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Zooplankton diversity of Chikkadevarayana canal in relation to physico-chemical characteristics

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Abstract

Plankton diversity and physico-chemical parameters are an important criterion for evaluating the suitability of water for irrigation and drinking purposes. In this study, we tried to assess zooplankton species richness, diversity and evenness to predict the state of Chickadevarayana canal water of Cauvery River according to physico-chemical parameters. A total of 51 taxa were recorded with 22 rotifers, 5 copepods, 6 cladocerans, 1 ostracoda and 17protozoans. More number of zooplankton species were recorded in Darasaguppe (30) followed by Edmuri (26), Kennala (20), Pandavpura (19) and Gendehosahalli (16). Among the rotifers, *Euchlanis sp.* species was abundant (194). *Acantholeberis curvirostris* was predominant among cladocerans (970). Among copepods, numerical superiorities were found in the case *Cyclops* sp. *Cypris* sp. was recorded in the ostracoda. *Centropyxis aculeate* repeated abundance in protozoans (412). The water samples analyzed for temperature, pH, electrical conductivity, alkalinity, hardness, dissolved oxygen, phosphate, sulphate and nitrate did not indicate variation. The occurrence of *Asplanchna herricki, Lacrymaria* sp, *Brachionus pala* and *Monostyla lunaris* showed highest similarity of occurrence reaching above 90%. The study revealed that the presence of certain species like *Monostyla, Lepadella*, *Leydigia*, *Keratella, Branchionus* and *Cypris* species can be considered as a biological indicator for eutrophication.

Key words

Zooplankton, Physico-chemical factors, Biological indicator, *Centropyxis aculeate*, Chikkadevarayana canal

Introduction

Aquatic ecosystem is the most diverse ecosystem in the world (Sharma and Tiwari, 2011). The biota of an aquatic ecosystem directly reflects the conditions existing in the environment in terms of the quality and quantity of the biota (Pathani and Upadyay, 2006). Zooplankton species are cosmopolitan in nature and they inhabit all freshwater habitats of the world, including polluted industrial and municipal wastewaters (Mukhopadhyay *et al*., 2007). Zooplanktons are microscopic organisms that are suspended in water. They include many kinds of protozoans, microcrustaceans and other micro invertebrates that are planktonic in water bodies (Omudu and Odeh, 2006). The zooplankton occupies an intermediate position in the food web in the aquatic ecosystem (Pathani and Upadyay, 2006).

A change in the physico-chemical aspects brings about a corresponding change in the relative composition and abundance of the organisms in that water (Adeyemi *et al*., 2009). Zooplanktons are important in environmental impact study. They are extremely responsive to change in the environment and thus indicate environmental changes and fluctuations that may occur (Sharma and Tiwari, 2011). They respond quickly to aquatic environmental change because most species have short generation time and respond to wide variety of disturbance including input of nutrient load (Sharma *et al*., 2008).

In view of the above, the present study was undertaken to investigate the diversity of zooplankton in relation to physico-chemical factors at 5 sites in Chikkadevaraya canal.

Materials and Methods

Description of the study site: Five sites namely Edmuri, Darasaguppe, Kennala, Pandavapura, Gendehosahalli were selected in Chikkadevarayana canal for investigation. Chikkadevarayana canal is a major canal of the KRS dam in Karnataka. It spans a length of 130 km, irrigating about 25949 acres agricultural land in three taluks besides being a source of drinking water for number of villages. Of late, the canal water is found to be polluted due to discharge of effluents from industries and distilleries of the area, in addition, various domestic activities like, washing of clothes, utensils, cattle, heavy vehicles.

Collection of samples: Surface water samples were collected in clean polythene containers every month from June 2010 to January 2011(eight months), during the early hours between 7.00 and 10.00 am. Zooplankton samples were collected monthly using plankton net made up of bolting nylon cloth (mesh -25µm) by sieving 100 l of water sample. This is then reduced to 100ml and to this 2ml of 4% formalin was added. The preserved samples were diluted to 10 ml with distilled water for their taxonomic study and numerical estimation.

Physico-chemical analysis of water: Temperature of water at each site was recorded on the spot using Centigrade Thermometer. Physico-chemical parameters like pH, electrial conductivity (EC), total dissolved solid (TDS), total solids (TS), total suspended solids (TSS), total hardness, Ca hardness, Mg hardness, Total alkalinity, dissolved oxygen, chlorides, phosphate, sulphate and nitrate content of water of each site was estimated using standard methods of APHA (2005).

Analysis of zooplanktons: The zooplanktons were observed under research microscope and photographed using digital camera (Jenoptic, Germany). Quantitative analysis of zooplankton was done by using lackeys drop method and identification was made using standard keys and monographs of Edmonson (1959), Needham and Needham (1966) and Altaff (2004).

The data of zooplanktons were subjected to a software program PAST (Hammer *et al*., 2001) to generate Dominance index, Shannon-Wiener index, Simpson diversity index, Pielou's evenness index, Menhinick's index, Margalef's index, Shannon's equitability index, Fisher α index, Berger Parker dominance index and Bray Curtis similarity index.

Results and Discussion

Physico-chemical results during the study period (June 2010 to January 2011) is presented in Table 1, while zooplankton diversity indices from five sampling stations are summarized in Table 2. The water temperature ranged from 19º to 24ºC at Edmuri, 23º to 25ºC at Darasaguppe, 23º to 26ºC at Kennala, 25º to 27ºC at Pandavapura and 24º to 25ºC at Gandehosahalli (Table 1). Temperature is one of the most important among the external factors which has profound influence and direct or indirect effect on biota of an ecosystem (Basu *et al*., 2010). Water temperature ranging between 13.5 to 32ºC is reported to be suitable for the development of the planktonic organism (Kamat, 2000; Gaikwad *et al*., 2008). The temperature value observed during the study indicates the ideal condition for the growth of zooplanktons.

The pH value which ranges between 7.72 to 7.78 at Edmuri, 6.93 to 7.64 at Darasaguppe, 7.22 to 7.54 at Kennala, 7.47 to 8.43 at Pandavapura, 7.57 to 8.35 at Gandehosahalli, indicates the alkaline nature. In the present investigation, EC value ranged from 471 to 598 μScm^{-1} among the five sampling sites (Table 1). Electrical conductivity is found to be good indicator of water quality (Gaikwad *et al*., 2008). The measurement of TDS integrates all anions and cations in the sample and some ions or combinations of ions are substantially more toxic than other ions or combinations of ions (Phyllis and Lawrence, 2007). TDS was maximum at Kennala (171 mg l^{-1}) and minimum at Pandavapura (118 mg l^{-1}) (Table 1).

Total alkalinity in Chikkadevaraya canal ranged from 105 to 210 mg l^{-1}. Maximum value was recorded at Kennala (210 mg l^{-1}) and minimum at Pandavapura (105 mg l^{-1}). The value of total hardness was 112 to 220 mg l^{-1} at Edmuri, 170 to 218 mg l^{-1} at Darasaguppe, 166 to 288 mg l^{-1} at Kennala, 132 to 220 mg l^{-1} at Pandavpura and 168 to 210 mg l^{-1} at Gandehosahalli respectively (Table 1). The greater alkalinity may be due to large scale use of its bank as open latrine and consequent washing of excreta in and near by the water body (Narasimha and Jaya Raju, 2001). Total hardness was due to high loading of organic substances, chlorides, detergents and other pollutants. Meshram (2005) reported that Ca hardness is essential for normal growth and development for many aquatic ecosystems. While DO ranged from 6.4 to 8.1 mg l^{-1} at Edmuri, 1.2 to 4.2 ppm at Darasaguppe, 1.6 to 6.4 mg l^{-1} at Kennala, 5.2 to 11.3 mg l^{-1} at Pandavapura, 7.2 to 13.3 at Gandehosahalli (Table 1), respectively. Dissolved oxygen is an important aquatic parameter whose measurement is vital in culture of any aquatic animal as it plays a crucial role in life processes (Vasanth *et al*., 2011).

Chloride occurs naturally in water as man and other animals excrete chloride together with nitrogenous compounds (Basu *et al.,* 2010). In high concentrations, chlorides in urban areas are indicators of large amounts of non-point pollution (Khare and Jadhav, 2008). Maximum value of chloride was recorded at Darasaguppe, (58.22 mg l^{-1}) and minimum value (35.20 mg l^{-1}) at Edmuri, (Table 1).

Table 1 : Physico–chemical variables at five sampling sites of Chikkadevarayana canal

Parameters	Edmuri	Darasguppe	Kennala	Pandavapura	Gendehosahalli
Temperature (^{0}C)	21.50 (19.0-24.0)	24.00 (23.0-25.0)	26.00 (23.0-26.0)	26.00 (25.0-27.0)	24.50 (24.0-25.0)
pH	7.75 (7.72- 7.78)	7.28 (6.93-7.64)	7.38 (7.22-7.54)	7.95 (7.47-8.43)	7.96 (7.57-8.35)
Conductivity (μScm^{-1})	471 (330-611)	567 (420-704)	598 (380-806)	517 (320-710)	562 (410-712)
TDS (NTU)	135 (122-146)	137 (128-142)	171 (130-218)	118 (96-138)	153 (134-170)
Total solids (mg l^{-1})	193 (176-210)	199 (180-220)	234 (217-250)	192 (152-230)	225 (155-260)
TSS (mg l^{-1})	58 (54-61)	62 (50-75)	63 (38-88)	74 (58-90)	72 (56-88)
D O (mg l^{-1})	7.25 (6.4-8.1)	2.7 (1.2-4.2)	4.00 (1.6-6.4)	8.25 (5.2-11.3)	10.25 (7.4-13.3)
Alkalinity (mg l^{-1})	130 (90-170)	195 (190-200)	210 (190-230)	105 (70-140)	175 (200-150)
Chlorides (mg l^{-1})	35.20 (28.40-42)	58.22 (48.28-68.16)	53.25 (62.48-44.02)	38.34 (39.76-36.92)	46.86 (51.12-42.60)
Hardness (mg l^{-1})	166 (112-220)	194 (170-218)	227 (166-288)	176 (132-220)	189 (168-210)
Calcium hardness (mg l^{-1})	38.07 (28.05-48.09)	47.69 (43.28-52.10)	46.89 (32.86-60.92)	39.27 (31.26-47.29)	43.98 (47.29-40.67)
Magnesium hardness (mg l^{-1})	31.21 (20.48-41.94)	35.69 (30.91-40.47)	43.94 (32.48-55.40)	33.35 (24.57-42.14)	35.06 (29.45-40.67)
Sulphate (mg l^{-1})	2.05 (1.35-2.75)	1.90 (0.35-3.46)	3.10 (1.50-4.7)	2.22 (1.20-3.25)	4.87 (1.45-8.3)
Phosphate (mg l^{-1})	0.05 (0.0-0.1)	0.75 (0.1-1.4)	0.4 (0.2-0.6)	0.52 (0.4-0.65)	1.3 (0.1-2.5)
Nitrate (mg l^{-1})	0.4(0.0-0.1)	1.10(0.9-1.3)	1.02(1.0-1.05)	0.3(0.0-0.6)	0.42(0.15-0.7)

Phosphate is the limiting nutrient for plankton growth in lakes, but high concentration of phosphates (> 1 mg^{-1}) occurs due to excessive fertilization, nuisance algae and rooted weed (Ostozic, 2000). The present investigation indicates that phosphate concentration of the canal fluctuated between 0.05 to 1.3 mg l^{-1}. Whereas nitrate value was low (0.3mg l^{-1}) at Pandavapura and high (1.10 mg l^{-1}) at Darasaguppe. Sulphate values ranged between 1.90 to 3.10 mg l^{-1} in the sampling sites of the study area (Table 1).

In aquatic ecosystem, zooplanktors play a critical role not only in converting plant food to animal food but also they themselves serve as source of food for higher organisms (Rajashekhar *et al*., 2010). The Chikkadevaraya canal was dominated by Rotifer species. Data obtained from study indicates that a total of 51 zooplankton species were recorded in five sites of Chikkadevaraya canal comprising of 17 Protozoans, 22 Rotifers, 5 Copepods, 6 Cladocerans and 1 Ostracod.

About 1700 species of rotifers have been described from the different parts of the world and 500 species was described from Indian water bodies (Arora and Mehra, 2003; Kiran *et al*., 2007). Site-wise variations in dominance, diversity, evenness, richness and other indices of community structure are given in Table 2. The rotifer family had highest number of species followed by protozoans, cladocerans, copepods and ostracods. The maximum diversity and population of rotifers was observed in Darasaguppe due to organic pollution and its eutrophic condition, than other sites. Similar result was reported by Lazo *et al*. (2009) in their study at Pasig River, Philippines. Rotifers' contributions to the zooplankton community may increase with eutrophication (Park and Marshall, 2000). Among Protozoans *Centropyxis aculeate* was commonly found in all the five sampling sites and was most abundant.

The species richness values R1 (3.37, 3.61) and R2 (0.63, 0.54) were high at Edmuri and Darasaguppe sampling station. The R1 and R2 value did not show larger fluctuations as it was observed that, R1 ranged from 2.17 to 3.73 and R2 ranged from 0.51 to 0.63 respectively. Menhinick and Margalefs richness hold good for analyzing a zooplankton community (Terdalkar and Pai, 2001). Shannon- Wiener diversity index (3.07) and Margalef's index (3.37) showed maximum values for Edmuri, indicating the significance of the effective numbers. Shannon-Wiener diversity index represents entropy. It is a diversity index taking into account

Table 2 : Diversity indices of zooplanktons at five sampling sites in Chikkadevarayana canal

Diversity indices	Edmuri	Darasaguppe	Kennala	Pandavapura	Gandehosahalii
Taxa_S	26	30	20	19	16
Individuals	1655	3084	1524	1312	979
Dominance_D	0.05383	0.1106	0.1288	0.09201	0.1085
Shannon_H	3.079	2.831	2.527	2.626	2.495
Simpson_1-D	0.9462	0.8894	0.8712	0.908	0.8915
Evenness_e^H/S	0.8361	0.5656	0.6261	0.7271	0.7573
Margalef (R1)	3.373	3.61	2.592	2.507	2.178
Menhinick (R 2)	0.6391	0.5402	0.5123	0.5245	0.5114
Equitability_J	0.9451	0.8324	0.8437	0.8918	0.8997
Fisher_alpha	4.379	4.61	3.251	3.148	2.716
Berger-Parker	0.1088	0.2879	0.3018	0.1921	0.2451

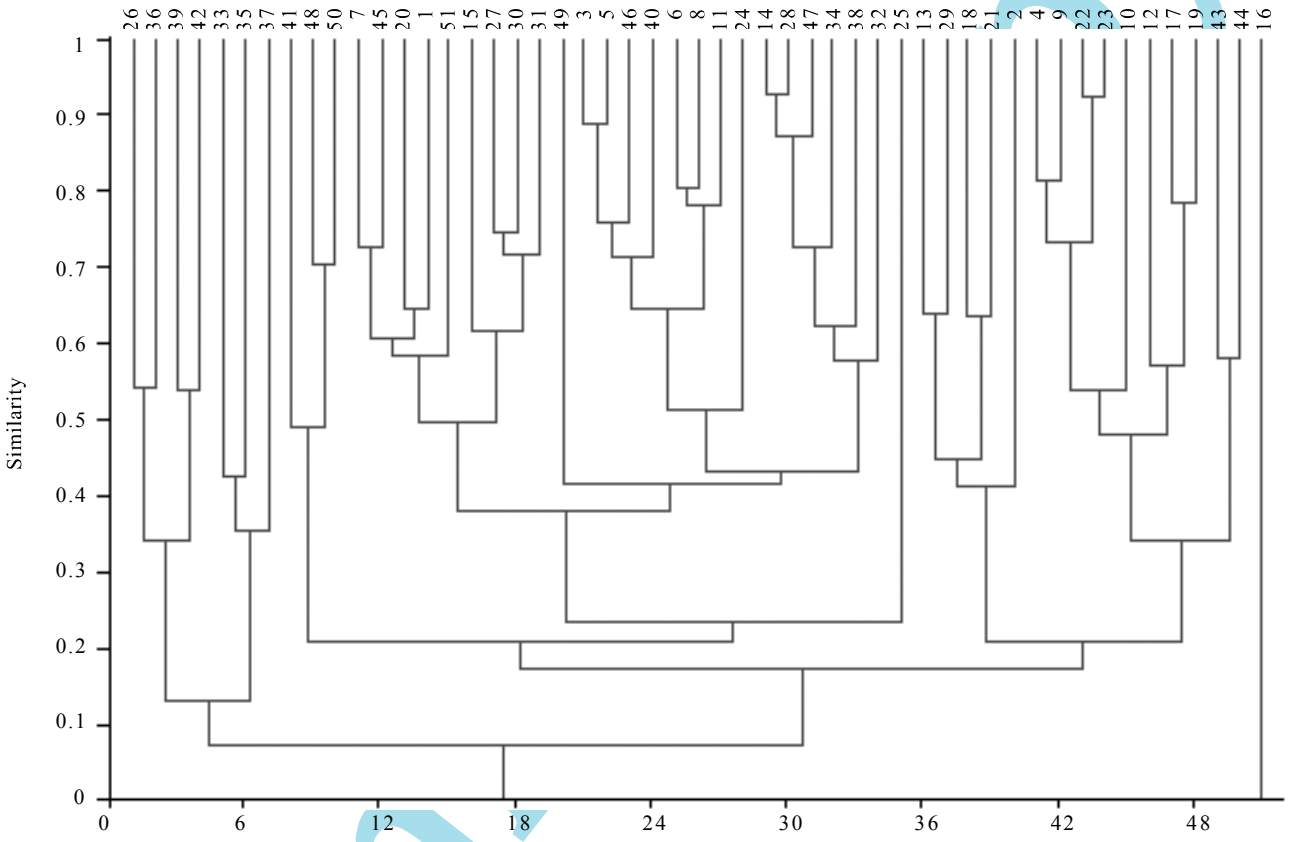

Fig. 1 : Bray-Curtis similarity index for distribution of species in Chikkadevarayana canal

the number of individuals as well as number of taxa. Shannon-Weiner index varies from communities with a single taxon to communities with many taxa. This index can also determine the pollution status of the water body. Normal values range from 0 to 4 (Hosmani, 2010). Examining the diversity in the range of polluted and unpolluted ecosystem concluded that the values of the index was greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderately polluted and values less than 1 is highly polluted (Mason, 1998). According to the present study, Shannon- Wiener diversity index values in the study area was as follows: Edmuri (3.07), Darsaguppe (2.8), Kennala (2.5), Pandavapura (2.6) and Gandehosahalli (2.4). The Simpson index values ranged between 0.87 to 0.94 which is a measure of diversity and is often used to quantify the biodiversity of habitats. It takes into account the number species as well as their abundance and the values range between 0 and 1. Greater the value greater will be the zooplankton diversity (Hosmani, 2010). Fishers index is a mathematical calculation for determining diversity within a

population, which represents first attempt to describe mathematically the related species and number of individuals of those species (Hosmani, 2010). The index is very low in Gandehosahalli (2.1) and highest in Darasaguppe reaching 4.61. This indicates that abundance odd species is in Chikkadevarayana canal. Berger-Parker dominance index is the number of individuals in the dominant taxon divided by number of individuals (n). It is the largest species proportion of all species in a community is most strongly influenced by evenness of these indices. Its reciprocal value is an index of diversity. In the present study it indicates that individuals of the community in five sampling sites are not completely evenly distributed. The values are high in Kennala (0.30), followed by Darasaguppe (0.28) and least in Edmuri (0.10). The Pielou's index states that evenness is also a diversity index, which quantifies how equal the community is numerically and is a constraint between 0 and 1 (Basavarajappa *et al.,* 2010). In the present study evenness of species in the canal was highest in Edmuri (0.83) followed by Gandehosahalli (0.75), Pandavapura (0.72), Kennala (0.62) and Darasaguppe (0.56). The evenness values of all the sampling in the study area were within a comparable range.

In order to understand the association of communities, similarity values of Bray-Curtis index were also determined. Only values above 90% were accounted to study the distribution of species in the canal (Fig.1). The occurrence of *Asplanchna herricki, Lacrymaria* sp, *Brachionus pala* and *Monostyla lunaris* showed highest similarity of occurrence reaching above 90%. These species have the capacity of close co-existence in the canal ecosystem. The lowest similarity of taxa was between *Trichotria tetractis* and *Pleurotrocha petromycon. Coleps hirtus* did not show any similarity with other species during the study period.

From the aforesaid data it could be made out the availability of water, safe habitat and food sources for zooplanktons in the canal are important for the occurrence which reflects diversity indices. As water quality are the important habitat characteristics that influences the distribution indices of zooplankton.

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