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Physico-Chemical Characterization and Quality Assessment of Hand Pump Groundwater: A Case Study

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Abstract

Groundwater is a vital source of drinking water in many urban and semi-urban regions of India, particularly where hand pumps serve as the primary supply. However, increasing urbanization, agricultural runoff, and improper waste disposal practices have raised serious concerns regarding groundwater quality. The present study aims to evaluate the physico-chemical characteristics of groundwater collected from hand pumps in the study area. A total of fifteen groundwater samples were collected and analyzed using standard methods prescribed by APHA (1998). Key parameters such as pH, electrical conductivity, total hardness, chlorides, alkalinity, and acidity were determined and compared with the Bureau of Indian Standards (BIS IS 10500:1991) and World Health Organization (WHO) guidelines for drinking water quality. The results indicate that the pH values of all samples ranged from 7.24 to 8.20, suggesting slightly alkaline nature but within permissible limits. Electrical conductivity values indicate moderate mineralization of groundwater. Total hardness values were found to be within acceptable limits, indicating no significant risk for domestic usage. However, chloride concentrations exceeded the desirable limit (250 mg/L) in most samples, although they remained within the permissible limit. Alkalinity levels were relatively low, and acidity remained constant across samples. Overall, the groundwater quality in the study area is found to be suitable for domestic and drinking purposes, with minor concerns related to elevated chloride concentrations. The study highlights the importance of regular monitoring and sustainable groundwater management to ensure safe water quality for the population.

Keywords: *Groundwater quality, Physico-chemical analysis, Pollution, Hand pump water, Drinking water standards.*

Introduction: Water is an essential natural resource, covering more than two-thirds of the Earth's surface. However, only a small fraction is available as freshwater suitable for human consumption. Increasing population growth, urbanization, industrialization, and agricultural activities have significantly contributed to the deterioration of water quality.Groundwater, a major source of drinking water in India, is highly vulnerable to contamination due to improper waste disposal, sewage discharge, and agricultural runoff containing fertilizers and pesticides. Contaminants entering water bodies not only degrade water quality but also pose serious risks to human health and aquatic ecosystems.

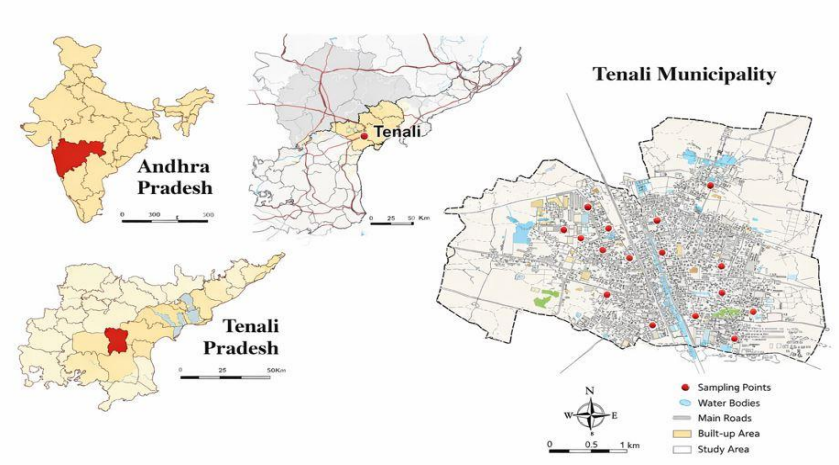
In recent years, rapid urban expansion has further intensified groundwater exploitation and pollution. Therefore, regular monitoring and assessment of groundwater quality are essential for sustainable water resource management. This study aims to evaluate the physico-chemical characteristics of groundwater samples collected from hand pumps in the study region and to assess their suitability for drinking purposes.

Objective of the Work: The present study aims to analyze the physico-chemical characteristics of groundwater samples collected from the study area. It further seeks to compare the obtained results with the drinking water standards prescribed by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO). Based on this comparative analysis, the study also evaluates the suitability of groundwater for domestic and drinking purposes.

Study Area: Tenali Municipality, located in Andhra Pradesh, India, is a rapidly developing urban region. It covers an area of approximately 15.11 km² and includes areas such as Tenali, Pinapadu, and Chinaravuru. The majority of residents depend on groundwater sources such as bore wells and hand pumps for their daily water needs.

Water supply schemes in the region are supplemented by surface water drawn from the Krishna River through the Prakasam Barrage. However, increasing demand and dependence on groundwater necessitate regular quality assessment.

Location Map:



Materials and Methods: Groundwater samples were collected from fifteen hand pump locations across the study area following standard sampling procedures. Samples were properly labeled and transported to the laboratory for analysis.

The physico-chemical parameters were analyzed using standard methods prescribed by the American Public Health Association (APHA, 1998). The parameters analyzed include:

- pH (Digital pH meter)
- Electrical Conductivity (Conductivity meter)
- Total Hardness (EDTA titration method)
- Chlorides (Silver nitrate titration method)
- Alkalinity (Titration with standard acid)
- Acidity (Titrimetric method)

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Table 1 Methods used for water analysis

Test Conducted	Units	Principle of the method
Temperature	^0C	Precision thermometer, measured in situ
Electrical conductivity	Mhoms	Digital conductivity meter
Turbidity	NTU	Turbidimeter
Total Solids	mgl^{-1}	Evaporation
Total Dissolved and suspended solids	mgl^{-1}	Filtration and evaporation
P^H		Digital pH meter
Total Alkalinity as $CaCO_3$	mgl^{-1}	Titration with std. H_2SO_4 P-alkalinity + MO – Alkalinity ---------- x 100 ml of sample taken
P-Alkalinity as $CaCO_3$	mgl^{-1}	Vol. Of H_2SO_4 required in presence of phenolphthalein x 1000 ml of sample taken
MO-Alkalinity as $CaCO_3$	mgl^{-1}	Vol. Of H_2SO_4 required in presence of methyl orange x 1000 ml of sample taken
Chlorides	mgl^{-1}	Titration with stand. $AgNO_3$ using $K_2Cr_2O_7$ as indicator
Total Hardness	mgl^{-1}	EDTA titrimetric method
BOD	mgl^{-1}	Sample measured for 5 days at 20^0C

Source: American Public Health Association (APHA) 1998

Physico-Chemical Characteristics of Ground Water

1) pH
2) electrical conductivity
3) Total harness.
4) Chlorides.
5) Alkalinity
6) Acidity

Environmental Significance: pH denotes whether water is acidic or alkaline. In stagnated and polluted water if pH is highly acidic or highly alkaline, that is dangerous to animals that may drink the water. The animal may die. So, this becomes an environmental issue and gains significance. When such polluted water mix with good water in a pond or lake, the fish and amphibians may be affected apart from cattle.

Conductivity measures the water's ability to conduct electricity. It is the opposite of resistance. Pure, distilled water is a poor conductor of electricity. When salts and other inorganic chemicals dissolve in water, they break into tiny, electrically charged particles called **ions**. Ions increase the water's ability to conduct electricity. Aquatic animals and plants are adapted for a certain range of salinity. Outside of this range, they will be negatively affected and may die. Some animals can handle high salinity, but not low salinity, while others can handle low salinity, but not high salinity. In addition to its direct effects on aquatic life, salinity also has many other important effects on water chemistry and water density.

Total hardness is a measurement of the mineral content in a water sample that is irreversible by boiling. Therefore, total hardness can be equivalent to the total calcium and magnesium hardness. Hard water is not seriously harmful to human health. However, water with a high level of hardness could cause serious problems in industrial settings wherein water hardness is typically monitored to prevent costly failures in components like cooling towers, boilers and other equipment that contains or processes water.

Chloride in reasonable concentrations is not harmful to humans. At concentrations above 250 mg/L it gives a salty taste to water, which is objectionable to many people. The chloride content of waters used for irrigation of agricultural crops is generally controlled along with the total salinity of the water. Evapotransportation tends to increase the chloride and salinity at the root zone of irrigated plants, making it difficult for crops to take up water due to osmotic pressure differences between the water outside the plants and within the plant cells. For this reason, chloride and total salinity concentrations at or below the drinking water standards are normally specified for waters used to irrigate salt-sensitive crops.

Alkalinity is important for fish and aquatic life because it protects or buffers against rapid pH changes. Higher alkalinity levels in surface water will buffer acid rain and their acid water and it prevents pH changes that are harmful to aquatic life.

Acidity interferes in the treatment of water. Aquatic life is affected by high water acidity. the organisms present are prone to death with pH of water. High acidity water is not used for construction purposes especially reinforced concrete construction due to the corrosive nature of high acidity water containing mineral acidity is not fit for drinking purpose. Standards for drinking water shown in Table 2.

Table 2. Indian Standards and WHO Guidelines for Drinking Water.

S.NO.	Parameter	BIS, Indian Standards (IS 10500:1991)		World Health Organisation (WHO Guidelines)
		Desirable limits	Permissible limits	Maximum allowable limits
1	Colour	5Hazen units	25 Hazen units	15 True colour units
2	Turbidity	5 NTU	10 NTU	5NTU
3	pHh	6.5-8.5	No Relaxation	6.5-8.5
4	Total hardness	300 mg/L	600 mg/L	500 mg/L
5	Chlorides	250 mg/L	1000 mg/L	250 mg/L
6	Nitrates	45 mg/L	100 mg/L	10 mg/L
7	Iron	0.3 mg/L	1.0 mg/L	0.3 mg/L
8	Dissolved oxygen	500 mg/L	2000 mg/L	1000 mg/L
9	Alkalinity	200 mg/L	600 mg/L	-
10	Calcium	75 mg/L	200 mg/L	-

Results: The study included Physio- chemical parameters for water. The samples were analysed and The results are shown in table 3.

S.No.	pH	Conductivity S/m	Chlorides (mg/L)	Acidity (mg/L)	Alkalinity (mg/L)	Total Hardness (mg/L)
1	7.24	1.7	395.2	252	10	257.5
2	7.25	2.1	394.8	255	10	252.2
3	7.25	1.4	399.8	245	10	252.5
4	7.27	1.6	399.8	244	10	252.2
5	7.28	1.8	398.8	255	10	252.4
6	7.29	1.9	399.8	255	10	257.5
7	7.30	1.8	395.8	255	15	255.4
8	7.32	2.0	394.8	255	10	252.5

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9	7.34	1.8	399.8	255	10	252.5
10	7.38	1.7	398.8	255	10	252.5
11	7.40	1.4	396.8	255	10	250.5
12	7.52	1.6	397.8	255	15	252.2
13	8.10	1.0	398.8	242	15	252.2
14	8.20	1.9	399.8	245	15	250.2
15	8.20	1.7	395.8	250	15	252.2

Table 3. Results of the Samples at the Study area

The results of the physico-chemical analysis indicate that the pH values of the groundwater samples ranged from 7.24 to 8.20, reflecting a slightly alkaline nature within the permissible limits for drinking water. Electrical conductivity values suggest a moderate level of mineral content in the groundwater. Total hardness was found to be within acceptable limits, indicating no significant health concerns. Chloride concentrations exceeded the desirable limit of 250 mg/L but remained within the permissible limit of 1000 mg/L, suggesting minor salinity issues. Alkalinity levels were observed to be relatively low across all samples, while acidity remained nearly constant throughout the study area. Overall, the groundwater quality in the study area is within acceptable limits for domestic use. However, elevated chloride levels suggest possible contamination from anthropogenic activities such as sewage and agricultural runoff.

Conclusion:

The present study reveals that groundwater from hand pumps in the Tenali region is generally suitable for drinking and domestic purposes based on physico-chemical parameters. Although most parameters fall within permissible limits, chloride concentrations exceed desirable levels, indicating a need for regular monitoring.

Sustainable groundwater management practices and periodic quality assessment are essential to prevent further deterioration and ensure safe water supply for the population.

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