

Application of QGIS in Monitoring Ground Water Level

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ABSTRACT: Groundwater is a critical resource in urban areas like Mumbai, where rapid urbanization has increased water demand. This study uses QGIS, an open-source GIS tool, to analyse and monitor groundwater levels using spatial data. Thematic maps such as slope, soil, geology, contour and well locations were generated and integrated to identify recharge and depletion zones. The results show that QGIS is an effective and economical tool for groundwater monitoring and supports sustainable water resource management.

I. INTRODUCTION

Groundwater is one of the most essential natural resources for meeting domestic, industrial, and agricultural water demands, especially in rapidly urbanizing regions such as Mumbai. Due to increasing population, urban expansion, and industrial growth, the dependence on groundwater has significantly increased, leading to issues such as declining water levels and over-exploitation of aquifers. Therefore, continuous monitoring and efficient management of groundwater resources have become crucial for sustainable urban development.

Traditional methods of groundwater assessment are often limited in their ability to represent spatial variations and complex interactions between environmental factors. In this context, Geographic Information Systems (GIS) provide an advanced and efficient platform for analysing and visualizing spatial data. Quantum GIS (QGIS), open-source GIS software, offers powerful tools for integrating, processing, and interpreting both spatial and non-spatial datasets.

In this study, QGIS is used to analyse groundwater levels in Mumbai by developing various thematic maps such as slope maps, contour maps, soil maps, geology maps, and well location maps. Each of these thematic layers plays a significant role in understanding groundwater occurrence and movement. For instance, slope influences runoff and infiltration, soil determines permeability, and geological formations control groundwater storage and flow.

The integration of these thematic layers enables a comprehensive understanding of groundwater behaviour across the study area. Spatial analysis techniques help in identifying recharge zones, depletion areas, and variations in groundwater levels. This approach supports better decision-making for sustainable groundwater management in urban environments.

II. LITERATURE SURVEY

2.1 Groundwater Data Analysis – M. Tech Thesis (GSDA, Pune)

This study analysed groundwater data of Thane district using observations from 120 wells over a period of 35 years. Seasonal groundwater models were developed to understand long-term variations. The study emphasized the importance of continuous monitoring and data-driven analysis for effective groundwater management.

2.2 GIS-Based Study of Groundwater Monitoring – Karhe Region, Maharashtra

In this study, groundwater samples were collected from dug wells using GPS-based location mapping. The Water Table Fluctuation (WTF) method was used to analyse recharge during dry and wet seasons. The results showed that

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groundwater levels depend on terrain characteristics, rainfall, and land use. The study highlighted the role of GIS in supporting irrigation planning and water resource management.

2.3 Application of Remote Sensing and GIS for Groundwater Potential Zonation – Bori-Chikli Watershed

This study used GIS-based weighted overlay analysis to identify groundwater potential zones. Various thematic layers such as geology, slope, drainage, and land use were integrated. The results indicated that most areas fall under poor to moderate groundwater potential zones. The study demonstrated that GIS and remote sensing are effective tools for groundwater assessment and planning.

III. PROBLEM STATEMENT AND OBJECTIVES**Probable Problem Statements****3.1 Lack of Spatial Data Integration in Groundwater Monitoring**

Existing groundwater monitoring systems often rely on isolated datasets and lack proper integration of spatial and non-spatial data. This results in poor understanding of groundwater variations across different regions. The absence of a unified GIS-based platform limits the ability to analyse relationships between terrain, soil, geology, and groundwater levels, leading to inefficient decision-making.

3.2 Inadequate Monitoring of Groundwater Variations

Traditional methods of groundwater monitoring are manual and time-consuming, often lacking real-time or seasonal analysis. These methods fail to capture spatial variations and temporal changes effectively, resulting in incomplete assessment of groundwater recharge and depletion patterns.

3.3 Impact of Urbanization on Groundwater Recharge

Rapid urbanization in cities like Mumbai has led to an increase in impervious surfaces such as roads and buildings, which restrict natural infiltration of rainwater. This reduces groundwater recharge and contributes to declining water levels, while existing monitoring systems fail to properly capture these impacts.

Exact Selected Problem Statement

Traditional groundwater monitoring systems suffer from lack of spatial integration, inefficient data analysis, and inability to represent real-time variations. These limitations make it difficult to understand groundwater behaviour, recharge zones, and depletion areas in urban regions.

Therefore, there is a need for an integrated GIS-based approach using QGIS to analyse, monitor, and visualize groundwater levels effectively, enabling better decision-making for sustainable groundwater management.

IV. OBJECTIVES

1. To analyse groundwater level variations in the study area
2. To develop spatial thematic maps using QGIS
3. To study seasonal fluctuations (pre-monsoon and post-monsoon)
4. To identify factors affecting groundwater recharge and depletion
5. To evaluate the impact of urbanization on groundwater levels

V. METHODOLOGY

The methodology adopted in this Publications, involves systematic processing of groundwater data using QGIS to analyse spatial variation and identify groundwater recharge and depletion zones in Mumbai.

5.1. Data Collection and Preparation

1. Groundwater data consisting of well locations (latitude and longitude) and water table depth was collected and organized in Microsoft Excel. The dataset was converted into CSV format for compatibility with QGIS.
 2. Secondary data such as Digital Elevation Model (DEM), soil data, and geology shapefiles were collected from reliable sources including Bhuvan Geoportal, OpenStreetMap, and Google Earth.
- All datasets were prepared and checked for consistency before analysis.

Table 1: Ground Water Depth Data - August of Month

Wells No	Location	Latitude	Longitude	Date	Water Depth in Meters
W1	Laxmi Nagar Mahul	19.02806	72.89667	8/26/2023	0.5
W2	Khar danda	19.07472	72.82333	8/26/2023	0.7
W3	Madh	19.14167	72.78972	8/26/2023	0.8
W4	Manori	19.21417	72.785	8/26/2023	1
W5	Film City – Habale Pada	19.16306	72.88806	8/26/2023	1.3

Courtesy: CGWB (Central Ground Water Board)

What is meant by water depth?

Water depth is the vertical distance measured from the free surface of a body of water (such as an ocean, lake, or river) down to the bottom or seabed at a specific point.

For Example: If water is found at 8 m below ground, then water depth = 8 m

It tells how deep you must dig a well or borewell to reach groundwater

Table 2: Ground Water Depth Data – November of Month

Wells No	Location	Latitude	Longitude	Date	Water Depth in Meters
W1	Laxmi Nagar Mahul	19.02806	72.89667	11/10/2023	0.5
W2	Khar danda	19.07472	72.82333	11/10/2023	0.7
W3	Madh	19.14167	72.78972	11/10/2023	0.8
W4	Manori	19.21417	72.785	11/10/2023	2.8
W5	Film City – Habale Pada	19.16306	72.88806	11/10/2023	1.3

Courtesy: CGWB (Central Ground Water Board)

5.2. Importing Data into QGIS

The CSV file containing well data was imported into QGIS using the “Add Delimited Text Layer” tool.

Longitude was assigned as the X-coordinate and latitude as the Y-coordinate.

A suitable Coordinate Reference System (CRS), “WGS 84 / UTM Zone 43N”, was selected to ensure spatial accuracy.

5.3. Base Map Preparation

The administrative boundary of Mumbai was used as the base layer.

OpenStreetMap was added to provide reference features such as roads, settlements, and landmarks.

All layers were clipped to the study area boundary to ensure focused analysis.

5.4. Generation of Thematic Maps

5.4.1. Soil Map

Soil data was imported as a shapefile and classified based on soil type.

Soil properties such as permeability and porosity influence groundwater recharge.

1. Permeable soil → High recharge
2. Impermeable soil → Low recharge

Methodology

1. Import soil shapefile.
2. Open layer properties → Symbology.

3. Select “Categorized”.
4. Classify based on soil type.
5. Apply colour scheme.

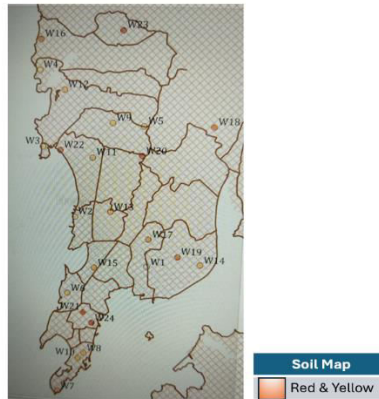


Fig 1: Soil Map

5.4.2 Geology Map

Geological data was used to identify rock formations and aquifer characteristics.

The study area is mainly composed of basaltic rocks.

1. Weathered/fractured basalt → Good groundwater storage
2. Massive rock → Low storage

Methodology

1. Import geology shapefile.
2. Open properties → Symbology.
3. Classify based on rock formation.
4. Apply suitable colours.

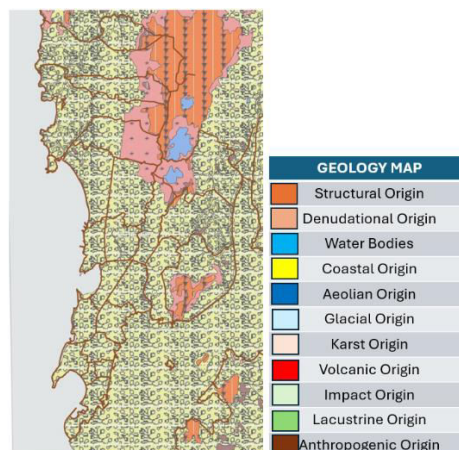


Fig 2: Geology Map

5.4.3 Slope Map

The slope map was generated using DEM data through raster analysis in QGIS.

Slope represents the rate of elevation change and plays an important role in controlling runoff and infiltration.

1. Low slope → High infiltration (good recharge)
2. High slope → High runoff (low recharge)

Methodology

1. Download DEM data (SRTM/Bhuvan).
2. Import DEM into QGIS.
3. Go to Raster → Analysis → Slope.
4. Generate slope raster layer.
5. Classify slope values into categories.

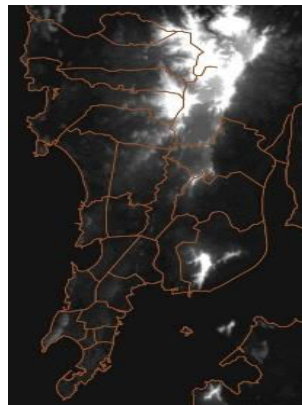


Fig 3: Slope Map

5.4.4 Contour Map

Contour lines were generated from DEM to represent elevation variations. These contours help in understanding terrain shape and groundwater flow direction.

1. Closely spaced lines → Steep slope
2. Widely spaced lines → Gentle slope

Methodology

1. Load DEM in QGIS.
2. Use Contour tool/plugin.
3. Set contour interval.
4. Generate contour lines.

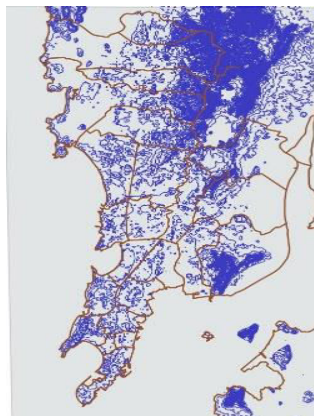


Fig 4: Contour Map

5.4.5 Well Location Map

Well Location Map Showing Spatial Distribution of Groundwater Wells

Methodology

1. Use imported CSV point data.
2. Display spatial distribution of wells.



Fig 5: Well Location Map

5.5. Spatial Analysis and Integration

All thematic layers (slope, soil, geology, and well location) were integrated using GIS overlay techniques. This helped in analysing relationships between different factors affecting groundwater.

The analysis was used to identify:

1. Groundwater recharge zones
2. Low potential areas
3. Critical depletion zones

5.6. Seasonal Analysis

Groundwater data from two time periods were analysed:

1. August (Post monsoon)
2. November (Early dry season)

Comparison of these datasets helped in understanding recharge during monsoon and depletion trends after monsoon.

7. Visualization and Interpretation

Final maps were prepared using suitable symbology and classification techniques.

Colour gradients were used to represent groundwater variation.

Maps were exported and used for interpretation of groundwater behaviour and decision-making.

VI. RESULTS AND DISCUSSION

The spatial analysis of groundwater data using QGIS provides insights into groundwater behaviour in Mumbai and the influence of factors such as slope, soil, and geology.

6.1 Spatial Distribution of Groundwater Wells

Groundwater wells are distributed across Mumbai, though not uniformly. Some areas have higher concentrations, which may slightly affect accuracy but still provide a reliable representation of groundwater conditions.

6.2 Slope Analysis

The slope map shows variation from flat coastal areas to moderately sloping regions.

1. Low slope → higher infiltration and recharge
2. High slope → higher runoff and lower recharge

Thus, gentle slope areas are favourable for groundwater recharge.

6.3 Contour Analysis

The contour map indicates elevation differences, with groundwater generally flowing from higher to lower regions.

1. Closely spaced contours → steep terrain
2. Widely spaced contours → gentle terrain

6.4 Soil Analysis

The study area is mainly covered with red and yellow soil, along with some alluvial and laterite soils.

1. Red & yellow soil → moderate permeability
2. Alluvial soil → higher recharge potential

Since soil type is mostly uniform, its influence on variation is limited.

6.5 Geology Analysis

The region is dominated by basaltic formations (Deccan Traps).

1. Fractured basalt → groundwater storage
2. Massive rock → low permeability

Geology plays a key role in controlling groundwater availability.

6.6 Integrated Analysis

The combined effect of slope, soil, and geology determines groundwater conditions.

1. Favourable conditions → higher recharge
2. Unfavourable conditions → low groundwater potential

6.7 Seasonal Variation

Groundwater levels are higher in post-monsoon and decrease during the dry season, indicating strong dependence on rainfall.

6.8 Impact of Urbanization

Urbanization reduces groundwater recharge due to increased impervious surfaces, reduced infiltration, and higher runoff.

6.9 Overall Interpretation

Groundwater in Mumbai is influenced by both natural factors and urbanization. QGIS proves to be an effective tool for analysing and managing groundwater resources

VII. CONCLUSION

The present study demonstrates the effective application of Geographic Information System (GIS) techniques using QGIS for monitoring and analyzing groundwater levels in an urban environment like Mumbai. The integration of spatial and non-spatial data enabled a comprehensive understanding of groundwater behavior across the study area.

The analysis of thematic maps revealed that groundwater conditions are significantly influenced by terrain characteristics, soil properties, and geological formations. Areas with gentle slopes, permeable soils, and favorable geological conditions were identified as potential groundwater recharge zones, while regions with steep slopes and hard rock formations showed lower groundwater potential.

The seasonal analysis indicated that groundwater levels are higher during the post-monsoon period and gradually decline during the dry season, highlighting the strong dependence of groundwater recharge on rainfall. Additionally, the impact of urbanization, particularly the increase in impervious surfaces, has reduced natural infiltration and contributed to declining groundwater levels.

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Overall, the study confirms that QGIS is an efficient, cost-effective, and reliable tool for groundwater monitoring. It provides valuable insights for sustainable water resource management and supports informed decision-making in urban planning.

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