Assessment of ground water quality for a developing town in Puducherry Union Territory using Water Quality Index

Jeyakumar R[1], Sudalai S[2], Nimisha T R[3], Arunprasath T[4]

[1,3,4]Post Graduates, [2]Assistant Professor
Centre for Pollution Control and Environmental Engineering,
School of Engineering and Technology,
Pondicherry University, Puducherry 605014, India

ABSTRACT: In this modern era there is a huge decline in fresh water resources that may be due to the industrialization, urbanization, increase in population and many other anthropogenic activities. Scarcity of the surface water makes people to depend on ground water resources for their needs. Utilization of ground water resources in an unsustainable manner has left the resource with distorted quality at many regions. In this study we attempt to assess the ground water quality of Villianur which is a rapidly developing town in Puducherry Union Territory of India. Water quality of the study area was determined using the Water Quality Index (WQI) by Weighted Arithmetic Mean Index Method. pH, Electrical Conductivity, Total Hardness, Total Alkalinity, Turbidity, Total Dissolved Solids, Fluoride and Iron were the water quality parameters used for the calculation of WQI. Five ground water samples were taken for the study and the WQI of them showed as 60.67, 28.16, 206.32, 69.32 and 115.80 respectively. The results indicate that there is deterioration in ground water quality of the region.

Keywords: **water quality, puducherry, weighted arithmetic mean index, groundwater**

INTRODUCTION

Water is a non renewable resource as we all are aware with the fact. It is not only important to human life but is the major constituent of other living things also. Different forms of water are found in everywhere around the planet earth. In this modern era there is a huge decline in fresh water resources that may be due to the industrialization, urbanization, increase in population and many other anthropogenic activities. Scarcity of the surface water makes people to depend on ground water resources for their needs. Over exploitation of ground water may leads to intricate environmental condition [1]. Utilization of ground water resources in an unsustainable manner has left the resource with distorted quality at many regions. The quality of ground water is the resultant of all the processes and reactions that act on the water from the moment it condensed in the atmosphere to the time it is discharged by a well or spring and varies with respect to the depth of the water table [2]. Water quality assessment is the evaluation of physical, chemical and biological characteristics of water in relation to natural quality, human effects and anticipated uses [3]. It is not easy to assess water quality for huge samples containing concentrations for many parameters [4]. The Conventional methods for evaluating quality of water are based on the comparison of experimentally determined parameter values with the existing guidelines [5]. In recent days water quality index (WQI) is one of the most effective tool used to ascertain the quality of water for domestic purposes. It is an approach which minimizes the data volume to a great extent and simplifies the expression of water quality status [6]. It is one of the most effective ways to communicate information on water quality trends to policy makers, to shape sound public policy and implement the water quality improvement programmes efficiently [7] [8].

Water Quality Index is defined as a rating reflecting the composite influence of different water quality parameters [7]. WQI is calculated from the point of view of the suitability of water for human consumption [9]. It quantifies the extent to which a number of water quality parameters changes from standard concentrations and more appropriate to find the water quality status across a range of water type over time. Thus the water quality index can tell us whether the overall quality of water has potential to various usage of water like drinking, irrigation etc. A number of water quality indices have been developed to abridge water quality data in a simple expressible and easy to understand manner. Water quality index was first formulated by Horton (1965) [10] and later on used by several workers for the quality assessment of different water resources [11]. The general WQI was first developed by Brown et al.,1970 [12] and later on improved by Deininger for the Scottish Development Department (1975). Many researchers have used the water quality index to access the water quality elsewhere [13]–[18]

In this study we attempt to assess the ground water quality of Villianur which is a rapidly developing town in Puducherry Union Territory of India. The town is located 9 km away from the head quarters of Puducherry and located at 11.9089° North (Latitude) and 79.7589° (Longitude). The climate of the study area is tropical monsoon type and receives rains from both the northeast and southwest monsoons. Maximum rainfall and occasional cyclones occur during the northeast monsoon. The ground water samples were collected from the five stations in Villianur as follows: Parasuramapuram (sample 1), Thillainagar (sample 2), Housing board (Thillainagar extension) (sample 3), Villupuram bye-pass road (sample 4) and Pudhunagar water tank (sample 5) for this study.

MATERIALS AND METHODS

Sampling and preservation method

Ground water samples were collected on March month of 2016. The samples were collected in clean pre-washed polyethylene bottles and were rinsed three times with the sample water at time of collection. After collection labeled in the field and then stored at 4°C in laboratory.

Water quality analysis

pH was measured using standard pH meter. The electrode of the meter was rinsed with distilled water before determining pH of the samples. Titrimetric methods were used to determine the Total Hardness (TH), Alkalinity and Acidity. Electrical conductivity (EC) was measured by portable hand EC meter. Iron and Fluoride concentrations were determined using UV-VIS spectrophotometer at 510 ηm and 570 ηm respectively. Digital turbidity meter was used to determine the Turbidity of the water samples. Total Dissolved Solids (TDS) were determined by standard method [19] .

Water quality index (WQI)

In this study Weighted arithmetic index method [12][15] has been adopted for the evaluation of the water Quality Index and in order to determine that all the 8 physico-chemical parameters were taken. The water quality rating q_i for the i^{th} water quality parameter was obtained from the following equation:

$$q_i = 100\,[v_i / S_i] \qquad (1)$$

Where,

v_i is value of the i^{th} parameter,

S_i is standard permissible value of the i^{th} parameter (Table 1)

This equation ensured that $q_i = 0$ when i^{th} parameter was absent in the water and $q_i = 0$ when the value of a parameter just equal to its permissible value. Thus, the larger value of q_i, more polluted was the water with i^{th} parameter. However, the quality rating of pH required special handling using the following equation:

$$q_{pH} = 100\,[(v_{pH} - 7.0) / (8.5 - 7.0)] \qquad (2)$$

Where,

v_{pH} is value of pH

The weights for the water quality parameters were assumed to be inversely proportional to the recommended standards for the corresponding parameters by the following equation:

$$W_i = K / S_i \qquad (3)$$

Where,

W_i is unit weight for the i^{th} parameter

S_i is standard value of the i^{th} parameter

K is constant of proportionality and is given by the following equation:

$$K = 1 / [\, 1/v_{s1} + 1/v_{s2} + \ldots\ldots\ldots + 1/v_{sn}\,] \qquad (4)$$

The overall Water Quality Index was evaluated by aggregating the quality rating with the unit weight linearly.

$$WQI = \Sigma\, q_iW_i / \Sigma\, W_i \qquad (5)$$

Water Quality has been classified into five categories based on its WQI value as follow: Excellent, good, poor, very poor and unsuitable for drinking with the values lies between 0-25, 26-50, 51-75, 76-100 and more than 100 respectively (Table 2) [20].

Table 1. Drinking Water Quality standards

Parameter	Unit	Recommending organization	Standard
pH	-	BIS	6.5 to 8.5
EC	µS/cm	ICMR	300
Total Hardness	mg/l	BIS	200
Total Alkalinity	mg/l	BIS	200
TDS	mg/l	BIS	500
Turbidity	NTU	BIS	5.0
Fluoride	mg/l	BIS	1.0
Iron	mg/l	BIS	0.3

Table 2. Classification based on Water Quality Index

WQI	Water quality rating
0 to 25	Excellent water quality
26 to 50	Good water quality
51 to 75	Poor water quality
76 to 100	Very poor water quality
More than 100	Unsuitable for drinking

RESULT AND DISCUSSION

Physico-chemical characteristics

pH

pH is an important parameter which indicates the suitability of water for various purposes. The pH values shown were in the range of 6.80 to 6.86 which means all the samples were within the permissible limit for drinking water and almost near to the neutral value (fig. 1).

Electrical conductivity

Water with high mineral content tends to have higher conductivity, which is general indication of high dissolved solid concentration of the water. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. The minimum conductivity 997 µS/cm was observed in sample 2 and the maximum conductivity 1595 µS/cm was observed in sample 4 (fig. 2). It is obvious from the results that all the five samples are beyond the maximum permissible limit of drinking water.

Total alkalinity

Alkalinity of water is a measure of its capacity to neutralize acids, without significant pH change. 200 mg/l is the maximum permissible limit for alkalinity as per BIS standard. The results showed the minimum value as 385 mg/l in the sample 5 and maximum value as 390 in sample 3 (fig. 3). Thus all the five samples are not within the permissible limit.

Total hardness

Total hardness value of the study area varies from 1060 mg/l to 1808 mg/l (fig. 4) and all samples are more than the permissible limit 200 mg/l. Hardness is caused by polyvalent metallic ions dissolved in water. Calcium and magnesium are principally responsible for hardness of water [21].The water samples also classified according to sawyer and Mcartly (1967) (Table 3) [22]. As per this classification the water having total hardness less than 75 mg/l is soft water. The water containing 75 – 150 mg/l is moderately hard water. The samples have total hardness 150 – 300 mg/l are hard water and samples have more than 300 mg/l are very hard water. In this case all the five samples from the study area are in very hard water category.

Turbidity

Turbidity is considered to be a very important factor in drinking water due to aesthetic and psychological reason, besides being a sign of pollution in some particular cases. The maximum permissible limit for turbidity in drinking water is 5 NTU as per BIS. In our study area except sample 2, all the samples are beyond the permissible limit and varies from 10 NTU to 35 NTU (fig. 5).

Table 3. Classification of water samples based on Total Hardness

Total Hardness (in mg/l)	Classification	Sample
< 75	Soft	Nil
75 – 150	Moderately Hard	Nil
150 -300	Hard	Nil
> 300	Very Hard	All samples

Table 4. Classification of water samples based on TDS

TDS (in mg/l)	Classification	Sample
< 1000	Fresh	1, 2, 3, 5
1000 – 10000	Brackish	4
10000 – 100000	Saline	Nil
> 100000	Brine	Nil

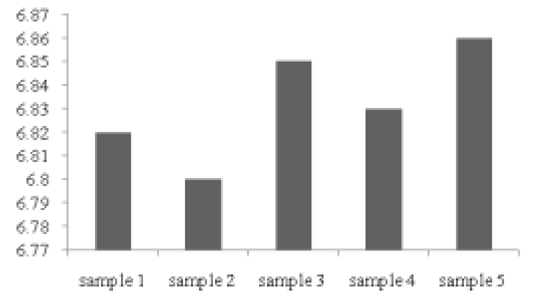

Fig. 1. pH

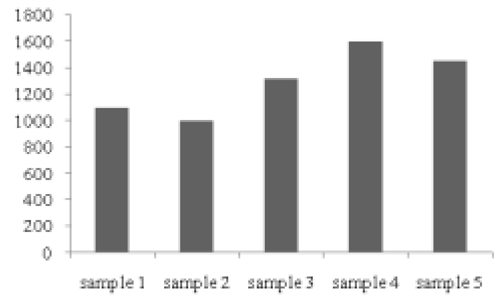

Fig. 2. EC (in µS/cm)

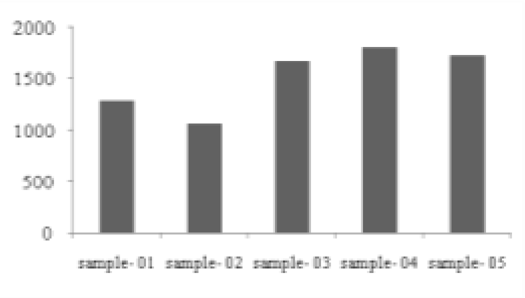

Fig. 3. Total Hardness (in mg/l)

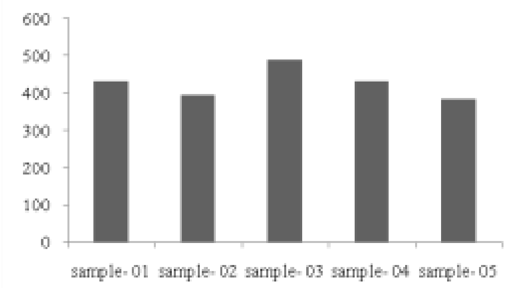

Fig. 4. Total Alkalinity (in mg/l)

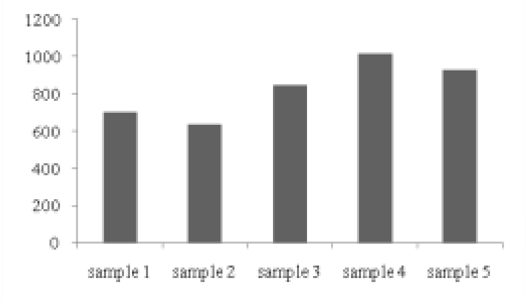

Fig. 5. Total Dissolved Solids (in mg/l)

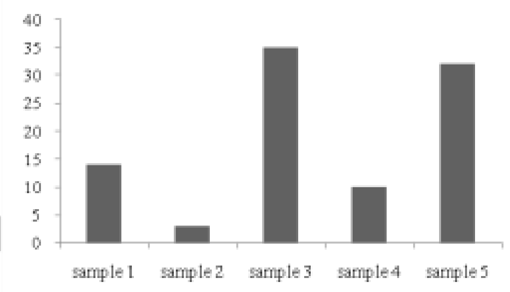

Fig. 6. Turbidity (NTU)

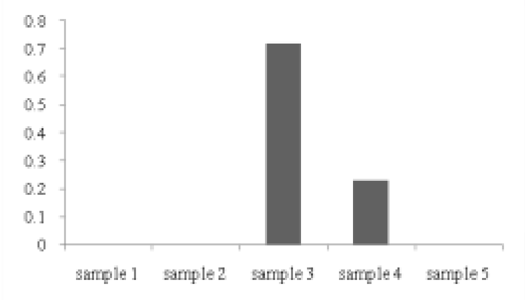

Fig. 7. Iron (in mg/l)

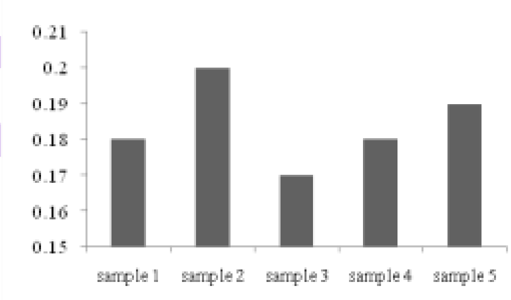

Fig. 8. Fluoride (in mg/l)

Total Dissolved Solids

The effects of TDS on drinking water quality depend on the levels of its individual components. The maximum permissible limit of TDS in drinking water prescribed by BIS is 500 mg/l. In our study all five samples are beyond the permissible limit of drinking water and varied from 638 to 1020 mg/l (fig. 6). Most of the ground water samples (except sample 4) were fresh water (TDS < 1000 mg/l) in nature as per classification suggested by Freeze and cherry (1979) (Table 4) [23]. Sample 4 comes under the category brackish (1000 < TDS < 10000 mg/l).

Iron

The water show high iron concentration is an indication of the presence of ferrous ions the precipitate as insoluble ferric hydroxide. 0.3 mg/l of iron is the maximum permissible for drinking water. Sample 1, 2 and 5 resulted very less iron concentrations which are not even in the detectable limit. Sample 4 contains 0.23 mg/l of iron which is within the permissible limit. Among five samples the sample taken from Villupuram by-pass road has more iron concentration as 0.72 mg/l of iron (fig. 7) and it was higher than the permissible concentration.

Fluoride

Fluoride content in all the samples was in the range of 0.17 to 0.20 mg/l (fig. 8) and within the permissible limit 1 mg/l. Thus fluoride content does not have any negative influence in the ground water.

Water Quality Index

Water quality index for all the samples were calculated using weighted arithmetic index method. pH, EC, TH, Total Alkalinity, TDS, Turbidity, Fluoride and Iron were the physicochemical water quality parameters taken to calculate the water quality index. A weight has been assigned to each parameter based on the equation 3. The results showed were 60.67, 28.16, 206.32, 69.04 and 115.80 for sample 1, sample 2, sample 3, sample 4 and sample 5 respectively (Table 5). Based on the classification sample 3 and 5 are unsuitable for drinking and the sample 1 and 4 are in poor condition. Among all the samples, the sample taken from Thillainagar alone showed good water quality. Thus based on the water quality index of all the five locations we can understand that the groundwater quality of the study area is in very poor condition.

Table 5. Water Quality Index of study area

S.No.	Samples	WQI	Water quality rating
1.	Sample- 01	60.67	Poor
2.	Sample- 02	28.16	Good
3.	Sample- 03	206.32	Unsuitable for drinking
4.	Sample- 04	69.04	Poor
5.	Sample- 05	115.80	Unsuitable for drinking

CONCLUSION

The study carried out on ground water samples in the study area showed that the pH and Fluoride are within the permissible limits. Electrical Conductivity, Total Dissolved Solids, Total Hardness, Total alkalinity, Turbidity and Iron are more than the prescribed maximum permissible limits. Water quality index has been calculated using the above mentioned parameters and the WQI for all the samples ranges from 28.16 to 206.32. This shows that the ground water of the study area indicating deterioration in quality during the study period. Further, regular monitoring of the ground water quality can be taken to check the variations in the ground water quality in study area.

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