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Studies on Groundwater Quality in and Around Kothamangalm Taluk, Kerala, India

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Abstract : *The water quality index (WQI) is a single number that expresses the quality of water by integrating the water quality variables. This paper deals with the assessment of ground water quality in and around Kothamangalam Taluk, Kerala state of India. . For calculating the WQI the following 12 physic-chemical parameters such as pH, Electric Conductivity, Total Dissolved Solids, Total Alkalinity, Chlorides, Total Hardness, Dissolved Oxygen, Fluoride, Calcium, Magnesium, Sulphate and Nitrate have been considered. WQI obtained ranges from 26 to 9199.977. High value of WQI is mainly due to higher concentrations of iron which makes the water unsuitable for drinking.*

Keyword: *Ground water, Physico-Chemical parameters, Water Quality Index, Water quality standards*

I. Introduction

The fresh water is of vital concern for mankind since it is directly linked to human welfare. Ground water is an important natural source of water supply all over the world. Its use in irrigation, industrial and domestic usage continues to increase where perennial surface water source are absent. The modern civilization, over exploitation, rapid industrialization and increased population has lead to fast degradation of our environment. The quality of ground water may depend on geology of particular area and also vary with depth of water table and seasonal changes and is governed by the extent and composition of the dissolved salts depending upon source of the salt and soil-surface environment.

Water quality index provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is understandable and usable for common man. A single number is not enough to describe the water quality: there are many other water quality parameters that are not included in the index. However, a water quality index based on some very important parameters can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water body with number (Yogendra et al., 2007).

II. Study Area

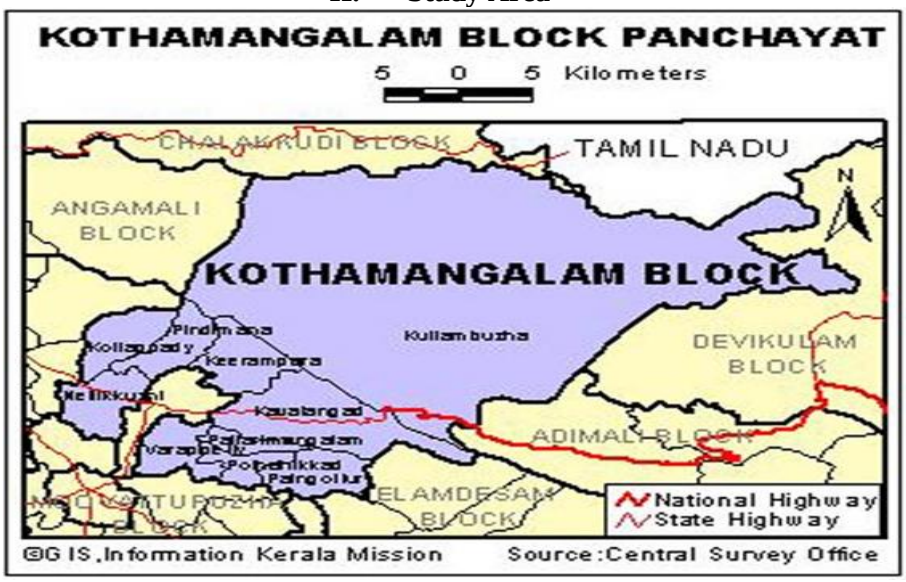

Fig. 1 sampling locations in the study area

For the present study, Kothamangalam Taluk of Ernakulum district was selected. It is located at a latitude of 10° 4′ 48″ N, and longitude of 76° 37′ 12″ E and is in the foothills of the Western Ghats and covers an area of 37.45 km^2. Kothamangalam taluk is divided into 10 panchayats and samples were collected from these panchayats.

III. Methodology

Water samples were collected from bore wells and open wells during monsoon a season from the study area. Samples were collected in acid washed plastic containers to avoid unpredictable change in characteristics as per standard procedures. The water samples were analysed for different physio-chemical parameters and were compared with the values of various quality standards such as World Health Organisation (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR).

A. Calculation of Sub index of Quality Rating (q_n)

Let there be n quality parameters where the quality rating or sub index (q_n) corresponding to the n^{th} parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value. The value of q_n is calculated using the following expression.

$q_n=100[(V_n-V_{io})/ (S_n-V_{io})]$

Where,

q_n=quality rating for the n^{th} water quality parameter

V_n=observed value of the n^{th} parameter

S_n=standard permissible value of n^{th} parameter

V_{io}=ideal value of n^{th} parameter in pure water

All the ideal values (V_{io}) are taken as zero for drinking water except for pH=7 and Dissolved Oxygen=14.6mg/L

B. Calculation of Quality Rating for pH

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5(for polluted water).Therefore the quality rating for pH is calculated from the following relation:

$q_{pH} = 100(V_{pH}-7.0)/(8.5-7.0)$

Where,

V_{pH} = observed value of pH during the study period.

C. Calculation of Quality Rating for dissolved oxygen

The ideal value (V_{io}) for dissolved oxygen is 14.6 mg/L and standard permitted value for drinking water is 5 mg/L. Therefore, quality rating is calculated from following relation:

$q_{DO}=100[(V_{DO}-14.6)/ (5-14.6)$.

D. Calculation of Unit Weight (W_n)

Calculation of unit weight for various water quality parameters is inversely proportional to the recommended standards for the corresponding parameters.

$W_n=K/S_n$

Where,

W_n= unit weight of n^{th} parameter

S_n=standard value for the n^{th} parameter

K=constant of proportionality and is given as (Kalavathy et al., 2011)

$K=1/[1/V_{s1}+1/V_{s2}+\ldots\ldots\ldots\ldots+1/V_{sn}]$

E. Calculation of WQI

WQI is calculated from the following equation

$$WQI = \sum_{i=1}^{n} q_n W_n \Big/ \sum_{i=1}^{n} W_n$$

Table 1 shows the classification of water quality status based on water quality index (Ramakrishnaiah et al., 2009 {5}, Bhaven et al., 2011 {9} and Srinivasa Kushtagi et, al., 2012[2]).

Table 1.Water quality classification based on WQI value

class	WQI index	Water quality status
I	<50	Excellent
II	50-100	Good water
III	100-200	Poor water
IV	200-300	Very poor water
V	>300	Water unsuitable for drinking

Table 2. Drinking water standards, recommending agencies and unit weights

Sl No:	PARAMETERS	STANDARD PERMISSIBLE VALUE	RECOMMENDED AGENCY	1/Sn	UNIT WEIGHT
1	pH	8.5	ICMR/BIS	0.118	0.031
2	EC (µ-s/cm)	300	ICMR	0.003	0.0008
3	TDS (mg/L)	500	ICMR/BIS	0.002	0.0005
4	TOTAL ALKALINITY(mg/L)	120	ICMR	0.008	0.002
5	CHLORIDES (mg/L)	250	ICMR	0.004	0.0008
6	TOTAL HARDNESS (mg/L)	300	ICMR/BIS	0.003	0.001
7	DO (mg/L)	5	ICMR/BIS	0.2	0.053
8	Ca (mg/L)	75	ICMR/BIS	0.013	0.0034
9	Mg (mg/L)	75	ICMR/BIS	0.033	0.0088
10	SULPHATE (mg/L)	150	ICMR/BIS	0.007	0.0018
11	NITRATE (mg/L)	45	ICMR/BIS	0.022	0.0058
12	IRON (mg/L)	0.3	ICMR/BIS	3.33	0.8891

Table 3 Observed values in monsoon season

Sample	pH	DO	Cl-	Alkalinity	$S0_4^{-2}$	Hardness	Ca	Mg	TDS	NO3-	EC	Iron
KAVALANGAD 1	7	7.2	10.99	13.2	0.5	20	6	14	17	0.1	37	0.15
KAVALANGAD 2	7	9.2	5.49	121.2	0.5	144	20	124	162	0.1	250	1.05
KEERAMPARA 1	7	9.1	10.49	30.6	0.25	34	5.2	28.8	34	0.1	67	0.69
KEERAMPARA 2	7	9.1	6.49	10	0.375	10	6	0	15	0.1	30	0.08
KLM MUNCIPALITY 1	7	7.4	9.49	62	1	66	58	12	100	0.1	40	0.41
KLM MUNCIPALITY 2	7	7.6	9.49	58	0.75	70	64	6	20	1.69	35	0.08
KOTTAPADY 1	7	11	5.65	162.6	4	130	72.6	57.4	231	0.15	450	0.08
KOTTAPADY 2	7	8.9	8.99	17.2	3	14	10.6	3.4	23	0.86	44	0.08
KUTTAMPUZHA 1	7	11	11.49	49.2	3.25	32	20	12	45	0.1	90	1.09
KUTTAMPUZHA 2	7	8.5	8.49	90	0.375	96	50	46	93	0.1	184	0.59
NELLIKUZHI 1	7	10	10.99	146	1.5	150	80	70	162	0.1	316	0.15
NELLIKUZHI 2	7	9	8.99	48	0.5	50	22	28	65	1.88	132	0.19
PAINGOTTOR 1	7	8	6.49	98	0.75	54	34	20	18	0.11	36	0.08
PAINGOTTOR 2	7	8.4	5.49	101	0.5	68	48	20	27	0.15	52	0.21
P.MANGALAM 1	7	10	10.99	18	3.5	22	9.2	12.8	205	0.1	401	1
P.MANGALAM 2	7	8	32.28	139.2	2.25	62	48	14	45	2.89	86	0.08
PINDIMANA 1	7	9.6	10.49	322.6	4	14	8	6	417	0.45	818	0.81
PINDIMANA 2	7	9.3	11.99	17.2	2.5	30	12	18	47	5.76	92	0.12
POTHANICADU 1	7	8.9	22.49	106	0.375	118	54	64	140	2.35	277	0.08
POTHANICADU 2	7	9.2	20.49	44	0.75	41.2	22	19.2	90	3.56	175	0.08
VARAPETTY 1	7	9.6	10.49	50	0.5	52	22	30	94	0.34	181	0.19
VARAPETTY 2	7	9.4	20.49	102	21.5	130	62	68	162	0.24	312	0.75

All values are expressed in mg/L, except pH and EC, pH in pH unit, EC in µ-s/cm at 25^{o}C

Table 4. Sample Calculation of WQI in monsoon

PARAMETERS	STANDARD VALUE	IDEAL VALUE	1/Sn	UNIT WEIGHT(Wn)	OBSERVED VALUES	QUALITY RATING(qn)	WEIGHTED (Wnqn)
pH	8.5	7	0.118	0.031	7	0	0
EC	300	0	0.003	0.0008	37	12.33	0.009864
TDS	500	0	0.002	0.0005	17	3.4	0.0017
TOTAL ALKALINITY	120	0	0.008	0.002	13.2	11	0.022
CHLORIDES	250	0	0.004	0.0008	10.99	4.396	0.0035168
TOTAL HARDNESS	300	0	0.003	0.001	20	6.66	0.00666
DO	5	14.6	0.2	0.053	7.2	77.083	4.085399
Ca	75	0	0.013	0.0034	6	8	0.0272
Mg	75	0	0.033	0.0088	14	46.67	0.410696
SULPHATE	150	0	0.007	0.0018	0.5	0.33	0.000594
NITRATE	45	0	0.022	0.0058	0.1	0.22	0.001276
IRON	0.3	0	3.33	0.8891	0.15	50	44.455
				ΣWn=0.998			ΣWnqn=49.023
WATER QUALITY INDEX =49.122							

Table 5.GWQI at each sampling station

Sl.NO:	DESCRIPTION	WQI	REMARKS
1	KAVALANGAD 1	49.122	EXCELLENT
2	KAVALANGAD 2	315.667	UNSUITABLE
3	KEERAMPARA 1	208.328	VERY POOR
4	KEERAMPARA 2	27.406	EXCELLENT
5	KOTHAMANGALAM MUNCIPALITY 1	126.18	POOR
6	KOTHAMANGALAM MUNCIPALITY 2	26.556	EXCELLENT
7	KOTTAPADY 1	27.265	EXCELLENT
8	KOTTAPADY 2	27.047	EXCELLENT
9	KUTTAMPUZHA 1	325.61	UNSUITABLE
10	KUTTAMPUZHA 2	179.453	POOR
11	NELLIKUZHI 1	47.781	EXCELLENT
12	NELLIKUZHI 2	60.03	GOOD
13	PAINGOTTOR 1	27.487	EXCELLENT
14	PAINGOTTOR 2	65.024	GOOD
15	PALLARIMANGALAM 1	302.726	UNSUITABLE
16	PALLARIMANGALAM 2	28.074	EXCELLENT
17	PINDIMANA 1	244.206	VERY POOR
18	PINDIMANA 2	38.92	EXCELLENT
19	POTHANICADU 1	28.056	EXCELLENT
20	POTHANICADU 2	27.203	EXCELLENT
21	VARAPETTY 1	59.716	GOOD
22	VARAPETTY 2	226.831	VERY POOR

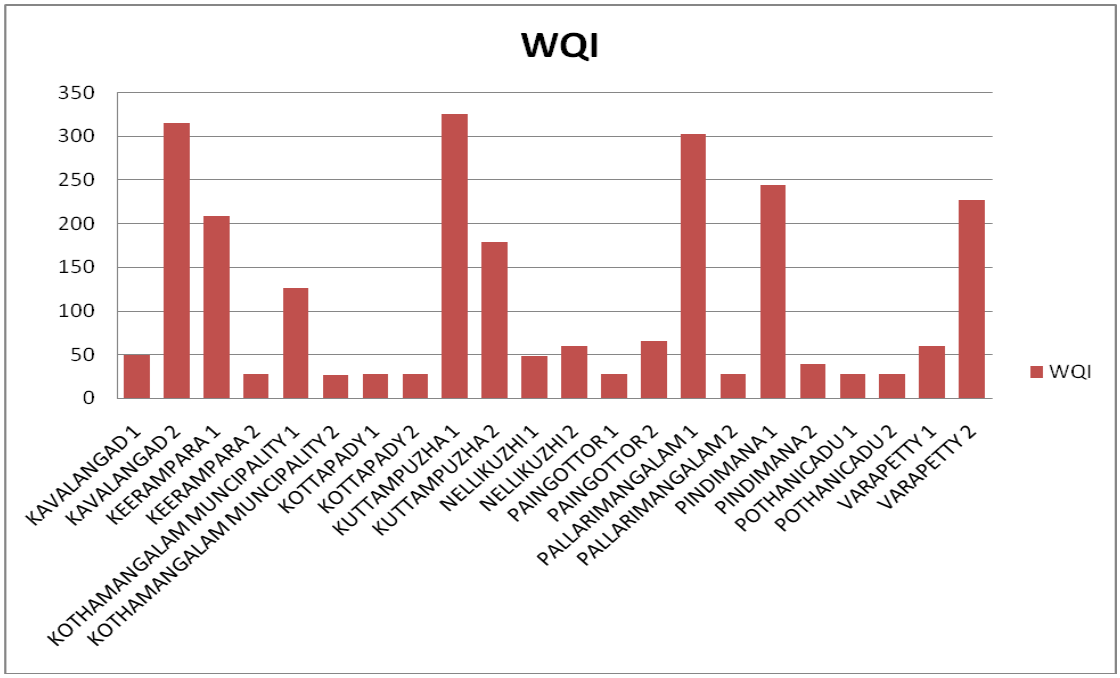

Fig. 2 WQI of sampling points

IV. Results And Discussions

The analytical results obtained for different study parameters such as pH, electrical conductivity, total dissolved solids, total alkalinity, chloride, total hardness, dissolved oxygen, calcium, magnesium, sulphate, nitrate and iron from different sampling locations of the year 2014-2015 are summarized in Table 3. Permissible limits and recommended agencies are described in Table 2. The results obtained are discussed below.

pH is an important parameter which determines the suitability of water for various purposes. If the water has pH less than 7, it may cause tuberculation and corrosion while higher the values may produce incrustation, sediment deposits and difficulties in chlorination for disinfection of water. In this study the pH in all the sampling locations is neutral.

Electrical conductivity of the present work lies in the range of 30 to 818. It is within the permissible limit

TDS is an important parameter for drinking water and other uses. It is mainly due to the addition of solids from runoff water, sewage and other effluents. In the study TDS was found in the range of 15 – 417 mg/L. The permissible limit is 500 mg/L as per IS 10500 standards.

Alkalinity is an important if it is less than 100 ppm is desirable for domestic use. However in large quantities it imparts bitter taste to water .In the present work it is found in the range of 10-322.6 mg/L and the sample taken from Pindimana, it is above the permissible limit.

Chloride occurs in all types of natural waters. The high value concentration of chloride considered to be an indication of pollution due to high organic waste of animal origin. In this study chloride ranges from 5.49 to 32.28 mg/L. It is within the permissible limit.

Hardness is a measure of ability of water to cause precipitation of insoluble calcium and magnesium salts of higher fatty acids from soap solution. In this study, the total hardness ranges between 10 - 150 mg/L. In the present investigation calcium and magnesium content are found in 5.2-80 mg/L and 0-124 mg/L respectively. They are within the permissible limit.

Water without adequate dissolved oxygen may be considered as waste water. Presence of dissolved oxygen in water may be due to direct diffusion from air and photosynthetic activity of autotrophs. Concentration below 5mg/L may adversely affect the functioning and survival of biological communities. The DO values obtained in the present study ranges from 7.2-11 mg/L. Therefore it is within the permissible limit.

Sulphate ion does not affect the taste of water, if present in low concentrations. Abnormal concentrations of sulphate may be due to the presence of sulphate ore bodies like pyrite, lignite and coal. The desirable limit of sulphate in drinking water is 250mg/L. The range of sulphate obtained is 0.25-21.5 mg/L and it is within the permissible limit.

Nitrate is the most important nutrient in an ecosystem. Generally water bodies polluted by organic matter exhibit higher values of nitrate. Nitrate value obtained in the study ranges from 0.1-5.76 mg/L. The permissible limit of nitrate is 45 mg/L and it is within the permissible limit.

The iron content of water ranges from 0.08-1.09 mg/L. The permissible limit is 0.3 mg/L. The maximum value of iron content is reported as 1.09 mg/L at Kuttampuzha and makes the water unsuitable for drinking. The main source of iron content in water is interaction with literate rocks.

V. Groundwater Quality Assessment

The groundwater quality is assessed based on WQI. The values of WQI in all the sampling locations were summarized in Table 5. On the basis of WQI the quality of water is categorized from excellent to unsuitable for drinking. The WQI computed for sample Kavalangad 2, Pallarimangalam 1and Kuttumpuzha 1 revealed that the water is unsuitable for drinking. The water samples from Keerampara 1, Kothamangalam Municipality 1, Kuttampuzha 2, Pindimana 1 and Varapetty 2 is of poor quality. The poor quality of water samples may be due to presence of iron content.

VI. Conclusion

The quality of water obtained from tube well is poor when compared to open well. Iron content can be a reason for the poor quality of water. Higher WQI indicates that proper water treatment method should be adopted before consumption. WQI in this study has been found useful in assessing the overall quality of water. This method appears to be more systematic. It is also helpful for public to understand the quality of water as well as being a useful tool in many ways in the field of water quality management.

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