

Water Level Fluctuations in Groundwater of Khelna Watershed, Maharashtra, India

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Abstract:

The present study describes the results of groundwater level variation in Khelna watershed in pre-monsoon and post monsoon seasons. Groundwater levels were monitored to understand the fluctuation by knowing water level of 26 village of watershed. The pre- monsoon groundwater level is 0.60 mbgl to 10.30 mbgl with average 3.41 mbgl and the post-monsoon groundwater level ranging from 5.80 mbgl to 21 mbgl with average 11.02 mbgl. The fluctuation in the watershed is found 1.20 to 11.60 mbgl with average value 6.31 mbgl. The average rainfall in the watershed is 730 mm with high spatial variation. Seasonal variations in groundwater levels in the watershed were influenced by the climatic conditions, geology, and water usage patterns.

Keywords: *Water Level, Khelna Watershed, Water Depletion, Maharashtra.*

INTRODUCTION

Groundwater plays a crucial role in India's water resources and significantly supports the country's population and economy. India is recognized as the world's largest extractor of groundwater, with nearly 230 km³ utilized every year (World Bank, 2012). Among the major usage sectors—domestic, drinking, industrial, and irrigation—agriculture alone accounts for approximately 90% of total groundwater withdrawal. Such heavy dependence has led to a rapid decline in groundwater reserves and stress on many aquifer systems across the nation.

In regions with strong seasonal climatic variations, groundwater acts as a key buffer against water scarcity (Bell and Roberts, 1991; Sha, 2005; Sajil Kumar et al., 2019; Chindarkar and Grafton, 2019; Kumar, 2022). Maharashtra is largely agrarian, with around 82% of rural residents relying on farming and nearly 85% depending on groundwater for drinking and irrigation needs. Before the early 1970s, groundwater exploitation was minimal; however, the severe drought in 1972, along with technological and financial advancements, triggered large-scale development of wells for irrigation. Although Maharashtra receives substantial rainfall, recurring droughts and

unregulated groundwater extraction continue to push many areas toward persistent water scarcity (CGWB, 2010; Zende and Nagarajan, 2012; Aher and Kathane, 2015; Aher et al., 2024).

As a dynamic resource, groundwater storage fluctuates based on recharge from rainfall and discharge through pumping or natural flow. Monitoring these fluctuations is essential for evaluating aquifer conditions and enabling sustainable management. Water-level hydrographs serve as reliable indicators of seasonal and long-term changes in storage, effects of drought, and anthropogenic stress. Continuous decline in groundwater levels in many regions is closely linked to excessive pumping, expanding irrigation demands, and frequent dry spells. Such depletion increases scarcity of drinking water, leading to social and economic distress. Therefore, understanding water-level behavior is vital for drought forecasting and mitigation (Taylor and William, 2001; Raju et al., 2006; Reddy, 2012; Katpatal et al., 2014; Kathane et al., 2015; Aher et al., 2019; Dhumal and Aher, 2021).

Groundwater behavior in Maharashtra varies seasonally due to climatic conditions, geology, and water use patterns. During the **pre-monsoon** period, high temperatures and continuous withdrawal cause a steep fall in water levels. With the onset of **monsoon**, significant rainfall infiltration improves the aquifer storage, especially where permeability is high. In the **post-monsoon** period, groundwater levels either stabilize or gradually decrease as recharge components decline. Hard-rock aquifers, which dominate drought-affected areas like Marathwada, have limited storage capacity and show rapid water-level fluctuations. Over-reliance on groundwater for irrigation during dry months accelerates depletion.

In this context, the present research focuses on assessing groundwater-level fluctuations (WLF) in the Khelna watershed of drought-prone Maharashtra. This work represents an initial attempt to document groundwater behavior in the region and provides valuable scientific inputs for future groundwater management and drought preparedness.

The study area

The present study focuses on the Khelna watershed located in the Sillod block of the Chhatrapati Sambhajnagar district, Maharashtra. The watershed covers an area of approximately 275 km² and encompasses 37 villages. Geographically, it is situated between 20°18'N to 20°35'N latitude and 75°26'E to 75°46'E longitude, falling under the Survey of India Toposheet Nos. 46P/7 and 46P/11. The Khelna River is the major drainage feature of this watershed. Originating in the Ajanta hill ranges, the river flows southward through settlements such as Kelgaon, Chichpur, Palod, Anvi, Ayhana, and Bhokardan, and ultimately joins the Purna River near Jaffrabad in Jalna district (Fig. 1). The drainage pattern and surface runoff conditions play a vital role in the seasonal groundwater recharge of this region. From a geological perspective, the watershed forms part of the Deccan Volcanic Province, consisting predominantly of basaltic lava flows belonging to the Late Cretaceous to Palaeogene period (≈68–62 Ma). Nearly 95% of the area is occupied by Deccan Trap basalts, while limited patches of alluvium occur along river courses (Fig. 2). The basaltic formations occur as sub-horizontal lava flow sequences, typically displaying a massive, compact middle unit underlain and overlain by weathered and vesicular zones. These upper vesicular units often contain secondary porosity developed through fracturing and weathering, making them potential groundwater-bearing horizons. Groundwater in this terrain occurs under unconfined to semi-confined and confined conditions, depending on the nature of the flow units and degree of structural development. The hydrogeological behavior—storage, occurrence, and movement—is therefore governed by the extent of vesicles, fractures, and joints within the basaltic units (GSI, 1999; Deshpande & Aher, 2012; Aher, 2017; Aher et al., 2020; Deshpande & Sayed, 2021).

METHODOLOGY

Groundwater-level fluctuations are typically illustrated through hydrographs, which help demonstrate seasonal changes in aquifer storage conditions. A general trend observed in hard-rock regions shows a sharp rise in water levels immediately after the monsoon, followed by a

gradual decline as groundwater is progressively extracted over time (Kumar, 2014; Zhang, 2012; Halder, 2020).

In this study, primary groundwater-level data were collected through field monitoring of 26 observation wells distributed across three hydrogeomorphic zones of the watershed: runoff zone, recharge zone, and storage zone. Elevation values for these well locations were taken from standard topographic surveys.

Groundwater levels were measured as depth to water table (m bgl) during two distinct hydrological periods:

- Pre-monsoon: May 2022
- Post-monsoon: October 2023

The recorded water-level data were analyzed to evaluate seasonal fluctuations and recharge behavior within the Khelna watershed. Interpretation of these variations provides insight into groundwater response to rainfall, aquifer characteristics, and extraction stress.

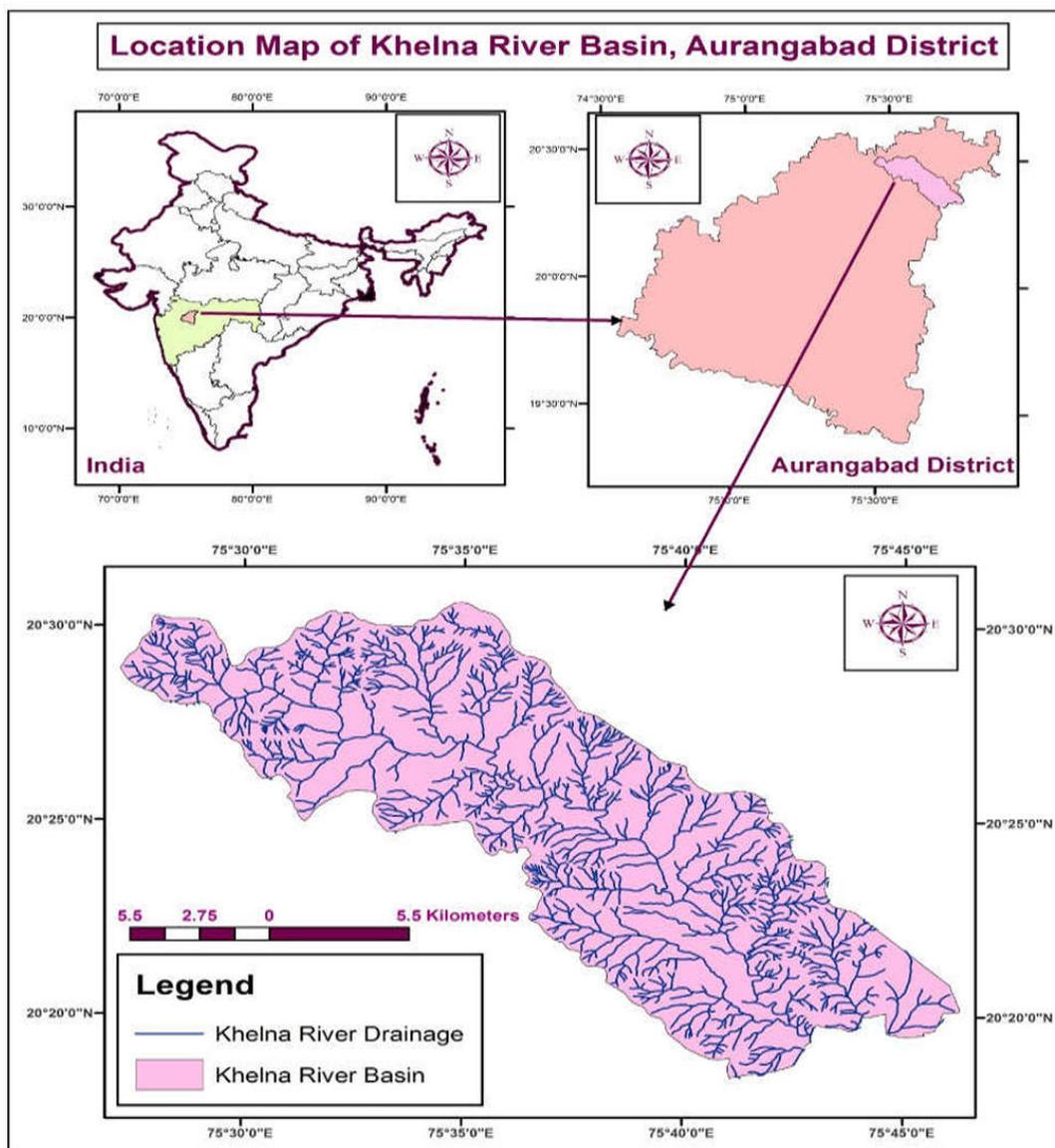


Figure 1: Location map of the study area

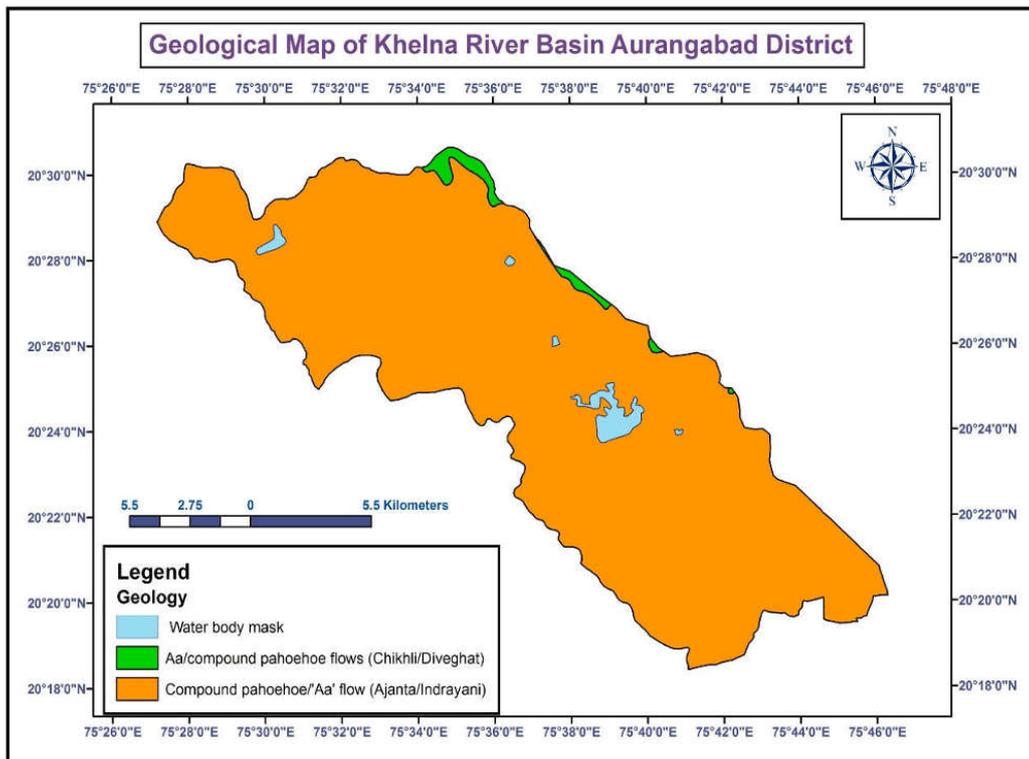


Figure 2: The geological map of the study area

RESULTS AND DISCUSSION

The outcome of the groundwater monitoring has been analyzed and presented using hydrographs and comparative bar plots that depict pre-monsoon and post-monsoon water levels for each observation well (Fig. 3). During the pre-monsoon period (May 2022), groundwater levels in the watershed varied from 0.60 m bgl at Jalki Ghat to 10.30 m bgl at Nanegaon, with an overall mean depth of 3.41 m bgl. In the post-monsoon period (October 2023), groundwater levels ranged between 5.80 m bgl at Ambhai and 21.00 m bgl at Nanegaon, with an average depth of 11.02 m bgl. The seasonal groundwater level fluctuation across the watershed was found to range from 1.20 to 11.60 m, with a mean

fluctuation of 6.31 m. The region receives an average annual rainfall of approximately 730 mm, however rainfall distribution is highly variable throughout the watershed, contributing to localized differences in recharge. The shallow groundwater depth observed at Jalki Ghat is attributed to its proximity to a local stream (nalla), indicating strong hydraulic connectivity between surface water and groundwater. Such interactions are common in basaltic terrains where secondary porosity features like fractures and weathered zones enhance recharge and subsurface flow connectivity. The detailed pre- and post-monsoon groundwater level measurements for each observation well are provided in Table 1.

Water Level Fluctuations in Groundwater of Khelna Watershed, Maharashtra, India

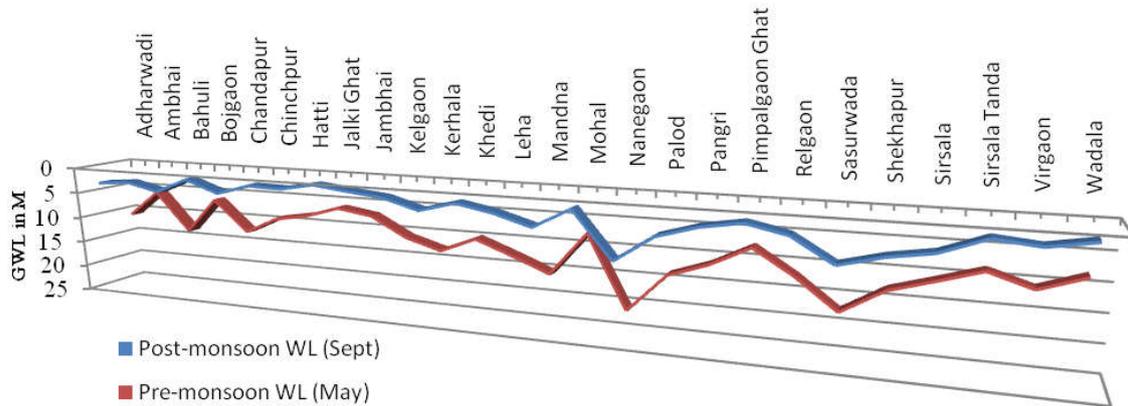


Figure 3: Static groundwater level of study area

Table 1: Details of the well location and water level data (pre-monsoon and post-monsoon)

Well. No	Village	Well Depth	WL (post) in mbgl	WL (Pre) in mbgl	Water-level fluctuation (m)
W1	Adharwadi	12	3.1	10.8	7.7
W2	Ambhai	8	2.55	5.8	3.25
W3	Bahuli	15.5	4	13.3	9.3
W4	Bojgaon	6.5	1.2	6.5	5.3
W5	Chandapur	14	3.5	12.5	9
W6	Chinchpur	9.5	1.6	9.4	7.8
W7	Hatti	8.3	1.8	8.3	6.5
W8	Jalki Ghat	6.3	0.6	6.3	5.7
W9	Jambhai	7.35	1.4	7.35	5.95
W10	Kelgaon	11.2	2.1	11	8.9
W11	Kerhala	15.8	4	13	9
W12	Khedi	12.3	2.2	10.2	8
W13	Leha	13.75	3.5	12.8	9.3
W14	Mandna	18.8	5.5	15.6	10.1
W15	Mohal	7.5	1.8	7.5	5.7
W16	Nanegaon	22.6	10.3	21	10.7
W17	Palod	14.6	5.5	13.9	8.4
W18	Pangri	11.7	3.4	11.4	8
W19	Pimpalgaon Ghat	9.2	2.2	7.8	5.6
W20	Relgaon	13.1	3.7	12.2	8.5
W21	Sasurwada	19.3	7.9	17.6	9.7
W22	Shekhapur	15.2	6	13.2	7.2
W23	Sirsala	11.6	4.8	11	6.2
W24	Sirsala Tanda	8.7	2	8.7	6.7
W25	Virgaon	11.6	2.7	11	8.3

W26	Wadala	10	1.4	8.4	7
Minimum		6.3	0.6	5.8	5.2
Maximum		22.6	10.3	21	10.7
Average		12.09	3.41	11.02	7.6

Rivers flowing through valleys and low-lying terrains often function as effective recharge zones, where surface water infiltrates into the subsurface and contributes to aquifer replenishment. Such areas typically exhibit shallower groundwater levels due to the continuous inflow of water from nearby streams and accumulated runoff. Depressions or low-elevation pockets act as natural storage basins, causing water to collect and gradually raise the water table, resulting in localized zones of high groundwater potential.

In contrast, regions situated at higher elevations, particularly near watershed divides, receive limited recharge because rainfall rapidly drains away due to steep gradients and increased runoff. For instance, Nanegaon, despite being located within the recharge zone, experiences significant fluctuations due to local hydrogeological conditions, whereas Ambhai, situated in the runoff zone near the watershed divide, frequently experiences groundwater scarcity. Wells in Ambhai tend to dry up during the summer months owing to insufficient infiltration and limited aquifer storage. Similarly, Adharwadi and other settlements along the recharge divide also show deeper groundwater levels and rapid post-monsoon decline.

Across the watershed, the mean pre-monsoon water depth is recorded as 3.41 m bgl, while the post-monsoon mean depth is 11.02 m bgl. Seasonal fluctuations range between 5.2 and 10.8 m, with an average of 7.6 m. The average well depth in the study area is approximately 12.09 m bgl, indicating that most wells penetrate only shallow aquifer zones, making them more sensitive to seasonal stress.

Groundwater levels in the watershed are strongly governed by surface topography and drainage patterns, which influence the pathways of infiltration and subsurface flow. Topography dictates gravitational flow of water—higher terrain exhibits deeper water tables, whereas

valley floors and floodplains show elevated groundwater levels due to focused recharge. Drainage networks guide both surface and subsurface water movement, establishing hydraulic connectivity between rivers, streams, and aquifers. Consequently, groundwater distribution, availability, and seasonal variability in the Khelna watershed are a direct response to terrain elevation, slope characteristics, and the underlying drainage configuration.

CONCLUSION

The analysis of groundwater data from the Khelna watershed highlights clear seasonal variations in water-level behavior. The average pre-monsoon groundwater level is 11.02 m bgl, while the average post-monsoon level rises to 12.09 m bgl, indicating a mean seasonal fluctuation of about 7.6 m across the watershed. The region receives an average annual rainfall of ~730 mm, but its spatial variability significantly affects recharge in different hydrogeological zones. Despite receiving considerable rainfall, a large proportion of runoff is lost from the watershed due to limited vegetation cover, inadequate soil-water conservation structures, and the predominance of hard-rock basalt formations offering low primary porosity. The pressure on groundwater resources is further intensified by excessive abstraction during dry months, leading to frequent summer water scarcity in villages situated near runoff zones and watershed divides. Climate change and increasingly erratic monsoon behavior have further reduced the predictability of seasonal recharge. To improve groundwater sustainability in this drought-prone basin, a site-specific watershed management strategy is essential. Key interventions should include, Construction of artificial recharge structures (check dams, percolation tanks, contour trenches), Increased surface water storage to reduce direct runoff and enhance infiltration, Adoption of **conjunctive use** of groundwater and harvested surface water, Promotion of micro-irrigation methods (drip and

sprinkler) to reduce irrigation withdrawals, Strengthening vegetation cover to improve soil-water retention and infiltration, Community-based monitoring and governance to regulate over-extraction. Effective implementation of these measures will help stabilize groundwater levels and secure long-term water availability for both agriculture and rural livelihoods in the Khelna watershed. Sustainable groundwater management is therefore crucial to enhancing resilience against droughts and ensuring water security in this environmentally sensitive region of Maharashtra.

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