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Original research article

Ground Water Quality Assessment with Reference of TDS and EC

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ABSTRACT

Groundwater is one of the natural water resources for domestic activities like bathing, washing, drinking, etc. , and agriculture purposes. Due to rapid growth in population, industrialization, urbanization intensive agriculture practices and over exploitation, the quality and quantity of groundwater are deteriorating. The objective of this investigation was to analyze the electrical conductivity (EC) and total dissolved solids (TDS) as water quality parameters. Twenty sampling sites of groundwater of Mathura district were gathered from various sources, including hand pumps and tube wells. According to this study, 40 percent of the samples were found within the acceptable limit for drinking, which is 500– 1000 mg/ L as defined by World Health Organization (WHO, 2017) and Bureau of Indian Standards (BIS, 2012), while sixty percent were above the allowable limit. Therefore, most samples of the groundwater in Mathura, Uttar Pradesh, do not meet the drinking water standards. These results indicate that the quality of water is not suitable for potable and irrigation purposes. Exceeding the suggested TDS thresholds in water can elevate the consumption of detrimental minerals such as lead, arsenic, and fluoride, as well as salts, which can lead to long- term gastrointestinal and cardiovascular problems after prolonged consumption. This research investigation provides insight into the pristine state of ground water quality in the study area and is hence relevant for water quality assessments in various domestic regions.

Keywords: Electrical conductivity; Ground water; Mathura; Total dissolved solid

1. Introduction

One of the world's most reliable natural resources is groundwater. The groundwater quality is affected by rainfall, geochemical processes in the ground, and the quality of water that is put back into the ground [1]. The study of groundwater quality in urban areas is an important step to ensure the safety of urban people particularly in locations with unpredictable tap water supplies [2]. In light of growing population, urbanization, industrialization, and agriculture, groundwater contamination by human activities is a major global concern. The anthropogenic contamination of groundwater and decreasing resource quantities as a result of over-

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extraction and the consequences of climate change are putting it under increasing stress [3]. The increased number of shallow & deep tube wells in the study area is evidence of the region's heavy reliance on ground water resources for irrigation purposes. In India, over 90 percent of the domestic population depends either on ground water or on untreated surface water, while 30 percent of the needs of the population in urban areas are satisfied by groundwater. They are also essential to sustain urban lifestyles and a variety of commercial and agricultural operations. Availability of surface water is less common in urban areas compared to rural areas in the study area. Even though more people in India now have access to clean drinking water, the enormous negative effects of unclean water on health still exist. It is found that 21% of communicable disease caused by water is found in India [4]. Regular monitoring of groundwater properties helps to reassure the public about its suitability for drinking and also helps to take effective steps. If quality of groundwater decreases so that there will be no impact on human health while drinking groundwater [5]. An evaluation of the water using measures like TDS and EC can provide us with some insight into the water's quality [6]. Results of electrical conductivity (EC) on ground water is directly related to concentration of ionized material in groundwater and it is also related to the issues causing excessive hardness and presence of other minerals. In natural waters, dissolved solids contains various minerals such as iron, potassium, sodium, magnesium, chlorides, carbonates, bicarbonates, phosphates, etc., and it contains minimum quantity of organic matter as well as dissolved gases [7]. In light of this, the current investigation evaluates the quality of groundwater in domestic parts of Mathura, Uttar Pradesh, India for both irrigation and drinking purposes. Mathura is a profoundly important religious destination that draws millions of tourists and devotees annually. Mathura, despite its cultural and religious importance, has suffered from a notable dearth of comprehensive and meticulous research regarding the groundwater quality in the region. We believe that by emphasizing the unique religious and cultural context of Mathura and the scarcity of detailed studies on its groundwater quality, our research makes a significant and original contribution to the scientific literature.

Ali et al., in 2024, studied the quality of groundwater in Achnera block, Agra district, and near the study area found TDS values higher than the permissible limit when compared with the guidelines of the WHO and BIS (2012). Ahmed et al., in 2020, studied the water quality of Mathura district and observed that both TDS and EC were above the maximum permissible limit prescribed by the WHO and BIS. Due to the above findings, we have selected Mathura district for the assessment of groundwater quality in terms of EC and TDS. The aim of the current research was to determine the quality of groundwater resources in the Mathura district for various uses like drinking and agricultural activities.

2. Materials and Methods

2.1 Study area

The district of Mathura is located in the state of Uttar Pradesh, India. It is a famous religious old city of Uttar Pradesh. The population of the Mathura district is 25.47 lakhs of people. The region that was looked into spans 3,303 square kilometers and is located between the latitudes of 27° 14' and 27° 17' and between the longitudes of 77° 17' and 78° 12'. In the summer season, the mean monthly temperature is approximately 42 degrees Celsius, whereas in the winter season, the mean monthly temperature varies from 2 degrees Celsius to 26 degrees Celsius. The Yamuna River is the only surface source of drainage in the region. The research area is depicted in Fig. 1.

2.2 Collection of samples

In the present study, water samples from 20 different sampling locations were collected as shown in Table 1 and from each sampling location 3 samples were collected and concurrent reading of these three samples have been considered. These sampling locations are spread over the whole district and represent the entire study area. The criteria of selecting of sampling locations depends on various factors, including available literature, geographic conditions, depths to capture potential variations, land use pattern, potential pollution sources, and hydrological attributes. Water samples (ground water samples, GWS 1-GW20) were taken from the 20 ground water sampling sites in Mathura district, which are listed in Table 1. Twenty samples of groundwater were taken from different wells using handpumps and placed in clean high-density polyethylene (HDPE) bottles. On the label of each bottle there was information about the type of analysis, the sample location, the day and time of the sampling, the analyst, and the analysis itself. To prevent skewed results, the containers were examined in the lab after collection. There are important considerations for sampling regimens, sampling techniques, and sample preservation and storage techniques [8]. The American Physical Health Association (APHA), 2012 includes recommendations for water sampling, saying that samples should be collected in HDPE bottles. Prior to collecting the sample, we must ensure that the sample container is free of all foreign objects and pollutants. We carefully cleaned the sample bottles three times using water from the tap and distilled water, respectively.

2.3 Methodology

Groundwater samples were taken in the months of April and May, 2022 from twenty sampling locations throughout the city of Mathura. In this study, spatial variation of water quality parameters was analyzed to quantify the observed trends and assess their significance accurately. Samples of ground water were taken and stored in HDPE bottles that had already been washed. According to analytical method, the groundwater samples were examined for EC and TDS (APHA 2012). While the definition of EC is measured in mS/cm at 25 °C. Using the digital Electric Conductivity meter (Aquasol)and digital TDS meter (Aquasol), the electrical conductivity (EC) and TDS were measured. The EC and TDS meters were calibrated by using standard buffer solution of 1.413 ms/cm and 706 PPM respectively, before analysis of water samples. Water electrical conductivity is inversely proportional to the quantity of dissolved ionized solids present. The capability of water to conduct an electric current is created by ions from the dissolved solids, and this ability can be assessed with a TDS meter.

Table 1. Location of water samples collection.

S.No.	Sample No.	Sampling Location	Block/District
1	GWL1	Nabipur	Kosi/Mathura
2	GWL2	Hasanpur nagla	Kosi /Mathura
3	GWL3	Surwari	Kosi /Mathura
4	GWL4	Ajijpur	Kosi /Mathura
5	GWL5	Agaryala	Chhata/Mathura
6	GLS6	Ajnokh	Chhata /Mathura
7	GWL7	Gidoh	Chhata /Mathura
8	GWL8	Jalalpur	Chhata /Mathura
9	GWL9	Datiya	Chhatikara/Mathura
10	GWL10	Dhana Jiwna	Chhatikara /Mathura
11	GWL11	Janu	Chhatikara /Mathura
12	GWL12	Dagheta	Chhatikara /Mathura
13	GWL13	Jait	Chhatikara /Mathura
14	GWL14	Girdharpur	Mathura City/Mathura
15	GWL15	Satoha	Mathura City /Mathura
16	GWL16	Khamini	Mathura City /Mathura
17	GWL17	Ganesara	Mathura City/Mathura
18	GWL18	Palikhera	Mathura City/Mathura
19	GWL19	Aring	Goverdhan/Mathura
20	GWL20	Jachonda	Goverdhan/Mathura

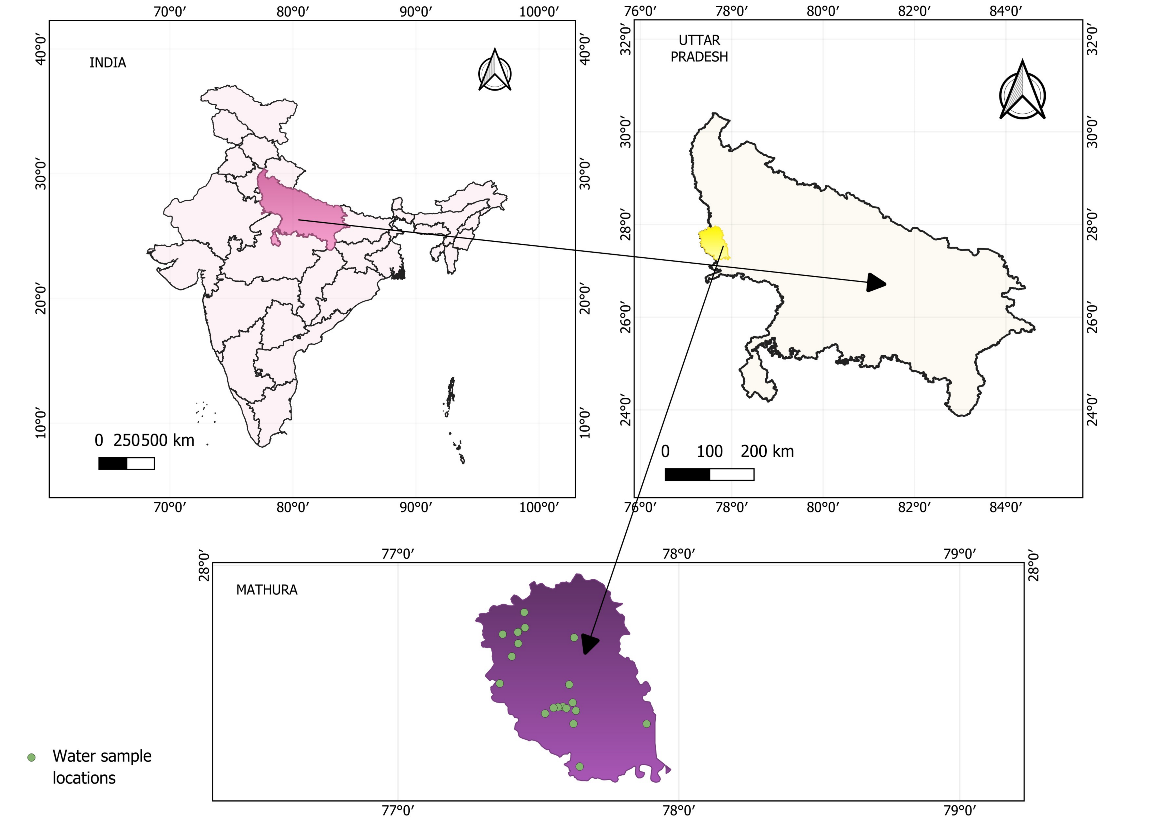


Fig. 1. Description of study area (Mathura, India).

Table 2. Groundwater parameters with APHA protocols.

S. No.	Water Parameters	Abbreviation	Unit	Analysis Method	Reference Method
1	Electrical Conductivity	EC	mS/cm	Digital Conductivity Meter	APHA,21st Edition
2	Total Dissolved Solid	TDS	mg/L	Digital TDS Meter	APHA,21st Edition

3. Results and Discussion

It is crucial to comprehend the quality of the groundwater because this is the main determinant of whether it is suitable for drinking, household, farming, and industrial uses. The data showed that there were significant differences in the tested samples from various sources in terms of their TDS and EC. Early investigations found a negative correlation between drinking water TDS concentrations and the prevalence of cancer, coronary heart disease, arteriosclerotic heart disease, and cardiovascular illness. According to a study, TDS levels in drinking water have an adverse relationship with total mortality rates [9]. One of the principal sources for drinking water on the entire planet is groundwater [10].

3.1 Electrical conductivity

An evaluation of water's ability to carry electric current is called electrical conductivity. In drinking water, 1.50 mS/cm is the recommended maximum EC level (WHO 2017). The investigation's findings are shown in (Table 3). The results were within the acceptable range by 40% shown in Table 4. Increased EC in the studied area implies salt

Table 3. Groundwater quality characteristics with respective values.

S. No.	Sample No.	Electric Conductivity (EC), mS/cm)	Total Dissolved Suspends (TDS), mg/L)
1	GWL1	1.210	800
2	GWL2	3.110	3050
3	GWL3	3.980	3400
4	GWL4	4.120	3600
5	GWL5	2.870	2220
6	GWL6	1.230	900
7	GWL7	1.440	1240
8	GWL8	3.420	2430
9	GWL9	4.105	3420
10	GWL10	2.975	2520
11	GWL11	1.260	950
12	GWL12	1.302	1050
13	GWL13	3.202	3110
14	GWL14	3.210	3200
15	GWL15	4.008	3560
16	GWL16	3.990	3320
17	GWL17	2.750	2100
18	GWL18	0.980	700
19	GWL19	0.760	650
20	GWL20	1.290	850

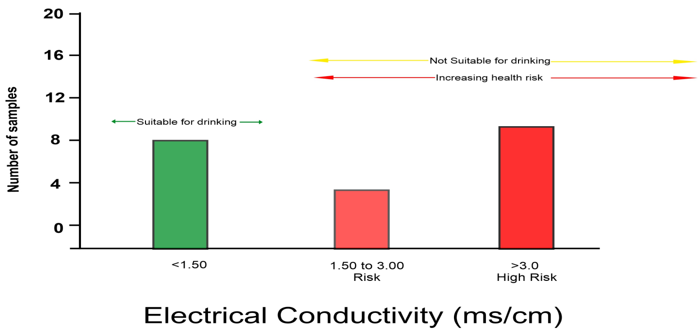


Fig. 2. EC concentration of groundwater sample.

enrichment in the groundwater. It is dependent on the temperature, ion concentration, and type of ions [11]. The EC can be categorized as Type I if the salt enrichments are low (EC<1.50 mS/cm), Type II if the salt enrichments are medium (EC 1.50 to 3.00 mS/cm), and Type III if they are high (EC >3.0 mS/cm) as prescribed by BIS and WHO standards for irrigation 40% of all groundwater samples fall under type I, 15% fall under Type II, and 45% fall under Type III (Fig. 2), according to the EC classification mentioned above. High EC enrichment in the research area could be caused by the impact of salt enrichments and saline intrusion. Because of all of these things, the process of dissolving may also speed up, which will raise the EC value in the end. The measurement of EC is directly linked to the amount of an ionized material present in water and may also be linked to issues with excessive hardness and other mineral contaminants The quantity of ions dissolved in water affects the amount of electricity that may pass through it. EC, on the other hand, is simple to test and provides data that is useful as a general indicator of total dissolved solids [12]. MilliSiemens/cm is the unit used to measure electrical conductivity (EC). At 25°C, the groundwater's EC ranges from 0.760 to 4.120 mS/cm (Table 3) with an average value of 2.5606 mS/cm. Table 3 and 5 provides the groundwater classification based on EC. In the study of Ahmed et al., 2020, during 2016, the average concentration of EC as observed in most of samples was above the permissible limit prescribed by the WHO, 2017 [13]. A graphical interpretation for risk examination of EC (Fig. 2) shows that only

40% of the samples are within the legal range, 15% are outside the range but are of poor quality, and 45% of the sample locations are dangerous. A point data groundwater samples map (Fig. 3) indicates EC variation in the study area.

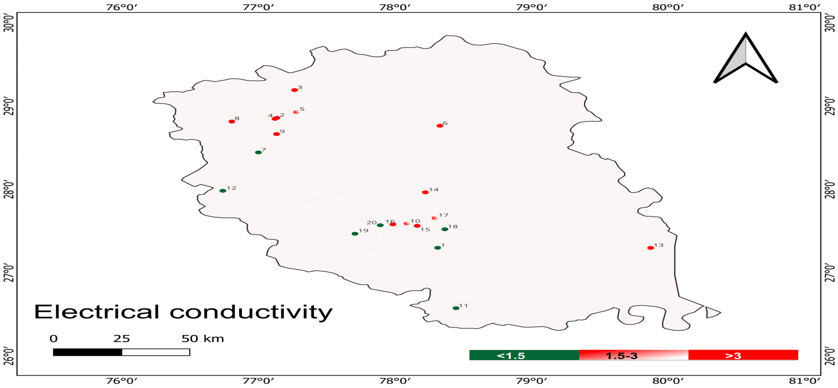


Fig. 3. EC concentration of groundwater samples.

3.2 Total dissolved solid

TDS is used to indicate the aesthetic qualities of drinking water and as a general indicator of a variety of chemical impurities. TDS of up to 500 mg/L is the maximum desired level, and TDS of up to 1,500 mg is the maximum allowed level, according to WHO guidelines. Human drinking water standards do not consider TDS to be a major contaminant that could harm human health.

Table 4. TDS-based groundwater classification.

S. No.	TDS range (mg/l)	Type of Water	Sample in (%)
1	<500	Desirable limit for Drinking	--
2	500 - 1000	Max. Allowable limit for Drinking	30%
3	<3000	For agricultural Uses	30%
4	>3000	not suitable for irrigation or drinking	40%

Table 3 shows that the TDS value in the study area ranges from 650 mg/L at the lowest point to 3600 mg/L at the highest point. This shows that most groundwater samples are above the maximum limit (Table 5). In the study by Ahmed et al. (2020), during July 2016, average concentration of TDS in Mathura district was in the range of 848-17170 mg/L which is above the permissible limit [13]. During 2022-2023, the average TDS of Achhnera block, Agra district, as observed by Ali et al. (2024) was above the permissible limit of BIS, 2012 in most of the regions [14]. TDS levels of up to 500 mg/L are preferred for drinking water, according to WHO and BIS specifications. The analysis reveals that while 40% of the samples fall into the category of maximum acceptable and the remaining 60% exceed the WHO and BIS specifications (2012) [15], not a single sample falls below the ideal TDS limit that can be safely used for drinking shown in (Table 4) and Fig. 4. 70 percent of the sample locations

Table 5. Surpassing the acceptable limits by WHO and BIS (2012) in groundwater samples.

S. No.	Characteristics of water quality	BIS standards (2012)		WHO Standards		Level in research area
		Max. desirable limit	Max. Permissible limit	Most desirable	Highest allowable limit	
1	TDS (mg/l)	500	2000	500	1500	650 - 3600
2	EC (mS/cm)	-	-	1.50	-	0.760 - 4.120

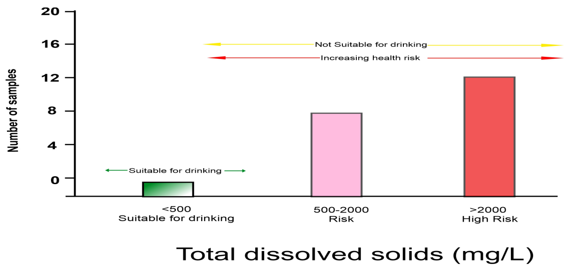


Fig. 4. TDS concentration of groundwater samples.

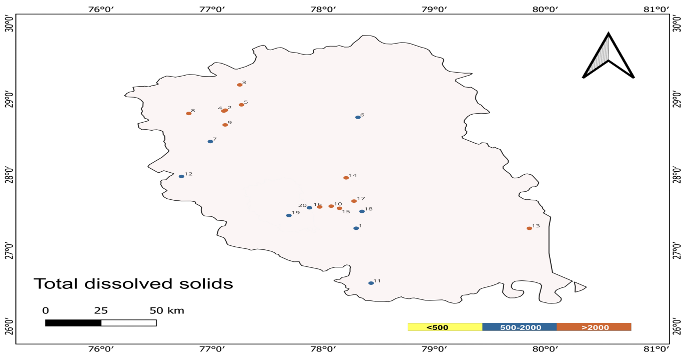


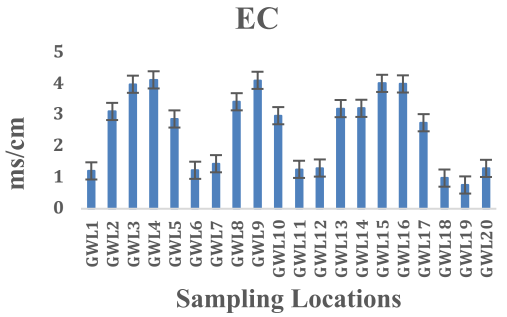
Fig. 5. Point data distribution map over study area for TDS.

in the study area's groundwater are brackish, whereas the remaining sample locations are fresh water [16] We now understand that water's true roles in the human body include regulating body temperature, lubricating joints and other tissues, and taking part in biochemical processes such as the movement of nutrition and impurities to and from the body's cells. There are no organizations throughout the world that have scientific evidence demonstrating that consuming water that contains low TDS would have negative health impacts. Some people contend that consuming water that has undergone extreme purification processes like reverse osmosis, distillation, or deionization "leaches minerals from the body and produces mineral deficits with subsequent adverse health repercussions." Our results show that 30% of the samples were between 500 mg/L and 1000 mg/L (Table 4) [17], which was considered safe to drink. A point data groundwater samples map indicating TDS variation in study area is shown in Fig. 5. The purpose of this paper is to determine whether low TDS water causes mineral loss from body tissues and any associated negative side effects. The body's homeostasis mechanisms, community water supplies with naturally occurring TDS of less than 50 mg/L, historical use of distilled water with naturally occurring TDS of less than 3 mg/L on heart navy ships, the United States Environmental Protection Agency's (USEPA) response to this issue, and other proof are presented to show that drinking water with low levels of minerals is safe. The components of body fluids are generally concentrated under the direction of the kidneys. Over 99% of the water it filters each day, roughly 180 liters (165 quarts), is reabsorbed, and only 1.0 to 1.5 liters is excreted as urine. The kidney excretes more water than usual in response to neurological and hormonal feedback processes when the osmolality of the fluid to be filtered by the kidney is below normal (low solute concentration, such as low TDS). This keeps the concentration in the bodily fluid at normal levels [18]. The bodily fluid osmolality is kept within normal limits by this renal homeostasis mechanism. The osmolality of the fluid that the kidneys will filter is kept within a tolerance of 1% of normal, or 300 mOsm/L. Antidiuretic hormone (ADH) from the pituitary gland, aldosterone from the adrenal glands, and thirst (as osmolality rises in around 1% of cases thirst) are the three primary hormonal and neurological regulatory systems triggered by aberrant concentration in the body fluids to be filtered by the kidney [19]. Due to these renal regulatory systems, consuming one litre of water would induce an increase in urine production nine times after 45 minutes (due to water absorption in the gut) and persist for around two hours. As a result, the kidney maintains homeostasis fast to keep the concentrations of solutes in the blood and other body fluids stable. Parathyroid hormone regulates calcium output by just a few percent in the extracellular bodily fluid. The concentrations of son during water ingestion are also increased by saliva. Typically, there are 15 mill equivalents of sodium chloride per litre (mEq/L), or 877 mg/L, and about 30 mEq/L of potassium ions in saliva (1170mg/L). As low TDS water is consumed, it is mixed with saliva, which raises the TDS before it reaches the gut to be absorbed (for instance, each one ml of saliva can raise the TDS level in eight ounces of water by around 10 mg/L) [20]. It is clear that consuming low TDS water cannot cause ill effects in healthy individuals. In contrast to a healthy diet, a healthy individual is one who is devoid of disease, hormone issues, etc. To die, like other bodily processes, maintains homeostasis: Consuming low TDS water would be a small (if any) contributing factor in any symptoms experienced if homeostasis is not maintained due to significant dietary shortages, diarrhea, or hormonal disruption. It was suggested that water be used after treatment because the majority of our results fall within the acceptable limit.

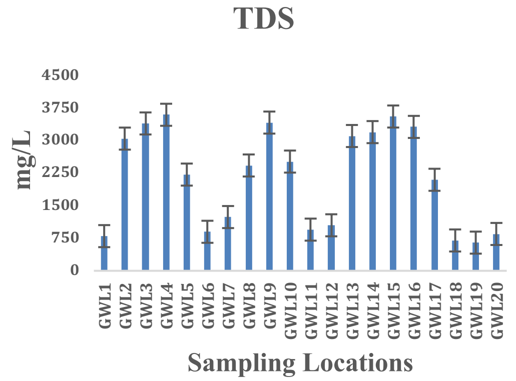
The interpretation of the results shows that high concentration of TDS and EC in the found water is due dissolution of minerals, salts and weathering of rocks and other hydrogeological phenomena. The high concentration represents of large number of different dissolved minerals in the groundwater which may cause health and environmental problems.

The maximum permissible limit of EC is 1.50 ms/cm as per the WHO, 2017 and for TDS BIS, 2012 and WHO, 2017 guidelines, it is 2000 and 1500 mg/L, respectively.

Statistical analysis for standard deviation has been incorporated for both EC and TDS as shown in Figs. 6(a)-(b) and descriptive analysis of groundwater quality as shown in Table 6.



(a)



(b)

Fig. 6. (a)-(b) Statistical analysis of EC and TDS.

Table 6. Descriptive analysis of Groundwater quality.

Parameters	EC	TDS
Minimum	0.76	650
Maximum	4.12	3600
Mean	2.5606	2153
Standard Deviation	1.227	1137
Skewness	-0.1430	-0.11
Kurtosis	-1.693	-1.79

The possible health and environmental effects include gastrointestinal irritation (laxative effects), taste, cardiovascular problems (heart disease, arteriosclerotic heart disease, and cardiovascular illness) on prolong consumption and high salt enrichment, and very high salinity in soil, which results in slow plant and crop growth, respectively. Thus, it is essential to maintain EC and TDS within safe permissible limits by using methods such as reverse osmosis, electro dialysis, ultra-filtration, nano filtration, ion exchange and solar distillation. Therefore, it helps in reducing possible health and environmental effects and contributes in sustainable development. Limitations of this research include water samples being gathered from designated sites and at precise time intervals. This method is incapable of capturing instantaneous variations or offering a thorough comprehension of water quality across large regions. Additional research will be necessary to assess the diversity of emerging pollutants that were not investigated in the present research. Further research will be carried out to understand the types of salts and minerals responsible for high TDS, their temporal variation can also be analyzed to understand their seasonal variations. Future research can be directed for removal of high TDS and salinity by various low-cost sustainable treatment methods.

4. Conclusion

The present study investigates the important details on the evolution of ground water quality in the rural parts of the Mathura district. The primary data showed that the research area's ground water is brackish to fresh in character and ranges in hardness from very hard to hard. 40% of samples fall within the maximum permitted level for water according to the WHO (2017) and BIS (2012) specifications of water based on TDS. The maximum allowed limit of TDS was exceeded in 60% of the ground water samples in the research area. The study demonstrates that, in contrast to BIS (2012) and WHO (2017), TDS of collected samples from 60% of the population was not found to be within allowed limits, and EC of samples from 45% of population was found to be excessive. Thus, consuming this water is not recommended. The suitability and quality of the water sites in the study region of the Mathura district are inadequate for consumption and agricultural use. The results of the analysis show that the water quality in many parts of the area under study is not good enough for use in homes or farms. EC and TDS can be removed by reverse osmosis, electro dialysis, exchange and solar distillation. Further research will be carried out to understand the types of salts and minerals responsible for high TDS; their temporal variation can also be analyzed to understand their seasonal variations. Future research can be directed for removal of high TDS and salinity by various low-cost sustainable treatment methods. Based on the findings of the comprehensive analysis, it has been determined that the majority of the groundwater sources in the Mathura area are unfit for consumption and are unsuitable for use in irrigation.

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