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Assessment of Ground Water Quality in Nellikkuzhy Panchayat of Kerala State, India

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ABSTRACT: *A Water Quality Index (WQI) provides a single number that expresses overall quality at certain location and time based on several water quality parameters. The objective of an index is to turn complex quality data in to information that is understandable and useable by the public. For calculating the WQI following 11 physico-chemical parameters such as pH, Electric Conductivity, Total Dissolved Solids, Total Alkalinity, Total Hardness, Chloride, Sulphate, Calcium, Magnesium, Nitrate, Dissolved Oxygen were taken to assess the impact of pollutants due to anthropogenic activities . The Water Quality Index value for the Ground water ranges from 50.47 to 63.18 during the monsoon season and 33.74 to 64.69 during the summer season. In the present investigation the quality of water was found to be good in all the sampling locations in Nellikkuzhy Panchayat.*

KEYWORDS: *Ground water, Water Quality Index, Physico-chemical parameters, Water quality standards.*

I. INTRODUCTION

Water is indispensable and one of the precious natural resource of our planet. Groundwater is an important natural source of water supply all over the world. Its use in irrigation, industries 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. To meet the rising demand it is imperative to recognize the fresh water resources and also to find out remedial methods for improvement of water quality. The quality of groundwater 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 dissolved salts depending upon source of the salt and soil subsurface environment. The development of growing regions in developing countries is allied several social, economical, environmental and technical aspect of concerned area along with the study of available, sustainable resources for civilization. Among all: groundwater is one of the vital resources confined everlasting. In the context of quality and quantity; ground water fluctuates in variably in its own which reflects the time to time status of groundwater as a whole for the region.

The quality of groundwater depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. Industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution of surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of heavy metal in excess. The situation gets worsened during the summer season due to water scarcity and rain water discharge. Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems.

II. LITERATUE REVIEW

Basavaraddi S.B. et al., (2012)[1] made a study on seasonal variation of groundwater quality and its suitability for drinking in and around Tiptur town, Tumkur district of Karntaka, India. Seven most important physicochemical parameters such as pH, Total Dissolved Solids (TDS), Total Hardness, Calcium, Magnesium, Chloride and Nitrate were taken for the calculation of Water Quality Index (WQI) of groundwater. The water quality index values for the groundwater ranged between 83.9 – 138.5 during monsoon and 67.91 – 130.5 during summer season. In their investigation the quality of water was found to be good in all the sampling locations in Tiptur town and surrounding areas.

Srinivas Kushtagi et al., (2012)[2] carried out studies on chemistry and Water Quality Index of groundwater in Chincholi Taluk, Gulbarga district, Karnataka state of India. Water samples from tube wells, open wells and hand pumps at various locations were collected and analyzed using standard procedural

methods. The analysis reveals that the groundwater of the area needs certain degree of treatment before consumption, and it also needs to be protected from the perils of contamination. From water quality index the water quality of Chincholi taluk was found to be good.

Mishra B.B et al., (2008)[3] studied the water quality index and suitability of water of Kohargaddi dam at Balrampur district of India. The seasonal variation in water quality parameters in rainy, winter and summer seasons were studied. The result revealed that the water in the dam is not suitable for irrigation and potable purposes. Suman Panwar et al., (2012)[4] assessed the groundwater quality in contiguous of integrated industrial estate at Pantnagar of Uttarkhand. Groundwater samples were collected during different seasons of summer, monsoon and winter in year 2011-12. Groundwater samples were tested for 11 physico-chemical parameters by following the standard methods and procedures. Indian standard (IS:10500) for drinking water quality were adopted for assessment of groundwater quality through calculation of Water Quality Index (WQI). The result of analysis reveals that the groundwater of the study area becomes contaminated due to anthropogenic activities.

Ramakrishnaiah C.R et al., (2009)[5] assessed the water quality index for the groundwater in Tumkur Taluk of Karanataka state, India. Groundwater samples were tested for 12 physicochemical parameters by following the standard methods and procedures for the calculation of WQI. The results of analysis have been used to suggest models for predicting water quality. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination. Rizwan Reza and Gurdeep Singh (2010)[6] made an attempt to understand the groundwater quality by using Water Quality Index (WQI) in Angul-Talcher region of Orissa. Twenty four groundwater samples were collected from open and tube wells during summer and post-monsoon seasons. The study reveals that the groundwater of a few locations needs some degree of treatment before consumption and it also needs to be protected from the danger of the prevailing contamination.

Yogendra K. and Puttaiah E.T (2008)[7] in their study calculated the Water Quality index (WQI) of an urban wtebody, Gopishetti Lake in Shimoga town of Karnataka state. The study aims to ascertain the quality of water for public consumption, recreation and other purposes. In this study Water Quality Index was determined on the basis of various physicochemical parameters like pH, Electrical Conductivity, Total Dissolved Solids, Total Alkalinity, Total Hardness, Total Suspended solids, Calcium, Magnesium, Chloride, Nitrate, Sulphate, Dissolved Oxygen and Biological Oxygen demand.

III. STUDY AREA

The Nellikkuzhy Panchayat is located at latitude N 10^{o} 02'35"- N 10^{o}05'16.1" and longitude between E 76^{o}33'49.4" to E 77^{o} 20'37.5". It has a total area of 2053 sq.km and it is divided into 21 wards. There are some plywood industries and one tyre manufacturing industry. The total population is 37763 and almost 90% is dependending upon open wells for drinking water.

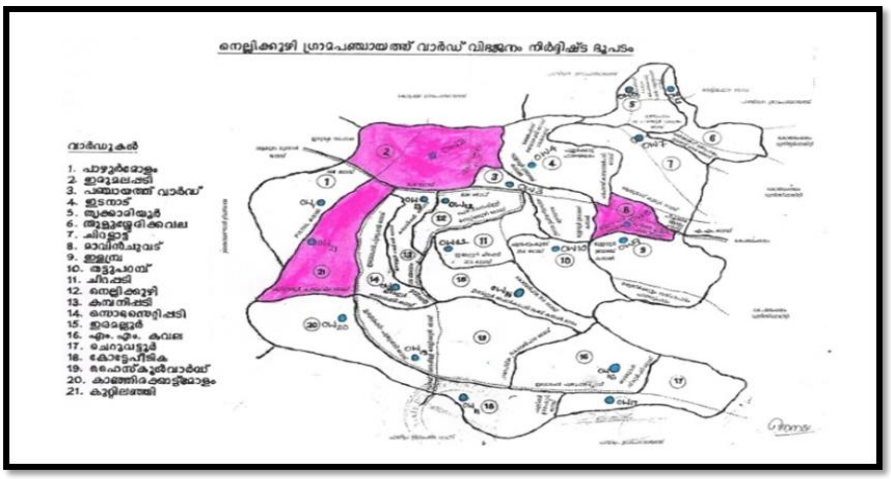

Fig. 1 Sampling locations in the study area

IV. CALCULATION OF WQI

Let there be *n* water 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

$$q_n = 100[(V_n-V_{io})/(S_n-V_{io})] \quad (1)$$

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=7.0 and Dissolved Oxygen = 14.6 mg/L.

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.

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 5mg/L. Therefore, quality rating is calculated from following relation:

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

Where,

V_{DO} = observed value of dissolved oxygen

Calculation of unit weight (W_n)

Calculation of unit weight (W_n) for various water quality parameters are inversely proportional to the recommended standards for the corresponding parameters.

Wn = K/S_n

Where,

W_n = unit weight of n^{th} parameters
S_n = standard value for n^{th} parameters
K = constant for proportionality and is given as (Kalavathy et al., 2011)[8]:
$K=1/[1/V_{S1}+1/V_{S2}+\ldots\ldots\ldots+1/V_{sn}]$

Calculation of WQI

WQI is calculated from the following equation

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

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 value	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 (Sn)	Recommended Agency	1/Sn	Unit Weight
1	PH	8.5	ICMR/BIS	0.118	0.083
2	EC (µ-s/cm)	300	ICMR	0.003	0.002
3	TDS (mg/L)	500	ICMR/BIS	0.002	0.001
4	Total Alkalinity (mg/L)	120	ICMR	0.008	0.006
5	Chlorides (mg/L)	250	ICMR	0.004	0.003
6	Total Hardness (mg/L)	300	ICMR/BIS	0.003	0.002
7	DO (mg/L)	5	ICMR/BIS	0.200	0.141
8	Fluride (mg/L)	1.5	BIS	0.667	0.471
9	Ca (mg/L)	75	ICMR/BIS	0.013	0.009
10	Mg (mg/L)	30	ICMR/BIS	0.033	0.024
11	Sulphate (mg/L)	150	ICMR/BIS	0.007	0.005
12	Nitrate (mg/L)	45	ICMR/BIS	0.022	0.016

Table 3 Observed values in monsoon

Sample	pH	DO	Cl^-	Alkalinity	Sulphate	Hardness	Ca	Mg	TDS	NO_3^-	EC
1	6.50	8.2	5.79	16	1	16	4.8	0.976	26	0.17	53
2	6.70	8.5	19.29	48	3.25	52	16	2.928	87	2.05	164
3	6.90	7.7	19.29	40	2.25	28	6.4	2.928	64	5.67	122
4	6.81	7.4	23.15	56	4.25	44	8	5.856	86	2.22	163
5	6.68	8.5	15.43	40	15.75	64	22.4	1.952	100	0	192
6	6.96	7.7	9.65	32	11.25	24	8	0.976	32	0.55	61
7	6.48	5.9	13.5	28	2.5	56	9.6	7.808	53	0	103
8	6.35	6.1	9.65	40	5	36	8	3.904	63	2.03	120
9	6.41	6.3	7.72	32	3.25	32	9.6	1.952	51	0	99
10	6.73	5.8	15.43	32	3	48	12.8	3.904	56	0.37	108
11	6.28	6.5	21.22	36	3.25	44	16	0.976	86	3.5	164
12	6.14	7.4	50.16	28	3.5	114	24	13.76	125	2.75	239
13	7.20	9	9.65	24	3.5	20	4.8	1.952	48	1.65	91
14	7.05	7.7	19.292	12	3	28	8	8	48	0.58	93
15	6.42	7.4	9.65	16	1.5	28	4.8	4.8	45	1.42	86
16	5.96	7.6	27.01	24	4	28	3.2	3.2	75	0.5	144
17	5.74	7.6	19.292	16	3.5	30	9.2	9.2	56	2.12	108
18	6.71	9	7.72	16	0.325	16	4.8	4.8	23	0.13	46
19	6.92	8.5	9.65	28	3.25	32	6.4	6.4	34	0	65
20	6.15	5.6	19.292	48	5	24	8	8	88	3.18	168
21	6.33	7.9	7.72	32	4.5	32	8	8	42	0.42	80

All values are expressed as mg/L, except pH and EC; pH in pH unit, EC: µ-s/cm at 25^o C.

Table 4 Observed values in Summer season

Sample	pH	DO	Cl^-	Alkalinity	Sulphate	Hardness	Ca	Mg	TDS	NO_3^-	EC
1	5.88	6.9	10	14	3	14	4.8	0.488	36	0.22	65
2	6.32	7.0	8	40	6	56	22.4	0	83	0	150
3	6.04	6.9	5	18	7.5	30	11.2	0.488	50	2.16	92
4	6.15	7.2	19	22	5	40	14.4	0.976	82	1.83	162
5	6.41	7.5	11	60	8	66	22.4	2.44	104	0	188
6	5.65	7.5	11	8	2.5	12	4.8	0.976	32	1.36	57
7	6.03	7.2	16	24	6.5	28	11.2	0.976	64	0.13	114
8	5.90	7.5	10	18	3	24	6.4	1.952	45	1.76	81
9	6.11	7.5	9	32	5	40	14.4	0.976	66	0.65	121
10	6.25	7.6	21	32	7	46	14.4	2.44	96	1.78	176
11	6.30	7.6	16	26	5.5	40	14.4	0.976	84	2.94	151
12	5.99	7.5	53	26	12	48	19.2	14.64	189	5.38	337
13	5.88	7.5	10	12	3.5	16	4.8	0.976	41	1.63	73
14	5.90	6.9	17	16	3	24	8	0	66	1.46	120
15	5.95	7.4	9	16	3.75	26	4.8	3.416	47	1.46	85
16	5.98	7.8	19	18	3	26	9.6	0	81	1.90	146
17	5.72	7.4	19	16	2.5	28	4.2	0	73	4.82	137
18	5.75	7.6	7	16	4.5	12	4.8	0	20	0.63	36
19	6.01	7.6	3	18	4	14	4.8	0	19	0.90	36
20	6.04	6.2	16	30	3.5	24	8	0	80	7.24	144
21	6.00	7.1	6	22	3	28	11.2	0	38	1.28	70

All values are expressed as mg/L, except pH and EC; pH in pH unit, EC: µ-s/cm at 25^o C.

Table 5. Sample Calculation of WQI in monsoon

WARD NO:1 MONSOON							
PARAMETERS	STNADARD VALUE	IDEAL VALUE	1/Sn	UNIT WEIGHT (Wn)	OBSERVED VALUES	QUALITY RATING(qn)	WEIGHTED (Wnqn)
PH	8.5	7	0.118	0.109	5.88	-74.667	-8.159
EC	300	0	0.003	0.003	65	21.667	0.0602
TDS	500	0	0.002	0.002	36	7.200	0.013
TOTAL ALKALINITY	120	0	0.008	0.007	14	11.667	0.086
CHLORIDES	250	0	0.004	0.004	10	4	0.015
TOTAL HARDNESS	300	0	0.003	0.003	14	4.667	0.013
DO	5	14.6	0.2	0.185	6.9	80.208	14.855
CALCIUM	75	0	0.013	0.012	4.8	6.400	0.077
MAGNESIUM	30	0	0.033	0.031	0.488	1.627	0.050
SULPHATE	150	0	0.007	0.006	3	2	0.013
NITRATE	45	0	0.022	0.020	0.22	0.489	0.010
				ΣWn=.3824			ΣWnqn=23.35
Water Quality Index=61.06							

Table 6.GWQI at each sampling station

MONSOON		
DESCRIPTION	WQI	REMARKS
OW1	61.06	GOOD
OW2	53.57	GOOD
OW3	58.72	GOOD
OW4	55.66	GOOD
OW5	50.47	GOOD
OW6	62.55	GOOD
OW7	57.49	GOOD
OW8	58.43	GOOD
OW9	54.79	GOOD
OW10	52.38	GOOD
OW11	50.95	GOOD
OW12	62.27	GOOD
OW13	58.34	GOOD
OW14	61.18	GOOD
OW15	58.26	GOOD
OW16	55.38	GOOD
OW17	62.56	GOOD
OW18	60.97	GOOD
OW19	55.1	GOOD
OW20	63.18	GOOD
OW21	58.2	GOOD

Table 7.GWQI at each sampling station

SUMMER		
DESCRIPTION	WQI	REMARKS
OW1	42.85	EXCELLENT
OW2	39.49	EXCELLENT
OW3	39.22	EXCELLENT
OW4	43.73	EXCELLENT
OW5	39.96	EXCELLENT
OW6	37.3	EXCELLENT
OW7	57.33	GOOD
OW8	57.96	GOOD
OW9	55.21	GOOD
OW10	52.6	GOOD
OW11	57.18	GOOD
OW12	59.92	GOOD
OW13	33.74	EXCELLENT
OW14	37.56	EXCELLENT
OW15	49.45	EXCELLENT
OW16	57.88	GOOD
OW17	61.61	GOOD
OW18	34.87	EXCELLENT
OW19	34.47	EXCELLENT
OW20	64.69	GOOD
OW21	48.76	EXCELLENT

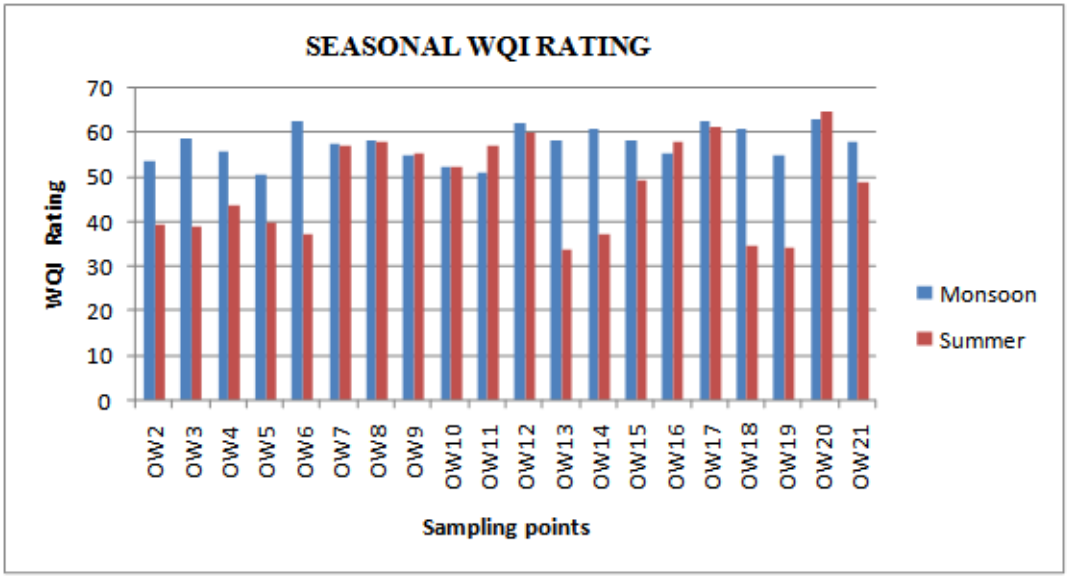

Figure 2 Seasonal WQI rating

V. RESULT AND DISCUSSION

The analytical results obtained for different study parameters such as pH, electrical conductivity, TDS, Alkalinity, Chlorides, Hardness, Dissolved oxygen, Calcium, Magnesium, Sulphate, Nitrate, Iron, Turbidity, Sodium, Potassium from different sampling locations in monsoon and summer of the year 2013-2014 as summarised in Table 3 & 4. Permissible limits and recommended agencies are described in Table 2. The results obtained for Monsoon and summer are discussed below.

pH of water is influenced by geology of the area buffering capacity of water. If the water has pH less than 7 may cause tuberculation and corrosion while higher the values may produce incrustation, sediment deposits

and difficulties in chlorination for disinfection of water. In the present study pH in all the sampling locations varied between 5.74 to 7.2 during monsoon and 5.65 to 6.41 during summer. The permissible limit of pH value of drinking water specified as 6.5 to 8.5 as per IS10500 standards. In some places pH value is slightly less than permissible limit.

TDS is an important parameter for drinking water and other uses. Water with high solid content is of inferior palatability and may produce unfavorable physiological reaction in the transient consumer. In the study TDS was found in the range of 23 mg/l to 125 mg/l during monsoon and 19 mg/l to 189 mg/l during summer. The permissible level of TDS is specified as 500 mg/l as per IS 10500 standards. Total hardness varied between 16 mg/l to 114 mg/l in monsoon and 12 mg/l to 66 mg/l in summer. Total hardness of water is characterised by content of calcium and magnesium salts. Calcium was 3.2 mg/l to 22.4 mg/l in monsoon season and in summer 4.2 mg/l to 22.4. In all sampling locations calcium and magnesium concentrations are within the IS 10500 standards.

Chloride concentrations in the all the sampling locations ranged between 5.79 mg/l to 50.16 mg/l in monsoon and 3 mg/l to 53 mg/l in the summer. The total chlorides observed are below the permissible limits. Nitrate varied between 0 mg/l to 5.67 mg/l during monsoon season and 0 mg/l to 7.24 mg/l during summer season. The values are found below the drinking standards. The range of electrical conductivity during monsoon varies from 46 µ-s/cm to 239 µ-s/cm and during summer season it varies from 36 µ-s/cm to 337 µ-s/cm. In some places value of electrical conductivity is above permissible limit. The total alkalinity during monsoon varies from 12 mg/l to 56 mg/l and during summer it varies from 8 mg/l to 60 mg/l. The values are within the permissible limit. Abnormal concentrations of sulphate may due to the presence of sulphate ore bodies like pyrite, lignite and coal. The desirable limit of sulphates in drinking water is 250 mg/l. The range of sulphate during monsoon season varies from 0.325 mg/l to 15.75 mg/l and during summer varies from 2.5 mg/l to 12 mg/l. Turbidity in water refers to the presence of suspended matter that interferes with the passage of light through water. Turbidity may be caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. Apart from affecting the aesthetics of water, turbidity interferes with effective filtration and disinfection of water .Limit of drinking water in case of absence of alternate source is 10 NTU, and the desirable limit is 5 NTU.Water Quality analysis of samples collected indicates that the turbidity ranges from 0 to 2 NTU during monsoon and 1.1 NTU to 13.5 NTU in summer. Dissolved oxygen is the factor that determines whether the biological changes are brought about by aerobic or by anaerobic organisms. The minimum dissolved oxygen in disinfection is 6 mg/l. Total dissolved oxygen ranges from 5.6 mg/l to 9 mg/l during monsoon and 6.2 mg/l to 7.8 mg/l during summer. The values obtained are within the permissible limit.

VI. GROUND WATER QUALITY ASSESSMENT

Water quality index (WQI) is one of meaningful approach in ground water and all other type of water like river, lake and surface water quality analysis. The values of WQI in all sampling locations were summarized in Table 6&7. The values of WQI in all sampling locations in monsoon and summer season were less than 100 indicating that the water is suitable for human use. On the basis of WQI the quality of water categorised from good to excellent. Hence the groundwater in the study area is suitable for drinking as well as irrigation purpose.

VII. CONCLUSION

At the outset, the overall WQI values computed in monsoon and summer falls between class I and II of Table 1, indicates that the water quality is good and suitable for drinking and other domestic purposes. Further the seasonal values of WQI indicate that in monsoon ground water is more affected than during summer. The seasonal variations of index values are due to variation in physicochemical characteristics of ground water. Application of WQI in this study has been found useful in assessing the overall quality of water. This method appears to be more systematic and gives comparative evaluation of the water quality in different seasons of the year. 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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