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Study on Hydrological Parameters in Three Lentic Ecosystems of Eastern Kolkata

Sheetal A., Sangram Keshari Rout, Sriparna Chakraborty, R. R. Anupama

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Abstract Three lentic water bodies were studied seasonally for various hydrological parameters viz., water pH, water temperature, dissolved oxygen, free carbon dioxide, turbidity, electrical conductivity, total dissolved solids. Well marked seasonal variations with distinct maxima and minima in each parameter were studied. pH value of waters from various water bodies showed an alkaline status throughout the study period. Correlation coefficient depicted a strong relationship between various hydrological parameters of three water bodies. Levels of different parameters from present study revealed organic pollution leading to eutrophication of water.

Keywords Hydrological parameters, Lentic water body.

Introduction

Physico-chemical characterization is one of the most important factors which are necessary for the survival of any water body. All physico-chemical parameters are limiting and their present or absence produce vital and important consequences on the biotic component of that particular water body [1]. The accumulation of various kinds of pollutants and nutrients through domestic sewage, municipal effluents and agricultural runoff into the ponds lead to the changes in physico-chemical characteristics of fresh water [2]. Physical and chemical factors like temperature, salinity, total dissolved solids, dissolved gases and nutrients influence the water quality directly or indirectly, which ultimately govern the healthy survival of organisms in aquatic ecosystems [3]. Some researchers stated that physical parameters such as temperature, turbidity and electrical conductivity are known to operate in Lake Ecosystem which plays a significant role in the composition, distribution and abundance of aquatic organisms [4]. The physical and chemical limnology of a pond is characterized by hydrologic impact, autogenic nutrient dynamics and biological aspects. Some reporters reported that water temperature is of enormous significance as it regulates various abiotic as well as biotic activities of an aquatic system [5]. This perusal of literature on ecological investigations of water bodies showed that long-term monitoring and comprehensive analysis of the physico-chemical parameters is crucial to a holistic approach in solving environmental problems of such systems.

Materials and Methods

The duration of research work carried out was nine months (from November 2015 to July 2016). The three water bodies were denoted as P-1, P-2 and P-3. The samples were collected fortnightly in the early morn-

Sheetal A., S. K. Rout*, S. Chakraborty, R. R. Anapama
Department of Aquatic Environment Management, Faculty of Fishery Sciences, WBUAFS, 5-Budherhat road, Panchasayar, Kolkata 700094, India
e-mail: skrout68@gmail.com
*Correspondence

ing (between 7.00 am and 9.00 am) from selected sites of the water bodies. Water samples were separately collected from three sampling stations of all selected water bodies in labelled and pretreated polyethylene bottles by random sampling technique. The sensitive parameters like temperature, dissolved oxygen and free carbon dioxide were analyzed onsite itself. For the estimation of other parameters such as electrical conductivity, turbidity, ammonia, water pH, sediment pH and total dissolved solids, collected water samples were bought to the laboratory and were analyzed according to the standard procedures of APHA. The surface water temperature was recorded using a mercury centigrade thermometer (0 to 50°C) to the nearest 0.10°C graduation at station itself. The pH of water samples were measured by a digital pH meter (Systronics Model No. MK – VI) following the electrometric. Turbidity of water samples were estimated directly by Nephelo-Turbidity meter (Systronics, India ; Model No. 132) and expressed in NTU (Nephelometric Turbidity Units). Systronics digital conductivity meter 306 was used to measure the electrical conductivity and results are expressed in µS/cm. Dissolved oxygen content of water samples was estimated following Winkler's odometric titration method. Free carbon dioxide of water samples were estimated following the acid-base titrimetric method [6]. Total dissolved solids (TDS) in water samples were estimated using the gravimetric principle by evaporating the filtered sample through a standard filter paper and weighing the residue left. Ammonia was estimated spectrophotometrically by phenate method. The concentration of ammonia in water sample was calculated from standard curve and the results are expressed in mg/l.

The estimation of sediment pH measured electrometrically. The electrodes of pH meter (Systronics: Model No. MK-VI) were immersed into the filtrate and the pH value was recorded after proper calibration.

Results and Discussion

The minimum and maximum temperature recorded from the three ponds varied from 19 ± 0.00°C to 33.8 ± 0.005°C in P-1, 18.9 ± 0.05°C to 33.5 ± 0.01°C in P-2 and 19 ± 0.005°C to 33.9 ± 0.005°C in P-3 respectively. Seasonally, the temperature was maximum in summer followed by monsoon and winter in three ponds. Statistical analysis revealed that water temperature among the ponds and months were significantly varying at $p \leq 0.05$. The minimum and maximum pH in three ponds varied from 6.2 ± 0.09 to 7.6 ± 0.11 in P-1, 5.8 ± 0.02 to 7.6 ± 0.04 in P-2 and 5.16 ± 0.05 in P-3 respectively. Seasonally, the pH was maximum during summer followed by monsoon and winter in P-1 and P-3. In P-2 maximum pH was during monsoon followed by summer and winter. Statistical analysis revealed that the water pH among the ponds and months were significantly varying at $p \leq 0.05$.

The minimum and maximum DO in three ponds varied from 6.2 ± 0.09 mg/l to 7.6 ± 0.11 mg/l in P-1, 5.8 ± 0.02 mg/l to 7.6 ± 0.04 mg/l in P-2 and 5.16 ± 0.05 mg/l to 7.8 ± 0.02 mg/l in P-3 respectively. Seasonally, DO was maximum in winter followed by summer and monsoon in three ponds. Statistical analysis revealed that dissolved among the ponds and months were significantly varying at $p \leq 0.05$.

The minimum and maximum free CO_2 values in three ponds varied from 9.2 ± 0.2 mg/l to 24.6 ± 0.09 mg/l in P-1, 10.3± 0.2 mg/l to 23.2 ± 0.05 mg/l in P-2 and 10.7 ± 0.2 mg/l to 24.1 ± 0.05 mg/l in P-3 respectively. Seasonally, free CO_2 was maximum during summer followed by monsoon and winter in three ponds. Statistical analysis revealed that free CO_2 among the ponds and months were significantly varying at $p \leq 0.05$.

The minimum and maximum turbidity in three ponds varied from 17.53± 0.1 NTU to 34.79± 0.07 NTU in P-1, 21.1± 0.58 NTU to 42.73± 0.05 NTU in P-2 and 26.4± 0.05 NTU to 45.26± 0.025 NTU in P-3 respectively. Seasonally, turbidity was maximum during monsoon followed by summer and winter in three ponds. Statistical analysis revealed that turbidity among the ponds and months were significantly varying at $p \leq 0.05$.

The minimum and maximum conductivity in three ponds varied from 1215.23±2.6 µS/cm to 1864.10±0.74 µS/cm in P-1, 1322.82±2.03 µS/cm to 2423.72±1.74 µS/cm in P-2 and 1025.56±1.41 µS/cm to2642±1.00 µS/cm in P-3 respectively. Seasonally, conductivity was maximum in summer followed by monsoon and winter in P-1 and P-3. In P-2, maximum conductivity was observed during winter followed by summer and monsoon. Statistical analysis revealed that electrical conductivity among the ponds and months were significantly varying at $p \leq 0.05$.

The minimum and maximum TDS values in three ponds varied from 827.31±2.00 mg/l to 1522.43±0.86 mg/l in P-1, 943.22±0.5 mg/l to 2165.68±5.6 mg/l in P-2 and 1212±2.00 mg/l to 1863.38±1.9 mg/l P-3 respectively. Seasonally, TDS was maximum during monsoon followed by winter and summer in P-1 and P-2. In P-3, TDS was maximum in monsoon followed by summer and winter. Statistical analysis revealed that TDS among the ponds and months were significantly varying $p \leq 0.05$.

The minimum and maximum ammonia values in three ponds varied from 0.017±0.003 mg/l to 0.037±0.004 mg/l in P-1, 0.015±0.002 mg/l to 0.078±0.006 mg/l in P-2 and 0.025±0.003 mg/l to 0.080±0.007 mg/l in P-3 respectively. Seasonally, ammonia was maximum in summer followed by monsoon and winter in P-2 and P-3. In P-1 maximum ammonia was during winter followed by monsoon and summer. Statistical analysis revealed that ammonia among the ponds and months were significantly varying $p \leq 0.05$.

In the present investigation seasonal variability of water temperature have been observed. It was maximum during summer comparatively less during monsoon and minimum during winter. A temperature of about 35°C is generally considered as threshold for survival of aquatic life [7]. Balakrishna [8] also recorded the maximum temperature in the month of May (summer) (32.0°C) and minimum in January (winter) (19.5°C). Similar results were obseved by some observer who also recorded the maximum (26°C) temperature in the month of March (summer) and minimum (22.5°C) in the month of December (winter) from Tamdalge tank in Kolhapur district, Maharashtra [9].

In the present study high pH was found during summer and low pH was found during winter season. This finding is comparable with the findings of some finders who recorded the pH ranging between 6.12 to 8.03 in Pindavani pond [10]. In the present investigation, high DO was found in winter and low in monsoon. These findings are in agreement with the findings of Rajagopal et al. [11] who found 2.0 to 7.0 mg/l of dissolved oxygen. Some researchers also reported a range of DO varying between 2.43 to 4.45 mg/l from pond water of Surguja District [12], and others also found DO ranging from 4.72 to 6.13 mg/l from Bilaspur district, Chhattishgarh [13].

In the present investigation, higher values of free carbon dioxide were during summer and lowest during winter. Similar results were obtained in Pilgrimage wetland of Gujarat, where they found that throughout the study period, the average concentration of free CO_2 was observed maximum (35.20 mg/l) and minimum (17.60 mg/l) [14].

In the present investigation seasonally, the turbidity values were maximum during monsoon and minimum during summer. High values of turbidity in monsoon may be due to influx of rain water from catchments area, cloudiness, less penetration of light, washes silts, sand, high organic matter and low transparency due to suspended inert particulate matter. However, low values of turbidity in summer may be due to clear atmosphere, evaporation of water and high light penetration. Similarly, results have been reported earlier [15, 16] recorded the highest turbidity in monsoon. Some researchers observed a wide range of variation with minimum of 15.75 NTU and that of maximum of 51.0 NTU in first year whereas during the second year of observation the range obtained was 14.86 to 47.0 NTU in Rudrasagar wetland of Tripura [17].

The present study revealed that the seasonally conductivity was maximum in summer followed by winter and monsoon which is in agreement with the earlier report [11, 18]. The high value of EC during June (summer) where as low during September and this might be due to high temperature, less solubility

Table 1. The average fortnight variation of water parameters (Mean±SD).

Parameters	Water bodies		Nov	Dec	Jan	Feb	Mar
Temperature (^{0}C) (Mean ± SD)	P-1	1	27.6 ± 0.1	19.5 ± 0.05	20.1 ± 0.15	23.1 ± 0.1	28 ± 0.03
		2	28 ± 0.1	19 ± 0.00	20.4 ± 0.05	21.4 ± 0.1	28.5 ± 0.05
	P-2	1	27.3 ± 0.1	18.9 ± 0.05	20.2 ± 0.05	21.5 ± 0.1	27.5 ± 0.05
		2	28.6 ± 0.15	19.1 ± 0.1	20 ± 0.05	23.1 ± 0.1	28.2 ± 0.05
	P-3	1	27.4 ± 0.2	19.1 ± 0.1	19.5 ± 0.00	24.1 ± 0.11	27.4 ± 0.06
		2	28.2 ± 0.3	19.0 ± 0.05	19.6 ± 0.1	22.3 ± 0.15	28.5 ± 0.06
pH	P-1	1	7.4 ± 0.11	7.4 ± 0.06	6.5 ± 0.01	6.2 ± 0.09	6.2 ± 0.02
		2	7.5 ± 0.02	6.4 ± 0.07	6.2 ± 0.04	6.6 ± 0.02	7.3 ± 0.15
	P-2	1	7.5 ± 0.03	6.5 ± 0.02	7.2 ± 0.07	7.3 ± 0.03	7.2 ± 0.03
		2	7.3 ± 0.04	5.8 ± 0.02	6.8 ± 0.05	6.8 ± 0.02	6.9 ± 0.02
	P-3	1	7.7 ± 0.02	6.2 ± 0.08	6.8 ± 0.01	7.2 ± 0.02	7.4 ± 0.02
		2	7.6 ± 00.2	5.2 ± 0.05	6.7 ± 0.02	7.5 ± 0.02	7.2 ± 0.08
DO	P-1	1	4.7 ± 0.015	6.1 ± 0.15	5.2 ± 0.08	4.7 ± 0.15	3.3 ± 0.015
		2	4.1 ± 0.05	6.3 ± 0.02	4.8 ± 0.06	4.5 ± 0.05	3.6 ± 0.07
	P-2	1	4.1 ± 0.015	5.6 ± 0.1	4.6 ± 0.2	4.2 ± 0.1	4.3 ± 0.09
		2	5.2 ± 0.05	5.8 ± 0.15	4.2 ± 0.2	4.3 ± 0.2	4.7 ± 0.05
	P-3	1	4.3 ± 0.01	5.3 ± 0.2	3.5 ± 0.15	3.3 ± 0.03	4.6 ± 0.1
		2	4.8 ± 0.06	5.7 ± 0.1	4.7 ± 0.12	3.5 ± 0.04	5.2 ± 0.02
Free CO_2 (mg/l)	P-1	1	10.3 ± 0.20	9.2 ± 0.03	14.9 ± 0.57	16.7 ± 0.13	17.8 ± 0.05
		2	11.3 ± 0.15	9.2 ± 0.20	14.5 ± 0.53	17.2 ± 0.06	18.1 ± 0.06
	P-2	1	14.4 ± 0.12	10.3 ± 0.20	16.3 ± 0.20	18.8 ± 0.04	18.6 ± 0.06
		2	15.0 ± 0.15	12.3 ± 0.20	15.3 ± 0.20	17.5 ± 0.04	17.3 ± 0.12
	P-3	1	10.7 ± 0.19	11.3 ± 0.06	18.7 ± 0.16	16.4 ± 0.05	20.7 ± 0.04
		2	11.1 ± 0.20	12.6 ± 0.10	17.4 ± 0.12	15.3 ± 0.05	19.2 ± 0.05
Turbidity (NTU)	P-1	1	17.53 ± 0.01	18.46 ± 0.09	20.62 ± 0.06	21.24 ± 0.05	19.54 ± 0.02
		2	17.51 ± 0.06	19.46 ± 0.01	20.41 ± 0.06	20.65 ± 0.08	16.32 ± 0.10
	P-2	1	21.14 ± 0.58	24.51 ± 0.01	24.51 ± 0.13	25.7 ± 0.04	24.4 ± 0.19

Table 1. Continued.

Parameters	Water bodies	1	Apr	May	Jun	Jul
Temperature	P-1	1	30.1 ± 0.06	33.2 ± 0.01	31.5 ± 0.01	29.9 ± 0.11
(^{0}C)		2	30.5 ± 0.05	33.8 ± 0.01	32.5 ± 0.05	31.1 ± 0.02
(Mean ± SD)	P-2	1	31.5 ± 0.05	31.5 ± 0.05	32.5 ± 0.05	29.4 ± 0.11
		2	31.5 ± 0.05	33.5 ± 0.01	32.7 ± 0.05	30.3 ± 0.17
	P-3	1	30.1 ± 0.06	33.2 ± 0.01	32 ± 0.00	30.5 ± 0.00
		2	31.5 ± 0.12	33.9 ± 0.01	32.7 ± 0.05	31.5 ± 0.05
pH	P-1	1	7.3 ± 0.02	7.5 ± 0.02	7.3 ± 0.03	7.2 ± 0.05
		2	7.4 ± 0.04	7.6 ± 0.11	7.3 ± 0.03	7.3 ± 0.1
	P-2	1	7.3 ± 0.02	7.5 ± 0.03	7.4 ± 0.06	7.6 ± 0.04
		2	7.3 ± 0.04	7.5 ± 0.03	7.3 ± 0.06	6.9 ± 0.2
	P-3	1	7.6 ± 0.03	7.7 ± 0.02	7.2 ± 0.09	7.7 ± 0.06
		2	7.8 ± 0.02	7.6 ± 0.05	7.3 ± 0.1	7.5 ±0.05
DO	P-1	1	3.8 ± 0.12	4.2 ± 0.05	2.3 ± 0.01	3.2 ± 0.05
		2	3.4 ± 0.04	4.5 ± 0.05	2.2 ± 0.05	3.6 ± 0.04
	P-2	1	3.4 ± 0.07	3.1 ± 0.03	2.6 ± 0.08	3.5 ± 0.05
		2	3.3 ± 0.07	3.3 ± 0.06	2.7 ± 0.09	3.7 ± 0.03
	P-3	1	3.1 ± 0.07	3.5 ± 0.08	2.7 ± 0.08	3.8 ± 0.02
		2	3.3 ± 0.07	3.0 ± 0.08	2.9 ± 0.11	4.2 ± 0.06
Free CO2	P-1	1	17.3 ± 0.03	24.6 ± 0.09	14.6 ± 0.02	20.2 ± 0.05
(mg/l)		2	16.5 ± 0.10	23.6 ± 0.13	15.2 ± 0.60	20.2 ± 0.12
	P-2	1	15.1 ± 0.04	23.2 ± 0.05	17.2 ± 0.05	18.2 ± 0.10
		2	16.2 ± 0.10	22.2 ± 0.05	16.4 ± 0.03	18 ± 0.070
	P-3	1	23.3 ± 0.22	24 ± 0.05	18.3 ± 0.07	19.3 ± 0.07
		2	24.1 ± 0.07	24.7 ± 0.05	18.5 ± 0.03	19.2 ± 0.06
Turbidity	P-1	1	16.69 ± 0.03	22.81 ± 0.05	24.88± 0.09	30.46 ± 0.06
(NTU)		2	19.69 ± 0.04	23.66 ± 0.04	27.63± 0.50	34.79 ± 0.07
	P-2	1	20.88 ± 0.03	24.73 ± 0.10	32.21± 0.12	38.69 ± 0.04

Table 1. Continued.

Parameters	Water bodies		Nov	Dec	Jan	Feb	Mar
Turbidity (NTU)	P-2	2	22.80 ± 0.17	25.69 ± 0.08	26.66 ± 0.05	26.79 ± 0.07	23.33 ± 0.07
	P-3	1	27.4 ± 0.02	27.7 ± 0.03	26.39 ± 0.04	28.29 ± 0.11	27.35 ± 0.06
		2	28.2 ± 0.03	28.0 ± 0.07	27.47 ± 0.05	27.52 ± 0.01	26.25 ± 0.07
Electrical conductivity (µS/cm)	P-1	1	1523.1 ± 2.7	1215.2 ± 2.6	1672 ± 2.08	1691 ± 0.80	1723 ± 1.00
		2	1423.2 ± 2.0	1274 ± 4.40	1433 ± 2.60	1254 ± 2.60	1532 ± 1.00
	P-2	1	1651 ± 1.4	1322.8 ± 2.03	2026.6 ± 1.52	2423.7 ± 1.74	1832.2 ± 3.21
		2	1523 ± 2.0	1434 ± 3.0	2245 ± 2.64	2352.6 ± 0.45	1611.6 ± 1.52
	P-3	1	2261 ± 1.72	1025.56 ± 1.41	2323 ± 3.4	2315 ± 2.64	2642 ± 1.00
		2	2148 ± 5.85	1125.2 ± 0.9	2234.3 ± 2.08	2261 ± 1.00	2522 ± 1.00
TDS (mg/l)	P-1	1	984.8 ± 3.09	1115.4 ± 2.4	1156.4 ± 1.06	1025 ± 1.80	1174.81 ± 1.53
		2	763 ± 1.50	1065.2 ± 3.09	1264.7 ± 1.70	1232 ± 2.04	1234 ± 1.76

Table 1. Continued.

Parameters	Water bodies		Nov	Dec	Jan	Feb	Mar
TDS (mg/l)	P-2	1	1287 ± 1.70	1532.5 ± 1.9	1425 ± 2.60	1425.6 ± 1.8	1543.3 ± 1.57
		2	1132.5 ± 2.5	1383.3 ± 1.7	1523.5 ± 2.41	1635 ± 3.00	1633.8 ± 1.56
	P-3	1	1274.3 ± 1.00	1823.2 ± 1.00	1542 ± 1.10	1542 ± 1.10	1543.3 ± 1.57
		2	1212 ± 2.00	1631.3 ± 1.05	1452 ± 1.66	1452 ± 1.66	1633.8 ± 1.56
Phosphate-phosphorus (mg/l)	P-1	1	0.18 ± 0.02	0.39 ± 0.02	0.44 ± 0.04	0.23 ± 0.02	28 ± 0.03
		2	0.2 ± 0.01	0.44 ± 0.04	0.17 ± 0.04	0.27 ± 0.03	28.5 ± 0.05
	P-2	1	0.62 ± 0.03	0.58 ± 0.08	0.68 ± 0.05	0.41 ± 0.02	27.5 ± 0.05
		2	0.57 ± 0.04	0.68 ± 0.05	0.60 ± 0.03	0.7 ± 0.03	28.2 ± 0.05
	P-3	1	0.25 ± 0.03	0.52 ± 0.05	0.47 ± 0.05	0.52 ± 0.04	27.4 ± 0.06
		2	0.34 ± 0.06	0.47 ± 0.05	0.35 ± 0.05	0.6 ± 0.01	28.5 ± 0.06
Nitrate-nitrogen (mg/l)	P-1	1	0.27 ± 0.03	0.14 ± 0.02	0.21 ± 0.02	0.2 ± 0.06	0.24 ± 0.04
		2	0.21 ± 0.02	0.16 ± 0.01	0.3 ± 0.05	0.12 ± 0.02	0.25 ± 0.03
	P-2	1	0.2 ± 0.05	0.14 ± 0.01	0.32 ± 0.03	0.23 ± 0.02	0.34 ± 0.03
		2	0.25 ± 0.04	0.19 ± 0.02	0.4 ± 0.03	0.23 ± 0.01	0.47 ± 0.03
	P-3	1	0.5 ± 0.07	0.35 ± 0.04	0.5 ± 0.08	0.63 ± 0.07	0.47 ± 0.04
		2	0.55 ± 0.04	0.32 ± 0.01	0.5 ± 0.05	0.72 ± 0.04	0.41 ± 0.03
Ammonia (mg/l)	P-1	1	0.037 ± 0.004	0.026 ± 0.006	0.029 ± 0.006	0.028 ± 0.002	0.030 ± 0.001
		2	0.015 ± 0.004	0.033 ± 0.003	0.024 ± 0.003	0.029 ± 0.003	0.017 ± 0.003
	P-2	1	0.015 ± 0.002	0.027 ± 0.003	0.035 ± 0.004	0.042 ± 0.001	0.066 ± 0.004
		2	0.034 ± 0.002	0.035 ± 0.003	0.033 ± 0.003	0.066 ± 0.005	0.047 ± 0.006
	P-3	1	0.046 ± 0.004	0.025 ± 0.003	0.033 ± 0.003	0.055 ± 0.006	0.060 ± 0.002
		2	0.032 ± 0.003	0.031 ± 0.001	0.037 ± 0.002	0.052 ± 0.001	0.072 ± 0.001
		2	0.032 ± 0.003	0.031 ± 0.001	0.037 ± 0.002	0.052 ± 0.001	0.072 ± 0.001

Table 1. Continued.

Parameters	Water bodies		Apr	May	Jun	Jul
Turbidity (NTU)	P-2	2	20.58 ± 0.06	29.66 ± 0.14	35.74 ± 0.07	42.73 ± 0.05
	P-3	1	24.61 ± 0.10	26.75 ± 0.03	33.45 ± 0.19	39.87 ± 0.06
		2	24.35 ± 0.13	29.48 ± 0.24	36.45 ± 0.03	45.26 ± 0.02

Table 1. Continued.

Parameters	Water bodies		Apr	May	Jun	Jul
Electrical conductivity (µS/cm)	P-1	1	1863.6±2.08	1824.53 ± 1.9	1564.66 ±3.2	1785 ± 4.00
		2	1753.6±3.05	1864.1 ± 0.74	1561.66 ±1.52	1675 ± 3.00
	P-2	1	2322 ±1.50	2072.8 ± 2.5	1925.6 ±3.05	1372.3 ± 1.5
		2	2133.3±1.5	2262.9 ± 1.6	2136.8 ±1.05	1533.3 ± 1.5
	P-3	1	2365.6±0.59	3124.3 ± 3.05	1862.6 ±0.58	1651.9 ± 0.63
		2	2422.6±2.08	3421 ± 1.00	1926.6 ±0.67	1731 ± 1.11
TDS (mg/l)	P-1	1	641.46±0.78	1255.6 ± 1.84	988.4 ±447	1221.6 ± 2.07
		2	727.3 ±2.00	1291.6 ± 1.85	982.2 ±1.04	1522.4 ± 0.86
	P-2	1	1051.5±1.46	963.9 ± 3.8	2072.3 ±1.5	1725.2 ± 2.06
		2	943.2 ±0.5	1573.2 ± 2.4	2165.68 ±5.6	1532.41 ± 0.8
	P-3	1	1613.5±1.5	2421.33 ± 1.5	1254.03 ±1.42	1024.24 ± 2.6
		2	1544.6±2.5	2562 ± 1.00	1163.38 ±1.9	974.62 ± 3.2
Phosphate-phosphorus (mg/l)	P-1	1	30.1 ±0.06	33.2 ± 0.01	31.5 ±0.01	29.9 ± 0.11
		2	30.5 ±0.05	33.8 ± 0.01	32.5 ±0.05	31.1 ± 0.2
	P-2	1	31.5 ±0.05	31.5 ± 0.05	32.5 ±0.05	29.4 ± 0.11
		2	31.5 ±0.05	33.5 ± 0.01	32.7 ±0.05	30.3 ± 0.17
	P-3	1	30.1 ±0.06	33.2 ± 0.01	32 ±0.00	30.5 ± 0.00
		2	31.5 ±0.12	33.9 ± 0.01	32.7 ±0.05	31.5 ± 0.05
Nitrate-nitrogen (mg/l)	P-1	1	0.22 ±0.02	0.16 ± 0.03	0.24 ±0.03	0.43 ± 0.08
		2	0.23 ±0.03	0.17 ± 0.01	0.25 ±0.03	0.42 ± 0.05
	P-2	1	0.33 ±0.07	0.38 ± 0.01	0.44 ±0.04	0.48 ± 0.03
		2	0.44 ±0.03	0.33 ± 0.02	0.47 ±0.01	0.47 ± 0.02
	P-3	1	0.51 ±0.01	0.65 ± 0.01	0.74 ±0.02	0.93 ± 0.06
		2	0.63 ±0.015	0.66 ± 0.01	0.77 ±0.04	1.05 ± 0.02
Ammonia (mg/l)	P-1	1	0.029 ±0.006	0.030 ± 0.004	0.032 ±0.004	0.018 ± 0.007
		2	0.021 ±0.001	0.025 ± 0.001	0.029 ±0.004	0.023 ± 0.003
	P-2	1	0.078 ±0.006	0.082 ± 0.007	0.069 ±0.001	0.053 ± 0.003
		2	0.061 ±0.001	0.074 ± 0.001	0.065 ±0.005	0.052 ± 0.002
	P-3	1	0.080 ±0.007	0.082 ± 0.007	0.073 ±0.001	0.065 ± 0.005
		2	0.075 ±0.001	0.074 ± 0.001	0.068 ±0.006	0.070 ± 0.002
		2	0.075 ±0.001	0.074 ± 0.001	0.068 ±0.006	0.070 ± 0.002

and high degradation of organic substances [11]. The results of the present study also support the findings earlier [19, 20]. Increasing levels of conductivity and cations are the products of decomposition and mineralization of organic materials [21].

The results of present investigation correlates with the findings of Manjare et al. [9] who found the total dissolved solids fluctuation ranging from 0.1 g/l to 2.2 g/l and the maximum value (2.2 g/l) was recorded in the month of June from Kolhapur district Maharashtra. The high value of total dissolved solids during rainy season may be due to addition of domestic waste water, garbage and sewage in the natural surface water body [22]. Increased high concentration of total dissolved solids increases the nutrient status of water body which was resulted into eutrophication of aquatic bodies [23].

In the present investigation, seasonally, ammonia was maximum in summer followed by monsoon and winter in P-2 and P-3. In P-1 maximum ammonia was during winter followed by monsoon and summer. The findings were similar to [24] who reported higher values of ammonia in summer and lower values in monsoon season in Ooty Lake, Tamil Nadu. Similar findings were also done by Parven and Rohan [25] in water bodies of Aligarh, where they found that ammonia ranges between 0.013 mg/l to 0.141 mg/l with maximum value in summer and minimum in winter. According to them, this can be due to high rate of decomposition of dead and decayed organisms and the amount of sewage entered into the water bodies.

Conclusion

On the account of status analysis of four lentic water bodies an attempt was done to compare the seasonal variations in the parameters like air temperature, water temperature, dissolved oxygen, free carbondioxide, electrical conductivity, turbidity and pH. The investigation enabled a comprehensive and systemic analysis of the seasonal physico-chemical fluctuations and the baseline data was generated which would help in planning better conservation measures and management of these water bodies. The investigation states that these water bodies are leading towards an alarming situation if anthropogenic stress continues. Thus a proper check on management for restoration of these water bodies must be done.

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