Assessment of ground water quality in pimpri chinchwad area

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Abstract:

Intensive agricultural practices using agrochemicals and the use of sewage and polluted drain water have significantly impacted groundwater quality in peri-urban areas of Pune, such as the Pimpri Chinchwad area. This study aimed to assess groundwater quality and map its spatial variation to evaluate its suitability for irrigation and drinking. The study used ordinary methods to create thematic maps showing groundwater quality parameters like electrical conductivity, sodium adsorption ratio, bicarbonate levels, magnesium/calcium ratio, total dissolved solids (TDS), chloride, nitrate, and hardness. Post-monsoon physicochemical data from bore well samples across the region were analyzed. Results indicate that the groundwater is generally of good quality, ranging from fresh to slightly brackish, with low salinity and alkalinity, making it suitable for drinking. The acceptable levels of total hardness and TDS confirm its suitability for consumption. Based on TDS values, the groundwater is classified as bicarbonate/calcium chloride/sodium chloride type.

Keywords:

Groundwater pollution, drinking water, physicochemical parameters, spatial interpolation.

1. Introduction:

Groundwater is a crucial renewable resource and a key water supply worldwide. In India, groundwater is the primary source of drinking water, particularly in rural areas, due to its relative cleanliness compared to surface water. The quality of groundwater is essential for its various uses, and it is influenced by physical and chemical parameters, which are affected by geological formations and human activities. Analyzing groundwater quality helps determine its suitability for drinking, agriculture, and industrial use, and it reveals changes caused by rock-water interactions or human influences. Groundwater typically contains key chemical elements such as calcium, magnesium, sodium, potassium, chloride, bicarbonate, and sulphate. Hydro geochemical studies involve analyzing these components in water samples.

This study focuses on the Pimpri Chinchwad area in Pune district, Maharashtra. Post-monsoon water samples were collected from various locations between January 2024 and April 2024 the physical parameters analyzed include pH and Total Dissolved Solids (TDS). The study aims to assess groundwater quality in the basin and visually represent it using Geographic Information System (GIS) technology. GIS is a powerful tool for managing and analyzing large volumes of spatial data. Over the past three decades, scientists have used GIS for spatial analysis and integration, including determining potential groundwater exploration sites through remote sensing and GIS techniques.

Pcmc map

2. Materials and methods:

Pimpri Chinchwad, a rapidly growing city in western Maharashtra, India, is situated at 18.6298°N latitude and 73.7997°E longitude, with an average elevation of 530 meters above sea level, as referenced in topographic sheet No. 56 C/SE. The city covers an area of 181 square kilometers and has a population of approximately 1.72 million. The region receives an average annual rainfall of about 722 mm. Daily temperatures range from 12°C to 30°C in winter and 35°C to 42°C in summer.

This area is considered chronically drought-prone due to inconsistent and insufficient annual rainfall, necessitating the intensive use and management of groundwater resources. Despite this reliance, municipal authorities have not implemented measures to supply treated groundwater or to inform residents about the suitability of borewell water for drinking according to WHO standards. Additionally, there is no comprehensive record of the number of private borewells in the city. Due to concerns over the quality and reliability of tap water, a significant portion of the population prefers groundwater for drinking.

For this study, groundwater samples were collected post-monsoon (January 2024to April 2024) from various locations throughout Pimpri Chinchwad. The analysis focused on physical parameters such as pH and Total Dissolved Solids (TDS). The data were then processed and visualized using Geographic Information System (GIS) technology, which allows for the storage, spatial correlation, and analysis of large volumes of data. GIS has been an invaluable tool for scientists across various disciplines over the past three decades, particularly for spatial queries and the integration of data to produce meaningful outputs. This study aims to leverage these capabilities to assess groundwater quality and identify suitable water sources for drinking and other uses in the region.

3. Groundwater sample collection and analysis:

In this study, groundwater samples were collected from various bore wells across different zones or wards of Pimpri Chinchwad, ensuring comprehensive coverage of the city. Sampling was conducted in January 2024, and the samples were analyzed for a range of physicochemical parameters.

To ensure the accuracy and cleanliness of the samples, the collection bottles were thoroughly washed with the water from the bore wells before being filled. Once collected, the samples were preserved appropriately and transported to the laboratory for detailed analysis. The physicochemical parameters analyzed included calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}), and sulphate (SO_4^{2-}). These parameters were then compared with the standard values recommended by the World Health Organization (WHO, 1993) and the Indian Standards Institution.

Sr. No.	Parameters	Desirable Limit Mg/l	Permissible Limit Mg/l	Maximum Allowance Concentration Mg/l
1	Alkalinity	50-200	20-400	400-600
2	Calcium	50-100	100-300	200-300
3	Magnesium	30-50	50-150	150
4	Total Hardness	300	600	500
5	Chlorides	250	1000	250
6	Sodium	20-200	200	20
7	Potassium	12	12	12

Additionally, other critical parameters such as pH, electrical conductivity (EC), and total dissolved solids (TDS) were measured to provide a comprehensive assessment of the groundwater quality. The preservation of samples followed standard procedures to prevent any alterations in their chemical composition before analysis.

The detailed analysis aimed to identify any potential health risks associated with the groundwater and to determine its suitability for drinking and other uses. By comparing the results with established standards, the study provided valuable insights into the groundwater quality of Pimpri Chinchwad and highlighted areas where intervention might be necessary to ensure safe water for the residents.

4. Collection of samples and drafting point source map:

For this study, groundwater samples were collected and a point source map was developed to classify groundwater quality based on thematic maps adhering to ISI (1991) standards for drinking water. Table 2 provides detailed point source data, which guided the creation of the groundwater quality classification map.

We identified the locations of various wells throughout the study area using GPS technology, which significantly improved the spatial accuracy of the data integrated into the Geographic

Information System (GIS). The precise coordinates of each well were recorded, facilitating accurate mapping and analysis.

MapInfo Professional software was utilized to process and visualize the data. Using the GPS coordinates, we prepared a point feature map indicating the positions of the various wells (Fig. 2). Groundwater samples were then collected from these wells and analyzed for various quality parameters.

The resulting water quality data formed a non-spatial database, which was stored in Excel format. This non-spatial data was linked to the spatial data within MapInfo Professional using the join function, allowing for seamless integration and analysis. By combining the spatial and non-spatial databases, we generated spatial distribution maps for the various water quality parameters.

These maps provided a visual representation of groundwater quality across the study area, highlighting zones with differing water quality levels. This information is crucial for identifying areas where groundwater is suitable for drinking and other uses, as well as areas requiring intervention to improve water quality. The integration of GPS technology and GIS software ensured a high level of accuracy and detail in the mapping process, enhancing the overall reliability and usefulness of the study’s findings.

The groundwater samples were tested following standard procedures outlined in the Indian Standards (IS) code. Each sample underwent rigorous analysis to determine its chemical composition, including key parameters such as calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}), and sulfate (SO_4^{2-}).

To facilitate comparison and interpretation of the data, the results for these chemical parameters were visually represented using bar graphs. These graphs depicted the concentration levels of each parameter across the various samples collected from different wells.

5. Groundwater quality testing and mapping:

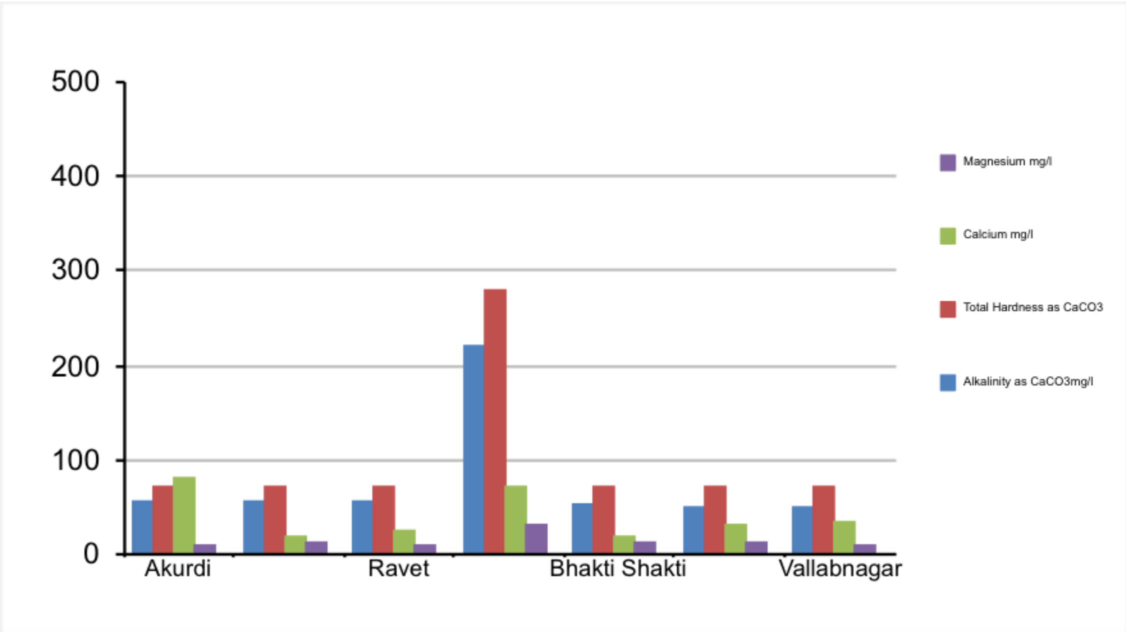
The graphical representation provided a clear and immediate visual summary of the data, making it easier to identify patterns and anomalies in groundwater quality. For instance, areas with higher concentrations of certain ions could be quickly identified, highlighting potential issues such as hardness or salinity that might affect water suitability for drinking and other use

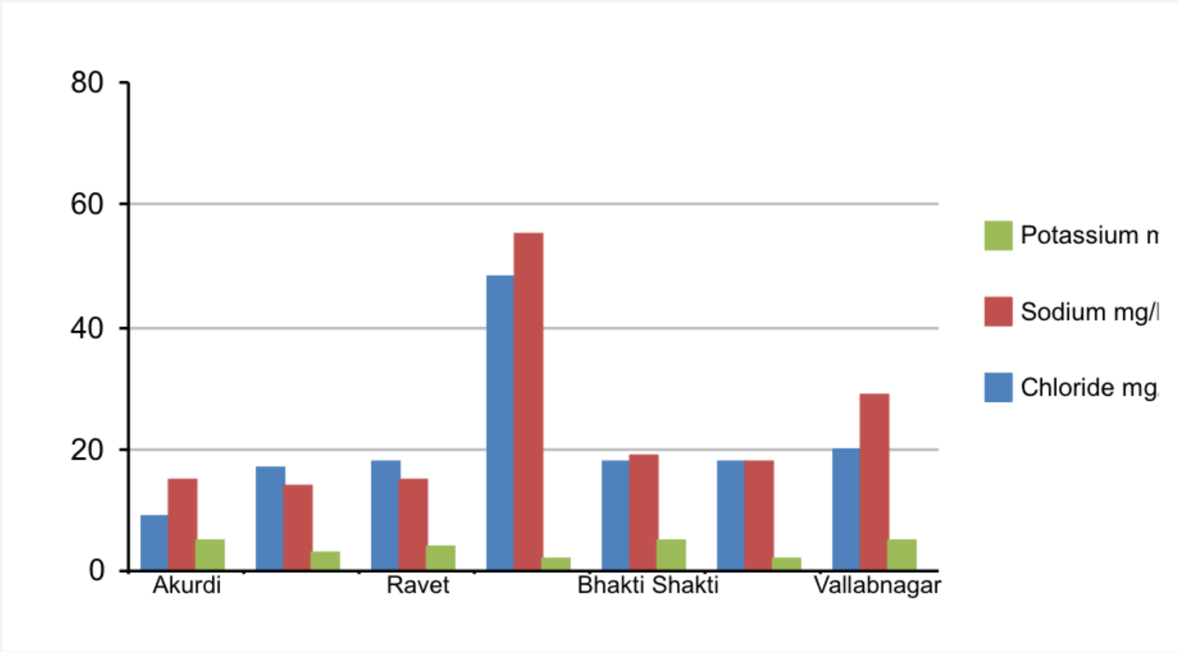
Additionally, these bar graphs allowed for a straightforward comparison with standard values recommended by the World Health Organization (WHO) and the Indian Standards Institution, ensuring that any deviations from acceptable limits could be promptly addressed. This visual approach not only enhanced the clarity of the findings but also served as an effective communication tool for presenting the results to stakeholders, including local authorities and the general public.

Overall, the combination of standard testing procedures and graphical data presentation ensured a robust and transparent assessment of groundwater quality in the study area. This methodology supports informed decision-making for groundwater management and interventions to ensure safe and sustainable water use.

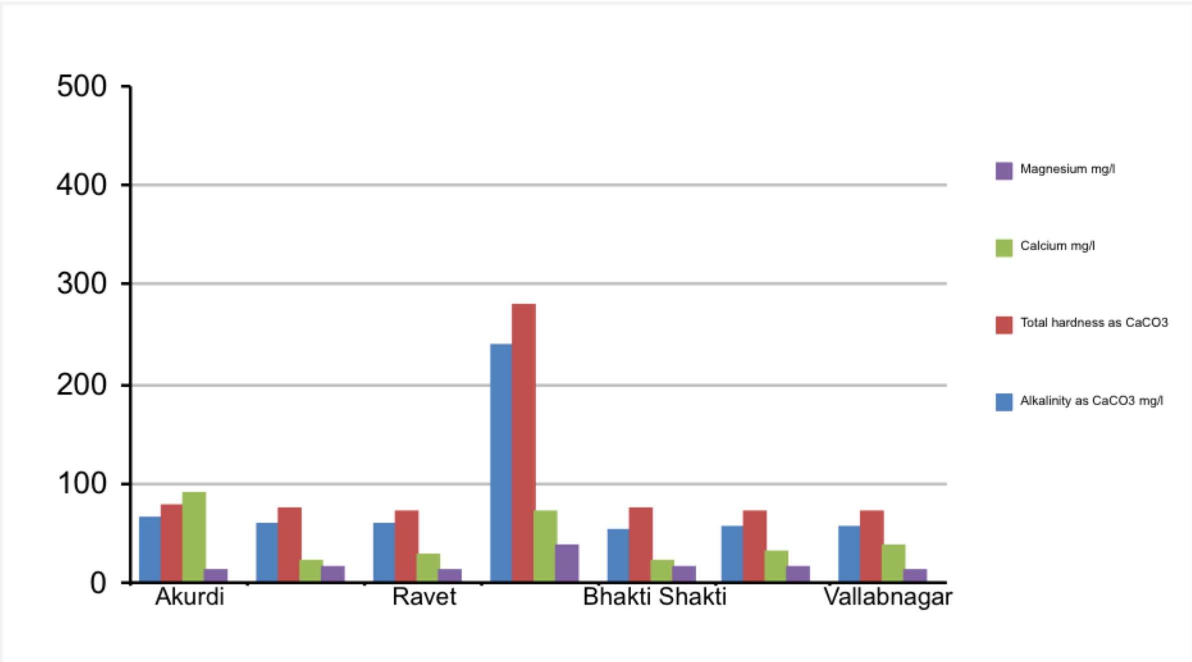
6. Result:

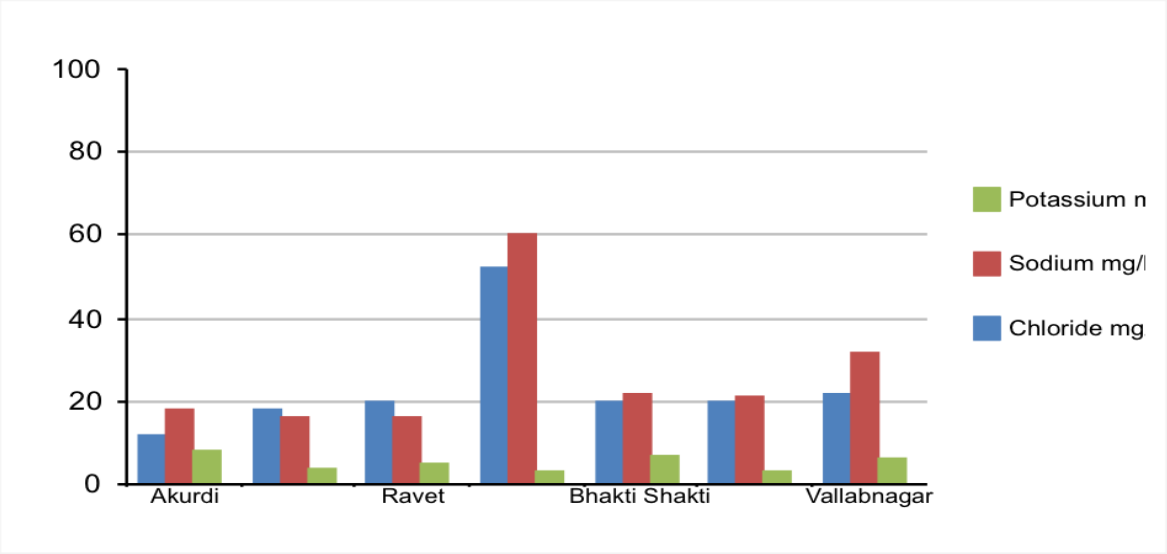
6.1. Graphical representation of January 2024:





6.2. Graphical representation of April 2024:





7. Key findings from the hydrogeochemical analysis include:

7.1. Excess contaminants in specific areas:

Hydrogeochemical analysis revealed that the Sanghavi sample had excessive concentrations of various compounds, making the water unfit for drinking. This highlights the need for targeted interventions in this area.

7.2. Localized water quality issues:

Several locations exhibited high levels of chloride, TDS, and hardness, indicating undesirable water quality for drinking purposes. These areas require immediate attention to ensure safe drinking water.

7.3. Salinity hazards:

Considerable portions of the basin showed high salinity levels, posing risks for agricultural use. These zones necessitate special management practices, such as adopting salt-tolerant cropping patterns, to mitigate the impact on agriculture.

7.4. General suitability:

Despite localized issues, most of the groundwater in the study area was found to be within permissible limits for drinking and irrigation, indicating generally good quality across the majority of the region.

7.5. Need for further investigation:

The study identified the necessity for detailed investigations to determine the sources of contamination and high salinity. Understanding whether these issues are due to natural geological factors or anthropogenic activities is crucial for developing effective mitigation strategies.

7.6. Implications for policy and management:

The findings underscore the importance of continuous monitoring and robust groundwater management policies. Implementing regular quality checks and public awareness campaigns can help in maintaining safe water standards and addressing contamination issues promptly.

Overall, this study demonstrates the efficacy of GIS in groundwater quality assessment and highlights critical areas for intervention to ensure the safety and sustainability of water resources in Pimpri Chinchwad.