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AN ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES AND WATER QUALITY OF BUDHASAGAR POND WATER

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ABSTRACT

Water pollution is one of three major pollutions threatening the environment today. Disposal of domestic, sewage, agricultural, and industrial waste change the physicochemical properties of water. They could result in an increased pH level, affect the hardness of the water, or change the chloride levels. These changes in physicochemical property of the water affect the aquatic habitat, may change the flavour of the water, could result in an increased heavy metals uptake by fishes, and pose health risks in other ways. The objective of the present study is to record physicochemical properties and assess the water quality of Budhasagar pond. Water samples were collected from the pond across three seasons twice between 2015-16 to 2016-17. It has been found that the water quality was fair (requires treatment) during both summers and the post-monsoon season in 2016-17. During the rest of the study period, the water quality was found to be of good class (requires no treatment). Filtration and disinfection of the pond should be carried out to minimize the health risk posed to people depended on the pond.

***Keywords**: Budhasagar pond, physicochemical properties of freshwater, overall water quality index (OWQI).*

Introduction

Even though two-third of the Earth's surface is covered with water, only 1% of this is freshwater. This freshwater is mainly found in ponds, rivers, lakes, and groundwater. These sources have served and supported evolving needs of the human civilization for millennials. Unfortunately, the latest evolution in the human civilization that took place in the form of industrial revolution in the 18th century has come to threaten the freshwater security for the whole human civilization as well as various animal and plant kingdoms. Researchers have attempted to bring attention to this growing insecurity and have predicted water insecurity to be the biggest crisis of the 21st century.

Water pollution is one of three major pollutions threatening the environment today. It is a broad term defined by the presence of unwanted contaminants in water and includes seawater as well as freshwater contamination. Seawater pollution threatens ocean and sea habitats such as seawater plants and fishes. Disposal of plastic at beaches and oil spills are two major sources of seawater pollution. Freshwater contamination is due to three primary sources: domestic, agriculture, and industrial. Disposal of domestic waste and sewage discharge into rivers and ponds pollute these freshwater sources. Agricultural runoffs containing chemical fertilizers and discharge of untreated industrial waste are major lethal sources of freshwater contamination.

Disposal of domestic, sewage, agricultural, and industrial waste change the physicochemical properties of water. They could result in an increased pH level, affect the hardness of the water, or change the chloride levels. These changes in physicochemical property of the water affect the aquatic habitat, may change the flavour of the water, could result in an increased heavy metals uptake by fishes, and pose health risks in other ways.

The research has been carried out with water samples from the Budhasagar pond. Budhasagar is a man-made perennial pond and is filled with water year-round. It is also connected with the municipal sewage of the Baldeobagh town. It also used to carry the industrial waste of a cotton mill in the town. The mill shut a couple of years ago, however. The pond serves the bathing and washing needs of town residents and fishing culture has also been continued since it was first started in 1961. Given the fact that the pond is sewage-fed and once served the disposal of a cotton mill, it is imperative to think that the pondwater may have faced deterioration in quality and physicochemical properties of the pondwater. We collected water samples from the pond across three seasons twice between 2015-16 to 2016-17. The objective of the present study is to record physicochemical properties and assess the water quality of Budhasagar pond.

Literature Review

Researchers have noted of seasonal variations in physicochemical properties, e.g., temperature, chlorine level, etc. of water bodies such as lakes, ponds, and rivers (Birge, 1911; Birge, 1916; Chandler, 1944; Hannan and Young, 1974; Hutchinson, 1957; Harshey et al., 1982; Juday, 1929). Chandler (1944), Welch (1952), Jolly and Chapman (1966), and Wetzel (1983) have also found influence of water temperature on its physicochemical, biological, and physiological parameters and activities.

Admse (1968), Ingols and heukelekian (1940), Luklema (1969), and Oswald (1960) have studied the effects of sewage discharge on the pH level of the water bodies. Chapman and Kimstach (1992), Hannan and Young (1974), and Lee et al. (2009) investigated the effects of industrial discharge on the pH level of water. Khalique and Afser (1995), Islam and Islam (1996), Rochar et al. (2004), Atkinson et al. (2007), Roldin et al. (2012), and Haiyan et al. (2013) further studied the variations in pH level with additional disposal of sewage into the water bodies.

Hutchinson (1957), Reid (1961), Ruttner (1963), George et al. (1966), DeSmet and Evens (1972), King (1981), Goldman and Home (1983), Wetzel (1983), and Kara et al. (2004) have carried out studies seasonal and otherwise variations in the level of dissolved oxygen in water bodies. Wetzel (1983), Hamoda et al. (1995), Schmitz (1996), Schmitz (1996), Panswad and Anan (1999), Glass and Silverstein (1999), and Lee et al. (1999) have studied the presence of chloride in water bodies and found that anthropogenic activities such as bathing domestic animals and washing clothes result in an increased concentration of chloride in the water bodies.

Mairs (1966) and Cole (1975) studied the hardness of water bodies and found two minerals, e.g., calcium and magnesium ions, to be the primary causes of an increased hardness of the water. The total hardness of water is a complex mixture of cations and anions (Mairs, 1966). Other researchers have studied the effects of sewage and industrial disposals on the hardness levels of water bodies (Moyle, 1949; Thomson, 1952l Chapman and Kimstach, 1992; and Meybeck et al., 1992).

Lawson (2011) studied the role of physicochemical properties of water bodies in the ability to dissolve heavy metals by its fish habitats. Merlini and Pozzi (1977) recorded the concentration of heavy metals in freshwater fish at different pH levels. Pascoe et al. (1986) investigated the heavy metals toxicity of fishes in the context of a changing hardness level of the water. Pascoe et al. found that an increase in hardness resulted in slower uptake of heavy metals in fishes. Del-Ramo et al. (1987) studied temperature as the independent variable affecting the heavy metals toxicity of freshwater crayfish.

Research Methodology

Sampling

Water samples were collected across three seasons, e.g., winter, summer, and post-monsoon, twice between 2015-16 to 2016-17. The samples were measured for their various physicochemical properties and the concentration of heavy metals. In each sample, three replicas were collected. Samples were collected from surface-level in 500ml polyethylene bottles between 9:30 A.M. to 11:00 A.M. To study dissolved oxygen in water, samples were fixed with manganous sulphate and alkaline iodide in 250ml B.O.D. bottles in the field itself.

Physiochemical analysis

Standard methods as suggested by Trivedy and Goel (1986) and APHA (1989) were followed to calculate the physicochemical parameters of sample water. We recorded temperature, pH level, dissolved oxygen, chloride, and total hardness of the sample water. Temperature was recorded on spot by using a graduated Celsius thermometer by dipping the thermometer bulb into the water for at least two minutes. pH levels were recorded using a composite digital device.

Dissolved oxygen: Dissolved oxygen was computed using Winkler's method (1888). 6.205g of $Na_2S_2O_3$ .5 H_2O was dissolved in a small quantity of distilled water. To this 0.4 g of solid NaOH was added and the solution was diluted to one litre. Alkaline potassium iodide solution was then prepared by dissolving 100g of KOH and 50g of KI in 200ml of boiled distilled water, and manganese sulphate solution was prepared by dissolved 100g of $MnSO_4$ $4H_2O$ in 200ml of boiled distilled water. We later dissolved 1g of laboratory-grade soluble starch in 100ml of boiled distilled water and added a few drops of formaldehyde solution to obtain the starch solution.

The water sample was poured into a 250 ml reagent vial and allowed to stand for several hours before analysis. To this mixture, 1 ml of manganous sulphate and 1 ml of alkaline iodide were added, and the mixture was quickly stopped without allowing any air to enter. The contents of the bottles were fully mixed by shaking them, and the precipitates were evenly spread. To dissolve the precipitates, 1 ml of concentrated sulphuric acid was applied. We used the first 25 millilitres of the sample, and then we added 1 millilitre of starch solution and titrated with 0.025 N sodium-thiosulphate until the blue hue was gone. Dissolved oxygen was then computed using the following formula.

$$DO = \frac{\mathrm{V * N * 8 * 1000}}{\mathrm{V1 - v}}$$

where,

N = normality of sodium thiosulphate,

V = ml of titrant used,

V_1 = volume of sample bottle, and

v = volume of $MnSO_4$ and KI added.

Total Hardness: To measure the total hardness of sample water, 1.179g of disodium salt of ethylene diamine tetra acetic acid dehydrates and 780mg of magnesium sulphate ($MgSO_4.7H_2O$) were dissolved in 50ml of distilled water. We then added 16.9g of NH_4Cl and 143ml of concentrated NH_4OH and diluted the solution to 250ml of distilled water. We then grounded 200mg of Eriochrome Black T and 100g of solid NaCl in a mortar and pestle and dissolved 3.723g of disodium ethylenediamine tetraacetate dehydrate in 100ml of distilled water.

1ml of buffer solution and a pinch of Eriochrome Black T indicator were added to a 25ml water sample. It turned the solution pink indicating hardness. This was titrated against EDTA solution until the blue hue faded and the total hardness was calculated as follows:

$$\text{Hardness (EDTA) as Mg/L CaCO3} = \frac{\mathrm{V * 1000}}{\text{ml sample}}$$

Chloride: We added two drops of potassium chromate ($K_2Cr_2O_4$) indicator to a 100ml water sample, which turned the solution yellow. This was then titrated against N/50 $AgNO_3$ solution until a brick red colour appeared. Chloride level was then calculated as follows.

$$CL = 7.1 \times V_1$$

where V_1 is the volume of silver nitrate used for titration.

Overall water quality index (OWQI)

There are five levels of surface water quality as defined by the OWQI, which was developed by Singh et al. (2015). The levels range from excellent to polluted, with excellent being the best possible. According to Indian Standards (BIS) and CPCB (CPCB) standards, as well as other international standards from the World Health Organization (WHO) and European Commission, concentration ranges have been specified for this purpose (EC). It was decided on the basis of social and environmental impact that 16 parameters would be chosen, and weights would be assigned depending on the importance of each parameter to water quality. Integrating complicated data increases knowledge of water quality issues, and a score describing water quality is generated as a result of the suggested index.

$$OWQI = \sum_{i=1}^{n} \mathrm{wi.Yi}$$

where,

w_i = weight of the i^{th} water quality parameter

Y_i = sub-index value of the i^{th} parameter

Table 1 Assignment of significant weight to water quality parameter

S.No.	Parameter	Weight factor
1.	pH	1
2.	Dissolved oxygen	4
3.	Total hardness	1
4.	Chloride	1

Table 2 Sub-indices function for various parameters

S.No.	Parameter	Range of Parameter	Sub-Index Function
1.	pH	6.5 - 8.5 6.0 - 6.4 & 8.6 - 9.0 5.5 - 5.9 & 9.1 - 9.5 < 5.5 & > 9.0	Y=100 Y=50 Y=25 Y=0
2.	Dissolved oxygen	8 and above 6 - 7.9 0 - 5.9	Y=100 Y=10*X+15 Y=12.5*X
3.	Total hardness	100 - 300 301 - 400 > 400	Y=100 Y=-0.2*X+155 Y=-0.25*X+175
4.	Chloride	200 and below 201 - 250 251 - 600	Y=100 Y=-0.4*X+175 Y=-0.0714*X+92.86

Table 3 Corresponding class and water quality as per OWQI

Class	OWQI Value	Status of Water
Heavily Polluted	0 - 24	Unsuitable for All Purposes
Poor	25 - 49	Special Treatment (Special Treatment)
Fair	50 - 74	Needs Treatment (Filtration & Disinfection)
Good	75 - 94	Acceptable
Excellent	95 - 100	Pristine Quality

Results and Discussion

Temperature (°C)

Table 4 lists the two-year temperature data across three seasons. Tables 5-7 presents some descriptive findings based on the data in Table 4. The water temperature ranged between 18.5 °C to 31.1 °C during the study period (Figure 3). It ranged between 18.8 °C to 27.8 °C in the year 2015-16 and between 18.5 °C to 31.1 °C in 2016-17. Seasonal variations in surface water temperature are illustrated in Figures 1-3.

Table 4 Year-wise and Season-wise Temperature (°C) of Budhasagar Pond Water

Season / Sample	2015-16				2016-17			
	A	B	C	Mean±S.D.	A	B	C	Mean±S.D.
Winter	19	19.2	18.8	19±0.2	18.5	19.3	18.7	18.8±0.41
Summer	27.3	27.7	27.8	27.6±0.26	29.4	30[illegible]	31.1	30.3±0.87

Post-monsoon	23.5	23.6	23.7	23.6±0.1	24.3	24.7	25.1	24.7±0.4

Table 5 Descriptive Statistics on Temperature (°C) for the Year 2015-16

	Winter	*Summer*	*Post Mon.*
Mean	19	27.6	23.6
S.E.	0.11547	0.152753	0.057735
Median	19	27.7	23.6
S.D.	0.2	0.264575	0.1
Sample Variance	0.04	0.07	0.01
Skewness	0	-1.45786	1.6E-13
Range	0.4	0.5	0.2
Minimum	18.8	27.3	23.5
Maximum	19.2	27.8	23.7

Table 6 Descriptive Statistics on Temperature (°C) for the Year 2016-17

	Winter	*Summer*	*Post Mon.*
Mean	18.83333	30.36667	24.7
S.E.	0.24037	0.504425	0.23094
Median	18.7	30.6	24.7
S.D.	0.416333	0.873689	0.4
Sample Variance	0.173333	0.763333	0.16
Skewness	1.293343	-1.11608	4E-14
Range	0.8	1.7	0.8
Minimum	18.5	29.4	24.3
Maximum	19.3	31.1	25.1

Table 7 Descriptive Statistics on Temperature (2015-16 to 2016-17)

	Winter	*Summer*	*Post Mon.*
Mean	18.9	28.95	24.15
S.E.	0.1	1.35	0.55
Median	18.9	28.95	24.15
S.D.	0.141421	1.909188	0.777817
Sample Variance	0.02	3.645	0.605
Range	0.2	2.7	1.1
Minimum	18.8	27.6	23.6
Maximum	19	30.3	24.7

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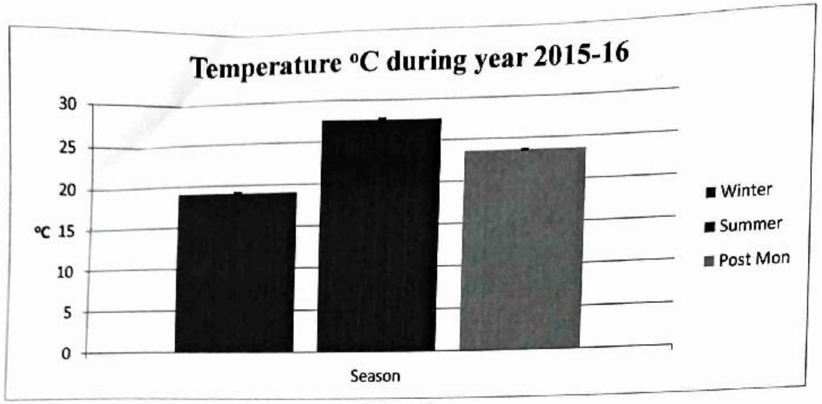

Figure 1

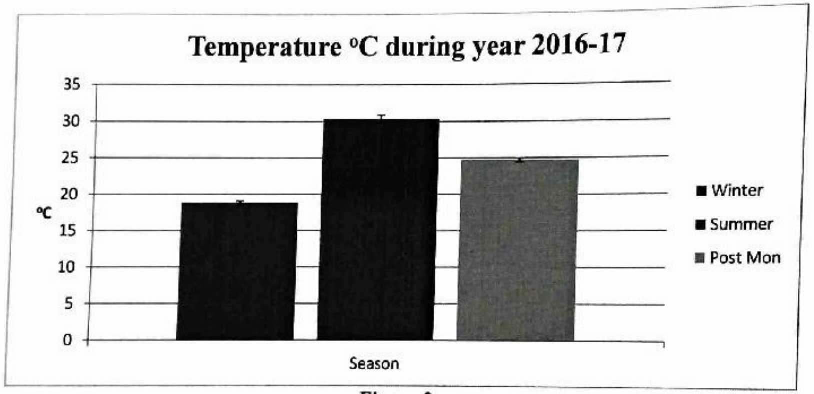

Figure 2

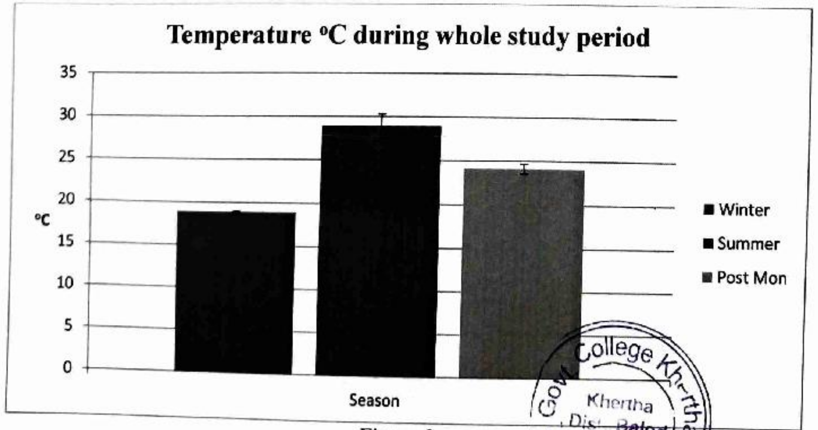

Figure 3

pH

The pH index is a useful tool for determining whether or not something is acidic, alkaline, or neutral in nature. The growth of aquatic Flora and Fauna is restricted by pH. Water's hydrogen ion content (H+) controls the pH. There are fourteen possible outcomes. Any amount above or below 7 is alkaline, and any value in the middle falls somewhere in the middle. At a given temperature, pH measures the activity of hydrogen ions in solution. It is the inverse of hydrogen ion (H+) and is expressed as a mole per litre concentration (APHA 1989). Table 8 lists the two-year pH data across three seasons. Tables 9-11 presents some descriptive findings based on the data in Table 8. The water pH level ranged between 18.5 °C to 31.1 °C during the study period (Figure 6). It ranged between 18.8 °C to 27.8 °C in the year 2015-16 and between 18.5 °C to 31.1 °C in 2016-17. Seasonal variations in pH levels are illustrated in Figures 4-6.

Table 8 pH Year wise and Season wise Budhasagar Pond

Season / Sample	Year 2015-16				Year 2016-17			
	A	B	C	Mean±S.D.	A	B	C	Mean±S.D.
Winter	6.7	6.9	6.8	6.8 ± 0.1	6.8	6.8	7.2	6.9±0.23
Summer	6.9	7.2	7	7.1±0.1	7.5	7.4	7.5	7.4±0.05
Post-monsoon	6.8	7.1	6.8	6.9±0.15	7.2	7.4	7.4	7.3±0.11

Table 9 Year 2015-16 pH Descriptive Statistics

	Winter	*Summer*	*Post Mon*
Mean	6.8	7.033333	6.9
S.E.	0.057735	0.088192	0.1
Median	6.8	7	6.8
S.D.	0.1	0.152753	0.173205
Sample Variance	0.01	0.023333	0.03
Range	0.2	0.3	0.3
Minimum	6.7	6.9	6.8
Maximum	6.9	7.2	7.1

Table 10 Year 2016-17 pH descriptive statistics

	Winter	*Summer*	*Post Mon*
Mean	6.933333	7.466667	7.333333
S.E.	0.133333	0.033333	0.066667
Median	6.8	7.5	7.4
Mode	6.8	7.5	7.4
S.D.	0.23094	0.057735	0.11547
Sample Variance	0.053333	0.003333	0.013333
Skewness	1.732051	-1.73205	-1.73205
Range	0.4	0.1	0.2

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Table 11 Whole study period pH descriptive statistics

	Winter	Summer	Post Mon
Mean	6.85	7.25	7.1
S.E.	0.05	0.15	0.2
Median	6.85	7.25	7.1
S.D.	0.070711	0.212132	0.282843
Sample Variance	0.005	0.045	0.08
Range	0.1	0.3	0.4
Minimum	6.8	7.1	6.9
Maximum	6.9	7.4	7.3

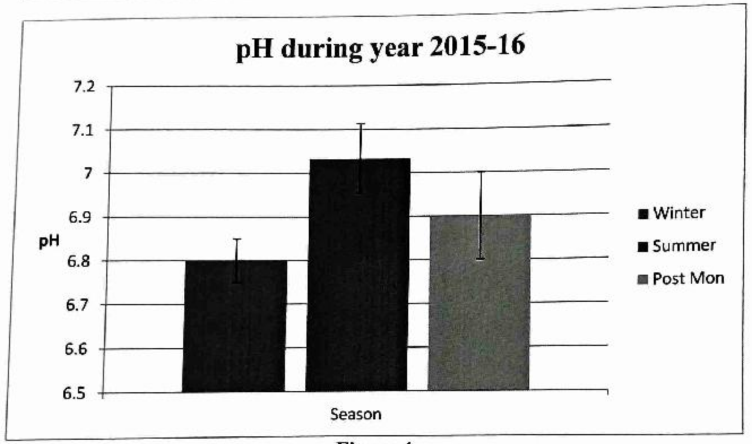

Figure 4

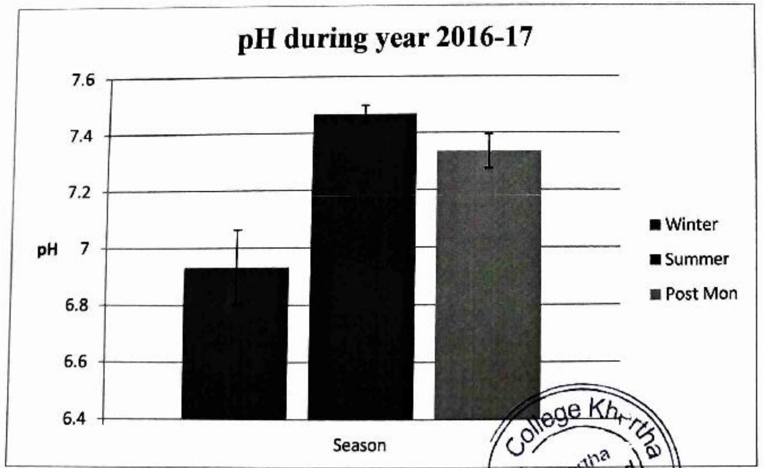

Figure 5

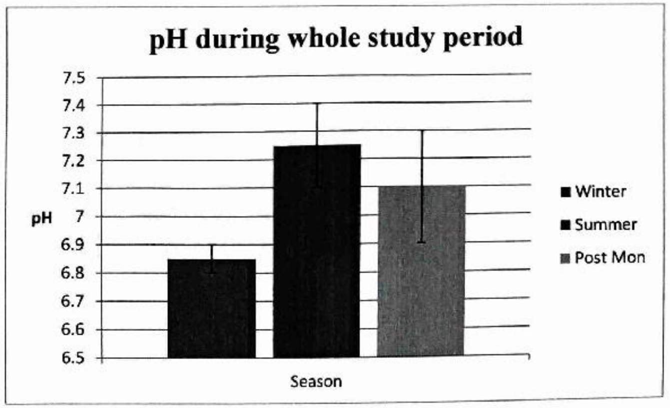

Figure 6

Dissolved Oxygen

All aquatic plants and animals rely on dissolved oxygen for proper metabolism. It's a crucial water quality indicator since it tells us a lot about what's going on biochemically in the water. Dissolved oxygen levels in ponds can fluctuate a lot in a day. As a result of photosynthesis, oxygen is created during the day. During the day, photosynthesis generates more oxygen than is consumed, therefore oxygen levels are typically lowest just before dawn and highest in the late afternoon. Table 12 lists the two-year dissolved oxygen data across three seasons. Tables 13-15 presents some descriptive findings based on the data in Table 12. The water dissolved oxygen level ranged between 18.5 °C to 31.1 °C during the study period (Figure 9). It ranged between 18.8 °C to 27.8 °C in the year 2015-16 and between 18.5 °C to 31.1 °C in 2016-17. Seasonal variations in surface water dissolved oxygen levels are illustrated in Figures 7-9.

Table 12 Dissolved Oxygen (mg/L) Year wise and Season wise Budhasagar Pond

Season / Sample	Year 2015-16				Year 2016-17			
	A	B	C	Mean±S.D.	A	B	C	Mean±S.D.
Winter	4.5	4.7	4.6	4.6±0.1	4.9	4.7	4.5	4.7±0.2
Summer	3.8	3.8	4.2	3.9±0.230	3.8	3.8	3.5	3.7±0.173
Post-monsoon	6.2	6.1	6.3	6.2±0.1	4.4	4.5	4.4	4.4±0.057

Table 13 Year 2015-16 dissolved oxygen descriptive statistics

	Winter	*Summer*	*Post Mon*
Mean	4.6	3.933333	6.2
S.E.	0.057735	0.133333	0.057735
Median	4.6	3.8	6.2
S.D.	0.1	0.23094	0.1
Sample Variance	0.01	0.053333	0.01

Range	0.2	0.4	0.2
Minimum	4.5	3.8	6.1
Maximum	4.7	4.2	6.3

Table 14 Year 2016-17 dissolved oxygen descriptive statistics

	Winter	*Summer*	*Post Mon.*
Mean	4.7	3.7	4.433333
S.E.	0.11547	0.1	0.033333
Median	4.7	3.8	4.4
Mode		3.8	4.4
S.D.	0.2	0.173205	0.057735
Sample Variance	0.04	0.03	0.003333
Range	0.4	0.3	0.1
Minimum	4.5	3.5	4.4
Maximum	4.9	3.8	4.5

Table 15 Whole study period dissolved oxygen descriptive statistics

	Winter	*Summer*	*Post Mon.*
Mean	4.65	3.8	5.3
S.E.	0.05	0.1	0.9
Median	4.65	3.8	5.3
S.D.	0.070711	0.141421	1.272792
Sample Variance	0.005	0.02	1.62
Range	0.1	0.2	1.8
Minimum	4.6	3.7	4.4
Maximum	4.7	3.9	6.2

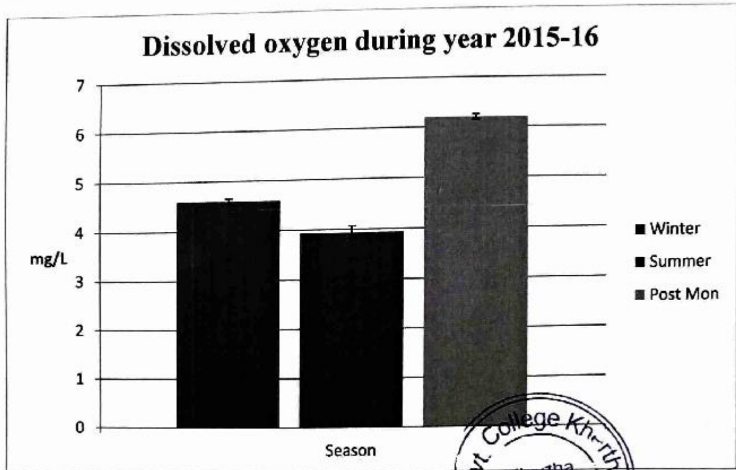

Figure 7

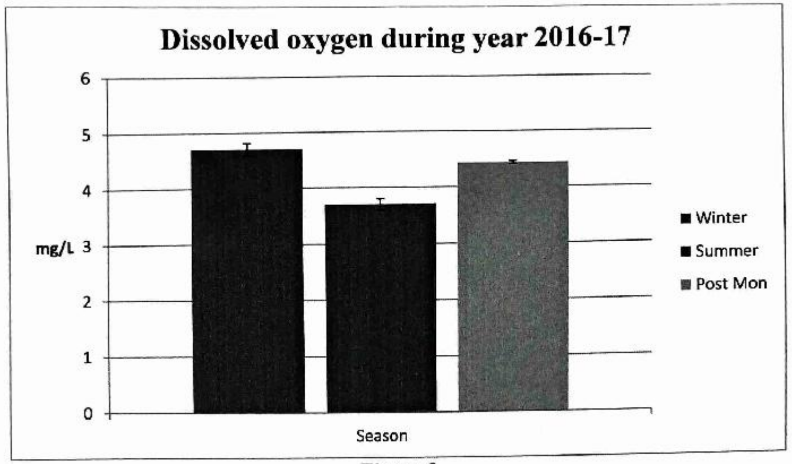

Figure 8

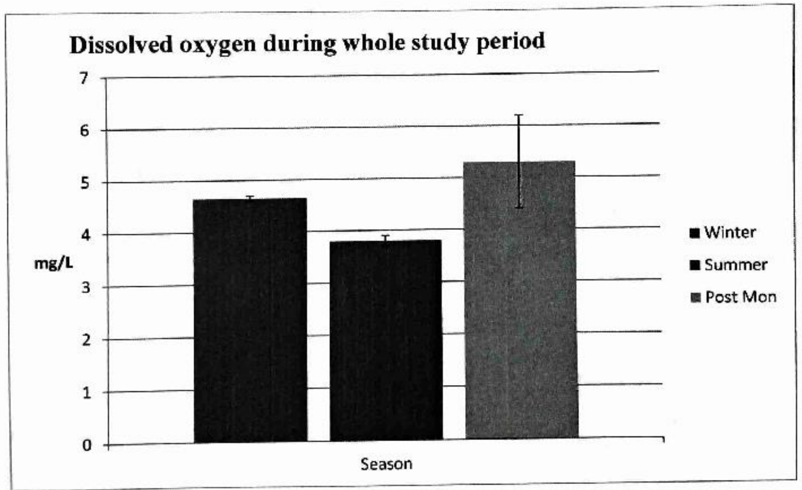

Figure 9

Total Hardness (TH)

Bivalent cations like Calcium and Magnesium, which are abundant in nature, are the primary cause of hardness. Calcium and Magnesium concentrations, both given as mg/L of CaCO3, are used to calculate total hardness. Temporary hardness is caused by calcium and magnesium carbonates and bicarbonates. Permanent Hardness is the result of exposure to sulphates and chlorides. Table 16 lists the two-year total hardness data across three seasons. Tables 17-19 presents some descriptive findings based on the data in Table 16. The water total hardness ranged between 18.5 °C to 31.1 °C during the study period (Figure 12). It ranged between 18.8 °C to 27.8 °C in the year 2015-16 and between 18.5 °C to 31.1 °C in 2016-17. Seasonal variations in total hardness levels are illustrated in Figures 10-12.

Table 16 Total Hardness Year wise and Season wise Budhasagar Pond

Season / Sample	Year 2015-16				Year 2016-17			
	A	B	C	Mean±S.D.	A	B	C	Mean±S.D.
Winter	140	142	141	141±1	145	149	148	147.3±2.08
Summer	171	173	172	172±1	197	193	194	194.6±2.08
Post-monsoon	120	126	126	124±3.46	129	131	130	130±1.00

Table 17 Year 2015-16 Total Hardness Descriptive Statistics

	Winter	*Summer*	*Post Mon.*
Mean	141	172	124
S.E.	0.57735	0.57735	2
Median	141	172	126
S.D.	1	1	3.464102
Sample Variance	1	1	12
Skewness	0	0	-1.73205
Range	2	2	6
Minimum	140	171	120
Maximum	142	173	126

Table 18 Year 2016-17 Total Hardness Descriptive Statistics

	Winter	*Summer*	*Post Mon*
Mean	147.3333	194.6667	130
S.E.	1.20185	1.20185	0.57735
Median	148	194	130
S.D.	2.081666	2.081666	1
Sample Variance	4.333333	4.333333	1
Skewness	-1.29334	1.293343	0
Range	4	4	2
Minimum	145	193	129
Maximum	149	197	131

Table 19 Whole Study Period Total Hardness Descriptive Statistics

	Winter	*Summer*	*Post Mon*
Mean	144.15	183.3	127
S.E.	3.15	11.3	3
Median	144.15	183.3	127
S.D.	4.454773	15.98061	4.242641

Sample Variance	19.845	255.38	18
Range	6.3	22.6	6
Minimum	141	172	124
Maximum	147.3	194.6	130

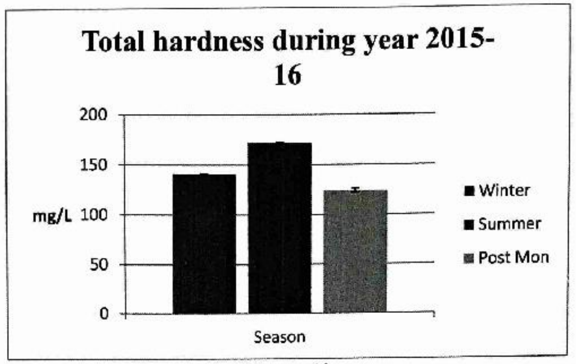

Figure 10

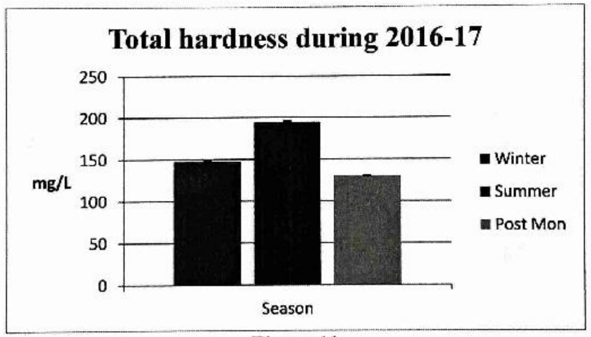

Figure 11

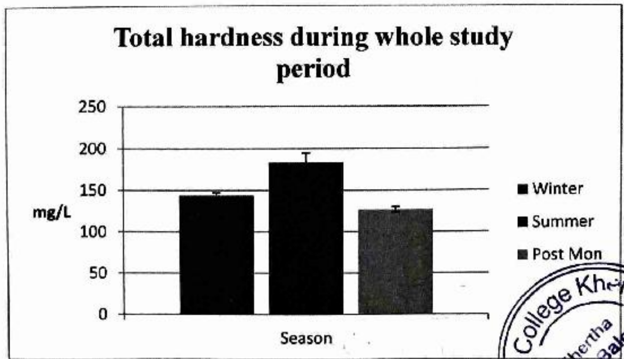

Figure 12

Chloride

Chloride is a salt of sodium, potassium, and calcium that naturally exists in water. Except when transformed into toxic oxides, chloride is relatively non-toxic to plants and animals. A high chloride value degrades flavour and has the potential to corrode metal surfaces. Table 20 lists the two-year chloride data across three seasons. Tables 21-23 presents some descriptive findings based on the data in Table 20. The chloride level ranged between 18.5 °C to 31.1 °C during the study period (Figure 15). It ranged between 18.8 °C to 27.8 °C in the year 2015-16 and between 18.5 °C to 31.1 °C in 2016-17. Seasonal variations in chloride levels are illustrated in Figures 13-15.

Table 20 Chloride Year-wise and Season-wise Budhasagar pond

Season / Sample	Year 2015-16				Year 2016-17			
	A	B	C	Mean±S.D.	A	B	C	Mean±S.D.
Winter	94	89	91	91.33±2.51	89	92	91	90.66±1.52
Summer	100	95	94	96.33±3.21	99	95	97	97±2
Post-monsoon	84	82	79	81.66±2.51	83	80	84	82.33±2.08

Table 21 Year 2015-16 Chloride Descriptive Statistics

	Winter	*Summer*	*Post Mon*
Mean	91.33333	96.33333	81.66667
S.E.	1.452966	1.855921	1.452966
Median	91	95	82
S.D.	2.516611	3.21455	2.516611
Sample Variance	6.333333	10.33333	6.333333
Skewness	0.585583	1.545393	-0.58558
Range	5	6	5
Minimum	89	94	79
Maximum	94	100	84

Table 22 Year 2016-17 Chloride Descriptive Statistics

	Winter	*Summer*	*Post Mon*
Mean	90.66667	97	82.33333
S.E.	0.881917	1.154701	1.20185
Median	91	97	83
S.D.	1.527525	2	2.081666
Sample Variance	2.333333	4	4.333333
Skewness	-0.93522	0	-1.29334
Range	3	4	4
Minimum	89	95	80
Maximum	92	99	84

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Table 23 Whole Study Period Chloride Descriptive Statistics

	Winter	*Summer*	*Post Mon*
Mean	90.995	96.665	81.995
S.E.	0.335	0.335	0.335
Median	90.995	96.665	81.995
S.D.	0.473762	0.473762	0.473762
Sample Variance	0.22445	0.22445	0.22445
Range	0.67	0.67	0.67
Minimum	90.66	96.33	81.66
Maximum	91.33	97	82.33

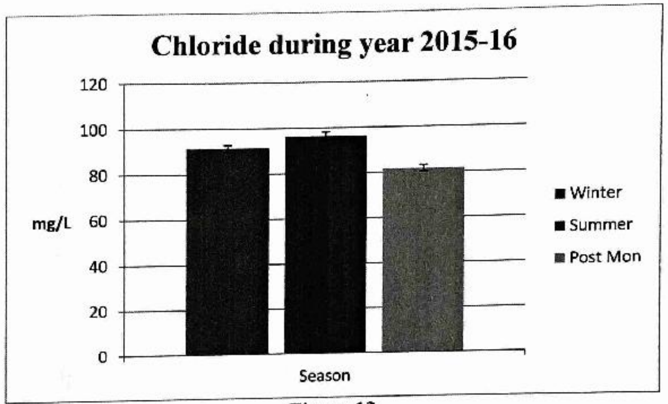

Figure 13

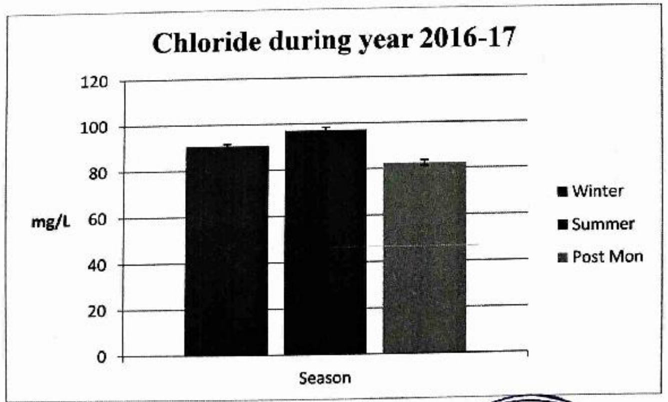

Figure 14

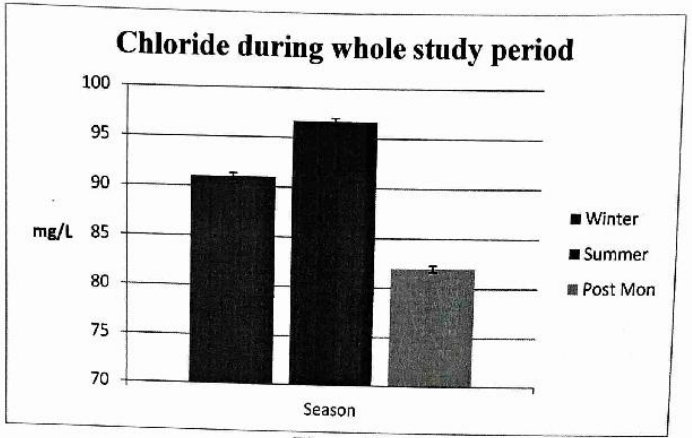

Figure 15

Overall water quality index (OWQI)

Overall water quality index shows status of water based on physiochemical properties. In the present study, it ranges from fair to good class. Fair indicates that the water body is contaminated and requires treatment such as filtration before consumption. Good class is indicative of acceptable quality of water. Good class water is safe to consume without treatment. Continuous evaporation due to high ambience temperature during the summer season in both years resulted in fair class categorisation of the pondwater. It was recorded as fair also during the post-monsoon season in 2016-17. In 2015-16, during the post-monsoon season, and during winters in 2015-16 and 2016-17, the water quality was recorded as good.

OWQI ranged between 69.28 to 86.85 during the two-year study period. It is recommended filtration and disinfection be carried out to clean the pondwater as it poses health risks to the aquatic life of the pond and to people dependent on the pond in one way or the other.

Summary and Conclusion

In the year 2015-16, the mean surface water temperature was recorded at 19±0.2 °C in winters, 27.6±0.26 °C during the summer season and 23.6±0.1 °C during the post-monsoon season. In 2016-17, the mean surface water temperature was recorded at 18.8±0.41 °C in winters, 30.3±0.87 °C during summer and 24.7±0.4 °C during the post-monsoon season.

In 2015-16, during the winter season, the mean dissolved oxygen value was found to be 4.6±0.1 mg/L. During the summer season, the mean dissolved oxygen value was found to be 3.9±0.23 mg/L. In the post-monsoon season, it was 6.2±0.1 mg/L. In 2016-17, during the winters, the mean dissolved oxygen value was 4.7±0.2 mg/L. The mean dissolved oxygen value was 3.7±0.17 mg/L in summer and 4.4±0.057 mg/L during the post-monsoon season.

The mean total hardness values ranged between 124±3.36 mg/L during the post-monsoon season to 141±0.1 mg/L in winters and 172±1 mg/L during summers in the year 2015-16. In 2016-17, the mean total hardness values ranged between 130±1.00 mg/L (post-monsoon seasons) to 147±2.08 mg/L (during winters) and 194.6±2.08 mg/L (during summer).

In 2015-16, the mean chloride value was 91.33±2.51 mg/L in winters, 96.33±3.21 mg/L in summer, and 81.66±2.51 mg/L during the post-monsoon season. Comparatively, it ranged between 80 mg/L (post-monsoon) to 99 mg/L (summer) in 2016-17.

Over the course of two years, the water temperature at Budhasagar Pond fluctuated between 18.5°C and 31.1°C, with the majority of the variation reflecting changes in air temperature. This pattern was observed by Welch (1952), Rao (1955), Munawar (1970a &

b), Hannan et al. (1974), Swarup et al. (1979), Harshey et al. (1982), Bagde and Verma (1985a & b), Sarwar (1985c & b), and Hannan et al. (1987) as well.

Over the course of the research, the pH of the water varied from 6.7 to 7.5. In the summer, the pH was found to be a little higher (May-June). After the monsoon season, pH values dropped substantially, with the lowest pH occurring in the winter. Higher pH values during summer have also been reported in different water bodies by Seenayya (1971), Zutshi and Vass (1978), Singh et al. (2009), Sithik et al. (2009), Godghate et al. (2013), Wanganeo (1984), Mishra (1988), Bandopadhyay and Gopal (1991), Khalique and Afser (1995), and Narain and Chauhan (2000).

During the summer, the pond's dissolved oxygen levels were lower and during the winter they were greater. The dissolved oxygen levels were highest following the monsoon season. Hutchinson (1957), Reid (1961), Ray et al. (1966), Badola and Singh (1981), Bandopadhyay and Gopal (1991), Munshi and Singh (1991), Shastree et al. (1991), Pandey et al. (1993), and Esmaeili and Johal (2005) have all come to similar conclusions.

The total hardness value ranged between 120 and 197 mg/L during the study period. Chloride levels were highest in summer, mild in post-monsoon, and lowest in winters. Ganpati (1940) and Zafar (1967), Hosmani (1975), Bhattacharya (1988), and Borker et al. (1988) have observed similar patterns in their research.

OWQI ranged between 69.28 to 86.85 during the two-year study period. It is recommended filtration and disinfection be carried out to clean the pondwater as it poses health risks to the aquatic life of the pond and to people dependent on the pond in one way or the other.

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