International Journal of Science, Environment and Technology, Vol. 4, No 6, 2015, 1678 – 1693

ISSN 2278-3687 (O)
2277-663X (P)

COMPARATIVE STUDY OF TWO LAKES (POWAI AND VIHAR) IN MUMBAI, WITH RESPECT TO PHYSICO-CHEMICAL PARAMETERS AND ZOOPLANKTON DIVERSITY

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Abstract: The drinking water supply of Mumbai city depends on the lakes like Vihar, Tulasi, Vaitarna (upper, middle and lower), and Bhatsa. The health of any waterbody is largely affected by the area surrounding it. Physico-chemical parameters of water and zooplankton biodiversity are two important players of lake's health. Presence of specific zooplanktonic groups can be taken as an indicator of water condition.
In present work, we selected Vihar and Powai lakes in order to understand and compare their various physico-chemical parameters and zooplankton biodiversity. We found that the water quality of the Powai lake is badly affected by the effluent and untreated sewage from nearby area, which has resulted in inclining the zooplankton biodiversity. We found the representative species of Rotifers, copepods, Cladocerans, protozoan, and ostracoda in both the lakes. Though high number of zooplankton species were recorded from Powai lake. The comparative limnology of these lakes gives new insights into the correlation of physico-chemical properties with the zooplanktons biodiversity.
Keywords: Vihar lake, Powai lake, zooplanktons, limnology.

Introduction

Biodiversity of any pond ecosystem is predominantly determined by water conditions (Buckton, 2007, Kosygin and Dhamendra, 2009; Sharma and Tiwari, 2011). In Mumbai, Powai lake and Vihar lake are among the largest fresh water lakes. The Powai lake is an artificial lake, situated in the Powai valley in the northern suburb of Mumbai (19.1300° N, 72.9100° E), covering area of 2.1 km^2. Vihar lake is the largest lake of the city, situated in Sanjay Gandhi National Park, in North Mumbai (19.1440° N, 72.9100° E), covering area of 7 km^2. The water of the Vihar lake is supplied to city's southern region for the drinking purpose. Whereas the water of the Powai lake is now polluted by sewage and industrial effluent, so considered as unfit for drinking purpose.

The Powai lake and the Vihar lake are surrounded by human habitat and small industries, which increases the human interference and chances of releasing untreated sewage water and

*Received Nov 21, 2015 * Published Dec 2, 2015 * www.ijset.net*

effluent in these lakes. Thus the lakes are prone to change their physico-chemical properties day by day. These changes also affect the life of organisms living in these lakes. Zooplanktons are essential components of the pond ecosystem, because they are present at the second tropic level as consumers (Wang et al., 2010; Sharma and Tiwari, 2011).

Fresh water zooplanktons mainly comprises of rotifers, cladocerans, copepods and ostracodes (Omudu and Odeh, 2006; Mukhopadhyay et al., 2007). Zooplanktons are floating in water that constitute an important food source for many species of aquatic organisms. Zooplanktons serve as indicators of the health of any aquatic body. They are very sensitive to the environment that they live in. A change in the environment leads to change in the tolerance, abundance, diversity and dominance of planktons. They are completely depending on phytoplanktons, a producer in pond ecosystem. Thus any change in pond water properties affects phytoplanktons and subsequently zooplanktons (Pathani and Upadyay, 2006). Many studies have shown the role of zooplanktons as bioindicators for various pond conditions like temperature, conductivity etc (Adeyemi et al., 2009, Ahmad et al., 2011; Mola, 2011). Thus in present project, zooplanktons were selected for the study the effects of various pond water parameters on pond ecosystem.

Number of physico-chemical parameters affect the abundance and diversity of zooplankton (Ratushnyak et al. 2006, Mathivanan et al. 2007, Raja et al., 2008, Rajagopal et al. 2010 and Park and Shin 2007). We were specifically interested to correlate the abundance and biodiversity of zooplanktons to the temperature, pH, electrical conductivity, salinity, dissolved oxygen and biological oxygen demand of proposed two Lakes. Zooplanktons are cosmopolitan in habitat, including highly polluted water. As seasonal changes and human interference with any pond make these parameters to change (Ghanai et al., 2010), so comparative study of the Powai and Vihar Lake will give us the information about how these parameters affect the pond ecosystem throughout the year.

Research objectives:

The objectives of present study were

1. To study the water parameters (water temperature, pH, electrical conductivity, salinity, chemical oxygen demand and biological oxygen demand) and the population of zooplanktons species in Vihar and Powai lakes.
2. To correlate the effect of these water parameters on zooplanktons diversity.
3. To study how the water parameters and zooplankton biodiversity changes over time (in seven months period from November 2014 to May 2015).

Materials and Methods:

Water sampling:

The water samples were collected twice a month, for seven months (November 2014 to May 2015). For each visit, three random locations were chosen and each of these water samples were analysed separately. All the samples were collected between 8 to 10 a.m. The samples were collected from the depth of five feet.

Zooplankton sampling and preservation:

For collecting zooplankton a net with mesh size 40µm was used. Two hundred litres of water was filtered through the net and filtrate was taken in another tube. This filtrate contains phytoplanktons, algae, and zooplanktons along with some debris. Further the filtrate was fixed in 5% formaldehyde solution and was taken to the lab for further analysis. At a time a drop of this solution was observed under binocular microscope on Sedgwick-Rafter cell. The identification of zooplanktons was done by using standard keys of Dhanapathi (2000) and Altaff (2004).

2. Analysis of the water sample:

The water samples for both (vihar and Powai) lakes were analysed for following physico-chemical parameters.

A) Water and air temperature:

Air and water temperature was measured by calibrated digital thermometer.

B) pH:

The pH of the water was measured by digital pH meter.

C) Salinity and Conductivity:

Water conductivity was measured by digital portable calibrated pen conductivity meter.

D) BOD and COD:

The protocols for BOD and COD were followed as per the guideline of APHA (2005).

Results:

The physicochemical properties of vihar and Powai lakes were studied and are given in table 1 to 6. The comparative representation of this analysis is depicted in graph 1 to 6.

Table 1: Mean temperature (in ^{0}C) with standard deviations.

	Nov	Dec	Jan	Feb	Mar	Apr	May
Air (Powai lake)	36.0±0.5	30.5±0.6	31.0±2.1	29.5±0.9	30.3±0.8	34.9±1.3	34.9±1.0
Water	34.0±0.4	29.0±0.7	29.0±1.4	28.3±0.8	28.4±0.4	32.2±1.0	32.1±1.1

(powai lake)							
Air (Vihar lake)	36.5±0.9	31.1±0.6	31.1±1.2	29.6±0.7	30.6±0.7	35.0±1.5	35.7±1.6
Water (Vihar lake)	31.5±0.5	26.7±0.4	27.5±2.6	27.3±0.4	28.1±0.2	32.2±1.1	32.3±0.3

Table 2: Mean pH of with standard deviations.

	Nov	Dec	Jan	Feb	Mar	Apr	May
Powai lake	7.44±0.14	7.59±0.03	7.56±0.04	7.50±0.02	7.58±0.05	7.67±0.02	7.54±0.11
Vihar lake	6.81±0.05	6.83±0.07	6.86±0.02	6.91±0.02	6.93±0.02	6.87±0.04	6.86±0.01

Table 3: Mean salinity (in ppm) with standard deviations.

	Nov	Dec	Jan	Feb	Mar	Apr	May
Powai lake	223.0±5.6	238.5±7.6	237.8±2.5	224.3±4.5	208.5±1.0	185.2±2.4	185.7±2.7
Vihar lake	73.5±1.9	69.8±1.7	74.2±2.5	71.3±3.3	73.2±0.8	76.7±2.7	72.5±1.0

Table 4: Mean conductivity (µmhos/cm) with standard deviations

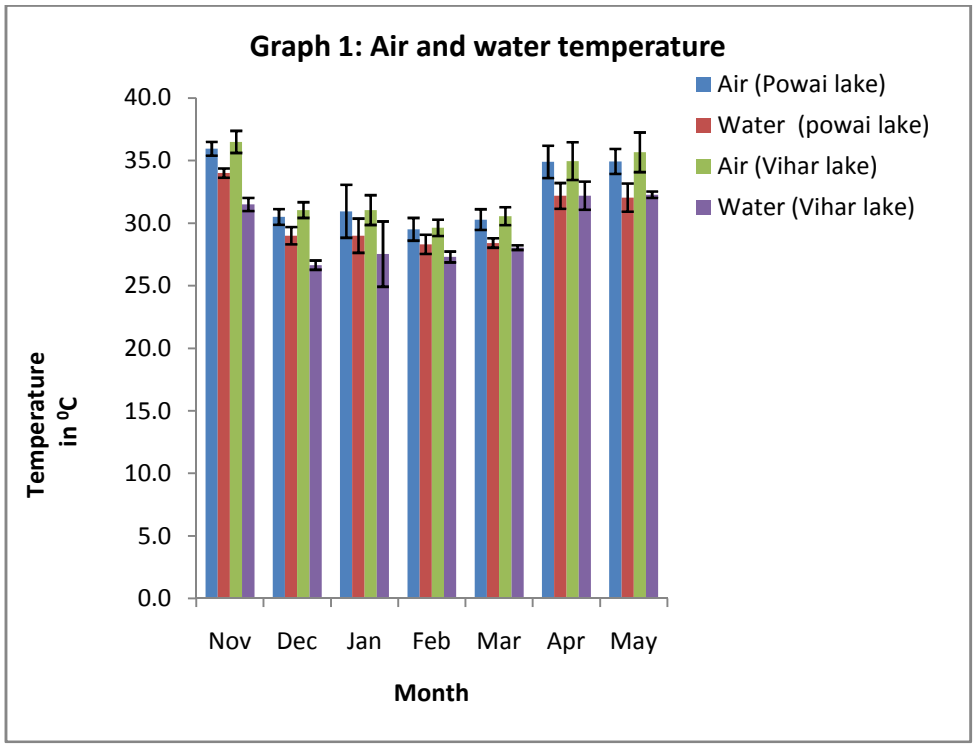
	Nov	Dec	Jan	Feb	Mar	Apr	May
Powai lake	425.3±9.5	418.5±22.5	365.7±10.2	367.8±2.8	371.3±4.2	396.8±21.4	400.5±36.0
Vihar lake	147.7±5.2	149.7±3.7	156.7±2.3	152.0±3.7	145.5±3.8	149.3±2.1	149.7±3.6

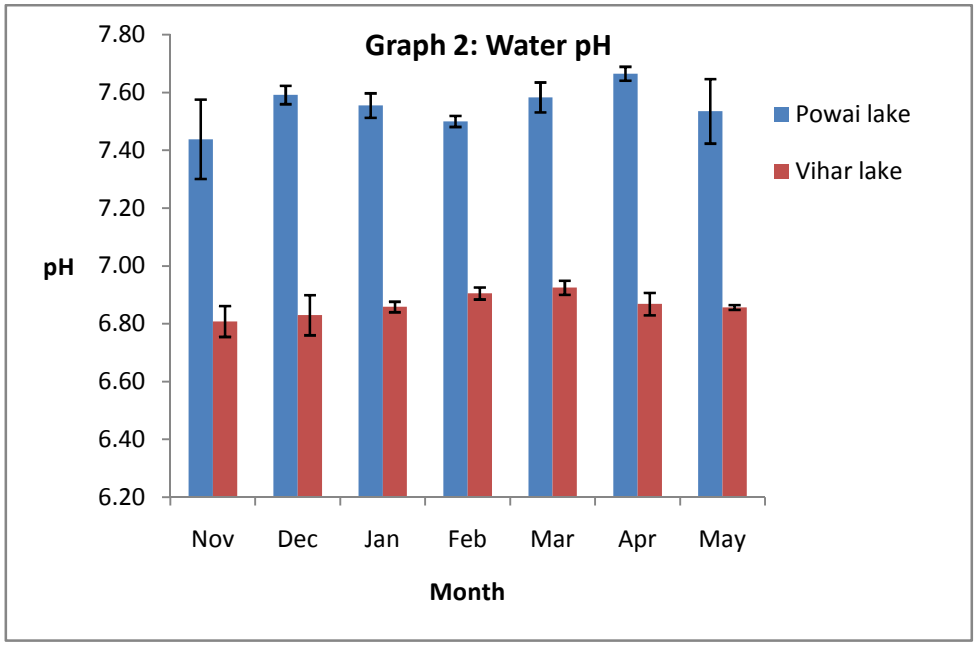
Table 5: Mean BOD (in mg/l) with standard deviations

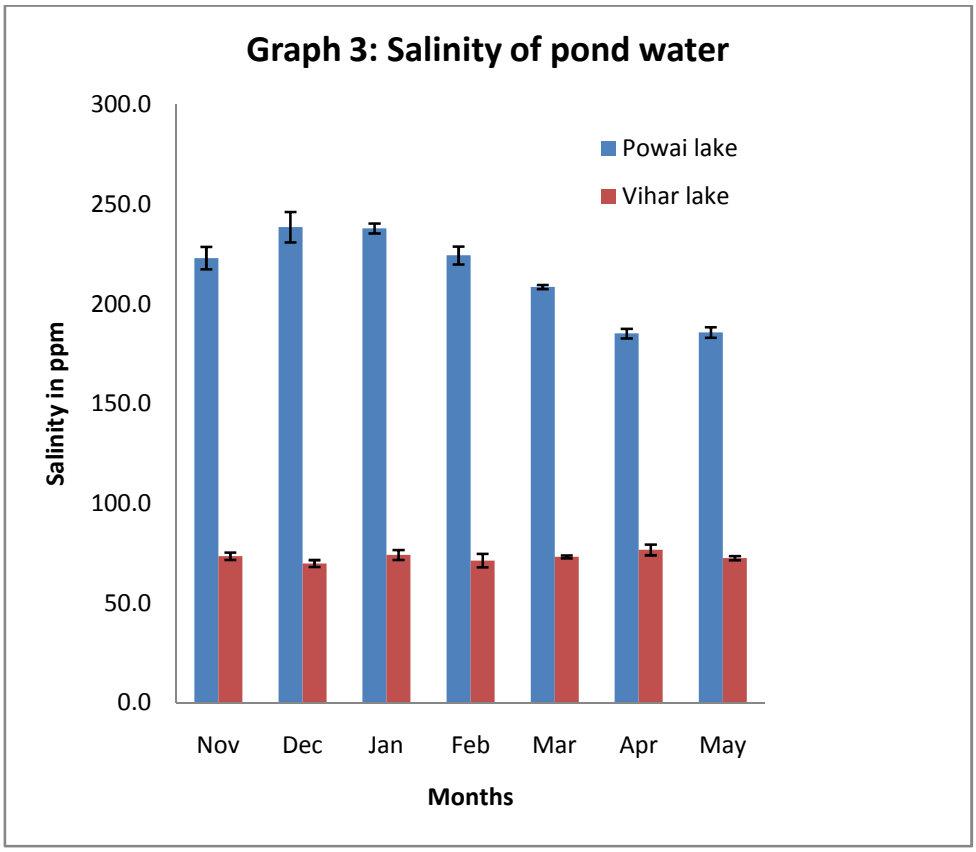
	Nov	Dec	Jan	Feb	Mar	Apr	May
Powai lake	39.5±2.6	41.9±2.7	41.8±3.8	40.2±2.3	43.2±2.7	43.2±2.8	46.4±2.7
Vihar lake	2.4±0.2	2.7±0.1	3.3±0.2	2.3±0.2	3.4±0.3	3.9±0.5	3.7±0.6

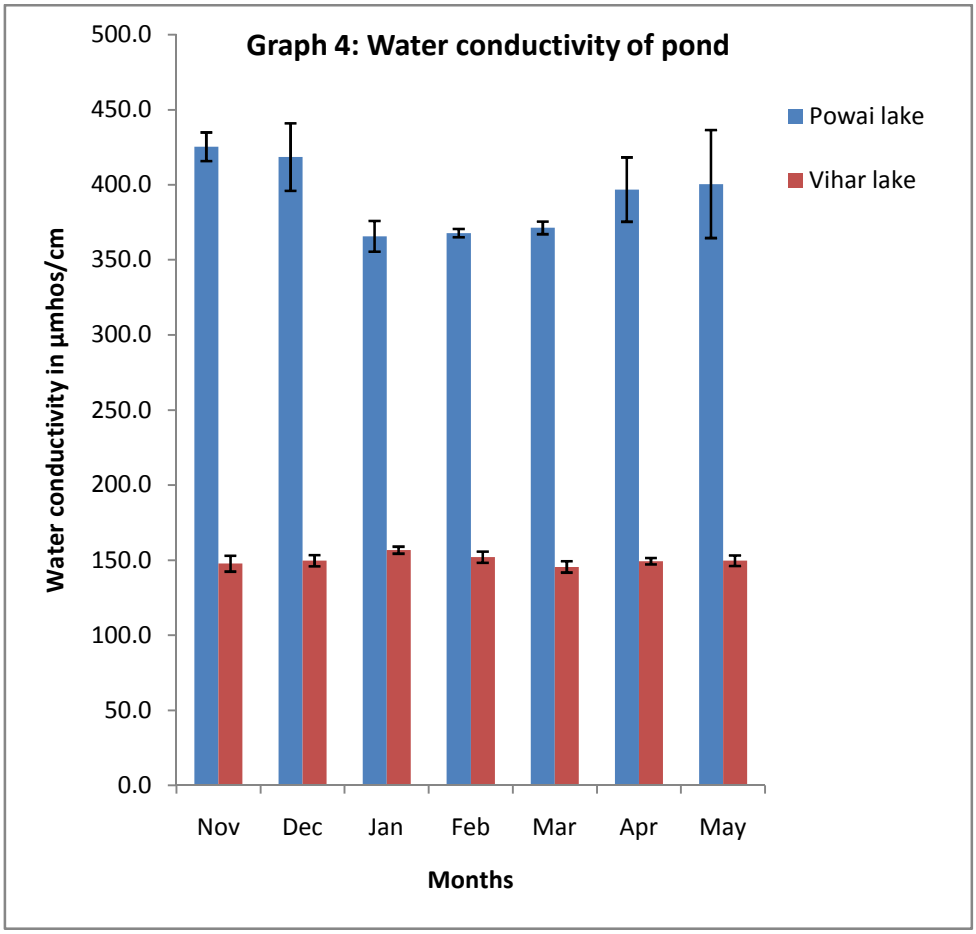
Table 6: Mean COD (in mg/l) with standard deviations

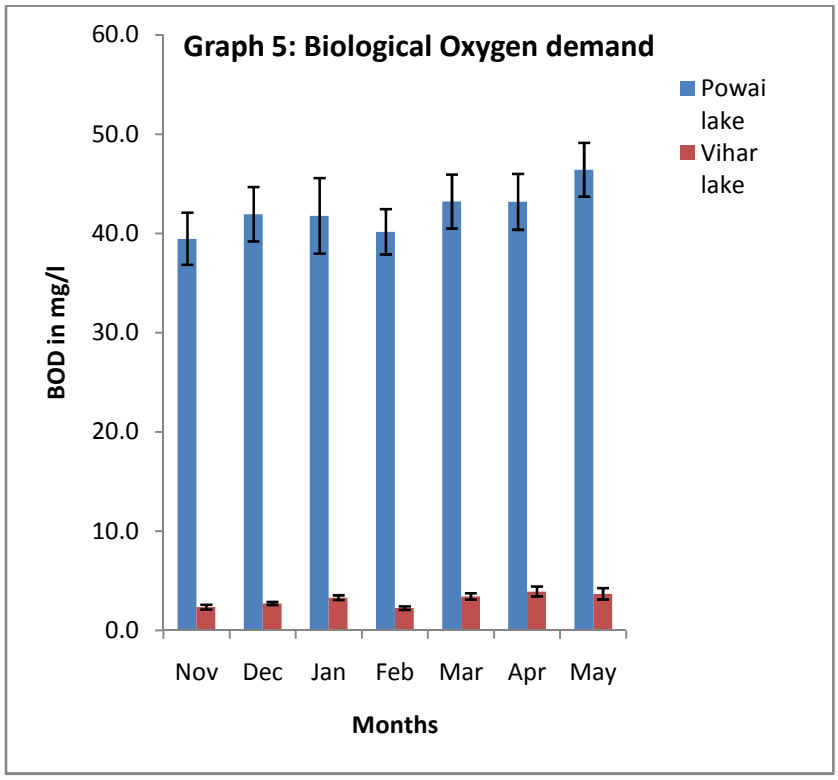
	Nov	Dec	Jan	Feb	Mar	Apr	May
Powai lake	86.8±4.3	82.1±4.5	77.5±2.4	78.7±5.0	82.9±6.5	83.0±5.5	81.7±5.1
Vihar lake	11.7±0.9	14.1±0.9	16.4±1.0	10.6±1.1	15.9±1.4	18.4±1.9	17.8±2.7

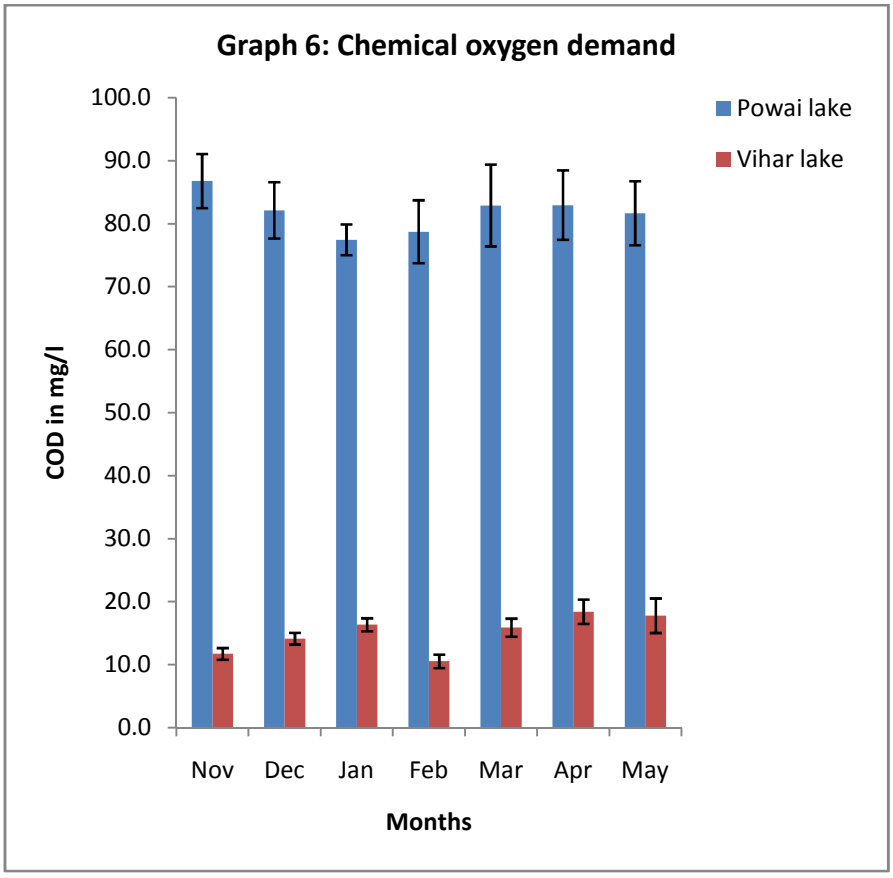

Graph 1: Air and water temperature
Air (Powai lake)
Water (powai lake)
Air (Vihar lake)
Water (Vihar lake)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature in °C
Nov
Dec
Jan
Feb
Mar
Apr
May
Month


Graph 2: Water pH
Powai lake
Vihar lake
7.80
7.60
7.40
7.20
7.00
6.80
6.60
6.40
6.20
pH
Nov
Dec
Jan
Feb
Mar
Apr
May
Month


Graph 3: Salinity of pond water
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Salinity in ppm
Powai lake
Vihar lake
Nov
Dec
Jan
Feb
Mar
Apr
May
Months


Graph 4: Water conductivity of pond
500.0
450.0
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
Water conductivity in µmhos/cm
Powai lake
Vihar lake
Nov
Dec
Jan
Feb
Mar
Apr
May
Months





The zooplanktons were identified from vihar and Powai lakes (table 7 and 8) and their comparative graphical representation is given in graph 7 to 10.

Table 7: List of zooplanktonic species identified from powai lake.(+ sign indicates presence; whereas – sign indicates absence of that species in the sample).

Order	species	Nov	Dec	Jan	Feb	Mar	Apr	May
Rotifers	***Anuraeopsisfissa***	+	-	+	-	-	-	-
	Anuraeopsis sp.	+	+	-	-	+	-	-
	Asplanchnabrightwelli	-	+	-	+	+	+	+
	Brachionusangularis	+	-	+	-	+	-	-
	Brachionuscalyciflorus	+	-	+	-	-	+	+
	Brachionusdiversicornis	-	+	-	-	+	-	-
	Brachionusforficula	-	+	-	+	-	+	-
	Brachionusquadridentata	-	+	-	-	-	-	-
	Filinialongiseta	+	-	-	+	+	+	+
	Keratellacochlearis	+	+	+	+	+	+	+
	Keratellatropica	+	-	+	-	+	-	+
	Lecanelunaris	-	-	-	-	-	-	-
	Testudinella patina	+	-	+	+	-	-	-
	Trichocercasimilis	-	-	-	-	-	-	+
	Trichocerca sp.	-	-	+	+	-	+	-
	TOTAL	**8**	**6**	**7**	**6**	**7**	**6**	**6**
Copepods	***Cyclops sp.***	+	-	+	+	-	-	+
	Cyclops vicinus	-	+	+	+	-	+	+
	Diaptomusnudus	-	+	-	-	+	+	-
	Eucyclops sp.	+	-	+	-	-	+	+
	Heliodiaptomuscontortus	-	-	-	+	-	-	-
	Mesocyclopsleuckarti	-	+	-	+	-	-	+
	Mesocyclops sp.	+	+		+	+	+	-
	Thermocyclopshylinus	+		+		+	+	+
	Thermocyclops sp.		+	+	+	-	-	+
	TOTAL	**4**	**5**	**5**	**6**	**3**	**5**	**6**
Cladocerans	***Alona sp.***	+	+	+	-	+	-	-
	Bosminalongirostris	-	+	-	+	-	+	-

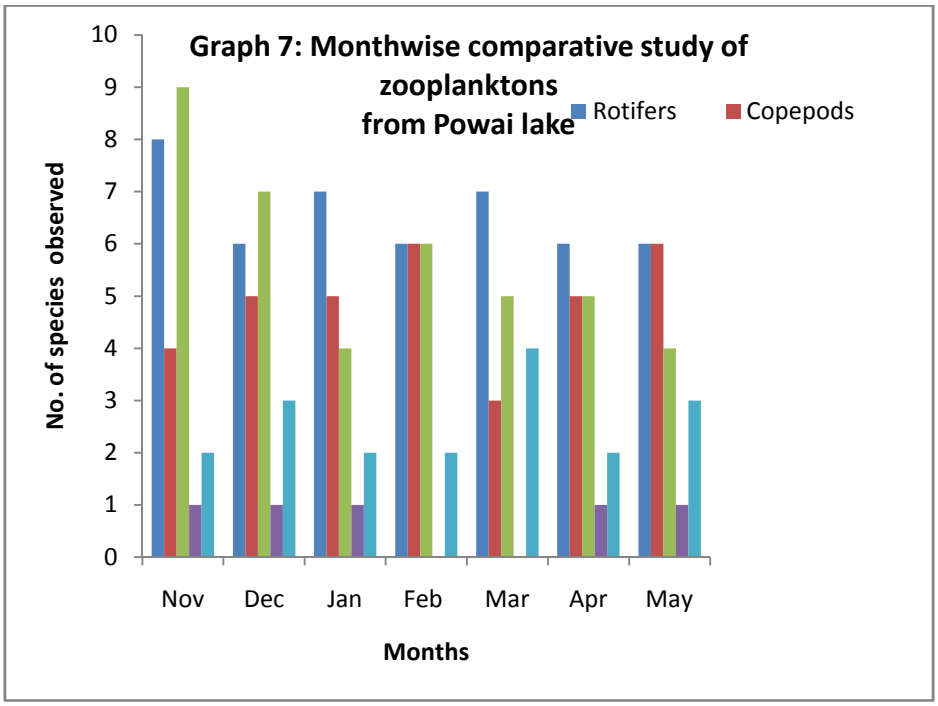
	Chydorussphaericus	+	-	-	-	-	-	-
	Daphnia lumholtzi	+	-	+	-	+	+	+
	Daphnia pulex	-	+	-	-	-	-	-
	Daphnia similis	+	+	+	+	+	-	+
	Diaphanosomaexcisum	+	-	+	+	-	+	-
	Diaphanosoma sp.	+	-	-	-	+	+	-
	Leydigiaacanthocercoids	-	+	-	-	-	-	-
	Macrothrix sp.	-	-	-	+	-	-	+
	Moinabrachiata	-	-	+	-	-	-	-
	Moinamicrura	+	-	-	+	-	+	-
	Pseudochydorusglobosus	+	-	-	-	+	-	-
	Simocephalusexpinosus	-	+	-	+	-	-	+
	Simocephalusvetulus	+	+	-	-	-	-	-
	TOTAL	**9**	**7**	**4**	**6**	**5**	**5**	**4**
Ostracoda	***Eucyprissp***	+	-	+	-	-	+	-
	Stenocyprismalcolmsoni	-	+	-	-	+	-	+
	TOTAL	+	+	+	-	-	+	+
Protozoa	***Arcelladiscoides***	+	-	+	-	+	+	-
	Arcella vulgaris	-	-	-	-	-	-	+
	Astramoebaradiosa	-	+	-	+	+	-	-
	Centropyxisecornis	-	-	-	-	-	+	+
	Centropyxisaculeata	-	+	-	+	-	-	-
	Difflugiarubsence	+	-	+	-	+	-	-
	Paramecium caudatum	-	+	-	-	+	-	+
	TOTAL	**2**	**3**	**2**	**2**	**4**	**2**	**3**

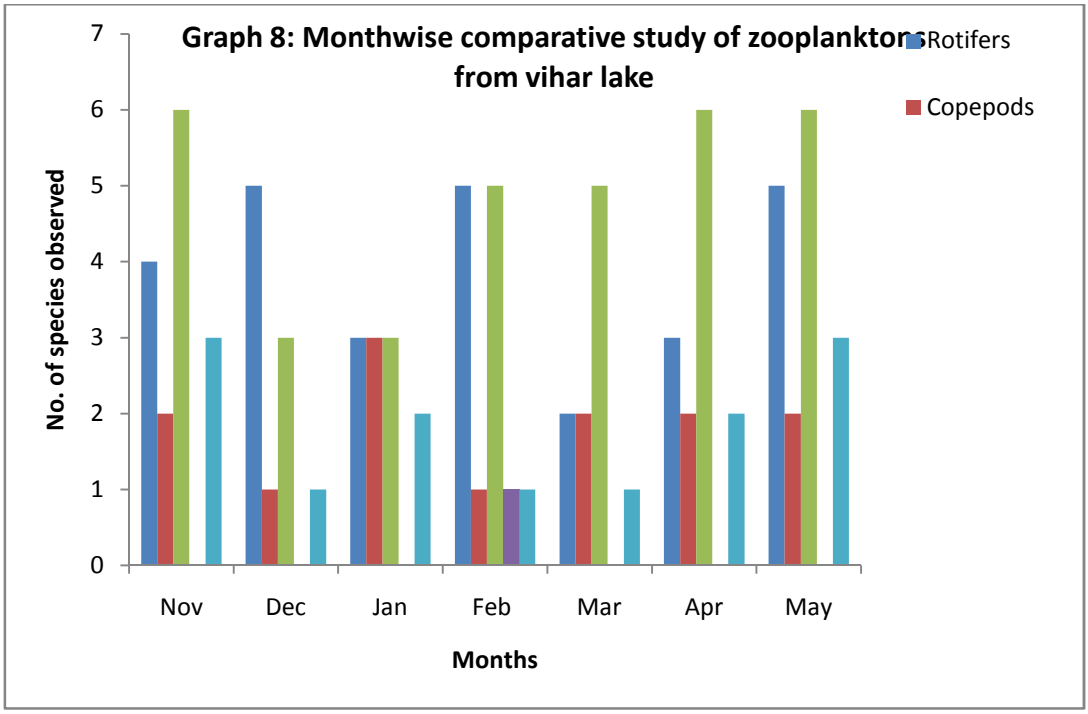
Table 8: List of zooplankton species identified from vihar lake. (+ sign indicates presence; whereas – sign indicates absence of that species in the sample).

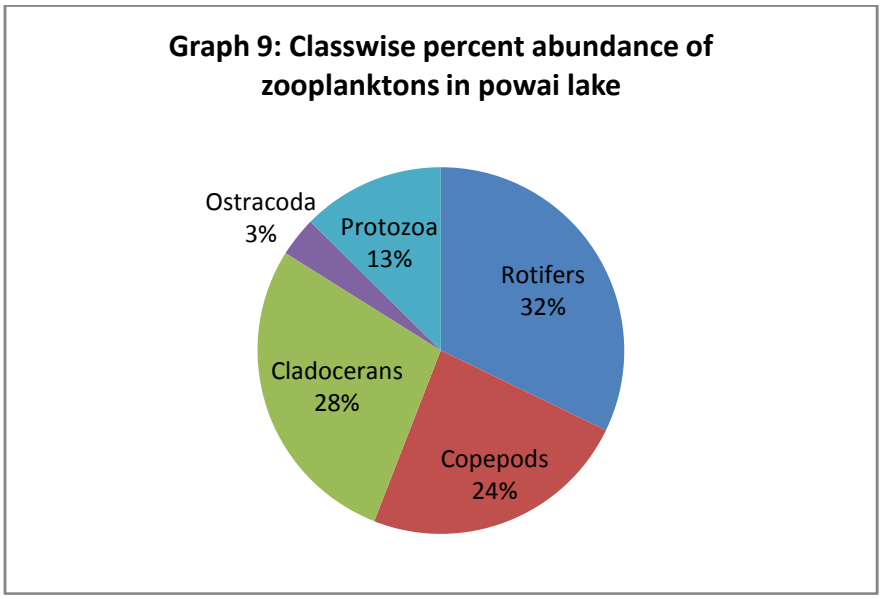
order	species	Nov	Dec	Jan	Feb	Mar	Apr	May
Rotifers	***Anuraeopsisfissa***	+	-	-	-	-	-	-
	Anuraeopsis sp.	-	+	-	+	+	-	+
	Asplanchnabrightwelli	-	-	-	-	-	-	-

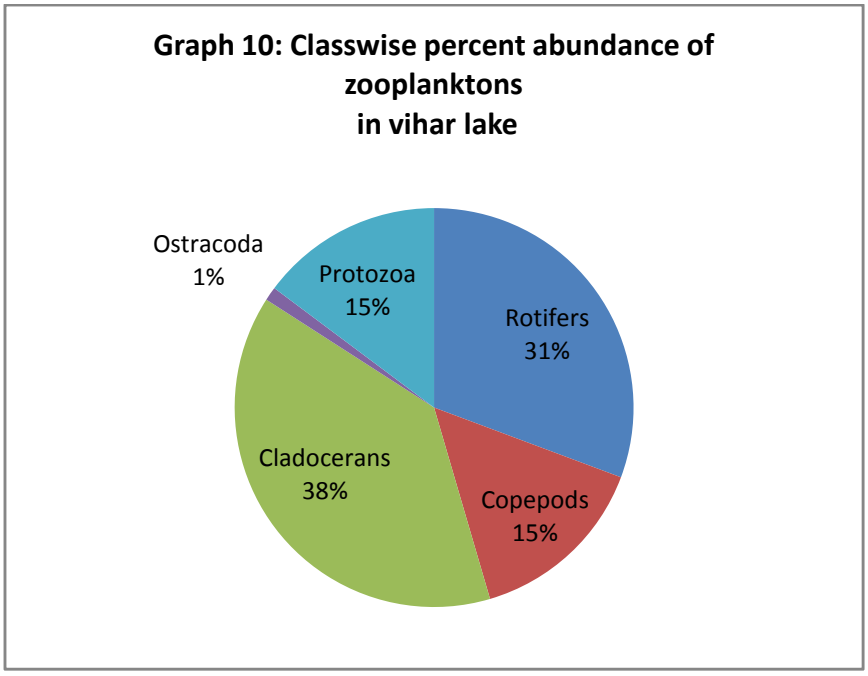
	Brachionusangularis	-	-	+	-	-	+	-
	Brachionuscalyciflorus	-	-	-	+	-	-	+
	Brachionusdiversicornis	+	-	+	-	-	-	-
	Brachionusforficula	-	+	-	-	-	+	-
	Brachionusquadridentata	-	-	-	-	-	-	-
	Filinialongiseta	+	-	-	+	-	+	-
	Keratellacochlearis	-	+	-	-	-	-	-
	Keratellatropica	-	-	-	-	-	-	+
	Lecanelunaris	-	+	-	+	-	-	-
	Testudinella patina	-	-	-	-	-	-	+
	Trichocercasimilis	+	-	+	-	+	-	-
	Trichocerca sp.	-	+	-	+	-	-	+
	TOTAL	**4**	**5**	**3**	**5**	**2**	**3**	**5**
Copepods	***Cyclops sp.***	+	-	+	-	-	-	-
	Cyclops vicinus	-	-	-	-	-	-	+
	Diaptomusnudus	-	-	+	-	-	-	-
	Eucyclops sp.	+	-	-	-	-	-	-
	Heliodiaptomuscontortus	-	-	-	-	+	-	+
	Mesocyclopsleuckarti	-	-	-	+	-	+	-
	Mesocyclops sp.	-	-	+	-	-	-	-
	Thermocyclopshylinus	-	-	-	-	+	-	-
	Thermocyclops sp.	-	+	-	-	-	-	-
	TOTAL	**2**	**+1**	**3**	**+1**	**2**	**2**	**2**
Cladocerans	***Alona sp.***	+	-	-	-	+	-	-
	Bosminalongirostris	-	-	-	+	-	-	+
	Chydorussphaericus	+	+	-	-	-	+	-
	Daphnia lumholtzi	-	-	-	+	-	-	+
	Daphnia pulex	-	-	+	-	+	-	-
	Daphnia similis	+	-	-	-	-	+	-
	Diaphanosomaexcisum	-	-	+	-	+	-	+
	Diaphanosoma sp.	+	-	-	+	-	-	-

	Leydigiaacanthocercoids	-	-	-	-	-	+	+
	Macrothrix sp.	-	-	+	-	+	+	-
	Moinabrachiata	-	+	-	-	-	-	-
	Moinamicrura	+	-	-	-	+	-	+
	Pseudochydorusglobosus	-	-	-	+	-	+	-
	Simocephalusexpinosus	+	-	-	-	-	+	+
	Simocephalusvetulus	-	+	-	+	-	-	-
	TOTAL	**6**	**3**	**3**	**5**	**5**	**6**	**6**
Ostracoda	***Eucyprissp***	-	-	-	-	-	-	-
	Stenocyprismalcolmsoni	-	-	-	+	-	-	-
	TOTAL	**0**	**0**	**0**	**1**	**0**	**0**	**0**
Protozoa	***Arcelladiscoides***	+	-	-	+	-	-	+
	Arcella vulgaris	-	-	-	-	+	-	-
	Astramoebaradiosa	-	+	+	-	-	-	-
	Centropyxisecornis	+	-	-	-	-	+	+
	Centropyxisaculeata	-	-	-	+	-	-	+
	Difflugiarubsence	+	-	-	-	-	+	-
	Paramecium caudatum	-	-	+	-	-	-	-
	TOTAL	**3**	**1**	**2**	**2**	**1**	**2**	**3**


Graph 7: Monthwise comparative study of zooplanktons from Powai lake
Rotifers
Copepods
No. of species observed
0
1
2
3
4
5
6
7
8
9
10
Nov
Dec
Jan
Feb
Mar
Apr
May
Months


Graph 8: Monthwise comparative study of zooplankton from vihar lake
Rotifers
Copepods
No. of species observed
0
1
2
3
4
5
6
7
Nov
Dec
Jan
Feb
Mar
Apr
May
Months





Discussion:

The physico-chemical properties of vihar and Powai lake gave important insights into variation due to seasonal changes affect these parameters. Correlation of these physico-chemical parameters with the number of zooplanktons proves that the zooplankton biodiversity is largely controlled by these parameters. In comparison the air and water temperature of vihar and Powai lake does not vary significantly as these lake are located close to each other. Other water parameter like pH of water shows significant difference in vihar and Powai lake. The water of Powai lake is more alkaline (pH ranging from 7.40 to 7.70) whereas the pH of vihar lake is below 7.00, these both pH falls in normal range.

Salinity of water body is due to presence of chloride salts; as the salinity increases the number of freshwater organisms find it difficult to tolerate it (Jeppesen *et. al.* 2002). The salinity of Powai lake is more than three times to that of vihar lake. Thus high salinity may one of the factor which makes the Powai water more suitable for the survival of zooplanktons.

Water conductivity is determined by the presence of number of ions Na^+, K^+, $HCO3^-$, $Mg2^+$, Cl^- etc. These ions interfere with the survival of zooplanktons (Thirumala *et. al.* 2007). Comparatively the conductivity of Powai lake is more than two fold than vihar lake. Thus the Powai water becomes more suitable for the survival of zooplanktons.

Biological oxygen demand (BOD) and chemical oxygen demand (COD) are interlinked parameters. It is well known that higher the organic waste, higher would be the BOD and COD (Kumar 2001). The COD values comprises of BOD and non-biological oxidisable organic material (Saksena *et. al.* 2008). The ratio of BOD to COD says a lot about the water quality, according to standards of WHO, BOD/COD for fresh water lies below 0.3, whereas as for sewage mixed high organic contaminated water has this ratio >0.3. The comparative analysis of vihar and Powai water shows this phenomenon clearly. The BOD and COD of Powai lake is many times higher than that of vihar lake. This property also makes the Powai water unfit for the survival of zooplanktons.

Zooplanktons are small microscopic organisms, typically 100 to 500 um (microns) in length, with two distinctive features. First, they have a ciliated region at the apical or head end called a corona. This is used for locomotion and for gathering of food particles from the water. In both the water samples, we found the representatives of four classes zooplanktons. Though the number of species found in Powai water are less than the vihar lake.

List of zooplanktons identified from vihar and Powai lake has proved that vihar lake has many more species of zooplanktons due to the good water quality. We believe that, various factors like high values of conductivity, salinity, BOD and COD in Powai water interferes with the survival of zooplanktons.

Conclusion:

Limnology of studied the vihar and Powai lakes gave important insights into the correlation of physico-chemical parameter and zooplankton biodiversity. We believe that, due to high organic content of Powai lake, the low zooplankton biodiversity was seen.

Acknowledgement:

We acknowledge The University of Mumbai for financially supporting this research work under minor research work. We also acknowledge the Hydraulic engineer, MCGM, Varali engineering hub, Varali, Mumbai, for giving us permission to collect water samples from Vihar and Powai lake.

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