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INTERNATIONAL JOURNAL OF CURRENT RESEARCH

International Journal of Current Research
Vol.3, Issue, 2, pp.152-160, February, 2011

ISSN: 0975-833X

RESEARCH ARTICLE

APPLICABILITY OF HEBER WATER QUALITY INDEX-1 [HWQI-1] ON GROUND WATER COLLECTED FROM TRICHIRAPPALLI AREA

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ARTICLE INFO

Article History:
Received 17th December, 2010
Received in revised form
15th January, 2011
Accepted 30th January, 2011
Published online 15th February, 2011

Key words:

Ground water,
Water pollution,
Heber Water Quality Index-I,
Physico-chemical properties,
National sanitation foundation.

ABSTRACT

During the past several decades, ground water quality has emerged as one of the most important and confronting environmental issues. In this present investigation, ground water quality of water samples collected from the wells of 10 selected places in and around pulivalam, an area located about 35km away from the Rockford city; Tiruchirappalli has been assessed using the Heber Water Quality Index-1(HWOI-I), a novel and indigenous statistical analysis. The parameters analyzed were Temperature, pH, Total Solids, Turbidity, Dissolved Oxygen, Biochemical Oxygen Demand, Fecal Coliform, and Fluoride. The total HWQI –I values, for all the samples are in the range of 40.5-53.5. These values suggest that almost all the water samples are bad in quality and not recommended for drinking and domestic uses. In addition to the total HWQI-1 values, proper attention has been paid to each individual parameter.

INTRODUCTION

Today human activities are constantly increasing by the way of industrial, domestic and agricultural wastes to the ground water reservoir. When ground water becomes contaminated, it cannot cleanse itself of degradable wastes as flowing surface water does (Poonam *et al.,* 2001). Ground water flows so slowly that contaminants are not diluted and dispersed effectively. Ground water also has much smaller population of decomposing bacteria and cold temperatures that slow down the chemical reactions that decompose wastes (Dee, 1990). Thus it can take hundreds to thousands of years for contaminated ground water to cleanse itself of degradable wastes on a human time scale; non-degradable wastes (such as toxic Pb, As, F) are these permanently (Hassan, 2004). Ground water is threatened with pollution from the following sources (Nyroos, 1994).

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1. Domestic Uses

Domestic wastes and methods of their disposal are of primary concern in urban areas.

2. Industrial Wastes

Most of the chemical industries produce wastes containing toxic heavy metals and also hazardous organic and inorganic effluents. These chemicals are contaminated with the ground water and severely pollute the ground water (Gupta *et al.,* 1997).

3. Agricultural Wastes

Mainly the ground water gets polluted by agricultural activities such as fertilizers, pesticides, insecticides, herbicides processing wastes and animal wastes, etc are constantly added to the water. These join the aquifers and posing danger to the ground water. The extent of ground water pollution depends on the factors such as Rainfall pattern, Depth of water table, Distance from the source of contamination, Soil properties such as texture, structure and filtration rate, etc.

Pulivalam is an area located about 35 km away from the Rockfort city, Tiruchirappalli. This is a semi-urban area where pesticide industry, metal processing industries, and cotton mill industries are situated. The population of this area is about 5000. Most of the population residing in this area is uneducated. People in this area largely depend on ground water for drinking and other domestic uses without knowing its inherent nature. The aforementioned industries discharge their effluents to the nearby soil which may percolate and thereby cause contamination of dangerous pollutants with the ground water. A close examination of the tooth of school children and adults (survey of dental fluorosis and skeletal fluorosis) reveals that the ground water of this area might be contaminated with fluoride ion in addition to the other dangerous pollutants. Also, the people who reside in this area are often suffering from several water borne diseases like cholera, dysentery, typhoid fever, etc. Therefore we feel that it is absolutely necessary to investigate the pollution load of the ground water of this area and create awareness among public and to suggest some remedial measures to the authorities concerned (Gupta and Sexena, 1997).

The following are the major objectives of this investigation:

(a) To visit the small scale industries located in this area to collect important information regarding the nature of effluent discharged into the soil.
(b) To check whether effluent discharged by these industries are properly treated or not.
(c) To collect ground water samples from 10 selected places of this area by means of specified and standard sampling procedure method
(d) To assess the quality of the collected water samples using our own Heber Water Quality index-I (HWQI-I)
(e) To create awareness among the school children and adults about the inherent nature of the water.
(f) To make suggestions to the authority concerned for the improvement of the ground water quality.

We have more than 35 parameters to assess the quality of any water system under examination. Analysis of all the 35 parameters is quite costlier, time consuming one and moreover it is not needed to analyze all the parameters as some of the parameters among them are interrelated. Keeping this point in mind, the staff members and senior students of Bishop Heber college have jointly formulated an indigenous water quality index named after our Bishop Heber College as Heber Quality–I (HWQI-I) based on quantitative approach (statistical approach).The applicability of this HWQI-I has been suitably tested and proved to be a successful one. Considering the climatic conditions and other related information, the following only nine parameters have been taken into consideration for the formulation of HWQI-I (Rajendran *et al*., 1998) Temperature, Turbidity, Total solids, Dissolved oxygen, Bio-chemical oxygen demand (BOD), pH, Nitrate, Phosphate, and Fecal Coliform. In addition to these parameters fluoride was also analyzed as it was suspected to be present, since the area is with rocks (Hosetti *et al*., 1994).

EXPERIMENTALS

In a developing country like India, people make use of ground water for their drinking and domestic uses without knowing its inherent nature. Hence the most reliable and effective way to control pollution is to analyze the rate of environmental pollution and then adopt a strategy which is suitable and economical (Rajendran *et al*., 1999). According to the prescription given by National Sanitation Foundation (NSF) of USA, the following nine parameters are considered to explain the water quality. Temperature (ΔT), Turbidity, Total Solids, Dissolved Oxygen, Bio-chemical Oxygen Demand, pH, Nitrates, Phosphate-Phosphorus and Fecal Coliform (Padmavathy and Rajendran, 2002).Using the results, weighing curve values (Q-values) and weightage factor of each parameter, a Water Quality Index (WQI) has been designed to assess the pollution load. This is found to be more suitable for testing the water quality in temperature regions like USA, since it has been formulated on the basis of their standard of living, climatic conditions, soil properties, industrialization, food consumption pattern, etc.,

Many studies have been undertaken to monitor the pollution load of ground waters. In the present study, an attempt has been made to study the applicability of a new Water Quality Index called Heber Water Quality Index-I ($HWQI_1$) for ground waters. From the parameter temperature, the other properties such as density, viscosity, vapour pressure and surface tension of water can be determined. The parameter temperature is important for its effects on the chemical and biological reactions in the organisms in water. Higher degrees reduce the solubility of gases and amplify the tastes and odours.

Temperature affects:

1. the amount of oxygen that can be dissolved in the water
2. changes the taste and odour
3. the rate of photosynthesis by algae and larger aquatic plants
4. the metabolic rates of aquatic organisms and
5. the sensitivity of organisms to toxic wastes, parasites and diseases.

It has been found that the parameters such as Temperature (ΔT^0C), phosphate-phosphorous in the WQI table are not of much significance to study the quality of water used for human consumption. The temperature (ΔT^0C) is not ordinarily considered as a pollutant because in the ecosystem, the water body is potentially susceptible to the temperature changes (Rajendran *et al*., 1999). In a tropical country like India, the atmospheric temperature is naturally high. So a small thermal change caused by thermal pollution may not seem to pose a major threat to the aquatic life. The major contribution of thermal pollution from nuclear power plants and industries also seems to be minimal. However it decreases the solubility of oxygen and other gases in water only to a small extent. Therefore, the Temperature (ΔT^0C) does not play a vital role in determining the water quality in tropical regions. So the least importance is given to this parameter (Rajendran *et al*., 2000).

Similarly, phosphorous discharged from agricultural run-off, detergents, urban and domestic wastes are a major pollutant, because its concentration in the aquatic environment is normally low due to the insolubility of major phosphates. If it is present in an appreciable amount in water, it will stimulate only the growth of algae and other aquatic plant forms, leading to a condition called “Eutrophication”. Needless to say “Eutrophication” is a condition where a water body becomes loaded with nutrients and dissolved solids with a decrease in the transparency of the water column which in turn reduces the DO in water and light penetration. Keeping these facts in mind and taking into consideration the valuable suggestions of scholars in this area, these two parameters viz., difference in temperature (ΔT^0C), phosphate-phosphorous and total nitrates have been removed. Instead, an important parameter (F^-) fluoride has been incorporated because the sampling places of this investigation are located in rocky area. From the extensive literature survey of health hazards caused by water pollutants, it is found that many people are afflicted with dental and skeletal fluorosis due to consumption of water containing fluoride beyond permissible limits (Mitchell *et al.*, 1990). The fluoride is richly found in the soil. It is also released from manufacturing plants of phosphatic fertilizers, brick, steel, glass and pottery by run-off from agricultural lands and by soil erosion. These fluorides are highly toxic and are mainly deposited in which cause “dental fluorosis” and “skeletal fluorosis”. It is reported that enamel is caused by fluoride concentration at 2ppm levels in drinking water in temperate regions, but it occurs at much lower concentrations (0.4-0.7 ppm) in the tropics (Kiran *et al*., 2004). Therefore the analysis of this parameter in ground waters (main source for human consumption) is considered to be very important. Hence they were included in the water quality testing procedure and anew called Heber Water Quality Index-I (HWQI-I $_1$) was designed with nine parameters namely DO, BOD, Fecal Coliform, pH, Nitrate, Chromium, Fluoride, Turbidity and Total Solids (Kumar *et al*.,1993). Data were collected from scholars in this area with the following objectives to design the $HWQI_1$ table.
They were asked to;
1. Arrange the nine parameters in the decreasing order of importance according to their opinion.
2. Make a scoring on a 9- point scale with “0” indicating the lowest rating and ‘9” indicating the highest.
3. Give same rating to two or more parameters of equal importance.
4. Assign weighing curve valve (Q-value) and to draw the graph for the newly introduced parameters, namely fluoride and chromium by giving them their corresponding acceptable limits.

Sampling station

Water samples ware collected from ten different wells in around Pulivalam, Tiruchirappalli district at a depth of 1 foot and they were labeled as Sample –I (Government Higher Secondary School), Sample-II (SVS Nagar), Sample-III (Elementary School), Sample –IV (Siva Temple), Sample-V (SVS Nagar Rice Mill), Sample-VI (West Street) Sample-VI I, (South Street), Sample –VI I I (West Street), Sample-IX (Indra Nagar), Sample-X (East Street).Nine Water quality parameters suggested by NSF-WQI and $HWQI_1$ were analyzed for the water sample to express the quality and quantity of pollution. A comparative study was made between the two Q- values for each sample.

MATERIALS AND METHODS

Water samples were collected from wells at a depth of 1 foot .The samples were collected in a previously washed and dried plastic container. The container was rinsed thoroughly with sample water, then it was immersed into the stream water and then the lid was removed exactly at the required depth. After filling, the container was closed and removed gently. The temperature and pH of all the samples were recorded immediately after collection. To analyze the parameter BOD, samples were collected in the BOD bottles and were incubated immediately in the laboratory. Dissolved Oxygen (DO) was fixed at the sampling site immediately after the collection. To study the biological parameter (Fecal Coliform) samples were collected separately and were tested within one hour. Rests of the analysis were carried out in the laboratory. After the collection of samples, containers were labeled with the information like date and time of collection, temperature and pH (Shamila and Rajendran, 2004). The Temperature was measured at the sample site immediately after collection of sample. A sensitive mercury thermometer graduated up to an accuracy of 0.1°C was used. While taking the reading, the scale of thermometer was immersed in to the water up to the level of mercury reading was attained. The temperature in centigrade was recorded. To minimize the error, the thermometer was calibrated with another thermometer of known accuracy. Total Solids are determined as the residue left after the evaporation of unfiltered sample. Total solids include both dissolved and suspended solids. Turbidity was measured by Nephelometric method. pH is measured by a pH meter using a glass electrode No:61. Dissolved oxygen was determined by Winkler's method. The percent saturation of dissolved oxygen present in water at a given temperature was determined through the use of percent saturation chart. A straight line was drawn between the water temperature of the sample site and the dissolved oxygen in mg/l. The percent saturation at the intercept on the sloping scale was recorded. Example: Let the DO value was 8 mg/l and the measured water temperature was 15^{0}C. Drawing a straight line between two values gives a percent saturation of about 80 %. It means that about 10 % of dissolved oxygen was used by something present in that water (Fig 1).

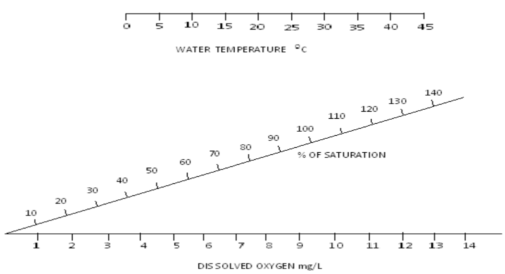

Fig.1. % saturation chart for dissolved oxygen

BOD_5 was measured by the quantity of O_2 utilized for the oxidation of organic matter by suitable microorganism during 5 days period. Fluoride was determined by SPADNS method using spectracolourimeter 103 (Systronic). The SPADNS colorimetric method is based on the reaction between fluoride and a Zirconium-dye lake. Fluoride reacts with the dye-lake dissociating a portion of it into a colorless complex anion (ZrF_6^{2-}) and the dye. As the amount of fluoride increases, the colour produced becomes progressively lighter. The reaction rate between fluoride and Zirconium ions is influenced greatly by the acidity of the reaction mixture. If the proportion of acid in the reagent is increased, the reaction can be made almost instantaneous. Under such conditions, however, the effect of various ions differs from that in the conventional alizarin methods. The selection of dye for this rapid fluoride method is governed largely by the resulting tolerance to these ions. Fecal Coliforms were tested and counted by MPN Index method.

Procedure for calculating the overall Water Quality Index (WQI)

The Heber Water Quality (WQI) for the sampling station of the Ground Water was formulated after the nine quality tests are completed and the results of each test recorded.

Procedure for determining Q-value

The test value was located on the bottom of the respective weighing curve chart and a vertical line was drawn until it intersects the weighing curve line. From the point of intersection, a horizontal line was drawn to the "Y "axis. The point of intersection of Q- value of that particular test result. This Q- value was recorded in column b on the HWQI chart. The weighing curve value (i.e., Q- value) for each test was multiplied by the weighing factor listed on the chart for a particular test. The value was then recorded in the total column of the HWQI chart. The weighing factor for each water quality test provides a relative measure of a test's importance to overall water quality. For example, from the WQI chart, dissolved oxygen (DO) with a weighing factor of 0.17 is considered a more important test than solids at 0.07 in overall water quality determination (Fig 2). Similarly, the weighing factor for fluoride and chromium (according to HWQI-I) were determined by the priority values given by various scholars in addition, they were asked to assign weighing curve value (Q- Value) and to draw the Q- graph, by giving them the corresponding acceptable limits of the parameters. For instance, Suppose change in temperature was measured as 0^{0}C from the weighing curve chart of change in temperature, the Q- value was completed as 93.The resulted Q- value was then multiplied by the appropriate weighing factor 0.10 and total for change in temperature was 9.3, and it was recorded in column D on the WQI chart. The overall water quality index (WQI) for the sampling station of the water system was determined by adding the total of the nine test results (column D). The WQI chart and the weighing curve charts for eight tests are shown in the following pages.

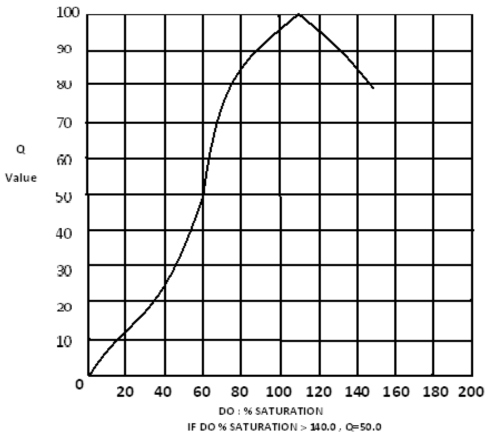

Fig. 2. DO % Saturation Chart

Water samples I, II, and III represent the well water taken from Government Higher Secondary School, SVS Nagar, Elementary School, respectively. The overall HWQI-I values were calculated to be 50.35 (Table -2), 51.13 (Table -3), 53.27 (Table –4) which indicates that these water system are very bad and should not be used for domestic uses especially for drinking. Dissolved oxygen is one of the most important parameters in water quality assessment and reflects the physical and biological processes taking place in it. The dissolved oxygen means oxygen is dissolved state obtained by the absorption from atmosphere. It keeps water fresh and its depletion is a signal severe pollution. Most aquatic plants and animals need a certain level of oxygen dissolved in the water for survival.

Factors affecting the DO are:

1. the amount and growth of algae and rooted aquatic plants
2. aerobic bacteria consume oxygen in the process of decomposition of plants, sewage and organic materials.
3. the major influencing factor is discharge of oxygen demanding chemical effluents and coolant from industries.

Looking at the % saturation level of DO, the water samples were considered to be excellent samples (100 %) table - 2 Government Higher Secondary School,(95%) Table -3 SVS Nagar, (90%) Table 4 Elementary school, respectively. These sampling stations are more spacious which enables greater dissolution of oxygen from the atmosphere. The most important biological parameter of water is fecal Coliform colonies. These bacteria can enter ground water through the direct discharge of feces from warm-blooded mammals and birds. Fecal Coliform bacteria by themselves are not pathogenic. But if they are accompanied with viruses and parasites, they will cause diseases and illness. If the Fecal Coliform counts are over 200colonies/100 ml of water samples, there is a greater chance that pathogenic organisms are also present. Apart from the above pollutants, some of the pollutants in water in the dissolved state are found to be hazardous even at low concentrations. Certain others are essential but produce toxic effects at higher concentrations. Biochemical Oxygen Demand is a measure of the quantity of oxygen used by the micro-organisms in the aerobic oxidation of organic matter. The amount of oxygen absorbed depends more on the nature of organic matter than its quantity. The decay of aquatic plants and animal tissues demand oxygen during its decomposition. More plant growth leads to more plant decay and therefore nutrients can be a major force in high BOD of ground water. The main sources of organic matter are swamps, bogs.

Human sources of organic matter called point sources are the effluent from:

1. pulp and paper mills
2. meat-packing plants
3. food processing industries and
4. waste water treatment plants

The much of dissolved oxygen is consumed in waters of high BOD. Organisms that are intolerant of low DO levels will not survive in this water. Such as caddis fly larvae, mayfly, nymphs and stonefly nymphs. The oxygen demand should not be more than 3ppm since Biochemical Oxygen Demand and Dissolved Oxygen are inversely related. Low BOD values (2.72 mg/l) table-2 Government Higher Secondary School. (2.33 mg/l) table-3 SVS Nagar. (0.78 mg/l) Table 4 Elementary School respectively. Also, it is substantiated by the low Fecal Coliform Colonies (64/100 ml), table-2 (11/100 ml), table-3 (28 /100 ml), and table-4 respectively. These low Fecal Coliform values and low BOD values indicate that the water system has low population of oxygen consuming pathogens and oxygen demand chemicals these water systems do not receive feces of birds and other animals as there are no trees around these wells, compared to the sampling station IV (Siva temple), V (SVS Nagar-Rice mill), VI (West Street), VII (South Street), VIII (West Street), IX (Indra Nagar),X (East Street).pH is the measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen

Table 1.Heber water quality index ($HWQI_1$)

S.No	Parameter	Test Result (Column A)	Q-Value (Column B)	Weighing Factor (Column C)	Total (Column D)
1.	Dissolved Oxygen	% Saturation		0.133	
2.	Fecal Coliform	Colonies /100 ml		0.130	
3.	BOD	mg/l		0.126	
4.	pH	Units		0.117	
5.	Chromium	mg/l		0.108	
6.	Fluorides	mg/l		0.105	
7.	Nitrates	mg/l		0.102	
8.	Total Solids	mg/l		0.09	
9.				0.09	

Overall Heber Water Quality-1 = -----------------------

Table 2. Sample –I (Government Higher secondary School)

S.No	Parameter	Test Result	Q-Value	$HWQI_1$ Weighing Factor	Total
1.	DO % Saturation	100%	98	0.133	13..03
2.	Fecal Coliform Colonies/100 ml	64	52	0.130	6.76
3.	BOD mg/l	2.722	74	0.126	9.32
4.	pH	7.48	93	0.117	10.88
5.	Temperature	28^0C	11	-	-
6.	Total Solids mg/l	30000	20	0.09	1.80
7.	Turbidity NTU	80	25	0.09	2.25
8.	Fluoride	1.12	60	0.105	6.30
				$HWQI_I$ Value	50.34

Table 3. Sample –II (SVS Nagar)

S.No	Parameter	Test Result	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO % Saturation	95 %	97	0.133	12.00
2.	Fecal Coliform Colonies/100 ml	11	68	0.130	8.84
3.	BOD mg/l	2.337	80	0.126	10.08
4.	pH	7.26	92	0.117	10.76
5.	Temperature (ΔT^0C)	28^0 C	11	-	-
6.	Total Solids mg/l	10000	20	0.09	0.45
7.	Turbidity NTU	120	5.0	0.09	6.30
8.	Fluoride mg/l	1.08	60	0.105	1.80
				$HWQI_I$ Value	51.13

Table 4. Sample –III (Elementary School)

S.No	Parameter	Test Result	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO % Saturation	90 %	95	0.133	12.63
2.	Fecal Coliform Colonies/ 100 ml	28	60	0.130	7.80
3.	BOD mg/l	0.78	94	0.126	1.84
4.	pH	7.44	92	0.117	10.76
5.	Temperature (ΔT^0C)	28^0 C	11	-	-
6.	Total Solids mg/ l	10000	20	0.09	1.80
7.	Turbidity NTU	120	5.0	0.09	0.45
8.	Fluoride mg/l	0.86	76	0.105	7.98
				$HWQI_I$ Value	53.26

ions in water. Depending upon the nature of the dissolved salts and minerals in water, it may be alkaline or acidic. It is measured by Colorimetric method or electrometric method. For potable water, pH value should be between 6.5 and 8.5 and for public water supplies, the pH value cause tuberculation and corrosion. The higher values cause incrustation, sediment deposition, difficulty in chlorination and other ill-effects on the human using the water. The pH value is very important in industries since many chemical and Biochemical reactions take place at low pH value or high range of pH value. The control of pH value is particularly much important in the chemical flocculation or trade wastes, treatment by digestion of sewage sludges and of trade wastes. The pH value is very important in the water treatment processes too. As for as the pH parameter is concerned these water systems are slightly alkaline which will not harm to the aquatic system. The parameter like Fluoride is also found to be an important one to monitor the water quality. Fluoride is one of the most active elements of the halogen group. It is the thirteenth element in the order of abundance constituting about 0.077 percent of the earth's crust. Fluorine is present in water resources as fluorides, which is essential for mineralization of bones and formation of dental enamel. The main source of fluoride to man is drinking water. The fluoride content of drinking water in this country is about 0.5 mg/l but in fluorosis-endemic areas, the natural water have been found to contain as much 3 to 12 mg/l of fluorides. Fluorides occur in traces in foods, but some foods such as sea fish, cheese and tea are rich in fluorine. The average adult man may ingest about 1 mg of fluoride daily from drinking water. I n addition to this, the daily diet may provide 0.25 to 0.35 mg of fluorine. Water may also be infested with fluoride by the contaminated domestic sewage and run-off from agricultural lands where phosphatic fertilizers are used. Fluorine is often called a two edged sword. Ingestion of large amount is associated with dental and skeletal fluorosis and inadequate amount with dental caries. Dental fluorosis is characterized by a lusterless, opaque appearance on the enamel which is yellow to brown in colour. It is known as enamel mottling In severe cases, loss of enamel is accompanied by 'pitting' which gives the tooth a corroded appearance. Skeletal fluorosis in the older people affects the bones, tendons and ligaments. This is followed by pain and stiffness of the back and later joints of both limbs a limitation of neck movements. Skeletal fluorosis has been reported to be a public problem of considerable magnitude in several districts of A.P, Haryana, Karnataka, Kerala, Punjab, Rajasthan and Tamilnadu. Fluoride levels below 0.5mg/l are usually associated with the high prevalence of dental caries. Since drinking water is the main sources of fluorine to man, a concentration of 0.5 to 0.8 mg/l in water is

Table 5. Sample –IV (Siva Temple)

S.No	Parameter	Test Result	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO % Saturation	75 %	83	0.133	11.04
2.	Fecal Coliform Colonies/ 100ml	150	41	0.130	5.33
3.	BOD mg/l	2.726	74	0.126	9.32
4.	pH	7	90	0.117	10.53
5.	Temperature ($\Delta T^0 C$)	28^0C	11	-	-
6.	Total Solids mg/l	3000	20	0.09	1.80
7.	Turbidity NTU	160	5.0	0.09	0.45
8.	Fluoride mg/l	1.38	30	0.105	3.15
				$HWQI_I$ Value	41.62

Table 6. Sample – V (SVS Nagar Rice Mill)

S.No	Parameter	Test Result	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO % Saturation	50 %	45	0.133	5.98
2.	Fecal Coliform Colonies/ 100ml	14	66	0.130	8.58
3.	BOD mg/l	0.389	96	0.126	12.10
4.	pH	7.12	90	0.117	10.53
5.	Temperature ($\Delta T^0 C$)	28^0C	11	-	-
6.	Total Solids mg/l	2000	20	0.09	1.80
7.	Turbidity NTU	120	5.0	0.09	0.45
8.	Fluoride mg/l	0.42	93	0.105	9.76
				$HWQI_I$ Value	49.20

Table 7. Sample –VI (West Street)

S.No	Parameter	Test Results	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO% Saturation	85 %	90	0.133	11.97
2.	Fecal Coliform Colonies/100ml	240	35	0.130	4.55
3.	BOD mg/l	2.339	80	0.126	10.08
4.	pH	7.39	92	0.117	10.76
5.	Temperature (ΔT^0C)	28^0C	11	-	-
6.	Total solids mg/l	1000	20	0.09	1.80
7.	Turbidity NTU	120	5.0	0.09	0.45
8.	Fluoride mg/l	0.81	84	0.105	8.82
				$HWQI_1$ Value	48.43

Table 8. Sample –VII (South Street)

S.No	Parameter	Test Results	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO% Saturation	70%	77	0.133	10.24
2.	Fecal Coliform Colonies/100ml	1100	23	0.130	2.99
3.	BOD mg/l	3.894	63	0.126	7.94
4.	pH	7.36	92	0.117	10.76
5.	Temperature (ΔT^0C)	28^0C	11	-	-
6.	Total solids mg/l	11000	20	0.09	1.80
7.	Turbidity NTU	120	5.0	0.09	0.45
8.	Fluoride mg/l	0.58	99	0.105	10.39
				$HWQI_1$ Value	44.57

Table 9. Sample –VIII (West Street)

S.No	Parameter	Test Result	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO% Saturation	50%	45	0.133	5.98
2.	Fecal Coliform Colonies/100ml	460	32	0.130	4.16
3.	BOD mg/l	3.502	62	0.126	7.81
4.	pH	7.64	93	0.117	10.88
5.	Temperature (ΔT^0C)	28^0C	11	-	-
6.	Total solids mg/l	18000	20	0.09	1.80
7.	Turbidity NTU	120	5.0	0.09	0.45
8.	Fluoride mg/l	0.70	90	0.105	9.45
				$HWQI_1$ Value	40.53

Table 10. Sample – IX (Indra Nagar)

S.No	Parameter	Test Result	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO% Saturation	95%	97	0.133	12.90
2.	Fecal Coliform Colonies/100ml	11	68	0.130	8.84
3.	BOD mg/l	4.273	62	0.126	7.81
4.	pH	6.90	87	0.117	10.17
5.	Temperature (ΔT^0C)	28^0C	11	-	-
6.	Total solids mg/l	6000	20	0.09	1.80
7.	Turbidity NTU	120	5.0	0.09	0.45
8.	Fluoride mg/l	1.36	34	0.105	3.57
				$HWQI_1$ Value	45.55

Table 11. Sample –X (East Street)

S.No	Parameter	Test Result	Q Value	$HWQI_I$ Weighing Factor	Total
1.	DO% Saturation	125%	88	0.133	11.70
2.	Fecal Coliform Colonies/100ml	460	32	0.130	4.16
3.	BOD mg/l	1.17	89	0.126	11.21
4.	pH	7.06	89	0.117	10.41
5.	Temperature (ΔT^0C)	28^0C	11	-	-
6.	Total solids mg/l	27000	20	0.09	1.80
7.	Turbidity NTU	120	5.0	0.09	0.45
8.	Fluoride mg/l	0.98	70	0.105	7.35
				$HWQI_1$ Value	47.08

considered a safe limit in tropic country like India. In temperate climates where the intake of water is low, the optimum level of fluorine in drinking water is accepted as 1 mg/l. The parameters such as Total Solids, Turbidity and Fluoride are having appreciably high values for the similar reasons stated for these samples. The high Total Solids and Turbidity might be due to the fact that the wells are rich of some metal sulphates, metal chlorides, etc, because these wells are located in the midst of cultivable lands.

The overall water HWQI- I values for sample-VI, sample-V, sample-VI, Sample-VII, sample-VIII, sample-IX, sample-X were found to be 41.62 (Table-1) Siva Temple, 49.21 (Table -6), SVS Nagar-Rice Mill, 48.43 (Table-7) West Street) 44.57 (Table -8)South Street,40.54 (Table-9) West Street,45.55 (Table -10) Indra Nagar,47.09 (Table-11) East Street respectively. These indicate that the water samples are very bad and cannot be used for drinking and for any domestic uses. As for as the parameter pH is concerned these water samples are considered to be excellent as they are neutral. This may be due to the fact that these water samples are having no sources for acidity such as mineral acids and organic acids and the sources for basicity such as metal hydroxides and organic bases. The DO value (%saturation) of these water samples were registered as 75%,50%,95%,125% respectively. (If the DO level of water system in terms of % saturation is the range of 80-125 then the Water system is treated as an excellent and suitable for most animals) which are considered to be an acceptable one for most animals including human beings. This low DO value may be due to the fact this well water systems are stagnant in nature (turbulence in any water system will increase the dissolution of oxygen from the atmosphere and hence higher DO level will be indicated for these water systems).The low DO level of these systems may also patly be due to the dense population of oxygen for survival. Another reason may be attributed to the fact that these water systems contain appreciable amount of Fecal Coliform Colonies (150/100 ml) Table -5 Siva Temple, (14/100 ml) Table-6 SVS Nagar-Rice Mill,(240/100 ml) Table-7 West Street ,(1100/100 ml), Table-8 South Street, (490/100 ml) Table-9 West Street, (11/100 ml) Table-10 Indra Nagar,(466/100 ml) Table-11 East Street respectively. When Fecal Coliform value is high, the DO value will be naturally low, because these pathogens will take up dissolved oxygen for oxidizing the organic matter present in the water samples. This high Fecal Coliform in these water systems is due to the fact that these water systems receive feces of some birds that fly across and stay on the trees present near by these wells. These water samples have BOD values (2.72 mg/l) Table-5 Siva Temple (0.38 mg/l) Table-6 SVS Nagar-Rice mill (2.34 mg/l) Table-7 West Street (4.274 mg/l) Table-10 Indra Nagar (1.17 mg/l) Table -11 East Street respectively. These are due to the presence of high Turbidity and high Total Solids values. A look at the parameter fluoride high values has been registered. For sample (1.38 mg/l) Siva Temple (0.42 mg/l) SVS Nagar-Rice mill (0.81 mg/l) West Street (0.58 mg/l) South Street (0.70 mg/l) West Street (1.36 mg/l) Indra Nagar (0.98 mg/l) East Street respectively which renders these water samples unfit for domestic purposes especially for drinking.

Because it exceeds the permissible limit 1.0 mg/l. These slight higher values of fluoride in this water system are due to the fact that these water systems are located in the rocky places.

Conclusion

Every one lives in one or more watersheds. Everyone is also a part of an ecosystem. Each watershed is a part of or comprises an entire ecosystem. In a developing country like India people especially living in semi urban area depend mostly on ground water for their drinking and other domestic uses. This present investigation was aimed at investigating the quality of ground water taken from 10 wells located in pulivalam area which is about 35 Kilometers away from Tiruchirappalli using an indigenous, a novel Heber Water Quality Index ($HWQI_I$) method. This method was found to be more suitable and reliable, less time consuming, less consumption of chemicals, etc. From the data obtained by the analysis of water samples taken from the aforementioned places. it is found to that almost all water samples analyzed in this investigation have the total $HWQI_I$ values in the range of 40.5-53.3 which suggests that almost all water samples are not suitable for domestic uses especially for drinking. A critical analysis on the magnitude of each parameter has been given in the discussion part of the dissertation. Based on the above findings and reasons it is concluded that almost all the water samples of this investigation should not be recommended for drinking, unless effective measures are taken to improve the quality of waste water system.

Acknowledgements

The author A.R. gratefully acknowledges the funding support rendered by the University Grants Commission, New Delhi for his major research project [F.No 35-147/2008(SR)]. He thanks the principal and the management of Sir Theagaraya College, Chennai-21 for the constant encouragement given. the other author CM thanks the Principal and the management of SDNB Vaishnav College for their support and encouragement rendered.

REFERENCES

Chaturvedi, M.K. Srivastava, A.K .1997. *Environmental impact assessment of an industrial complex*, Indian J. Environ. Protection. 17(9): 662-669.

De, A.K. 1990. *Environmental chemistry*, II edition, Wiley Eastern Limited, New Delhi.

Gupta, A.K. Sexena, G.C. 1997. *Correlation studies among various water quality parameters in groundwater in different urban industrial zones of Agra*. Indian J. Environ. Protection. 17(6): 434-441.

Hassan, A.E. 2004. *Validation of numerical ground models used to guide decision making,* USA.

Hosetti, B.B. Kulkarni, A.R. and Patel, P. 1994. Indian J. Environ. Health. 36 (2): 238-242.

Kiran, B. 2004. *Understanding Environment*, Sage Publications, India Private Ltd.

Kumar S, and Singh, K.P. 1993. *Comparative profile of contaminants in ground water and surface water resources in west kasha hills*. Indian J. Environ. Protection. 13(5): 349-345

Nyroos, H. 1994. *Water quality assessment in water protection planning, Publication of the water and environment research institute*. 14: 1-85.

Mitchell, M.K. and William, B.S. 1990. *Field manual for water quality monitoring, an environmental education program for schools* (4^{th} edition).Thompson – Shone printers, Michigan, USA.

Poonam, T. and Namita, J. 2001. *A Comparative Study of Some Physico – chemical Parameters of Some Irrigated with Recycled and Tub well water*, Indian J. Environ. Protection. 21(6): 525-528.

Padmavathy, S. Rajendran, A. Ramachandramoorthy, T. and Priyadarshini, S. 2002. *A measure of pollution load in lake water on the basis of WQI and NSF suggestions*, Indian J Environ. Protection. 23(6): 654-659.

Malathy, T. Princy Merlin, J. Rajendran, A. Jeyakar Chellaraj, D.A. and Subramanian, N.S.1998. *A Study on the applicability of a new Water Quality Index HWQI-1*, Indian J Environ. Protection. 19(1): 43-47.

Padmavathy, S. Rajendran, A. and Anitha Christy, J. 2003. *Study on the extent of soil pollution of solid wastes dumping land*, Indian J Environ. Protection. 23(6): 706-708.

Rajendran, A. Sharon, A.A. Jeyakar Chellaraj, D.A. and Princy Merlin, J. 1999. *Formulation of a new Water Quality Index- HWQI-2*, Indian J Environ. Protection. 19(1): 842-845.

Gugan, S. Ramesh Kumar, C. Princy Merlin, J. Rajendran, A. and Jeyakar Chellaraj, D.A. 2000. *Formulation of a New Heber Water Quality Index (HSQI-1) for Rice and Sugarcane cultivation*, Poll Res.19 (3): 485-489.

Shameela Rajam, P. and Rajendran, A. 2004. *A Novel method of preparation and characterization of an artificial resin- An effective water purifier*, Indian J Environ. Protection. 24(4): 289-292.