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LIMNOLOGICAL INVESTIGATION OF TWO TEMPLE TANKS OF PURI, INDIA

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Two temple tanks (Markandeya and Indradyumna)of Puri, India, were studied for monthly variation in their phytoplankton distribution and physico-chemical properties of water during 1992. Altogether 59 algal species were identified in both the tanks. In Markandeya tank Cyanophytes constituted 95.6-98% of the total phytoplankton followed by chlorophytes (1.0-3.8%) and bacillariophytes (0-0.6%) whereas in Indradyumna tank chlorophyta members were dominant (82.4-94.2%) followed by cyanophytes (0-15.8%) and bacillariophytes (1.7-7.3%). Year round presence of *Microcystis aeruginosa* Kütz. together with higher quantity of various nutrients in Markandeya tank indicated its eutrophic nature whereas lower nutrient content and absence of bloom forming and other organic pollution indicator species in Indradyumna tank showed its oligotrophic status.

Key words: Physico-chemical characteristics, Phytoplankton quality, algal forms, temple tanks.

Considerable attention has been paid to limnological condition of various aquatic environments of India (Ganapati, 1940; Sreenivasan, 1972 and Adoni & Vaishya, 1985). Most of the temple tanks of India which are routinely used for various religious performances, are now polluted due to dumping of organic substances into these water bodies (Swain and Adhikary, 1991). In polluted waters a characteristic algal flora come up and they serve as the indicator of the quality of water (Philipose, 1972). So algal bioassay as well as the physico-chemical studies can be employed to assess the water quality testing of freshwater bodies (Krishnamoorthi & Chaudhury, 1990). Taking these views into consideration, the present investigation was aimed at comparing the phytoplankton composition and physico-chemical properties between two religiously important temple tanks of Puri (Orissa, India) in respect of their trophic status.

MATERIALS AND METHODS

The temple tanks, Markandeya and Indradyumna located at 4 Km distance between each other within the Puri city on the east coast of India (19° 83'N and 85° 82' E) were chosen as the study sites. These are about 600 years old perennial waterbodies, used for bathing and various religious performances by numerous pilgrims from all parts of India. Both the tanks are large rectangular in shape (approx. 400 x 500') with stone lining at all sides. These tanks are cleared by municipality authorities many times a year during the festivals. Each tank is about 5 m deep and has an outlet on the upper surface of the stone lining through which excess water drained out during rainy season. In Markandeya tank, being located near the Jagannath temple, various decomposable organic matters as left-overs of religious rites were dumped by the pilgrims almost every day throughout the year. These waste organic matters after decomposition enrich the waterbody, which encourage dense growth to *Microcystis aeruginosa* Kütz.

Analysis of physico-chemical properties of the two waterbodies was made at monthly intervals during January 1992 to December, 1992. The water samples were collected on a clear day before noon in plastic jerkins. Surface water temperature, transparency, pH and dissolved oxygen concentration were measured on the spot, using minimum-maximum thermometer, Secchi disc, Systronics digital pH meter and Winkler's method (APHA) respectively. Light and dark bottle method (Gaarder & Gran, 1972) was employed for estimation of gross primary production (GPP). Free CO_2, total hardness, chloride, total phosphorus, total nitrogen, magnesium and sulphate content were estimated according to the methods described by Adoni (1985). The qualitative as well as the quantitative occurrence of various algal members was also studied. For quantitative estimation of total phytoplanktons, 50 ml of the sample were centrifuged and the pellet was diluted to 0.5 ml. One drop of the concentrated suspension was taken in a Neubauer haemocytometer counting chamber and the cell number was counted under light microscope. For qualitative analysis, samples were collected using a plankton net (NXX13, 15 µ;

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Table 1: Monthly values of Physico-chemical characteristics and productivity of water of Markandeya tank (January 1992 to December 1992).

Parameter	1992 J	F	M	A	M	J	J	A	S	O	N	D
Water temperature (°C)	24.0	25.5	30.0	31.5	32.8	33.0	33.2	31.5	30.2	30.0	30.2	28.4
Secchi transparency (cm)	66.0	67.0	71.0	60.0	50.0	52.0	55.0	71.0	101.0	80.0	62.0	58.0
pH	9.4	9.4	9.2	9.1	8.8	8.7	8.5	8.5	8.5	8.6	8.8	9.1
DO ($mg.l^{-1}$)	6.54	6.87	7.2	7.07	6.2	6.0	5.93	5.67	4.93	6.4	7.4	7.27
Free CO_2 ($mg.\ l^{-1}$)	Abs	Abs	Abs	Abs	Abs	2.45	4.38	6.48	7.35	8.23	10.2	7.0
Carbonate ($mg.l^{-1}$)	0	31.3	45.0	39.6	34.2	25.0	0	0	0	0	0	0
Bicarbonate ($mg.l^{-1}$)	70.7	86.7	125.3	133.3	141.3	137.3	133.3	104.0	74.7	110.7	146.7	90.7
Chloride ($mg.\ l^{-1}$)	123.3	115.0	105.0	107.5	110.0	76.7	45.8	100.0	156.7	151.7	146.7	150.0
Ca-Hardness ($mg.l^{-1}$)	98.5	122.9	93.8	111.9	118.8	92.7	85.4	112.5	135.6	135.0	131.3	117.7
Total Hardness ($mg.l^{-1}$)	133.3	128.3	109.0	112.0	115.0	110.1	98.3	108.3	136.7	185.0	200.0	176.7
Total Phosphorus ($mg.l^{-1}$)	1.3	1.0	1.05	1.15	1.3	1.2	1.3	1.8	1.5	2.05	1.85	1.4
Total Nitrogen ($mg.l^{-1}$)	4.36	4.4	5.9	5.14	4.5	3.05	2.48	2.91	2.33	2.61	3.03	3.73
Magnesium ($mg.l^{-1}$)	8.45	1.32	3.71	0.03	0	4.2	3.13	0	0.25	12.2	16.7	14.3
Sulphate ($mg.l^{-1}$)	2.47	2.88	3.24	3.63	4.18	3.38	2.75	8.75	14.8	6.63	3.44	3.13
GPP ($mg.l^{-1}$)	0.65	0.91	1.12	1.24	1.04	0.91	0.72	0.49	0.53	0.72	1.17	0.98

Rigosha & Co. Ltd., Tokyo), fixed with Lugol's iodine on the spot and were identified following standard monographs (Desikachary, 1959; Philipose, 1967; Thompson, 1959 and Patrick, 1959).

RESULTS AND DISCUSSION

The water temperature of the tanks ranged between 24° C to 33.2°C showing a uniform pattern of variation as both the study sites were located in the same city. Secchi transparency varied from 50 cm to 101 cm in Markandeya tank (Table 1) and from 77.9 to 103.6 cm in Indradyumna tank (Table 2). The transparency was higher during rainy season due to the dilution of waterbodies. The pH varied from 7.2 to 8.1 in Indradyumna tank whereas it ranged from 8.5 to 9.4 in Markandeya. Year round occurrence of bloom forming plankton, *Microcystis aeruginosa* was observed only in the later tank. Dissolved oxygen content was more in Markandeya tank (4.93-7.4 $mg.l^{-1}$) than the Indradyumna tank (2.5-6.4 $mg.l^{-1}$), which agreed with the findings of Philipose (1972), that *Microcystis* bloom make the surface water supersaturated with oxygen during the day time. Free CO_2 was absent during summer months in Markandeya tank might be due to its complete consumption and/or its conversion into carbonic acid and ultimately into stable carbonates and bicarbonates (Rawson, 1939). In Indradyumna tank, free CO_2 content varied from 5.0 to 13.3 mg/l^{-1} showing highest value in August because it could not be utilized quickly by the phytoplankton as their abundance was

Table 2: Monthly values of Physico-chemical characteristics and productivity of water of Indradyumna tank (January 1992 to December, 1992)

Parameter	1992 J	F	M	A	M	J	J	A	S	O	N	D
Water temperature (°C)	25.0	26.5	28.0	30.0	32.0	32.5	33.0	32.0	32.0	31.0	30.0	29.0
Secchi temperature (cm)	96.3	96.5	103.6	94.4	89.9	79.8	76.1	77.9	87.2	88.9	89.8	88.0
pH	7.2	7.6	7.9	8.0	8.1	8.1	7.8	7.4	7.3	7.7	8.0	8.0
DO ($mg.l^{-1}$)	5.6	5.5	5.2	3.3	2.5	2.7	3.4	3.5	3.7	4.3	6.4	6.2
Free Co_2 ($mg.l^{-1}$)	5.0	7.83	13.0	13.1	12.5	10.0	7.5	13.3	19.5	12.6	7.0	5.83
Carbonate ($mg.\ l^{-1}$)	0	0	0	0	0	0	0	0	0	0	0	0
Bicarbonate ($mg.l^{-1}$)	41.2	43.1	84.3	92.6	100.8	77.9	71.5	40.3	35.8	45.0	65.1	56.8
Chloride ($mg.l^{-1}$)	90.0	81.3	75.0	78.8	82.5	58.8	37.5	103.5	117.5	130.0	132.5	122.5
Ca-hardness ($mg.l^{-1}$)	24.0	27.7	31.7	16.7	2.0	8.33	15.0	25.0	34.3	33.1	31.2	26.1
Total Hardness ($mg.l^{-1}$)	36.7	55.0	63.3	60.8	51.7	61.7	72.5	62.5	36.0	33.7	31.8	28.3
Total Phosphorus ($mg.l^{-1}$)	0.15	0.19	0.2	0.16	0.13	0.16	0.18	0.21	0.36	0.2	0.15	0.13
Total Nitrogen ($mg.l^{-1}$)	2.08	2.1	2.03	2.44	3.06	2.61	2.14	2.5	2.74	2.45	2.17	2.26
Magnesium ($mg.l^{-1}$)	3.08	6.64	7.7	10.7	12.1	13.0	14.0	9.11	0.41	0.14	0.15	0.53
Sulphate ($mg.l^{-1}$)	0.67	0.92	1.41	1.25	1.18	1.0	0.94	3.08	8.24	6.58	6.5	2.17
GPP ($mg.C.l^{-1}.h^{-1}$)	0.33	0.39	0.66	0.52	0.4	0.33	0.39	0.4	0.42	0.46	0.65	0.45

Table 3: Total phytoplankton and percentage of different phytoplankton groups in Markandeya and Indradyumna tanks. (January 1992 to December 1992).

		1992											
		J	F	M	A	M	J	J	A	S	O	N	D
(i)	Markandeya Tank												
	Total Phytoplankton number (Count.l^{-1})x10^9	12.8	13.2	13.7	15.6	18.0	17.4	7.8	8.4	12.6	12.3	12.0	12.2
	Phytoplankton groups in percentage :												
	Cyanophyta	98.1	97.9	97.1	98.8	98.6	98.9	95.6	96.9	98.7	98.9	98.9	98.5
	Chlorophyta	1.6	1.9	2.6	1.0	1.4	1.1	3.8	2.6	1.0	1.1	1.0	1.2
	Bacillariophyta	0.3	0.2	0.3	0.2	0	0	0.6	0.5	0.3	0	0.1	0.3
(ii)	Indradyumna Tank												
	Total Phytoplankton number (Count.l^{-1})x10^9	0.16	0.15	0.09	0.08	0.08	0.08	0.08	0.07	0.06	0.15	0.18	0.17
	Phytoplankton group in percentage :												
	Cyanophyta	15.8	9.2	9.3	7.8	8.6	9.6	0	5.3	0	0	4.7	9.3
	Chlorophyta	82.4	89.1	88.0	89.0	88.4	83.1	93.2	88.3	93.8	94.2	88.1	86.4
	Bacillariophyta	1.8	1.7	2.7	3.2	3.0	7.3	6.8	6.4	6.2	5.8	7.2	4.3

less during rainy season. Alkalinity of water in Indradyumna tank was only due to the bicarbonate content (35.8-100.8 mg/l^{-1}) as carbonate was entirely absent throughout the study period. In Markandeya tank bicarbonate alkalinity varied from 70.7 to 146.7 mg/l^{-1} whereas carbonate alkalinity was observed only during February, March, April, May and June, 1992 (Table 1). Chloride content varied from 37.5 to 132.5 mg/l^{-1} in Indradyumna tank whereas 45.8 to 156.7 mg/l^{-1} of chloride content in Markandeya showed its eutrophic status (Munawar, 1970). Total hardness content and Ca-hardness was about two times more in Markandeya than Indradyumna throughout the year. The insoluble calcium carbonate react with the carbonic acid to form soluble calcium bicarbonate explained high alkalinity status of Markandeya tank, as water rich in alkalinity were rich in calcium (Zafar, 1964). Magnesium content varied from o to 16.7 mg.l^{-1} in Markandeya and 0.41 to 14.0 mg.l^{-1} in Indradyumna tank. Magnesium content was considerably less than calcium content in both the tanks. Total phosphorus content was more (1.0-2.05 mg.l^{-1}) in Markandeya tank than Indradyumna (0.13-0.36 mg.l^{-1}). Total nitrogen content varied from 2.33 to 5.9 mg.l^{-1} and from 2.03 to 3.06 mg.l^{-1} in Markandeya and Indradyumna tank respectively (Table 1,2). Sulphate content ranged from 0.67 to 8.24 mg/l^{-1} in Indradyumna tank (Table 2). The value was more (2.47-14.8 mg.l^{-1}) in Markandeya (Table 1). Gross primary production of Markandeya tank (ranged from 0.49-1.24 mgC.l^{-1}.h^{-1}) was higher than that of Indradyumna tank (ranged from 0.33-0.66 mgC.l^{-1}.h^{-1}) throughout the year. However, both the tanks show two distinct peaks of primary production, one during March-April and the other in November (Table 1,2). The chemical characteristics of water of both the tanks also showed summer and winter peaks, however, sudden variation of the physico-chemical properties even within a season was clearly observed. This is because, these tanks are used by thousands of pilgrims for bathing, dumping of leftovers of religious rites and clearance by municipality authorities many times in a year during the festivals connected with Jagannath temple.

The cyanophytes varies from 95.6 to 98.9 per cent of the total phytoplankton population in Markandeya tank whereas it was 0-15.8 per cent in Indradyumna (Table 3). The percentage of *Microcystis* sp. varied from 94.2 to 98.3 of total phytoplankton in Markandeya tank during the entire study period. There are reports that bloom of *Microcystis* show its common occurrence in many eutrophic waters in India (Choudhury & Rao, 1985). Quantity of chlorophytes and bacillariophytes of Markandeya tank during 1992 were between 1.0-3.8% and 0-0.6% of the total phytoplankton respectively. To the contrary in Indradyumna tank chlorophyta members were dominant (82.4-94.2%) followed by cyanophytes (0-15.8%) and bacillariophytes (1.7-7.3%) during the same year. As a whole 59 algal species were identified in these two tanks (Table 4) out of which 31 species were present in

Table 4: Seasonal variation of phytoplankton quality of Markandeya and Indradyumna tank (January 1992 to December 1992).

Phytoplankton	Rainy season (Jun. -Sep.)		Winter season (Oct. -Jan.)		Summer season (Feb. -May)	
	Markandeya	Indradyumna	Markandeya	Indradyumna	Markandeya	Indradyumna
Cyanophyta						
Microcystis aeruginosa f. *aeruginosa* Kütz.	++	-	++	-	++	-
Microcystis aeruginosa f. *flos-aquae* Wittr.	+	-	++	-	-	-
Microcystis wesenbergii Kütz.	+	-	++	-	+	-
Microcystis viridis (A. Br) Lemm.	-	-	+	-	-	-
Gloeocapsa sp. Kütz.	-	+	+	+	-	-
Dactylococcopsis sp. Hansg.	-	-	-	-	+	-
Merismopedia punctata Meyen.	+	+	+	-	+	-
Oscillatoria brevis (Kütz.) Gomont	-	-	+	-	-	-
Aphanizomenon flos-aquae (L.) Ralfs	-	-	+	-	-	+
Anabaena sp. Bory	-	-	-	-	+	-
Anabaena flos-aquae (Lyngb.) Breb.	+	-	+	-	+	-
Anabenopsis circularis (West, G.S.) Wolosz. and Miller	-	-	-	-	+	-
Gloeotrichia pisum (Agardh) Thuret	+	-	-	-	+	-
Chlorophyta						
Pandorina sp. Bory	-	-	-	-	+	+
Shroederia setigera (Schroder) Lemm.	+	-	-	+	+	-
Dictyosphaerium pulchellum Wood	-	-	-	+	+	-
Coelastrum microporum Nageli	+	-	+	-	-	-
Coelastrum sphaericum Nageli	-	-	+	-	-	-
Pediastrum boryanum (Turpin) Meneghini	-	-	+	-	+	-
Hydrodictyon raticulatum (L.) Legerheim	-	-	+	-	-	-
Chlorella conductrix Brandt.	-	++	-	-	-	-
Chlorella parasitica (Brandt) Beijerinck	-	-	-	-	-	+
Chlorella vulgaris Beijerinck	+	+	+	+	+	+
Occystis sp. Nag.	-	-	+	-	-	-
Ankistrodesmus convolutus Cords.	+	-	+	+	+	+
Ankistrodesmus falcatus (Corda) Ralfs	-	-	+	+	-	+
Ankistrodesmus sp. Corda.	-	-	-	-	+	-
Closteridium bengalicum Turner	+	-	-	-	-	-
Closteridium obesum (W.et G.S. West) Smith	-	-	-	+	-	-
Tetraedron minimum (A. Braun) Hansg.	-	-	+	-	-	-
Tetraedron pentadricum var. *minimum* W.et G.S. West	-	-	+	-	-	-
Tetraedron regularae var. *torsum* Turner	-	-	-	-	-	+
Tetraedron trilobulatum (Reinsch) Hansg.	-	-	-	+	-	+
Selenastrum bibraeanum Reinsch.	-	-	-	+	-	-
Selenastrum gracile Reinsch.	+	+	-	+	+	+
Scenedesums acuminatus (Lagerheim) Chodat	-	+	+	+	-	+
Scenedesums bijugatus var. *bicellularis* (Chodat) Comb. Nov.	+	+	-	+	-	+
Scenedesmus bijugatus var. *qraevenitzii* (Bernard) Comb.	-	+	+	+	-	+
Scenedesmus quadricauda var. *longispina* (Chodat) Smith	+	-	-	-	+	-
Scenedesmus quadricauda var. *quadrispina* (Chodat) Smith	-	+	-	+	+	+
Crucigenia apiculata (Lemm.) Schmidle	-	+	+	+	-	-
Crucigenia tetrapedia (Kirchner) W.et. G.S. West.	-	-	-	-	-	+
Actinastrum hanzschii var. *elongatum* Legerheim	+	-	+	-	-	-
Mesotaenium sp. Nag.	-	-	-	+	-	-
Cylindrocystis brebissonii Meneghini	-	-	-	+	-	-
Closterium acerosum Nitzsch	-	-	-	-	+	-
Closterium setaceum Ehr.	-	?	+	+	-	-
Cosmarium sp. Corda	-	-	-	+	-	-
Ulothrix sp. Kütz.	-	-	-	+	+	-
Uronema sp. Lagerhei•	-	-	+	-	-	-
Stigeoclonium eubricum Dillw.	-	-	+	-	-	-
Bacillariophyta						
Acanthes hypotheca Bory	-	-	+	-	-	-
Mastogloia danseii Thwaites	-	-	-	+	+	+
Frustulia rhomboides Ehr.	-	+	-	+	-	+
Pinnularia nobilis Ehr.	-	+	-	+	-	+
Calonies amphisbaena Bory	+	-	+	-	-	-
Amphora ovalis Kütz.	-	+	+	-	-	-
Cymbella cistata Hempr and Ehr.	-	-	-	-	+	-
Stephanodiscus nigarae Ehr.	-	-	-	+		-

+, Occur, ++, Occur abundantly; -, absent.

Indradyumna. Higher number of phytoplankton species occur in both the tanks during winter season followed by summer and rainy seasons (Table 4). The bloom forming and the organic pollution indicator algal species described by Palmer (1980) such as *Microcystis aeruginosa* f. *aeruginosa* Kütz.,

Microcystis aeruginosa f. *flos-aquae* Wittr., *Microcystis wesenbergii* Kütz., *Microcystis viridis* (A.Br.) Lemm., *Gloeocapsa* sp. Kütz.,*Aphanizomenon flos-aquae* (L.) Ralfs, *Oscillatoria brevis* (Kutz.) Gomont, *Anabaena flos-aquae* (Lyngb.) Breb.,*Chlorella vulgaris* Beijerinck, *Secendesmus acuminatus* (Lagerheim) Chodat, *Scenedesums quadricauda* var. *longispina* (Chodat) Smith occurred in the Markandeya tank. It has been reported that slight change in physical or biotic environment can favour one species over other and also alters the phytoplankton quality of waterbodies (Treshow, 1970). Thus higher value of pH, D.O., alkalinity, hardness, calcium and chloride concentration, phosphorus and nitrogen content, lower secchi transparency and distributional variation in algae, mostly the long lasting presence of *Microcystis aeruginosa* Kütz. bloom indicate Markandeya tank as an eutrophic waterbody. To the contrary the nutrient status and the quantitative and qualitative composition of algal members showed the oligotrophic nature of Indradyumna tank.

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REFERENCES

Adoni A D 1985 *Work-book on Limnology* DOE-MAB Report Prativa Publishers Sagar India.

Adoni A D & A K Vaishya 1985 Phytoplankton productivity : Seasonal Dial and Vertical periodicity in a central Indian reservoir. In *Proc Nat Symp Pure and Appl Limnology Bull Bot Soc Sagar* (A D Adoni ed.) pp 187-192.

American Public Health Association 1975 *Standard methods for examination of water and waste water*, New York.

Choudhury P R, AVJ Rao J P Kotangale & K P Krishnamoorthi 1985 Studies on diurnal and vertical distribution of phytoplankton in waste water stabilisation pond. In *Proc Natl Symp Pure and Appl Limnology Bull Bot Soc Sagar* (A D Adoni ed.) pp 197-203.

Desikachary T V 1959 *Cyanophyta*, I C A R Monograph on Algae I C A R New Delhi.

Gaarder T & H H Gran 1927 Investigation of the production of plankton in the Oslo Fjord, *Repp et Proc Verb Cons Int Explor Mer* **42** pp 1-48.

Ganapati S V 1940 The ecology of a temple tank containing a permanent bloom of *Microcystis aeruginosa* Kütz (Henfr), *J Bom Nat Hist Soc* **42** 1-13.

Krishnamoorthi K P & P R Chaudhuri 1990 Algae in Freshwater ecosystem In *Perspectives in Phycology (Prof M O P Iyengar Centenary Celebration Volume)* (V N Raja Rao ed.) Today & Tomorrows Printers & Publishers New Delhi pp 183-188.

Munawar M 1970 Limnological studies of freshwater ponds of Hyderabad, India I. The biotope, *Hydrobiologia* **35** 127-162.

Palmer C M 1980 *Algae and water pollution*, Castle House Publication Ltd. England.

Patrick R 1959 *Bacillariophyceae* In Freshwater Biology (W T Edmondson ed.), John Wiley and Sons, New York, pp 171-189.

Philipose M T 1967 *Chlorococcales*, ICAR New Delhi.

Philipose M T 1972 Notes on the ecology, role and possible control of some common blue-green algae blooms in Indian Freshwater fish ponds. In *International Symposium on Taxonomy and Biology of Blue-green Algae*, (T V Desikachary ed.) Madras pp 455-460.

Rawson, D S 1939 Physical and chemical studies of plankton and bottom funds of Okanagar lake *B C. Bull Fish Res Bd Can* **56** 3-70.

Sreenivasan A 1972 Ecology of Blue-green algae in tropical inland water In *International Symposium on Taxonomy and Biology of Blue-green Algae*, (T V Desikachary ed.) Madras pp 461-469.

Swain N & S P Adhikary 1991 Dependence of growth of *Microcystis aeruginosa* (Kütz emend Elenkin) on pH of the culture medium, *J Freshwater Biol* 3 131-137.

Thompson R H 1959 *Algae In freshwater Biology* (W T Edmondson) John Wiley and Sons, New York pp 115-170.

Treshow M 1970 *Environment and plant responses* MC Graw Hill Inc New York.

Zafar A R 1964 On the ecology of alge in certain fish ponds of Hyderabad India I Physico-chemical complexes *Hydrobiologia* 23 179-195.