



## To study physiochemical parameters of potable water sources of Agra city (Uttar Pradesh) India

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### Abstract

Assessment of some water quality parameters like conductivity, total dissolved solid (TDS) and *pH* are useful and important parameters to measure the salinity and pollution assessment of water. In this paper, studies pertaining to ground water quality were carried out in Agra, NCR of Delhi, to check water suitability for drinking and irrigation purpose. Water samples were collected from hand pumps, tap water and submersible pump and analyzed for *pH*, Total dissolved solids (TDS) and electrical conductivity. Electrical conductivity and TDS are directly proportional to each other ( $TDS = k EC$ , at 298K) for water samples and showing strong Correlation between EC and TDS. Estimated TDS/EC ratio in water samples indicates water quality and is always influenced by salinity. Therefore, periodical monitoring and analysis of water quality parameters and treatment of water resources in all the area require immediate attention for proper planning, framing strategies, effective policy and better management of water resources to improve water quality for sustaining healthy ecosystems in the area.

**Keywords:** water quality, TDS, EC, salinity, pollution, water management

### Introduction

Like most of developing countries urbanization and industrialization have not gone in pace with environmental pollution, resulting in numerous problems arising from environmental pollution. This is specifically true about water bodies wherein various toxic solid wastes, effluents and emission are being discharged, resulting in an excessive amount of toxic and hazardous metals in local ground water. Due to discharge of untreated industrial effluents in the sewage channels, the ground water quality is deteriorated to great extent therefore availability of healthy, clean and good quality drinking water is a matter of great concern in the urban areas. The method of determining TDS in water supplies most commonly used is the measurement of specific conductivity with a conductivity probe that detects the presence of ions in water. TDS concentration describes the presence of inorganic salts and small amounts of organic matter in water and EC is the measure of water capacity to conduct electrical current <sup>[1]</sup>. *pH* is an important operational parameter in determining disinfection efficacy. Conductivity or electrical conductivity (EC) and total dissolved solids (TDS) are frequently used as water quality parameters and these are indicators of salinity level which make them very useful as one way in studying seawater intrusion <sup>[2-5]</sup>. The values of EC and TDS are correlated <sup>[6-8]</sup>. TDS analysis is very important and main parameter which can illustrate ground water quality, particularly in understanding the effect of seawater intrusion better than EC analysis <sup>[9]</sup>. The correlation of these two parameters can be estimated by the following equation:  $TDS (mg/L) = k \times EC (\mu S/cm)$ . The value of *k* shall increase along with the increase of ions in water. However, the relationship between conductivity and TDS is not directly linear; it depends on the activity of specific dissolved ions average activity of all ions in the liquid and ionic strength; the *k* value for natural water was formulated <sup>[10, 11, 12]</sup>. The contribution of TDS and EC ratio require for accuracy in monitoring and assessment, and further research is need for better results. Primary sources for receiving TDS in waters are agricultural runoff and residential (urban) runoff, clay-rich mountain waters, leaching of soil contamination, and point source water pollution discharge from industrial or sewage treatment plants. The most common chemical constituents are calcium, phosphates, nitrates, sodium, potassium, and chloride, which are found in nutrient runoff. The chemicals may be cations, anions, molecules or agglomerations on the order of one thousand or fewer molecules, so long as a soluble micro-granule is formed. More exotic and harmful elements of TDS are pesticides arising from surface

runoff. Certain naturally occurring total dissolved solids arise from the weathering and dissolution of rocks and soils.

**Table 1:** Correlation of EC and TDS in various type of water

Water Sample	EC at 25 0C ( $\mu\text{S}/\text{cm}$ )	TDS/EC = (k)
Natural water	500 – 3,000	0.55 – 0.75 [10]
Distillate water	1 – 10	0.5 [12]
Freshwater	300 – 800	0.55
Seawater	45,000 – 60,000	0.7
Brine water	65,000 – 85,000	0.75

## Materials and Method

### Study area

Agra is located at 25.98°N 78.27°E geographical coordinates. It has an average elevation of 190 meters. The people use hand pump water and submersible water for their daily need. The literature survey reveals that no water quality management studies are made in this region so far. Hence the present study was planned and undertaken.

### Sampling and sampling stations

The samples were collected in clean polythene bottles without any air bubbles as per requirements. The bottles were rinsed before sampling and tightly sealed after collection. Temperature, odor, taste and colour of the samples were measured at the study stations itself and at the time of collection of samples. The physicochemical parameters of ground water of five stations of Agra District viz. Shiv Nagar, Shivpuri, Kothi gate, Agra College and Delhi Road were studied. These all stations are located in the radius of 20 km area. The ground water was collected mainly from hand pumps in these stations during the months of January 2020 to March 2020. The depth of the hand pumps ranged from 90-130 feet at all these stations. The sampling sites/ locations of source and corresponding habitats are shown in table 2.

Analysis was carried out for various water quality parameters such as color, odor, temperature, pH, electrical conductivity (EC), total dissolved solids (TDS) etc. Electrical conductivity is a measure of the inorganic ion content of water and is not of direct concern for public health. High conductivity may be an indicator of acceptability in high total dissolved solids (TDS) waters, and sudden changes can be an indicator of pollution in the area. It may therefore be a useful indicator or operational parameter. All values obtained were compared with standard limit recommended by WHO and ISI (Table 3) [13]. Concentrations of TDS in water vary considerably in different geological regions owing to differences in the solubilities of minerals. The reagents used for the analysis were AR Grade and distilled water was used for preparations of solutions.

**Table 2:** Sample station specifications for ground water samples

S. No.	Sample Station No.	Sample Station Name	Habitat
1	SS1	Shiv Nagar	Residential/Agricultural area
2	SS2	Shivpuri	Residential/Agricultural area
3	SS3	Kothi gate	Residential/Agricultural area
4	SS4	Agra College	Residential/Agricultural area
5	SS5	Delhi Road, Merino industry	Residential/Agricultural area

**Table 3:** Drinking water standard limits

S. No.	Parameter	Indian Standard	WHO
1	pH	6.5-8.5	7.0-8.0
2	EC	1500 $\mu\text{S}/\text{cm}$	400 $\mu\text{S}/\text{cm}$
3	TDS	500 mg/L	300 mg/L

TDS concentration describes the presence of inorganic salts and small amounts of organic matter in water and EC is the measure of water capacity to conduct electrical current by all types of ions [14]. The sources of material in TDS and EC can come from nature, i.e. geological condition and seawater, and from human activities, i.e. domestic and industrial waste and also agriculture [7, 8, 15, 16]. There are many standards that govern TDS and EC in water. For health reason, desirable limit for TDS is between 500 mg/L and 1,000 mg/L and for EC is no more than 1,500  $\mu\text{S}/\text{cm}$  [17]. Salinity level is other main quality parameter [18, 19].

TDS has also been classified into four types:

- Freshwater with TDS < 1,000 mg/L.
- Brackish water with TDS between 1,000 and 10,000 mg/L.
- Saline water with TDS from 10,000 till 100,000 mg/L.
- Brine water with TDS > 100,000 mg/L [18].

Classification of water based on EC is divided into 6 types:

- Non-saline, if EC < 700  $\mu\text{S}/\text{cm}$ .
- Slightly saline, if EC between 700 and 2,000  $\mu\text{S}/\text{cm}$ .
- Moderately saline, if EC higher than 2,000 and less than 10,000  $\mu\text{S}/\text{cm}$ .
- Highly saline with EC value from 10,000 till 25,000  $\mu\text{S}/\text{cm}$ .
- Very highly saline, if EC value between 25,000 and 45,000  $\mu\text{S}/\text{cm}$ .
- Brine water with EC more than 45,000  $\mu\text{S}/\text{cm}$  <sup>[19]</sup>.

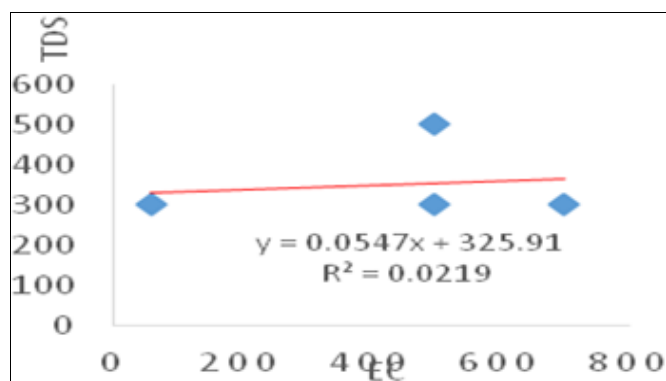
## Results and Discussion

### Correlation of TDS-EC in freshwater of five sample stations

The samples of freshwater were taken from groundwater of five sample stations. The main difference between the two locations is the EC value. Measured values of electrical conductivity and total dissolve solid with the names of sample stations and locations are given in the table 4. Figure A shows that TDS/EC ratio in freshwater is 0.65 ( $R^2 = 0.97$ ), this value is among the range which has been published <sup>[10]</sup>. Although figure B shows a higher ratio ( $R^2 = 0.96$ ). This indicates that the correlation of both parameters is strongly influenced by the EC values. However, all the findings are in accordance with the conclusion drawn by McNeil and Cox in which the obtained variation of TDS/EC ratio for freshwater can be vary 0.5 till  $\geq 1.00$  <sup>[20]</sup>. The important minerals of freshwater are generally sodium, calcium, magnesium, bicarbonate type or calcium, sodium, bicarbonate, chloride type. Accordingly, it has been found that the most correlated major ions, especially to TDS, are chloride, sodium, and magnesium <sup>[21]</sup>. Figure C shows the correlation of TDS-EC in freshwater, where correlation ( $R^2 = 0.80$ ). The TDS of all samples (Except SS 5) is in the range of 500-2000 (mg/l) which is according to IS 10500:2012. Highest value for TDS is observed at SSV College and lowest at Delhi road in analysis. The highest EC is shown by SSV College station and this is due to less use of hand pump. Lowest EC is represented by Delhi road station. By analyzing it is observed that except SS5 all sample stations have fit drinking freshwater for utilization.

**Table 4:** Measured values

Sample Stations		Conductivity ( $\mu\text{S}/\text{cm}$ )	TDS (mg/l)
1. Shiv Nagar	street 1	500	500
	street 2	500	300
	street 3	600	300
	street 4	700	300
2. Shiv puri	New shivpuri	600	300
	Devlok	500	300
	Tyagi nagar	550	300
	Old shivpuri	540	280
3. Kothigate	Gali 1	500	300
	Gali 2	600	400
	Gali 3	600	300
	Gali 4	500	300
4. SSV College	Tap water	800	500
	Submercible	1000	600
	R.O.	200	200
	Handpump	1100	700
5. Delhi Road	Petrol pump	100	100
	Merino industries Ram swaroop	100	100
	JSS school	100	100
	Prakash regency	100	100



**Fig 1**

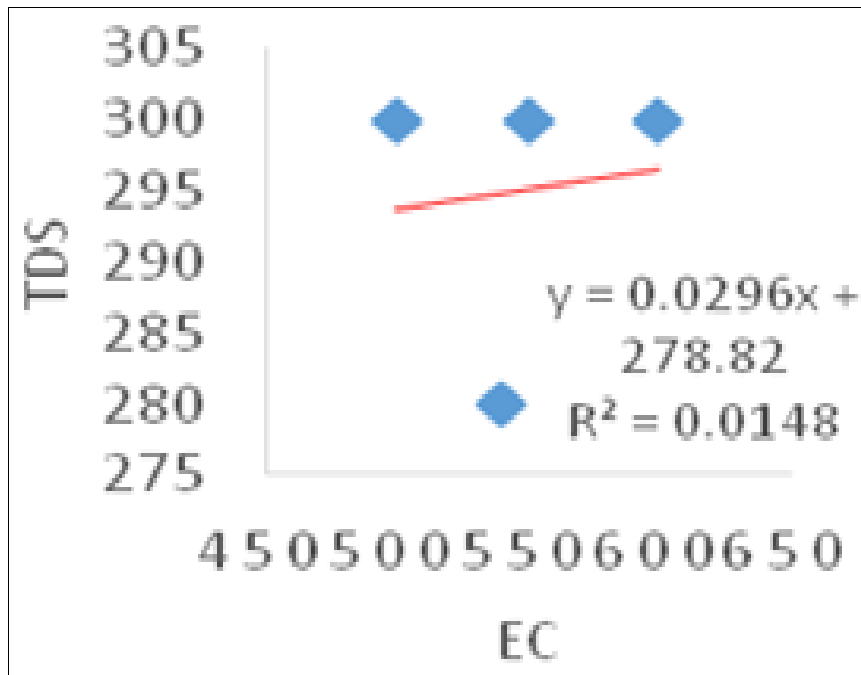


Fig 2

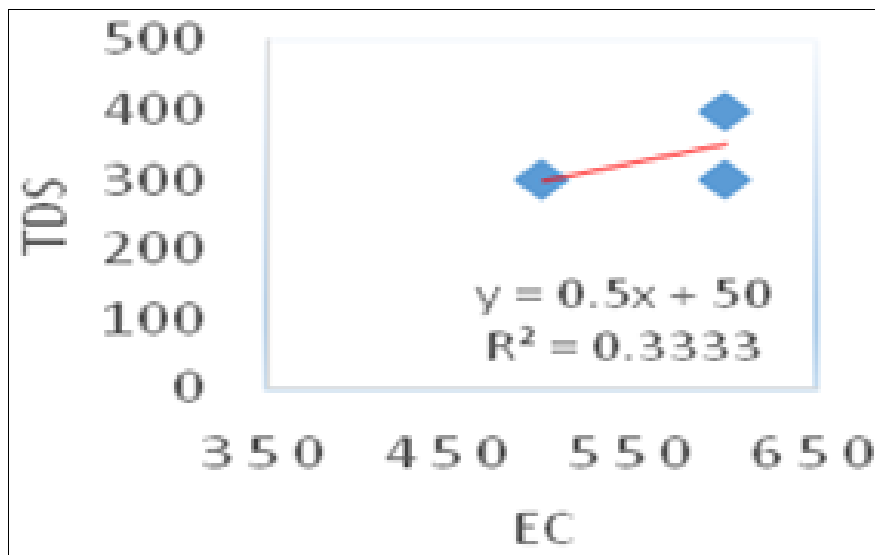


Fig 3

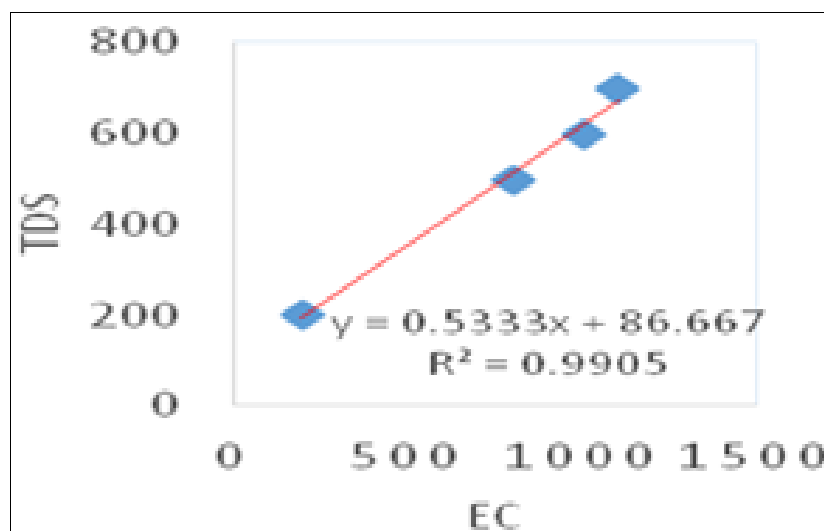


Fig 4

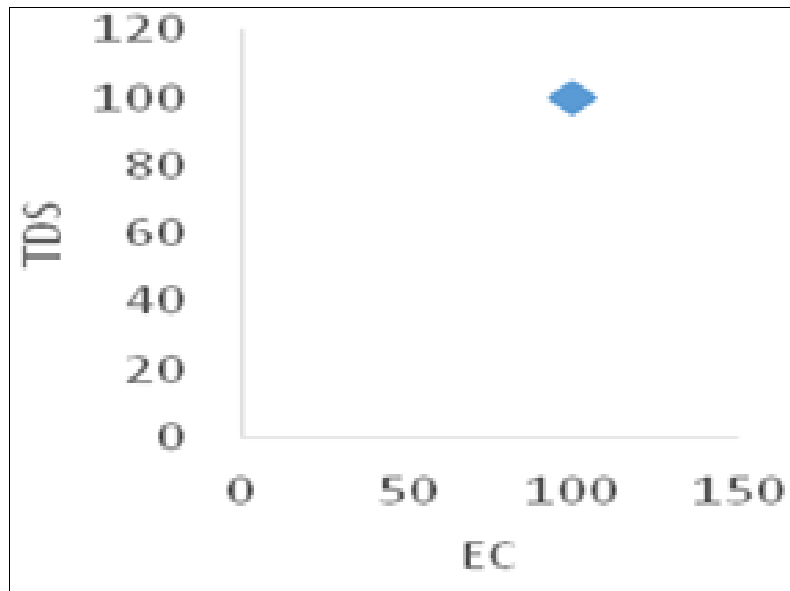


Fig 5

**Comparison of correlation of TDS-EC in freshwater of three locations**

At first location, the EC value is less than 6,000  $\mu\text{S/cm}$  [22], while at second location the EC value is higher up to 10,000  $\mu\text{S/cm}$ , and at third location the EC value is up to 1,000  $\mu\text{S/cm}$ . Results were compared with samples from the first location with the values obtained in 2009 [22]. Similarly, obtained results were compared with the values obtained in analysis in 2019 for second location [23]. The correlation between these parameters is shown in figure A, B and C. However, the drinking water quality parameters are many and different for different sources [24]. Figures A, B and C represent TDS and EC correlation in linear regression equation of fresh water samples for three different locations and regression determination coefficient ( $R^2$ ) is calculated.

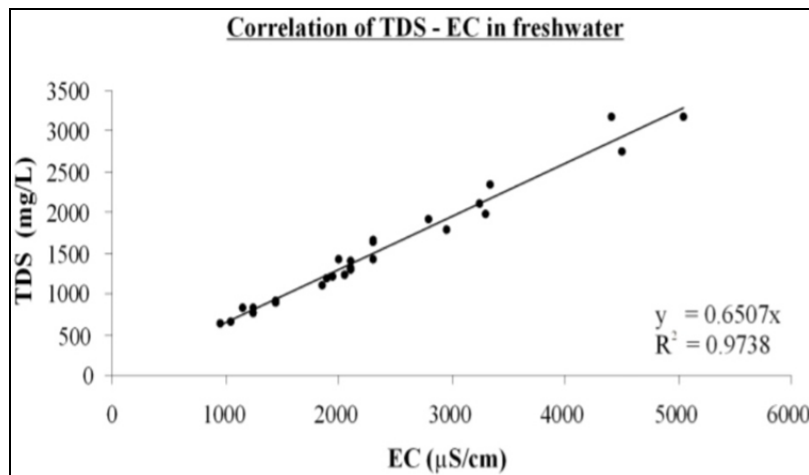


Fig 6

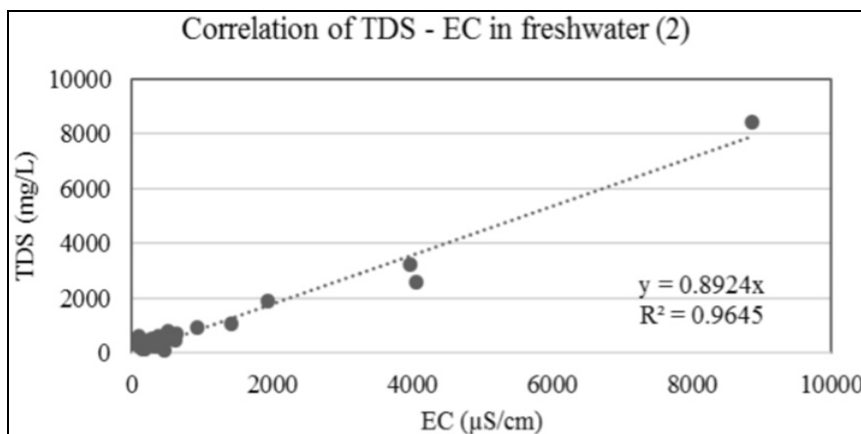


Fig 7

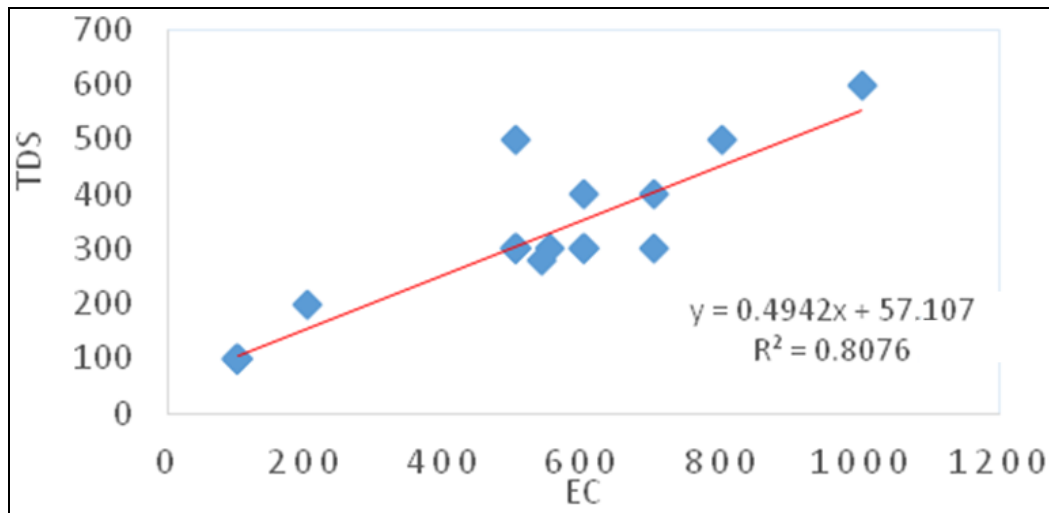


Fig 8

Figure C represents the location chosen by the authors of this paper. Figure A shows that TDS and EC ratio in freshwater is 0.65 ( $R^2 = 0.97$ ) and it can be written as:  $TDS = 0.65 \times EC$ . This value falls in the range which has been published and well documented [9]. Figure B shows that TDS and EC ratio is ( $R^2 = 0.96$ ) and it can be written as:  $TDS = 0.89 \times EC$ . This value is among the range which is again in the documented range. Whereas figure C indicates that TDS and EC ratio is ( $R^2 = 0.80$ ) and it can be written as:  $TDS = 0.4942(EC) + 57.107$ . This value is also compared with other results [10]. The difference indicates that the correlation of both parameters is strongly influenced by the EC values. All the results are in accordance with the conclusion drawn by McNeil and Cox, in which the obtained variation of TDS/EC ratio for freshwater can be vary 0.5 till  $\geq 1.00$ . The important ions of freshwater are generally sodium, calcium, magnesium, bicarbonate type or calcium, sodium, bicarbonate, chloride type [20] and these play role in TDS/EC ratio. Among all most correlated major ions contributing for TDS are chloride, sodium, and magnesium [21]. TDS in water supplies originate from natural sources, sewage, urban and agricultural run-off, and industrial wastewater.

### Conclusions

Salinity is the indication of property of both water and soil and is characterized by amount of dissolved salts present and expressed as grams of salt present in one kilogram of water or soil with a unit of parts per thousand or ppt. Dissolution of salts results in higher density of salty water than fresh water. EC and TDS are water quality parameters which indicate level of salinity. Measurement and calculation of TDS value are based on EC value and depends on many parameters which contribute for water quality. The TDS/EC ratio for freshwater can be vary in the range of 0.5 till  $\geq 1.00$ . The relationship between TDS and EC is may be linear or nonlinear and depends only on water salinity and type of material dissolved in water. Higher salinity level shows more complex mathematical equations to describe these parameters. Gravimetric analysis provides better results for of TDS concentration. Salinity is the total concentration of all dissolved salts in water. TDS combines the sum of all ion particles (organic & inorganic both) that are smaller than  $2\mu$ . TDS is important to analyze ground water quality, particularly to understand the effect of seawater intrusion better than conductivity results. The correlation of TDS and conductivity are not always linear. In areas where the TDS content of the water supply is very high, the individual constituents should be identified because it can be useful for public health department. Drinking water generally has a TDS below 500 mg/L, however, higher TDS Fresh Water is drinkable but taste may be objectionable. Total dissolved solids (TDS) concentration is the total cations (positively charged) and anions (negatively charged) ions in the water and TDS test gives a qualitative measure of the number of dissolved ions but does not tell us ion relationships. Total dissolved solids test is used as an indicator test to determine the general quality of the water, sources of total dissolved solids can include all of the dissolved cations and anions. Effective policy and better planning are needed to improve water quality through integrated water management practices for healthy ecosystems in the area.

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