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Evaluation of Water Quality Index of Surface Water in Kuroorthodu River, Kothamangalam, Kerala, India

Dr. Jai M Paul[1], Jitto Jose[2], Liya Ann Suresh[2], Merin George[2], Syamkrishna P.S[2]
[1]Associate. Professor, Civil Engineering Department, M. A College of Engineering, Kothamangalam, India
[2]Students, Civil Engineering Department, M. A College of Engineering, Kothamangalam, India

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 12 physico-chemical parameters such as pH, Electric Conductivity, Total Alkalinity, Total Hardness, Chloride, Sulphate, Calcium, Magnesium, Nitrate, Fluoride, Dissolved Oxygen, Turbidity were taken to assess the impact of pollutants due to anthropogenic activities. The present work deals with the monitoring of variation of seasonal water quality index of some strategically selected points of Kuroorthodu river. The Water Quality Index value for the Surface water ranges from 8.6 to 190.9 during the monsoon season and 15.3 to 103.8 during the post-monsoon season.*

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

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I. Introduction

The availability of water both in terms of quality and quantity is essential for the very existence of mankind. Water, though indispensable and plays a pivotal role in our lives, is one of the most badly abused resources. Lack of awareness and civic sense, use of inefficient methods and technology lead to more than 50% of water wastage in the domestic, agriculture & industrial sectors. Water pollution is rendering much of the available water unsafe for consumption.

Surface water is the water that flows along the surface of the earth and is the second largest source of fresh water, the first being ground water. Precipitation, springs, melting of glaciers etc. are the major sources of surface water. The modern civilization, over exploitation, rapid industrialization and increased population has lead to fast degradation of our environment. There is heavy extraction of water for domestic, industrial and agricultural purpose. Age-old customs and habits of community, cattle bathing and washing in rivers are responsible for rampant pollution of river water. The release of domestic waste water, agricultural runoff water & industrial effluents promote excessive growth of algae in water bodies, which results in their eutrophication. 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 surface water 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.

Several states in the country are facing problems due to over exploitation of ground water resources and pollution of surface water. Its manifestations are declining per capita water availability, falling water tables and deterioration of water quality. Accurate information on the condition and trends of water resources quantity and quality is required as a basis for economic and social development, and for the development and maintenance of environmental quality. There has been increased interest and work over the past few years on the use of indicators to monitor change. Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. It, thus, becomes an important parameter for the assessment and management of surface water.

II. Literature Review

Lakshmi E. and Dr. G Madhu conducted water quality analysis in the river Periyar of Eloor-Edayar industrial stretch which has been a subject of pollution study for many years. Indexing of water quality variables was carried out using water quality index method developed by Canadian Council of Ministry of Environment (CCME). All sampling sites under investigation fell under the poor quality index range, with Kuzhikandam, site exhibiting the lowest. Water quality deteriorated, as river flows downstream especially towards the Eloor Ferry. Statistical correlation reveals that water quality index decreases with increase in calcium, sulphate, chloride, nitrate-n, total hardness, fluoride, conductivity and vice versa while water quality index increases with increase in pH and DO.

Sikder, M.T., Hosokawa, T., Gumiri, S., Ardianor, Uddin M.K., Tareq, S.M., Shammi, M., Kamal, A.K.I., and Kurasaki, M. conducted multi parameter water quality analysis at the Buriganga River, Shitalakshyaa River, Turag River and the Bongshi River in Dhaka, Bangladesh on January (Sikder et al., 2013), August (Sikder et al., 2012) and November, 2011. These three seasons were characterized as dry, monsoon and post monsoon, respectively. It was based on the 10 most prevailing parameters (pH, Conductivity, Nitrate ions, Phosphate ions, Escherichia coli number, Cadmium, Chromium, Lead, Copper and Manganese) with a scale of 1 to 4, wherein the grades are classified into 1: good; 1.1-1.5: slightly polluted; 1.6-2.0: moderately polluted; 2.1-2.9: heavily polluted and 3.0-4.0: gravely polluted. Water Quality index was found to be between 1.5 and 3 during all seasons.

G. Deepa, P. N. Magudeswaran carried out water quality studies in the Chitrapuzha river, Ernamkulam, Kerala, India. The investigation was carried out for determining the various physico-chemical parameters and biological characteristic of Chitrapuzha river for summer 2014 in Ernamkulam district. The following parameters were analyzed DO, FC, pH, BOD, Phosphate, Nitrates, Turbidity and TDS. All the measured parameters were found to be very high compared to limit prescribed by WHO, and thereby unfit for both drinking and irrigation. The water quality index of the samples ranged from 60 to 90.

Abdul Hameed M. Jawad Alobaidy, Bahram K. Maulood, Abass J. Kadhem analysed raw and treated water of Tigris river within Baghdad. The water treatment plants followed the traditional treatment process, in which raw water after aeration was treated with coagulant (alum and lime) and pre-chlorination as required. After flocculation, it was carried over to the sand bed filter for filtration. After this, bleaching powder or chlorine gas was added for disinfection to ensure the Residual Chlorine at the tail end was in the range of 0.2 to 0.5 mg/L. It was concluded that raw water was poorest in quality throughout the year and the efficiency of WTPs ranged from 25.07 to 63.30 in the whole period of study.

III. Study Area

The Kothamangalam municipality is located at coordinates 10°4′48″N and 76° 37′ 12″ E. It has an area of 37.45 km^2 and is divided into 31 electoral wards. Kothamangalam urban agglomeration has a total population of 114,574 according to the 2011 census, 56,753 being males and 57,821 females. There are 30,067 households in the Kothamangalam municipality. The Kuroorthodu river is an important source of fresh water in the municipality.

IV. Calculation of Wig

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

$q_n = 100[(V_n-V_{io})/(S_n-V_{io})]$			(1)
Where,			
q_n	=	quality rating for the n^{th} water quality parameter.	
V_n	=	observed value of the n^{th} parameter.	
Sn	=	standard permissible value of n^{th} parameter.	
Vio	=	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:

qpH	=	$100[(V_{pH}-7.0)/(8.5-7.0)]$
Where,		
VpH	=	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,			
	VDO	=	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, Bhaven et al. 2011 and Srinivasa Kushtagi et. al. 2012,).

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)	1/Sn	Recommended Agency	Unit Weight (Wn)
1	PH	8.5	0.118	ICMR/BIS	0.093
2	EC	300	0.003	ICMR	0.003
3	Turbidity	2	0.500	ICMR	0.395
4	Total Alkalinity	120	0.008	ICMR	0.007
5	Chlorides	250	0.004	ICMR	0.003
6	Total Hardness	300	0.003	ICMR/BIS	0.003
7	DO	5	0.200	ICMR/BIS	0.158
8	Fluride	1.5	0.667	BIS	0.527
9	Ca	75	0.013	ICMR/BIS	0.011
10	Mg	30	0.033	ICMR/BIS	0.026
11	Sulphate	200	0.005	ICMR/BIS	0.004
12	Nitrate	45	0.022	ICMR/BIS	0.018

Table 3 Observed values in monsoon

Sample no	pH	EC	Turbidity	Total alkalinity	Chlorides	Total hardness	DO	Fluoride	Ca	Mg	Sulphate	Nitrate
1	6.9	58	5.7	34	9.9	36	7.5	0.5	37.5	48	1.125	0
2	7	54	8.1	36	3.5	28	7.2	0.5	12.5	16	0.527	0

3	6.8	60	11.2	36	3.9	135.6	6.1	1	27.5	35.5	0.5	0
4	6.78	58	6.1	30	3.5	36	8.3	0.5	10	12.9	1.25	0
5	6.69	70	7.3	36	4.5	21.6	6.8	0.5	22.5	29.1	5	0
6	6.51	68	4.8	34	5.5	27.6	8.4	0.5	12.5	16	0.472	0
7	6.44	71	5.3	52	4.5	21.2	7.2	0.5	10	12.9	0.625	0
8	6.5	67	2.8	40	4.9	18	8.6	0.5	7.5	9.7	0.375	0

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 post monsoon season

Sample no	pH	EC	Turbidity	Total alkalinity	Chlorides	Total hardness	DO	Fluoride	Ca	Mg	Sulphate	Nitrate
1	5.66	57	5.7	28	8.5	24	8.1	0.5	14	17.8	3.75	0
2	5.13	82	6.3	16	15.5	14	7.8	1	7	8.9	2.5	0
3	4.7	81	6.4	14	16.5	16	6.4	1	27.9	35.65	2.7	0
4	3.49	260	6.1	0	35.5	18	7.7	0.5	29.7	37.87	2.7	0
5	3.42	280	5.1	0	37.5	24	7.2	1	19.2	24.51	3.75	0
6	3.91	141	5.9	42	25	24	8.9	0.5	29.7	37.87	2.75	0
7	5.31	64	4.1	46	10.5	20	6.3	1	17.4	22.28	6.5	0
8	5.78	57	3.4	54	7	28	8.9	0.5	19.2	24.51	7.5	0

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.

SAMPLE NO.					**1**		
Sl.No.	**Parameters**	**Standard Value (Sn)**	**1/Sn**	**Unit Weight (Wn)**	**Observed Values**	**Quality Rating (qn)**	**Weighted (Wnqn)**
1	PH	8.5	0.118	0.093	6.9	-6.667	-0.620
2	EC	300	0.003	0.003	58	19.333	0.051
3	Turbidity	2	0.500	0.395	5.7	285.000	112.604
4	Total Alkalinity	120	0.008	0.007	34	28.333	0.187
5	Chlorides	250	0.004	0.003	9.9	3.960	0.013
6	Total Hardness	300	0.003	0.003	36	12.000	0.032
7	DO	5	0.200	0.158	7.5	73.958	11.688
8	Flouride	1.5	0.667	0.527	0.5	-100.000	-52.680
9	Ca	75	0.013	0.011	37.5	50.000	0.527
10	Mg	30	0.033	0.026	48	160.000	4.214
11	Sulphate	200	0.005	0.004	1.125	0.563	0.002
12	Nitrate	45	0.022	0.018	0	0.000	0.000
			1.577	**1.246**			**76.017**
WATER QUALITY INDEX					**61.0**		

Table 6.WQI at each sampling station

MONSOON SEASON		
Sample No	WQI	REMARKS
1	61.0	GOOD
2	97.4	GOOD
3	190.9	POOR
4	62.9	GOOD
5	84.7	GOOD
6	41.1	EXCELLENT
7	50.1	GOOD
8	8.6	EXCELLENT

Table 7.GWQI at each sampling station

POST-MONSOON SEASON		
Sample No	WQI	REMARKS
1	51.6	GOOD
2	100.4	GOOD
3	103.8	POOR
4	49.3	GOOD
5	75	GOOD
6	46.7	EXCELLENT
7	69.6	GOOD
8	15.3	EXCELLENT

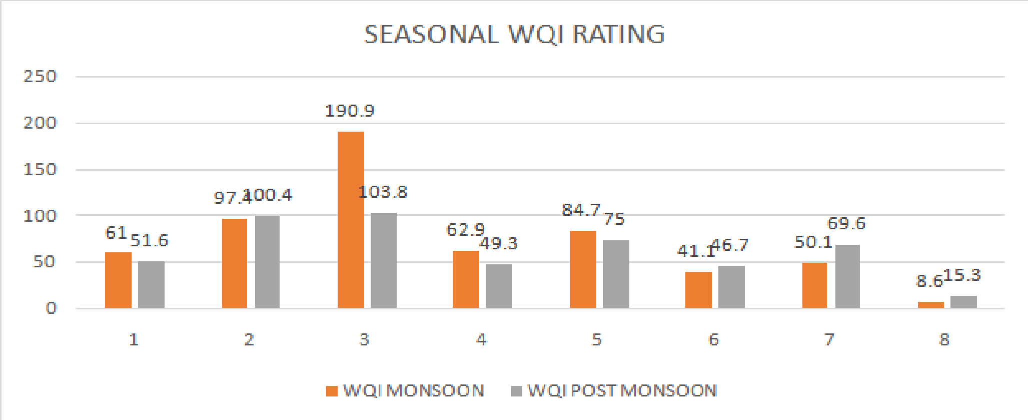

Figure 2 Seasonal WQI rating

V. Result and Discussion

The analytical results obtained for different study parameters such as pH, Electrical Conductivity, Alkalinity, Chlorides, Hardness, Dissolved oxygen, Calcium, Magnesium, Sulphate, Nitrate, Flouride, Turbidity from different sampling locations in monsoon and post-monsoon of the year 2017-2018 as summarised in Table 3 & 4. Permissible limits and recommended agencies are described in Table 2. The results obtained for Monsoon and post-monsoon 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 6.44 to 7 during monsoon and 3.42 to 5.78 during post-monsoon. The permissible limit of pH value of drinking water specified as 6.5 to 8.5 as per IS-10500 standards. In some places pH value is slightly less than permissible limit.

Total hardness varied between 18 mg/L to 135.6 mg/L in monsoon and 14 mg/L to 28 mg/L in post-monsoon. Total hardness of water is characterised by content of calcium and magnesium salts. Calcium was 7.5 mg/L to 37.5 mg/L in monsoon season and in post monsoon 7 to 29.7 mg/L. In all sampling locations calcium and magnesium concentrations are within the IS-10500 standards.

Chloride concentration in the all the sampling locations ranged between 3.5 mg/L to 9.9 mg/L in monsoon and 7 mg/L to 37.5 mg/L in post-monsoon. The total chlorides observed are below the permissible limits.

The range of electrical conductivity during monsoon varies from 54 µ-s/cm to 71 µ-s/cm and during post-monsoon season it varies from 57 µ-s/cm to 280 µ-s/cm. The values are found below the drinking standards.

The total alkalinity during monsoon varies from 34 mg/L to 52 mg/L and during post-monsoon it varies from 0 mg/L to 54 mg/L. The values are within the permissible limit. Nitrate content is absent in all the samples collected.

The desirable limit of sulphates in drinking water is 250 mg/L. The range of sulphates during monsoon season varies from 0.325 mg/L to 1.25 mg/L and during post-monsoon varies from 2.7 mg/L to 7.5 mg/L. The fluoride content varies between 0 mg/Land 1 mg/L for all the samples which is within the permissible limit of 1.5 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. Turbidity limit of drinking water in case of absence of alternate source is 10 NTU, and the desirable limit is 5NTU.Water Quality analysis of samples collected indicates that the turbidity ranges from 2.8 to 11.2 NTU during monsoon and 3.4 NTU to 6.4 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 6.1 mg/L to 8.6 mg/L during monsoon and 6.3 mg/L to 8.9 mg/L during post-monsoon. The values obtained are within the permissible limit.

VI. Surface Water Quality Assessment

Water quality index (WQI) is one of the meaningful approaches in surface water and ground water quality analysis. The values of WQI in all sampling locations are summarized in Table 6&7. The values of WQI in 2 sampling locations are less than 50 during monsoon and post-monsoon season indicating that the water is of excellent quality. One location has water quality of 190.9 during monsoon and 103.8 during post-monsoon. The rest of the samples have water quality between 50 and 100. On the basis of WQI the quality of water is categorised from good to excellent.

VII. Conclusion

At the outset, the overall WQI values computed in monsoon and post-monsoon falls between class I and II of Table 1 at all sample points except one, indicating that the water quality is good and suitable for drinking and other domestic purposes after conventional treatment. At the third sampling point (10°04’05”N,76°37’22”E), the water quality ranges from 100 and 200 indicating poor water quality. The seasonal variations of index values are due to variation in physicochemical characteristics of surface 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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