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STUDY OF GROUND WATER QUALITY IN DIFFERENT SEASON NEAR TAMSHA RIVER IN AZAMGARH DISTRICT

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ABSTRACT

Azamgarh district is located at eastern district of Uttar Pradesh on the southern strand of the Tamsa River. In order to study the groundwater quality of Azamgarh district, water samples were collected from hand pump and submersible pump across different seasons. The suitability of drinking water check in many urban places of Azamgarh District near Tamsha River during the summer, Winter and Rainy Season. The groundwater quality in urban area near Tamsha River in Azamgarh district integrating hydro-chemical analyses, spatial and seasonal patterns, and health risk evaluations. It establishes that while groundwater in the region is largely suitable for irrigation, significant spatial heterogeneity exists in terms of its portability. The groundwater is predominantly and effected by the using of fertilizers, industrial discharge, and domestic wastewater infiltration. Parameters such as EC and TDS exhibit peak concentrations during the summer period, suggesting a lag effect of monsoonal leaching and infiltration processes.

KEYWORDS: Water, TDS, Tamsa River, EC, BIS Standard

Water is an important substance of living organism in the Earth. On the surface of the Earth, water is distributed unevenly. The total water present on earth accounts 3% as freshwater, while the other 97% is found in the ocean which is saline in nature. Out of these3%, freshwater 69% exists in glaciers, 30% as underground water and less than 1% in lakes, rivers, and marshes. Therefore, groundwater and surface water are the major sources of freshwater. Around 2.5 billion people depend on groundwater for their everyday water requirement. The water demand is increasing due to growing global population leading to excessive abstraction of groundwater i.e., beyond its natural recharge potential, unavoidably leading to decline in water levels, water quality, seawater intrusion and groundwater pollution. About 17% of groundwater blocks are extensively used while 5% and 14% are in crisis and semi-critical stages, according to the National Groundwater Board of India. A variety of physical and chemical factors influence the quality of drinking water, and each has an impact on how safe and suitable the water is to drink.

AREA OF RESEARCH AND RESEARCH METHODOLOGY

Azamgarh district is an eastern district of Uttar Pradesh, located on the southern strand of the Tamsa River. Azamgarh border is connected with Mau, Gorakhpur, Ghazipur, Jaunpur, Sultanpur, and Ambedkar Nagar. The district headquarters in Azamgarh have eight tehsils and 22 blocks. The ground water is the most important natural resources for human. The availability of drinking water in many parts of Azamgarh during the summer season decreases because highly use of ground water in agricultural, domestic, and industrial purposes. Increasing in the rate of population and industrialization, ground water quality is affected in chemical concentration like NO_3, TDS, Chloride and fluoride ion, hardness, possess very serious health problem in India. On behalf of different problem, we examine the physical-chemical characteristics of groundwater and its comparison with WHO and BIS data for contaminations and suitability for drinking purposes. Groundwater quality is characterized by evaluating various physico-chemical and biological factors, including pH, electrical conductivity, total dissolved solids (TDS), alkalinity, hardness. All study data of Azamgarh will be compare with other cities of India. In order to study the groundwater quality of Azamgarh district, water samples were collected from hand pump and submersible pump across different seasons. We collected 500 ml of water samples in low density polyethylene (LDPE) bottles and measure its pH, TDS, electrical conductivity (EC), Hardness. The pH was measured by a digital pH meter. The pH was calibrated by dissolving pH tablets of 4 and 7 pH in 100 ml of distilled water. EC was measured by digital EC meter. Total dissolved solid (TDS) was measured by gravimetric method and TDS meter.

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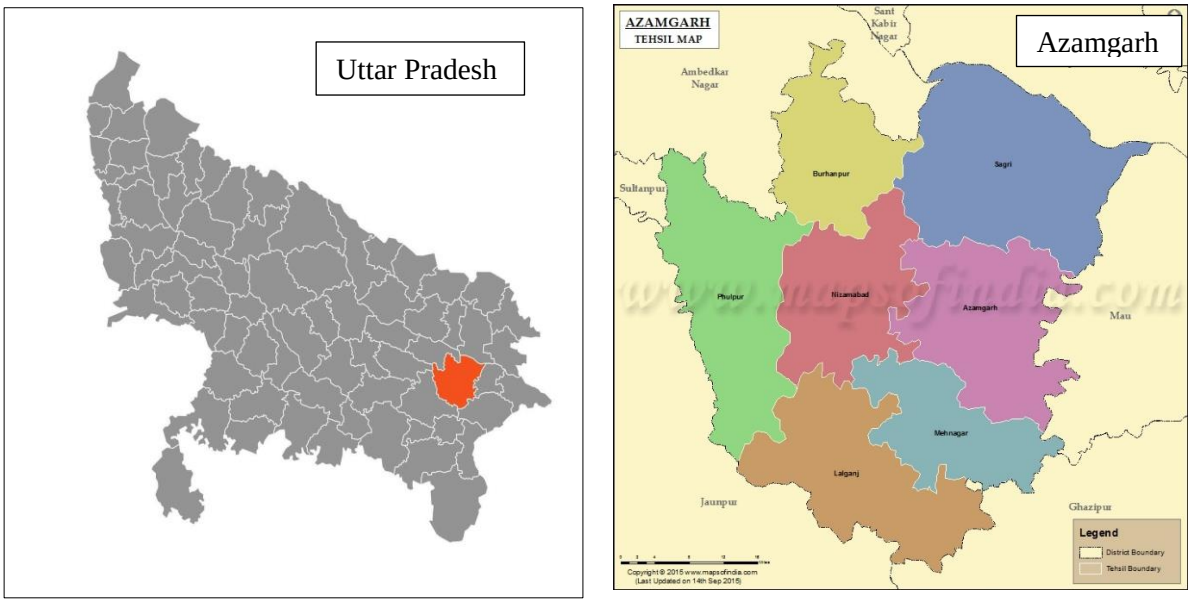
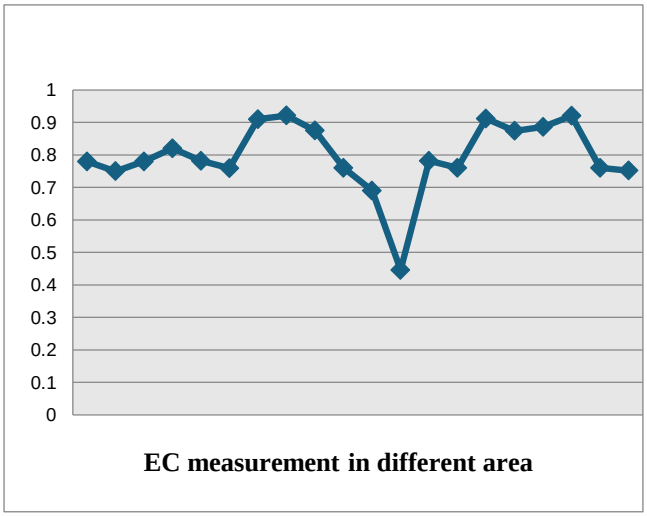


Figure: Uttar Pradesh and Azamgarh Map (From Google)

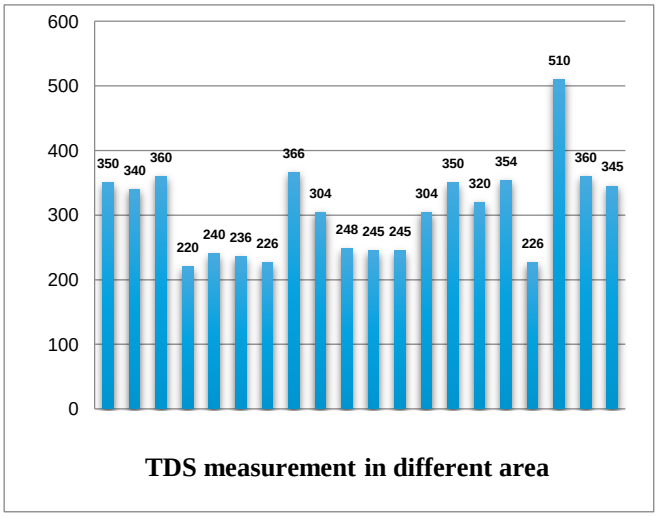
RESULTS AND DISCUSSION

Acidic, basic or neutral nature of groundwater is described based on pH value; it is the parameter which is defined as the negative logarithms of hydrogen ion concentration in the solution. The pH of the groundwater spanning from 6.60 to 7.79, indicating that the pH of the groundwater was slightly acidic to alkaline in nature. The observed seasonal average pH value was 7.23 in Sammer, 7.21 in Rainy and 7.13 in Winter season, and was within the permissible standards for several usages. The highest pH value in groundwater samples was 7.23±0.24 in Sammer and lowest was 7.13±0.23 in Winter season (Table 1). Acidity or alkalinity of ground water effect both chemical reactions and biological activities. The normal range of ground water pH according to BIS it varies from 6.5 to 8.5.

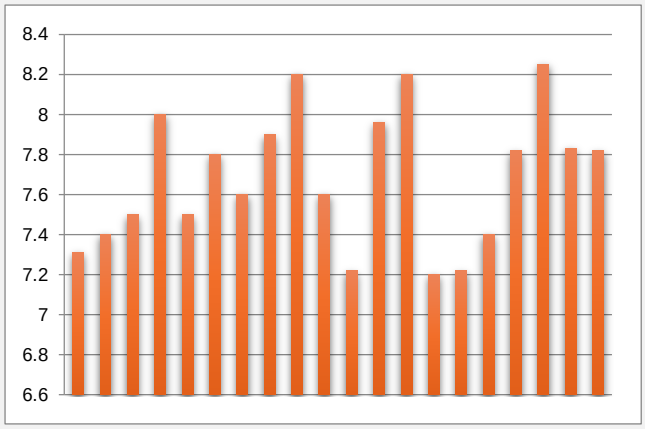
EC gives information on the dissolved ion quantity and general water quality. The electrical conductivity (EC) is the properties of the ion which is measure current flow by the ions. It is used to determine the concentration of ions in water and more will be ions dissolve in the water greater will be electrical conductance of water. The EC values range from 730 to 2340 micro-Siemens per centimeter with a mean value 1235 micro-Siemens per centimeter in pre-rainy season, 1231 micro-Siemens per centimeter in rainy season and 1146 micro-Siemens per centimeter in post-rainy season (Table 1).



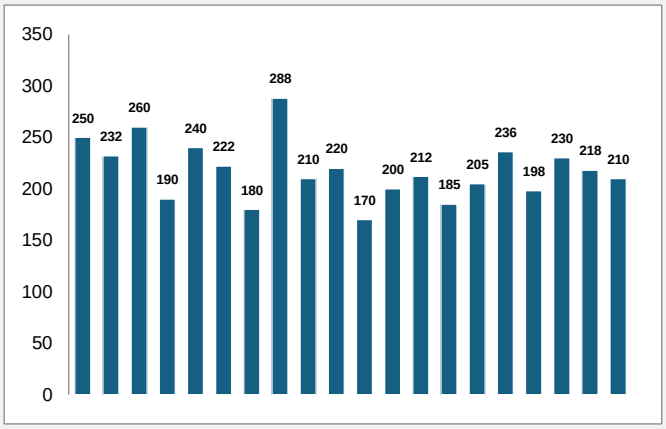
EC measurement in different area



TDS measurement in different area



pH measurement in different area



Alkanity measurement in different area

Measurements of Total Dissolved Solids (TDS) reveal the total amount of dissolved inorganic and organic materials in Water. TDS evaluation is essential for evaluating water quality, industrial operations, and environmental effects. The total amount of dissolved solids (TDS) in water, which includes both organic and inorganic components, is measured. With a mean value of 649 milligram per liter in the summer season, 691 milligram per liter in the rainy season, and 630.3 milligram per liter in the winter season, amount of total dissolve solid ranges from 390 to 1200 milligram per liter (Table-1). Overall, the groundwater is suitable for drinking water except 24.24% (in summer), 30.3% (in rainy) and 21.21% (in winter) of groundwater samples which has TDS values above the recommended limits (BIS, 2012). Both the EC and TDS were reported to be maximum in winter as compared to other two seasons. The variations in the concentration of TDS and EC could be due to rainwater infiltration, hydro geochemical processes such as leaching and dissolution of ions, mineralization, and ion-exchange caused by both geogenic and anthropogenic activity.

In water analysis, alkalinity is a measure of a solution's ability to neutralize acids, according to the principle of the alkalinity test. Bicarbonate (HCO_3^-), carbonate (CO_3^{2-}) and hydroxide (OH) ions are the main causes. The Normal range of alkanity from 200 to 600 mg/L (BIS standard)

Table 1: Data of measured groundwater quality parameters of the study area in different season

Parameters	Standard water quality Parameter	Summer Season March - June			Rainy Season July - October			Winter Season November - February		
		Min	Max	Average	Min	Max	Average	Min	Max	Average
pH	6.5-8.5	6.8	7.54	7.24	6.8	7.8	7.21	6.6	7.51	7.1
EC (µS/cm)	750-2000	765	2060	1235	764	1860	1229	729	2350	1145
TDS (mg/L)	500-2000	412	1085	651	389	1159	689	402	1200	629

The correlation matrix for groundwater quality parameters highlights several significant associations (Table 1). A strong positive correlation (>0.8) was observed between EC and TDS in all seasons. Likewise, EC and SO_4^{2-} showed a positive correlation (>0.7) during the summer and rainy periods, while EC and Cl had a moderate positive correlation (>0.6) specifically in the rainy season. TDS and SO_4^{2-} also displayed a moderate positive correlation (>0.6) in both the summer and rainy seasons.

In summer season, three principal components (PCs) having eigen value >1 were identified as the most significant principal components, which represent 77.76% of the variance in the groundwater quality of study area (Table 2). The first principal component (PC1) explains 41.84% of the overall variance and has a strong correlation with Na, K. In contrast, parameters like EC, TDS show weak contributions to this component. PC1 likely reflects the interplay of processes such as mineral dissolution, evaporation, and potential human influence. The prominence of Na, K suggests natural geochemical sources as the primary contributors, with possible anthropogenic impacts.

During the rainy season, three principal components (PCs) with eigenvalues greater than 1 were identified as key contributors, explaining 80.55% of the variance in groundwater quality (Table 2). PC1, accounting for 36.42% of the variance, is strongly

influenced by Na, K while parameters like Ca, SO_4^{2-}, and Cl^- contribute minimally. This suggests that PC1 is associated with natural processes such as mineral weathering and carbonate dissolution. PC_2 explains 31.27% of the variance, with high loadings of EC, TDS, Ca reflecting salinity levels and possible anthropogenic inputs from agricultural runoff or industrial activities. PC3, contributing 12.86% of the variance, is dominated by pH and F^-, highlighting fluoride enrichment linked to pH-controlled processes, likely driven by natural geogenic factors.

During the winter season, three principal components (PCs) with eigenvalues greater than 1 were identified, explaining 77.27% of the variation in groundwater quality (Table 2). PC1, contributing 40.27% of the variance, is strongly influenced by Na, K indicating the impact of mineral weathering, carbonate dissolution, and evaporate sources. PC2, accounting for 22.54% of the variance, shows high loadings of EC and TDS with weaker contributions from Ca, SO_4^{2-}, and F, reflecting salinity influences. PC3, contributing 14.47% of the variance, is mainly linked with pH, with minor impacts from F and NO_3^-, highlighting localized geogenic or anthropogenic factors. The results suggest that cations are mainly derived from natural processes, while anions are influenced by salinity, alkalinity, and localized factors.

The groundwater in Azamgarh district is utilized for household, agricultural, and factory purposes. A significant portion of the population relies on untreated groundwater for drinking. However, elevated levels of NO_3^- and F^- were detected in groundwater samples. The correlation matrix for groundwater quality parameters highlights several significant associations. A strong positive correlation (>0.8) was observed between EC and TDS in all seasons.

Table 2: Principal component (PC) analysis of water parameter

Parameters	Summer Season March - June			Rainy Season July - October			Winter Season November - February		
	PC (1)	PC (2)	PC (3)	PC (1)	PC (2)	PC (3)	PC (1)	PC (2)	PC (3)
pH	0.05	-0.783	-0.193	-0.024	-0.247	0.842	0.045	0.08	-0.763
EC	0.5	0.69	-0.145	0.143	0.889	0.049	0.208	0.871	0.027
TDS	0.567	0.674	-0.17	0.242	0.839	-0.078	0.291	0.828	-0.004

Extraction Method- Principal Component Analysis & Rotation Method- Varimax with Kaiser Normalization

CONCLUSION

This research provides a significant measurement of groundwater quality in urban area near Tamsha River in Azamgarh district integrating hydro-chemical analyses, spatial and seasonal patterns, and health risk evaluations. It establishes that while groundwater in the region is largely suitable for irrigation, significant spatial heterogeneity exists in terms of its portability. The groundwater is predominantly and effected by the using of fertilizers, industrial discharge, and domestic wastewater infiltration. Parameters such as EC and TDS exhibit peak concentrations during the summer period, suggesting a lag effect of monsoonal leaching and infiltration processes. The study also reveals that nearly half of the aquifer samples fell in to the 'poor' to 'unsuitable' classes for drinking according to DWQI classifications. High levels of TDS, hardness due to Ca^{+2}, Mg^{+2}, Cl^-, CO^{-2} in several locations indicate the presence of both natural geochemical mobilization and anthropogenic contamination. Irrigation suitability assessment based on SAR and Na% categorically affirms that groundwater across seasons is mostly excellent for agricultural usage. The observed low SAR values (<10) across all samples imply minimal risk of sodality-related soil degradation, making the groundwater a reliable resource for sustaining the district's predominantly agrarian economy. However, the risks posed by fluoride and nitrate contamination, particularly in shallow aquifers, cannot be overlooked. In conclusion, this research not only maps the current status of groundwater quality in urban area of Azamgarh district but also emphasizes the necessity of region-specific, season-aware, and health- sensitive water governance frameworks. Strengthening institutional mechanisms, expanding water quality surveillance and integrating community participation are vital steps towards achieving long-term water security and public health safety in this socio-economically significant district of eastern Uttar Pradesh.

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