



# Zooplankton diversity of freshwater lakes of Chennai, Tamil Nadu with reference to ecosystem attributes

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## ABSTRACT

Zooplankton diversity of twelve water bodies of Chennai with reference to variation during pre-monsoon, monsoon, post-monsoon and summer seasons is investigated and reported. Out of 49 zooplankton species recorded, 27 species belonged to Rotifera, 10 species to Cladocera, 9 species to Copepoda and 3 species to Ostracoda. The Rotifers dominated compared to all other zooplankton groups in all the seasons. However, the diversity of zooplankton varied from season to season and the maximum diversity was recorded in pre-monsoon season while minimum was observed in monsoon season. The common and abundant zooplankton in these water bodies were *Brachionus calyciflorus*, *Brachionus falcatus*, *Brachionus rubens*, *Asplanchna brightwelli* and *Lecane papuana* (Rotifers), *Macrothrix spinosa*, *Ceriodaphnia cornuta*, *Diaphnosoma sarsi* and *Moina micrura* (Cladocerans), *Mesocyclops aspericornis*, *Thermocyclops decipiens* and *Sinodiaptomus (Rhinediaptomus) indicus* (Copepods) and *Stenocypris major* (Ostracod). The density of the zooplankton was high during pre-monsoon and post-monsoon period than monsoon and summer seasons. Ecological indices for zooplankton of twelve water bodies showed variation with regard to dominance, diversity and evenness in different lakes and different seasons. Results of present study indicated lower diversity and density of zooplankton compared to previous reports which indicate decline of their ecological attributes.

**Key Words:** Freshwater, biodiversity, zooplankton, lakes

## INTRODUCTION

The phytoplankton and zooplankton constitute primary producers and primary consumers of the aquatic ecosystem, respectively and play a vital role in determining the productivity of the water bodies. The diversity of plankton, apart from contributing towards the sustenance of the ecosystem attributes also serves as indicators of water quality and pollution. Considering the important role the zooplankton play in the aquatic ecosystem, there are many recent reports on the diversity and seasonal

distribution of this group (Sharma and Uchchariya, 2018; Adhikari et.al., 2017; Rao 2017; Sharmila and Shameem, 2017; Sinha and Singh 2016; Pawar 2016; Das and Kar ,2016; Manickam et. al., 2015).

In Chennai, water from the lakes and wetland constitute bulk of the city water supply system. They control urban flooding by storing large quantities of storm water runoff. Further, they support biodiversity by providing habitats/ nursery grounds for the juveniles of aquatic and semi-aquatic organisms. These water bodies are also rich in aquatic floral vegetation that maintains the micro environment necessary for the inhabitation of the fauna (Altaff *et. al.*, 2016). Review of literature on the zooplankton diversity of freshwater bodies in and around Chennai city reveals that there is no published report on this subject in recent time and also considering the importance of study of plankton from environmental monitoring point of view, the present study aims to update the list of zooplankton species and their seasonal variation in the fresh water bodies in and around Chennai city.

## MATERIALS AND METHODS

Studies on diversity of zooplankton of 12 freshwater bodies (Chetpet Lake, Padi Lake, Kilkattalai Lake, Narayanapuram Lake, Velachery Lake, Madhavaram Lake, Chembarambakkam Lake, Puzhal Lake, Porur Lake-I, Porur Lake-II, Retteri Lake and Pallikaranai Wetland) in and around Chennai (13.0827° N, 80.2707° E) have been conducted from July 2014 to June 2015. The lakes and wetland investigated for zooplankton diversity situated within 50 km of Chennai city are described earlier by Altaff et al (2016). Zooplankton diversity and density was investigated to record variation during pre-monsoon (July- September), monsoon (October- December), post-monsoon (January- March) and summer (April-June) seasons. Zooplankton samples were collected from these water bodies on 4<sup>th</sup> and 5<sup>th</sup> September 2014 for pre-monsoon, on 14<sup>th</sup> and 15<sup>th</sup> November 2014 for monsoon, 15<sup>th</sup> and 16<sup>th</sup> February 2015 for post-monsoon and 26<sup>th</sup> and 27<sup>th</sup> May 2015 for summer season. Zooplankton samples were collected from the water bodies by towing plankton net made up of bolten silk with a mesh size of 100 µm from surface water to 3 ft. depth and preserved in 5% formalin (Goswami 2004). Diversity of zooplankton was studied following the taxonomic key characters described in the standard literature (Edmondson, 1959; Michael,

1973; Battish, 1992; Dussart and Defaye, 1995; Dhanapathi, 2000). For quantitative analysis 100 l of water from the water bodies was filtered through the zooplankton net and preserved in 5% formalin and different groups were enumerated using Sedgwick-Rafter chamber and number of individuals per liter (ind/l) was calculated. Zooplankton ecological indices i.e. index of diversity; dominance and evenness were calculated applying the method of Shannon and Weaver (1949), Simpson (1949) and Pielou (1966), respectively. The data was statistically analyzed by SPSS 10.0 and Statistica 6.0.

## RESULTS

### Diversity of Zooplankton

A total 49 zooplankton species were recorded during the present study. Out of 49 species, 27 species belonged to Rotifera, 10 species to Cladocera, 9 species to Copepoda and 3 species to Ostracoda. Class Rotifera was dominated among all the zooplankton groups in all the seasons. However, the diversity of zooplankton varied from season to season and the maximum diversity was recorded in pre-monsoon season while minimum was observed in monsoon season (Table 1). During pre-monsoon period maximum contribution was made by class Rotifera and minimum was by Ostracoda. Class Rotifera contributed 63% of species while Class Cladocera and Copepoda contributed 15% of species each and Ostracoda only 7% species during pre-monsoon season. During monsoon period over all percentage of zooplankton species of different group contributed was Class Rotifera 64%, Cladocera 12%, Copepoda 15% and Ostracoda 8%. During post-monsoon period over all percentage of zooplankton species of different group contributed were Class Rotifera 56%, Cladocera 21%, Copepoda 14% and Ostracoda 9%. During summer period over all percentage of zooplankton species of different group contributed was Class Rotifera 60%, Cladocera 15%, Copepoda 17% and Ostracoda 8%. The overall percentage contribution species of different groups of zooplankton from twelve water bodies in all the four seasons was Class Rotifera 61%, Cladocera 16%, Copepoda 15% and Ostracoda 8%.

On the basis of qualitative study during pre-monsoon period, among the rotifers, *Brachionus rubens*, *Brachionus calyciflorus*, *Brachionus falcatus*, *Brachionus ureceolaris*, *Brachionus angularis*, *Asplanchna brightwelli*, *Lecane papuana* and *Lepadella acuminata*

were the most common species. During this period *Macrothrix spinosa*, *Ceriodaphnia cornuta* and *Diaphnosoma sarsi* were the common cladoceran species. All the four cyclopoid copepods, viz. *Mesocyclops aspericornis*, *Mesocyclops thermocyclopoides*, *Thermocyclops decipiens* and *Thermocyclops hyalinus* occurred commonly while *Cypris protubera* and *Stenocypris major* were common ostracods. During monsoon period, among the rotifers, *Brachionus calyciflorus*, *Brachionus falcatus*, and *Asplanchna brightwelli*, were the most common species. During this period *Ceriodaphnia cornuta* and *Moina micrura* were the common cladoceran species. Among copepods *Mesocyclops aspericornis*, *Mesocyclops thermocyclopoides*, and *Thermocyclops decipiens* occurred commonly while *Cypris protubera* was the common ostracod. During post-monsoon period, among the rotifers, *Brachionus calyciflorus* and *Brachionus durgae* were the most common species. During this period *Moina macrocoba*, *Macrothrix spinosa* and *Ilyocryptus spinifer* were the common cladoceran species. Among copepods *Mesocyclops aspericornis* and *Mesocyclops thermocyclopoides*, occurred commonly while *Stenocypris major* was the common ostracod. During summer period, among the rotifers, *Brachionus calyciflorus* was the most common species. During this period *Moina micrura* and *Ceriodaphnia cornuta* were the common cladoceran species. Among copepods *Mesocyclops aspericornis*, *Mesocyclops thermocyclopoides* and *Thermocyclops decipiens* occurred commonly while *Cypris protubera* was the common ostracod.

In all seasons, among the rotifers *Brachionus calyciflorus*, *Brachionus falcatus*, *Brachionus rubens*, *Asplanchna brightwelli* and *Lecane papuana* were the dominant species. *Macrothrix spinosa*, *Ceriodaphnia cornuta*, *Diaphnosoma sarsi* and *Moina micrura* were dominant among Cladocera. *Mesocyclops aspericornis* and *Thermocyclops decipiens* and *Sinodiaptomus (Rhinediaptomus) indicus* were recorded during all the seasons among Copepoda and only one species of class Ostracoda namely *Stenocypris major* was found throughout the study period.

With regard to station wise diversity of zooplankton, in pre-monsoon season it ranged between 25 and 33 species and maximum diversity was recorded in Narayanapuram Lake while minimum was recorded in Kilkattalai, Puzal and porur-II Lakes. In monsoon season diversity of zooplankton ranged between 17

and 28 species and maximum diversity was recorded in Narayanapuram Lake while minimum was recorded in porur-I Lake. In post-monsoon season diversity of zooplankton ranged between 18 and 30 species and maximum diversity was recorded in Narayanapuram Lake while minimum diversity was recorded in Kilkattalai and Puzhal Lakes. In summer season diversity of zooplankton ranged between 19 and 24 species and maximum diversity was recorded in Pallikaranai wetland while minimum was recorded in Madhavaram and Chembarambakkam Lakes.

### Density of Zooplankton

The mean density of zooplankton of 12 water bodies of Chennai during pre-monsoon ranged between 66.30 ind/ l to 317.66 ind/l. During this season minimum density was recorded at Chembarambakkam Lake while maximum density was recorded at Kilkattalai Lake. The density of zooplankton during monsoon period ranged between 29.30 ind/ l to 135.98 ind/l. During this season minimum density was recorded at Chembarambakkam Lake while maximum density was recorded at Chetpet Lake. The density of zooplankton during post-monsoon period ranged between 37.66 ind/ l to 415.65 ind/l. During this season minimum density was recorded at Kilkattalai Lake while maximum density was recorded at Padi Lake. The density of zooplankton during summer period ranged between 31.30 ind/ l to 191.31 ind/l. During this season minimum density was recorded at Chembarambakkam Lake, while maximum density was recorded at Madhavaram Lake (Table 2). In general it is observed that the density of the plankton was high during pre-monsoon and post-monsoon period than during monsoon and summer seasons. However, comparatively lower density of zooplankton was recorded during monsoon than summer season. Even though in majority of the lake investigated in the present study rotifers, cladocerans and cyclopoid copepods were major contributing groups towards zooplankton density, the naupliar and copepodids stages of copepod also occurred in significant numbers.

In the case of Chetpet lake nauplii and copepodids of copepods showed predominance in all the four seasons. Cladocerans and ostracods also recorded in higher density. In Padi lake very high density of ostracods (349 ind./l) was recorded during post monsoon period and rotifers occurred in high numbers (160 ind./l) during pre-monsoon period.

**Table 1. Diversity of Zooplankton of twelve water bodies of Chennai during all the seasons (July 2014-June 2015)**

Zooplankton	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10	St. 11	St. 12
<b>Rotifers</b>												
<i>Brachionus rubens</i>	△☆○	△●○	△●☆	△☆○	●	△●	●☆	△☆	△●	△○	△●	△
<i>Brachionus calyciflorus</i>	△●☆○	△●☆○	△☆○	△●☆○	△●☆○	△●☆○	△●☆○	●☆	△●○	●☆	△●☆○	△●○
<i>Brachionus diversicornis</i>	△●☆○	△☆	△●○	●	△☆	●	●☆	△●○	△☆○	△○	△●	☆
<i>Brachionus falcatus</i>	△☆	△○	△●	△●☆○	△○	△☆	△●☆○	△☆○	●☆	△●○	△○	△●☆○
<i>Brachionus quadridentatus</i>		△☆○	●☆	△○	△●☆○	△●☆○	△●○	●	△○	△	●☆	☆○
<i>Brachionus caudatus</i>	△●☆○	●☆	△○	△●☆		△☆○	●	△●○	☆	●☆	△○	●☆
<i>Brachionus ureceolaris</i>	△○	△●☆	△☆○	△●☆○	△☆○	●	△☆○	△☆	△●○	●	△☆○	△●○
<i>Brachionus angularis</i>	△●☆○	△		△●☆○	△●☆	△●☆○	△●	△●○	△☆	△☆○	●☆	●○
<i>Brachionus bidentata</i>	△☆		△☆○	●	△●○	☆	△●☆○	☆	△○	△●	△○	△●☆
<i>Brachionus plicatilis</i>	●☆	△●☆○	△○	●☆	△●☆○	△○		△●○		△●☆○	△☆○	
<i>Brachionus farficula</i>	△●○	△☆○	●☆	△○	△○	△●☆	△☆	●	△●☆○	△○	●☆	△●○
<i>Brachionus durgae</i>	☆	△●	☆	△●☆○	●☆	△○	△●☆○	△☆		△●☆	△●○	△☆○
<i>Asplanchna brightwelli</i>	△☆	△●☆○	△○	△●☆	△	△●☆		△○	△●☆○		△●☆○	☆○
<i>Asplanchna sieboldi</i>	△●☆	●	△☆	△○	△●○	●☆	△●○	●☆	△		●☆	△○
<i>Asplanchnopus bhimavaramensis</i>		△	☆	△●	●☆	△○	●☆	△●○	△○	△●☆○	△○	●☆
<i>Keratella cochlearis</i>	△●○	△●☆○	●	△☆○	△○	●☆	△●☆○			△○	☆	△☆○
<i>Keratella procurva</i>	●☆	△	△○	●☆	△●☆	△☆○	●☆	△●☆○	△●	△	●☆	△○
<i>Keratella tropica</i>	△☆○	●☆	△☆	●	△○	△●☆○	△	△○		●☆	△	△●☆○
<i>Lecane papuana</i>	△●○	△●○	△●○	△●☆○	●☆	△●	●	△●☆	●☆	△●○	△●○	△●☆
<i>Lecane (Monostyla) bulla</i>	△●○	☆	△●○	△☆○	△●☆○	☆	△☆○	△●○	△●○	●	△●☆○	△☆
<i>Lecane (Monostyla) hamata</i>	☆	△●○	△☆	△●○	△●○	△●○	△●○	☆	△	△●○	☆	△☆○
<i>Filinia longiseta</i>	△●☆○	△☆○	●	△●☆	△○	△●☆○		●	△●☆	☆	△●○	●
<i>Filinia terminalis</i>	△○	△●☆	△●○	●	△●☆	△	△●☆○	△○	☆	△●○	△☆	☆
<i>Platylas quadricornis</i>	△●☆○	△○	●☆○	△☆○	△●○	△●☆○	○	△●○	●☆○	△●☆○	☆○	△●○
<i>Epiphones clavulata</i>	△☆○	●☆	△○	●	△☆	☆	△●	△○	△○	☆	△●○	△●☆
<i>Lepadella acuminata</i>		△	△●☆○	△●	△○	△●☆	△☆	☆	△	●☆	△○	△☆○
<i>Lepadella patella</i>	△	△●☆○		△☆○	●☆	△●○	△●☆○			●☆	●	☆

Zooplankton diversity of freshwater lakes of Chennai, Tamil Nadu with reference to ecosystem attributes.

<b>Cladocerans</b>												
<i>Diaphanosoma sarsi</i>	△●☆	△○	△●	●☆	△☆○	☆	△●○	○	☆	△	☆	△
<i>Diaphanosoma excisum</i>	☆	△●☆	●	●☆	△●☆○	○	△		☆	△○	●☆	△☆○
<i>Ceriodaphnia cornuta</i>	△●○	☆	△○	△☆○	△●☆		●☆○	☆	△●○		△●○	△☆○
<i>Moina micrura</i>	△●☆○	△●☆○	☆○		△●	☆○	☆		☆○	△●	●☆○	△●☆○
<i>Moina macrocopa</i>		☆		△☆	●☆	☆	☆	△●○	☆		△☆○	△☆
<i>Simocephalus vetuloides</i>			☆	△☆○	●		●☆		△	☆	△	△☆○
<i>Macrothrix spinosa</i>	△☆	☆	●	△☆	△☆○	△●☆○	△○	△●☆○	△○	△☆	△☆	△
<i>Ilyocryptus spinifer</i>	△☆	☆		△●☆		△●☆○	△☆		☆	☆○	☆	○
<i>Pleuroxus aduncus</i>	△	☆		●☆	△○		☆	○				△●☆○
<i>Alona quadrangularis</i>	☆	△●○		△○	△		△☆○				☆	
<b>Calanoid copepods</b>												
<i>Heliodiaptomus viduus</i>			○	△☆		△○	☆	△○			●	
<i>Sinodiaptomus indicus</i>				△●☆○		△○	△●☆○	△○	△●○	●○	△○	
<i>Allodiaptomus raoi</i>				●		○	○	△	○	△☆	△●☆○	
<i>Neodiaptomus schmakeri</i>			○	△●		☆	●	○	△		△☆○	●
<b>Cyclopoid copepods</b>												
<i>Mesocyclops aspericornis</i>	△●☆○	△☆○	△●☆○	△●☆○	△●☆	△●☆	●	△●☆○	△●○	△☆○	△●☆○	△●○
<i>Mesocyclops thermocyclopoides</i>	●☆○	△●☆	△●☆	△☆○	△●☆○	△●☆○	△●☆○	●☆	△●☆○	●☆	△●☆	△●☆○
<i>Thermocyclops decipiens</i>	△●○	△●☆○	△☆	△●☆○	△●☆○	△●☆	△●○	△●○	△☆○	△●○	△●☆○	☆
<i>Thermocyclops hyalinus</i>	△○	●	△○	△●☆○	△		△☆	☆	△☆○	△☆○		△●☆
<b>Harpacticoid copepods</b>												
<i>Cletocamptus albuquerquensis</i>												△○
<b>Ostracods</b>												
<i>Cypris protubera</i>	△●☆	△●☆○	○	●☆	△●☆	☆	△●☆○		△●☆○	△●☆○	△☆	△●☆○
<i>Stenocypris major</i>	△●	△●☆○	●○		△●☆○	△☆○	△	☆○	△☆○	△☆	△●☆○	●☆○
<i>Cyprinotus nudus</i>	☆	●☆○	△○	☆	△●	△		●○	△●☆	☆	●	△●☆○

Note: (△- Pre monsoon), (●- Monsoon), (☆- Post- monsoon), (○- Summer)

1. Chetpet Lake, 2. Padi Lake, 3. Kilkattalai Lake, 4. Narayanapuram Lake, 5. Velachery Lake, 6. Madhavaram Lake, 7. Chembarambakkam Lake, 8. Puzhal Lake, 9. Porur Lake-I, 10. Porur Lake-II, 11. Retteri Lake 12. Pallikaranai Wetland.

**Table 2. Density of Zooplankton of twelve water bodies of Chennai during all the seasons (July 2014-June 2015)**

Zooplankton	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10	St. 11	St. 12
<b>Pre-monsoon</b>												
Rotifers	23.33 ±0.88	160.00 ±20.30	83.66 ±5.84	21.33 ±1.45	15.33 ±0.88	166.33 ±2.40	32.00 ±5.03	24.00 ±1.52	38.66 ±3.84	24.33 ±1.85	24.66 ±3.84	34.66 ±0.33
Cladocerans	6.33 ±0.66	3.00 ±0.57	2.66 ±0.33	6.33 ±1.20	12.33 ±0.33	14.00 ±1.15	12.66 ±1.20	4.66 ±0.88	2.33 ±0.33	4.00 ±0.57	6.66 ±1.45	13.66 ±0.66
Ostracods	2.67 ±0.88	41.00 ±3.51	2.33 ±0.88	-	13.66 ±0.66	4.00 ±0.57	1.33 ±0.33	-	4.66 ±0.88	7.33 ±0.88	3.33 ±1.20	1.00 ±0.00
Nauplii & Copepodids	54.33 ±0.88	40.66 ±2.33	189.0 ±0.00	27.00 ±3.21	107.33 ±10.71	16.67 ±2.60	12.67 ±0.88	29.00 ±3.60	21.66 ±1.76	5.33 ±0.88	16.33 ±1.45	18.00 ±2.64
Calanoids	-	-	-	25.67 ±3.52	-	7.33 ±0.66	-	-	8.00 ±0.57	-	13.00 ±0.57	-
Cyclopoids	10.66 ±0.88	11.33 ±1.20	38.33 ±2.66	14.67 ±1.85	25.67 ±2.02	10.00 ±2.15	6.33 ±1.76	11.00 ±1.73	-	13.33 ±2.33	-	18.00 ±1.73
Harpacticoids	-	-	-	-	-	1.00 ±0.00	-	7.33 ±1.20	-	-	-	-
Mysids	-	-	-	-	-	-	-	-	14.00 ±1.15	13.66 ±0.88	-	-
Others	1.00 ±0.00	7.00 ±2.08	1.66 ±0.33	2.67 ±0.33	1.00 ±0	-	1.33 ±0.33	-	1.00 ±0.00	-	-	-
<b>Total</b>	<b>98.32 ±4.18</b>	<b>262.99 ±29.99</b>	<b>317.66 ±23.92</b>	<b>97.66 ±11.58</b>	<b>175.33 ±14.62</b>	<b>219 ±9.92</b>	<b>66.3 ±9.54</b>	<b>76 ±8.94</b>	<b>90.3 ±8.55</b>	<b>68 ±7.41</b>	<b>74.3 ±9.41</b>	<b>85.3 ±5.37</b>

Table Continue....

<b>Monsoon</b>												
Rotifers	14.67 ±2.02	30 ±0.57	13.33 ±1.20	20.33 ±2.72	15.33 ±1.20	31.33 ±3.84	20.66 ±1.45	12.66 ±0.88	13.66 ±1.76	12.00 ±0.57	15.00 ±1.00	1.33 ±0.33
Cladocerans	43.66 ±2.60	1.33 ±0.33	7.00 ±0.57	12.33 ±0.88	6.66 ±0.88	3.66 ±0.88	2.66 ±0.33	3.66 ±0.66	-	-	10.66 ±0.88	-
Ostracods	29.66 ±2.90	6.66 ±0.66	2.00 ±0.57	-	13.33 ±1.20	6.33 ±0.33	-	1.00 ±0.00	6.33 ±0.33	-	4.00 ±0.57	18.33 ±2.40
Nauplii & Copepodids	21.66 ±4.33	1.00 ±0.00	8.00 ±1.00	50.00 ±3.21	25.33 ±0.88	18.33 ±1.45	-	12 ±1.52	15.66 ±2.90	11.66 ±1.20	12.33 ±0.33	33.66 ±4.33
Calanoids	-	-	12.00 ±0.57	25.33 ±4.25	-	-	-	-	-	5.00 ±0.57	6.33 ±0.33	4.33 ±0.66
Cyclopoids	22.33 ±4.70	-	1.00 ±0.00	12 ±2.08	17.00 ±0.57	14.33 ±1.45	6 ±0.57	3.66 ±0.88	8.00 ±0.57	-	6.66 ±1.20	6.33 ±0.88
Harpacticoids	-	-	-	-	-	-	-	-	-	-	-	1.33 ±0.33
Mysids	-	-	-	-	-	-	-	-	-	5.66 ±0.66	-	-
Others	4.00 ±0.00	1.00 ±0.00	3.00 ±1.15	3.33 ±0.66	1.00 ±0.00	3.66 ±1.20	-	-	1.66 ±0.33	1.33 ±0.33	1.00 ±0.00	1.00 ±0.00
<b>Total</b>	<b>135.98</b> <b>±16.55</b>	<b>39.99</b> <b>±1.56</b>	<b>46.33</b> <b>±5.08</b>	<b>123.33</b> <b>±13.82</b>	<b>78.66</b> <b>±4.74</b>	<b>77.7</b> <b>±9.16</b>	<b>29.3</b> <b>±2.36</b>	<b>33</b> <b>±3.95</b>	<b>45.3</b> <b>±5.91</b>	<b>35.7</b> <b>±3.35</b>	<b>56</b> <b>±4.32</b>	<b>66.3</b> <b>±8.95</b>

Table Continue....

Zooplankton	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9	St. 10	St. 11	St. 12
<b>Post-monsoon</b>												
Rotifers	21.00±2.8 8	47.00±5.8 5	14.00±1.52	27.00±2. 64	18.66±1.4 5	50.00±4. 72	2.66±0.6 6	17.00± 1.15	23.66±2. 18	7.00±1. 15	36.66±2. 60	38.33±4. 91
Cladocerans	4.00±1.15	6.66±1.20	-	12.33±0. 88	12.66±1.2 0	13.66±1. 20	5.33±1.2 0	9.66±0. 66	9.00±1.1 5	3.33±0. 88	12.66±1. 20	31.33±1 0.98
Ostracods	1.00±0.00	349.00±6. 80	1.00±0.00	1.00±0.0 0	7.33±0.88	-	-	1.00±0. 00	7.00±1.1 52	5.00±1. 15	8.00±0.5 7	13.66±1. 33
Nauplii & Copepodids	36.67±3.1 7	5.33±1.45	13.00±1.00	23.33±1. 45	17.33±4.3 7	27.00±1. 76	16.66±3. 17	25.33± 2.02	11.66±1. 20	22.33± 1.20	2.00±0.0 0	12.66±1. 20
Calanoids	-	-	-	34.33±3. 75	-	7.33±0.8 8	20.33±1. 76	-	--	-	11.66±0. 33	1.00±0.0 0
Cyclopoids	13.67±1.4 5	6.33±0.33	7.00±1.15	46.33±3. 52	47.66±2.4 0	16.33±3. 52	11.00±1. 00	4.66±0. 88	5.33±0.3 3	-	18.33±2. 40	12.66±0. 66
Harpacticoids	-	-	-	-	-	1.00±0.0 0	1.00±0.0 0	1.33±0. 33	-	1.00±0. 00	-	13.33±0. 88
Mysids	-	-	-	-	-	1.33±0.3 3	1.00±0.0 0	-	-	9.00±1. 15	-	-
Others	7.33±0.88	1.33±0.33	2.67±0.33	6.00±1.1 5	5.66±0.88	-	-	-	1.00±0.0 0	2.33±0. 33	-	1.00±0.0 0
<b>Total</b>	<b>83.37±9. 53</b>	415.65±1 5.96	37.66±4.01	150.33±1 3.41	109.33±11 .19	117±12.4 3	58±7.81	59±5.0 6	57.7±6.0 3	50±5.8 8	89.3±7.1 1	124±19. 98
<b>Summer</b>												
Rotifers	6.00±0.57	15.00±1.1 5	16.00±1.52	15.00±2. 08	10.33±1.7 6	157.67±2 5.43	15.66±3. 17	15.00± 0.57	10.66±1. 45	22.00± 0.57	44.66±1. 20	81±1.73
Cladocerans	1.33±0.33	1.00±0.00	18.33±1.45	15.00±3. 51	6.67±1.20	3.33±0.3 3	1.00±0.0 0	3.66±0. 66	-	1.33±0. 33	7.66±0.6 6	22.33±0. 66
Ostracods	-	63.00±3.1 7	1.00±0.00	23±4.35	1.33±0.33	88	0	2.66±0. 88	4.00±0.5 7	1.00±0. 00	-	23.00±1. 15
Nauplii & Copepodids	68.00±9.8 6	-	8.00±2.51	23±4.35	14.67±0.3 3	2.33±0.6 6	1.00±0.0 0	1.33±0. 33	4.00±0.5 7	16.00± 2.30	-	7.67±1.4 5



Calanoids	-	-	11.66±0.66	8.66±1.4	5	1.33±0.3	4.00±0.5	1.33±0.	1.00±0.0	11.00±	17.66±1.	-
Cyclopoids	28.33±1.4	3.66±0.66	2.67±0.88	34.67±1.	8.00±2.08	1.33±0.	8.67±1.4	7.33±0.	13.00±1.	14.00±	10.00±1.	11.33±0.
Harpacticoids	-	-	-	2.33±0.3	5.50±0.33	3	1.00±33	-	-	-	1.00±0.0	-
Mysids	-	-	-	4.33±0.8	-	1.33±0.3	-	-	-	-	-	-
Others	-	1.00±0.00	3.33±1.20	-	1.33±0.33	46	-	00	-	57	3	0
<b>Total</b>	<b>103.66±</b>	<b>83.66±4.9</b>	<b>61±8.24</b>	<b>126±18.1</b>	<b>47.66±6.3</b>	<b>191±31.7</b>	<b>31.3±5.2</b>	<b>32.3±3.</b>	<b>32.7±3.6</b>	<b>67.3±7.</b>	<b>82.3±5.4</b>	<b>146.3±5.</b>
	<b>12.21</b>	<b>8</b>	<b>61±8.24</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>1</b>	<b>67</b>	<b>0</b>	<b>59</b>	<b>9</b>	<b>33</b>

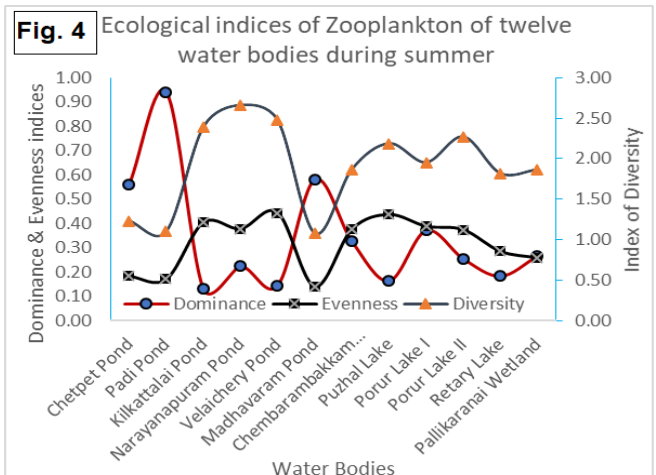
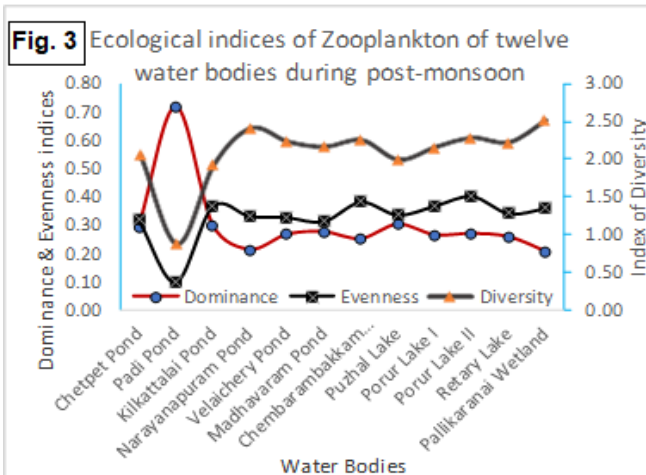
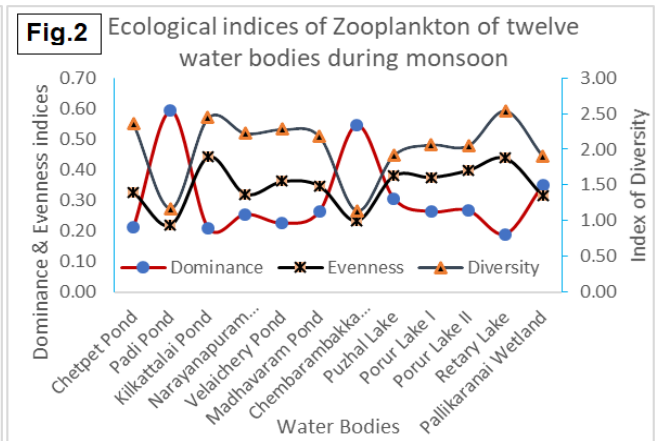
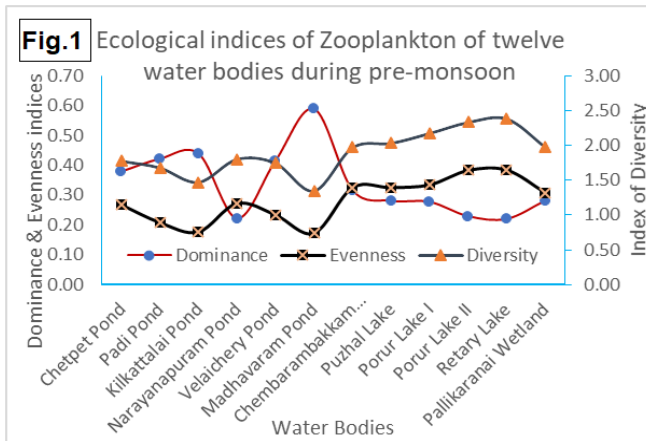
Note: (△- Pre monsoon), (●- Monsoon), (☆- Post- monsoon), (○- Summer)

1. Chetpet Lake, 2. Padi Lake, 3. Kilkattalai Lake, 4. Narayanapuram Lake, 5. Velachery Lake, 6. Madhavaram Lake, 7. Chembarambakkam Lake, 8. Puzhal Lake, 9. Porur Lake-I, 10. Porur Lake-II, 11. Retteri Lake 12. Pallikaranai Wetland.

**Table 3. Ecological Indices of Zooplankton during Four Seasons (July 2014- June 2015)**

Name of the Water body	Pre-monsoon (July-September)			Monsoon October-December)			Post-monsoon (January-March)			Summer (April-June)		
	DM	DV	EV	DM	DV	EV	DM	DV	EV	DM	DV	EV
Chetpet Lake	0.38	1.78	0.27	0.21	2.35	0.33	0.29	2.04	0.32	0.56	1.23	0.18
Padi Lake	0.42	1.68	0.21	0.59	1.17	0.22	0.72	0.86	0.10	0.94	1.10	0.17
Kilkattalai Lake	0.44	1.47	0.18	0.21	2.44	0.44	0.30	1.92	0.37	0.13	2.39	0.40
Narayanapuram Lake	0.22	1.80	0.27	0.25	2.23	0.32	0.21	2.40	0.33	0.22	2.66	0.38
Velachery Lake	0.41	1.75	0.23	0.22	2.28	0.36	0.26	2.22	0.33	0.15	2.47	0.44
Madhavaram Lake	0.59	1.35	0.17	0.26	2.18	0.35	0.27	2.16	0.31	0.58	1.08	0.14
Chembarambakkam Lake	0.32	1.97	0.33	0.55	1.14	0.23	0.25	2.24	0.38	0.33	1.87	0.38
Puzhal Lake	0.28	2.03	0.33	0.31	1.92	0.38	0.30	1.98	0.34	0.16	2.19	0.44
Porur Lake I	0.28	2.17	0.33	0.26	2.06	0.38	0.26	2.15	0.37	0.37	1.95	0.39
Porur Lake II	0.23	2.33	0.38	0.27	2.05	0.40	0.27	2.27	0.40	0.26	2.27	0.37
Retteri Lake	0.22	2.38	0.38	0.19	2.54	0.44	0.26	2.21	0.34	0.18	1.82	0.29
Pallikaranai Wetland	0.28	1.97	0.31	0.35	1.91	0.32	0.20	2.51	0.36	0.27	1.86	0.26

Note: DM-Dominance; DV-Diversity; EV-Evenness



Nauplii and copepodids and rotifers were predominant in Kilkattalai lake and their density during pre-monsoon period was 189.0 ind./l and 83.66 ind./l respectively. In Narayanapuram lake all the four groups of zooplankton occurred in even numbers. In this lake cyclopoid copepods (46.33 ind./l) and their nauplii and copepods (50 ind./l) showed high contribution towards density during post-monsoon and monsoon seasons, respectively. Higher density of cyclopoid copepods was recorded in Velachery Lake compared to other groups of zooplankton. Nevertheless, nauplii and copepodids of this group showed high density (107.33 ind./l) during pre-monsoon period. Higher density of rotifers were recorded in Madhavaram lake during all the four seasons and very high density of this group was evident during pre-monsoon (166.33 ind./l) and summer (157.67 ind./l) seasons. In Chembarambakkam lake rotifers, calanoid copepods, cladocerans and cyclopoid copepods were recorded in higher density than ostracods. Harpacticoids copepods were also recorded from this station. In Puzhal lake rotifers and nauplii and copepodids of copepods

occurred in high density, while cladocerans and cyclopoid copepods occurred in moderate density. In Porur lake-I rotifers numerically dominated the zooplankton in all the four seasons and it was followed by the nauplii and copepodids of the copepods. Cyclopoid copepods and ostracods occurred in moderate density. During pre-monsoon period mysids occurred in substantial number (14 ind./l) in this station. In Porur lake-II also rotifers showed higher density compared to other groups of zooplankton. Cyclopoid copepods and their developmental stages were next to rotifers in abundance. Mysids occurred prominently in this lake during pre-monsoon, monsoon and post-monsoon period. In Retteri Lake rotifer density was high during summer (44.66 ind./l) and post-monsoon period (36.66 ind./l). Calanoid and cyclopoid copepods as well as cladocerans occurred in moderate density during different seasons. In Pallikaranai wetland rotifers were numerically dominant group during summer (81 ind./l), post-monsoon (38.33 ind./l) and pre-monsoon (34.66 ind./l) period. In this station all the other groups of zooplankton occurred in moderate density.

### Ecological Indices of Zooplankton

Results of ecological indices for zooplankton of twelve water bodies showed variation with regard to dominance, diversity and evenness in different lakes and different seasons. During pre-monsoon period minimum dominance value was recorded in Narayanapuram Lake and Retteri Lake (0.22) while maximum value was recorded in Madhavaram Lake (0.59). Diversity values in this season ranged between 1.35 and 2.38, the minimum and maximum values were recorded in Madhavaram and Retteri lakes, respectively. Evenness values in this season ranged between 0.17 and 0.38, the minimum value was recorded in Madhavaram Lake and maximum value in Retteri and Porur lake-II. During monsoon period minimum dominance value was recorded in Retteri Lake (0.19) while maximum value was recorded in Padi Lake (0.59). Diversity values in this season ranged between 1.14 and 2.54, the minimum and maximum values were recorded in Chembarambakkam and Retteri lakes, respectively. Evenness values in this season ranged between 0.22 and 0.44, the minimum value was recorded in Padi Lake and maximum value in Retteri Lake. During post-monsoon period minimum dominance value was recorded in Pallikaranai Wetland (0.20) while maximum value was recorded in Padi Lake (0.72). Diversity values in this season ranged between 0.86 and 2.51, the minimum and maximum values were recorded in Padi and Pallikaranai Wetland, respectively. Evenness values in this season ranged between 0.10 and 0.38, the minimum value was recorded in Padi lake and maximum value in Chembarambakkam lake. During summer period minimum dominance value was recorded in Kilkattalai Lake (0.13) while maximum value was recorded in Padi lake (0.94). Diversity values in this season ranged between 0.1.10 and 2.66, the minimum and maximum values were recorded in Padi and Narayanapuram Lake respectively. Evenness values in this season ranged between 0.17 and 0.39, the minimum value was recorded in Padi Lake and maximum value in Porur Lake-I Comparative account of dominance, diversity and evenness indices of twelve water bodies during four seasons in presented in figures 1-4 and table 3.

### DISCUSSION

The degradation of water bodies can have multiple impacts on the local ecosystem. The most pronounced

being increased incidences of urban flooding. In addition to this, deterioration of water quality, decline in the number of aquatic species and loss of aesthetic and recreational spaces are some of the impacts of degradation of urban water bodies. Growth of algal blooms and eutrophication presents the biggest challenge to the health of the urban water bodies (Altaff *et. al.*, 2016). Zooplankton play a critical role in aquatic ecosystems not only as primary consumers but also they themselves serve as a source of food for higher organisms. Zooplankton provides the main food for fishes and can be used as indicators of the trophic status of water body (Verma and Munshi, 1987).

A moderate seasonal variation in zooplankton population was recorded during the present investigation. In general, the maximum diversity was recorded in pre-monsoon season (29 species), moderate diversity in post-monsoon season (25 species) while low diversity was observed in monsoon and summer seasons (22 species in each season). The pre-monsoon season is most favorable period for the growth and multiplication of zooplankton species. The period of August to November is the most favorable for growth of zooplankton population and this may be due to increase of phytoplankton population. Similar finding has been also reported by Abdus and Altaff, (1995) and Kumar, (2001) in different freshwater ponds.

Less zooplankton population during monsoon season is on account of high turbidity which restricts growth of the planktonic population. Besides this, regular flash out of lake water during the rain is also a major cause of less plankton diversity. The presence of *Brachionus angularis*, *Brachionus falcatus*, *Brachionus calysoflorus*, *Keratella tropica*, *Macrothrix spinosa*, *Ceriodaphnia cornuta*, *Diaphnosoma sarsi* and *Moina micrura*, *Diaphanosoma excisum*, *Mesocyclops aspericornis*, and *Thermocyclops decipiens* in all the seasons indicates the higher trophic status of the lakes as these species are indicator of eutrophication (Agarkar *et al.*, 1994; Kumar *et al.*, 2010).

In the present study higher diversity of zooplankton was recorded in Narayanapuram Lake and Pallikaranai Wetland compared to other water bodies. Even though all the lakes investigated in the present study showed impact of urbanization Narayanapuram Lake appears to be less impacted while Pallikaranai Wetland is a vast area and this may be the possible reasons for

harbouring comparatively high diversity of zooplankton. The low diversity in Chembambakkam Lake and Porur Lake-I and II might be due to usage of biocide chemicals for purification of water. Zooplanktonic population of all the lakes in general reveals the eutrophic condition of these water bodies which is on account of anthropogenic activities such as domestic waste disposal in the form of sewage and solid wastes.

Quantitative studies showed that the rotifers dominated numerically in majority of the lakes and this group was followed by the larval forms of copepods. Cyclopoid copepods occurred in many lakes but in moderate density. However, cladocerans and calanoid copepods existed in less number of lakes investigated in the present study. It is interesting to note that there is significant variation in the density of different groups of zooplankton in the 12 water bodies investigated. The major groups i.e. rotifers, cladocerans, copepods and ostracods showed dominance in one or two lakes investigated.

Results of the ecological indices indicated typical tropical nature of all the water bodies investigated. In all the water bodies diversity values showed opposing trend with dominance values while diversity values showed similarity with evenness values. Higher variation in the ecological indices of zooplankton in the water bodies is observed during monsoon and summer season than in pre-monsoon and monsoon period.

An important application of diversity indices in zooplankton studies is their usage in the assessment of pollution. Species diversity is a function of species richness and evenness with which the individuals are distributed in these species (Margalef, 1958). For Indian lakes, the Shannon-Weiner diversity index proposed as diversity index greater than ( $> 4$ ) is clean water; between 3-4 is mildly polluted water and less than 2 ( $< 2$ ) is heavily polluted water (Shekhar et al., 2008). Since, the Shannon-Weiner diversity index in the present study ranged between 0.86 - 2.54 in the water bodies investigated, therefore, these water body oscillates between moderately polluted to highly polluted. The present results indicate consistently higher zooplankton indices with broadly identical values.

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