Extended Abstract DOI: https://doi.org/10.64862/ajeg.2025.2sp.22.116 Open Access

Evaluation of Groundwater Level Fluctuation and Its Effects on Industries in Shahjadpur, Sirajganj, Bangladesh

Md Nazmul Islam Hasan[1*], Khondaker Emamul Haque[1], Shamim Ahmed[2] and Md Mahedi Hasan[1]

[1]Department of Geology and Mining, University of Rajshahi, Rajshahi 6205, Bangladesh
[2]Institute of Environmental Science, University of Rajshahi, Rajshahi 6205, Bangladesh

(*Corresponding E-mail: hasanjunaid48@gmail.com)

Received: August 20, 2025, Accepted: September 18, 2025

Abstract: **This study investigates groundwater level fluctuations and their industrial implications in Shahzadpur Upazila, Sirajganj, over a ten-year period (2015–2024). Secondary data were obtained from the Bangladesh Meteorological Department (BMD) and Bangladesh Water Development Board (BWDB) and analyzed using standard hydrogeological methods. The study area lies within the Jamuna–Karatoya floodplain, under a subtropical monsoon climate with distinct pre-monsoon, monsoon, and post-monsoon seasons. The average annual rainfall is approximately 1610 mm, while the population of Shahzadpur stands at 601,633 (BBS). Climatic analysis shows average maximum and minimum temperatures of 30.1°C and 19.5°C, respectively. Relative humidity peaks during July–August and reaches its minimum from November to February. Groundwater depth varies seasonally, ranging from 5.90 m in the pre-monsoon to 2.40 m in the post-monsoon period. These fluctuations are driven primarily by recharge–discharge processes, with high evaporation intensifying water table decline during March–April. Despite seasonal variability, the groundwater system generally maintains a state of dynamic equilibrium. Integration of well data, hydrographs, and climatic variables reveals distinct patterns of groundwater fluctuation. These patterns are closely associated with industrial water abstraction, irrigation demand, seasonal rainfall distribution, and urban expansion. Findings indicate an increasing strain on groundwater resources, driven by industrial intensification and compounded by climate variability and urban growth. Such pressures present risks to the long-term sustainability of groundwater reserves. The results underscore the vulnerability of industrial operations to groundwater depletion and variability. Disruptions in supply may lead to operational inefficiencies, economic losses, and environmental degradation. The study highlights the urgent need for sustainable groundwater management strategies to balance industrial development with environmental resilience in the Shahzadpur region.**

Keywords: ***Groundwater level fluctuation, Groundwater resources, Industrial extraction.***

Introduction

Groundwater, comprising about 30% of global freshwater, is vital for sustaining industrial operations but faces depletion from overexploitation, climate variability, and rapid growth. Shahzadpur, a major industrial hub in Sirajganj, relies heavily on groundwater for production processes, making it highly vulnerable to fluctuations. Declining levels increase pumping costs, reduce water quality, and risk land subsidence, threatening industrial stability. This study assesses groundwater fluctuations in Shahzadpur, their industrial impacts, and the driving factors behind them. It further proposes strategic management measures to ensure sustainable groundwater use and industrial growth.

Methodology

The flowchart (Figure 1) outlines the methodological framework adopted in this study, beginning with systematic data collection from secondary sources (BMD, BWDB, BBS). The process proceeds to data acquisition and processing, ensuring consistency and reliability of datasets for subsequent analysis (Shrestha et al., 2016). The methodology incorporates three key datasets: geographical, meteorological, and hydrogeological data, which collectively provide a comprehensive understanding of groundwater dynamics (Kumar et al., 2020). Geographical data establish spatial characteristics of the study area, while meteorological inputs such as rainfall, temperature, and humidity define climatic influences on recharge (Shahid, 2011). Hydrogeological data, including groundwater levels and aquifer properties, capture subsurface variations critical for water balance assessment (Mukherjee et al., 2015).

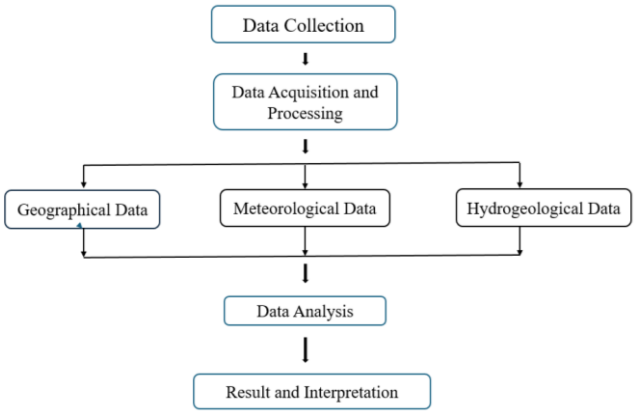

Figure 1, Flowchart of the work.

These datasets are subjected to data analysis, integrating hydrographs, climatic trends, and spatial correlations to reveal seasonal and interannual groundwater fluctuations. The final stage involves result interpretation, linking groundwater variability to industrial demands, irrigation needs, and climate-induced stresses. Overall, this structured approach provides a robust analytical framework to evaluate groundwater sustainability in Shahzadpur.

Linear Regression

$$m = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sum_{i=1}^{n}(X_i - \bar{X})^2} \ldots\ldots\ldots (i)$$

$$c = \bar{Y} - m\bar{X} \ldots\ldots\ldots (ii)$$

$$Y_i = mX_i + c \ldots\ldots\ldots (iii)$$

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2 \sum_{i=1}^{n}(Y_i - \bar{Y})^2}} \ldots\ldots\ldots (iv)$$

Consecutive Observations

$$Slope_i = \frac{Y_{i+1} - Y_i}{X_{i+1} - X_i}, i = 1,2, \ldots, n-1 \ldots\ldots\ldots (v)$$

Results and discussion

Groundwater levels in Shahzadpur (2015–2024) display strong seasonality: shallowest during July–September (~2.4 m depth) when monsoon recharge is high, and deepest in March–April (~5.9 m) from high evaporation and intense pumping. A temporary stabilization occurred during the COVID-19 dip (2019–21), but post-2022 recovery reversed it. Higher pumping costs, energy demand and risk of land subsidence and quality deterioration loom for the industrial sector. Without rain-water harvesting, efficiency gains and integrated resource management, aquifer sustainability is at risk.

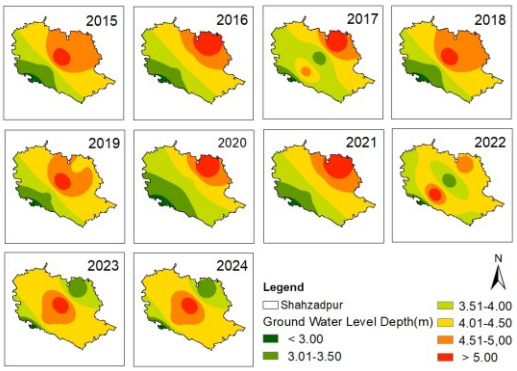

Figure 2, Spatial variation in groundwater level.

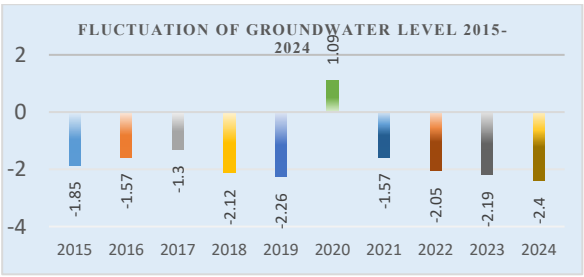

Figure 3, Temporal variation in groundwater level.

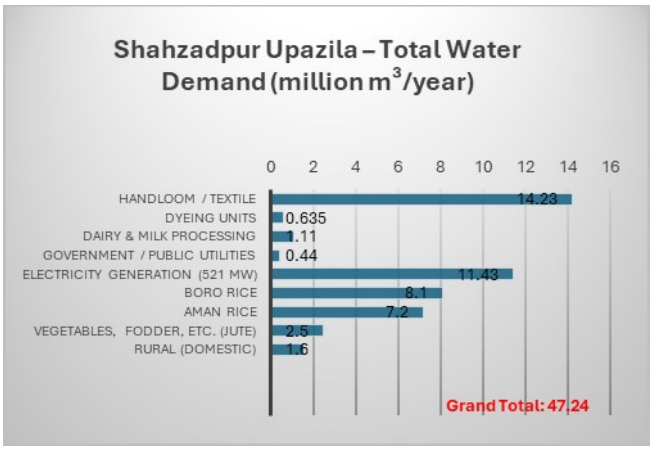

Figure 4, Water demand in Shahzadpur.

Conclusion

This study evaluated groundwater-level changes and industrial impacts in Shahzadpur (Sirajganj) from 2015 to 2024. Results show clear seasonality: depths ranged from ~5.90 m in the pre-monsoon dry period to ~2.40 m during post-monsoon recharge. Although the aquifer system appears in dynamic equilibrium, industrial extraction and climate variability are creating increasing stress. Hydrogeological analysis shows deeper aquifers have better yield, yet unsustainable withdrawal threatens long-term viability. Industrial reliance on groundwater introduces risks like higher pumping costs, declining water quality and land subsidence. The study concludes that while current supplies remain operational, urgent adoption of sustainable management practices is essential to protect industrial growth, groundwater security and environmental stability.

References

Kumar, C. P., Singh, R. D., and Yadav, B. R. (2020). Groundwater assessment methodologies and applications. Singapore: Springer.

Mukherjee, A., Bhanja, S. N., and Wada, Y. (2015). Groundwater of South Asia. Dordrecht: Springer.

Shahid, S. (2011). Impact of climate change on irrigation water demand in northwestern Bangladesh. Climatic Change, 105(3–4), 433–453. https://doi.org/10.1007/s10584-010-9895-5

Shrestha, S., Pandey, V. P., and Shivakoti, B. R. (2016). Assessment of groundwater resources in Asian monsoon regions. Journal of Hydrology, 535, 637–649. https://doi.org/10.1016/j.jhydrol.2016.02.02