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Appraisal of water quality index for drinking purpose of groundwater in Pennagaram Block, Dharmapuri District, Tamilnadu, India

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Abstract

The present study is targeted to determine the Ground water quality index (WQI) of Pennagaram Block, Dharmapuri District, Tamilnadu, India. The WQI categorized by gathering groundwater samples during the month of September 2015 and analyzed for physicochemical parameters. The following parameters have been measured for manipulative the Water Quality Index such as pH, Electrical conductivity, Total Dissolved solids, Total Alkalinity, Total Hardness, Calcium, Magnesium, Chloride, Nitrate, Sulphate, Fluoride, Dissolved oxygen. The outcomes of water quality index have been have been utilized for better comprehension for the present water nature of the review region. And also it has been used to suggest the models for recognizing the water nature of the review area region. This analysis exposes that the quality of groundwater of the study area region needs a certain level of management earlier consumption, and it requires an alternate source of water or threatened from the dangers of groundwater pollution.

Keywords: Physicochemical Parameters, Fluoride, Groundwater, Pennagaram, Water Quality Index.

Introduction

Underground water is an important accepted source of water for urban and rustic environments. It is used for household and other water supply and water system everywhere throughout the world. Groundwater is monstrously essential for human water supply in both town and provincial ranges of growing countries. Groundwater is utilized as a major or additional water system for agricultural improvement. Estimates of America and Asia only recommend that more than 1000 million individuals are definitely trusting upon these sources. Accessibility of protected and dependable birthplace of water is an essential for commercial improvement[1].

Human prosperity is weakened by unhygienic surroundings open sewage conveying and positioning waste water into normal water bodies. Fast growth of urban areas, particularly in creating nations, has affected the availability and nature of underground water because of its dishonorable wastage transfer, especially in townranges[2].

Further, once the groundwater is polluted, its excellence can't be resorted by discontinuing the contaminants from the sources[3]. As indicated by WHO association, nearby 80% of the infections and illness in are caused by unclean aquatic resources. Better quality of water will resolve the social–financial advancement, as the administration need is moved to different segments of the economy. Groundwater excellence depends on, to certain degree, on its natural alignment which may be enhanced by natural and anthropogenic sources[4].

The superiority of the water is described by means of its physicochemical and micro biological limits. It is measured with the assistance of different parameters to show the contamination level in groundwater. With the use of directories to gather and compress huge measurements of water quality information has progressively picked up response to mirror the composite impact of those parameters[5].

Water quality index (WQI) is an arithmetical device used to change extensive amounts of water quality information into a single derived numeral which looks like the level of contamination or at the end of the day the water order as superb, great, medium, terrible, and extremely bad[6].

The idea of WQI was initially utilized by Horton in 1965, and after that it was established by Brown et al and improved by Deininger[7-9]. The improvement of WQI of groundwater is depicted by different writers. Backman et al., show a directory for assessing and mapping the level of groundwater damage and the test is applied in the southwestern region of Finland and the central region of Slovakia[10]. In any city, a groundwater quality director is most authoritative for consumption determinations and as a sensible sign of possible environmental prosperity problems[11]. The fundamental reason for this review was to talk about the appropriateness of groundwater for human intake constructed on the derived WQI values.

Study area: The study area is positioned in Northern part of Tamil Naduat 30 km distance from the west of Dharmapuri town and at 25 km distance from Palakodu. Dharmapuri and

Palakodu is the closest railway station from Pennagaram. It falls amongst 77°50'EL to 77°52'EL and 11° 53'NL to 12 °19'NL covering an area of 1096.22 km^2. In these, Plain area covers an area of 604.48 Km^2.

The weather condition of the review region is warm and waterless in summertime (March to June) and it is cold and misty in winter (November to February). The warm climate begins early in March, the highest temperature being felt in May. The climate chills off progressively from around the inner of June and December. The mean extreme temperature falls to 29.6^0C.

The major source for renew of water in this area is only the rainfall, during monsoon season. The normal rainfall is 902.1 mm. During 2013 – 2014 the actual rainfall of the district is 707.4mm. As the review range is underlain by the Archaean crystalline parts, groundwater may happen in the broke rocks.

Materials and methods

Water sampling: During the month of September 2015 eighty groundwater samples were gathered and preserved from various areas of Pennagaram block of Dharmapuri district. Sampling stations cover the overall area of Pennagaram block villages. The groundwater samples were received in a pre-cleaned two liter polyethylene bottles with no air bubbles. The containers were washed before testing and firmly fixed after accumulation and marked in the field. The temperature of the groundwater samples were measured at the time of sample gathering.

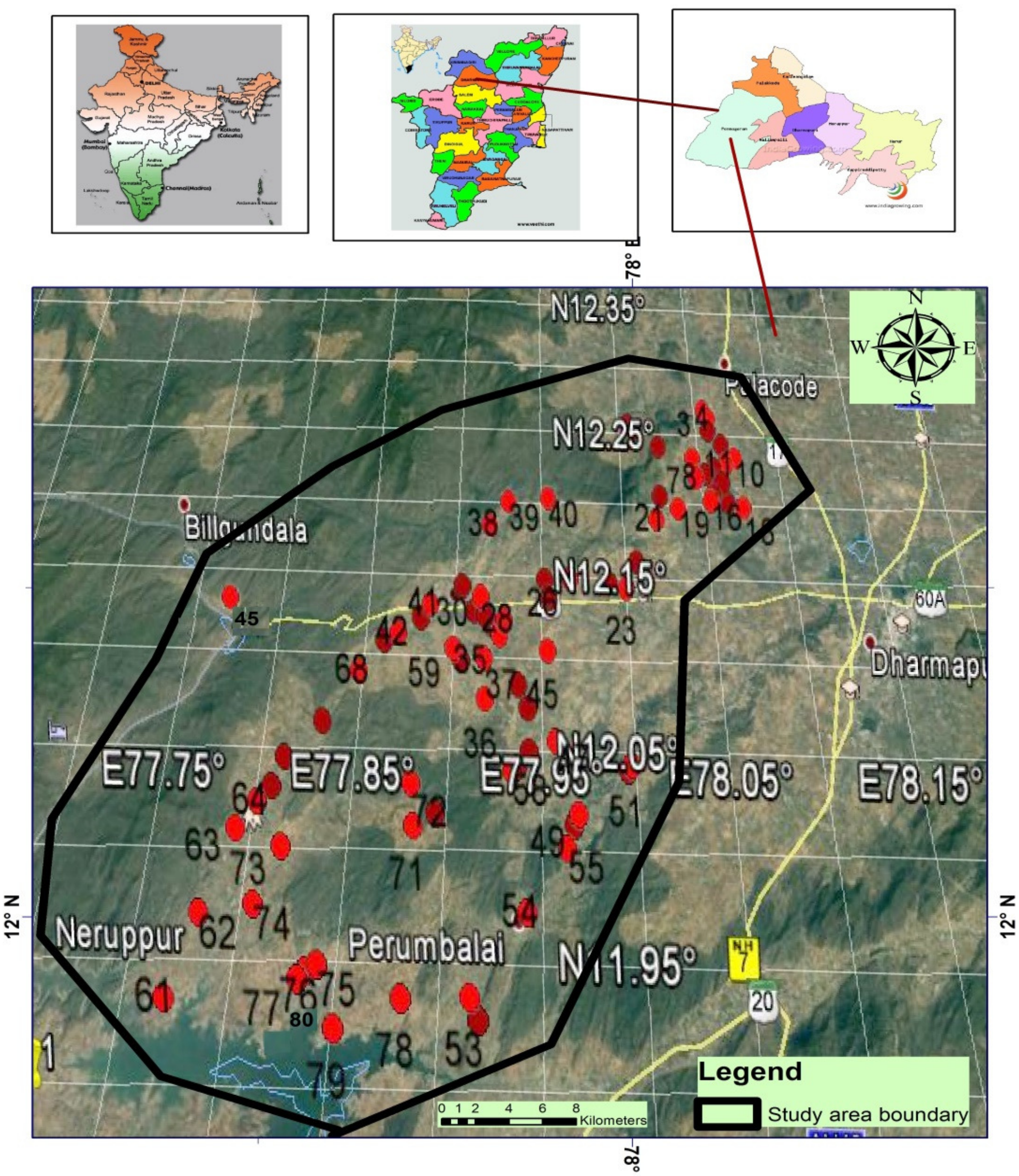

Figure-1: Represents Sampling Stations of the review region.

Analysis of water quality parameters: The investigation was completed for different groundwater Quality parameters according to standard techniques prescribed by APHA (1995). The groundwater excellence parameter values are in ppm or mg/L but EC in µs/cm and pH is no unit. So as to compute the WQI scores are totally ten water excellence parameters such as pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), Total Alkalinity (TA), Total Hardness (TH), Calcium (Ca), Magnesium (Mg), Dissolved oxygen (DO), Nitrate and fluoride has been chosen.

These are the parameters to decide the nature of the groundwater quality. The following steps for the calculation of Water Quality Index (WQI) are given.

WQI Weightage: Commonly, the development of WQI includes three stages: (1) Assortment (2) Calibration and (3) Accumulation of the parameters to be included[12]. In the assortment step, the crude expository outcomes for chose water quality parameters, having distinctive units of estimation, are changed into unit less sub-index values[13].

The resulting values are then accumulated using the following steps[14].

Parameter selection: The determination of water quality parameters that will make up the record relies on upon a few elements, for example, the motivation behind the file, the significance of the parameter, and the accessibility of data information. Intake water excellence appraisal, need ought to be given to those substances which are known to be vital to wellbeing (potability) and which are known to be available in substantial quantities in the water source (WHO).

The WQI in this review is computed based on pH, EC, TDS,TA, TH, Ca, Mg, DO, Nitrate and Fluoride.

Weight assignment: The persistence of a task of masses to water quality parameters is to signify every parameter's significance to the general water quality. Bigger weight esteem infers the more noteworthy significance of the variable with respect to public health. In this manner, every of the selected parameters has been relegated a weight (wi) in view of a size of 1 to 5, where 5 mean high significance.

These weights are based on the prevailing weights used[15,16].

Comparative weight calculation: Comparative weight (W_i) can be controlled by dividing the specific weight of every parameter (wi) by the aggregate of the heaviness of all selected parameters (W):

$$W_i = w_i / \sum wi \quad (1)$$

Where W_i is the comparative weight and w_i is the weight of every parameter.

Quality rating calculation: In this step, the intention of quality rating (Q_i) for every parameter, as follows:

$$Q_i = (c_i / s_i) \times 100 \quad (2)$$

Where Q_i is the quality rating, c_i is the counting of every parameter in each sample and s_i is the BIS (Bureau Indian Standards) for every parameter in mg/L as per the rules of BIS.

Sub-index calculation: The sub-index SI_i for every parameter is resolved utilizing the accompanying condition:

$$SI_i = W_i \times Q_i \quad (3)$$

It combines its quality rating as well as its assigned weight.

Computation of WQI: The computation of WQI is used to determine based on the next equation:

$$WQI = \sum SI_i \quad (4)$$

The equation generates a WQI score, higher WQI scores indicating poorer water quality, and lower scores indicate excellent water quality. Totally these following steps are followed,

Relative weight (W_i), $W_i = w_i / \sum wi$, $Q_i = (c_i / s_i) \times 100$,
$SI_i = W_i \times Q_i$, $WQI = \sum SI_i$

Classification of water quality excellence based on WQI scores: The calculated WQI scores are classified into five types, “Superb” to “Extremely bad”, as shown in Table-1.

Table-1: Classification of Water Quality Excellence based on WQI Scores.

WQI value	Water Quality
<50	Superb Water
50 – 100	Great Water
100 – 200	Medium Water
200 – 300	Terrible Water
>300	Water extremely bad for Drinking

Results and discussion

In this part the water nature of 80 stations covering the review region have been built up by deciding the physico-chemical parameters according to the standard techniques.

Table-2: Comparative weight of physicochemical parameters.

Parameters	BIS	Weightage (w_i)	Comparative weight (W_i)	Quality Rating (Q_i)	Sub-index
pH	6.5 – 8.5	4	0.129	83.29	10.74
EC	<300	1	0.032	309	9.88
TDS	500 – 2000	4	0.129	32.16	4.14
TH	300 – 600	3	0.097	66.66	6.4
TA	200 – 600	3	0.097	70	6.72
Ca	75 – 200	2	0.065	61.05	3.9
DO	>5	4	0.129	141.8	18.29
Mg	30 – 100	2	0.065	23	1.48
NO_3^-	45	4	0.129	32.89	4.23
F^-	>1.5	4	0.129	130.7	16.86
		w_i=31	$\sum W_i = 0.999$	$\sum Q_i = 917.62$	WQI = 82.64

Table-3: Summary of fundamental information for different parameters*.

Water Parameters	Minimum value	Maximum value	Intermediate (Median)	Average
pH	6.94	8.09	7.48	7.48
EC	786	2424	1413	1460
TDS	546	1682	980	1013
TH	230	2010	695	781
TA	210	1250	605	623
Ca	33.5	566	117	136
DO	3.19	7.49	4.8	4.91
Mg	22.9	293	105	108
NO_3^-	6.84	57.2	36.8	35.2
F^-	0.21	2.33	0.99	1.1

*Units are in ppm or mg/L but pH is no unit and EC is µS/cm.

The value of pH is normally 6.5 to 8.5inintake water. And the study area displayed that the value of pH ranges from 6.94 to 8.09. Therefore the Sampling station shows that all are within the permissible limit.

Nitrate move into the groundwater through the nitrogen cycle. Yet 1mg/L of nitrogen is equal to 4.5mg/L of nitrate. In the study area the nitrate concentration ranges from 6.84mg/L or ppm to 57.2mg/L or ppm. The maximum desirable limit of nitrate is 45mg/L. More than 30 stations are higher than the permissible limit. The pH and Nitrate variations are represented in Figure-2.

Electrical conductivity (EC) is the capability to convey electric current through it and it and it is communicated in µS/cm. The

EC values range from 786 to 2424 µS/cm, wherever the EC values are increasing the quality of water will be decreased. So the lower conductivity of water is suitable for drinking as well as higher. Total Dissolved Solids (TDS) is the amount of dissolved matter in water. It is given by the weight of the solid material on dehydration of water to waterlessness at high temperature. In the study area, TDS in groundwater ranges from 546 to 1682mg/L. The variations of EC and TDS are shown in the Figure-3.

Dissolved Oxygen (DO) values ranges from 3.19 to 7.49 ppm or mg/L. The required limit of DO is 5mg/L. More than 50% of the samples from the study area region had upper than the allowable limit. Fluoride concentration of the review region varies between 0.21 to 2.33mg/L. The fluoride concentration in intake water must have to be 0.6 mg/L to 1.5mg/L. More than 30% of samples excess than the permissible limit. Higher fluoride concentration causes dental and skeletal fluorosis, which represents a serious health problem. These variations are represented by Figure-4.

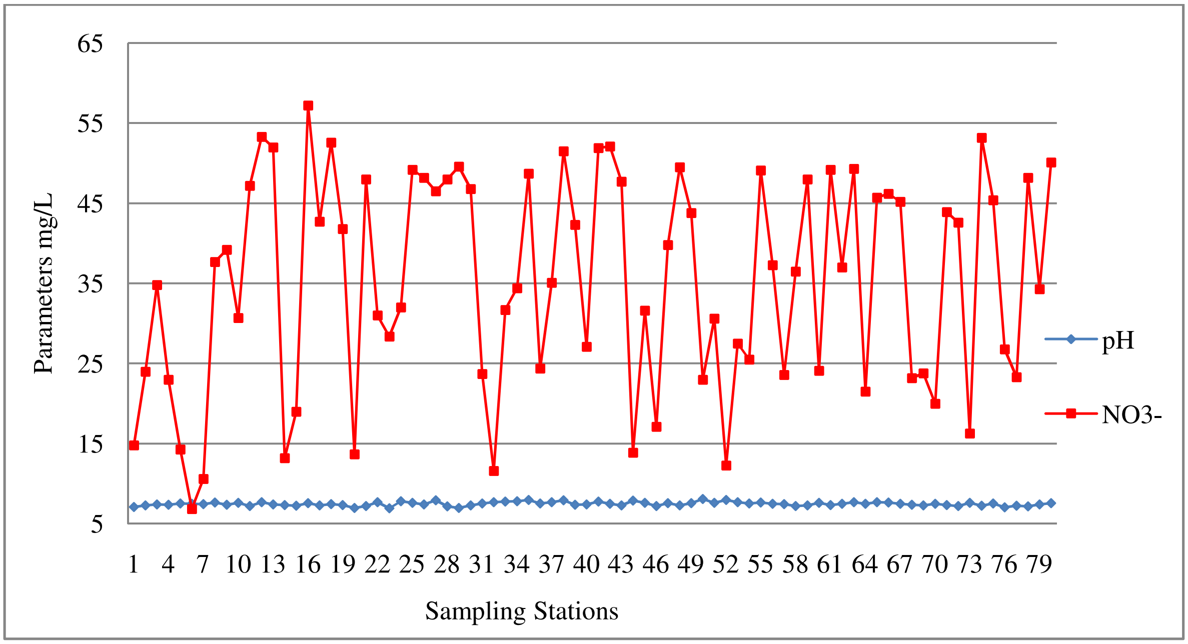

Figure-2: pH and Nitrate variations during the study period.

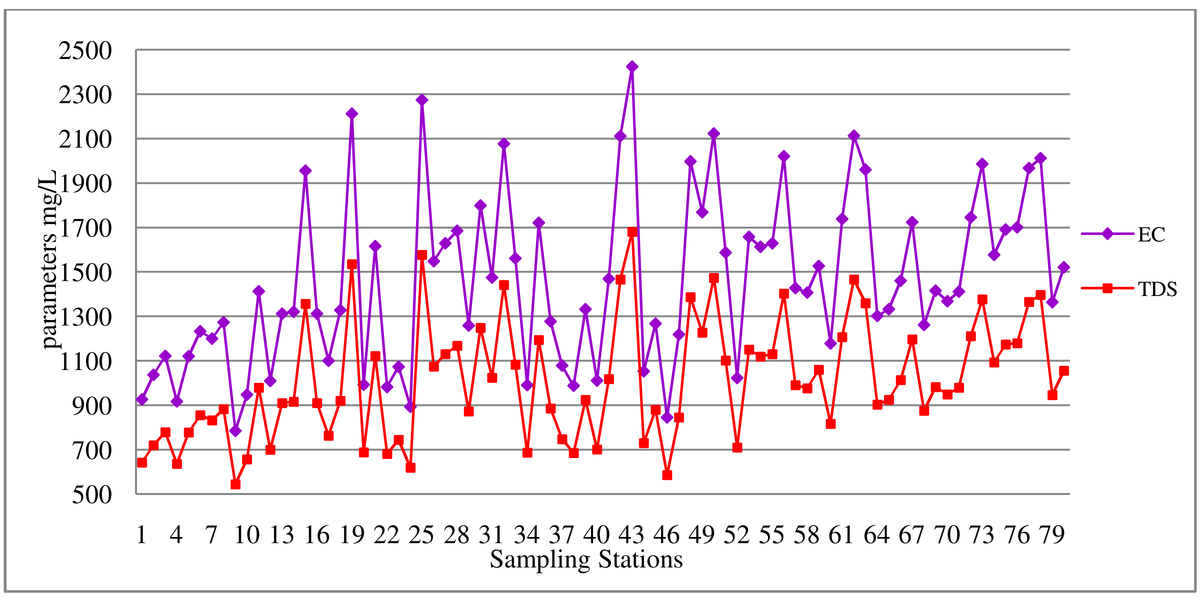

Figure-3: Shows the variations of EC and TDS.

Total hardness (TH) is a quantity of calcium and magnesium count level in water. It ranges from 230 to 2010 mg/L. The maximum allowable range of Total Hardness is 600 mg/L. More than 50% of the groundwater samples are higher than the permissible level. Calcium transpires in mostly due to the existence of minerals such as limestone, dolomite, etc. Acceptable level of calcium is 200mg/L. Just 10% of the specimens are higher than the allowable level. These variations are represented by Figure-5.

The reason for the Total Alkalinity of water is based on the presence of hydroxide derivatives of carbonates. The limit for drinking water is 600mg/L. It ranges between 210 to 1250 mg/L. More than 50% of Samples are excess than the acceptable limit. The main reason for the Magnesium concentration of water is the existence of Biotite and agutite minerals. The Acceptable level of magnesium concentration is 100mg/L. the results of the magnesium concentration ranges from 22.9 to 293 mg/L. Over half of the samples are over as far as possible. These variations are shown in the Figure-6.

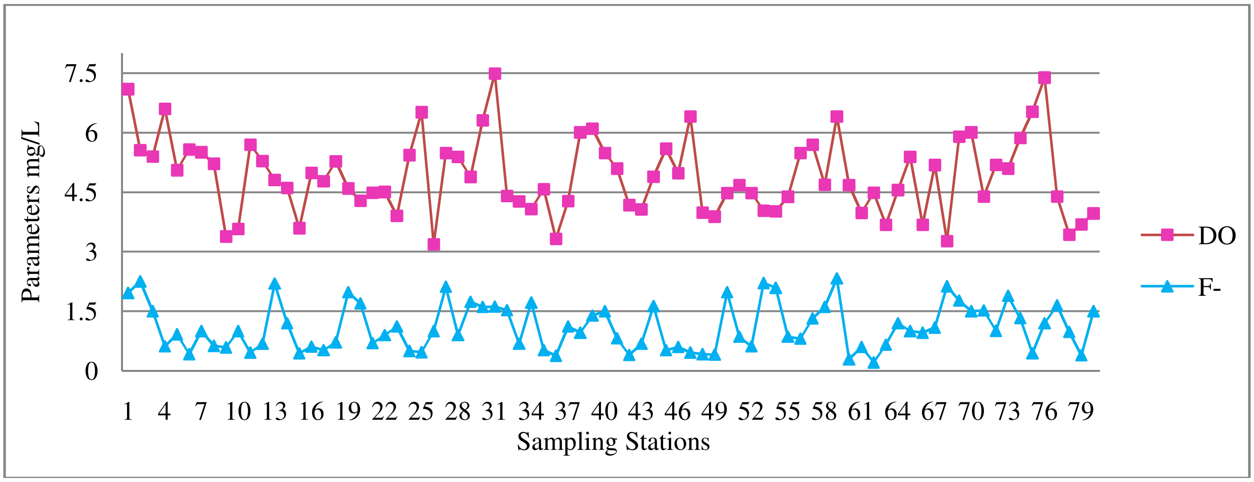

Figure-4: DO and Fluoride variations during the study period.

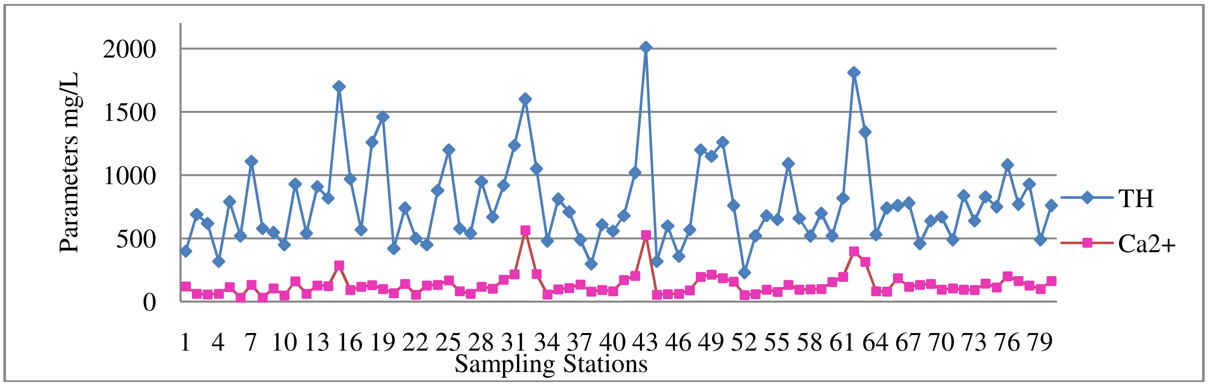

Figure-5: Total Hardness and Calcium variations during the study period.

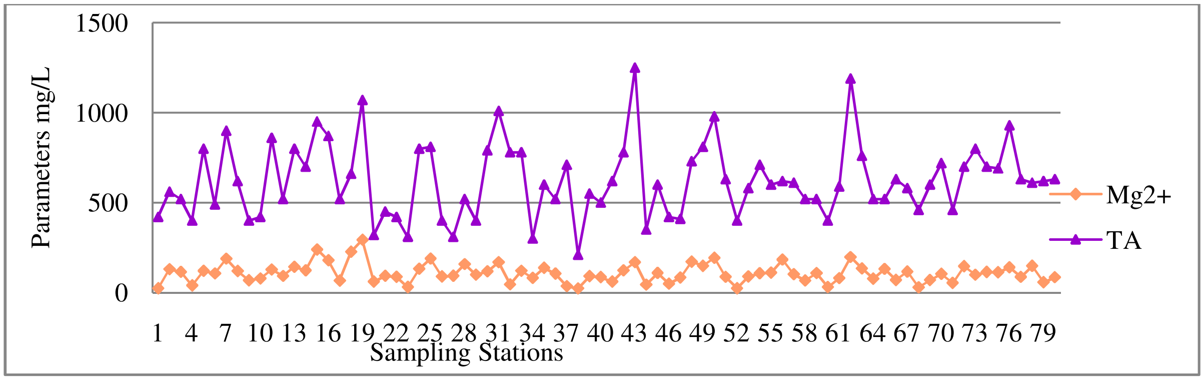

Figure-6: Shows the TA and Mg concentrations.

The manipulated WQI scores are classified in the study area as namely, superb water (WQI below 50), great water (WQI 50 – 100), Medium water (WQI 100 – 200), Terrible water (WQI 200 – 300) and Water extremely bad for drinking (WQI above 300).

The Table-4 displays the proportion of groundwater samples that falls in various categories. It is also witnessed that the most of the samples were in the Medium quality (71.25%) and great quality (28.5%) category in showed in Figure-7 and Figure-8 indicating unhealthy for drinking. This recommends the groundwater from the review range is polluted due to leaching and anthropogenic activities. The high scores of WQI have to be observed the upper value of physico chemical parameters in groundwater.

Table-4: WQI based Classification of Groundwater in Study area.

WQI value	WQI Category	Sampling Station Numbers
<50	Superb water	-
50 – 100	Great water	1,4,6,9,10,12,17,20,22,23,34,36,37,38,40,44,45,46,47,52, 60, 68, 79 (28.5%)
100 – 200	Medium water	2,3,5,7,8,11,13,14,15,16,18,19,21,24,25,26,27,28,29,30, 31, 32, 33, 35, 39, 41, 42,43,48,49,50,51,53,54, 55, 56, 57, 58, 59, 61, 62, 63, 64, 65, 66, 67, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 80 (71.25%)
200 – 300	Terrible water	-
>300	Water extremely Bad for drinking	-

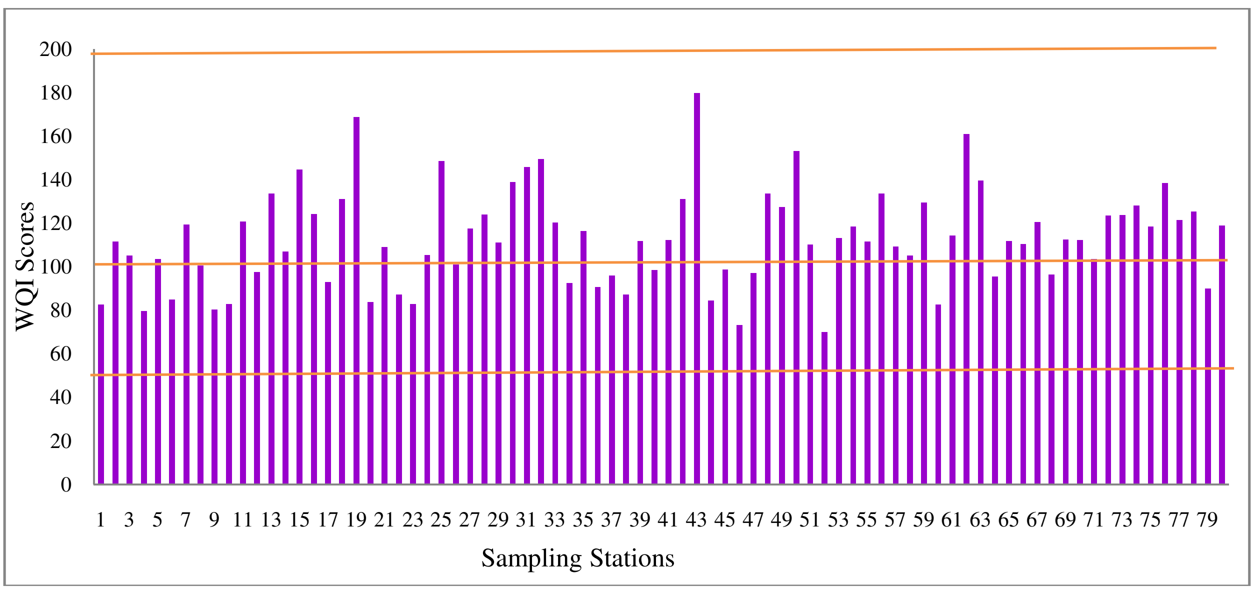

Figure-7: Represents WQI scores of Groundwater samples.

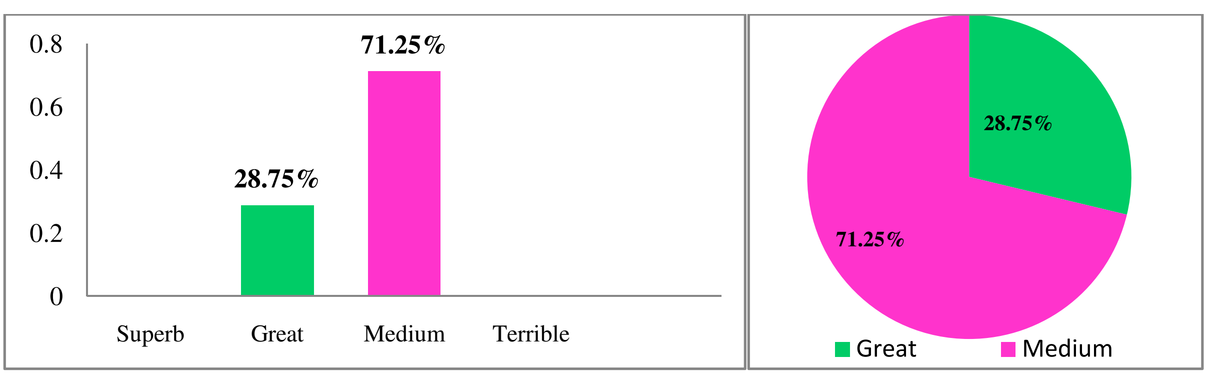

Figure-8: Represents the groundwater samples falls under WQI scores.

Conclusion

The manipulated WQI scores between from 70.01 to 179.8. The minimum WQI value recorded from Arakasanahalli (Sample No. 52), whereas a maximum WQI value recorded from puthur (Sample No. 43). The average WQI of the groundwater is 112.8 in the review region. The majority of the groundwater samples fall on Great (71.25%) and Medium (28.75%) category indicates that unhealthy for drinking purpose. Because of Pennagaram block has a highly polluted area, the influence of natural mineral sources of contamination. This overall WQI value (Figure-7) indicates Medium water quality. The pH, EC, TDS, TA, TH, Nitrate and Fluoride are the main reason for the extraordinary scores of WQI. There is a need to supply safe consumption water to the people living in rustic region of Pennagaram block of Dharmapuri district. This study raises the instant attention towards the improvement of groundwater excellence in the region of review area. This investigation exposes that the quality of groundwater of the study area region needs a certain level of management earlier consumption, and it requires an alternate source of water or threatened from the dangers of groundwater pollution.

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