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Investigation of Water Quality Index and Langelier Index for the Ground Water Samples in Thottiyam Taluk of Tiruchirappalli District, Tamil Nadu

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In the present study, the potable nature, corrosive nature and the correlation values for the quality parameters have been evaluated from mathematical calculations for 50 ground water samples. From the calculated values of water quality index and langelier index, about 40 % of the water samples have been found to be good in their quality and 60 % of the samples with mild scaling tendency. The correlation matrix for the different water parameters has also been determined to study the relationship between the parameters.

Key Words: Water quality index, Langelier index, Thottiyam Taluk.

INTRODUCTION

The water quality is associated with the nature of surface rocks exposed for interaction with water. The compositions are widely variable representing different lithology ranging from soft rock aquifers to hard rock aquifers. A common problem is the presence of fluoride and nitrate in the sub surface water. The fluoride problem is lithology based whereas the nitrate problem represents seepage of agricultural wastewater into the ground. The presence of fluoride in excess (more than 1.5 ppm) causes dental and skeletal fluorosis. The permissible limit of fluoride in drinking water (1.5 ppm) suggested by world health organization (WHO-2004)[1] varies with respect to the climatic condition of a country, nature of the diet taken by the people. Fluorides are present in insignificant amounts in calcified tissues like bones and teeth. In India, majority of fluoride values in water are within 6 ppm[2].

EXPERIMENTAL

The present study area is Thottiyam Taluk of Tiruchirappalli district which is known for plantain, sugar cane and paddy crops. From 20 various villages, 50 ground water samples from open well, hand pump and bore

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well were collected and analyzed for the various water quality parameters namely pH, electrical conductivity (EC), total alkalinity (TA), calcium hardness (CH), magnesium hardness (MH), total hardness (TH), total dissolved solids (TDS), phosphate (P) and fluoride (F) as per the standard procedures (APHA-1998)[3].

Estimation of water quality index (WQI)

The water quality index is a useful and efficient tool for communicating the information of overall quality of water[4]. To determine the suitability of the groundwater for drinking pruposes, Water Quality Index is computed by adopting the method proposed by Tiwari and Mishra[5] which is formulated as,

$$WQI = \text{Antilog } [S\ W^{n}_{n=1} \log 10\ q_n]$$

where, W_n, Weightage = K/S_n and K, Constant = $1/(S^{n}_{n=1}\ 1/S_i)$

S_n and S_i correspond to the WHO/ICMR standard value of the parameters. Quality rating (q) is calculated as

$$Q_{ni} = [(V_{actual} - V_{ideal})/V_{standard} - V_{ideal})] \times 100$$

where, Q_{ni} = quality rating of i^{th} parameter for a total of n water quality parameters, V_{actual} = Value of the water quality parameter obtained from the laboratory analysis, $V_{standard}$ = Value of the water quality parameter obtained from the standard tables, V_{ideal} for pH = 7 and for the other parameters it is equivalent to zero.

The water quality parameters, their WHO/ICMR standards, ideal value and the corresponding weightage are given in Table-1.

TABLE-1
WATER QUALITY PARAMETERS, THEIR WHO/ICMR STANDARDS, IDEAL VALUES AND ASSIGNED WEIGHTAGE

Parameter	Standard (S_n and S_i)	Ideal value (V_i)	Weightage (W_n)
pH	8.5	7	0.1476
Alkalinity	120 ppm	0	0.0105
Total hardness	300 ppm	0	0.0042
TDS	1000 ppm	0	0.0013
Fluoride	1.5 ppm	0	0.8366

Langelier index (LI)

Langelier Index (LI) is an indication of instability with respect to $CaCO_3$. A zero value indicates that water is in chemical balance. A positive value indicates the tendency to deposit calcium carbonate and a negative value indicates the tendency to dissolve calcium carbonate. The value of Langelier Index can be calculated from the equation, given below.

Langelier Index = pH – [A+B – log Ca^{2+} – log (alkalinity)]

where A = a constant derived from temperature; B = a constant derived from total dissolved solids.

According to Langelier, the corrosive action of water is principally due to an excess of free CO_2 and its interaction with calcium and magnesium carbonates. In the presence of carbon dioxide, these salts are held in solution as bicarbonates and for any given concentration of calcium and magnesium there is a corresponding concentration of carbon dioxide to prevent the decomposition of these bicarbonates back into carbonates. Corrosion is accelerated by low pH values, so that in water of low alkalinity and high free carbon dioxide, the attack is much more rapid as compared to water which is high in alkalinity and is low in CO_2 content.

RESULTS AND DISCUSSION

The values of WQI and LI have been shown in the Table-2. The values show that 20 samples were found to be good in their quality. But the remaining 13 and 10 samples were poor and very poor respectively in their quality. Among the 50 samples, 7 samples were considered unfit for drinking purpose. The minimum and maximum values of the WQI for the samples under good quality was found between 26.48 and 49.99. The WQI value ranged from 56.16 and 74.50 for the poor quality samples. In the samples under very poor quality, the WQI value ranged from 77.6 to 97.0. The samples that were considered to be unfit were found from 101.3 to 117.4. The evaluation of LI showed that 18 out of 50 samples were found between the values +1 and +2, respectively, which reflects their severe scaling tendency. The LI values of 20 samples were observed between 0 and +1 and indicating that the samples show mild scaling tendency. Only 2 samples showed a negative value witnessing the nature of slight corrosiveness to lime scale.

TABLE-2
WQI AND LI VALUES FOR THE GROUND WATER SAMPLES

S. No.	Sampling station	WQI	Quality	LI	Cause
1	Thottiyam	62.1	P	+1.43	SST
2	Thottiyam	77.6	VP	+1.15	SST
3	Balasamuthiram	46.9	G	+1.01	SST
4	Balasamuthiram	35.8	P	+0.93	MST
5	Balasamuthiram	65.1	P	+0.70	MST
6	Balasamuthiram	70.9	P	+0.84	MST
7	Arasalur	116.3	U	+1.31	SST
8	Arasalur	40.1	G	+0.42	MST
9	Arasalur	33.5	G	- 0.82	SCLS

S. No.	Sampling station	WQI	Quality	LI	Cause
10	Arasalur	65.8	P	+0.53	MST
11	Arasalur	29.9	G	+0.70	MST
12	Arasalur	39.5	G	+0.86	MST
13	Keelakkarai kadu	47.2	G	+0.90	MST
14	Keelakkarai kadu	49.9	G	+0.76	MST
15	Melakkarai kadu	96.0	VP	+1.29	SST
16	M. Puthur	54.1	P	+0.60	MST
17	M. Puthur	64.0	P	+0.73	MST
18	Suruttai palayam	46.8	G	+1.39	SST
19	Nattham	101.3	U	+1.28	SST
20	Nattham	56.1	P	+0.61	MST
21	Kaduvetti	88.0	VP	- 0.09	SCLS
22	Kaduvetti	65.9	P	+0.67	MST
23	Anigalpatti	42.9	G	+0.03	MST
24	Anigalpatti	107.6	U	+0.52	MST
25	Kattuputhur	102.5	U	+0.64	MST
26	Kattuputhur	37.8	G	+0.26	MST
27	Kattuputhur	74.5	P	+0.52	MST
28	Kattuputhur	78.0	VP	+1.60	SST
29	Kattuputhur	44.6	G	+1.51	SST
30	Alampalayam	94.8	VP	+1.50	SST
31	Alampalayam	108.8	U	+1.34	SST
32	Alampalayam	48.4	G	+0.80	MST
33	Nagainallur	26.4	G	+0.90	MST
34	Nagainallur	111.7	U	+1.36	SST
35	Marachipatti	45.3	G	+0.81	MST
36	Marachipatti	97.0	VP	+1.07	SST
37	Balasamuthiram	65.4	P	+0.20	MST
38	Mulilipadi	96.8	VP	+1.09	SST
39	Mulilipadi	46.2	G	+1.17	SST
40	Mulilipadi	43.1	G	+0.81	MST
41	Alagari	117.4	U	+1.74	SST
42	Manamedu	65.1	P	+1.89	SST
43	Manamedu	79.5	VP	+1.75	SST
44	Manamedu	38.8	G	+0.22	MST
45	Manamedu	44.6	G	+0.91	MST
46	Kidaram	87.1	VP	+0.55	MST
47	Kidaram	70.0	P	+0.88	MST
48	Kandhanoor	94.0	VP	+1.00	MST
49	Kandhanoor	47.4	G	+0.34	MST
50	Arangoor	71.5	P	+0.42	MST

G-Good; P-Poor; VP-Very Poor; U-Unfit for Drinking; MST-Mild scaling tendency; SST-Severe scaling tendency; SCLS-Slightly corrosive to lime scale; 0-25: Excellent; 26-50: Good; 51-75: Poor; 76-100: Very Poor; > 100: Unfit for Drinking

Table-3 shows the correlation for seven water quality parameters. There is a positive correlation observed for the pairs PA-TA, PA-TDS, TH-TDS and pH-F. The positive values reflect the inter- dependence of the two related parameters. From the correlation value of PA-TDS (0.29), the presence of hydroxide species could be ascertained.

TABLE-3
CORRELATION MATRIX FOR THE WATER QUALITY PARAMETERS

Parameters	pH	PA	TA	TH	TDS	P	F
pH	1						
PA	0.06	1					
TA	- 0.17	0.38	1				
TH	- 0.01	- 0.01	0.06	1			
TDS	- 0.02	0.29	- 0.03	0.27	1		
P	0.12	- 0.06	0.06	- 0.01	- 0.15	1	
F	0.32	- 0.07	- 0.14	- 0.03	- 0.03	- 0.01	1

PA-Phenolpthalein alkalinity; TA-Total alkalinity; TH-Total hardness; TDS-Total dissolved solids; P-Phosphate; F-Fluoride

Conclusion

From the data of water quality index, there were 60 % of the water samples with good quality. The remaining samples need to be monitored for the potable nature by bringing the quality parameters within the recommended limit of world health organisation (WHO). The langelier index value showed that 60 % of the samples have the tendency to form mild scaling tendency and 36 % of the samples with severe scale forming tendency. Both the WQI and LI values reflect the presence of maximum amount of total hardness and total dissolved solids. The parameters need to be monitored by certain techniques namely boiling the samples or exposing the samples to solar radiation to bring down the level of Total hardness.

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