ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION ON THE BANK OF NOYYAL RIVER AT TIRUPPUR, TAMIL NADU, INDIA

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ABSTRACT. Tiruppur is a textile city located on the banks of Noyyal River a tributary of the River Cauvery. Twenty groundwater samples were collected in identical locations from bore wells. The concentrations of physicochemical parameters of pH, Electrical Conductivity (EC), Total Hardness (TH), Ca, Mg, Na, K, HCO_3 , SO_4 , Cl and NO_3 were analyzed. The results of the concentrations were interpreted and measured with different irrigation indexes like Percent Sodium (%Na), Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), Permeability Index (PI), Kelly's Ratio (KR), CAI-1 and CAI-2 were analyzed.

1. INTRODUCTION

The water resource is certainly inexhaustible gift of nature. It is an established fact that proper maintenance, conservation and use of the water resource will definitely avoid the changes of water famine for future generations for an indefinite period. Once contamination of groundwater in aquifers occurs by means of industrial activities and urban development, it persists for hundreds of years because of very slow movement of water in them and prompts investigations on their quality [1]. The water quality assessment may give clear information about the subsurface geologic environments in which the water presents [2]. The addition of various kinds of pollutants and nutrients through the agency sewage, industrial effluents, agricultural run-off etc. into the water bodies brings about a series of changes in the physicochemical and characteristics of water, which have been the subject of several investigations [3]. However, increasing demand and withdrawal, significant changes in land use pattern and vast industrial effluent entering the hydrological cycle stresses the quality and quantity of groundwater [4].

Utilization of land varies from place to place due to rapid urbanization and industrialization, without following the strict environmental norms, causing a lot of variation of quality of groundwater within a short distance, which constrains the developmental activities drastically everywhere [5]. The present study was carried out for qualitative analysis based on physico-chemical parameters of groundwater.

2. MATERIALS AND METHODS

Study area

Tiruppur is situated among latitude $11^{\circ}10'N$ to $11^{\circ}22'N$ and longitudes $77^{\circ}21'E$ to $77^{\circ}50'E$. Tiruppur is a fast growing industrial city in Tiruppur district of Tamilnadu, also known as 'Banian City' of India. It is located on the bank of the Noyyal River, a tributary of the River Cauvery. The hosiery industry in Tiruppur provides substantial contribution to the economy in the form of income, employment and foreign exchange generation. However, the rapid growth of the industry has resulted in serious environmental problems, especially from the bleaching and dyeing units. The region is an agricultural area with paddy as the main crop. The river Noyyal is a seasonal river and it originates from Vellingiri Hills in the Western Ghats of Coimbatore District [6]. The study area occupies mostly charnockites, granites and complex gneisses which highly rich minerals such as

pyroxene, mica, garnet etc. The place of study at which water samples are collected is referred to as “Stations”. The groundwater samples are collected during winter season 2013. Five stations are selected. They are represented as Authupalayam (S1), Mangalam (S2), Karuvampalayam (S3), Mannarai (S4), Ponapuram (S5). The samples are collected in each station using sampling techniques. The samples were analyzed for Physico-chemical parameters using standard procedures [7].

Fig. 1. Location map of study area

3. RESULTS AND DISCUSSION

The results of irrigational water quality parameters are tabulated in Table 6. The results are discussed and compared with standard values of WHO [8].

Residual Sodium Carbonate (RSC)

Irrigation water containing large amounts of sodium is of special concern due to effect of sodium on the soil and poses hazards of sodium. Excess of sodium in water which produces the undesirable effects of changing soil properties and reducing soil permeability. Hence, the assessment of sodium concentration is necessary while considering the suitability for irrigation [9]

$$RSC = CO_3^{2-} + HCO_3^{2-} - (Ca^{2+} + Mg^{2+})$$

The RSC values are less than 1.25 meq/L in all the groundwater samples. Hence all the groundwater samples fall under safe category which can be used for irrigation purposes. Sodium concentration is important in classifying the irrigation water because sodium reacts with soil to reduce its permeability. Soils containing a large proportion of sodium with carbonate as the predominant anion are termed alkali soils; those with chloride or sulphate as the predominant anion are saline soils [10]. Hence in the present study all the groundwater samples fall under the safe category (Table 1).

Table 1. Classification of water based on RSC values.

RSC VALUES (Meq/L)	CLASS	STATIONS
<1.25	SAFE	All the Samples
1.25-2.5	MARGINAL	--
>2.5	UNSUITABLE	--

Sodium Adsorption Ratio (SAR)

The excessive sodium content relative to the calcium and magnesium reduces the soil permeability and thus inhibits the supply of water needed for the crops. SAR indicates the degree to which irrigation water tends to enter into cation-ex-change reactions in soil.

$$SAR = \frac{Na^+}{\sqrt{Ca^{2+} + Mg^{2+}/100}}$$

In the present study all the ground water samples fall within the excellent category which can be used for irrigation based on the SAR classification (Table 2). Sodium is replaced the calcium and magnesium is a hazard as it causes damage to the to the soil structure and becomes compact and impervious [11].

Table 2. Classification of water based on SAR values.

SAR VALUES (Meq/L)	CLASS	STATIONS
<10	EXCELLENT	All the samples
10-18	GOOD	--
18-26	FAIR	--
>26	POOR	--

Percent sodium (% Na)

The values of percent sodium lie in the range of 15 to 43 % (Table 1). The percent sodium values fall in the range of excellent category is found at stations 1B, 3A, 3B,3D, 4A-4C, 5A and 5B, good category is observed at stations 1A, 1C,1D,2A-2D,3C, 4D and 5D, and permissible category is noticed at station 5C. For irrigation purpose, the percentage of sodium is important, because sodium reacts with soil to reduce permeability [12]. When the concentration of sodium is high in irrigation water, sodium ions tend to be absorbed by clay particles, displacing Mg^{2+} and Ca^{2+} ions. This exchange process of Na^+ in water for Ca^{2+} and Mg^{2+} in soil reduces the permeability and eventually results in soil with poor internal drainage [13]. Hence, air and water circulation is restricted during wet conditions and such soils become usually hard when dry.

$$\%Na = \frac{Na^+ + K^+}{Ca^{2+} + Mg^{2+} + Na^+ + K^+} \times 100$$

Table 3. Classification of water based on % Na values.

%Na VALUES	CLASS	STATIONS
<20	EXCELLENT	1B, 3A, 3B,3D,4A-4C, 5A and 5B
20-40	GOOD	1A, 1C,1D,2A-2D,3C, 4D and 5D
40-60	PERMISSIBLE	5C
60-80	DOUBTFUL	--
80-100	UNSUITABLE	--

Kelley's ratio (KR)

Kelley's ratio values lie in the range of 0.13 to 0.54 meq/L (Table 6). The KR values are below the permissible limit (>2 meq/L) in all the groundwater samples. The values of Kelley's ratio is greater than two are unfit for irrigation [14]. Hence in the present study indicates that all the groundwater samples are suitable for irrigation.

$$KR = \frac{Na^+}{Ca^{2+} + Mg^{2+}}$$

Table 4. Classification of water based on KR values.

KR VALUES (Meq/L)	CLASS	SAMPLES
<1	SUITABLE	All the samples
1-2	MARGINAL	--
>2	UNSUITABLE	--

Permeability Index (PI)

The soil permeability is affected by long term use of irrigation water. It is influenced by sodium, calcium, magnesium and a bicarbonate content of soil [15]. It has evolved a criterion to assess the suitability of water for irrigation based on Permeability Index (PI).

$$PI = \frac{Na^+ + HCO_3^-}{Ca^{2+} + Mg^{2+} + Na^+} \times 100$$

From the obtained results, the PI values are fall under class 2 at stations 1A-4D, 5C, 5D and class 3 category is found at stations 5A and 5B as per Doneen's classification. This indicates that all the groundwater samples are suitable for irrigation [15].

Table 5. Classification of water based on PI values.

PI VALUES (Meq/L)	LIMITING VALUES OF PI	STATIONS
>75	CLASS -1	--
25-50	CLASS -2	1A-4D, 5C and 5D
<25	CLASS -3	5A and 5B

Chloro alkaline Indices (CAI)

The CAI is essential to know the changes in chemical composition of groundwater during its travel in the sub-surface. The Chloro-alkaline indices CAI 1 and CAI 2 are suggested by Schoeller [16], which indicate the ion exchange between the groundwater and its host environment. The Chloro-alkaline indices used in the evaluation of base Exchange are calculated using the below equations.

$$CAI - 1 = \frac{(Cl^- - (Na^+ + K^+))}{SO_4^{2-} + HCO_3^- + CO_3^{2-} + NO_3^-}$$

$$CAI - 2 = \frac{(Cl^- - (Na^+ + K^+))}{Cl^-}$$

In the present study the values of CAI-1 in the range of 0.640 to 0.983 meq/L and CAI-2 in the range of -0.171 to 1.721 meq/L respectively. Hence most of the samples have positive values in CAI-1 and CAI-2 respectively except at station 5C. If CAI is negative, there will be an exchange between Na + K with calcium and magnesium (Ca + Mg) in rocks. If the ratio is positive, there is no base change in CAI. The positive value indicates the absence of base exchange. The negative value of the ratio indicates base exchange between sodium and potassium in water with calcium and magnesium in the samples [17].

4. CONCLUSION

In the present study, the assessment of groundwater samples for irrigation has been evaluated on the basis of standard guidelines. The analysis evidently says that groundwater in the study is fit for Irrigation and other domestic purposes. Most of the groundwater samples are affected by high electrical conductivity, sodium, Potassium, TDS and Magnesium hazards as concerned with irrigation water. According to irrigation classification values the salinity of groundwater persists at majority of sites. The ground water samples leads to surface and subsurface water may interact with country rock. Hence the salinity of water and soil must be permeable with adequate drainage facilities for satisfactory crop growth.

Table 6. Shows the values of Irrigational quality of groundwater samples.

STATIONS	RSC	SAR	%NA	KR	PI	CAI 1	CAI 2
1A	3.484	0.722	21.16	0.214	39.135	0.64	0.648
1B	5.579	0.701	18.19	0.177	31.368	0.919	0.67
1C	5.239	1.363	32.43	0.388	39.184	0.938	1.293
1D	5.141	1.118	31.2	0.319	36.484	0.931	1.287
2A	5.853	1.043	26.62	0.255	35.408	0.956	1.015
2B	5.673	1.138	27.27	0.281	37.072	0.953	0.894
2C	3.367	0.738	24.34	0.251	38.189	0.964	1.356
2D	4.141	0.77	24.29	0.244	34.469	0.872	0.719
3A	7.582	0.639	16.74	0.147	25.457	0.93	0.605
3B	7.205	0.587	15.12	0.136	25.589	0.947	0.693
3C	4.268	0.932	28.85	0.285	37.255	0.944	1.721
3D	4.369	0.494	18.09	0.148	30.118	0.936	0.851
4A	-6.44	0.629	17.44	0.152	28.011	0.982	1.539
4B	6.107	0.764	20.83	0.187	30.898	0.95	1.094
4C	2.409	0.48	20.65	0.177	41.084	0.943	0.857
4D	-2.97	0.75	25.95	0.259	41.539	0.932	1.338
5A	6.896	0.528	15.71	0.134	22.543	0.941	1.124
5B	-7.95	0.717	20.08	0.169	24.239	0.918	0.686
5C	4.105	1.712	43.71	0.544	47.286	0.665	-0.17
5D	4.648	0.912	28.22	0.273	34.988	0.946	1.711

* All the above concentrations are expressed in meq/L and % Na and PI in %.

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