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Ground Water Quality Characteristics Study by Using Water Quality Index in Tambaram Area, Chennai, Tamil Nadu

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Abstract: Groundwater quality has a special significance for drinking, Industrial and domestic water supply. In this study groundwater samples were collected from suburban regions of Tamil Nadu to analyze the characteristics of water for drinking standard. The study aims to understand the distribution of groundwater quality in Tambaram area, Chennai. The following objectives of the study are to determine groundwater quality parameters such as pH, Alkalinity, Electrical conductivity, Chloride, Hardness, Total dissolved solids and dissolved oxygen. The study area Tambaram is not provided with very good water satisfactory system. So the public mostly depend on the ground water or other alternate system. There is a need to analyze the water quality for the domestic and drinking purposes. Water quality index (WQI) was then calculated to find the aptness of the ground water for domestic purposes.

Key words: Groundwater · Water quality Index

INTRODUCTION

As the growth rate of urbanization and industrialization in the metropolitan cities such as Chennai are too fast, there is an increasing demand on water and equivalent increase on pollution of the groundwater and the degradation of the existing wetlands is noted overall. The pollution (Shanmugam *et al.* 2005) gets increasing day by day due to the ever increase of population. Thus the quality of the water must be expressed in mathematical or any other physical form in order to explore the character of the water. The water quality index (WQI) is an efficient method (Mishra *et al*. 2001, Naik *et al*. 2001, Singh 1992, [1]) in defining the characteristics of the water (Brown *et al*. 1972). In groundwater study, WQI helps in categorizing the water whether it is fit or unfit for drinking. The calculation of the water quality index originally started with Horton (1965) and Landwehr (1974). Indexing a perfect definition for the water quality was further developed by several researchers there onward. Brown and his colleagues (1972) developed a water quality index by assigning proper weightage for the parameters based on their analysis. The contaminants which alter the groundwater both physically and chemically can be altogether expressed in WQI. This index is the reduction of large amount of water quality data into a single numerical value [2], Ramakrishniah *et al*. 2009).

In order to estimate the groundwater quality index, several parameters has to be analyzed and proper weightage must be assigned for each one. The most important parameters of the groundwater are pH, electrical conductivity, turbidity, total hardness, total dissolved solids, dissolved oxygen, total alkalinity, sodium, chlorides and iron. pH is the measure of hydrogen ion activity in the water or other solutions. Pure water has pH value close to 7 at 25°C. Solutions with pH less than 7 are termed as acidic and solutions with pH greater than 7 are termed as basic or alkaline. Exposure to extreme pH values (both low and high pH) results in irritation to the eyes, skin and mucous membrane for humans (WHO Guidelines for drinking water quality). Electrical conductivity is generally used as an indicator of the amount of salt and ion contents present in the water. The purer the water, lower the conductivity and higher the resistivity. Groundwater conductivity is measured in micro-mhos/cm.

Turbidity is the haziness of the water caused by the suspended individual particles. Groundwater can contain suspended solid mater of varying sizes. The heavier particles can quickly settle at the bottom whereas the

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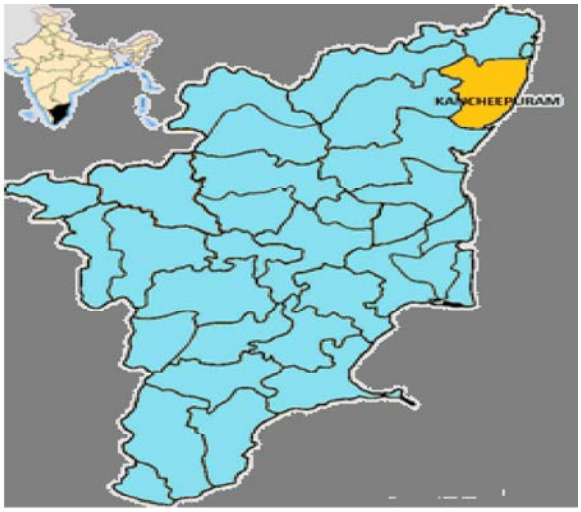

Fig. 1: Chennai District Map

suspended solids are not enough heavy to get settled up remain in suspension and lead to appear as turbid. The unit of turbidity is NTU (Nephelometric Turbidity Unit). The hardness of the water depends on the amount of minerals present in it. Hardness is caused by the compounds of calcium and magnesium and also by several other minerals. Water is an excellent solvent and readily dissolves the minerals which come in contact with it. As the groundwater moves through the soil and rocks, it dissolves very small amounts of minerals and holds them in solution. The dissolved calcium and magnesium in water are the two most common minerals that make the water 'hard'. Generally total hardness is measured in mg/l. Total dissolved solids are the inorganic substances that are present in the dissolved form. The sizes of these dissolved substances are even less than two micrometer and cannot be detected in the sieve tests. TDS is measured in parts per million (ppm).

Dissolved oxygen is a measure of the amount of gaseous oxygen (O_2) dissolved in the water. Oxygen gets into water by diffusion from the surrounding air, by aeration. Open wells contain high dissolved oxygen as they are exposed to open air whereas the bore wells have comparatively less exposed has low level of dissolved oxygen. Alkalinity can neutralize the acid nature of the water. It is the sum of addition of all the bases present in the water. Bicarbonate is the dominant anion which contributes much larger part to alkalinity.

Sodium compounds are commonly found in the rocks and soil about a significant percentage. The groundwater gets sodium as they flow through it by dissolving. The rise in sodium in the groundwater acts one of the key components for the finding of saltwater intrusion in the coastal areas. It is measured in mg/l. Chlorine is never found in free form in nature and most commonly occurs as sodium chloride. As like sodium, the chlorine compounds are highly soluble in water and thus the groundwater gets chlorides by dissolving it. It is measured in mg/l. Iron is also an important composition of groundwater which is essential for drinking in small amounts. It is a naturally occurring metal present in many types of rock. Concentrations of iron in groundwater are often higher than those of measured in surface waters proves that the metal got in groundwater by dissolution. The drinking water limit of iron must be less than 0.3mg/l.

The objective of the current study is to discuss drinking water quality based on the water quality index.

Study Area: Tambaram town is situated 24 km south of the capital city of Chennai. Tambaram is located in Kancheepuram district in the Indian state of Tamil Nadu. It borders Selaiyur, Vengaivasal, Madambakkam and Sithalapakkam.


Fig. 2: Study Area Map

Table 1:

Parameter	WHO(2004)	Indian Standards
pH	6.5–8.5	6.5-8.5
Conductivity (iS/cm)	-	-
Chloride(mg/l)	250 (mg/l)	250-1,000 (mg/l)
Hardness	500 (mg/l)	300-600 (mg/l)
Total dissolved solids	500 (mg/l)	500-2,000 (mg/l)
Dissolved oxygen	4 (mg/l)	-
Alkalinity	-	-

The famous Grand Southern Trunk Road and Railway route from Chennai Egmore to Kanyakumari divide the town into east and West. The Municipal Town, Tambaram is described as Gateway of the Beautiful Metropolitan City, Chennai.

MATERIALS AND METHODS

The present study was carried out in Tambaram, Chennai. A total of 15 water samples were collected and each sample was given ID such as S1 to S15. The locations of the samples are collected by using handheld GPS (Table 1). All the water samples were collected from each station from bore wells. These samples were analyzed for different parameters by following standard methods [3-5]. Therefore the aim is to study the Physico-chemically in order to understand the quality of water. The following objectives are of the study are (i) To determine groundwater quality parameters such as pH, Alkalinity, Electrical conductivity, Cl-, Hardness, Total dissolved solids, dissolved oxygen The following table presents the current primary standards for drinking water based on WHO and the Indian Standards is given in the Table 2.

RESULT AND DISCUSSION

Physico-Chemical Parameters: The analyzed result of the various parameters from the study area is given in the table 3. The pH can be defined as the negative logarithm (to the base 10) of hydrogen ion activity (mg/l of water). The most commonly measured chemical attribute of water is its acidity or pH. In the study area, the samples lie with a minimum and maximum pH value of 6.1-7.9 with the average of 7.1 (Table 3).

[6-10] These samples pH values shows some of the bore wells are acidic as well as alkalinity in nature. Pure water is electrically non-conductive but groundwater invariably contains dissolved solids and thus, is conductive. Its conductivity depends on the concentration of dissolved solids. Electrical conductivity is measured using a conductivity meter and is the conductance of 1 cm of water. [11-12] The unit of measurement is μS/cm. In the study area, the electrical conductivity ranges between 1304 – 8460 with an average of 3829.7 (Table 3) and also it was found to be normal in sample S7-S15. But the samples S1-S6 have more electrical conductivity, which may conduct electric in high level. The sum of all dissolved solids in a water sample is known as the Total Dissolved Solids (TDS). It is an index of the impurity of the water. In the study area, the TDS ranges between 1950 – 3150 with an average of 2269.7 (mg/l). The DO ranges between 6.8 – 9.0 with an average of 7.8 (mg/l) (Table 3) samples S12 and S15 have the highest value of dissolved oxygen. The samples S4, S6, S9 and S13 have

Table 3: Result of analysed Physico-chemical parameters

Sample ID	Lat	long	pH	EC	TDS	DO	ALKALINITY	HARDNESS	CHLORIDE
S1	12.98	80.263611	7.9	1828.0	1980.0	8.5	160.0	280.0	260.2
S2	12.974167	80.263333	7.1	1651.0	1950.0	7.5	135.0	190.0	255.2
S 3	12.969167	80.263056	7.5	1810.0	1990.0	8.5	125.0	295.0	282.3
S 4	12.963056	80.258056	6.8	1875.0	2100.0	7.1	155.0	475.0	279.4
S 5	12.958333	80.258889	6.9	1810.0	2140.0	7.5	115.0	550.0	307.7
S 6	12.955	80.257222	7.6	1304.0	2134.0	7.2	120.0	525.0	206.5
S 7	12.950556	80.253333	7.1	1745.0	2130.0	8.3	120.0	640.0	368.7
S 8	12.948056	80.254444	6.1	1876.0	2140.0	7.4	175.0	590.0	265.7
S 9	12.943056	80.254167	7.2	1887.0	2190.0	7.9	135.0	485.0	297.8
S 10	12.937222	80.253333	6.3	6780.0	2500.0	7.4	130.0	615.0	277.0
S 11	12.933889	80.250556	7.4	6660.0	2455.0	7.2	125.0	550.0	271.7
S 12	12.9275	80.251667	7.9	6690.0	2230.0	6.8	135.0	540.0	257.8
S13	12.923056	80.253611	6.5	6480.0	2256.0	7.9	115.0	530.0	247.3
S 14	12.916389	80.249444	6.3	6590.0	2700.0	9.0	120.0	440.0	320.0
S 15	12.929444	80.248333	7.9	8460.0	3150.0	9.0	115.0	420.0	297.7

Table 4: Water Quality Parameter, BIS Standards and their Weightages

Parameters	V_s	V_{ideal}	Weightage (W_i)
pH	6.5-8.5	7	0.3027058
Chlorides (mg/l)	250	0	0.01
Total Hardness (mg/l)	300	0	0.0085766
Alkalinity (mg/l)	120	0	0.02144166
Dissolved Oxygen (mg/l)	4	14.6	0.64325
Total Dissolved Solids (mg/l)	500	0	0.005146
Electrical Conductivity (mmho/cm)	300	0	0.0085766

the lowest dissolved oxygen. In the study area the Alkalinity ranges between 1150 – 175 with an average of 132 (mg/l) (Table 3) the samples S1, S2, S12 have the highest alkalinity value. The samples of S4, S5 and S8, S10, S14, S15 have the lowest alkalinity value. Hardness in water is caused by dissolved calcium and, to a lesser extent, magnesium. It is usually expressed as the equivalent quantity of calcium carbonate WHO (2004). The hardness of water reflects the nature of the geological formations with which it has been in contact (Sawyer and McCarty 1978). In the study area, ranges between 190 – 640 (mg/l) (Table 3) where S2 sample have the lowest hardness value. The samples S7, S8 and S10 have the highest value of hardness. The other samples have the normal range of hardness value. The chloride value range in the study area is permissible. In the study area the chloride ranges between 206.5 – 368.7 with an average of 279.9 (mg/l) (Table 3) the S6 sample have highest contamination of chloride and S5 sample has lowest contamination of chloride.

Water Quality Index (WQI): Water Quality Index (WQI) is a most efficient method for assessing the quality of water. Water Quality Index (WQI) is a tool for communicating the information on overall quality of water and rates the quality of each sample locations. It acts as the perfect indicator of the quality of the water. It was first proposed by Horton (1965) to determine the suitability of the groundwater for drinking purposes. Analyzed groundwater sample data are tabulated in Table1. WQI is computed adopting the following formula.

$$WQI = \frac{\sum_{i=1}^{n} W_i q_i}{\sum_{i=1}^{n} W_i}$$

where, W is the unit weightage factor computed using the following equation, $W_n = K/S_n$ and K is the proportionality constant derived from,

$$K = \left[\frac{1}{\sum_{n=1}^{n} \left(\frac{1}{S_i} \right)} \right]$$

where S_n and S are the Bureau of Indian Standard values of the water quality parameter (Table 2). Quality rating is calculated using the formula,

$$q_{ni} = \left[\frac{(V_{actual} - V_{ideal})}{(V_{s\,\tan dard} - V_{ideal})} \right] x100$$

Table 5: Water Quality Index Values for the Study Area

Sample Station	pH	Electrical Conductivity	Alkalinity	TDS	Dissolved Oxygen	Total Hardness	Chlorides	$\Sigma W_i \log_{10} q_i$	WQI=Antilog $[\Sigma W_i \log_{10} q_i]$
1	1.77815	2.7848	2.124938	2.59769	1.760023	1.970036	2.017367	1.79086	61.78
2	0.8239087	2.7406258	2.05115252	2.591064	1.82592	1.80163	2.00894	1.735866	54.43
3	1.5228	2.78056	2.0177287	2.59988	1.760023	1.9927	2.05277	1.400047	25.12
4	1.124978	2.79588	2.115	2.623249	1.84975	2.1995572	2.048286	0.972011	9.37
5	0.249401	0.02384	0.042487	0.0135414	1.174543	0.01941	0.021512	1.544742	35.05
6	1.60205	2.638155671	2	2.630024	1.843917	2.243038	1.91698	1.772245	59.18
7	0.8234	2.764679	2	2.629409	1.774	2.329058	2.168733	1.53	33.93
8	1.77815	2.796111	2.16385	2.6314437	1.832	2.29373	2.026451	1.8411537	69.36
9	1.124938	2.79865	2.051152	2.6414741	1.80076	2.20862	2.075984	1.743091	55.34
10	1.669	3.3541084	2.03476	2.69897	1.832026	2.3117538	2.04454	1.81081	64.68
11	1.42596	3.3463529	2.017728	2.6910814	1.8439	2.263241	2.036149	1.743931	55.45
12	1.778151	3.348304	2.05115	2.649334	1.86678	2.255272	2.031334	1.86564	73.39
13	1.522878	3.334453	1.981516	2.654369	1.80071	2.247154	1.995284	1.743867	55.44
14	1.669	3.341764	2	2.732393	1.72282	2.16633	2.01721	1.739326	54.86
15	1.778151	3.450249	1.98151	2.79934	1.722882	2.146128	2.07583	1.772753	59.25

Table 6: Water quality Index for groundwater (Priti Singh and I.A. Khan 2011)

SNo	WATER QUALITY INDEX	DESCRIPTION
1	0-25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very Poor
5	>100	Unfit For Drinking

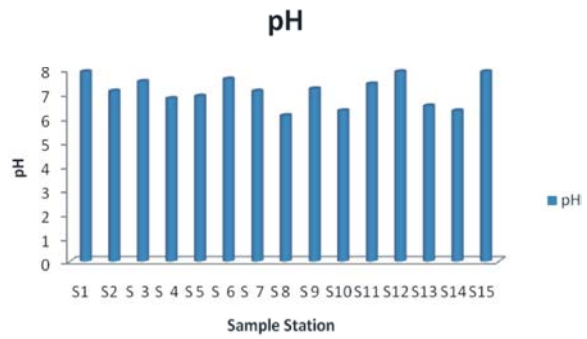

Fig. 3a: pH Concentration at different station

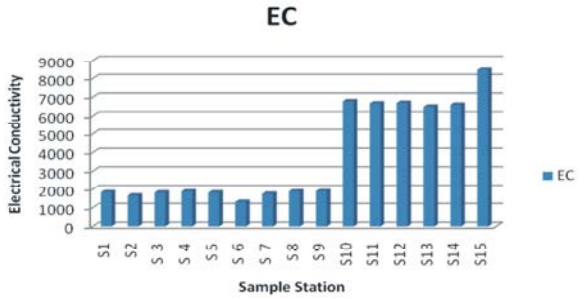

Fig. 3b: Electrical Conductivity at different station

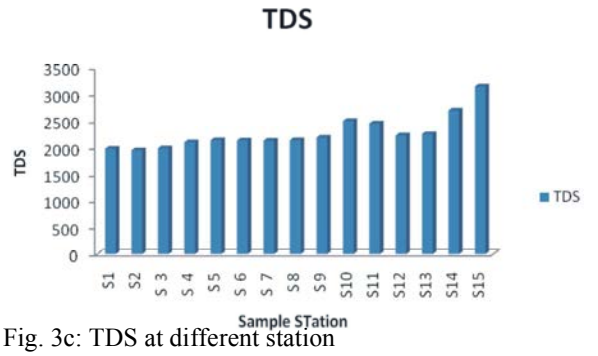

Fig. 3c: TDS at different station

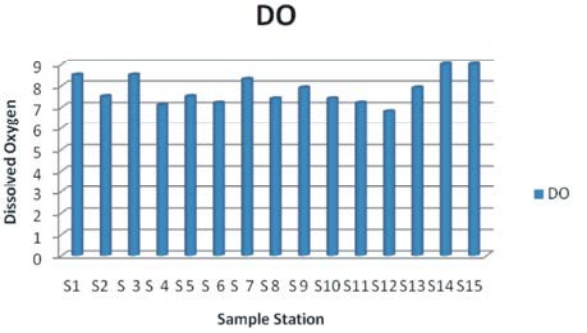

Fig. 3d: Dissolved Oxygen at different station

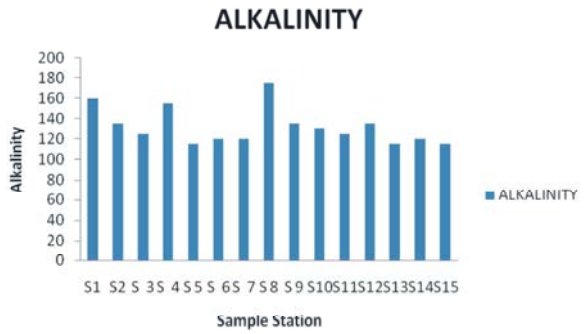

Fig. 3e: Alkalinity at different station

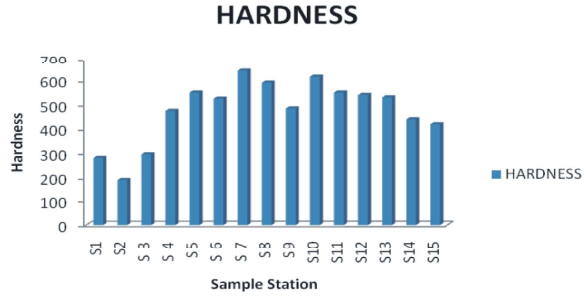

Fig. 3f: Hardness at different station

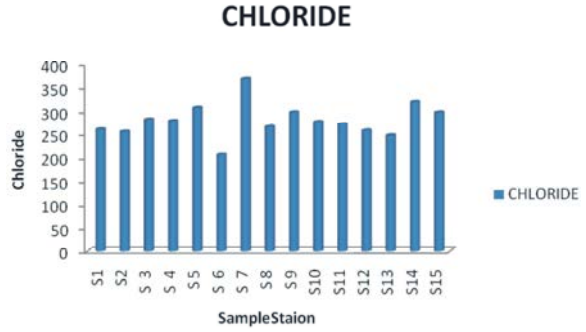

Fig. 3g: Chloride Concentration at different station

where, q_{ni} is the quality rating of i[th] parameter for a total of n number of water quality parameters. V_{actual} is the value of the water quality parameter obtained from laboratory analysis. V_{ideal} is the value of the water quality parameter can be obtained from the standard tables. V_{ideal} for pH is 7 and Dissolved Oxygen is 14.6 mg/lit and for other parameters it is equivalent to zero. $V_{standard}$ is the BIS standard of the water quality parameter. Based on the WQI values, the water quality is rated as excellent, good, poor, very poor and unfit for human consumption

(Table 6). The water quality parameter, BIS Standards and the relative Weightages are shown in the Table 4. Table 5 shows the calculated values of Water Quality Index for each location. The spatial quality of ground water for various parameters is shown in the Figure 3 a-g.

CONCLUSION

The quality of groundwater collected from the study area where studied by analysis of the Physico-chemical parameters. The main purpose of this study was to create a database, map and assess the groundwater quality in study area. From the study it is inferred that the pH in most of the wells area in acidic and alkaline in nature. However in most of locations the groundwater is not suitable for drinking it can be mainly due to high concentration of chloride content. From the WQI index value it is clearly shown that majority of the bore wells are poor to very poor in quality.

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