public Awareness: Local people must be educated about the dangers of groundwater contamination and the importance of water conservation and safe sanitation practices for today and tomorrow.

The findings indicate that continuous monitoring, effective management practices, and treatment measures are critical for preserving groundwater quality. Thus, this work provides a comprehensive understanding of groundwater quality across diverse aquifers, emphasizing the need for strategic measures to safeguard water safety and sustainability. Future research should focus on exploring advanced water treatment technologies and the effectiveness of different groundwater management strategies for improving the water quality.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Table-1 Name of Sampling Spot and Code

S. No.	Name of Sampling Spot	Code
1	Dharni	AD 1
2	Paratwada	AD 2
3	Chandurbazar	AD 3
4	Varha	AD 4
5	Jarud	AD 5

Physical Parameters

Table-2 Physical Parameters

SAMPLE	COLOUR	TASTE & ODOR	TEMPERATURE
AD1	Colourless	Tasteless and Odourless	24
AD2	Colourless	Tasteless and Odourless	23
AD3	Colourless	Tasteless and Odourless	25
AD4	Colourless	Tasteless and Odourless	23
AD5	Colourless	Tasteless and Odourless	25

Physicochemical Analysis

Table-3 pH, E.C., and T.D.S

Sample code	pH	E.C	T.D.S.
AD1	8.4	385	231
AD2	7.8	523	314
AD3	8.2	819	492
AD4	8	1244	746
AD4	8	605	363

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Table-4 D.O., C.O.D., B.O.D.

Sample code	D.O.(mg/L)	B.O.D.(mg/L)	C.O.D.(mg/L)
AD1	7.9	6	25
AD2	8	9	20
AD3	7.7	4	25
AD4	8	7	27
AD4	7	7	24

Table-5 parameters -hardness, Chloride alkalinity nitrate fluoride phosphate sulphate

Sample code	Ca. Hardness. (mg/L)	Mg. Hardness. (mg/L)	Total Hardness. (mg/L)	Alkalinity .(mg/L)	Nitrate. (mg/L)	Fluoride. (mg/L)	phosphate. (mg/L)	Chloride. (mg/L)	sulphate. (mg/L)
AD1	40	16	56	72	3	0.29	0.14	52	34
AD2	100	124	224	216	10	0.27	0.81	16	08
AD3	132	156	288	26	36	0.15	0.25	36	22
AD4	188	220	408	376	41	0.37	0.14	60	129
AD4	108	100	208	192	33	0.17	--	30	29