

## Seasonal Variation in Physicochemical and Biological Parameters of Pond Waters in Bhawanipatna Town, Kalahandi, Odisha

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### Abstract—

The main objective of this study was to assess the physicochemical and biological parameters of four pond waters in Bhawanipatna town (viz. Purusottam Sagar, Ram Sagar, Purunapada Bandh and Darpan Sagar) of Kalahandi district. The analysis was made in three seasons viz. pre monsoon, monsoon and post monsoon during the year 2013. The effects of the cultural practices and the daily use of pond by the local inhabitants on the quality of the pond water were studied. The results confirm that all the four ponds are severely polluted and the pollution load is increasing gradually with the increase in population of the town.

Keywords— Pond Water, Kalahandi, Cultural practices, Inhabitants, Pollution load,

### I. INTRODUCTION

Water is the most important amenity of life. It is subjected to all forms pollution, from the point and non point sources, with every developing step of the country. Water quality reflects the composition of water as affected by the natural and anthropogenic activities expressed in terms of measurable quantities and related to intended water use [1]. The physicochemical properties and biodiversity of aquatic body governs the quality of water and hence the quality of life [2]. They are helpful in determining the structural and functional status of natural water [3]. However, the limnological study about the lentic water body, suggests that this form of water is prone to a rapid decline in quality due to overburden load from various sectors of society. Industrial, sewage and municipal wastes are being continuously added to the water body which affect the physicochemical properties of water body making them unfit for use by the livestock and other organisms [4]. The global freshwater resource is facing serious threats and pressure of sustaining in nature [5][6][7]. Industrialization, urbanization and modern agricultural practices influence the water quality quantitatively and qualitatively [8]. It is therefore very important to assess the various conditions and have relevant information about the quality of water to formulate various management strategies for the resources.

Ponds have been used as a traditional source of water supply in many places of the country since time in memorial. Ponds provide habitat for invertebrates, fish and birds [9]. However, the quality of pond water has deteriorated due to discharge of waste water from domestic pipelines, use of detergents, animal bathing, idol immersion, aquaculture etc. This deterioration has not only adversely affected the health of the surrounding people but also has ruptured the aquatic life and fishing. Several physicochemical and biological factors may impart a stress on fish growth and reproduction [10]. The water quality, hydrology and habitat conditions reflect the impact of the urban drainage of the receiving water body [11]. The present study was carried out to assess the quality of four pond water bodies of Bhawanipatna town.

### II. MATERIALS AND METHODS

The study area belongs to Bhawanipatna town in Kalahandi district of Odisha and lies between 19°54'07.90" N, 83°9'31.08" E to 19°54'58.69" N, 83°10'19.87" E. The study includes four ponds, namely, Purusottam Sagar, Ram Sagar, Purunapada Bandh, Darpan Sagar. All the four ponds are located inside the town and three out of four ponds (Purusottam Sagar, Ram Sagar, Purunapada Bandh) are located in the vicinity of the residential areas, whereas, Darpan Sagar is located away from the residential areas. Table I gives the demography data of different wards under Bhawanipatna municipality thereby suggesting the number of dependents on each pond for various purposes.

The sampling was done thrice a year i.e. at Pre monsoon (April), Monsoon (August), and Post monsoon (November). Three water samples from each pond were collected in plastic bottles and were tightly capped inside the water, in the first week of respective months. The bottles were then immediately transported to laboratory for analysis of water quality parameters. However, the temperature was recorded on the spot and water samples to be used for DO analysis was also fixed on the spot. The other parameters were analyzed as per the [12] standard.

Table I: Demography of different wards under bhawanipatna municipality

Ponds	Inhabitants using the pond (Ward No.)	Population of ward as per 2001 census	Total Population
Purusottam Sagar	6	2314	8577
	12	6263	
Ramsagar	3	3745	7954
	4	4209	

Purunapada Bandh	1	4022	8556
	14	4534	
Darpan Sagar	9	3962	6912
	11	2950	

### III. RESULTS AND DISCUSSION

In the present study, water samples from various ponds were taken in three seasons and were subjected for various physicochemical and biological analyses. The values of various parameters in three seasons were subjected to two-way ANOVA (without replication) to see whether significant difference exists with respect to different ponds and seasons at 0.05 confidence limit.

In the present study, the pH of pond water was near acidic to slightly alkaline with minimum pH being 6.76 in Purunapada bandh during monsoon and maximum pH being 8.11 in Ram Sagar during Pre monsoon.

Conductivity in all ponds was maximum in monsoon and minimum in post monsoon. The maximum conductivity was found in Ram Sagar (1472  $\mu\text{S}/\text{cm}$ ) during the monsoon season and the minimum conductivity was found in Darpan Sagar (383  $\mu\text{S}/\text{cm}$ ) during post monsoon.

The highest temperature was found in Purusottam sagar (38<sup>0</sup>C) during pre monsoon and lowest temperature was observed in Darpan Sagar and Purusottam sagar (31<sup>0</sup>C) during monsoon and post monsoon respectively.

The maximum TDS was found in Ram Sagar (1200 mg/l) during monsoon and minimum TDS was found in Ram Sagar (200 mg/l) during post monsoon. Here the maximum TSS was found in Ram Sagar (1660mg/l) during monsoon and minimum TSS was found in Darpan Sagar (120mg/l) during post-monsoon season. The maximum TS was found in Ram Sagar (2860 mg/l) during monsoon and minimum TS was found in Ram Sagar (420 mg/l) during post monsoon. A high value of TS confirms the presence of ions of nitrate, phosphate, sodium, potassium.

Maximum Nitrate content was found in Ram Sagar (98 mg/l) during monsoon and minimum nitrate content was found in Purusottam Sagar(12 mg/l) during post monsoon. Maximum Phosphate content was found in Purusottam Sagar (78 mg/l) during monsoon and minimum phosphate content was found in Purunapara Bandh (9 mg/l) during pre monsoon. A high level of nitrate and phosphate in the all the pond waters of the present study was mainly due to the excessive use of these ponds by the peoples for their daily domestic use.

Maximum Sodium content was found in Purunapara Bandh (281mg/l) in monsoon and minimum sodium content was found in Darpan Sagar (21.54mg/l) in post monsoon. Maximum Potassium content was found in Purusottam Sagar (773 mg/l) in monsoon and minimum Potassium content was found in Purusottam Sagar (215 mg/l) in post monsoon. In the present study high levels of sodium and potassium was found in all the pond waters than the normal level. This may be due to the sediment mineralization in the pond which might have caused the nutrient to solubilize into the water body.

Maximum sulphate content was found in Purusottam Sagar (174.14 mg/l) during monsoon and minimum sulphate content was found in Darpan Sagar (49.92 mg/l) during post monsoon. The present study found out that the sulphate content in all the pond waters were well within the permissible limit.

Maximum DO content was found in Purunapara Bandh (8.4 mg/l) during post-monsoon and minimum DO content was found in Purunapara Bandh (2.40 mg/l) during pre-monsoon. DO content increased from pre-monsoon to monsoon to post-monsoon. The present study discovers low level of DO in all the pond waters. This indicates large organic matter load in the water body which might have been due to the domestic runoff and cultural activities like immersion of idols in the ponds.

Maximum COD was found in Purusottam Sagar (256 mg/l) during monsoon and minimum COD was found in Ram Sagar and Darpan Sagar (12 mg/l) during post monsoon. The present study found out high COD values in all the pond waters thereby suggesting the fact that the ponds are contaminated with large amount of non biodegradable waste. This might have been due to the agricultural runoff and cultural practices like idol immersion. However, less COD in post monsoon indicates dilution of the organic matter content in water after intense rainfall.

Maximum Total Alkalinity was found in Ram Sagar (299 mg/l) during monsoon and minimum Total Alkalinity was found in Darpan Sagar (125mg/l) during post monsoon. From the present study, it was found that only Ram Sagar pond exceeds the desirable limit with respect to alkalinity, where as all other ponds are well within the desirable limit. This might have been due to the fact that Ram Sagar pond is a small pond upon which large population is dependent on for the domestic use.

Maximum Turbidity was found in Purusottam Sagar (636.56 NTU) during pre-monsoon and minimum Turbidity was found in Darpan Sagar (22.15 NTU) during post monsoon. The present study reveals high turbidity in all the water samples from the four ponds. This can be well understood by the fact that all other parameters like sodium, potassium, nitrate, phosphate etc. are in high levels in the ponds thereby indicating high amount of salt formation due to these ions.

Maximum Acidity content was found in Ram Sagar (43 mg  $\text{CaCO}_3/\text{l}$ ) during monsoon and minimum Acidity content was found in Purunapada Bandh and Darpan sagar (15 mg  $\text{CaCO}_3/\text{l}$ ) during pre monsoon. Maximum Free  $\text{CO}_2$  was found in Ram Sagar(58.65 mg/l) during post-monsoon and minimum Free  $\text{CO}_2$  was found in Purunapara Bandh and Darpan Sagar (6.60 mg/l) during pre monsoon. Acidity in the water samples from the four ponds showed a low value which suggests that the pond water was not acidic in nature. Similarly, the free carbon dioxide in the water samples from the four ponds showed that the value was well within limits.

Maximum Chloride was found in Ram Sagar (135.61 mg/l) during pre-monsoon and minimum Chloride was found in Darpan Sagar(43.55 mg/l) during post monsoon. In the present study, the chloride content in the water samples from all the four ponds were found to be within the permissible limit.

Maximum Total Hardness was found in Ram Sagar (162.00 mg CaCO<sub>3</sub>/l) during post-monsoon and minimum Total Hardness was found in Purusottam Sagar (41.20 mg CaCO<sub>3</sub>/l) during monsoon. In the present study, the water samples analysis of all the pond waters revealed that the total hardness of the water samples was within the permissible limit.

Maximum Phytoplanktons was found in Ram Sagar (4842.00 total count/l) during monsoon and minimum Phytoplankton was found in Darpan Sagar (658 total count/l) during monsoon. The phytoplanktons quantification in all the pond water samples showed that the phytoplanktons number in all the ponds are within the permissible limit.

Maximum Fe content was found in Ram Sagar (0.528 mg/l) during pre monsoon and minimum Fe content was found in Purunapara Bandh (0.326 mg/l) during monsoon. Maximum Cu content was found in Darpan Sagar (0.129mg/l) during pre monsoon and minimum Cu content was found in Darpan Sagar (0.012 mg/l) during monsoon. Maximum Ni content was found in Darpan Sagar (0.097mg/l) during pre monsoon and minimum Ni content was found in Ram Sagar (0.023mg/l) during monsoon. Maximum Co content was found in Darpan Sagar (0.056mg/l) during pre monsoon and minimum Co content was found Purusottam Sagar (0.026mg/l) during pre monsoon. Maximum Zn content was found in Ram Sagar (0.014mg/l) during pre monsoon and minimum Zn content was found in Purusottam Sagar and Darpan Sagar (0.001mg/l) during monsoon. Maximum Pb content was found in Purunapada Bandh (0.340mg/l) during pre monsoon and minimum Pb content was found in Ram Sagar (0.123mg/l) during post monsoon. Maximum Cd content was found in Darpan Sagar (0.093mg/l) during post monsoon and minimum Cd content was found in Ram Sagar (0.008mg/l) during monsoon. In the present study, the water samples from all the four ponds were found to contain high concentration of metals with respect to iron, copper, nickel, cobalt, lead and cadmium. Only zinc content was found to be within permissible limit in all the four ponds.

Besides these parameters, the water samples were also tested for few qualitative characteristics like taste and odour. The taste of these water samples was not agreeable and the odour of the samples was also objectionable.

The Two-way ANOVA worked out for each of the above parameters is given in Table VI. The table clearly suggests that conductivity, nitrate, sodium, total alkalinity, chloride, total hardness, Fe and Cd content show significant difference with respect to both ponds and seasons ( $F \geq 4.76$ ,  $F \geq 5.14$ ;  $P < 0.05$ ) whereas sulphate, turbidity, phytoplanktons, Cu, Ni and Co content showed no significant difference with respect to both ponds and seasons ( $F \leq 4.76$ ,  $F \leq 5.14$ ;  $P > 0.05$ ). Significant variation of pH, temperature, TDS, TSS, TS, phosphate, potassium, DO, COD, acidity, free carbon dioxide and Pb content were found with respect to different seasons only ( $F \geq 5.14$ ;  $P < 0.05$ ).

The correlation among various water parameters of Purusottam Sagar, Ram Sagar, Purunapara Bandh and Darpan Sagar taking all the seasons in account is given in Table- VIII, IX, X and XI respectively. Further, a correlation matrix was also worked out and given in Table-XII considering all the parameters irrespective of ponds. The value of "r" marked with an asterisk (\*) represents strong positive or negative correlation at 0.05 level of significance. When all the parameters irrespective of the ponds were correlated, then pH was found to show significant positive correlation with EC, TDS, TS, DO, total alkalinity, free carbon dioxide, chloride and total hardness, while EC showed significant positive correlation with Na, sulphate, DO, total alkalinity, acidity, chloride and total hardness ( $r \geq 0.815$ ,  $p < 0.05$ ). However, the parameters showed significant negative correlation are temperature with COD, TDS with K and turbidity and K with free carbon dioxide ( $r \geq - 0.815$ ,  $p < 0.05$ ).

Table II- Physico-chemical and biological parameters of purusottam Sagar

Parameters	Pre Monsoon	Monsoon	Post Monsoon	Mean±S.D
pH	7.46	6.8	7.34	7.20±0.29
Conductivity	549.1	742	451.5	580.87±120.70
Temperature (° C)	38	35	31	34.67±2.87
TDS (mg/l)	400	600	400	466.67±94.28
TSS (mg/l)	660	1300	160	706.67±466.57
TS (mg/l)	1060	1900	560	1173.33±552.89
Nitrate (mg/l)	59	68	23	50.00±19.44
Phosphate (mg/l)	42	73	24.5	46.50±20.05
Sodium (mg/l)	132.4	196	25.41	117.94±70.39
Potassium (mg/l)	432	773	215	473.33±229.67
Sulphate (mg/l)	96	174.14	84.48	118.21±39.83
DO (mg/l)	2.88	3.28	6.24	4.13±1.50
COD (mg/l)	40	256	20	105.33±106.85
Total Alkalinity (mg CaCO <sub>3</sub> /l)	162	158	147	155.67±6.34
Turbidity (NTU)	636.56	209.31	71.93	305.93±240.42
Acidity (mg CaCO <sub>3</sub> /l)	16.5	33	19	22.83±7.26
Free Carbon Dioxide (mg/l)	0	16.28	38.15	18.14±15.63
Chloride (mg/l)	67.45	55.38	59.64	60.82±5.00
Total Hardness (mg CaCO <sub>3</sub> /l)	68	41.2	93.4	67.53±21.31
Phytoplankton	2262	2620	3242	2708.00±404.89

(total count/l)				
Fe (mg/l)	0.494	0.414	0.442	0.450±0.033
Cu (mg/l)	0.104	0.112	0.121	0.112±0.007
Ni (mg/l)	0.039	0.051	0.065	0.052±0.011
Co (mg/l)	0.026	0.041	0.051	0.039±0.010
Zn (mg/l)	0.004	0.001	0.008	0.004±0.003
Pb (mg/l)	0.263	0.221	0.232	0.239±0.018
Cd (mg/l)	0.047	0.021	0.032	0.033±0.011

Table III- Physico-chemical and biological parameters of ram sagar

Parameters	Pre Monsoon	Monsoon	Post Monsoon	Mean±S.D
pH	8.11	7.14	7.7	7.65±0.40
Conductivity	943.3	1472	745.7	1053.67±306.61
Temperature (° C)	37	34	32	34.33±2.05
TDS (mg/l)	600	1200	200	666.67±410.96
TSS (mg/l)	920	1660	220	933.33±587.95
TS (mg/l)	1520	2860	420	1600.00±997.73
Nitrate (mg/l)	62	98	26	62.00±29.39
Phosphate (mg/l)	14	56	29.5	33.17±17.34
Sodium (mg/l)	161.8	227	80.58	156.46±59.86
Potassium (mg/l)	387	578	239	401.33±138.77
Sulphate (mg/l)	148.8	165.12	111.36	141.76±22.50
DO (mg/l)	3.44	4.56	7.84	5.28±1.87
COD (mg/l)	100	252	12	121.33±99.13
Total Alkalinity (mg CaCO <sub>3</sub> /l)	278	299	227	268.00±30.23
Turbidity (NTU)	335.04	69.01	51.34	151.80±129.77
Acidity (mg CaCO <sub>3</sub> /l)	16.5	43	22.3	27.27±11.37
Free Carbon Dioxide (mg/l)	0	22	58.65	26.88±24.19
Chloride (mg/l)	135.61	115.02	101.25	117.29±14.12
Total Hardness (mg CaCO <sub>3</sub> /l)	158	126.6	162	148.87±15.83
Phytoplankton (total count/l)	3884	4842	3882	4202.67±452.08
Fe (mg/l)	0.528	0.411	0.418	0.452±0.054
Cu (mg/l)	0.075	0.043	0.087	0.068±0.019
Ni (mg/l)	0.042	0.023	0.028	0.031±0.008
Co (mg/l)	0.037	0.031	0.035	0.034±0.002
Zn (mg/l)	0.014	0.011	0.012	0.012±0.001
Pb (mg/l)	0.185	0.132	0.123	0.147±0.027
Cd (mg/l)	0.018	0.008	0.012	0.013±0.004

Table IV- Physico-chemical and biological parameters of purunapada bandh

Parameters	Pre Monsoon	Monsoon	Post Monsoon	Mean±S.D
pH	8	6.76	7.59	7.45±0.52
Conductivity	780.5	1266	665.4	903.97±260.27
Temperature (° C)	36	36	34	35.33±0.94
TDS (mg/l)	600	1000	400	666.67±249.44
TSS (mg/l)	400	1300	140	613.33±497.01
TS (mg/l)	1000	2300	540	1280.00±745.30
Nitrate (mg/l)	24	57	12	31.00±19.03
Phosphate (mg/l)	9	39	21.5	23.17±12.30
Sodium (mg/l)	150.3	281	80.19	170.50±83.21
Potassium (mg/l)	298	647	225	390.00±184.15
Sulphate (mg/l)	129.6	162.62	105.6	132.61±23.38

DO (mg/l)	2.4	2.56	8.4	4.45±2.79
COD (mg/l)	24	128	16	56.00±51.02
Total Alkalinity (mg CaCO <sub>3</sub> /l)	226	199	173	199.33±21.64
Turbidity (NTU)	54.99	51.78	25.78	44.19±13.08
Acidity (mg CaCO <sub>3</sub> /l)	15	33	20.3	22.77±7.55
Free Carbon Dioxide (mg/l)	6.6	14.52	48.4	23.17±18.13
Chloride (mg/l)	122.83	102.67	103.09	109.53±9.41
Total Hardness (mg CaCO <sub>3</sub> /l)	102	59.2	99.4	86.87±19.59
Phytoplankton (total count/l)	1252	882	4260	2131.33±1512.75
Fe (mg/l)	0.453	0.326	0.331	0.370±0.059
Cu (mg/l)	0.083	0.042	0.067	0.064±0.017
Ni (mg/l)	0.056	0.036	0.043	0.045±0.008
Co (mg/l)	0.04	0.028	0.034	0.034±0.005
Zn (mg/l)	0.005	0.002	0.006	0.004±0.002
Pb (mg/l)	0.34	0.176	0.156	0.224±0.082
Cd (mg/l)	0.061	0.021	0.041	0.041±0.016

Table V- Physico-chemical and biological parameters of darpan sagar

Parameters	Pre Monsoon	Monsoon	Post Monsoon	Mean±S.D
pH	7.43	6.96	7.51	7.30±0.24
Conductivity	491	788.8	383	554.27±171.60
Temperature (° C)	37	31	32	33.33±2.62
TDS (mg/l)	600	800	400	600.00±163.30
TSS (mg/l)	940	1280	120	780.00±486.89
TS (mg/l)	1540	2080	520	1380.00±646.84
Nitrate (mg/l)	14	24	15	17.67±4.50
Phosphate (mg/l)	12	28.5	15.5	18.67±7.10
Sodium (mg/l)	113.8	163	21.54	99.45±58.64
Potassium (mg/l)	318	678	253	416.33±186.92
Sulphate (mg/l)	128.64	68.16	49.92	82.24±33.64
DO (mg/l)	3.12	3.68	4.08	3.63±0.39
COD (mg/l)	132	240	12	128.00±93.12
Total Alkalinity (mg CaCO <sub>3</sub> /l)	158	184	125	155.67±24.14
Turbidity (NTU)	185.17	86.96	22.15	98.09±67.01
Acidity (mg CaCO <sub>3</sub> /l)	15	30	15.7	20.23±6.91
Free Carbon Dioxide (mg/l)	6.6	17.6	44	22.73±15.69
Chloride (mg/l)	69.58	59.21	43.55	57.45±10.70
Total Hardness (mg CaCO <sub>3</sub> /l)	68	68.6	80	72.20±5.52
Phytoplankton (total count/l)	890	658	2680	1409.33±903.48
Fe (mg/l)	0.342	0.331	0.365	0.346±0.014
Cu (mg/l)	0.129	0.012	0.043	0.061±0.049
Ni (mg/l)	0.097	0.031	0.049	0.059±0.028
Co (mg/l)	0.056	0.037	0.041	0.045±0.008
Zn (mg/l)	0.008	0.001	0.001	0.003±0.003
Pb (mg/l)	0.295	0.165	0.185	0.215±0.057
Cd (mg/l)	0.085	0.063	0.093	0.080±0.013

Table VI: Two way anova (without replication) of various parameters between ponds and seasons

Parameters	Source of Variation	SS	df	MS	F(cal)	F(tab)	S or NS
pH	Between ponds	0.35	3	0.12	3.59	4.76	NS
	Between seasons	1.50	2	0.75	23.45	5.14	S
Conductivity	Between ponds	542056.16	3	180685.39	16.66	4.76	S
	Between seasons	552224.76	2	276112.38	25.46	5.14	S
Temperature	Between ponds	6.25	3	2.08	0.86	4.76	NS

	Between seasons	46.17	2	23.08	9.55	5.14	S
TDS	Between ponds	80000.00	3	26666.67	0.89	4.76	NS
	Between seasons	620000.00	2	310000.00	10.33	5.14	S
TSS	Between ponds	164366.67	3	54788.89	2.41	4.76	NS
	Between seasons	3006066.67	2	1503033.33	66.15	5.14	S
TS	Between ponds	297700.00	3	99233.33	1.22	4.76	NS
	Between seasons	6338066.67	2	3169033.33	39.04	5.14	S
Nitrate	Between ponds	3491.00	3	1163.67	5.74	4.76	S
	Between seasons	3656.17	2	1828.08	9.02	5.14	S
Phosphate	Between ponds	1370.56	3	456.85	4.73	4.76	NS
	Between seasons	2133.88	2	1066.94	11.03	5.14	S
Sodium	Between ponds	9813.10	3	3271.03	8.49	4.76	S
	Between seasons	54404.35	2	27202.17	70.63	5.14	S
Potassium	Between ponds	12318.25	3	4106.08	1.25	4.76	NS
	Between seasons	402885.50	2	201442.75	61.41	5.14	S
Sulphate	Between ponds	6164.31	3	2054.77	2.45	4.76	NS
	Between seasons	6276.78	2	3138.39	3.74	5.14	NS
DO	Between ponds	4.33	3	1.44	0.90	4.76	NS
	Between seasons	31.45	2	15.73	9.85	5.14	S
COD	Between ponds	9525.33	3	3175.11	2.03	4.76	NS
	Between seasons	88162.67	2	44081.33	28.15	5.14	S
Total Alkalinity	Between ponds	25324.67	3	8441.56	29.49	4.76	S
	Between seasons	4298.67	2	2149.33	7.51	5.14	S
Turbidity	Between ponds	114627.54	3	38209.18	2.55	4.76	NS
	Between seasons	147898.40	2	73949.20	4.93	5.14	NS
Acidity	Between ponds	76.92	3	25.64	3.41	4.76	NS
	Between seasons	815.62	2	407.81	54.22	5.14	S
Free CO <sub>2</sub>	Between ponds	115.49	3	38.50	1.26	4.76	NS
	Between seasons	4030.11	2	2015.05	65.93	5.14	S
Chloride	Between ponds	8944.72	3	2981.57	70.50	4.76	S
	Between seasons	1028.26	2	514.13	12.16	5.14	S
Total Hardness	Between ponds	12710.67	3	4236.89	32.71	4.76	S
	Between seasons	2580.19	2	1290.09	9.96	5.14	S
Phytoplankton	Between ponds	12650643.67	3	4216881.22	4.63	4.76	NS
	Between seasons	4957984.67	2	2478992.33	2.72	5.14	NS
Fe	Between ponds	0.026912	3	0.008971	7.30	4.76	S
	Between seasons	0.015485	2	0.007743	6.30	5.14	S
Cu	Between ponds	0.005211	3	0.001737	2.01	4.76	NS
	Between seasons	0.004195	2	0.002097	2.43	5.14	NS
Ni	Between ponds	0.001276	3	0.000425	1.29	4.76	NS
	Between seasons	0.001082	2	0.000541	1.64	5.14	NS
Co	Between ponds	0.000227	3	0.000076	0.87	4.76	NS
	Between seasons	0.000089	2	0.000044	0.51	5.14	NS
Zn	Between ponds	0.000158	3	0.000053	8.79	4.76	S
	Between seasons	0.000035	2	0.000017	2.89	5.14	NS
Pb	Between ponds	0.014978	3	0.004993	3.62	4.76	NS
	Between seasons	0.025091	2	0.012546	9.08	5.14	S
Cd	Between ponds	0.007218	3	0.002406	33.51	4.76	S
	Between seasons	0.001243	2	0.000622	8.66	5.14	S

Table VII: Comparison of the water quality of all ponds with different water quality standards

	Purusottam Sagar		Ram Sagar		Purunapada Bandh		Darpan Sagar		Permissible Limit			
	Range	Average	Range	Average	Range	Average	Range	Average	CPCB	BIS	CPHEFO	WHO
pH	6.8-7.46	7.20	7.7-8.11	7.65	6.76-8.00	7.45	6.96-7.51	7.30	6.5-8.5	6.5-8.5	7-8.5	7-8.5
conductivity	451.5-742	580.87	745.7-1472	1053.67	665.4-1266	903.97	383-788.8	554.27	-	-	-	-
Temperature	31-38	34.67	32-37	34.33	34-36	35.33	31-37	33.33	-	-	-	-
TDS	400-600	466.67	200-1200	666.67	400-1000	666.67	400-800	600.00	500 ppm	-	500 ppm	500 ppm
TSS	160-1300	706.67	220-1660	933.33	140-1300	613.33	120-1280	780.00	-	-	-	-
TS	560-1900	1173.33	420-2860	1600.00	540-2300	1280.00	520-2080	1380.00	-	-	-	-
Nitrate	23-68	50.00	26-98	62.00	12.0-57	31.00	14-24	17.67	45 mg/l	45 mg/l	45 mg/l	50 mg/l
Phosphate	24.5-73	46.50	14-56	33.17	9.0-39	23.17	12-28.5	18.67	5 mg/l	5 mg/l	5 mg/l	5 mg/l
Sodium	25.41-196	117.94	80.58-227	156.46	80.19-281	170.50	21.54-163	99.45	-	-	-	-
Potassium	215-773	473.33	239-578	401.33	225-647	390.00	253-678	416.33	-	-	-	-
Sulphate	84.48-174.144	118.21	111.36-165.12	141.76	105.6-162.624	132.61	49.92-128.64	82.24	-	-	-	-
DO	2.88-6.24	4.13	3.44-7.84	5.28	2.4-8.4	4.45	3.12-4.08	3.63	6 mg/l	6 mg/l	6 mg/l	8-10 mg/l
COD	20-256	105.33	12-252	121.33	16-128	56.00	12-240	128.00	-	-	-	-
Total Alkalinity	147-162	155.67	227-299	268.00	173-226	199.33	125-184	155.67	-	-	-	-
Turbidity	71.93-636.56	305.93	51.34-335.04	151.80	25.78-54.99	44.19	22.15-185.17	98.09	5NTU	5NTU	2.5 NTU	5NTU
Acidity	19-33	22.83	22.3-43	27.27	15-33	22.77	15-30	20.23	-	-	-	-
Free Carbon dioxide	16.28-38.148	18.14	22-58.652	26.88	6.6-48.4	23.17	6.6-44	22.73	-	-	-	-
Chloride	55.38-67.45	60.82	101.246-115.02	117.29	102.666-122.83	109.53	43.5514-69.58	57.45	-	-	-	-
Total Hardness	41.2-93.4	67.53	126.6-162	148.87	59.2-102	86.87	68-80	72.20	-	-	-	-

Table VIII: Correlation matrix among various parameters in purusottam sagar

	pH	EC	Temp	TDS	TSS	TS	NO <sub>3</sub>	PO <sub>4</sub>	Na	K	SO <sub>4</sub>	DO	COD	T Alka	Turbidity	Acidity	Free CO <sub>2</sub>	Chloride	TH
pH	1.000																		
EC	*-0.873	1.000																	
Temp	0.089	0.407	1.000																
TDS	*-0.985	*0.943	0.082	1.000															
TSS	-0.811	*0.993	0.510	*0.899	1.000														
TS	*-0.853	*0.999	0.444	*0.929	*0.997	1.000													
NO <sub>3</sub>	-0.516	*0.867	0.807	0.655	*0.919	*0.887	1.000												
PO <sub>4</sub>	*-0.860	*1.000	0.432	*0.934	*0.996	*1.000	*0.881	1.000											
Na	-0.667	*0.945	0.683	0.784	*0.977	*0.957	*0.982	*0.954	1.000										
K	*-0.843	*0.998	0.460	*0.923	*0.998	*1.000	*0.896	*0.999	*0.963	1.000									
SO <sub>4</sub>	*-0.958	*0.976	0.199	*0.993	*0.945	*0.966	0.739	*0.970	*0.852	*0.962	1.000								
DO	0.241	-0.682	*-0.945	-0.403	-0.763	-0.712	*-0.956	-0.702	*-0.884	-0.725	-0.508	1.000							
COD	*-0.969	*0.966	0.158	*0.997	*0.930	*0.955	0.711	*0.959	*0.829	*0.949	*0.999	-0.471	1.000						
T Alka	-0.092	0.564	*0.984	0.260	0.656	*0.900	0.587	0.803	0.612	0.372	*-0.989	0.333	1.000						
Turbidity	0.444	0.048	*0.932	-0.284	0.164	0.090	0.539	0.076	0.372	0.108	-0.169	-0.763	-0.210	*0.852	1.000				
Acidity	*-1.000	*0.888	-0.059	*0.990	*0.829	*0.868	0.542	*0.875	0.689	*0.859	*0.967	-0.270	*0.976	0.122	-0.416	1.000			
Free CO <sub>2</sub>	-0.087	-0.408	*-1.000	-0.084	-0.512	-0.446	-0.808	-0.434	-0.684	-0.462	-0.201	*0.946	-0.160	0.984	*-0.931	0.057	1.000		
Chloride	*0.868	-0.516	0.572	-0.770	-0.413	-0.480	-0.022	-0.492	-0.208	-0.464	-0.689	-0.274	-0.719	0.416	*0.830	*-0.852	-0.571	1.000	
TH	0.778	*-0.985	-0.557	0.874	0.998	0.992	*-0.940	0.990	*-0.987	0.994	0.925	0.797	*-0.908	-0.697	-0.218	-0.797	0.558	0.362	1.000

Table IX: Correlation matrix among various parameters in ram sagar

	pH	EC	Temp	TDS	TSS	TS	NO <sub>3</sub>	PO <sub>4</sub>	Na	K	SO <sub>4</sub>	DO	COD	T Alka	Turbidity	Acidity	Free CO <sub>2</sub>	Chloride	TH
pH	1.000																		
EC	-0.764	1.000																	
Temp	0.522	0.151	1.000																
TDS	-0.665	*0.990	0.289	1.000															
TSS	-0.588	*0.971	0.383	*0.995	1.000														
TS	-0.620	*0.980	0.345	*0.998	*0.999	1.000													
NO <sub>3</sub>	-0.575	*0.967	0.397	*0.993	*1.000	*0.998	1.000												
PO <sub>4</sub>	-0.691	*0.994	0.256	*0.999	*0.991	*0.996	*0.989	1.000											
Na	-0.522	*0.949	0.454	*0.984	*0.997	*0.993	*0.998	*0.977	1.000										
K	-0.633	*0.983	0.329	*0.999	*0.998	*1.000	*0.997	*0.997	0.991	1.000									
SO <sub>4</sub>	-0.380	*0.887	0.591	*0.943	*0.972	*0.961	*0.975	*0.931	*0.987	*0.956	1.000								
DO	-0.158	-0.516	*-0.924	-0.633	-0.706	-0.677	-0.717	-0.605	-0.760	-0.664	0.854	1.000							
COD	-0.693	*0.995	0.253	*0.999	*0.991	*0.995	*0.988	*1.000	*0.977	*0.997	*0.930	-0.603	1.000						
T Alka	-0.368	*0.881	0.601	*0.939	*0.968	*0.957	*0.972	*0.926	*0.985	*0.953	*1.000	*-0.860	*0.925	1.000					
Turbidity	0.785	-0.200	*0.938	-0.059	0.040	-0.001	0.056	-0.094	0.118	-0.018	0.275	-0.736	-0.097	0.288	1.000				
Acidity	*-0.975	*0.889	-0.319	*0.815	0.754	0.780	0.743	*0.835	0.699	0.790	0.577	-0.066	*0.836	0.566	-0.627	1.000			
Free CO <sub>2</sub>	-0.287	-0.398	*-0.967	-0.524	-0.606	-0.573	-0.619	-0.494	-0.667	-0.559	-0.777	*0.991	-0.492	-0.785	*-0.819	0.066	1.000		
Chloride	0.521	0.152	*1.000	0.290	0.383	0.346	0.398	0.257	0.455	0.330	0.591	-0.925	0.254	0.602	*0.938	-0.318	*-0.967	1.000	
TH	*0.859	*-0.987	0.012	0.954	0.919	0.935	0.913	0.964	0.885	0.940	0.800	0.370	0.964	-0.792	0.357	*-0.951	0.244	0.011	1.000

Table X: Correlation matrix among various parameters in purunapada bandh

	pH	EC	Temp	TDS	TSS	TS	NO <sub>3</sub>	PO <sub>4</sub>	Na	K	SO <sub>4</sub>	DO	COD	T Alka	Turbidity	Acidity	Free CO <sub>2</sub>	Chloride	TH	
pH	1.000																			
EC	0.623	1.000																		
Temp	-0.192	0.648	1.000																	
TDS	-0.788	-0.009	0.756	1.000																
TSS	*0.877	*0.922	0.304	-0.394	1.000															
TS	*0.834	-0.087	0.702	*0.997	-0.465	1.000														
NO <sub>3</sub>	0.830	-0.082	0.706	*0.997	-0.460	*1.000	1.000													
PO <sub>4</sub>	-0.726	0.085	*0.814	*0.996	-0.306	*0.985	*0.986	1.000												
Na	-0.777	0.009	0.767	*1.000	-0.378	*0.995	*0.996	*0.997	1.000											
K	*0.881	-0.179	0.634	*0.985	-0.545	*0.996	*0.995	*0.965	*0.982	1.000										
SO <sub>4</sub>	-0.723	0.090	*0.817	*0.995	-0.302	*0.984	*0.985	*1.000	*0.997	*0.964	1.000									
DO	0.169	-0.666	1.000	-0.740	-0.326	-0.685	-0.689	-0.800	-0.752	-0.615	-0.803	1.000								
COD	*0.923	-0.274	0.554	*0.964	-0.625	*0.982	*0.981	*0.935	*0.959	*0.995	*0.933	-0.535	1.000							
T Alka	0.335	*0.946	*0.861	0.317	0.747	0.241	0.247	0.405	0.334	0.151	0.409	*0.872	0.053	1.000						
Turbidity	-0.092	0.721	*0.995	0.686	0.398	0.627	0.631	0.752	0.699	0.553	0.755	0.997	0.468	*0.907	1.000					
Acidity	0.999	-0.591	0.231	*0.812	0.857	*0.855	*0.852	0.753	0.801	*0.899	0.750	-0.208	*0.938	-0.297	0.132	1.000				
Free CO <sub>2</sub>	0.014	-0.774	0.984	-0.627	-0.469	-0.564	-0.569	-0.698	-0.641	-0.485	-0.701	*0.988	-0.397	0.938	*-0.997	-0.054	1.000			
Chloride	0.766	*0.980	0.484	-0.207	*0.981	-0.283	-0.278	-0.114	-0.190	-0.370	-0.109	-0.504	-0.460	*0.862	0.569	-0.740	-0.632	1.000		
TH	*0.962	0.386	-0.452	0.926	0.712	0.953	0.951	0.886	0.919	0.977	0.884	0.431	0.993	0.065	-0.361	*-0.972	0.286	0.562	1.000	

Table XI: Correlation matrix among various parameters in darpan sagar

	pH	EC	Temp	TDS	TSS	TS	NO <sub>3</sub>	PO <sub>4</sub>	Na	K	SO <sub>4</sub>	DO	COD	T Alka	Turbidity	Acidity	Free CO <sub>2</sub>	Chloride	TH	
pH	1.000																			
EC	*-0.992	1.000																		
Temp	0.518	-0.408	1.000																	
TDS	*-0.925	*0.965	-0.156	1.000																
TSS	*-0.812	*0.878	0.078	*0.973	1.000															
TS	*-0.845	*0.905	0.020	*0.985	*0.998	1.000														
NO <sub>3</sub>	*-0.975	*0.939	-0.697	*0.817	0.661	0.704	1.000													
PO <sub>4</sub>	*-0.998	*0.998	-0.459	*0.949	*0.850	*0.879	*0.957	1.000												
Na	*-0.846	*0.906	0.018	*0.985	*0.998	*1.000	0.705	*0.880	1.000											
K	*-1.000	*0.993	-0.512	*0.928	*0.816	*0.849	*0.973	*0.998	*0.850	1.000										
SO <sub>4</sub>	*-0.996	*0.999	-0.441	*0.955	*0.860	*0.889	*0.951	*1.000	*0.890	*0.997	1.000									
DO	0.039	-0.163	0.834	-0.415	-0.615	-0.568	0.186	-0.107	-0.566	-0.047	-0.127	1.000								
COD	*-0.914	*0.957	-0.125	*1.000	*0.979	*0.989	0.799	*0.939	*0.990	*0.917	*0.946	-0.442	1.000							
T Alka	*-0.897	*0.945	-0.088	*0.998	*0.986	*0.994	0.776	*0.925	*0.994	*0.901	*0.933	-0.476	*0.999	1.000						
Turbidity	-0.017	0.142	*0.846	0.395	0.597	0.549	-0.207	0.085	0.548	0.025	0.105	*-1.000	0.422	0.457	1.000					
Acidity	*-0.984	*0.955	-0.660	*0.845	0.697	0.738	*0.999	*0.970	0.739	*0.983	*0.965	0.137	*0.828	0.806	-0.158	1.000				
Free CO <sub>2</sub>	0.360	-0.473	-0.611	-0.687	0.837	-0.803	-0.142	-0.422	-0.802	-0.367	-0.441	*0.946	-0.709	-0.735	*-0.939	-0.191	1.000			
Chloride	-0.249	0.368	0.699	0.598	0.768	0.729	0.026	0.314	0.727	0.256	0.334	*-0.977	0.622	0.651	*0.973	0.076	*-0.993	1.000		
TH	0.576	-0.674	-0.400	-0.843	0.945	0.924	-0.379	-0.630	0.923	-0.582	-0.646	*0.839	0.859	0.878	*-0.827	-0.424	*0.970	*-0.935	1.000	

Table XII: Correlation matrix among various parameters in different pond waters

	pH	EC	Temp	TDS	TSS	TS	NO <sub>3</sub>	PO <sub>4</sub>	Na	K	SO <sub>4</sub>	DO	COD	T Alka	Turbidity	Acidity	Free CO <sub>2</sub>	Chloride	TH	
pH	1.000																			
EC	*0.951	1.000																		
Temp	0.170	0.465	1.000																	
TDS	*0.843	0.764	0.094	1.000																
TSS	0.563	0.355	-0.544	0.233	1.000															
TS	*0.855	0.660	-0.356	0.691	*0.864	1.000														
NO <sub>3</sub>	0.457	0.549	0.337	-0.084	0.520	0.343	1.000													
PO <sub>4</sub>	-0.237	-0.077	0.320	-0.700	0.089	-0.297	0.753	1.000												
Na	0.727	*0.894	0.787	0.650	-0.096	0.266	0.397	-0.045	1.000											
K	-0.758	-0.683	-0.093	*-0.990	-0.117	-0.600	0.217	0.779	-0.613	1.000										
SO <sub>4</sub>	0.664	*0.849	0.767	0.342	0.118	0.265	0.771	0.395	*0.885	-0.255	1.000									
DO	*0.867	*0.929	0.431	0.498	0.510	0.637	*0.817	0.266	0.770	-0.382	*0.906	1.000								
COD	-0.038	-0.289	*-0.874	-0.242	0.792	0.463	0.152	0.112	-0.683	0.305	-0.448	-0.094	1.000							
T Alka	*0.971	*0.953	0.231	0.693	0.620	*0.820	0.655	-0.001	0.722	-0.585	0.768	*0.954	0.011	1.000						
Turbidity	-0.465	-0.385	-0.007	*-0.869	0.142	-0.345	0.556	*0.931	-0.405	*0.930	0.044	-0.023	0.370	-0.246	1.000					
Acidity	0.795	*0.838	0.326	0.352	0.615	0.640	*0.903	0.400	0.633	-0.221	*0.854	*0.979	0.070	*0.916	0.152	1.000				
Free CO <sub>2</sub>	*0.940	0.798	-0.122	*0.906	0.620	*0.930	0.196	-0.495	0.516	0.844	0.370	0.657	0.128	*0.852	-0.622	0.585	1.000			
Chloride	*0.912	*0.989	0.553	0.786	0.215	0.567	0.463	-0.132	*0.945	-0.723	*0.849	*0.878	-0.424	*0.897	-0.457	0.763	0.755	1.000		
TH	*0.944	*0.879	0.063	0.631	0.757	*0.890	0.673	0.024	0.578	-0.513	0.669	*0.918	0.200	*0.982	-0.168	*0.912	*0.857	0.798	1.000	

#### IV. CONCLUSIONS

The comparison of the water quality of all the ponds with various water quality standards is given in Table VII. From the table it is evident that all the pond water samples showed high value for electrical conductivity, phosphate, COD, TDS, turbidity, cadmium content, lead content and copper content exceeding the permissible limit excepting Purusottam sagar with respect to TDS which was within the limit. Both the Purusottam sagar and Ram sagar water samples showed high nitrate content exceeding the limit. Moreover, the DO content in all the ponds was low but the lowest value being recorded in the Darpan sagar. Except the Purunapada Bandh (government owned), all the other ponds are privately owned and hence the pollution load in these ponds is getting cumulative over the years. Hence, proper and timely cleaning of these ponds by the government is the urgent need of the hour.

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