A Novel Measurement of Groundwater Quality and Its Suitability for Irrigation in Dindigul Corporation

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Abstract

The main aim of the study is to evaluate groundwater quality suitable for irrigation purpose in Dindigul Corporation, Tamil Nadu, India. In the study area 30 water samples were collected to determine the physical parameters and chemical parameters. Sodium Adsorption Ratio (SAR), Sodium percentage (SP), Potential Salinity (PS), Residual Sodium Carbonate (RSC), Kellys Ratio and Soluble Sodium Percent (SSP) have been determined for analyse the irrigation water quality. From the analysis result reveals that SAR value indicates 84% of excellent 13% of good and 3% of unsuitable water category. Based on sodium percent 10% are good, 50% are permissible and 40% are unsuitable for irrigation. Based on PS and RSC ratio about 97% comes under unsuitable water and 3% are suitable water for irrigation. Kellys Ratio and SSP values indicate 27% of good quality and 73% are unsuitable irrigation water. The high concentration of salinity found in western part of the study area. The result shows that most of the samples are unfit for irrigation.

Keywords: Groundwater quality, irrigation, Dindigul corporation, SAR, Salinity, USSL.

1. Introduction

Ground water is a vital national freshwater resource. It is used for drinking, irrigation and industrial purpose. It is one of the most important components of human life. The quality of ground water depends on a large number of individual, hydrological, physical, chemical and biological factors. Ground water contamination is mostly found in urbanized area, agricultural area and industrial area by the result of human activities. The study area is famous for industries such as lock iron safe manufacturing, leather tanneries, soap industries and other chemical and manufacturing industries. More than 65 tanneries are situated in Dindigul Corporation. Tanners use a large number of chemicals during tanning process. The tannery effluents are discharged into nearby pond and land. These effluents pollute ground water and agricultural land. The water quality parameters such as Na, K, Ca, Mg, Cl, HCO3 and SO4 has been analyzed for irrigation purpose in the study area.

2. Study Area

Dindigul is a city located in south Indian state of Tamilnadu and lies between 10026201900 201D N to 10016201900 u201D North latitude and 77055201900 u201D to 7802201900 u201D longitude. Its mean sea level is 280.11 and covering a geographical area of 110.20sq.km. Dindigul Corporation includes 10 villages. Sirumalai hill located at south part of the study area. The study area is covered by crystalline metamorphic rocks of archean age belonging to the khondalite and charnockite group of rocks. The soil type is mostly black soil with red sandy soil. Kudavanar and Kudiraiyar are main rivers of the study area. The temperature ranges from a maximum of 37°C to a minimum of 29°C during summer and maximum of 26°C to minimum 20°C recorded during winter. The study area receives rainfall from northeast monsoon and southwest monsoon. The average annual rainfall is about 836mm. The relative humidity varies between 65% and 85%. The total population of the study area is 3,37,874 as per census 2011.
3. Material and Methods

In the study area 30 ground water samples are collected in 1 litter polythene bottles from bore wells. The bottles were cleaned and rinsed with sample water before sampling. The water samples were sent to the laboratory for analyse the parameters. Water quality parameters were analysed through EC, TDS, PH, SAR, RSC, SSP, PS, and Kelleys ratio for irrigation purpose. These criteria used to estimate the ground water quality for agricultural use.

4. Result and Discussions

Sodium Adsorption Ratio (SAR) Sodium adsorption ratio is used for evaluating the sodium hazard associated with irrigation water. The high sodium hazards lead to a decrease in infiltration and permeability of the soil result into the problems with crop production. SAR value was calculated using the formula proposed by Richard (1952). All the values expressed in epm Value. SAR = (Na)/(%u221A(%u3016Ca%u3017ˆ(2 ) Mg) 2 /2) In the study area, SAR value of the ground water samples range from 1.87 to 63.56. About 83% of ground water samples are ¡10 indicate excellent category (S1), while 17% of samples within the range of 10 %u2013 18 indicates good quality (S2) for irrigation. There is no water samples locations come...
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4.1 Electric Conductivity

Salinity hazard in ground water is measured by Electric conductivity. EC is generally related to the amount of dissolved solids or minerals. EC of water will be increase with increase of dissolved solids. Higher EC in water creates a saline soil. Higher salt content in irrigation water affect plants growth, soil permeability. Electric conductivity varies between 1.06 and 5.06 sCm⁻¹. In the study area the water samples are not found in excellent and good category. About 43% of water sample showed EC value of permissible limit of 750-2000 sCm⁻¹. Eastern zone of the study area comes under this category. About 27% water sample have doubtful (2000-3000 sCm⁻¹) and remaining 30% water sample have unsuitable water with above 3000 EC value. Western part of the study area fall in unsuitable water for irrigation.

4.2 U.S.S.L Classification for Irrigation Water

Wilcox (1955) determined U.S.S.L classification to analyse ground water quality for irrigation. U.S.S.L diagram is based on Sodium Adsorption Ratio and Electric Conductivity of water. The EC value is plotted on X axis and SAR on Y axis. The irrigation water has been divided into four classes based on salinity hazard (EC). C1 %υ2013 low saline water (0-250μsCm⁻¹) C2 %υ2013 Medium saline water (250-750μsCm⁻¹) C3 %υ2013 High saline water (750-2250μsCm⁻¹) C4%υ2013 Very high saline water (>2250μsCm⁻¹) Based on the sodium hazard (SAR) water has been classified into four categories S1, S2, S3, S4 represent low, medium, high and very high sodium hazard respectively. From the analysis 14 samples fall in C3S1 category, which indicate high salinity with low sodium. 4 samples come under C3S2 level indicating high salinity with medium sodium. 4 samples fall into C4S1 category, which represent very high salinity with low sodium water. 6 samples come under C4S2, which represent very high salinity with medium sodium. 2 samples fall into C4S3, which indicate very high salinity and high sodium hazard. C4S2 and C4S3 of water sample areas located in western part of study area. Most of the tanneries found in these areas. From the analysis the ground water sample from above the categories are not suitable for irrigation. In some places northeast and southeastern part of the study area saline resistant crops such as cotton, maize, millet, onion, tomato, brinjal can be cultivated.

4.3 Sodium Percentage SP

Sodium percent is classified based on Wilcox (1955) to determine the Sodium Hazard. The high sodium concentration in ground water leads to re-
The sodium replacing adsorbed Calcium and Magnesium was a hazard as it causes damage to the soil structure. The following formula used to measure Sodium percentage %Na = (Na K) / (Ca Mg Na K) \times 100 According to Wilcox groundwater was classified based on average Sodium percent as excellent (¡20), Good (20-40) permissible (40-60) and unsuitable (¿60). In the study area the Sodium Percentage was found in range from 33.65 to 99.05 epm. From the analysis no water sample location comes under excellent category. About 10% of water samples indicate good in quality. Nearly 50 % of sample locations have permissible limit. Remaining 40 % of water samples comes under unsuitable for irrigation water.

**Fig. 6:** Sodium Percentage (SP)

4.4 Potential Salinity PS
Doneen (1962) determined the potential Salinity for assessing the suitability of water for irrigation. According to his opinion the low solubility salts get precipitated in the soil and lead to successive irrigation, where as the high concentration of soluble salts increase the salinity of the soil. The below mentioned formula used in the estimation of potential salinity is expressed as \( PS = Cl + So4 \) In the study area the PS of the water samples varied from 4.75 to 30.55 meq/l. From the analysis no water sample area comes under the excellent (¡3) water irrigation category. About 3% of the sample location has good to injurious water for irrigation (3-5). About 97 % of ground water sample locations are injurious to unsuitable water for irrigation (¿5). According to map except south part of Thottanuthu, the remaining areas are not suitable for irrigation.

4.5 Residual Sodium Carbonate RSC
Eaton (1950) classified Residual Sodium Carbonate for assessing water quality for irrigation. Ground water having high concentration of Carbonate and Bicarbonate ions tends to precipitate calcium and magnesium. As a result, the relative proportion of sodium increase will lead to decreasing the soil permeability. The RSC value is determined by the following formula \( RSC = [HCO3 CO3] \%u2013 (Ca Mg) \) Where, all Ionic concentration is expressed in epm. RSC values less than 1.25 are considered as safe for irrigation purpose, if the value is between 1.25 and 2.5 mg/L, the water is within the marginal range. RSC level more than 2.5 mg/L are rendered unsuitable for irrigation purpose. In the present study area RSC value range between 0.05 and 30.3. All the groundwater samples fall in above2.5 and indicate unsuitable for irrigation category except at south part of Adiyanuthu showing the value had in below 1.25.

4.6 Kellys Ratio
The sodium iron concentration measured to determine the ground water quality by Kelly%u2019s Ratio (1940). The below mentioned formula is
used to estimate Kelly’s Ratio $\text{KR} = \frac{\text{Na}}{(\text{Ca Mg})}$ A Kelly’s Ratio of more than one indicates excess level of Sodium in water. In present study area Kelly’s Ratio value varied from 0.21 to 3.83 epm. According to Kelly’s Ratio about 27% of ground water location are less than 1 and indicate good quality water for irrigation purpose, while remaining 73% ground water samples are more than 1 and indicate unsuitable water for irrigation. Based on the map the southern part of Adiyamuthu, Thotanuthu, Chettinaikenpatti, Kurumpapatti areas have suitable for irrigation and the remaining areas are unsuitable water for irrigation.

**Fig. 7:** Kelly’s Ratio

### 4.7 Soluble Sodium Percent (SSP)

Soluble Sodium Percent (SSP) Soluble Sodium Percent is used to measure sodium hazard. SSP is defined as the ratio of sodium to the total cations. SSP For ground water was calculated by the following formula. $\text{SSP} = \frac{\text{Na}}{(\text{Ca Mg Na}) \times 100}$

The SSP value is range from 29.80 to 99.01 epm. In the study area about 27% of water sample are less than 50 and indicate good quality of water for irrigation and 73% of water sample location comes under more than 50 indicate unsuitable water for irrigation purpose. According to map the western part of study area such as Pillarnatham, western part of Dindigul city, Pallapatti, Ponmanthurai comes under unsuitable for irrigation.

**Fig. 8:** Soluble Sodium Percent (SSP)

The analysis reveals that most of the sample locations have high salinity and sodium concentration. 30 samples collected from the study area to determined water quality parameters. The USSSL classification results that all the ground water samples have high and very high saline water with medium to high sodium hazard. The western part of the study area such as Ponmanthurai, Pallapatti, Pillayarnatham, Dindigul town (Save-
riarpallayam and Jinnanagar) areas are affected by very high salinity and sodium hazard. Because of most of the tanneries are found in these areas. Ground water suitability of these areas is unfit for irrigation. In the eastern part of the study area, saline resistant crops such as cotton, maize, millet, onion, tomato, brinjal can be cultivated

5. References