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Evaluation of ground water quality and its suitability for drinking and agriculture purposes in erode taluk, tamilnadu, india

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ABSTRACT:

Groundwater quality of the Erode taluk was assessed to understand the contamination processes due to the presence of various contaminant sources and the suitability of groundwater for drinking and irrigation purposes. Ten groundwater samples have been collected from Erode taluk of Tamilnadu state of India. Their physicochemical parameters like colour, odour, turbidity, TDS, EC, pH, TA, TH, Ca^{2+}, Mg^{2+}, Na^{+}, NH_3^{+}, NO_2^{+}, NO_3^{-}, Cl^{-}, F^{-}, SO_4^{2-}, PO_4^{2-} and DO were assessed. The results were compared with the drinking water guidelines of Indian Standard (IS) and World Health Organization (WHO). The important constituents that influence the water quality for irrigation such as Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR), Kelly's Ratio (KR) and Soluble Sodium Percentage (SSP) were assessed and compared with standard limits.

Key words: **Groundwater, physicochemical parameters, IS, WHO, Electrical Conductivity, Sodium Adsorption Ratio, Magnesium Adsorption Ratio.**

INTRODUCTION

Water is a dynamic renewable natural resource. Its availability with good quality and adequate quantity is very important for human life. Ground water is an important source of water supply. As a result of population, urbanization, deforestation and mining excessive withdrawal of ground water without proper recharge takes place results in the shortage and contamination of the subsurface water. So it is very important to estimate quality and quantity of ground water resource and also need proper planning for continued utilization of water. Groundwater has become the major source of water supply for domestic, industrial and agricultural sectors of many countries. Man's activities such as food production, nutrition are dependent on water availability in adequate quantities and good quality. The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. In India, as groundwater is ultimate and key water resource, people use groundwater for drinking purpose. In addition to this, groundwater is also used in agricultural and industrial fields. If the groundwater used for drinking and other domestic activities is contaminated due to increase in population, industrialization and urbanization and it creates intimidation to the health of the people. To protect and manage quality and quantity of groundwater is essential for the healthy development of any country.

Objectives of the study

- To evaluate the ground water quality by physio-chemical parameters analyses at various locations of erode taluk.
- To assess the ground water suitability for drinking purpose by comparing the physio chemical parameter with IS and WHO standards.
- Finally to access the ground water suitability for irrigation purposes for various methods such as EC, SAR, KR, MAR and SSP.

STUDY AREA

The present study is related to the groundwater quality of some places of the Erode Taluk which is situated in Erode district of Tamilnadu state of India. Erode taluk having population of about 8,20,720 as per the 2011 census. Erode taluk having the male population of 4,10,323 and female population of 4,10,397. Erode taluk have the sex ratio of 1000:1000. Erode taluk is located between 10°35' N and 12°00' N latitude and 76°50' E and 77°50' E longitude. It is positioned North Western part of Tamilnadu. The average annual rainfall of Erode taluk region is 812 mm. The boundaries of the

district are Namakkal and Karur in East, Coimbatore and Nilgiri in the West, Dindugal in the South and Karnataka in the North direction. Erode taluk is characterized with a scantry rainfall and a dry climate with dry weather throughout except during the monsoon season. Map of Erode taluk as shown in *figure 1*.

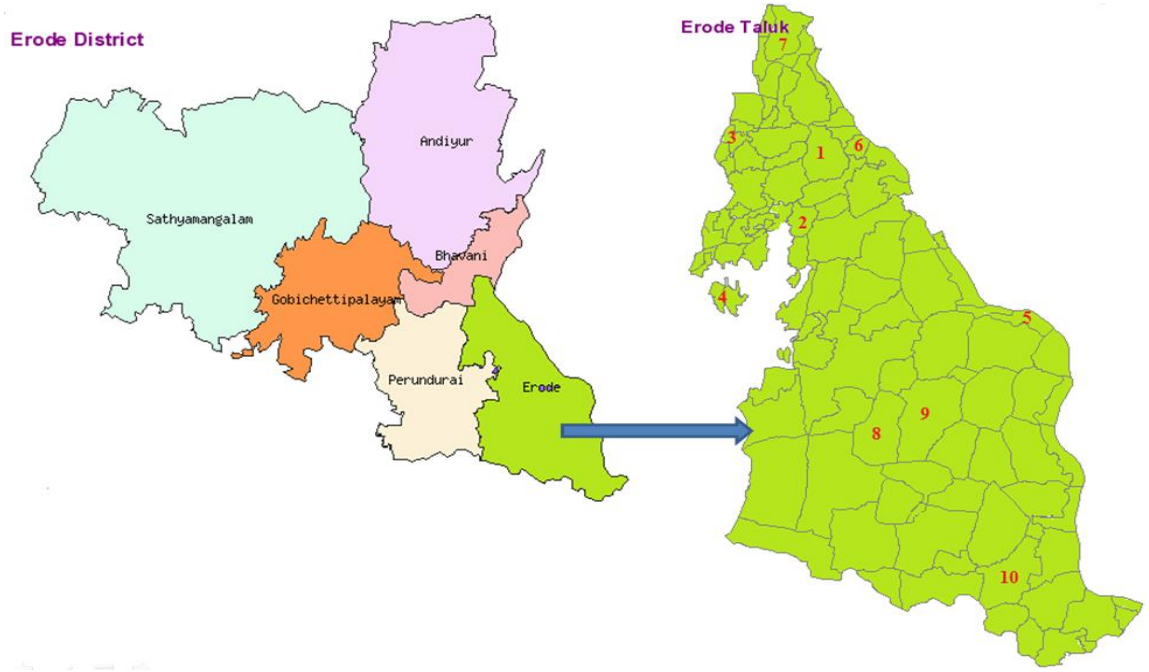

Figure 1 - Map of Erode Taluk

MATERIALS COLLECTION

The current study was designed to investigate the conditions of ground water contamination in the study areas. The hydro geochemistry study was undertaken by randomly collected 10 ground water samples from open wells covering entire Erode taluk during the period of 2017 - 18. Groundwater samples from the selected sites were collected and taken in the pre-cleaned plastic polythene bottles. Prior to sampling, all the sampling containers were washed and rinsed thoroughly with the ground water. Open wells were selected for sampling, which are functional and continuously in use for drinking and agricultural purposes. The sampling location of ground water samples as shown in *Table 1*.

Table 1 - Locations of ground water samples

Sample No.	Locations
S1	Anainasuvampalayam
S2	Thindal
S3	Moolakarai
S4	Nasiyanur
S5	Vendipalayam
S6	Ayyampalayam
S7	Elavamalai
S8	Velampalayam
S9	Elumathur
S10	Itchipalayam

METHEDOLOGY

Physio chemical parameters such as, Colour, Odour, Turbidity, Total Dissolved Solids (TDS), Electrical Conductivity (EC), pH, Total Alkalinity (TA), Total Hardness (TH), Ca^{2+}, Mg^{2+}, Na^{+}, NH_3^{+}, NO_2^{+}, NO_3^{-}, Cl^{-}, F^{-}, SO_4^{2-}, PO_4^{2-} and Dissolved Oxygen (DO) were assessed. The results were compared with the drinking water guidelines of Indian Standard (IS) and World Health Organization (WHO). The agricultural requirements has calculated and analysed by Sodium Adsorption Ratio(SAR), Kelley's Ratio (KR), Sodium Soluble Percent (SSP), Electrical Conductivity (EC), Magnesium Absorption Ratio (MAR).

RESULTS AND DISCUSSION

Ground water samples of open wells were collected from ten different places (domestic, agricultural & industrial areas) of Erode Taluk. Values of different physicochemical characteristics of groundwater samples are shown in *Table 2*. Quality of these water samples is compared with IS & WHO Standards. The values of pH and Concentrations of Ammonia and Sulphate ion values of all groundwater samples were found within the desirable limit. It indicates groundwater suitability to drinking purpose. Values of Turbidity, Total Alkalinity and Concentrations of Calcium, Magnesium and Chloride ion values of the groundwater samples exceeded the desirable limit but within permissible limit in the absence of alternate source. It indicates groundwater slightly not suitable for drinking purpose. So it requires some primary treatments such as sedimentation, softening methods like lime soda process, demineralization, etc.,

Table 2 - Values of physicochemical parameters of ground water samples

Physical Chemical Parameters	**Water Limit**			**Ground Water Sample No**									
	IS		**WHO**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
	(A)	**(B)**											
Appearance	-	-	-	C&C	C&C	C&C	C&C	C&C	C&C	C&C	C&C	C&C	C&C
Odour	**Agreeable**	**Agreeable**	-	O	O	O	O	O	O	O	O	O	O
Tur. (NTU)	**1**	**5**	**< 5**	1	5	2	1	1	2	3	4	5	2
TDS (mg/l)	**500**	**2000**	-	381	2270	1203	586	491	586	667	2020	996	368
EC (µS/cm)	**1500**	**1500**	**250**	544	1972	1148	838	701	838	953	1142	1137	526
pH	**6.6 - 8.5**	**6.6 - 8.5**	**6.6 - 8.5**	7.80	7.36	8.10	7.28	7.80	7.30	7.53	8.19	7.97	7.65
TA (mg/l)	**200**	**600**	-	196	400	280	288	240	284	300	280	268	188
TH (mg/l)	**200**	**600**	**150 - 500**	188	708	626	296	256	300	272	480	602	180
Ca^{2+} (mg/l)	**75**	**200**	-	35	78	67	77	64	75	72	86	77	35
Mg^{2+} (mg/l)	**30**	**100**	-	24	51	50	25	23	27	22	25	34	22
Na^{+} (mg/l)	**200**	**200**	-	81	125	108	98	212	92	83	91	225	54
NH_3^{+} (mg/l)	**0.5**	**0.5**	-	0.34	0.47	0.30	0.13	0.18	0.13	0.20	0.35	0.26	0.18
NO_2^{+} (mg/l)	**-**	**-**	-	0.13	0.35	0.11	0.04	0.04	0.03	0.05	0.14	0.12	0.43
NO_3^{-} (mg/l)	**45**	**45**	**50**	10	28	58	10	22	19	16	50	55	23
Cl^{-} (mg/l)	**250**	**1000**	**250**	32	450	280	46	32	44	70	230	240	31
F^{-} (mg/l)	**1**	**1.5**	**1.51**	0.7	1.7	0.6	0.8	1.6	0.7	1.6	0.8	0.9	0.5
SO_4^{2-} (mg/l)	**200**	**400**	**500**	25	101	67	47	30	48	61	66	62	28
PO_4^{2-} (mg/l)	-	-	-	0.24	0.51	0.27	0.21	0.17	0.42	0.34	0.16	0.24	0.21
DO	-	-	-	1.20	1.80	1.10	0.90	0.80	0.90	1.00	1.20	1.10	1.30

C&C: Clear & Colourless, O: Objectionable

- (A) BIS (10500 - 2012) Standards - Acceptable Limit
- (B) BIS (10500 - 2012) Standards - Permissible limit in the Absence of Alternate Source
- WHO (2008) - World Health Organization's Guideline

Total Dissolved Solids, Electrical Conductivity, Total Hardness and Concentrations of Sodium, Nitrate, and Fluoride ion values of the groundwater samples exceeded the permissible limit. It indicates groundwater not suitable to drinking purpose and requires proper treatments such as sedimentation, aeration, filtration, chlorination and also biological treatments. Critical Parameter Exceeding the Permissible Limit as shown in *Table 3*. There is no

desirable limit for values of Dissolved Oxygen and Concentrations of Nitrite and Phosphate ion values of the groundwater samples. Usage of groundwater without proper treatment causes gastro intentional irritation, tasteless, blue baby syndrome, respiratory failure, variation in blood pressure, paralysis, dental & skeletal fluorosis, etc., to human beings and also it affects animal life. Charts showing variation of values of groundwater samples for different locations as shown in figures 2, 3, 4 and 5 respectively.

Table 3 - Critical Parameter Exceeding the Permissible Limit

Sl. No.	Parameter	BIS Permissible Limit	No. of Sample Exceeding Permissible Limit	Percentage of Sample Exceeding Permissible Limit
1	TDS	2000	2	20
2	EC	1500	1	10
3	TH	600	3	30
4	Na^+	200	2	20
5	NO_3^-	45	3	30
6	F^-	1.5	3	30

Charts Showing Variation of the Values of Groundwater Samples for Different Locations

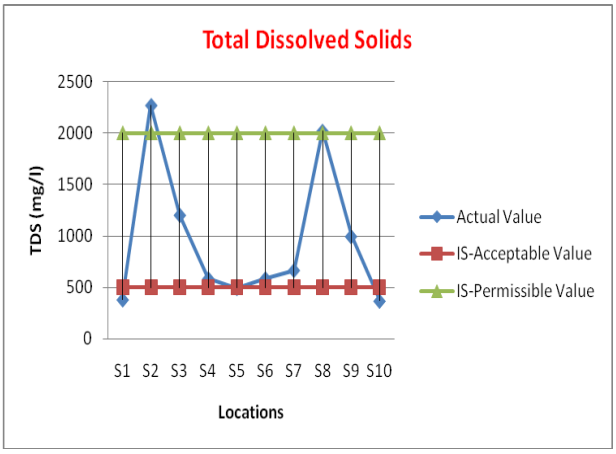

Figure 2 - TDS values of ground water samples

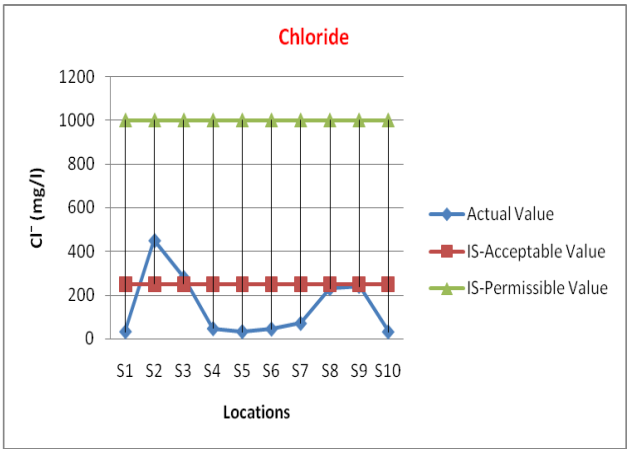

Figure 4 - Chloride values of ground water samples

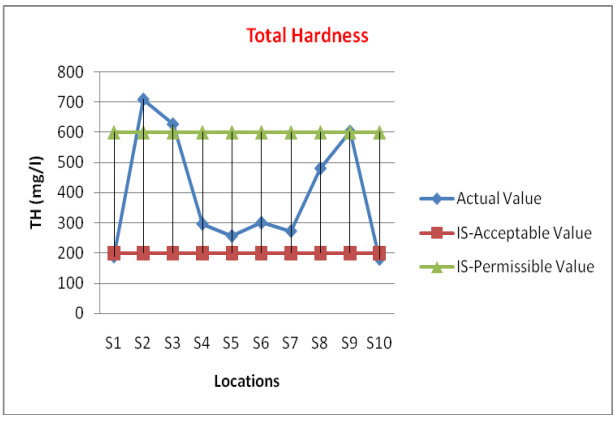

Figure 3 - Total Hardness values of ground water samples

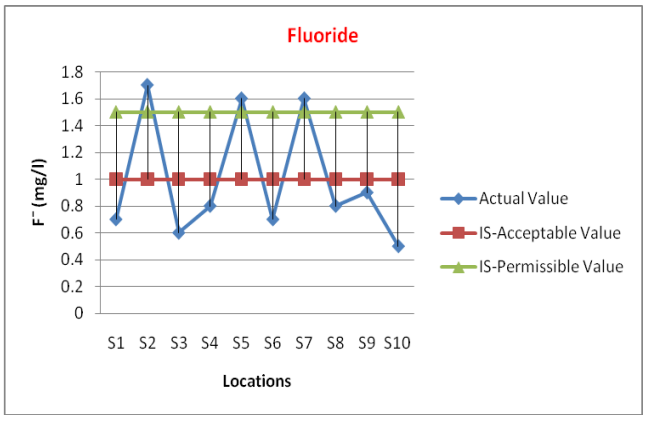

Figure 5 - Fluoride values of ground water samples

IRRIGATION WATER QUALITY

Groundwater is the main source of irrigation in entire study area. Quality of water is assuming great importance with the rising pressure on industries and agriculture and rise in standard of living. The adequate amount of water is very essential for proper growth of plants but the quality of water used for irrigation purpose should also be well within the permissible limit otherwise it could adversely affect the plant growth. Questions have been raised as to the social and environmental sustainability of this intensive mode of crop production. The continuous use of poor quality water without drainage and soil management may lead to saline and sodic soil, particularly in clayey soils. The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. The methods used for analyze the irrigation water quality are

- Kelley's Ratio (KR)
- Sodium Absorption Ratio (SAR)
- Sodium Soluble Percent (SSP)
- Electrical Conductivity (EC)
- Magnesium Adsorption Ratio (MAR)

***Kelley's Ratio (KR)*:**

Sodium measured against Ca^{2+} and Mg^{2+} is used to calculate Kelley's ratio. The formula used in the estimation of Kelley's ratio is expressed as, Kelley's Ratio, **$KR = Na^{+}/ [Ca^{2+} + Mg^{2+}]$.** Classification of groundwater based on the KR as shown in *Table 4*.

Table 4 - Classification of groundwater on the basis of KR

Values	No. of Samples	Percentage of Samples (%)	Suitability
< 1	7	70	Good
> 1	3	30	Unsuitable

A Kelley's Ratio (KR) of more than one indicates an excess level of sodium in waters. Hence, waters with a Kelley's Ratio less than one are suitable for irrigation. This method concludes that 70 % of ground water suitable for irrigation purpose.

Sodium Absorption Ratio (SAR):

The sodium adsorption ration (SAR) indicates the effect of relative cation concentration on sodium accumulation in the soil; thus, sodium adsorption ratio (SAR) is a more reliable method for determining this effect than sodium percentage. Sodium adsorption ration (SAR) is calculated using the following formula: **$SAR = [Na^{+}] / \{([Ca^{2+}]+[Mg^{2+}])/2\}^{½}$** Ions are expressed as milliequivalents per liter (meq/L). Classification of the groundwater based on the SAR as shown in *Table 5*.

Table 5 - Classification of groundwater on the basis of SAR

Values	No. of Samples	Percentage of Samples (%)	Suitability
< 10	-	-	Excellent
10 – 18	8	80	Good
18 – 16	-	-	Fair
> 26	2	20	Poor

The potential for a sodium hazard increases in waters with higher sodium adsorption ration (SAR) values. It is proportion of sodium to calcium and magnesium, which affect the availability of water to the crop. This method shows that 80% of the ground water samples are suitable for agricultural purposes.

***Sodium Soluble Percentage (SSP)*:**

The Soluble Sodium Percentage (SSP) for ground water was calculated by the formula, **$SSP = [Na^{+}/(Ca^{2+} + Mg^{2+} + Na^{+})] \times 100$** ,Where the concentrations of Ca^{2+} , Mg^{2+} and Na^{+} are expressed in milliequivalents per litre (meq/l). Soluble Sodium Percent is an important factor for studying sodium hazard. It also used for identify the quality of water for agricultural purposes. High percentage of sodium water for irrigation purpose may stunt the plant growth and reduces the soil permeability. Classification of groundwater based on the SSP as shown in *Table 6*

Table 6 - Classification of groundwater on the basis of KR

Values	No. of Samples	Percentage of Samples (%)	Suitability
< 50	7	70	Good
> 50	3	30	Bad

The Soluble Sodium Percent (SSP) values less than or equal to 50 indicates good quality water and if it is more than 50 indicates the unsuitable water quality for irrigation. This method shows that probably 70 % of the ground water in our study area is good for irrigation.

Electrical Conductivity (EC):

Conductivity is the measure of capacity of a substance to conduct the electric current. Most of the salts in water are present in their ionic forms and capable of conducting

current and conductivity is a good indicator to assess ground water quality. Classification of groundwater based on the EC as shown in *Table 7*.

Table 7 - Classification of groundwater on the basis of EC

S.No	Values	Type of Water	Total No. of Samples	Suitability
1	< 250	Low saline	-	Entirely safe
2	250-750	Moderately saline	3	Safe under practically all condition
3	750-2250	Medium to high saline	7	Safe only with permeable soil moderate teaching
4	> 2250			
i	2250-4000	High salinity	-	Unfair for irrigation
ii	4000-6000	Very high salinity		
iii	> 6000	Excessive salinity		

Majority of the ground water in the study area is suitable for irrigation purposes.

***Magnesium Adsorption Ratio (MAR)**:*

Magnesium content of water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. The Magnesium Adsorption Ratio (MAR) was calculated using the following equation is given by **MAR= $[Mg^{2+}/(Ca^{2+} + Mg^{2+})]$ x 100** where, all the ionic constituents are expressed in meq/L.

Generally, calcium and magnesium maintain a state of equilibrium in most waters. More magnesium in water will adversely affect crop yields as the soils become more saline. It shows that 80 % of groundwater is suitable for agricultural purposes.

Classification of groundwater on the basis of MAR as shown in *Table 8*.

Table 8 - Classification of groundwater on the basis of EC

Values	No. of Samples	Percentage of Samples (%)	Suitability
< 50	8	80	Suitable
> 50	2	20	Unsuitable

CONCLUSION

The present study has led to conclude that the quality of water samples studied were acceptable from the majority of the physicochemical parameters but as Total Dissolved Solids, Electrical Conductivity, Total Hardness and Concentrations of Sodium, Nitrate, and Fluoride ion values of all the samples were violating the permissible limit suggested by IS & WHO. It requires proper treatments such as sedimentation, aeration, filtration, chlorination and also biological treatments. So the water should be treated properly before its usage as drinking water to avoid probable adverse effects. The agricultural requirements has calculated and analysed by Sodium Adsorption Ratio(SAR), Kelley's Ratio (KR), Sodium Soluble Percent (SSP), Electrical Conductivity (EC), Magnesium Absorption Ratio (MAR) from that 70 – 80 % of the groundwater of the study area is suitable for agricultural or irrigation purpose. Due to presence of some contaminants or pollutants in groundwater will affect the agricultural activities of Erode taluk area. To control groundwater contamination by using effective utilization of industries, less use of fertilizers in agricultural field, and also some artificial recharge methods. Finally I conclude that, this paper helps to public should be made aware of drinking water quality. For the welfare of the human being, water quality should be assessed on the regular basis for drinking and agricultural purposes.

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