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A Modified Water Quality Index for Ponds Connected with River Noyyal, Coimbatore, India

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The present investigation was carried out for determining the various physico-chemical and biological characteristics of surface water quality of ponds connected with river Noyyal at Coimbatore, India. The sampling points were selected on the basis of their importance. Four sampling locations namely, at source, Ukkadam pond, Singanallur lake and Sulur pond were selected and water samples were collected mostly from open wells at Noyyal river basin in and around Coimbatore district. For surface water determination of water quality index is essential and prerequisite. Among the several methods of water quality determination, the widely used is the index of National Sanitation Foundation water quality index (NSF-WQI) which has been followed in this present study. The physico-chemical and biological parameters include dissolved oxygen, pH, biochemical oxygen demand, phosphate, nitrates, turbidity, total dissolved solids and fecal coliforms counts were analyzed. The correlation coefficients between physico-chemical and biological parameters were calculated to establish a linear relationship between parameters. Highly correlated parameters are identified and linear relationship was developed by using regression analysis. These calculations are also carried out between stations. All the measured parameters except in river Noyyal at source (S_1) were found to be very high especially during summer season compared to limits prescribed by WHO and thereby it is suggested unfit for public use.

Keywords: Noyyal river, Surface water, Water quality index, Correlation and regression, National sanitation foundation.

INTRODUCTION

The surface water quality is a matter of serious concern today. Due to their role in carrying off the municipal and industrial wastewater and run-off from agricultural land in their vast drainage basins, rivers are among the most vulnerable water bodies to pollution. The surface water quality in a region is largely determined both by the natural processes and anthropogenic influences of urban, industrial and agricultural activities and increasing exploitation of water resources [1]. Surface water quality in a region is largely determined in terms of its physical, chemical and biological parameters [2].

Today, the largest cities with highly developed industry are built along the river basins. Large quantities of hazardous wastes often come out as a result of industrial production when improperly stored, can spread to the environment. Physico-chemical features of water play an important role in structure and functioning of the lade ecosystem [3]. Water is one of the most abundant compounds found in nature as it covers three-fourths of surface of the earth [4]. Attention on water contamination and its management has become a need of the hour as it has reaching impact on human health [5-8]. Continuous assessment of physical, chemical and biological parameters of water is an essential part of current water quality control programs. These efforts lead to accumulation of considerable information which cannot usually produce direct judgmental determination of water quality [9].

A systematic study of correlation and regression coefficients of the water quality parameters not only helps to assess the overall water quality, but also to quantify relative concentration of various pollutants in water. This provides the necessary information which may be used in water quality management programmes [10-16].

The present study has been carried out to evaluate the water quality characteristics of ponds connected with river Noyyal at Coimbatore, India using water quality index (WQI-NSF) method. Also the relation between various surface water quality parameters has been derived by using regression analysis. Regression models based on observed surface water quality parameters provide general indication of the quality of pollution loads on relative magnitude of loads. This approach is also useful to detect changes in water quality constitutions within the system.

Study area: The river Noyyal, a tributary of Cauvery originates from Velliangiri hillocks on the Western Ghats in Tamil Nadu, India and drains in to Cauvery river. This cuts through the states of Karnataka, Tamil Nadu and enters Bay of Bengal. It flows through Coimbatore, Tirupur, Erode and Karur districts. The Noyyal river basin covers a total area of 3510 km^2 and extents about 170 km from west to east. The average width of the basin is 25 km and the annual rainfall varies extensively. River Noyyal is a seasonal river flooded during monsoon season and reduces to small pools during summer season. The river supplies water to several tanks located in and around Coimbatore. The area of land irrigated by river in Coimbatore district is approximately 1600 acres [17].

Coimbatore big lake also known as "Ukkadam pond" is situated close to Ukkadam bus-stand Coimbatore. The capacity of the tank is 69.95 mc.ft and depth is 19.10 feet and the tank is located to the north of the river Noyyal. During the rainy season adequate quantity of water is flooded in to the tank from river Noyyal and thereby helping the fisherman societies in carrying out fishing [18].

Singanallur lake is situated at the right side of the Coimbatore. The bund on the lake is over 3 km long and catchment area is 11.776 sq. miles; water spread area 1.153 sq.km with maximum flood discharge of 100.95 cu.sec. The catchment area collects rain water during monsoon season. It has a capacity of 52.27 mc.ft with a depth of 13.95 feet [19]. The major cause of pollution is due to drainages from Sanganur, industrial effluents, sewage, municipal solid wastes, *etc.*

The Sulur fresh water pond also known as Sulur lake is situated in Sulur town panchayath, 25 km east of Coimbatore city. The pond receives water from the catchment areas of Western Ghats through river Noyyal during rainy seasons. The total depth of the pond is 13.05 feet and an area of about 0.480 sqkm. The total water holding capacity of the pond is 32.21 million cu.ft. Nearly 750 acres of Sulur village gets irrigation facilities from the pond [20].

EXPERIMENTAL

The sample locations were in both rural and urban area Surface water samples were collected from four stations around Coimbatore district *viz.*, river Noyyal at source (S_1), Ukkadam pond (S_2), Singanallur Lake (S_3) and Sulur pond (S_4) during rainy and summer season between 2013-2014. Samples were collected in plastic bottles for physico-chemical purpose and in sterilized glass bottle for bacteriological quality to avoid unpredictable changes in the characteristics.

Methods of analysis: pH was measured using Digital pH meter. Dissolved oxygen and biochemical oxygen demand was measured using Winkler's titrimetric method. The multiple-tube fermentation method was used to determine the presence of bacteria. The confirmed and complete test was carried out for the samples by using the nutrient froth. The turbidity was measured by using Digital Turbidity meter, 863D 'Bio-Chem make. The evaporation method is used for determining the total solids by using standard procedures and Nitrate ion was determined using Brucine method. To determine the total phosphorus stannous chloride method is used by following the established procedure [21].

Statistical analysis: To establish a relationship between two water quality parameters such that the changes in the values of one parameter cause the change in the other parameters. The correlation coefficient (ρ) between each pair of parameters is calculated using eqn. 1. It gives a rough but fairly useful indication of the water quality and also facilitates a rapid monitoring of the status of water pollution.

$$\rho = \frac{E(XY) - E(X)E(Y)}{\sigma_X \sigma_Y} \quad (1)$$

where,

$$E(X) = \frac{\Sigma x}{n},\ E(Y) = \frac{\Sigma y}{n},\ E(XY) = \frac{\Sigma xy}{n},\ E(X^2) = \frac{\Sigma x^2}{n}$$

$$\sigma_X = \sqrt{E(X^2) - [E(X)]^2} \text{ and } \sigma_Y = \sqrt{E(Y^2) - [E(Y)]^2}$$

σ_X = standard deviation of X, σ_Y = standard deviation of Y and n = number of samples.

If the values of correlation coefficient (ρ) between two parameters say X and Y are fairly large implies that these two parameters are highly correlated. In such cases, it is feasible to try lines of regression of the form given in eqn. 2.

$$Y - E(Y) = \frac{\rho \sigma_y}{\sigma_X}[X - E(X)] \quad (2)$$

RESULTS AND DISCUSSION

The physico-chemical and biological characteristics of the water samples in different seasons are given in Table-1 along with the respective water quality index value. The water quality index was calculated using the eight parameters. The eight resulting values were then added to an overall water quality index [22].

Water quality index = 0.19 Dissolved oxygen + 0.18 Faecal coliform + 0.12 pH + 0.12 BOD + 0.11 Total phosphate + 0.11 Nitrates + 0.09 Turbidity + 0.08 Total solids

The sampling station S_1 in the Western Ghats of Coimbatore is considered to be the source point of river Noyyal and it has greater dissolved oxygen value 95.50 and 94 % saturation during rainy and summer season, respectively. As expected, with the river reaching plains and travelling a distance of about 30 km, the dissolved oxygen value starts lowering and reaches 84 and 80 % saturation during rainy and summer season, respectively at Sulur pond (S_4). The reason for decrease in dissolved oxygen from 95.50 to 84 % during rainy season and from 94 to 80 % during summer season is owing to the discharge of industrial effluents and domestic wastewater into the river stream especially at Sulur pond (S_4). Low percentage of saturation of dissolved oxygen has affects the fish community on the whole, especially during spawning period because the respiratory system requires dissolved oxygen to breath [23,24].

Faecal coliform count refers to the presence of domestic sewage concentration in water. It is seen that there is a steady increase in concentration of faecal coliforms from S_1 to S_4 during both rainy and summer season indicating that certainly domestic sewage is let into the river stream. At Sulur pond (S_4) there is comparatively maximum coliforms during rainy

TABLE-1
PHYSICO-CHEMICAL CHARACTERISTICS OF WATER SAMPLES COLLECTED FROM DIFFERENT STATIONS OF RIVER NOYYAL DURING RAINY AND SUMMER SEASONS (2013)

Parameters	Rainy season				Summer season			
	River Noyyal-Source (S_1)	Ukkadam Pond (S_2)	Singanallure Lake (S_3)	Sulur Pond (S_4)	River Noyyal-Source (S_1)	Ukkadam Pond (S_2)	Singanallure Lake (S_3)	Sulur Pond (S_4)
DO (% saturation)	95.50	91	86.20	84	94	90	83.20	80
FC (MPN/100 mL)	2.00	20.10	38.10	165	3.00	82	105	203
pH	7.20	7.32	7.50	8.70	7.35	7.60	7.38	8.20
BOD (mg/L)	0.80	3.95	4.80	4.60	0.85	4.50	6.50	5.20
P (mg/L)	0.25	1.45	1.40	2.0	0.40	1.65	2.10	2.8
N (mg/L)	0.50	3.80	4.00	4.50	0.68	4.50	5.20	6.20
Turbidity (NTU)	2.00	14.00	16.00	35	1.75	14.6	19.00	48
TDS (mg/L)	58.50	550	450	670	72.00	620	690	780
Water quality index	93.13	67.53	65.85	54.84	90.49	62.61	58.83	53.25

and summer season because of free flow of sewage into the river.

For potable water, the BIS, WHO and ICMR standards have prescribed the limiting value of pH between 6.50 to 8.50. In all these samples, pH value ranged between 7.20 to 8.20. The results obtained from analysis of water samples of river Noyyal at various stations in the study areas are shown in Table-1.

The minimum biochemical oxygen demand in river Noyyal at source (S_1) 0.80 mg/L and 0.85 mg/L was observed during rainy and summer season, respectively and the maximum value of biochemical oxygen demand was observed in Sulur pond (S_4) 4.60 mg/L and 5.20 mg/L during rainy and summer season, respectively.

In the present study, the concentration of phosphate in river Noyyal was found to be ranging from 0.25 to 2.8 mg/L. Among the four sampling stations, S_4 showed high phosphate content when compared to other stations during both rainy and summer season. The high concentration of phosphate in S_2, S_3 and S_4 may be due to human and animal waste that are flushed into water ways, either from poorly treated sewage, surface runoff or some industrial waste that carries phosphorous into the river which eventually has a considerable effect on the quality of river [25].

In the present study, the nitrate concentration in surface water samples ranged between 0.50 to 6.20 mg/L. The amount of nitrate found to be high at Sulur pond (S_4) 4.50 to 6.20 mg/L compared to Singanallur Lake (S_3) 4.00 to 5.20 mg/L and Ukkadam pond (S_2) 3.80 to 4.50 mg/L and source (S_1) 0.50 to 0.68 mg/L during rainy and summer season, respectively.

The measurement of turbidity of water is useful in monitoring proper filtration and to determine the effectiveness of treatment process with different dosages of chemicals [26]. In the present study, the water from river Noyyal at source (S_1) has good turbidity 2 NTU and 1.75 NTU during rainy and summer season, respectively. While other samples at S_2, S_3 and S_4 shows 14.00 NTU and 14.6 NTU, 16.00 NTU and 19.00 NTU, 35 NTU and 48 NTU during rainy and summer season are shown in Table-1.

According to WHO the permissible limit of total dissolved solids for drinking water is < 500 mg/L [27]. In the present study, the minimum value of total dissolved solids was found in a range of 58.50 to 72.0 mg/L at S_1 during rainy and summer season, respectively. The maximum value was found in a range 670 to 780 mg/L at S_4 during rainy and summer season, respectively (Table-1).

TABLE-2
CORRELATION BETWEEN PHYSICO-CHEMICAL CHARACTERISTICS OF SURFACE WATER IN RAINY AND SUMMER SEASONS (2013)

Parameters	DO	FC	pH	BOD	N	P	Turbidity	TDS
Rainy season								
DO	1							
FC	-0.8064	1						
pH	-0.7931	0.9995	1					
BOD	-0.9014	0.5480	0.5241	1				
P	-0.9089	0.7714	0.7516	0.9272	1			
N	-0.9111	0.6744	0.6520	0.9758	0.9860	1		
Turbidity	-0.9070	0.9571	0.9479	0.7572	0.9225	0.8585	1	
TDS	-0.8420	0.7073	0.6854	0.9110	0.9898	0.9769	0.8775	1
Summer season								
DO	1							
FC	-0.9384	1						
pH	-0.6763	0.8739	1					
BOD	-0.8280	0.7262	0.3223	1				
P	-0.9577	0.9724	0.7469	0.8661	1			
N	-0.9035	0.9168	0.6540	0.9240	0.9811	1		
Turbidity	-0.9005	0.9846	0.9292	0.5992	0.9175	0.8332	1	
TDS	-0.8016	0.9101	0.7617	0.8052	0.9396	0.9617	0.4545	1

TABLE-3
CORRELATION BETWEEN VARIOUS STATIONS OF SURFACE WATER OF RIVER NOYYAL DURING RAINY AND SUMMER SEASONS (2013)

Stations	Rainy season				Summer season			
	River Noyyal-Source (S_1)	Ukkadam Pond (S_2)	Singanallure Lake (S_3)	Sulur Pond (S_4)	River Noyyal-Source (S_1)	Ukkadam Pond (S_2)	Singanallure Lake (S_3)	Sulur Pond (S_4)
River Noyyal-Source (S_1)	1				1			
Ukkadam Pond (S_2)	0.5545	1			0.6207	1		
Singanallure Lake (S_3)	0.5673	0.9988	1		0.6167	0.9974	1	
Sulur Pond (S_4)	0.4738	0.97849	0.9819	1	0.5508	0.9891	0.9955	1

TABLE-4
LINEAR CORRELATION COEFFICIENT AND REGRESSION EQUATION FOR SOME PAIRS OF PARAMETERS DURING RAINY AND SUMMER SEASONS (2013)

Pair of parameters	Rainy season				Summer season			
	Correlation coefficient	Regression coefficient		Regression equation	Correlation coefficient	Regression coefficient		Regression equation
		a	b			a	b	
pH and FC	0.9995	106.96	-765.12	FC = 106.96 pH - 765.12	0.9846	0.23	-2.10	TUR = 0.23FC -2.10 6.81
FC and TUR	0.9571	0.18	6.81	TUR = 0.18 FC + 6.81	0.9292	0.019	7.24	pH = 0.019TUR + 7.24
TUR and P	0.9225	0.0497	0.44	P = 0.0497 TUR + 0.44	0.7617	585.8	-3975.7	TDS = 585.8 pH - 3975.7
P and BOD	0.9272	2.359	0.55	BOD = 2.359 P + 0.55	0.9617	0.008	0.35	N = 0.008TDS + 0.35
BOD and DO	-0.9014	-2.49	97.97	DO = -2.49 BOD + 97.97	0.9811	0.41	0.036	P = 0.41N + 0.036
DO and N	-0.9111	-0.34	33.36	N = -0.34 DO + 33.36	-0.9577	-6.03	97.28	DO = -6.03P + 97.28
N and TDS	0.9769	136.17	-13.84	TDS = 136.17N -13.84	-0.8280	-0.315	31.63	BOD = -0.315DO + 31.63

TABLE-5
LINEAR CORRELATION COEFFICIENT AND REGRESSION EQUATION BETWEEN STATIONS DURING RAINY AND SUMMER SEASONS (2013)

Pair of stations	Rainy season				Summer season			
	Correlation coefficient	Regression coefficient		Regression equation	Correlation coefficient	Regression coefficient		Regression equation
		a	b			a	b	
S_2 and S_3	0.9988	0.81	5.97	$S_3 = 0.81S_2 + 5.97$	0.9974	0.816	8.19	$S_3 = 0.816S_2 + 8.19$
S_3 and S_4	0.9819	1.46	10.80	$S_4 = 1.46\ S_3 + 10.80$	0.9955	1.530	0.32	$S_4 = 1.53S_3 + 0.32$

Correlation between physico-chemical and biological characteristics is given in the Table-2. The parameters having correlation coefficient (ρ) numerically greater than or equal to 0.8 is considered for establishing a relation between them. The correlation coefficients between the stations are shown in Table-3. It is observed that the mean differences between the observed and expected values of the water quality parameters are less, which is approximately 1.5 %. It is also notes that the correlation coefficient among the parameters in S_1, S_2 and S_3 are fairly large. Also, it is clear that the parameters having positive correlation indicates the increase in one parameter increases the value of the other whereas negative correlation shows that the increase in one decrease the other. Table-4 indicate the linear relation between the parameters in rainy and summer seasons, respectively and Table-5 shows the relation between the stations. It is observed that the errors obtained by predicting approximate values of the parameters using these linear relations are less than 3 %.

Based on the statistical analysis, the researcher explicitly found that one station's values of water quality parameters is being analyzed means the other two stations value can be easily determined.

Conclusion

River water pollution is not only an aesthetic problem, but a serious economic and public health problem as well. The river Noyyal which flows from its source (S_1) across Coimbatore through Ukkadam pond (S_2), Singanallur Lake (S_3) and Sulur pond (S_4), presented a perceptible change in its water quality in this stretch. A slow and definite decrease in water quality index (WQI) values from S_1 to S_4 indicate that the water has been polluted by industrial effluents, domestic sewage, agricultural runoff and other human activities. Regular monitoring of river and taking suitable remedial measures like collection of domestic sewage and setting up the common treatment plant before discharge of sewage in to river system is required. This will control pollution and prevent the depletion of the quality of Noyyal river water and its connected tanks. It is found that all the parameters under consideration are mostly correlated and the corresponding linear model can be established using regression analysis. The linear relationship between the parameters of river water samples is very useful to get fairly accurate idea of quality of the river water by determining a few parameters experimentally.

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REFERENCES

1. K.P. Singh, A. Malik and S. Sinha, *Anal. Chim. Acta*, **538**, 355 (2005).
2. H. Boyacioglu, *Water SA*, **32**, 389 (2006).
3. I.D. Okram, B.M. Sharma and E. Singh, *J. Environ. Biol. Conserv.*, **8**, 13 (2003).
4. S.K. Beebi, A.S. Dadhich and P. Arunakranti, *Nat. Environ Pollut. Technol.*, **3**, 303 (2004).
5. V.S. Shrivastava, *Ind. J. Environ. Prot.*, **12**, 581 (1992).
6. V.S. Shrivastava, *Ind. Pollut. Res.*, **15**, 315 (1996).
7. T.B. Singh, B. Indu and S. Devendra, *Pollut. Res.*, **18**, 111 (1999).
8. D.K Sinha and A.K. Srivastava, *Indian J. Environ. Health*, **37**, 205 (1995).
9. M. Sharife, Proceedings Beijing Symposium, October, IAHS Publ. No. 197 (1990).
10. Y.D. Ravichandra and K. Ramakrishnan, *Asian J. Chem.*, **19**, 2679 (2007).
11. K. Jothivenkatachalam, A. Nithya and S. Chandramohan, *Rasayan J. Chem.*, **3**, 649 (2010).
12. F. Maqbool, A.H. Malik, Z.A. Bhatti, A. Pervez and M. Suleman, *Pak. J. Agric. Sci.*, **49**, 95 (2012).
13. K.K. Yadav, N. Gupta, V. Kumar, S. Arya and D. Singh, *Recent Res. Sci. Technol.*, **4**, 51 (2012).
14. M.M. Heydari, A. Abasi, S.M. Rohani and S.M.A. Hosseini, *Middle-East J. Scient. Res.*, **13**, 1238 (2013).
15. Aziz-ur-Rahman and O.C. Muhammad, *African J. Environ. Sci. Technol.*, **8**, 86 (2014).
16. S. Gummadi, G. Swarnalatha, Z. Vishnuvardhan and D. Harika, *IOSR J. Environ. Sci. Toxicol. Food Technol.*, **8**, 27 (2014).
17. M. Palanivel and P. Rajaguru, Proceedings of the Workshop on Environmental Status of the River Tamil Nadu, India, p. 53 (1999).
18. G. Nirmaladevi, M. Jeyaraj and P.N. Magudeswaran, *J. Biosci.*, **1**, 100 (2014).
19. M. Jeyaraj, G. Nirmaladevi and P.N. Magudeswaran, *Int. J. Res. Develop. Technol.*, **2**, 2349 (2014).
20. S. Umavathi, K. Logankumar, S. Subhashini and S. Logaswamy, *Nat. Environ. Pollut. Technol.*, **6**, 491 (2007).
21. APHA, Standard methods for the Examination of Water and Wastewater, American Public Health Association, Washington, DC, vol. 86, 1216 (1995).
22. P.N. Magudeswaran, Ph.D. Thesis, Water Quality Assessment of Noyyal River, Bharathiyar University, Coimbatore, India (2004).
23. A. Jammel, *Pollut. Res.*, **17**, 111 (1998).
24. E. Huge, *J. Water Resour. Res.*, **123**, 2227 (1987).
25. Indian Standards Tolerance Limits for Inland Surface Water Subjected to Pollution (1982).
26. M.M. Wani, *Indian J. Environ. Prot.*, **22**, 121 (2002).
27. WHO, Guidelines for Drinking Water Quality, Geneva, Switzerland (1984).