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Groundwater quality assessment of Saharanpur, Uttar Pradesh (India)

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ABSTRACT

Groundwater is very important natural resource with significant implications for several aspects of human life, the environment, and economic activities. India is highly dependent on groundwater for several purposes such as industrial activities, agriculture and drinking water supply. It is essential to manage groundwater resources sustainably to ensure their availability for current and future generations. In present work, groundwater quality of Saharanpur, Uttar Pradesh (India) was evaluated. Water samples were collected from seven different locations of Saharanpur and analyzed for temperature, pH, total dissolved solid (TDS), electrical conductivity (EC), calcium (Ca^{2+}), magnesium (Mg^{2+}), total hardness (TH), and total alkalinity (TA). This study will help society to effectively address future challenges, and realize the full potential of groundwater sustainably.

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1. Introduction

Water is crucial for biotic elements on Earth and it is necessary for the survival of all living things. Its importance on earth cannot be overstated. Water is important to preserve biodiversity, ecosystems and the stability of our climate. Because it mediates so many chemical interactions, it is integral to many biological functions. It supports the growth of aquatic organisms, promotes the development of plants and animals, and helps in the transportation of essential nutrients and minerals. In addition, water is essential for commerce, agriculture and human survival (Singha et al. 2021). Most of the earth's freshwater are stored as Groundwater. A large percentage of the world's population depends on groundwater for domestic purpose and for many industrial, environmental, and agricultural processes (Singh et al. 2012; Khatri and Tyagi, 2015). Groundwater is naturally filtered by the soil, making it appear clear and clean. It is more protected than surface water but may be polluted due to various natural and man-made activities. As groundwater moves through the soil, it breaks down metals such as calcium, manganese, etc. These metals can then be found in groundwater in excess. Groundwater quality may also be affected by industrial wastewater, urban activity, agriculture and leachate (Chatterjee et al. 2010; Singha et al. 2021). Pesticides and fertilizer's applied to lawns or crops can build up and move into groundwater (Khatri and Tyagi, 2015). Some pesticides and fertilizers that have been absorbed into cultivated soil may also end up in well water. Poor water quality is one of the highest contests of 21st century for societies, and it may unfavorably upsetting human health, food generation, ecosystem purposes and economic development (Kushwah et al., 2023).

Groundwater pollution affects ecosystems, human health and the environment in many different ways. Polluted groundwater can cause significant health risks if consumed or irrigated (Rao, 2006, Rawat, et al., 2018). Long-term health conditions such as cancer can be caused by exposure to hazardous substances such as organic compounds and heavy metals. Pollution can affect aquatic life by introducing hazardous compounds into the area,

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reducing oxygen levels and disrupting nutrient balance. This can lead to disruption of the food chain, depletion of fish stocks and general deterioration of the aquatic environment. Resolving groundwater pollution can be difficult, as pollutant can persist for years. Mitigating pollution and its long-term effects may be expensive and difficult. Groundwater is the key source of water for domestic use in many areas (Khatri and Tyagi, 2015). Pollution from this source may have significant adverse effects on society and culture, such as community renewal and disruption of customs. To reduce the effects of groundwater pollution, it is important to prevent pollution through strict laws, ethical waste management practices, and cleanup of already polluted areas. This important natural resource is essential for the environment and the population.

Monitoring of groundwater quality is a key element in the management of responsibly managed water resources (Chatterjee et al. 2010). In order to ensure compliance with regulations, it plays an important role in protecting citizens' health and ecosystem protection as well as promoting sustainability of resource use. To address emerging threats to the quality of groundwater and ensure that safe, clean drinking water continues to be available, regular and comprehensive monitoring is essential. In present research, groundwater quality of Saharanpur district of Uttar Pradesh, India was monitored.

2.   Study area

Saharanpur is located in Uttar Pradesh (India) at an average elevation of 269 meter (Fig.1). Population of city is more than 10 lakh and total area covered is 46.74 km^2. When compared to the summer, Saharanpur experiences far less precipitation throughout the winter season. Yearly average temperature of city is 23.2 °C and annual total precipitation is 1208 mm.

3.   Collection and analysis of water samples

Water samples were collected from 7 different locations. From each location 3 samples were collected. Water samples were collected in 1 liter plastic bottles. After collection of water samples, bottles were securely capped to prevent contamination. All sampling bottles were labeled with essential information such as mane and location of sampling site, date and time of water sample collection. The parameters that were assessed were as follows, Temperature, pH, TDS, EC, calcium (Ca^{2+}), magnesium (Mg^{2+}), total hardness (TH), and total alkalinity (TA). The samples were underwent standard procedures for the analysis of physico-chemical characteristics.

4.   Results and discussion

Descriptive statistics of all measured variables is shown in Table 1. Descriptive statistics included the minimum, maximum and average concentration observed water quality parameters. It also included the standard deviation, kurtosis and skewness. It indicates the degree of asymmetry while Kurtosis represents the degree of flatness of a distribution.

Temperature is an important part of groundwater quality management and assessment. It provides important information about pollution, microbial activity and chemical reactions to protect groundwater resources. Temperature of all water samples were found to vary from 24°C to 30.8°C (Fig. 2).

The pH is a significant criterion to consider when evaluating and maintaining water quality. It affects the physical, chemical, and biological properties of water, the pH level of water has a direct impact on the well-being of aquatic ecosystems. Many aquatic species can only survive within a certain pH range. The pH of water affects the availability and solubility of various chemicals compounds. The pH also affects the effectiveness of some water treatment methods, such as chlorination.
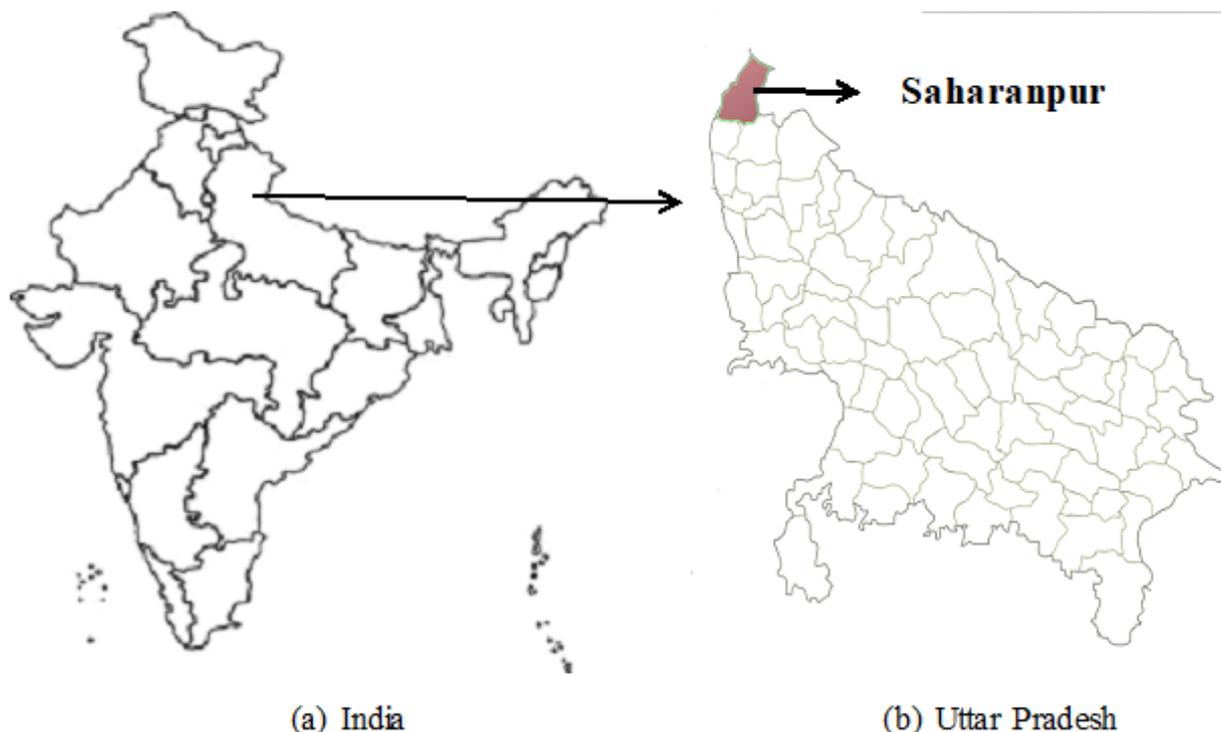

(a) India   (b) Uttar Pradesh

Fig. 1 Study area (Saharanpur, Uttar Pradesh)

Table 1 Descriptive statistics of measured water quality parameters

	pH	TDS	EC	Ca^{2+}	Mg^{2+}	TH	TA
Minimum	7.1	116.0	231.0	60.0	70.0	150.0	70.0
Maximum	7.8	268.0	536.0	180.0	160.0	300.0	300.0
Mean	7.4	189.3	369.9	137.1	105.7	242.9	154.3
*Std. Dev.	0.2	56.4	124.0	42.3	36.9	53.5	85.2
Kurtosis	-0.4	-1.6	-1.9	0.8	-1.8	0.3	-0.4
Skewness	0.1	0.2	0.1	-0.9	0.5	-0.8	0.9

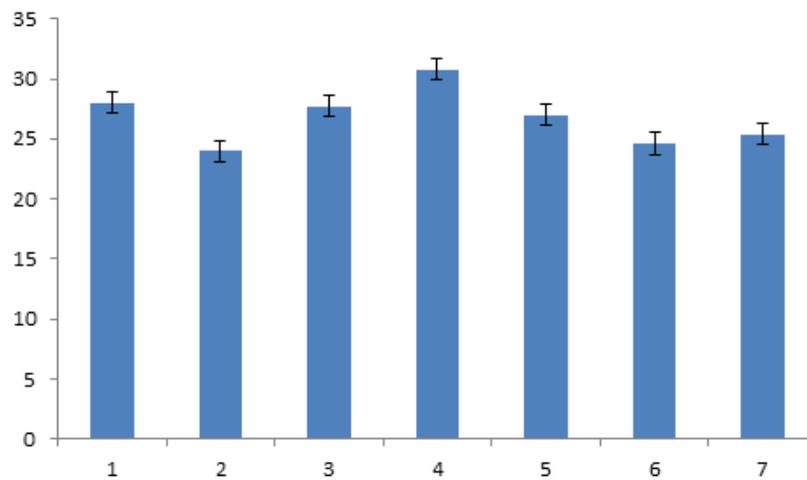*** Standard Deviation**

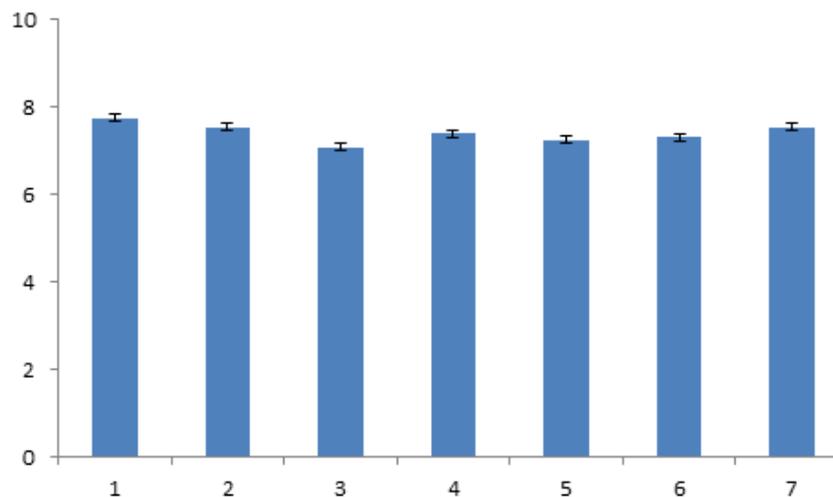**Fig. 2 Spatial variation of temperature**

Fig. 3 Spatial variation of pH

It has an important impact the safety and taste of drinking water, the integrity of infrastructure, and the general well-being of the environment and population. Maintaining water quality and sustainability requires careful pH monitoring and management. The pH of the collected groundwater samples were ranged between 7.1 and 7.8, showing almost neutral to slightly alkaline. These pH values fall under the allowable limits of Bureau of Indian Standards (BIS).

TDS is a key indicator in water quality assessment because it provides comprehensive information about the dissolved materials in water. Salts, minerals and organic waste are just some of the dissolved impurities often associated with high TDS levels. High TDS levels can affect the taste and smell of water. Water with high TDS can have harsh or salty taste that is not suitable for drinking or cooking. Pipes and equipment in water distribution systems and industrial processes can corrode due to high TDS levels. It can also lead to the accumulation of scale deposits, which reduces the efficiency of the heat exchange system and increases maintenance costs. Increased TDS levels in natural water bodies can interrupt the balance of ions, salts and minerals, which can be harmful to aquatic ecosystems. For natural water systems to be environmentally friendly, TDS monitoring is crucial. TDS monitoring helps ensure that drinking water meets safety standards. Average concentration of TDS in groundwater samples was 189.3 mg/L

and maximum concentration was 268 mg/L which was below | the permissible limits of BIS.
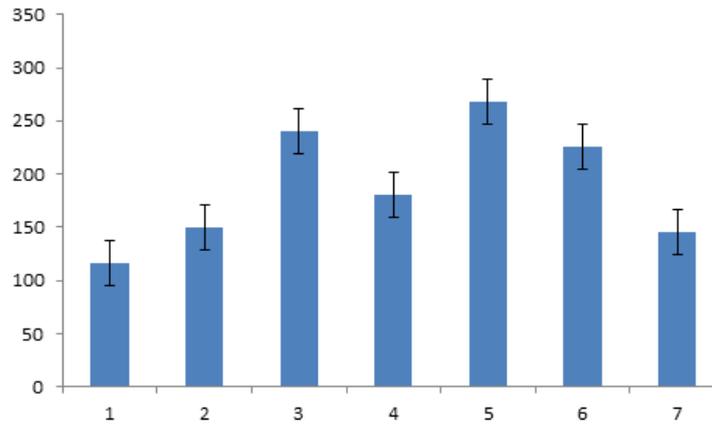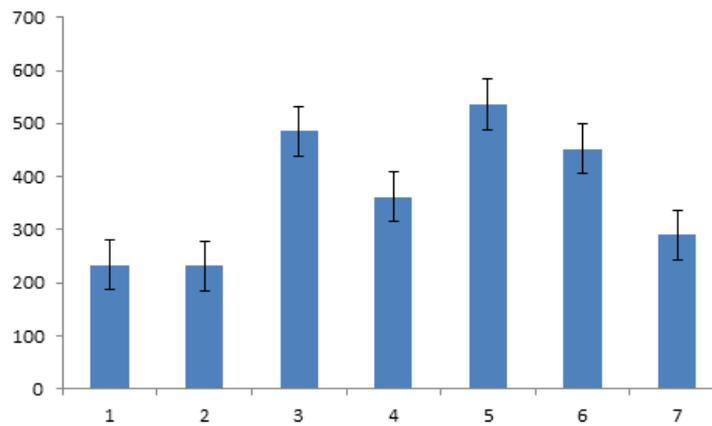

Fig. 4 Spatial variation of TDS

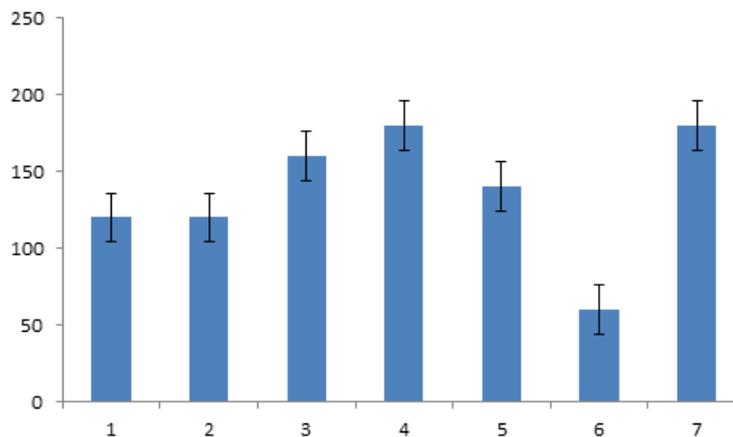**Fig. 5 Spatial variation of EC**

Fig. 6 Spatial variation of Ca²⁺

Electrical conductivity (EC) is a vital parameter for evaluating water quality. The concentration of dissolved ions in water, such as salts, minerals and other charged particles, is closely correlated with EC. Elevated levels of EC often indicate the presence of significant dissolved materials that can affect water quality. EC is the decisive measure for determining the salinity of fresh and sea water. Increase in salinity of water is often associated with elevated EC levels and can have adverse effects on aquatic ecosystems, including fish and plant species that are accustomed to certain salinity levels. Pollution from urban growth, agricultural runoff, and industrial discharges increases the ion content of water, which increases EC values. EC is also used in agriculture to assess its suitability for irrigation. Excessive salinity can harm crops and soil quality. EC measurements help to farmers for taking decisions about soil management and water use. Changes in EC can destabilize the balance of ions and minerals in an aquatic ecosystem. The EC values of the observed samples were found in the range from 231 to 536 μS/cm, with an average of 369.9 μS/cm.

One important factor in groundwater quality assessment is TH. This is mainly caused by multivalent cations, especially calcium (Ca^{2+}) and magnesium (Mg^{2+}) in water. Groundwater hardness is largely determined by the geology of a particular location. When groundwater seeps through geological

formations that contain high concentrations of calcium and magnesium minerals such as gypsum, limestone and dolomite,
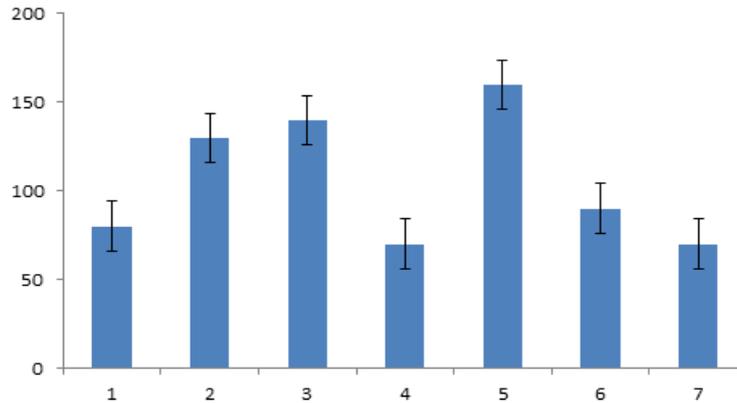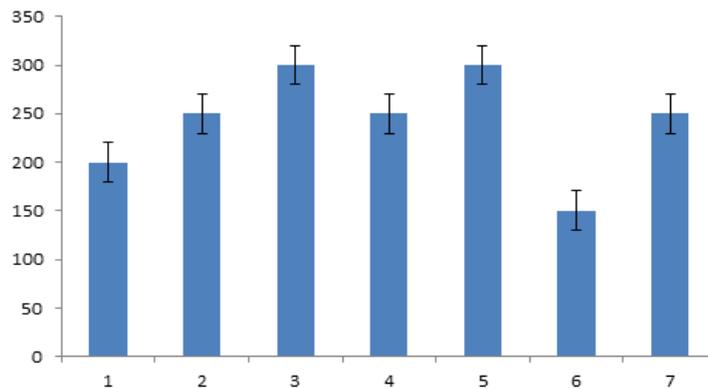

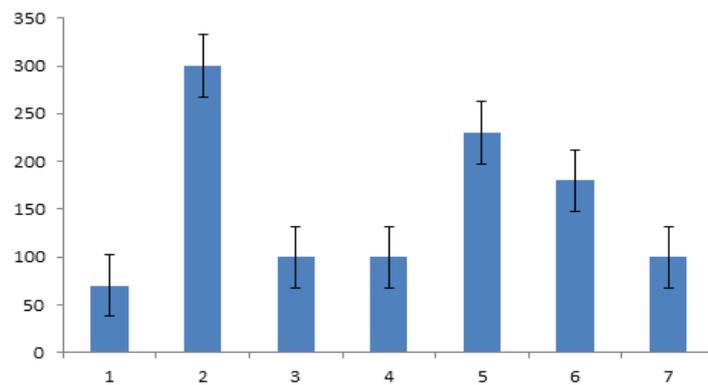**Fig. 7: Spatial variation of Mg^{2+}**

Fig. 8: Spatial variation of hardness

Fig. 9: Spatial variation of total alkalinity

Table 2 Correlation matrix among the various water quality parameters

	pH	TDS	EC	Ca^{2+}	Mg^{2+}	TH	TA
pH	1.00						
TDS	-0.92	1.00					
EC	-0.90	0.98	1.00				
Ca^{2+}	-0.05	-0.13	-0.7	1.00			
Mg^{2+}	-0.57	0.66	0.55	-0.09	1.00		
TH	-0.44	0.36	0.32	0.73	0.62	1.00	
TA	-0.12	0.26	0.07	-0.40	0.61	0.10	1.00

it can become hard. Hardness can also be caused by various human activities. Agricultural farm runoff and the use of fertilizers can pollute groundwater with calcium and magnesium ions. In addition, the use of detergents and the disposal of wastewater can make groundwater hard. Minerals such as calcium and magnesium are generally not toxic to humans but can affect the taste and smell of water. While some people may love the taste of hard water, others may prefer the taste of soft water. Excessive hardness can cause limescale deposits on boilers, water pipes and other equipment. This scale

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Singh et al., 2023

can cause heat exchange systems to become inefficient, increasing energy consumption and maintenance costs. Hard water can lessen the cleaning power of soaps and detergents. The quality of the soil can be impacted by the hardness of the water used in irrigation. Excess calcium and magnesium from hard water can seep into the soil, causing salinity and lowering crop yields. For agriculture to be sustainable, total hardness must be regularly monitored. Monitoring and management of hardness is essential to ensure effective treatment and compliance with legal requirements. Spatial variation of Ca^{2+}, Mg^{2+} and total hardness is shown in Fig. 6, 7 and 8.

Alkalinity is an essential factor in terms of groundwater quality. It shows the ability to neutralize water and acid and is mainly caused by basic materials such as hydroxides (OH^-), bicarbonates (HCO_3^-) and carbonates (CO_3^{2-}). The alkalinity of groundwater is strongly influenced by the geological structure of a certain place. As groundwater seeps through carbonate-rich rocks such as limestone and dolomite, minerals can dissolve in the water and make it more alkaline. Groundwater can become alkaline due to human sources. Elevated alkalinity levels can be caused by various industrial processes, sewage discharges and agriculture. Groundwater alkalinity is also caused by soil and its microbial activity. Through chemical interactions, microorganisms can produce and consume alkalinity, which changes the alkalinity and pH of the water. Alkalinity acts as a natural buffer to help maintain pH stability and prevent fluctuations. Keeping the pH of the water at a level suitable for different forms of aquatic life and habitats depends on this buffering capacity. This helps in preventing sudden drops in pH that can be harmful to aquatic life. Alkalinity can protected water pipes against corrosion under acidic condition. Water with low alkalinity can be corrosive, which can cause dangerous substances such as lead and copper to leach into the water supply. Alkalinity is an important part of drinking water treatment. This can affect the addition of chemicals such as coagulants and disinfectants to the water treatment process, which ensure effective removal and treatment of contaminants. An important part of aquatic ecosystem health is alkalinity. It helps maintain a stable pH level in lakes, rivers and streams for aquatic animals to survive and reproduce. Aquatic ecosystems are exposed to imbalances caused by changes in alkalinity. In an agricultural situation, alkalinity can affect soil quality. Excessive alkalinity of irrigation water can damage crops and increase soil salinity. Spatial variation of total alkalinity is shown in Fig.9.

Table 2 shows the correlations between observed water quality parameters. The Pearson correlation coefficient, which calculates the linear relationship between two variables, is the most often used correlation coefficient. Each water quality parameter in a correlation matrix was compared to every other water quality parameter. Correlation coefficients are used to quantify the direction and strength of the relationships between the water quality parameter. Strong negative correlation was observed between pH and TDS & EC and strong negative correlation was observed between TDS and EC.

5. Conclusion

Groundwater is an important natural water resource. Various natural and anthropogenic activities are adversely affecting the quality and quantity of groundwater. Water quality monitoring is important for water quality management and evaluation because it tells us about the chemical composition of water and its suitability for a specific use. It promotes the preservation of natural ecosystems, sustainable agriculture, efficient industrial processes and clean & safe drinking water. In this study, it was observed that average concentration of Ca^{2+} (137.1 mg/L) was greater than average concentration of Mg^{2+} (105.7 mg/L). There was a lot of variance in the observed data of EC (std. dev 124 µS/cm) around the mean (369.9 µS/cm). Monitoring is necessary to maintain water quality and protect the health and well-being of communities and the environment.

Authors Contribution

Neha Singh: Drafted the manuscript; **Vinod Kumar Kushwah:** Survey of study area, collection of water samples, Analysis of samples in laboratory; **Kunwar Raghvendra Singh:** Performed Statistical analysis and Critical revision of the article.

Conflict of interest: There is no conflict of interest.

References

Chatterjee, R., Tarafder, G., Paul, S., 2010. Groundwater quality assessment of Dhanbad district, Jharkhand, India. B. Eng. Geol. Environ. 69, 137-141.

Khatri, N. and Tyagi, S., 2015. Influences of natural and anthropogenic factors on surface and groundwater quality in rural and urban areas. Frontiers, 8(1), 23-39.

Kushwah, V.K., Singh, N., Singh, K.R., 2023. Multivariate statistical techniques for the evaluation of Groundwater quality of Mathura (India). J. Appl. Sci. Innov. Technol. 2 (1), 47-51.

Rawat, K.S., Singh, S.K., Gautam, S.K., 2018. Assessment of groundwater quality for irrigation use: a peninsular case study. Appl. Water Sci, 8, 1-24.

Singh, V.K., Bikundia, D.S., Sarswat, A. Mohan, D., 2012. Groundwater quality assessment in the village of Lutfullapur Nawada, Loni, District Ghaziabad, Uttar Pradesh, India. Environ. Monit. Assess. 184, 4473-4488.

Singha, S., Pasupuleti, S., Singha, S.S., Singh, R., Kumar, S., 2021. Prediction of groundwater quality using efficient machine learning technique. Chemosphere, 276, 130265.

Subba Rao, N., 2006. Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India. Environ. Geol, 49, 413-429.