WATER QUALITY AND PHYTOPLANKTON COMMUNITY STRUCTURE OF SOME COMMUNITY PONDS OF BHUBANESWAR CITY

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Abstract: Community ponds like temple and other ponds have immense importance in Indian villages and towns as these are used for collection of drinking water, bathing, washing of clothes, utensils and cattles, religious works and irrigation. Although analysis of water quality and pollution load in Indian rivers and lakes have been made widely (Trivedy 1989), much attention has not been to the analysis of water quality and pollution load of community pond. Water Quality and pollution load of three community ponds of Bhubaneswar city were monitored for 2 years. The Ponds exhibited a BOD/COD ratio of > 3 every month and water quality index calculated from thirteen physio-chemical and one biological taken together varied from 168-870 indicating level of nutrient load and pollution in the ponds. During the course of Investigation, 24 taxa were isolated belongs to two major group of Algae, class Chlorophyceae (8) and Bacillariophyceae(16). The water is unsafe for human use. Appropriate recommendations have been made.

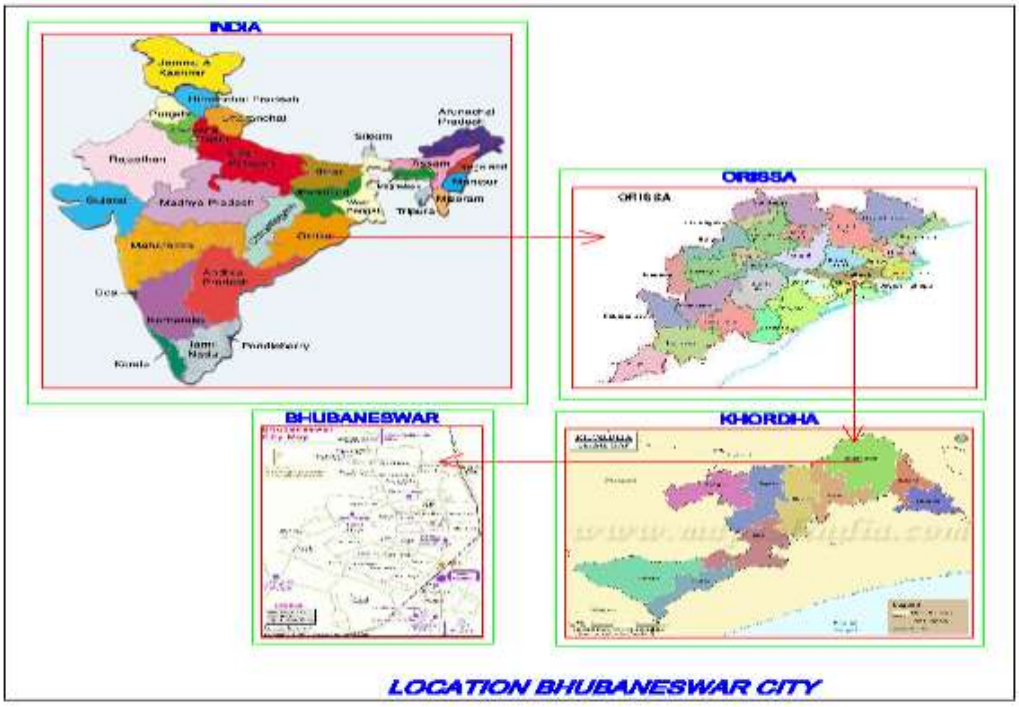
(Key Words: Community Ponds, Water Quality Index, Water Pollution, Phytoplankton)

1. Introduction

Community ponds like temple and other ponds have immense importance in Indian villages and town as these are used for collection of drinking water, bathing, washing of clothes, utensils and cattle, religious works and irrigation. Although analysis of water quality and pollution load in Indian rivers and lakes have been made widely (Trivedy, 1989) much attention has not been given to the analysis of water quality and pollution load of community ponds. This work forms a part of comprehensive research work carried out for two year on some temple and other ponds of Bhubaneswar city to assess water quality, phytoplankton community structure, pollution load and safety of its use by the people.

2. Materials and Methods

Bhubaneswar is located in the Khurda district of Odisha, India between 20°12′ to 20°25′ N latitude and 85°44′E to 85°55′E longitude on the western fringe of the coastal plain across the main axis of the Eastern Ghat. It is situated on the South Eastern Railway line joining Howrah and Madras at a distance of 435 km South of Calcutta. The present study confined to the Bhubaneswar city which is carried by Bhubaneswar Municipality Corporation (BMC) with an area of 146 Sq.km with 67 wards. The town has about 20 ponds used for religious purposes, for bathing, washing, fish culture etc Three important ponds for the point of view of human use. One Temple pond (TP) named as Kapileswar, one small Community Pond (SC) named Potapokhari and other Large Community Pond (LC) named as Sundarapada Lake were studied. The large community pond receives municipal drain in rainy and winter season.



The area, perimeter and vegetation species of three types of ponds is reflected in **Table-1.** This region experiences three distinct seasons, summer extending from mid March to mid June, Rainy extends for mid June to October and winter for November to February. The water samples were collected once in a month from November 2016 to October 2017. Surface water samples were directly collected with the help of 1 lit. Capacity bottle and was subjected to analyse physico-chemical parameters and phytoplankton community structure were done. Samples were collected during morning hours and analysed in the Botany

laboratory of Regional Institute of Education, Bhubaneswar. Analysis was done after methods outlined by Golterman (1978), APHA (1985) and Trivedy and Goel (1984).

Table 1

Name of the Pond	Area of Pond	Perimeter of Pond	Uses	Plant species (Vegetation)	
				Shore line vegetation	Macrophyte
Temple Pond (TP) Kapileswar	0.22	224	Feet washing Utensil cleaning	*Panicum sps.* *Zoysia sps.* *Cyperus sps.* *Paspalum sp.* *Panicum sp.*	*Salvania* *Scripus sp.* *Ipomoea sp.* *Marsilea sp.* *Potamogeton sp.* *Azolla sp.* *Ceratophyllunt pilm sp.* *Wolfia sp.* *Nelumbim sp.* *Hydrilla sp.*
Small Community Pond (SC) Pota Pokhri	2.49	503	Bathing Washing	*Ipomoea carnea*	
Large Community (LC) Sunderpada lake	5.49	1090	Washing clothes, Washing vehicles, Utensil cleaning, Bathing, Receives municipal drain discharge during Rainy & Winter	*Eclipta* sp. *Heliotropium* sp. *Ipomoea carnea* *Spiranthus* sp. *Astracanthus* sps.	

Water Quality Index

A water quality index (WQI) is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water. Out of 19 parameters studied, 14 parameters were taken for calculating water quality index. (Deininger and Maciunas 1971, Karkins, 1974). The purpose of calculating WQI is to find out suitability of pond water for human consumption. The weights for various

water quality parameters are assumed to be inversely proportional to the recommended standard **(Table-4)** for the corresponding parameters.

$$W_i = \frac{K}{S_i} \quad \text{..... Eqn. (1)}$$

Where W_i = Unit weight of the ith parameter

S_I = (i= 1, 2, 3,…., 14) refers to water quality parameters

K = Constant

For simplicity K=1

Calculation of WQI

(i) Calculation of the quality rating for each water quality parameters,

(ii) Aggregation of these sub indices into overall index.

Calculations

Let there be N water quality parameter and P_i is to be taken into account for calculating the WOI. Then the quality rating (q_i) corresponding to the i^{th} parameter of Pi is a number reflecting the relative value of this parameter in the polluted water with respect to its standard value (Si).

$$\therefore q_i = \frac{100(V_i - V_{i0})}{(S_i - V_{i0})} \quad \text{..... Eqn. (2)}$$

Where V_i = The measured value of the i^{th} parameter in the polluted water.

V_{i0} = The ideal value of this parameter in pure water.
S_i = The standard value for the i^{th} parameter.

Since, the ideal value V_{i0}=0 for the drinking water for most parameter, Eq.(2) can be written as:

$$q_i = 100\left(\frac{V_i}{S_i}\right) \quad \text{..... Eqn. (3)}$$

Eqn.(2) and Eqn. (3) ensure that q_i=0 if the ith parameter is totally absent in the polluted water and q_i=100, if the amount of this parameter is just equal to its permissible value S_i for the drinking water. But there are some exceptions.

a) For DO, the ideal value may be taken as 14.6 mg/1 (solubility of O_2 in pure water at $0^{\circ C)}$. Since the standard for drinking water is 5.0 mg/1, Eqn. (2) can be written as

$$q_{DO} = 100(V_{DO} - 14.6)/(5 - 14.6) \quad \text{..... Eqn. (4)}$$

Where V_{DO} = observed value of dissolved oxygen.

b) For pH, the ideal value is 7.0 (Neutral water) and the permissible value is 8.5. So Eqn. (2) for this case may be written as

$$q^{pH} = 100(V_{pH} - 7.0)/(8.5 - 7.0)) \quad \text{..... Eqn. (5)}$$

V_{pH} = observed value of pH

c) In case of MPN of Coliform, the permissible value for drinking water is 1 per 100 ml, while their actual number in ponds may be much more per 100 ml.

$$q^{MPN} = \frac{\log_{10} V_{MPN} + 1}{\log_{10} S_{MPN=1}} \times 100 \quad \text{..... Eqn. (6)}$$

Where V_{MPN} = MPN of Coliform/100 ml of water

S_{MPN} = Standard for Coliform for the drinking water.

= 1 per 100 ml on 1 is added to the number and denominator to avoid division by zero, since $\log_{10}^{1} = 0$

So, the overall water quality index (WQI) may be calculated

$$WQI = \left(\sum_{i=1}^{N} q_i W_i \right) / \sum_{i-1}^{N} W_i \quad \text{..... Eqn. (7)}$$

3. Results and Discussion

Water samples from surface was analysed for physic-chemical, Biological parameters, BOD/COD, water quality and indices phytoplankton analysis are respectively in Table 2, 3, 4 and 5.

(1) **Temperature:** Maximum and minimum temperature were observed in all the three ponds during winter and summer. There was no significant difference in surface temperature between the ponds. It varied for 24.5 to 31.8°C.

(2) **pH**: It varied from 7.68 to 8.71, 8.8 to 9.6 and 8.8 to 9.3 in TP, SC and LC respectively. The minimum range of pH was observed during rainy season in all the ponds except the small community pond where the lower value occurred in winter. Higher pH was observed during summer time. Klein (1973) have

pointed that the pH value in between 6-7 and 8.4 are suitable while pH below 5.0 are above 8.3 are detrimental. The pH of the community ponds were above 8.5 indicating their unsuitability.

(3) **Turbidity:** It is expressed as Nephelometric turbidity expand units (NTU). Temple pond was less turbid (3 to 8.1) than the SC pond (15.5 to 32) and LC pond (61.1 to 308). Maximum turbidity was observed in the rainy season in Temple pond and in summer season in community pond. Minimum turbidity was observed in summer in Temple pond and in winter in the community pond. The higher turbidity values in the community ponds coincide with higher density of phytoplanktons and concentration of total solids.

(4) Dissolved Oxygen: The dissolved oxygen ranged from 5.71 to 7.58, 2.8 to 10.12 and 3.7 to 7.9 mg lit^{-1} in Temple pond, SC pond and LC pond respectively. Maximum value was observed in summer in Temple pond and Rainy in Community Ponds. Minimum value observed during winter in Temple pond and summer in community ponds. The differential may be due to the differential growth of macrophtes in the ponds. The seasonal low level of DO_2 in the ponds is indicative of stress problem for aquatic organisms and pollution.

(5) Total Alkalinity: Total alkalinity ranged from 128 to 159, 300 to 428 and 131.5 to 187 mg lit^{-1} in Temple pond, SC pond and LC pond respectively. The greater alkalinity for the community pond is due to washing of excreta into the pond.

(6) Total Solids and Dissolved Solids: Total solids ranged from 290 to 326.6 mg lit^{-1}, 1.11 g^{-1} to 1.35 g^{-1} and 360 mg lit^{-1} to 585 mg lit^{-1} in Temple pond, SC pond and LC pond respectively. Total dissolved solids ranged from 238.7 to 293.3 mg lit^{-1}, 1.045 to1.34 g^{-1} and 368.3 to 473.3 mg lit^{-1} in Temple pond, SC pond and LC pond respectively. The SC pond had greater amount of solids due to open air latrine. Water with high dissolved solid have inferior palatability. For these reasons, a limit of 500 mg lit^{-1} (ICMR standard) is desirable for drinking water. Higher suspended solids in the water of SC pond may be very harmful to fish.

Total Hardness and Calcium:

Total hardness ranged from 76.5 to 110.5, 152 to 203.5 and 59.5 to mg lit^{-1} in Temple pond, SC pond and LC pond respectively. Calcium ranged from 10.9 to 23.5, 18.5 to 37.6 and 10.9 to 19.3 mg lit^{-1} in Temple pond, SC pond and LC pond respectively. Minimum values of hardness and calcium were observed in summer in all ponds and maximum values occurred in winter in Temple pond, SC pond and in the Rainy season in LC pond. Greater hardness and calcium value in the SC pond was due to large scale human use.

Magnesium:

Magnesium ranged from 12 to 13.8, 21.8 to 26.7 and 7.5 to 9.7 mg lit^{-1} in Temple Pond, SC pond and LC pond respectively. Lower amount of magnesium was observed in Summer in the Temple Pond and in Rainy season in the Community Pond where as higher values were found in Winter for Community Ponds and in Rainy season for Temple Pond.

Sodium and Potassium:

Sodium concentration varied from 62.5 to 74.3, 290 to 342.5 and 94.3 to 150 mg lit^{-1} in Temple Pond, SC Pond and LC Pond respectively. Potassium ranged from 14 to 21, 94 to 190, 21 to 31.3 mg lit^{-1}. Minimum amount of sodium was found respectively in rainy season in Temple Pond and in winter in the Community Ponds whereas maximum amount was found during summer in all the ponds. Minimum potassium occurred in rainy season in Temple pond and LC pond but in winter in the SC Pond. Maximum value of sodium and potassium was found in winter, rainy and summer in Temple Pond, SC and LC pond respectively.

Chloride:

Chloride content ranged from 72.2 to 90.4, 382.9 to 526.5 and104.5 to 166.6 mg lit^{-1} in Temple Pond, SC pond and LC pond respectively. Minimum amount of chloride occurred in winter and maximum amount occurred in summer in all the ponds.

Nitrate, Phosphate and Sulphate:

In the temple pond, NO_3^-, PO_4^- and SO_4^- remained in the range of 0.002-0.029, 0.004-0.031 and 0.021-0.038 mg lit^{-1} respectively. In SC pond, NO_3, PO_4 and SO_4 remained in the range of 0.004-0.058, 0.006-0.018 and 0.025-0.043 mg lit^{-1} respectively. In LC pond, NO_3, PO_4 and SO_4 remained in the range of 0.002-0.071, 0.006-0.018 and 0.052-0.071 mg lit^{-1} respectively. Minimum amount of SO_4 occurred in winter in all the ponds. Maximum amount of NO_3 was found in summer in Temple pond and in winter in the Community Ponds. Maximum amount of PO_4 was found in winter in Temple pond and SC pond and in summer in LC pond. Maximum SO_4 was found in Rainy in all the three ponds. Concentration of nitrate is more than 0.3 mg lit^{-1} is considered sufficient to stimulate algal bloom (Raina et al., 1984). The study ponds are below this limit.

BOD and COD:

The five day biological oxygen demand indicated low value in Temple pond. BOD ranged from 2.5-8.3, 14.5-18.4 and 12.6-20 mg lit^{-1} in Temple pond, SC pond and LC pond respectively. Low BOD value was found in winter in all the ponds. High BOD value was found in the Rainy season in the Temple pond

and SC pond but in summer in the LC pond. Martin (1970) considered water body with BOD more than 8 mg lit^{-1} to be moderate polluted. COD values ranged from 15.6-22.7, 118.7-146.8 and 55.5-118.6 mg lit^{-1} in Temple pond, SC pond and LC pond respectively. High COD value was seen in summer in the Community ponds and in Winter in the Temple pond.

Total Coliform:

The MPN of Coliform count in 100 ml of water ranged from 23-2400, 150-4600, and 93-1100 in Temple pond, SC pond and LC pond respectively. Highest count was found in rainy season and lowest in summer in all the ponds. This result is similar with the findings of Sinha (1991). The drinking water standard recommended by ICMR for Coliform group is 1 per 100 ml. Hence all the ponds were found to be heavily contaminated with Coliform group and unfit for drinking purposes.

WQI :

For the purpose of present study, the use of water for drinking and personal hygiene has been treated as primary consideration. The reason for this preference is that nearly 80% for our population live in more than half a million villages and all of these villages have negligible facility of any kind, either for potable water or for excreta disposal. The typical water source for these villages is often a pond or a well. The report prepared by the WHO and the World Bank "The importance of Safe Community Water Supply and Sanitation in the Control of Diseases such as Diarrhoea, Typhoid, Parathyroid, Salmonelloses, Chlolera, Hepatitis, Amoebiasis and Giardiasis is well established."

The value of WQI was always more than 100 in all the three ponds indicating that the water is unsuitable for human use. In the Temple pond, the value of WQI varied from 168-282, is lesser than other two ponds (SC Pond 384-483, LC Pond 380-870). The quality of water in summer in the Temple pond was better than the other two ponds. It may be the presence of a large macrophytic population and lesser human activity. High density microcystis population was present in the LC pond and high density population of Chlorophyceae and Bacillariophyceae was found in SC Pond during summer. Hence, it is recommended that the appropriate authority in Odisha should take immediate steps to provide alternate source of water to the people and advice people not to use unsafe water. The pond can be profitably used for fish culture by the Fishery Department. Bhubaneswar Municipal Corporation (BMC) should make provision of public latrine facilities and waste disposal.

Phytoplankton Community Structure:

During the course of the present investigation, 24 taxa were isolated from the surface water of the three ponds (Table-5). The phytoplankton population in the water body was represented by two major

groups of algae – Chlorophyceae and Bacillariophyceae. Chlorophyceae was represented by 4 orders belongings to either Desmids or branched / Unbranched filamentous types. Of these order Conjugales represented highest number of taxa (*Cosmarium pseudopyramidetum, S. reniforme* and *Xanthidium brebissonic*) followed by Ulotrichales, and *Cladophoralus*. *Bulbochasta gigentia* is the only species representing filamentous Oedogoniales.

Bacillariophyceae was represented by only two orders; Centrales with two species and Pinnales with 12 species. A complete list of various species of phytoplankton along with their seasonal distribution through different month is tabulated in Table No.5.

Epithemis argus, Navicula oblonga, Grammatophora sps., *Navicula amphispaena, Eunutia robusta, Pinnularia viridis, Rhizosolenia eriensis, Gyrasigma* and *Microspora* were by far the most common and represented through all the month of observation. *Cormarium reniforms, Pithophore* sps., *Cosmarium pseudopyramidatum* and Cladophora were least abundant. In general, diatoms formed the principal phytoplanktonic flora in the study pond.

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Table 2: Physico-Chemical & Biological Parameters of community Ponds

		Temple Pond	Small Community Pond	Large Community Pond
pH	S	8.71 ± 0.24	9.532 ± 0.116	9.392 ± 0.296
	R	7.682 ± 0.238	9.535 ± 0.110	8.817 ± 0.207
	W	8.0 ± 0.341	8.835 ± 0.190	8.937 ± 0.303
Total alkalinity	S	128 ± 3.265	401.5 ± 12.974	187 ± 14.62
	R	130.50 ± 6.42	300 ± 21.684	131.5 ± 12.801
	W	159 ± 7.449	428 ± 89.799	140.66 ± 9.625
Total Hardness	S	76.50 ± 2.559	152 ± 12.842	59.5 ± 11.52
	R	102.50 ± 10.213	163 ± 29.188	79.25 ± 5.644
	W	110.50 ± 5.507	203.5 ± 4.041	73.0 ± 2.748
DO_2	S	7.58 ± 1.037	2.849 ± 1.052	3.710 ± 0.708
	R	5.84 ± 0.721	10.120 ± 3.148	7.964 ± 0.824
	W	5.71 ± 0.594	4.251 ± 1.687	6.937 ± 0.661
Chloride	S	90.42 ± 5.151	526.536 ± 56.372	166.647 ± 22.54
	R	72.69 ± 6.141	421.937 ± 31.801	106.37 ± 22.174
	W	72.26 ± 3.903	382.93 ± 12.947	104.598 ± 3.919
Na	S	74.33 ± 6.369	342.5 ± 60.104	150.0 ± 19.901
	R	62.50 ± 3.535	299.0 ± 55.154	112 ± 53.74
	W	64.0 ± 1.414	290.5 ± 41.719	94.333 ± 9.907
K	S	19.0 ± 0.707	127 ± 8.03	31.333 ± 1.079
	R	14.0 ± 1.414	190 ± 98.994	21.0 ± 5.656
	W	21.0 ± 2.828	94 ± 15.936	24.666 ± 6.975
Ca	S	10.93 ± 1.372	18.502 ± 2.059	10.933 ± 1.048
	R	18.29 ± 2.70	29.852 ± 5.83	19.341 ± 3.245
	W	23.55 ± 2.412	37.636 ± 2.976	13.246 ± 2.035
Mg	S	12.00 ± 0.448	25.814 ± 3.286	7.856 ± 2.267
	R	13.87 ± 2.227	21.852 ± 4.425	7.555 ± 1.311
	W	12.61 ± 0.296	26.733 ± 1.352	9.749 ± 1.419
Turbidity	S	3.0 ± 2.828	32.0 ± 1.414	30888 ± 16.97
	R	8.133 ± 1.839	22.533 ± 12.9	166.533 ±
	W	4.0 ± 2.828	15.5 ± 0.707	150.119
				61.15 ± 5.161
Total solids	S	290 ± 19.436	1350 ± 0.104	585 ± 95.065
	R	326.666 ±	1113 ± 0.177	431.666 ±
	W	133.557	1121 ± 0.12	134.365
		303.333 ±		360 ± 67.453
		111.933		
Total dissolved solids	S	238.75 ± 12.99	1340 ± 0.105	478.333 ±48.676
	R	293.333 ±	1245 ± 0.107	383.333 ± 160.83
	W	106.914	1096 ± 0.107	368.333 ± 83.541
		266.666 ± 86.914		
Temperature	S	31.5 ± 2.012	30.525 ± 0.83	31.025 ± 1.558
	R	30.45 ± 1.124	30.112 ± 1.178	30.187 ± 0.967
	W	25.525 ± 1.198	26.062 ± 1.176	25.737 ± 1.065
Total Coliform	S	23	150	93
	R	2400	4600	1100
	W	2400	1100	390
Nitrate	S	0.029 ± 0.001	0.052 ±	0.068 ± 0.007
	R	0.002 ± 0.007	0.004 ±	0.002 ± 0.0007

	W	0.024 ± 0.005	0.058 ±	0.071 ± 0.011
Phosphate	S	0.008 ± 0.001	0.009 ±	0.018 ± 0.009
	R	0.004 ± 0.002	0.006 ±	0.006 ± 0.005
	W	0.031 ± 0.008	0.018	0.016 ± 0.004
Sulphate	S	0.038 ± 0.006	0.041 ±	0.053 ± 0.004
	R	0.038 ± 0.016	0.043 ±	0.071 ± 0.002
	W	0.021 ± 0.005	0.025 ±	0.052 ± 0.009

Table 3: Seasonal BOD and COD data of three study ponds (X ± SEM)

Seasons	Temple Pond		Small Community Pond		Large Community Pond	
	COD	BOD	COD	BOD	COD	BOD
Summer	17.39 ±4.206	3.035 ±1.463	146.83 ±21.665	15.218 ± 1.24	118.60 ±33.786	20.084 ±1.249
Rainy	15.60 ± 6.317	8.345 ± 1.621	119.401 ±29.247	18.49 ±1.147	55.53 ±12.65	15.66 ±3.65
Winter	22.765 ±5.104	2.538 ±2.463	118.76 ±15.26	14.54 ± 5.315	73.10 ± 8.089	12.62 ±7.289

= Value in mg lit^{-1}

Table 4 : Water Quality Index (WQI) of study Ponds of Bhubaneswar

Parameter (Pi)	ICMR standard (Tiwari & Ali, 1988) (Si)	Unit weight (Wi)	Temple Pond			Small Community Pond			Large Community Pond		
			Summer (qiwi)	Rainy (qiwi)	Winter (qiwi)	Summer (qiwi)	Rainy (qiwi)	Winter (qiwi)	Summer (qiwi)	Rainy (qiwi)	Winter (qiwi)
pH	7-8.5	0.07164	8.16696	3.2238	4.7759	12.5703	12.1071	8.7639	11.4241	8.6769	9.2510
Alkalinity	120[(2)]	0.00417	0.44479	0.4534	0.5525	1.3952	1.0425	1.4872	0.6498	0.4569	0.4888
Total Hardness	200	0.00167	0.04258	0.0570	0.0615	0.0846	0.0907	0.1132	0.0331	0.441	0.0406
DO	5[(1)]	0.10030	7.32190	9.1481	9.2881	12.2260	4.6805	10.8125	1.1471	6.9332	8.006
BOD	5[(2)]	0.10030	6.08821	16.7400	5.0912	30.5273	37.1069	29.1821	40.2885	31.4239	25.3257
Cl	250	0.00200	0.07233	0.0581	0.5610	0.4212	0.3375	0.3063	0.1333	0.0850	0.0836
Na	20[(1)]	0.02507	9.31764	7.8343	8.0224	49.9323	37.4796	36.4141	18.8025	14.0392	11.8246
K	10[(1)]	0.05015	9.52850	7.0210	10.5315	63.6905	95.2850	47.141	15.7134	16.5315	12.3699
Ca	75	0.00668	0.09737	0.1628	0.2097	0.1647	0.2658	0.3352	0.0973	.1722	0.1179
Mg	50	0.00668	0.09737	0.1628	0.2097	0.1647	0.2658	0.3352	0.0973	0.1722	0.1179
MPN/ Coliform	1/100 ml	0.50156	118.40415	219.6570	219.6570	159.2769	233.7993	202.6561	148.8452	202.6591	180.088
Turbidity	5	0.10030	6.01800	16.3147	8.0240	64.1920	45.2011	31.0930	617.8480	334.0651	122.6669
Total solids	500[(3)]	0.00100	0.05800	0.0653	0.0606	0.2700	0.2226	0.2242	0.1170	0.0863	0.0720
COD	20	0.02507	2.18071	1.9558	2.8535	18.4062	14.9669	14.8873	14.8665	6.9606	9.1630
$\sum Wi$		0.99988	167.98194	282.9691	269.4419	413.6745	483.0238	383.9512	870.1233	616.2835	379.6935
$WQI\sum_{qiwi}/\sum_{wi}$			168.002	283.003	269.474	413.724	483.081	383.9972	870.198	616.357	379.739

All values except pH, Turbidity and MPN Coliform are in mg lit^{-1}

Table 5: Seasonal distribution of phytoplankton in different month in the study pond.

No.	Species	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1	*Epithemia argus*	+	+	+	+	+	+	+	+	+	+	+	+
2	Gyrosigma	+	+	+	+	+	+	+	+	+	+	+	+
3	Grammatophore	+	+	+	+	+	+	+	+	+	+	+	+
4	Navicula	+	+	+	+	+	+	+	+	+	+	+	+
5	*Navicula oblonga*	+	+	+	+	+	+	+	+	+	+	+	+
6	*Euxitisa robusta*	+	+	+	+	+	-	+	+	+	+	-	+
7	Ulothrix	+	+	+	-	+	-	-	-	+	+	-	-
8	*Rhizosolenia eniensis*	+	+	+	+	+	+	+	+	+	+	+	+
9	*Navicula amphisbaena*	+	+	+	+	+	+	+	+	+	+	+	+
10	*Bulbochaeta gigantean*	+	-	-	-	-	+	+	+	+	+	+	+
11	*Xanthidium brebissomii*	-	-	-	-	+	+	-	-	-	-	-	-
12	*Cocconeis placentula*	-	+	+	+	+	+	+	+	+	+	+	+
13	*Gamphonema parvulum*	+	+	+	+	+	-	-	-	-	-	-	-
14	*Cosmarium pseudopyramidatum*	-	+	-	+	-	-	-	-	-	-	-	-
15	*Eunutia pectinals*	+	+	+	+	+	+	+	+	+	+	+	+
16	Pithophore	-	-	-	-	-	+	-	-	-	-	-	-
17	Unknown species	+	+	+	+	+	+	+	+	+	+	+	+
18	*Pinnuleria viridis*	+	+	+	+	+	+	+	+	+	+	+	+
19	Unknown species	+	+	-	-	-	+	-	+	-	-	+	-
20	*Cyclotella compta*	-	-	-	+	-	-	-	-	-	-	-	-
21	*Cormarium reniforma*	-	+	-	-	-	-	-	-	-	-	-	-
22	Cladophora	+	-	+	-	-	-	-	-	+	+	+	+
23	Microspora	+	+	+	+	+	+	+	+	+	+	+	+
24	Cynedra	-	-	+	+	+	+	+	-	-	+	-	-

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