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Original Research Paper

Microbial Diversity and Water Quality Index in Temple Ponds of Udupi District, Karnataka, India

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ABSTRACT

Microbes in freshwater quite often change its quality and render it unfit for human use. Among these, planktonic algae play a major role. The Canadian Council of Ministers of the environment (CCME) formulated a water quality index (WQI) to facilitate evaluation of surface water quality for protection of aquatic life with specific guidelines. It includes scope (F1), frequency (F2), and amplitude (F3), with a table of values ranging between 0 and 100 determining nature of the index. This index was applied to four temple ponds of Udupi district and the surface water in all four was characterized as poor (values ranged between 37 and 40). According to the index the water quality is almost always endangered. The conditions usually deviate from normal levels. The reasons for this is the variation in total acidity, dissolved oxygen, free carbon dioxide and the overgrowth of bacteria. About 17 algal species and 7 fungal species occurred in these ponds. The reasons for the varied conditions may be attributed to the fluctuation of the number of the devotees visiting the ponds during festival seasons.

INTRODUCTION

Water Quality Index indicates the quality of water for any intended use. It is defined as a rating, reflecting the composite influence of different water quality parameters on the overall quality of water. With an intention of protecting aquatic life the Canadian Council of Ministers of the Environment (CCME) formulated a Water Quality Index (WQI) with specific guidelines.

The sampling protocol requires at least four parameters sampled at least four times. The findings must reflect the water quality in a given water area as accurately as possible. Water quality guidelines are numerical values that define physical, chemical or biological characteristics of the water that cannot be exceeded without causing harmful effects. During a detailed study of temple ponds of Udupi district, considerable variations in water quality were recorded. Bacterial population was extremely high while planktonic algae dominated the ponds. The present study is aimed at determining the relation between the Water Quality Index (WQI) and the microbial diversity and also the suitability of the pond water for human use.

MATERIALS AND METHODS

Udupi is one of the coastal districts of Karnataka, situated between 13°05'N to 13°35'N and 74°41'E with an extended geographical area of 929 square km. It is a place of religious importance and is well known for its "Sri Krishna Temple". The four temple ponds studied are located in Udupi district. They are Sri Krishna temple pond, Udupi (VT1), Sri Anegudde Vinayaka temple pond, Kumbhasi

(VT2), Sri Kotilingeshwara temple pond, Koteshwara (VT3) and Sri Kundeshwara temple pond, Kundapura (VT4). The description and location of these ponds are presented in Table 1.

Water samples for the analyses of the physicochemical complexes were collected during December 2007 to March 2008 at monthly intervals. Standard methods were used for the determination of various parameters (APHA 1995). IS: 10500 (1991) standards were used as objective values. Determination of the total bacterial count was done by standard plate count technique (Aneja 2004). Fungi were isolated (Aneja 2004) and identified by the method of Barnette & Hunter (1972). Planktonic algae were collected and sedimented as per the method described by Welch (1952), and identified after making camera lucida drawings with the help of Monographs by Desikachary (1959), Prescott (1952) and Philipose (1960).

Calculation of the CCME-WQI: Scope (F1) is the number of parameters that are not compliant with water quality guidelines; frequency (F2) number of times that the guidelines are not respected and amplitude (F3) the difference between non-complaint measurements and the corresponding guidelines. The square of each term and the square root of the sum are divided by 1.732 and are based on the fact that each of the three factors contributing to the index can reach the value of 100. The final value is subtracted from 100. The index produces a value from 0 to 100 and the WQI is characterized as 95.0 to 100: excellent, 80-94.9: good, 65 to 79.9: fair, 45.0 to 64.9: marginal and 0.0 to 44.9: poor.

$$\text{CCME WQI} = 100 - \frac{\sqrt{F1^2 + F2^{2+} F3^2}}{1.732}$$

$$F1 = \frac{\text{Number of failed parameters}}{\text{Total number of parameters}}$$

$$F2 = \frac{\text{Number of failed results}}{\text{Total number of results}}$$

F3 is asymptotic function, representing normalized sum of excursions (nse) in relation to guidelines.

$$F3 = \frac{\text{nse}}{0.1 \times \text{nse} + 0.01}; \quad \text{nse} = \frac{\sum \text{excursions}}{\text{Total No. of results}}$$

Excursions are calculated as follows:

$$\text{Excursion 1} = \frac{\text{Failed test result}}{\text{Guideline}} - 1$$

$$\text{Excursion 2} = \frac{\text{Guideline}}{\text{Failed test result}} - 1$$

Excursion 3 = if guideline is zero (equal to zero): failed test result.

The values of the index are given in Table 2.

RESULTS AND DISCUSSION

Analytical results of the physicochemical parameters, objective values and total bacterial population are presented in Table 3. The calculated CCME WQI values are presented in Table 4. In each pond 16

Table 1: Details of the four temple ponds.

Properties	VT1	VT2	VT3	VT4
Location	Nearest to the temple	Both side of temple	Left side of temple (50 metres apart)	Front side of temple (50 metres apart)
Catchment Area	Pond origin	Pond origin	Pond origin and paddy field	Pond origin
Depth	20 feet	10 feet	25 feet	15-20 feet
Aquatic vegetation	nil	Little algae	*Hydrilla, Vallisnaria*	Little algae
Aquatic fauna	Fishes	Fishes	Fishes	Rich in Fishes
Usage of water	Priest and Matt students bath, washing of pooja utensils	Priest and family use, washing of pooja utensils	Priest usage, washing of pooja utensils	Not in usage

VT1 - Sri Krishna temple pond, Udupi; VT2 - Sri Anegudde Vinayaka temple pond, Kumbhasi; VT3 - Sri Kotilingeshwara temple pond, Koteshwara; VT4 - Sri Kundeshwara temple pond, Kundapura

Table 2: CCME value categorization.

Rating	CCME WQI	Characterization
Excellent	95.0-100	Water Quality intact. Condition close to natural levels
Good	80-94	Water Quality is protected with only a minor degree of threat or impairment, conditions rarely depart from natural desirable levels.
Fair	65.0-79.9	Water Quality usually intact, but occasionally endangered, conditions often deviate from natural levels.
Marginal	45.0-64.9	Water Quality frequently endangered. Conditions often deviate from natural levels.
Poor	0.0-44.9	Water Quality almost always endangered, conditions regularly deviate from normal levels.

parameters deviate from the objective values. Chemical Oxygen Demand (COD) values were low and treated as negligible. As a result of the variations the values of the Water Quality Index attained a numerical value of 37 and 40 in all the four ponds. The pond water according to Table 2 is characterized as poor. Sri Krishna Temple Pond reached a highest value of 40 and was the most polluted, while in the other ponds the WQI ranged between 37 and 39. The water quality in all the four temple ponds is almost endangered and conditions in them usually deviate from the normal values.

Free carbon dioxide and the dissolved oxygen are almost equally contributing as a main source of deviating parameters, which is an indication that microorganisms in the pond are in excess. The total acidity is also very high, and bacterial population is always beyond the prescribed limits in all the four temple ponds.

The distribution pattern of microorganisms in the pond is presented in Table 5. Two species of Cyanophyceae, five species each of Chlorophyceae, Bacillaryophyceae and Desmidaceae were recorded in these ponds. The diversity was highest in Sri Krishna Temple Pond, Udupi. A few species of fungi like *Aspergillus, Fusarium, Penicillium* and yeasts were also present, indicating the extent of pollution in the water bodies.

According to Palmer (1969), Kumar (1990) and Hosmani (1975) excessive growth of certain algae like *Anabaena, Microcystis* and *Scenedesmus* is known to indicate nutrient enrichment in waters. Goldman & Horne (1983) concluded that some diatoms grow well in polluted waters, while temperature and light intensity regulate seasonal appearance of algal blooms. Venkateswarlu (1986) opines that increase in average number of Bacillaryophyceae reflects bad quality of water. Low num-

Table 3: Physicochemical parameters in four temple ponds of Udupi (December 2006 to March 2007).

Sl.No.	Parameter	VT1				VT2				VT3				VT4				Objective Value
		Dec.	Jan.	Feb.	Mar.	Dec.	Jan.	Feb.	Mar.	Dec.	Jan.	Feb.	Mar.	Dec	Jan.	Feb.	Mar.	
01	Temperature (°C)	17.0	21.0	21.3	19.0	18.6	23.0	22.0‘	20.0	20.0	24.3	20.0	17.2	21.5	21.6	19.5	24.0	25.0
02	pH	6.8	6.8	6.8	6.4	7.1	7.4	7.0	7.2	7.8	8.0	7.9	8.1	7.2	7.9	7.2	7.5	8.5
03	Total Acidity (mg/L)	9.8	10.2	10.3	10.4	10.1	10.7	11.4	10.7	12.3	12.3	12.3	12.4	11.9	11.8	9.8	12.1	6.5
04	Total Alkalinity (mg/L)	20.6	23.4	21.2	21.5	25.3	19.2	22.8	24.3	23.5	19.9	23.4	22.5	20.7	22.9	19.4	21.7	20.0
05	Dissolved Oxygen (mg/L)	8.9	8.9	9.4	9.4	9.8	10.4	9.8	9.9	9.3	10.9	9.2	9.5	10.3	9.5	10.4	10.0	5.0
06	Biochemical Oxygen Demand (mg/L)	2.4	1.9	2.3	2.5	2.6	2.3	3.2	2.7	2.9	2.8	2.9	2.8	2.0	2.2	2.6	2.2	5.0
07	Free Carbon Dioxide (mg/L)	9.8	10.9	10.4	10.3	10.3	11.5	10.8	10.9	10.9	12.6	11.2	11.0	10.9	10.9	9.9	10.2	0.75
08	Total Hardness (mg/L)	155	184	163	157	162	138	184	163	171	194	191	167	169	173	164	171	600
09	Calcium (mg/L)	31.5	32.0	32.0	38.0	36.2	36.0	32.2	34.0	30.2	38.0	33.4	31.3	31.0	33.4	34.3	31.9	75.0
10	Magnesium (mg/L)	19.4	23.3	20.3	20.4	19.9	19.9	21.8	20.7	20.6	21.6	20.1	20.9	20.9	23.2	19.6	21.0	30
11	Chlorides (mg/L)	7.9	7.9	8.3	8.9	7.8	10.3	9.2	8.5	8.4	8.9	9.4	8.8	8.5	9.6	7.9	8.6	10.0
12	Chemical Oxygen Demand (mg/L)	0.02	0.03	0.02	0.01	0.003	0.02	0.03	0.01	0.01	0.04	0.08	0.004	0.05	0.18	0.003	0.003	250
13	Total Bacterial Count (avg/100 mL)	1500	1000	1500	1000	2100	2300	1000	2300	1900	1300	1000	1400	1400	1000	1300	1500	100

* Values almost negligible = excursion 3; objectives values as per IS1:0500, 1991

Table 4: Calculated value of the CCME Water Quality Index in temple ponds of Udupi.

No.	Parameter	Symbol	VT1	VT2	VT3	VT4	Rating
1	Scope	F1	30.76	38.46	30.77	30.76	Water Quality in all ponds almost always endangered, conditions usually deviate from the normal levels. Total Acidity, Dissolved oxygen, Free carbon dioxide and total bacteria play a key role – Poor.
2	Frequency	F2	30.76	32.69	30.77	30.76	
3	Amplitude	F3	95.73	97.12	95.74	96.04	
4	Normalized sum of equations	nse	22.40	24.28	22.49	23.53	
5	WQI	WQI	40	37	39	39	

Table 5: Distribution of microorganisms in temple ponds of Udupi.

No.	Species	VT1	VT2	VT3	VT4
	Cyanophyceae				
01	*Phormidium fragile*	+	-	+	
02	*Oscillatoria salina*		+		
	Chlorophyceae				
03	*Pediastrum duplex*	+			
04	*Oedogonium*	+	+	+	+
05	*Spirogyara crassa*	+	+	+	+
06	*Oocystis gigas*	+	+	+	+
07	*Scenedesmus perforatus*		+	+	+
	Bacillariophyceae				
08	*Navicula similis*	+	+	+	+
09	*Stauromies phoemiertron*	+		+	+
10	*Synedra ulva*	+		+	+
11	*Gomphonema pervalun*	+	+		
12	*Navicula rhyncephala*				+
	Desmides				
13	*Cosmarium gexangulase*	+	-	+	-
14	*Cosmarrium protuberans*	+	-	+	-
15	*Cosmaium maculatum*	+	-	+	-
16	*Cosmarium nymammianum*	+	+	-	-
17	*Cosmarium pyramediatum*	-	+	-	-
	Fungi				
18	*Aspergillus niger*	+	-	+	+
19	*Aspergilus ochraceous*	-	+	-	-
20	*Fusarium*	+	-	-	+
21	*Pencillum*	-	+	+	+
22	*Rhizopus*	-	-	-	-
23	*Trichoderma*	+	-	-	-
24	*Saccharomyces*	+	+	-	+
	Total species	17	12	13	12

bers may be due to excess growth of Cyanophyceae. Low amount of free carbon dioxide and high values of dissolved oxygen indicate the presence of algal blooms. In the present study, the ponds experienced minor algal blooms, but the total bacterial count was always high while free carbon dioxide and dissolved oxygen values were almost hand in hand. Chlorides were quite below the permissible limits indicating that pollution of animal origin is low. The contamination due to bacteria and fungi may be attributed to the devotees visiting these ponds during festive seasons, thus often altering the static conditions in the ponds.

CONCLUSION

The CCME WQI serves as an important tool in determining the quality of water for any intended use as well as for protection of aquatic life. The determination requires very few parameters and is left to the choice of the analyst provided relevant factors are selected. According to categorization of the CCME WQI all the four temple ponds of Udupi can be considered as poor. The water quality is almost always endangered and the conditions in them usually deviate from normal values. Total acidity, dissolved oxygen, free carbon dioxide and total bacteria play a key role. Sri Krishna Temple Pond, Udupi has the poorest water quality, followed by Sri Anegudde Vinayaka Temple Pond with

Kumbashi, the least contaminated among the four. However, all four ponds need regular treatment, such as chlorination, at least during peak months or before the festive seasons.

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