

Application of Water Quality Index (WQI) For Ground Water Quality Interpretation

Jeyalakshmi Suresh Kumar, Natesan Manoharan, Rajangam Udayakumar

Abstract: Water Quality Index (WQI) is a widely used technique in defining the quality of groundwater and finding whether it is advisable for human use. It is utmost necessary steps to understand the physical and chemical parameters defining the water quality for particular period and location using WQI calculation as it gives information in a single value. WQI has been calculated in twenty ground water samples collected from selected sampling stations at Madurai in the pre-monsoon, monsoon and post monsoon seasons. The water quality index values suggested that almost all the ground water samples were above 150, which indicated that they were unfit for drinking and one sample from Vilangudi had WQI less than 100 which indicated the water as poor category for drinking but could be used for irrigation purposes. The groundwater quality is also defined to be little better during post monsoon season in all the samples than during pre-monsoon and monsoon season.

Keywords: Groundwater, Indian Standards Institution (ISI), Indian Council of Medical Research (ICMR), World Health Organization (WHO), Physicochemical, Water quality index (WQI),

I. INTRODUCTION

Water is a necessary prerequisite for a varied scope of human activities like drinking, agricultural, industrial, electricity production, product development, and disposal of garbage. Ground water is of high value than surface water as it is normally free from pollutants [1]. But such ground water too is contaminated by various reasons. The contamination of water is mainly because of increasing inhabitants, leading to urbanization, industrial development, excess use of chemicals in the fields, and other human interventions [2] and also failure of monsoon and improper management of rain water. Regular incessant checking of the physical, chemical and biological quality of ground water is needed to reduce the effect of the change in quality on mankind and other lives.

Water quality index (WQI) is widely used for evaluating the contamination in the ground water and so it may be outlined as “a rating, reflecting the composite influence of various quality parameters on the overall quality of water.” [3]. The water quality index is generally categorized into two elements like physico-chemical and biological indices. The physico-chemical indices are built on the values of different physico-chemical parameters in every water sample [4].

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In this calculation where mathematical equation is used, various water quality parameters applied in the formula gives back a single value as water quality index. This value calculated provided easy way to understand the water quality and decide on the proper use of any water body. It is the understanding of water quality for the doable uses by combining complicated information and generating a score that describes easy water quality standards. [5].

The chemical constituents of the thrown out trash on the land without disposing properly could penetrate and pollute the underground water table. Effect of contamination being reported in various studies at different study area paved way for the present study in Madurai to understand the pollution level of ground water during the study period.

II. METHODS

In this study, attempts have been made to calculate the WQI of ground water samples collected from selected stations of Madurai, Tamil Nadu, India. (Table-I) World Health Organization (WHO) standards were adopted for calculation of WQI based on physico-chemical data by using the methods proposed by Horton [3] and modified by Tiwari and Mishra [6]. By utilizing ten water quality parameters pH, Total Dissolved Solids, Total Hardness, Total Alkalinity, Calcium, Magnesium, Chloride, Nitrate, Potassium and Sulphate, WQI values are calculated in this study to understand the exact status of the water in the study area for various uses.

WQI CALCULATION

WQI was calculated using Horton’s method [3]. Quality rating and unit weight of every water quality parameter was calculated using permissible limits as specified by Indian Standards Institution (ISI), Indian Council of Medical Research (ICMR) or World Health Organization (WHO).

Formula to calculate WQI is done using the Equation (1) as referred by Horton, 1965.

$$WQI = \frac{\sum q_n W_n}{\sum W_n} \dots \dots \dots (1)$$

In the equation, q_n specifies Quality rating of every n th water quality parameter.

W_n = Unit weight of every n th water quality parameter.

Table- I: GPS Coordinates of the Sample Locations in the Madurai (Study area).

| Sample Sites No. | Sampling Sites | Latitude (N) | Longitude (E) |
|------------------|-------------------|--------------|---------------|
| S1 | Anna Nagar | 9.91954 | 78.15568 |
| S2 | Palanganatham | 9.9081538 | 78.097039 |
| S3 | Kosakulam | 9.96696 | 78.11795 |
| S4 | Aanaiyur | 9.96112 | 78.10811 |
| S5 | Koodal Nagar | 9.96159 | 78.10163 |
| S6 | Theppakulam | 9.913787 | 78.14545 |
| S7 | Oomatchikulam | 9.99773 | 78.13966 |
| S8 | Thirunagar | 9.88096 | 78.05691 |
| S9 | Thiruparankundram | 9.8813 | 78.0671 |
| S10 | Nagamalai | 9.93684 | 78.03268 |
| S11 | Ponnagaram | 9.93046 | 78.1114 |
| S12 | KK Nagar | 9.93358 | 78.1459 |
| S13 | Pudur | 9.94715 | 78.14998 |
| S14 | Iyer Bungalow | 9.96945 | 78.13855 |
| S15 | Vilangudi | 9.95446 | 78.08766 |
| S16 | Avaniyapuram | 9.87484 | 78.11008 |
| S17 | Jaihindpuram | 9.90625 | 78.11145 |
| S18 | Thiruppalai | 9.9754 | 78.13604 |
| S19 | Kochadai | 9.94065 | 78.08366 |
| S20 | Thirumangalam | 9.84474 | 78.01129 |

Quality rating (q_n) calculation

Formula to calculate quality rating (q_n) is done using the equation (2).

$$q_n = [(V_n - V_{id}) / (S_n - V_{id})] \times 100 \dots \dots \dots (2)$$

In the equation,

V_n specifies the exact value of every nth water quality parameter at a given sample location.

V_{id} specifies Ideal value for every nth parameter in pure water. Here in this study, V_{id} for pH = 7 and 0 for all other parameters.

S_n specifies standard permissible value of every nth water quality parameter.

Unit weight (W_n) calculation

Formula to calculate unit weight (W_n) is done using the equation (3).

$$W_n = k / S_n \dots \dots \dots (3)$$

In the equation,

S_n = Standard permissible value of every nth water quality parameter.

k = Constant of proportionality and it is calculated using the equation (4).

$$k = [1 / (\sum 1 / S_n = 1, 2, \dots, n)] \dots \dots \dots (4).$$

CLASS OF WATER USING WQI VALUES

The WQI values calculated from the samples from the study area is classified within the ranges specified in Table-II to empathize the recommended usages of the ground water.

Table-II: WQI, class of water and recommended usage of water [7].

| S.No. | WQI range | Class of water | Recommended usages |
|-------|-----------|--|---------------------------------------|
| 1 | 0-25 | Excellent | Drinking, Irrigation and Industrial |
| 2 | 25-50 | Good | Domestic, Irrigation and Industrial |
| 3 | 51-75 | Fair | Irrigation and Industrial |
| 4 | 76-100 | Poor | Irrigation |
| 5 | 101-150 | Very Poor | Restricted use for Irrigation |
| 6 | Above 150 | Unfit for Drinking or irrigation purpose | Proper treatment required before use. |

WQI OF THE SAMPLE LOCATIONS

The WQI values of the ground water samples collected from sampling locations for post monsoon, pre-monsoon and monsoon samples are calculated using ten physicochemical parameters given in Table-IV for the all the twenty samples.

III. RESULTS

The WQI values of the sample locations during pre-monsoon, post-monsoon and monsoon seasons are calculated and presented in Table-V.

Table-IV: Standard values of water quality parameters and their corresponding ideal values and unit weights

| S.No | Parameters | S _n | Recommending Agency for S _n | Ideal Value (V _{id}) | k value | Unit weight |
|------|-----------------|----------------|--|--------------------------------|---------|-------------|
| 1 | pH | 8.5 | ISI | 7 | 3.58 | 0.421368 |
| 2 | TDS | 500 | ISI | 0 | 3.58 | 0.007163 |
| 3 | Tot. Alk | 120 | ICMR | 0 | 3.58 | 0.029847 |
| 4 | TH | 300 | ICMR | 0 | 3.58 | 0.011939 |
| 5 | Ca | 75 | ICMR | 0 | 3.58 | 0.047755 |
| 6 | Mg | 50 | ICMR | 0 | 3.58 | 0.071633 |
| 7 | NO ₃ | 45 | ISI | 0 | 3.58 | 0.079592 |
| 8 | CL | 250 | ISI | 0 | 3.58 | 0.014327 |
| 9 | SO ₄ | 200 | ISI | 0 | 3.58 | 0.017908 |
| 10 | K | 12 | WHO | 0 | 3.58 | 0.298469 |



Based on WQI values, it is clear that none of the study samples are found to be in the range of 0 to 75. Only one sample S15 is found to be within 76-100 range in all the three seasons. Most of the samples from the study area showed very poor quality of ground water as it had highest WQI values and so proved to be unfit for drinking or irrigation purpose. The results are shown in Table-VI.

WQI of pre-monsoon groundwater samples

The index values calculated for pre monsoon samples are shown in Table-V. S6 (Theppakulam) sample is found to be within 101 to 150 range which accounts to be very poor water. Almost all the pre monsoon ground water samples are very poor and unfit for drinking when compared with Table-II & VI. Only one sample (S15) of the study area is in good quality during pre-monsoon season.

WQI of post monsoon groundwater samples

The index values calculated for post monsoon samples are shown in Table-V. S6, S3, S4 and S9 samples are found to be within 101 to 150 range which accounts to be very poor water. Almost all the post-monsoon ground water samples are very poor and unfit for drinking when compared with Table-II & VI. Only one sample (S15) of the study area is in good quality during post monsoon season. WQI values are little lower in post monsoon samples than pre-monsoon and monsoon samples.

WQI of monsoon groundwater samples

The index values calculated for monsoon samples are shown in Table-V. S6 (Theppakulam) sample is found to be within 101 to 150 range which accounts to be very poor water. Almost all the monsoon ground water samples are very poor and unfit for drinking when compared with Table-II & VI. Only one sample (S15) of the study area is in good quality during monsoon season.

Table-V: WQI values of Pre-Monsoon, Post-Monsoon and Monsoon samples

| Sample Id | WQI | | |
|-----------|-------------|--------------|---------|
| | Pre-Monsoon | Post-Monsoon | Monsoon |
| S1 | 460 | 434 | 458 |
| S2 | 179 | 155 | 174 |
| S3 | 158 | 139 | 152 |
| S4 | 176 | 145 | 194 |
| S5 | 225 | 193 | 233 |
| S6 | 121 | 102 | 129 |
| S7 | 189 | 168 | 212 |
| S8 | 750 | 697 | 788 |
| S9 | 193 | 150 | 187 |
| S10 | 437 | 338 | 456 |
| S11 | 717 | 646 | 769 |
| S12 | 327 | 295 | 392 |
| S13 | 840 | 805 | 913 |
| S14 | 344 | 269 | 393 |

| | | | |
|-----|-----|-----|-----|
| S15 | 88 | 63 | 83 |
| S16 | 267 | 166 | 305 |
| S17 | 342 | 289 | 357 |
| S18 | 419 | 314 | 525 |
| S19 | 369 | 260 | 377 |
| S20 | 185 | 156 | 249 |

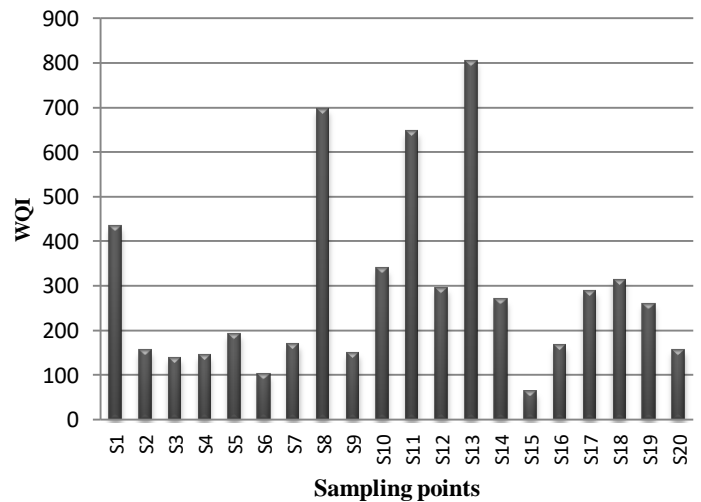


Fig. 1. Water quality index (WQI) values for Post-monsoon ground water samples

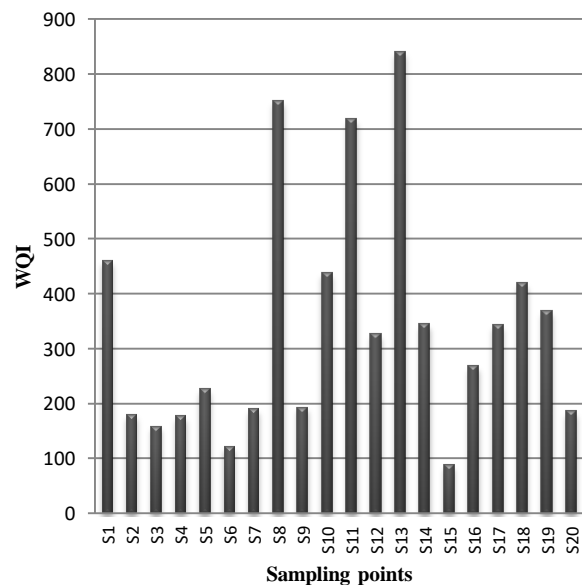
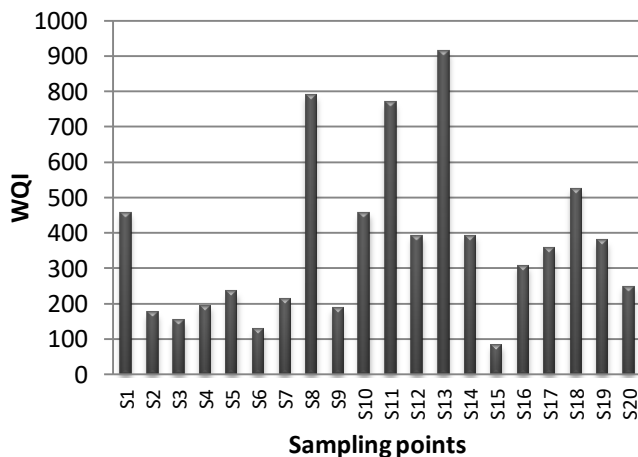


Fig. 2. Water quality index (WQI) values for Pre-monsoon ground water samples

Table-VI: Water Quality Index values for the study area

| S. No | Water Quality Index | Class of Water | Study area - samples | | |
|-------|---------------------|--------------------|--|--|--|
| | | | Pre-monsoon | Monsoon | Post-monsoon |
| 1 | 76-100 | Poor | S15 | S15 | S15 |
| 2 | 101-150 | Very Poor | S6 | S6 | S6, S3, S4, S9 |
| 3 | Above 150 | Unfit for Drinking | S1, S2, S3, S4, S5, S7, S8, S9, S10, S11, S12, S13, S14, S16, S17, S18, S19, S20 | S1, S2, S3, S4, S5, S7, S8, S9, S10, S11, S12, S13, S14, S16, S17, S18, S19, S20 | S1, S2, S5, S7, S8, S10, S11, S12, S13, S14, S16, S17, S18, S19, S20 |

Fig. 3. Water quality index (WQI) values for monsoon ground water samples



IV. DISCUSSION

WQI values of both pre-monsoon and monsoon samples share the same status, which shows 5% of the total ground water samples are poor and 5% are very poor and 90 % are totally unfit for drinking. S15 (Vilangudi) sample has poor status for drinking but it can be used for irrigation as it is only the recommended usage for this particular status. S6 (Theppakulam) sample has very poor quality which has restricted use for irrigation purpose also. 18 samples had WQI values above 150 which are totally unfit for drinking. This study is proved to be in agreement with the findings by Sirajudeen et al [8]. S15 (Vilangudi) water sample is far better than any other samples from the study area. The WQI value is less than 100. From the study it is clear that only in this sample pollution rate is comparatively less than any other samples in the study area.

And WQI of post monsoon samples states that 5% of the total groundwater samples are poor, 20% are very poor, 75% are unfit for drinking. S15 (Vilangudi) sample has poor status for drinking but it can be used for irrigation as it is only recommended usage for this particular status. S3 (Kosakulam), S4 (Aanaiyur), S9 (Thiruparankundram) samples has very poor quality and so these samples cannot be used as well for irrigation. According to WQI values, groundwater quality is proved to be little lower in samples collected in post-monsoon samples than in samples in pre-monsoon and monsoon season.

Earlier study showed that pollution with potassium, calcium, magnesium, nitrate, and sulphate in the sampling sites [9] has recommended us to suggest people living in the study area especially in S8, S11, S13 to carefully monitor the

quality of ground water and follow further treatment where needed before any human use.

V. CONCLUSION

From the above investigations it is clear that all the ground water samples under study are either very poor or poor or totally unfit for drinking. WQI values are slightly lower in post-monsoon season than pre-monsoon and monsoon season. This increase in WQI might be due to increased potassium and total dissolved solids. Therefore it is mandatory to carefully monitor these ground water sources immediately. So from the present study it is suggested to take steps in reducing the pollution load as ground water is the base for every other water sources.

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