Available online at www.joac.info

ISSN: 2278-1862

Journal of Applicable Chemistry

2013, 2 (2):317-327

(International Peer Reviewed Journal)

Consumers Water Quality Indices

Sarala Thambavani D[1*] and Uma Mageswari T.S.R[2]

1. Sri Meenakshi Government Arts College for Women (Autonomous), Madurai, Tamilnadu, India., Research and Development Centre, Bharathiar University, Coimbatore.
2 PSNA College of Engineering & Technology, Dindigul, Tamilnadu

Email: sarala_dr@yahoo.co.in, umamageswaritsr1980@gmail.com

Received on 12th March and finalized on 16th March 2013.

ABSTRACT

The present work is aimed at assessing the water quality index (WQI) for the ground water at Batlagundu, Dindigul District. 23 physico chemical parameters have been analyzed at six different areas of Batlagundu. Different water quality indices such as weighted arithmetic mean, weighted geometric mean, National Sanitation foundation (NSFWQI) and Canadian Council of Ministers and Environment (CCMEWQI) have been used. The parameters namely temperature, pH, sulphate, nitrate, phosphate, Dissolved Oxygen, BOD and COD values were within the permissible limits of BIS and WHO. But other parameter values were found to exceed the permissible limits. The water quality indices indicate that the water quality is poor. This analysis also reveals that the ground water of this area needs some degree of treatment before consumption and it also need to be protected from further contamination.

Keywords: WQI, arithmetic mean, geometric mean, NSFWQI, CCMEWQI, BOD, COD, Ground water.

INTRODUCTION

Water, the elixir of life is a prime natural resource, a basic human need and a precious national asset. Ground water is superior to surface water because of the effective filtering effect. It is the cheapest and most practical means of providing water to communities [1]. Water scarcity is increasing worldwide and pressure on the existing water resources is increasing due to growing demand of different sectors such as domestic, agricultural, Industrial and hydropower. Evaluation of water quality is important research topic in the recent years. Once the groundwater is contaminated, its quality cannot be restored by stopping the pollutants from their resource [2]. It therefore becomes imperative to regulate and monitor the quality of groundwater and to device ways and means to protect. The total annual replenishable groundwater resources in India have been assessed as 433 billion cubic meters (BCM) and the next annual groundwater availability is estimated as 399 BCM. Existing gross groundwater draft as on March 2004 for all uses is 231BCM per year [3] Water, the precious gift of nature to human being is going to be polluted day-by-day with increasing urbanization. Rapid urbanization, especially in developing countries such as India, has affected the availability and quality of ground water due to its exploitation. The provision of safe drinking water resources the incidences of many water borne diseases. [4, 5] have reported that waste water also changes the physical and chemical nature of a water body. The quality of water is assessed in terms of its physical, chemical and biological parameters [6]. The main problem in water quality monitoring is the complexity associated with analyzing the large number of measured variables [7]. The data sets contain rich information about the behavior of the water resources.

Water quality index(WQI) is recognized as one of the most effective ways of communicating information on water quality to both citizens and policy makers[8].Numerous water quality indices have been formulated all over the world which can easily judge out the overall water quality within a particular area promptly and efficiently. For example, US National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministers of the Environment Water Quality Index(CCMEWQI) [9]),British Columbia Water Quality Index(BCMEWQI), and Oregon Water Quality Index(OWQI) [10 -12].These indices are based on the comparison of the water quality parameters to regulatory standards and give a single value to the water quality of a source[12,13].The objective of the present work is to discuss the suitability of ground water for human consumption based on computed water quality index values.

MATERIALS AND METHODS

Study Area : The study area is Batlagundu town panchayat in Dindigul district in the state of Tamilnadu. It is located 450km south of state capital Chennai and situated at the foot hills of the Kodaikanal mountain range. It has an average elevation of 320 meters (1049 feet). Batlagundu is also known as "BETEL CITY". This area is endowed with 25 medium scale industries and 2000 small scale industries. The economy of the town is mostly dependent on agricultural products like betel leaf, and is a home to banana leaf commission, coconut powder exports, spinning mills, and other business. Batlagundu is geographically located at Longitude and Latitude is 77 ^{0} 45' 33.84" E and 10 ^{0} 9' 55.80" N . As per census 2001 Batlagundu had population of 22,007.Average temperature and humidity is 22^{0} C and 86% respectively. Six stations were chosen for sample collection in the study area as described in fig. 1 and description of sampling stations given in table 1.

Table 1. Description of water quality sampling sites

Longitude	Latitude	Description	Place	Site No
77 ^{0} 51' 11.60" E	10 ^{0} 9' 53.01" N	Near Pushpak Perfume Industry ,	Nilakottai	S_1
77 ^{0} 45' 40.24" E	10 ^{0} 10' 0.32" N	Near Village Primary Health Centre	Mallanampatti	S_2
77 ^{0} 45' 41.99" E	10 ^{0} 11' 9.98" N	Near Land fill	Usilampatti Road,	S_3
77 ^{0} 45' 42.39" E	10 ^{0} 11' 10.23" N	Near drainage	Anna Nagar, Batlagundu	S_4
77 ^{0} 45' 33.84" E	10 ^{0} 9' 55.80" N	Residential area	Middle Street, Batlagundu	S_5
77 ^{0} 45' 33.99" E	10 ^{0} 9' 56.05" N	Near agriculture field	Periyakulam Road, Batlagundu	S_6

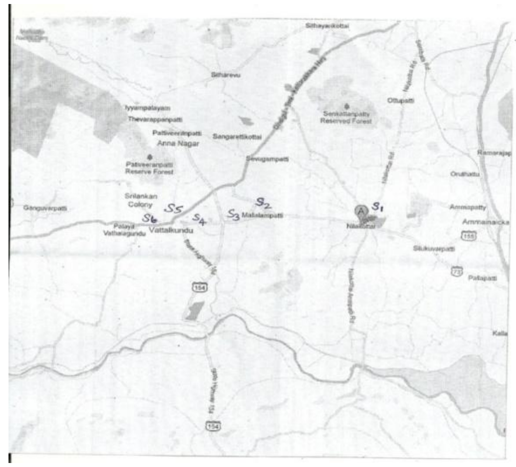


Fig. 1 Map of the Study Area
S_1 - Nilakottai, S_2 - Mallanampatti, S_3 - Anna Nagar, Usilampatti road, S_4 - Anna nagar, Batlagundu, S_5 - Middle Street, Batlagundu, S_6 – Periyakulam Road Batlagundu

In order to determine water quality index, ground water samples collected from six sampling stations in triplicates. Samples were collected in polythene bottles and analyzed for various water quality parameters as per standard procedures [14 - 16] given in Table 2.The experimental values were compared with standard values recommended by World Health Organization (WHO) and Indian standards for drinking purposes given in Table 3.

Water Quality Index(WQI) :WQI may be defined as a 'rating that reveals the composite influence of a number of water quality parameters on the overall water quality [17].Water quality index provide information on a rating scale from 0 to 100.The water quality index has been considered to give a criteria for water classification based on the use of standard parameters for water characterization[18-25].This index is a mathematical instrument used to transform large quantities of water characterization data in to a single number, which represents the water quality level.WQI is calculated from the point of view of the suitability of ground water for human consumption.

Table 2. Water quality parameters units and analytical methods used

S. No	Parameters	Abbreviation	Units	Analytical Methods	Instruments
1.	Temperature	Temp	^{0}C	Instrumental	Mercury Thermometer
2.	Colour	Colour	Pt-Co Scale	Visual comparison method	---
3.	Turbidity	Turbidity	NTU	Nephelometric method	Nephelometer
4.	Total Dissolved Solids	TDS	mg/L	Filtration and Gravimetric method	Temperature controlled oven
5.	Electrical conductivity	EC	µS/cm	Instrumental	Electrometric
6.	pH	pH	pH unit	Instrumental	pH meter
7.	Total Hardness	Hardness	mg/L	Digital Titrimetric	EDTA Titration
8.	Total Alkalinity	Alkalinity	mg/L	Digital Titrimetric	Neutralising With standard HCl
9.	Calcium	Ca	mg/L	Digital Titrimetric	EDTA Titration
10.	Magnesium	Mg	mg/L	Digital Titrimetric	EDTA Titration
11.	Chloride	Cl	mg/L	Digital Titrimetric	Argentometric Titrimetric method

12.	Sulphate	SO_4	mg/L	Colorimetric Turbidimetric method	UV – VIS Spectrophotometer
13.	Nitrate	NO_3	mg/L	Colorimetric PDA method	UV – VIS Spectrophotometer
14.	Nitrite	NO_2	mg/L	Diazotisation Method	UV – VIS Spectrophotometer
15.	Fluoride	F	mg/L	Colorimetric SPANDS method	UV – VIS Spectrophotometer
16.	Sodium	Na	mg/L	Flame photometric method	Flame Photometer
17.	Potassium	K	mg/L	Flame photometric method	Flame Photometer
18.	Iron	Fe	mg/L	Colorimetric method	UV – VIS Spectrophotometer
19.	Ammonia	NH_3	mg/L	Nesslerization method	UV – VIS Spectrophotometer
20.	Phosphate	PO_4	mg/L	Colorimetric Stannous chloride method	UV – VIS Spectrophotometer
21.	Dissolved Oxygen	DO	mg/L	Titrimetric method	Winklers Iodometric method
22.	Biochemical Oxygen Demand	BOD	mg/L	5 days incubation,$20^0{}_C$	Winkler Azide Method
23	Chemical Oxygen Demand	COD	mg/L	Potassium dichromate Oxidation (open reflux,titrimetric)	Dichromate method

Calculation of WQI

Method 1: For calculating the water quality index (WQI),the method followed by [26-28] have been employed. In this method the quality rating scale has been assigned to the parameters, which is also weighted according to its relative importance in the overall water quality. The maximum weight of 4 has been assigned to the parameters like pH and TDS to their major importance in water quality assessment. Other parameters like sodium, potassium and iron are assigned the minimum weight of 1 as they play fewer roles in the water quality assessment. The standards for drinking water recommended by [29]was taken for the calculation.

Table 3. Physico Chemical changes of ground water samples collected from six different sampling stations

Parameter	**BIS**	**WHO**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**
Temp in ^{0}C	-	40± 5	22.8	22.6	22.5	22.3	22.0	22.9
Colour (Hazen Unit)	5.0	15 TCU	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless
Turbidity(NTU)	5.0	5.0	2.0	5.0	1.0	4.0	6.0	3.0
TDS (mg/L)	500	1000	701	1472	1610	1453	2130	1216
EC (µmho/cm)	-	300	1030	2164	2300	2130	3132	1788
pH	6.5 -8.5	6.5 8.5	7.9	8.03	7.7	8.1	7.7	7.9
Total Hardness (mg/L)	300	500	252	384	900	360	660	288
Total Alkalinity (mg/L)	200	-	300	260	400	260	296	232
Calcium (mg/L)	75	-	56	80	200	77	136	61
Magnesium (mg/L)	30	30	27	44	96	40	77	33
Chloride (mg/L)	250	250	96	470	525	450	780	370
Sulphate (mg/L)	200	400	49	119	106	146	125	116

Nitrate (mg/L)	45	10	19	13	10	14	20	10
Nitrite (mg/L)	0.06	-	0.32	0.27	0.3	0.24	0.38	0.22
Flouride (mg/L)	1.0	1.5	0.6	2.0	0.4	0.4	0.4	0.6
Sodium (mg/L)	-	200	104	272	198	264	336	240
Potassium (mg/L)	-	200	26	78	12	66	84	60
Iron (mg/L)	0.3	0.3	0.71	0.52	0.5	0.61	0.98	0.94
Ammonia (mg/L)	-	-	0.73	0.45	0.3	0.57	0.86	0.36
Phosphate (mg/L)	-	5.0	0.59	0.8	1.0	0.69	0.98	0.69
DO (mg/L)	-	> 5	5.5	5.2	6.3	5.6	6.3	6.0
BOD (mg/L)	-	5	2.0	2.0	2.3	2.0	2.0	1.0
COD (mg/L)	-	20	5.0	6.0	6.9	5.0	6.0	4.0

The unit weight of each parameter is calculated by the formula

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

The quality rating scale (q_i) for ten physico chemical parameters is taken for the calculation .The values for the parameters have been divided in to four stages viz. permissible, slight, moderate and severe for which quality rating (q_i) ranges from 0 to 100. For calculating WQI the sub index(SI) is first found out for each parameters, which is

$$(SI)_i = q_i W_i \quad \text{......................................} \quad (1a)$$

And thus the formula which is

$$WQI = \frac{(SI)_i}{(w_i)} \quad \text{.............................} \quad (1b)$$

$$WQI=\sum q_i W_i \text{ as } w_i = 1 \quad \text{.............} \quad (1)$$

Water Quality status determined using formula 1for the ground water collected from Six sampling sites as shown in fig.2

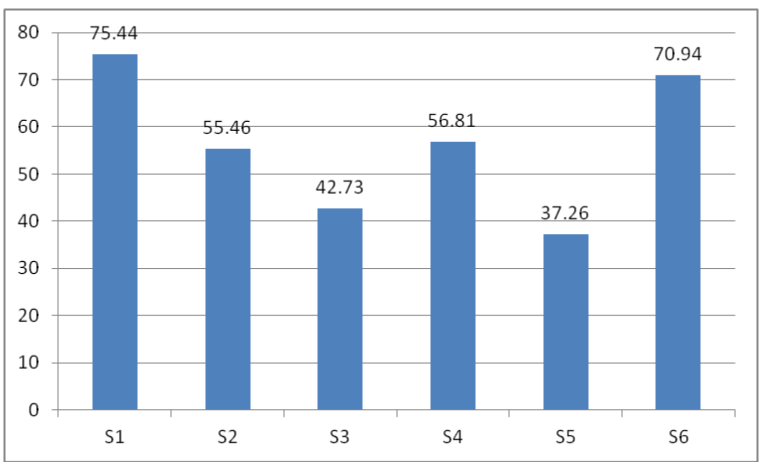


Fig 2 Results of water quality Index using formula 1

Method 2: The WQI has been calculated by using the standards of drinking water quality recommended by [30, 31]. The weighted arithmetic index method [32] has been used for the calculation of WQI. Further quality rating or sub index (qn) was calculated using the following expression.

$$q_n=100\,[V_n-V_{10}] / [S_n-V_{10}] \quad \text{.....................} \quad (2a)$$

where- qn = Quality rating for the n^{th} quality water parameter, Vn = Estimated value of the n^{th} parameter at a given sampling station, Sn = Standard permissible value of the n^{th} parameter, V_{10} = Ideal value of n^{th} parameter in a pure water

Ideal value in most cases $V_{10} = 0$ except in certain parameters like pH and DO. Calculation of quality rating for pH and DO ($V_{10} \neq 0$) is 7.0 and 14.6 mg L^{-1} respectively. Unit weight was calculated by a value inversely proportional to the recommended standard values S_n of the corresponding parameters.

$$W_n = \frac{K}{S_n} \quad \text{.. (2b)}$$

Where- W_n = Unit weight for the n^{th} parameter, S_n = Standard permissible value of the n^{th} parameter, K = Constant for proportionality

The overall water quality index was calculated by aggregating the quality rating with the unit weight linearly.

$$WQI = \sum \frac{q_n W_n}{W_n} \quad \text{.. (2)}$$

Water Quality status determined using formula 2 for the ground water collected from Six sampling sites as shown in fig.3

Method 3 : In this study the water quality index (WQI) was determined according to National Sanitation Foundation (NSF) which created and designed a standard index. The mathematical expression for NSFWQI is given by

$$NSFWQI = \sum_{i=1}^{p} W_i I_i \quad \text{…………………….. (3)}$$

Where- I_i is the sub index for i^{th} water quality parameter, W_i is the weight associated with i^{th} water quality parameter, p is the number of water quality parameters.

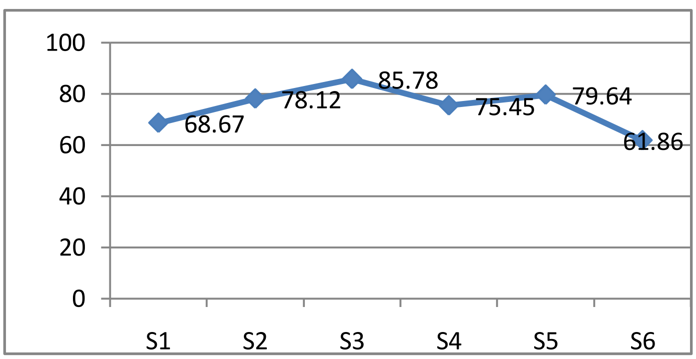
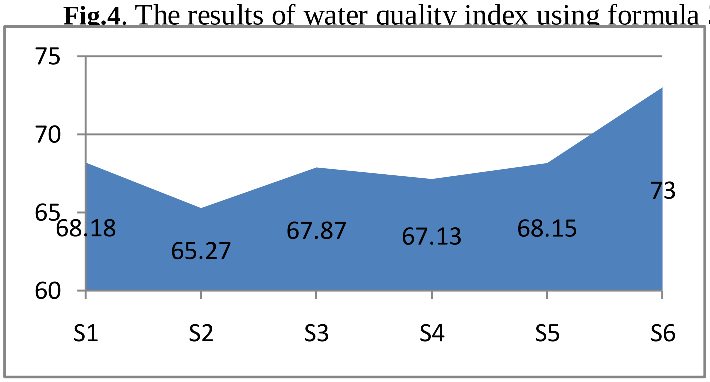


Fig.3 Results of water quality Index using formula 2

The physico chemical parameters such as DO, pH, BOD, Temperature, Total Phosphate, Nitrate and Turbidity are used to calculate WQI The results are recorded and transferred to a weighting curve chart where a numerical value is obtained. For each test, the numerical value or Q value is multiplied by a "weighting factor". The resulting values are then added to arrive at an overall water quality index (WQI).The highest score a water body can receive is 100.The results of water quality index as shown in fig.4

Fig.4. The results of water quality index using formula 3



Method4: Water quality index is calculated by the methods proposed by [33]and modified by [26]. For calculating WQI, the following steps were used.

Step -1:

$$Qn=100\ [(V_n-V_i) / (V_s-V_i)] \quad \ldots\ldots\ldots\ldots (4a)$$

where- Qn = Quality rating, V_n = Actual amount of n^{th} parameter, V_s = Recommended WHO standard of corresponding parameter, V_i = the ideal value of this parameter, V_i = 0 except for pH and DO, V_i = 7.0, For pH V_i = 14.6 mg/L for DO

Step -2: Unit weight (W_n) was calculated by a value inversely proportional to the recommended standard values Sn of the corresponding parameters.

$$W_n = K/S_n \quad \ldots\ldots\ldots\ldots (4b)$$

Sn = Standard permissible value of the corresponding parameter prescribed by WHO, K = Constant for proportionality

$$\sum_{n=1}^{14} Wn = 1 \quad \ldots\ldots\ldots\ldots (4c)$$

Step -3: Sub indices (SI) = $(Q_n)^{Wn}$ ………………. .(4d)

Step -4: The overall WQI was calculated by taking geometric mean of these sub indices

$$WQI = \sum_{n=1}^{14} (SI_n) = \sum_{n=1}^{14} (Q_n)^{W_n}$$

OR

$$WQI = antilog_{10} \left[\sum_{n=1}^{14} W_n \ log_{10} \ Q_n \right] \ldots\ldots 4$$

Using the formula 4, the water quality status of six sampling sites as given below in fig.5

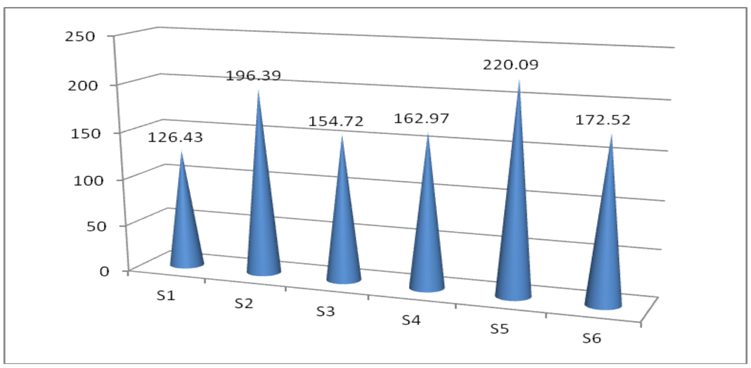


Fig.5 Results of water quality Index

Method 5: Canadian Council of Ministers and Environment(CCMEWQI)

The CCMEWQI provides a mathematical framework for assessing ambient water quality conditions relative to water quality objectives. The CCMEWQI model consists of three measures of variance from selected water quality objectives (Scope; Frequency; Amplitude). **Scope (F1):** The number of variables whose objectives are not met. **Frequency (F2):** The frequency by which the objectives are not met. **Amplitude (F3):** The amount by which the objectives are not met.

The measure for scope (F1) is calculated as follows:

F1 = [No of failed variables / Total no of variables] X100 …. (5a)

The measure for Frequency (F2) is calculated as follows:

F2 = [No of failed tests / Total no of tests] X 100 ……………(5b)

The measure for Amplitude (F3) is calculated as : The number of times by which an individual concentration is greater than (or less than, when the objective is a minimum) the objective is termed an "excursion" and is expressed as follows. When the test value must not exceed the objective

$$Excursion_1 = [\text{Failed Test Value / Objective}]-1 \quad \ldots\ldots\ldots\ldots\ldots \quad (5c)$$

For the cases in which the test value must not fall below the objective

$$Excursion_2 = [\text{Objective / Failed Test Value}]-1 \quad \ldots\ldots\ldots \quad (5d)$$

$$nse = \frac{\sum_{i=1}^{n} excursion}{No\ of\ Tests} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5e)$$

$$F_3 = \frac{nse}{0.01\ nse + 0.01}] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5f)$$

The CCME Water Quality Index (CCMEWQI)

$$CCME\ WQI = 100 - [\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732}] \ldots\ldots\ldots \quad (5)$$

The divisor 1.732 normalizes the resultant values to a range between 0 and 100, where 0 represents the "worst" water quality and 100represents the "best" water quality.CCMEWQI results were given in Table.4

Table 4 Calculated values of CCMEWQI

Term of the Index	**Value**	**Rating of water quality**
Scope F1	58.33	**Marginal**. Water quality is frequently enda deteriorated. Conditions often deviate from desirable levels.
Frequency F2	50.00	
nse	0.736	
Amplitude F3	42.39	
CCME-WQI	49.35	

RESULTS AND DISCUSSION

A rise in temperature of the water leads to the speeding up of the chemical reactions in water, reduces the solubility of gases and amplifies the taste and odor. In our present investigation ground water temperature varied between 22.0^{o}C and 22.9^{o}C, which falls within the limit of WHO standard. Turbidity values of sampling sites S_1, S_2, S_3, S_4 and S_6 were found to be within the limits prescribed by WHO & BIS standards. Sampling site S_5 was found to be more turbid indicating more discharging waste, more urban domestic activities and algal growth. Electrical conductivity and total dissolved solids were found to be very high for all the six sampling sites. Water with high mineral contents has higher conductivity, which is a general indication of high dissolved solid concentration of the water [34]. Therefore conductivity measurements can be used as a quick way to locate potential water quality problems. pH is one of the most important factors that serve as an index of pollution. The pH for the sampling sites were determined S_1 (7.9), S_2 (8.03), S_3 (7.7), S_4 (8.1), S_5 (7.7) and S_6 (7.9). In the present investigation pH values for all the six sampling sites were found within the range of BIS (6.5-8.5) and WHO (6.5-8.5) standards. The Total Hardness values for S_1, S_2.S_4 and S_6 were found to be within the WHO standards but higher values of hardness for S_3 and S_5 can be attributed to low water level and high rate of evaporation of water and addition of calcium and magnesium salts. Total alkalinity values for all six sampling sites were found to be higher than BIS standard due to the presence of excess of free CO_2 product as a result of decomposition process coupled with the mixing of sewage and domestic waste. The quantities of Calcium in natural water depend upon the type of rocks. The values of Calcium for S_1 and S_6 were found to be within the permissible limit of 75 mg/L and for other sites S_2, S_3, S_4 and S_5 were found to be above the limits.

Magnesium hardness particularly associated with the sulphate ion has laxative effect on persons unaccustomed to it [35]. The values of Magnesium for all other sampling sites were found to be higher than BIS and WHO standards except S_1. Chloride is one of the most important parameter in assessing the water quality. The high concentration of chloride is considered to be an indication of pollution due to high organic waste of animal origin. [36]. In the present study, the sampling site except Nilakottai (S_1) all other sampling sites Mallanampatti (S_2), Anna Nagar, Usilampatti Road(S_3), Anna Nagar, Batlagundu(S_4), Middle Street, Batlagundu(S_5) and Periyakulam Road Batlagundu(S_6) were found to have high concentration of chloride than the prescribed limits of BIS and WHO. Sulphate concentration in collected ground water samples were within the permissible limits of Indian standards WHO standards. Sulphate does not affect the taste of water if present in low concentration. Nitrate is the most important nutrient in an eco system. In our study area, Nitrate varies from 10 to 20 mg/ L which complies with the permissible limits of 45mg/L as per Indian standards .High concentration of nitrate may cause physiological damage , for example , water containing more than 45 mg /L has been reported to cause blue baby syndrome (or) methemoglobinemia. The presence of small quantities of fluoride in drinking water may prevent tooth decay. Fluoride is poisonous at high level, and dental fluorosis is easily recognized, Skeletal damage may not be clinically obvious until advanced stages have occurred. Fluoride concentration in sample sites S_1, S_3, S_4, S_5 and S_6 were found to be within the prescribed limits of BIS and WHO , but the sample S_2 which was found to be higher than the limits needs defluoridation for drinking. Sodium content adversely affect the soil nutrients up taking capacity. Water containing more than 200 mg/L sodium should not be used for drinking. In our present study except S_1 and S_3, all other sampling sites S_2, S_4, S_5 and S_6 were found to be more than 200 mg/L. According to WHO the prescribed limit of potassium is 200 mg/L. The values of potassium for all sampling sites were found to be within the limits of WHO standard. In the present investigation the concentration of Iron in the ground water samples exceeds the permissible limit 0.3 mg/L as per Indian standards and WHO standards. The ground water samples exhibited high iron contamination is an indication of the presence of ferrous salts that precipitate as insoluble ferric hydroxide and settles out as rusty salt.

Phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate level. Phosphate concentration of ground water samples collected was in the range of 0.59 to 1.0 which falls within the prescribed limit of WHO standards. The concentration of Dissolved oxygen regulates the distribution of flora and fauna. The present investigation indicated that the concentration of Dissolved Oxygen fluctuated between 5.2 to 6.3 mg/L. Concentration below 5mg/L may adversely affect the functioning and survival of biological communities and below 2m/L may lead to fish mortality. Water without adequate Dissolved oxygen may be considered as waste water. BOD is the measurement of the amount of biologically oxdisable organic matter present in the waste. The increased values of BOD indicate the nature of chemical pollution. The BOD values obtained in the present study were within the WHO standards. The maximum prescribed limit of COD is 20 mg/L as per WHO standard. The minimum values of COD might be due to low organic matter while the maximum value might be due to high concentration pollutants and organic matter. In present study, values of COD for all sampling sites were found to be within WHO standards.

APPLICATIONS

Application of the present work is the water quality indices was brought to the notice of the public, they can effectively monitor their water quality and they serve as a convenient tool to highlight specific environmental conditions, and to help governmental decision makers in evaluating the effectiveness of regulatory program.

Table 5: Consolidated WQI results

Method	S_1	S_2	S_3	S_4	S_5	S_6

	WQI	Quality	WQI	Quality	WQI	Quality	WQI	Quality	WQI	Quality	WQI	Quality
1	75.44	Good	55.46	Medium	42.73	Bad	56.81	Medium	37.26	Bad	70.94	Good
2	68.67	Poor	78.12	Very poor	85.78	Very poor	75.45	Very poor	79.64	Very poor	61.86	Poor
3	68.18	Medium	65.27	Medium	67.87	Medium	67.13	Medium	68.15	Medium	73.00	Good
4	126.43	Poor	196.39	Poor	154.72	Poor	162.97	Poor	220.09	Very poor	172.52	Poor
5	**49.35**						**Marginal**					

CONCLUSIONS

The consolidated WQI results were given in Table 5. Water Quality index is a useful tool for "communicating water quality information to the public and to legislative decision makers," it is not "a complex predictive model for technical and scientific application" [37].Water quality indices of the present study was calculated from important various physico chemical parameters in order to evaluate the suitability of water for various purposes. The calculated water quality index value provides an easy way of understanding the overall water quality and water management. The water quality rating at more of the sampling sites clearly showed that the status of the water body is poor and not totally safe for human consumption.

REFERENCES

[1] K.Park, Textbook of Preventive and Social medicine. 20th ed, Banarsidas Bhanot publishers, Jabalpur, India, **2009**

[2] C.R.Ramakrishnaiah, C. Sadashivaiah, G. Ranganna, *E-J Chem.*, **2009**, 6, 523-30.

[3] R.Chatterjee, R. Purohit , Curr sci., **2009**,96,1581-91.

[4] C.Chimnoy, M. Raziuddin, *Nat Env and poll Tech.*, **2002,** 1(2), 181-189.

[5] S.V.Agarkar, *Asian Journal of Chemistry*, **1998,** 10(04), 997-998.

[6] A.Sargoankar, V.Deshpande, *Environ. Monit. Assess*, **2003,** 89, 43-67.

[7] K.Saffran, Canadian water quality guidelines for the protection of aquatic life, **2001**

[8] H.Q.Khan, *Environmental Earth Sciences*, **2011,** 1255-1262.

[9] A.Lumb, H.Dough, S.Tribeni, *Environmental Monitoring and Assessment,* **2006,** 113,411-429.

[10] P.Debels, R. Figuera, R.Urrutia, R.Barra, X.Niell, *Environmental Monitoring and Assessment*, **2005,** 110, 301-322.

[11] P.R.Kannel, S.Lee, Y.S.Lee, S.R.Kanel, S.P.Khan, *Environmental Monitoring and Assessment*, **2007,**132, 93-110.

[12] S.A.Abbasi, Water quality indices, state of the art report, National Institute of Hydrology, Scientific contribution no. INCOH/SAR-25/2002, Roorkee: INCOH, **2002,** 73.

[13] A.A.Khan, R.Paterson, H.Khan, Modification and Application of the CCME WQI for the Communication of Drinking water Quality Data in Newfoundland and Labrador , Presented at 38th, Central Symposium on water Quality Research, Canadian Association on water Quality 10-11 February 2003, Burlington, Canada, **2003.**

[14] APHA, AWWA and WPCF, *Standard Methods for the Examination of Water and Wastewater*, American Public Health Association, Washington D.C., 14, **1995**.

[15] R.K.Trivedy, P.K. Goel, Chemical and biological methods for water pollution studies, Environment publication, Karad, India. **1984.**
[16] NEERI, Manual on water and waste water Analysis, National Environment Engineering Research Institute Nagpur, (3402), **1986**.
[17] S.B.Shankar, L. Sanjeev, *Environmental Engineering Science*, **2008,** 25(6):911-915
[18] S.F.Pesce, D.A. Wunderlin, *Water Research*, **2000,** 34(11), 2915-2926.
[19] P.K.Swamee, A. Tyagi, *Journal of Environmental Engineering*, **2000,**126,451-455
[20] A.A.Bordalo, W.Nilsumranchit, K.Chalrmwat, *Water Research,* **2001,** 35(15),3635-3642.
[21] C. Cude, *American Water Resources Association*, **2001,**37(1),125-137
[22] J.W.Nagel,*Water science and Technology*, **2001,**43,285-292.
[23] S.B.Jonnalagadda, G. Mhere, *Water Research*, **2001,** 35, 2371-2376.
[24] S.M.Liou, S.L.Lo, C.Y. Hu, *Water Research*, **2003,** 37, 1406-1416.
[25] A.H.Hector Hernandez-Romero, C.Tovilla- Hernandez,E.A. Malo, R.Bello-Mendoza, *Marine Pollution Bulletin*, **2004,** 48, 1130-1141.
[26] T.N.Tiwari, M.A. Mishra, *Indian J. Environ Proc.* **1985,** 5, 276-279.
[27] D.F.Singh, *Maharashtra.Proc*, *Acad.Environ. Biol*, **1992,** 1(1):61-66.
[28] Patel Sehul, K.K.Desai, *Poll Res.*, **2006,**25(2), 281-285
[29] WHO, Guidelines for drinking water quality Vol. 1-3, World Health Organization, Geneva, **1984.**
[30] BIS standards of water for drinking and other purposes Bureau of Indian Standards.
[31] ICMR Manual of standards of quality for drinking water supplies. ICMR, New Delhi.**1975.**
[32] R.M.NBrown, J.McCleiland, R.A.Deininger, M.F.O.Connor, *Water Poll. Res. Jerusalem,* **1972,** 6,787-797.
[33] R.K. Horton, *J.Water Poll.cont.Fed.*, **1965,** 37, 300.
[34] S.Mumtazuddin, A.K.Azad, *I Research Journal of Environmental Sciences*, **2012,** 1(1), 7-11.
[35] S.Khursid, Zaheeruddin, A.Basheer. *Ind.J.Env.Prot.* **1988,** 18(4), 246-249.
[36] J.P.Singh, P.K.Ray, *Environment and Ecology*, **1995,** 13(2), 330-335.
[37] N.I.McClelland, **1974**. Water Quality Index Application in the Kansas River Basin prepared for the U.S Environmental Protection Agency - Region 7. (EPA- 907/9-74-001)