



# Comparative study on physicochemical status and diversity of macrophytes and zooplanktons of two urban ponds of Chandannagar, WB, India

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## Abstract

Present investigation has made an attempt to assess the variations in physicochemical status of two urban ponds (constructed boundary: Pond A and natural boundary: Pond B) of Chandannagar and also established the variations in the diversity of macrophytes and zooplankton of the study areas during winter (Nov–Dec, 2017). Limnological parameters recorded from two spots collected in three phases, such as temperature, pH, transparency, conductivity, DO, BOD, total dissolved solids (TDS), total suspended solids (TSS), total alkalinity, total hardness and chloride, were evaluated. From this observation, it is reported that there are marked variations in different water quality parameters of two urban ponds during the study period. The value of water temperature in Pond A and B was 22.0 and 21.3 °C, respectively. pH value (7.9) was highest in Pond B. Pond B water was more turbid than Pond A. The highest values of other parameters like conductivity (218.50 µS/cm) DO (8.47 mg/l), BOD (5.69 mg/l), TDS (135.19 mg/l), TSS (67.60 mg/l), total alkalinity (181.15 mg/l), total hardness (145.66 mg/l) and chloride (58.94 mg/l) were found in case of Pond B. Maximum macrophytic vegetations were found in Pond B in comparison with Pond A. The study of the zooplankton community reveals that the maximum occurrence of rotifers in Pond B indicates pollution status.

**Keywords** Physicochemical status · Macrophytes · Zooplankton · Urban ponds

## Introduction

All living organisms on this planet need water for their growth and survival. Almost every aspect of life on our planet is governed by water. Freshwater is not only a finite resource but also essential for agriculture, industry and even human existence, and without its inadequate quantity and quality, sustainable development will not be possible (Kumar 1997). The deterioration of water quality of freshwater resource is becoming faster which leads to a global problem (Mahananda et al. 2005). Discharge of toxic chemicals over extraction of aquifer and contamination water body with unwanted substances excessive

algal growth are some of the major causative agents of water quality degradation. Several researchers (Ghose and Basu 1968; Patil and Tijare 2001; Singh and Mathur 2005; Gupta and Shukla 2006) observed that freshwater is gradually becoming a scarce commodity due to exorbitant pollution, over exploitation, etc. Dwivedi and Pandey (2002) reported that industrial waste water, sewage and municipal wastes are being continuously added to water reservoirs which affect the physicochemical quality of water and also making them unfit for even use of livestock and other organisms. Uncontrolled discharge of domestic waste water into the ponds has resulted in eutrophication of ponds (Pandey and Pandey 2003). The added unwanted substances may be arbitrarily classified as biological, chemical, physical and radiological impurities in addition to industrial wastes, commercial solvents, metal, acid, salts, sediments, pesticides, herbicides, plant nutrients, radioactive materials, decaying animal bodies, vegetable matters and living microorganisms (Gay and Proop 1993). All these impurities result in degradation of water quality, like bad taste, colour, odour, turbidity,

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hardness, corrosiveness, staining and frothing. Ponds which are relatively small in size are important part of our urban ecosystem, and they perform several environmental, social and economic functions, viz. as a source of drinking water, recharging groundwater, acting as sponges to control flooding, supporting biodiversity and providing livelihoods (Saha et al. 2017). Ponds have been used since time immemorial as a traditional source of water supply in India. However, the water of the ponds, lakes and rivers is polluted mainly due to discharge of waste water from the residential areas, sewage outlets, solid wastes, detergents, automobile oil wastes, fishing facilities and agricultural pesticides from farmlands (Hassan et al. 2013). Natural water bodies may contain different types of impurities in the different forms, such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities (Adeyeye 1994). Both the phytoplankton and zooplankton communities influence the water quality characteristics and are important components in the production of standing waters. The macrophyte, the aquatic plant grows in or near the water bodies, plays an important role for maintaining the ecological balance and resilience (Dykyjova 1971, 1978; Adams and McCracken 1974; Pandit 1984) and also are key factors for primary production of an aquatic ecosystem (Dhore and Lachure 2014; Bhute and Harney 2017). Macrophytes are of several types: emergent, rooted submerged, free submerged and free floating. Macrophytes also serve as indicator species responding to changes in water quality and contaminants to cause pollution in several ecosystems (Best 1982). Different studies have been done on aquatic macrophytes from different freshwater bodies by different researchers (Unni 1971; Crowder et al. 1977; Zutshi et al. 1980; Billore and Vyas 1981; Dey and Kar 1989; Islam 1990; Kodarkar 1996; Salaskar 1998; Bhaumik et al. 2004, Kumar and Pandit 2005; Ghavzan et al. 2006; Devi and Sharma 2007). Transparency, nutrient concentration and land are the different factors responsible for proper growth and distribution of macrophytes in the reservoirs and rivers (Bini et al. 1999; Akasata et al. 2010). Zooplankton is a heterotrophic planktonic community floating in water and acts as important food source for many aquatic organisms. Besides this, zooplankton also serves as an indicator organism of water type, fish yield, and/or total biological production. Distribution of zooplankton species is influenced by abiotic and biotic factors, viz. temperature, dissolved oxygen, salinity and other physicochemical characteristics (Jeje and Fernando 1986). Balarabe (1989) reported that zooplankton is primary consumers feeding mainly on phytoplankton and is regarded as secondary producers in the trophic structure of an aquatic ecosystem. The ecology of zooplankton diversity in aquatic bodies has been carried out by several

workers (Gulati 1964; Mathew 1978; Suganan 1997; Jha 1997; Kumar et al. 2007; Tripathi et al. 2008a, b). The relationship between the physicochemical parameters and plankton production of water bodies was studied intensively by Kutama et al. (2011) and Hassan et al. (2013).

The present study mainly focuses on the contamination status and effects of contamination coming from the human settlements into two urban ponds (A and B) of Chandannagar, Hooghly, out of which one has a constructed boundary and the other bears a natural boundary. This study endorses some important limnological parameters like temperature, pH, transparency, conductivity, DO, BOD, total dissolved solids (TDS), total suspended solids (TSS), total alkalinity, total hardness and chloride. The present study intended to highlight the diversity of flora and fauna, i.e. variations of macrophytic vegetations and zooplankton species of the selected ponds (Ponds A and B) during the study period (Nov–Dec, 2017).

## Materials and methods

### Description of study area

Chandannagar, formerly known as Chandernagore, is a Corporation city and former French colony located 35 km north of Kolkata, in West Bengal, India. It is situated at 22.87° N latitude and 88.38° E longitude and 16 m elevation above the sea level. The water samples for physicochemical analysis were collected between 11.00 am to 12.00 noon during winter season (Nov–Dec, 2017) from two urban ponds: Pond A is located near Madhyanchal region of Chandannagar with constructed boundary used for household and fishing purposes by the local people, and the Pond B is located at colony area of Subhash Palli, Chandannagar, having natural boundary admitting common human activities like bathing, washing of clothes and washing of animals which in turn add nutrients to water and alter the quality of water. Samples were collected in three phases during entire study period (Nov–Dec, 2017) of total 60 days.

### Collection of water samples for analysis of limnological parameters

The samples were collected in plastic container from a depth of 5–10 cm below the surface water of each pond in three phases. The physicochemical characteristics of water like temperature, pH, transparency, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), total suspended solids (TSS), total alkalinity, total hardness, and chloride were determined in winter by following standard methods of APHA (1998). Temperature, pH, transparency, conductivity, DO of the water of two

ponds were measured at their collection sites. Temperature was recorded with the help of mercury thermometer, pH was recorded by hand pH meter, water transparency was measured by using black and white disc, and conductivity was measured by using hand conductivity meter (EC TESTER), whereas DO was measured by following Winkler's iodometric method. For the measurement of other physicochemical parameters, water samples were collected in plastic sampling bottles and transported to the laboratory. All the water samples collected in three phases during winter were analysed and expressed as Mean  $\pm$  SD.

### Collection of macrophytes

The aquatic macrophytes were also collected from two urban ponds (A and B) during the winter (Nov–Dec, 2017) season. Macrophytes of shallow waters were collected directly, while the others of deeper water with the help of long handled hook. After collection, the specimens were washed thoroughly and soaked with filter paper and kept in polythene bags and brought to the laboratory for identification by using the method adopted by Cook (1996) and Kodarkar (1996).

### Analysis of zooplankton species

For zooplankton analysis, specimens were collected from two urban ponds (A and B) with plankton net having mesh size of 50–55  $\mu\text{m}$  and then preserved in 4% formaldehyde solution. The zooplankton was observed under microscope, and taxonomic identification was done following the literature of Edmondson (1959), Sehgal (1983), Jeje and Fernando (1986), Sharma and Michael (1987), Battish (1992), Sharma (1998) and Venkataraman (1999).

## Results and discussion

Comparative study on physicochemical data of two urban ponds (A and B) of Chandannagar was recorded after collecting and analysed the water samples in three phases, and the Mean  $\pm$  SD values of different water quality parameters are shown in Table 1.

The present study mainly focuses the variations of water quality of two urban ponds during winter (Nov–Dec, 2017). The importance of physicochemical parameters in assessing water quality is well established (Mitra 1995; Kataria et al. 1996; Kudesia 2000; Sunkad 2008) (Tables 2, 3).

Murugesan et al. (2004) reported that the increasing water temperature was responsible for increasing the chemical and biological reaction in water body and reducing the solubility of gases. During the present investigation, there was no

**Table 1** Variations in the physicochemical parameters of water samples collected from two urban Ponds (A and B) of Chandannagar during the study period (Nov–Dec, 2017)

Parameters	Pond A (constructed boundary)	Pond B (natural boundary)
Temperature ( $^{\circ}\text{C}$ )	22.0 $\pm$ 0.07	21.3 $\pm$ 0.14
pH	7.5 $\pm$ 0.12	7.9 $\pm$ 0.19
Transparency (cm)	63.0 $\pm$ 2.05	51.5 $\pm$ 1.58
Conductivity ( $\mu\text{S}/\text{cm}$ )	123.11 $\pm$ 21.2	218.50 $\pm$ 33.1
DO (mg/l)	5.80 $\pm$ 0.60	8.47 $\pm$ 1.18
BOD (mg/l)	2.79 $\pm$ 0.41	5.69 $\pm$ 0.52
TDS (mg/l)	118.33 $\pm$ 20.21	135.19 $\pm$ 24.56
TSS (mg/l)	51.52 $\pm$ 12.38	67.60 $\pm$ 15.08
Total alkalinity (mg/l)	167.80 $\pm$ 23.39	181.15 $\pm$ 37.56
Total hardness (mg/l)	128.30 $\pm$ 16.25	145.66 $\pm$ 28.17
Chloride (mg/l)	35.20 $\pm$ 4.11	58.94 $\pm$ 5.116

Values are mean  $\pm$  SD (3 samples during study period)

DO dissolved oxygen, BOD biochemical oxygen demand, TDS total dissolved solids, TSS total suspended solids

significance difference in temperature of the water of two ponds (A and B).

pH is an important parameter which helps to determine the acid–base balance of river water (Bhalla and Waykar 2012). pH of water helps to determine the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. The pH of water affects the solubility of many toxic and nutritive chemicals and so the presence of these substances in any aquarium system affects the aquatic organism and pH is also positively correlated with electrical conductance and total alkalinity (Gupta et al. 2009). Karanth (1987) reported that the higher pH values indicated the carbon dioxide and carbonate-bicarbonate equilibrium was affected more due to change in physicochemical condition. The permissible level of pH in drinking water is 6.5 to 8.5. In case of both Ponds A and B, the value of the pH indicates the alkaline in nature and also within permissible limit.

Dokulil et al. (2006) reported that water transparency was not only a crucial parameter of lake optics but also one of the important indexes of eutrophication evaluation of lake which directly reflect the lake limpid and muddy degree and was affected by suspended solids and phytoplankton of water. Water transparency was shown higher in Pond A than in Pond B. Water transparency is mainly affected by the factors like rainfall, Sun's position in the sky, angle of incidence of rays, cloudiness, visibility, turbidity and planktonic growth. High turbidity is responsible for damages to benthic community (Anitha 2002).

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. It depends on the presence of ions, on their total concentration, mobility and

**Table 2** Variations in aquatic macrophyte vegetations of two urban ponds (A and B) of Chandannagar recorded during the study period (Nov–Dec, 2017)

Name of the macrophytes	Family	Types	Pond A	Pond B
<i>Ipomoea</i> sp.	Convolvulaceae	Emergent	+	+
<i>Hydrilla</i> sp.	Hydrochorideae	Rooted submerged	+	+
<i>Ceratophyllum</i> sp.	Ceratophyllaceae	Free submerged	+	+
<i>Eichhornia</i> sp.	Pontederiaceae	Free floating	–	+
<i>Lemna</i> sp.(Major)	Lemnaceae	Free floating	–	+
<i>Lemna</i> sp. (Minor)	Lemnaceae	Free floating	–	+
<i>Pistia</i> sp.	Araceae	Free floating	+	+
<i>Azolla</i> sp.	Salviniaceae	Free floating	–	+
<i>Nymphaea</i> sp.	Nymphaeaceae	Rooted free floating leaves	–	+

(+) = Present; (–) = Absent

**Table 3** Variations in zooplankton specimens of two urban ponds (A and B) of Chandannagar recorded during the study period (Nov–Dec, 2017)

Name of the zoo-plankton	Phylum	Family	Pond A	Pond B
<i>Brachionus</i> sp.	Rotifera	Brachionidae	–	+
<i>Keratella</i> sp.	Rotifera	Brachionidae	–	+
<i>Cyclops</i> sp.	Arthropoda	Cyclopidae	+	+
<i>Cypris</i> sp.	Arthropoda	Cyprididae	–	–
<i>Diaptomus</i> sp.	Arthropoda	Diaptomidae	+	–
<i>Bosmina</i> sp.	Arthropoda	Bosminidae	+	–
<i>Daphnia</i> sp.	Arthropoda	Daphniidae	+	+
<i>Moina</i> sp.	Arthropoda	Moinidae	+	–

(+) = Present; (–) = Absent

valence and on the temperature of measurement. Electrical conductivity is found to be good indicator of water quality (Gaikwad et al. 2008). Sastry et al. (1999) found the concentration of dissolved solids to be proportional to the ionic strength and proposed that the increase in conductivity may be due to leachate infiltration from soil. Conductivity of Pond A (123.11  $\mu\text{S}/\text{cm}$ ) was lower than Pond B (218.50  $\mu\text{S}/\text{cm}$ ).

DO is one of the most important parameters of water quality analysis. The amount of oxygen dissolved in a reservoir is affected by temperature of water, salinity, altitude, water inflow and photosynthetic activity of algae and plants (George et al. 2004; Abowei 2010). In the progress of summer, dissolved oxygen decreased due to increase in temperature and microbial activity (Moss 1972; Morrissette and Mavnic 1978). Dokulil et al. (2006) reported that the fluctuation in dissolved oxygen was caused by biological processes and formation of eutrophication of water. DO level was found within optimum range in case of Pond A, i.e. 5.80 mg/l but high in case of Pond B (8.47 mg/l).

Biochemical oxygen demand determination (BOD) is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds by microorganisms

and oxidation of certain inorganic materials. BOD determination is used for assessing the organic pollution (Barai and Kumar 2013) and also used for the measurement of the amount of organic materials of an aquatic system supporting the growth of microorganisms (Keramat 2008). BOD level was found 2.79 mg/l in Pond A but 5.69 mg/l in Pond B. So, water of Pond A may be used for domestic purposes but not Pond B.

Total dissolved solids (TDS) is an important parameter in determining the water quality standards, and it accounts for the various types of solids in dissolved form which may be organic or inorganic (Jayakumar et al. 2009). Several researchers (Bharathi and Krishnamoorthy 1990; Tripathy and Adhikary 1990) reported that TDS is proportional to the degree of pollution. TDS were maximum during summer and minimum during monsoon (Narayan et al. 2007; Jacklin Jemi and Regini Balasingh 2011). During the present study period, maximum value of total dissolved solids was recorded in case of Pond B (135.19 mg/l) and minimum in case of Pond A (118.33 mg/l). In water, total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates, nitrates organic matter, salt and other particles.

Total suspended solids (TSS) are solids in water that can be trapped by a filter. TSS can include a wide variety of materials, viz. silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life. Total suspended solids (TSS) in case of both Ponds A and B were found to be of 51.52 mg/l and 67.60 mg/l, respectively.

Alkalinity is a capacity of water which helps to neutralize a strong acid (Shinde et al. 2011). Anions, viz. carbonate ( $\text{CO}_3^{2-}$ ), bicarbonate ( $\text{HCO}_3^-$ ), hydroxyl ( $\text{OH}^-$ ), phosphate ( $\text{PO}_4^{3-}$ ) and silicate ( $\text{SiO}_4^{4-}$ ), are contributed alkalinity to water. Boyd (1982) reported that the uptake or release of carbon dioxide by organisms might change the proportion of carbonates and bicarbonates in water. During summer the concentration of nutrient increased the alkalinity of water (Arasu et al. 2007), but the alkalinity became

decreased in monsoon due to dilution of rainwater (Shinde et al. 2010). Total alkalinity of Pond A (167.80 mg/l) was found to be lower than Pond B (181.15 mg/l).

Hardness is an important parameter for detecting water pollution. According to Baruah et al. (1993) and Rao (2001), total hardness of water indicates the water quality in terms of calcium and magnesium only. In the present investigation, the hardness of Ponds A and B was 128.30 mg/l and 145.66 mg/l, respectively. So, it was moderate hardness in both the cases.

Chloride anion is generally present in natural waters. Prakash (2004) reported that in natural freshwater, high concentration of chloride is regarded as an indicator of pollution. Human and animal excreta and also industrial effluents are bearing huge quantities of chlorides along with nitrogenous compounds (Naik and Purohit 1997). Chloride concentration is higher in organic wastes and its higher concentration in natural water is a definite indication of pollution from domestic sewage. The ecological significance of chloride lies in its potential to regulate salinity of water. The chloride content of water samples of Pond A was 35.20 mg/l but in Pond B was 58.94 mg/l. Due to constructed boundary of Pond A restricted entry of the sewage run-off from the streets but due to natural boundary Pond B failed to restrict the surface run-off which leads to substantially higher levels of chloride content in the water.

Several researchers (Skubinna et al. 1995; Melzer 1999; Penning et al. 2008; Sondergaard et al. 2010; Poikane et al. 2015) reported that macrophytes are important structural components and bioindicators of freshwater lakes, and its occurrence and species composition are dependent on the nutrient conditions, water level, water temperature and transparency. Variations in macrophyte species is affected by changing environmental conditions (Short and Neckles 1999; Rooney and Kalf 2000; Silva et al. 2008). Aquatic macrophytes not only play an important role in maintenance of aquatic ecosystem, but also they absorb different dissolved nutrients, nitrogen and phosphorus from polluted water in maintaining the resilience of ecosystem. The study of the macrophytes gives us valuable information and also maintains healthy aquatic environment. But on the other hand, when the macrophytes are present in surplus amount, they not only reduce productivity of aquatic system, accumulate silts but also produce huge amount of nutrients causing death, pollute water and produce foul odour and smell (Wahane et al. 2017). During the field survey various type of macrophytes, e.g. emergent (*Ipomoea* sp.), rooted submerged (*Hydrilla* sp.), free submerged (*Ceratophyllum* sp.) and free floating (*Eichhornia* sp., *Lemna* sp., *Pistia* sp., and *Azolla* sp.), have been observed. Maximum macrophytes were found in Pond B than in Pond A due to efficient and adequate nutrients coming from different sources. The

presence of *Lemna* sp. and *Eichhornia* sp. also indicates the pollution load in Pond B.

Zooplankton species inhabits in the freshwater habitats of the world, including polluted water bodies caused by industrial and municipal waste waters (Mukhopadhyay et al. 2007). The diversity and density of each genus of zooplankton varied in each pond. Usually the number of zooplankton increases with the early rainy season and gradually declines as the rainy season progresses (Balarabe 1989; Agwigo 1997). Here, the maximum zooplankton species was found in Pond A. But the presence of rotifers signifies the pollution status of Pond B.

## Conclusion

The study evaluated the water quality of two different kinds of ponds of Chandannagar, Hooghly, WB, and a comparative assessment of certain important physicochemical parameters like temperature, pH, transparency, conductivity, DO, BOD, TSS, TDS, total alkalinity, total hardness, chloride, and also diversity of macrophytes and zooplankton community was done. Analysis of physicochemical parameters is very essential and important to test the water before it is used for domestic, agricultural, industrial or any other purposes. Therefore, it is necessary that the quality of domestic and drinking water should be checked. Comparatively highest level of pollution status was observed in Pond B than in Pond A due to the presence of some macrophytes (*Eichhornia* and *Lemna*) and rotifers (*Brachionus* and *Keratella*).

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