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Seasonal variations of water characteristics in three urban ponds with different management practices at Kolkata of West Bengal, India

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Abstract
The present study was carried out from January 2014 to June 2014 to make a comparative ecological assessment of three urban ponds of Kolkata, West Bengal, India with different management practices. The average value of water temperature in P-1, P-2 and P-3 ponds were 29.6, 30.0 and 29.8˚C respectively, the average value of water pH was the highest in the P-2 (7.32). The maximum average DO value was found in P-2 (5.66 mg l-1), average value of free CO2 was maximum in the P-3 (38.08 mg l-1). The highest value of alkalinity was found in P-3 (314 mg l-1). The maximum concentration of BOD and COD were recorded in P-3 accordingly (3.07 mg l-1) and (75.16 mg l-1). The highest average value of Phosphate-phosphorous was recorded in P-2 (0.23 mg l-1) and the Nitrate-nitrogen concentration was recorded maximum in P-3 (1.49 mg l-1). The average value of conductivity was highest in P-3(1.97 mS/cm) followed by P-1(1.41 mS/cm) and P-2 (0.77 mS/cm).The present finding established that, the well managed pond (P-2) showed better ecological conditions compare to unmanaged ponds.

Keywords: Water characteristic, seasonal variation, urban ponds, management practices, Kolkata

1. Introduction
Water is an indispensable natural resource on earth. All life including human being depends on water. Due to its unique properties water is of multiple uses for living organism [1,2].Water is life and life is fully dependent on the economical status now a days. In India, about 70% of the existing water is contaminated, out of which 8-16 % water is contaminated by industrialized pollution and 84-92% by sewage pollution and others [3].As a growing metropolitan city in a developing country Kolkata faces socioeconomic problems, overpopulation and substantial urban pollution. Urban Kolkata consists of about 3000 ponds and act as a model case to find out the role of the ponds in any city [4].In the ecosystem water is considered to be the most important component for the life but day by day the quality of water become degraded. The water of the ponds, lakes and river are polluted mainly due to discharged waste water from residential areas, sewage outlets, solid wastes, detergents, oil wastes, and agricultural pesticides from farmlands [5].There are several diseases have been identified among the human beings, which are caused by using contaminated water. Water born disease infections occur during washing, bathing and consumption of contaminated water during food preparations. Therefore it is necessary that the quality of water should be checked at regular time of interval because the financial losses due to water born diseases have negative impact on the nation. Without proper knowledge of water chemistry, it is very difficult to understand the biological phenomenon fully, because the chemistry of water reveals much about metabolism of the ecosystem and explains the general hydro-biological interrelationship. Physico-Chemical characteristics are highly important with regard to the occurrence and abundance of species. Discharge of urban, industrial and agricultural wastes have increased the quantum of various chemicals that enter the receiving water, which considerably alter their physico-chemical characteristics. Nutrients like phosphorous and nitrogen from the domestic wastes and fertilizers accelerate the process of eutrophication [6]. Temperature, dissolved oxygen, Water pH, Free carbon-dioxide, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Phosphate Phosphorus, Nitrate-Nitrogen, and total alkalinity are significant parameters used to study the water quality [7]. Several studies deal with the physicochemical status of water have been done by several authors [8-15].

But, there were no such studies from this region and therefore a study of some physico-chemical parameters was undertaken in different ponds from Kolkata municipal areas to check the pond water quality with different management practices of these urban ponds.

2. Materials and Methods

2.1 Study Area

The present study was carried out for a period of six months from January 2014 to June 2014. Three ponds with different management practices were selected to make a comparative ecological study among them. The water bodies identified for the present study are situated within the municipal boundary of Kolkata, West Bengal. First pond (P-1), Bibek Nagar Jheel, moderately managed is situated near the Jadavpur railway station with around 8000 m^2 area and surrounded by cemented wall. Second pond (P-2), situated at Panchasayar, an earthen well managed pond with 7500 m^2 area. The third pond (P-3), namely Baghajatin Park pond is situated near Highland Park, highly unmanaged with 6000 m^2 area. The water samples were collected fortnightly in the early morning (between 7.30 am to 9.30 am) from each pond.

2.2 Water quality parameters

The variations in water parameters such as temperatures, pH, dissolved oxygen, free carbon dioxide, total alkalinity, biological oxygen demand (BOD), chemical oxygen demand (COD), phosphate-phosphorous, nitrate nitrogen and conductivity was estimated following standard methods [16]. General features of the three ponds were provided in the Table 1.

Table 1: General features of three studied ponds under urban Kolkata

Features	Bibek Nagar Jheel pond (P-1)	Panchasayar pond (P-2)	Baghajatin Park pond (P-3)
Latitude	22˚29'57.9"N	22˚88'57.9"N	22˚88'59.9"N
Longitude	88˚22'27.3"E	88˚22'27.3"E	88˚22'27.3"E
Area (m^2)	8000	7500	6000
Average Depth (m)	5-6	6-7	3-4
Type of water body	Perennial	Perennial	Perennial
Source of water	Rain fed, water seepage and surface run off	Rain fed, water seepage and surface run off	Rain fed, water seepage and surface run off
Purpose of use	Domestic purposes, washing, bathing, idol immersion etc.	Bathing without soap, cooking. Vehicle washing and idol immersion not allowed.	Bathing, washing, dumping, domestic purpose, idol immersion etc.
Management status	Moderately managed, concrete dyke, fish culture practices.	Well managed, regular cleaning and monitoring, natural earthen dyke, fish culture practices.	Unmanaged, no proper cleaning and monitoring, no such type of fish culture.

3. Results and Discussion

3.1 Temperature

Water temperature plays an important role in the ponds. The variations in the temperature were influenced by factors such as air temperature, humidity, wind and solar energy [17]. The average water temperature of P-1, P-2 and P-3 pond was found to be 29.62, 30.08 and 32.41˚C (Fig. 1). The water temperature was found suitable for fish growth due to standing water of those water bodies. [15] found temperature ranged from 20.9 ºC to 33.8 ºC in their study period. 24.75ºC to 28.5 °C temperature was reported by [18, 19].

3.2 Water pH

The average water pH was 7.22, 7.32 and 7.31 in P-1, P-2 and P-3 ponds respectively (Fig. 2). [18, 20] reported the range of pH 6.93 to 7.55 and 7.5 to 8.4 respectively. [21] reported a range of pH in between 7.0 and 8.3.According to [22], pH ranged between 5.0 to 8.5 is best for plankton growth. [23], have found pH values ranging from 5.0 to 8.0 during their study period. The results obtained during the present study are somewhat similar to the above findings. On all the occasion the pH values were above 7.0 except during June in P-1 pond (6.8) and in P-3 pond (6.9).

3.3 Dissolved Oxygen

Dissolved oxygen (DO) plays an important role in the aquatic environment and is essential for growth of phytoplankton and fish productivity. The average DO concentration in the water body P-1, P-2 and P-3 were 4.03, 5.66 and 3.54 mg l^{-1} respectively (Fig. 3).. At the P-1 pond the DO varied from 3.1 to 5.9 mg l^{-1}, in P-2 pond between 4.2 to 7.46 mg l^{-1} and in a P-3 pond it varied between 2.1 to 8.0 mg l^{-1}. The DO is said to be utilized by microorganisms during the decomposition process of organic matter. [24] reported highest value also in winter at a Budha reservoir in Raipur. [19] reported a range of DO in between 5.18- 9.72mg/l.Shrivastava and Kanungo (2013) reported a range of DO 2.43 - 4.45 mg/l in their study. [25] reported D.O ranged in between 6 mg/L to 8.24 mg/L where highest value has found in winter.

3.4 Free carbon-dioxide

In P-3 pond the average free carbon-dioxide value was 38.08 mg l^{-1} which was significantly higher than P-1 pond (27. mg l^{-1}) and P-2 pond (14.83 mg l^{-1}) (Fig. 4). A similar kind of observations in a community pond in Ganjam district of Orissa was also reported [26]. High value of free Carbon dioxide values of 14.82 mg l-1 to 38.07 mg l-1 was reported by [27] and similarly free Carbon dioxide value ranges from 28.6 to 72.4 mg l-1 was reported \by [28,29] investigated free CO_2 ranges from 4.75 to 26.14 ppm of ten ponds in and around Santiniketan, West Bengal. It was relatively high during the summer months which can be due to the faster decomposition of organic matter and high temperature [5,30].

3.5 Total Alkalinity

Alkalinity is the capacity of water to neutralise acids and an ability to absorb hydroxyl ion without significant pH change [31]. The range of alkalinity 40-90 mg/l is considered as highly productive. In P-3 pond the average alkalinity value was 314 mg l^{-1}, which was significantly higher than P-2 pond (145.91 mg l^{-1}) and P-1 pond (226.33 mg l^{-1}) (Fig. 5).. The alkalinity was high during the summer seasons. The month of April showed the highest alkalinity (273±32.52 mg l^{-1}) and (355±1.41 mg l^{-1}) in both P-1 and P-3 pond respectively [32]. found alkalinity (460 mg/l) of three urban lakes of Jaipur.The results obtained from the present study were in close conformity with the findings of [33, 34].

3.6 Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

Biological oxygen demand (BOD) is a measure of oxygen required by microbes to degrade the organic matter under

aerobic condition. BOD increases with the increased inflow of the domestic waste [35]. High BOD depletes the oxygen level to a critical condition thus indicating the pollution status of waters. In the present study the average value of BOD was 3.07 mg l^{-1} in P-3 which was significantly higher than P-1 (0.95 mg l^{-1}) and P-2 (1.13 mg l^{-1}) (Fig. 6). [36] observed minimum B.O.D. value1.6 mg/L) in June and maximum value (2.5 mg/L) in July. C.O.D. values convey the amount of dissolved oxidisable organic matter present in it [10].The average COD values in the water body P-1, P-2 and P-3 were 56.8, 58.4 & 75.1 mg l^{-1} respectively (Fig. 7). [37] showed C.O.D. value ranges from 110 mg/L to 140 mg/L where the highest value was found during summer. [38] reported the variation of BOD and COD in the seasonal water bodies of Kalyani (West Bengal) where COD was very much higher (245.2 ± 3.35 mgl^{-1}) from October to January and thereafter through gradual decrease, COD reached its minimum value in September (108.00 ± 2.45 mgl^{-1}). Comparatively high (62.56 ± 3.2 mgl^{-1}) and low (9.4 ± 0.66 mgl^{-1}) BOD content were observed in December-January and in October-November respectively.The BOD in different months in P-3 fluctuated between 0.9 & 6.2 mg l^{-1} indicating the pond status as moderately polluted. The status of other two ponds is unpolluted.

3.7 Phosphate Phosphorus

Phosphorus is an essential nutrient present in soil and water in inorganic and organic forms. It is considered as one of the limiting nutrient causing eutrophication leading to extensive algal growth. The average phosphate phosphorus concentration in the water body P-1, P-2 and P-3 was 0.22, 0.23 and 0.17 mg l^{-1} respectively (Fig. 8). [39] phosphate value range of 0.01 mg/liter to 0.79 mg/liter in lakes of Thane city. [40] reported in their study that phosphate value maximum in summer and minimum in winter. [33] made a study on phosphate (7.5 mg/l) which was very high compared to the standard limit of drinking water. [40] recorded Phosphate phosphorus value of lake water in Maharashtra which ranged between 0.0064 mgl^{-1} to 0.876 $mgl.^{-1}$

3.8 Nitrate-Nitrogen

In the present study the average nitrate-nitrogen concentration in the water body P-1, P-2 and P-3 were 1.27, 1.46 and 1.49 mg l^{-1} respectively (Fig. 9). Nitrate value was higher in winter and lower in summer in all three ponds under study. [39] observed high values of nitrate nitrogen (0.14 mgl^{-1}) in post monsoon and low values (0.03 mgl^{-1}) in the pre monsoon in some fresh water reservoirs of Karnataka. [40] recorded nitrate level ranged between nil to 0.14 mgl^{-1} in the main lake of Thane in Maharashtra. [41] recorded the maximum nitrate value in Satyavaram pons as 12.24 µg/l in September and the minimum value (4.61 µg/l) in February. She also recorded the maximum phosphate value of 3.56 µg/l in the month of October and the minimum value, 1.14 µg/l, in the month of February.[42,43] reported that in winter, nitrate value is higher which was similar for these two water bodied P-2 and P-3.

3.8 Conductivity

The monthly variation in conductivity varied between a minimum of 0.693 mS/cm (February) and a maximum of 2.25 mS/cm (April) in P-1(Fig. 10). The minimum and maximum average values of P-2 and P-3 were 0.267 (February) and 1.135 (June), 0.979 (February) and 3.07 mS/cm (June) respectively. The Maximum average value was found in P-3 in the month of june. The pattern of distribution was more or less similar in all the water bodies. Natural waters usually have EC values of 20 to 1500 µmhos/cm repoted by [44] However the standard limit set by [45] is 250 µmhos/cm. All the studied ponds exceeds WHO standards but P-3 showed significantly higher value than other ponds. It may be due to leachate in filtration from soil. [46] found the concentration of dissolved solids to be proportional to the ionic strength and proposed the similar justification. The monthly average value of Conductivity showed progressive increase in summer in all the ponds under study as also recorded by [47]. It may be due to the high rate of evaporation and lower level of water during summer seasons. The result also supports the findings of [33].

4. Conclusion

In the light of the present findings it can be concluded that there is a clear cut differences in the physico-chemical parameters of experimental water bodies. Most of the water quality parameters including water pH, Free CO2, Alkalinity, Phosphate Phosphorus, Nitrate-Nitrogen, COD, Conductivity were highest in P-3 and lowest value of the DO and BOD was also recorded in P-3. So, from the overall study, it can be said that the health status of P-3 is significantly inferior. The reason may be due to high level of anthropogenic activity and poor maintenance of this water body. After studying all the parameters, it can be concluded that the ecological condition of P-2 is better than P-1. The reason may be due to the better management practices like no washing of utensils, clothes and vehicles etc. by the society's people.

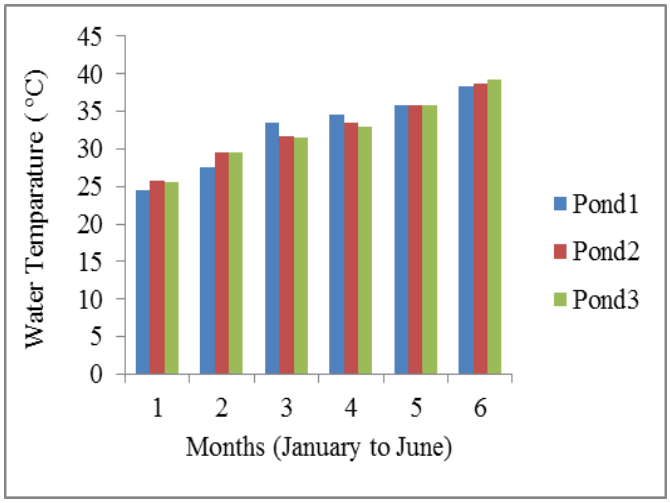

Fig 1: The monthly mean variation in water Temperature

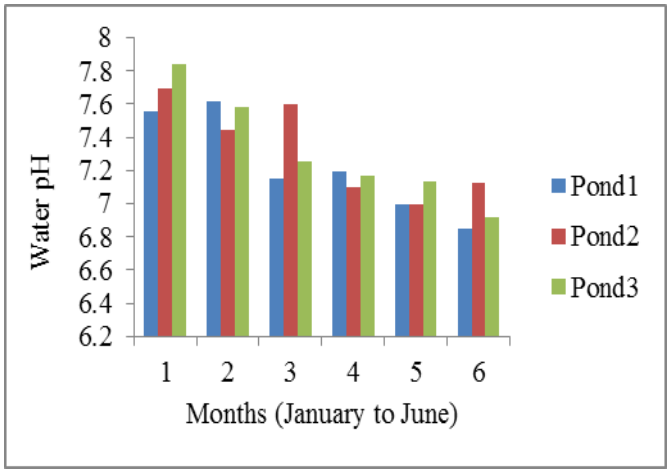

Fig 2: The monthly mean variation in water pH

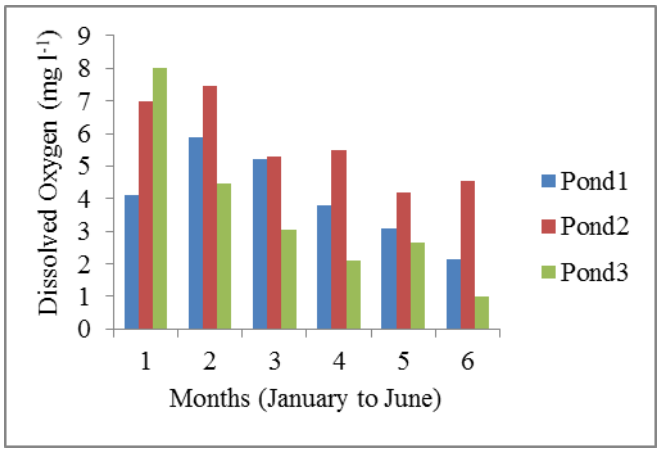

Fig 3: The monthly mean variations in water DO

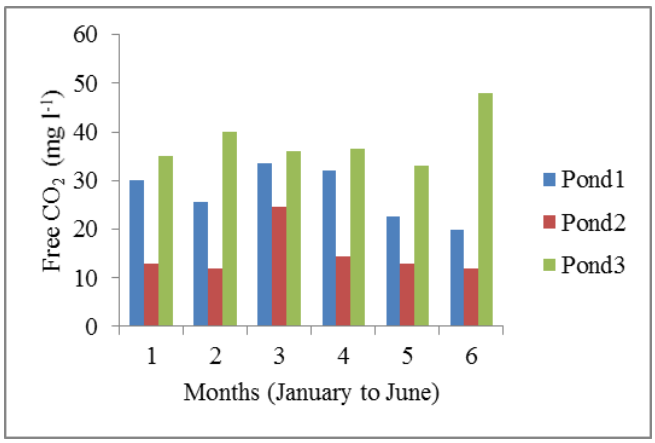

Fig 4: The monthly mean variation in water free carbon dioxide

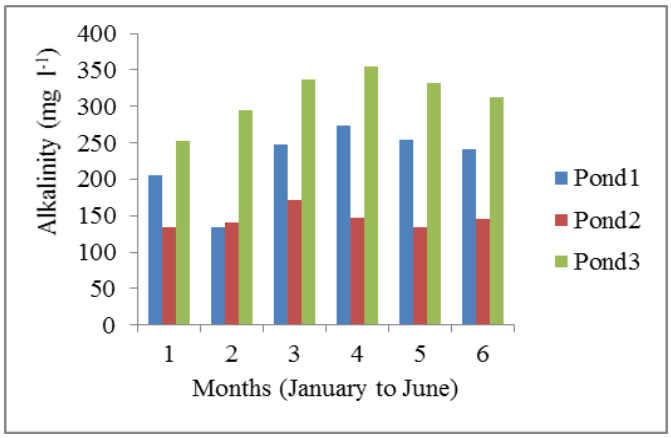

Fig 5: The monthly mean variation in water Alkalinity

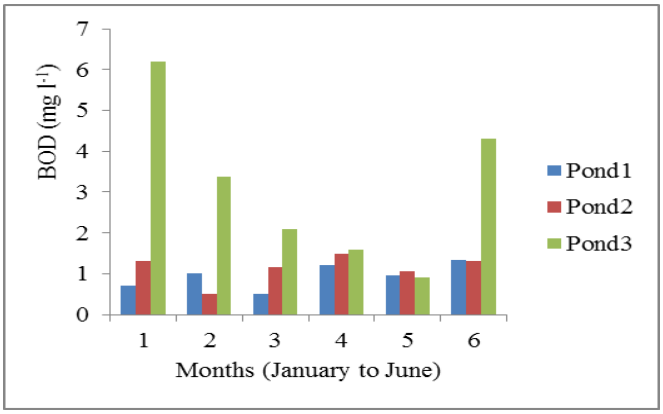

Fig 6: The monthly mean variation in water BOD

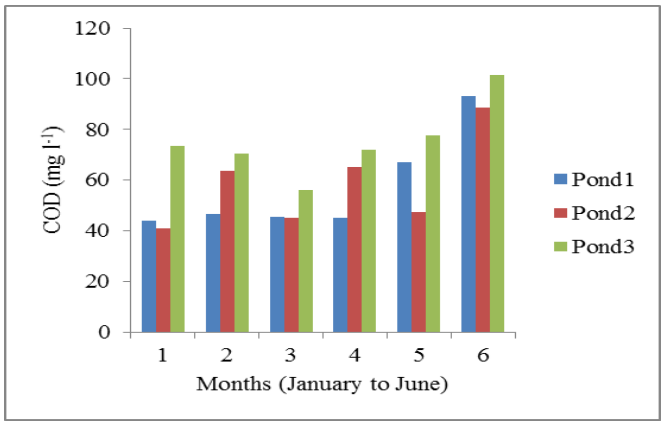

Fig 7: The monthly mean variation in water COD

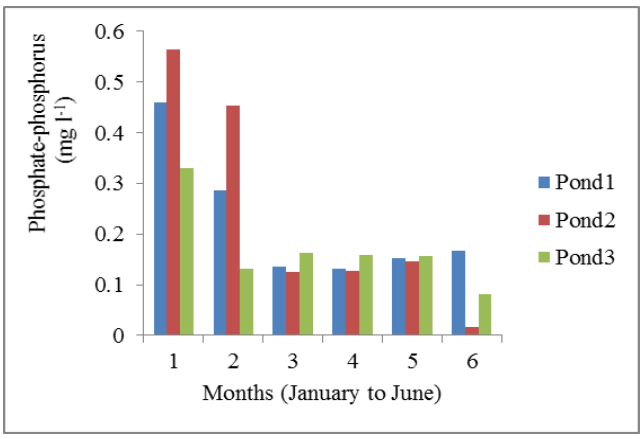

Fig 8: The monthly mean variation in water phosphate phosphorus

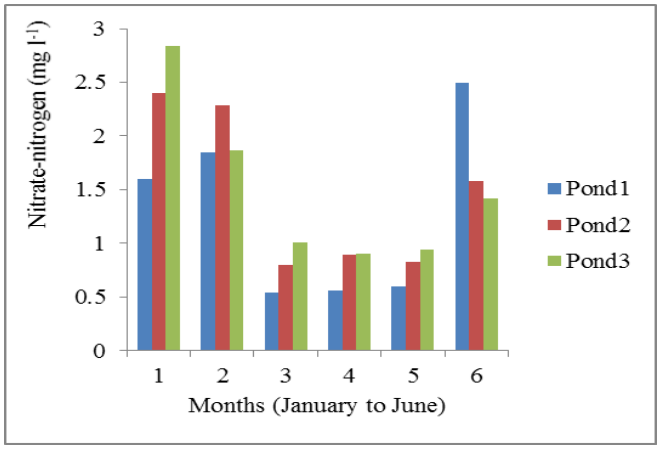

Fig 9: The monthly mean variation in water nitrate nitrogen

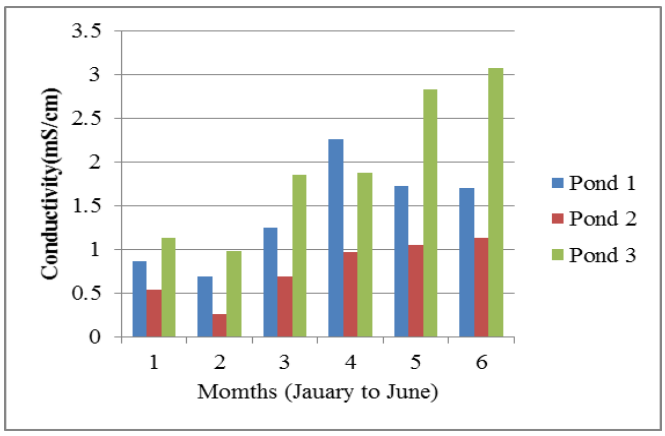

Fig 10: The monthly mean variation in water conductivity

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