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Seasonal study of zooplankton diversity in the polluted water stretch of Buddha Nullah, Ludhiana

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Abstract
Zooplankton species are cosmopolitan in freshwater habitat but are also found in industrial and municipal waste- waters. The present study was carried out to determine the zooplankton diversity in the polluted water stretch of Buddha Nullah at Ludhiana. Zooplankton samples were collected from five different spots *viz*, Machhiwara, Budhewal, Jamalpur, Sunder Nagar and Walipur of Buddha Nullah, Ludhiana seasonally (April, June, July and December 2015), using zooplankton net having mesh size 60µm. Mainly two phyla were identified such as Rotifer and Crustacean, with rotifer comprising 3 species, cladocera 4 species and copepoda 4 species. The dominant zooplankton were present throughout the year. The seasonal zooplankton diversity showed that the pollution indicator *Brachionus* sp. of rotifera were found at polluted water spots i.e. Jamalpur, Sunder Nagar and Walipur (downstream) during summer months and crustaceans (both copepods and cladocerans) recorded in both summer and winter seasons at non-polluted spots i.e. Machhiwara and Buddhewal (upstream). The pollution indicator species of rotifers at downstream spots describes the higher levels of organic pollution and eutrophication of Buddha Nullah. The pollution of Buddha Nullah emphasizes the fact that water is unfit for consumption and domestic use. The effect of water on human and domestic animals would also be harmful to health.

Keywords: Zooplankton, Buddha Nullah, polluted water, Rotifers, Crustaceans

1. Introduction
Zooplanktons are the microscopic organisms present in almost all the water bodies, in deep ocean water, sunlit zone and where food resources are abundant [1]. Zooplankton feed on bacterioplankton, phytoplankton, other zooplankton as a cannibalistic behaviour, detritus and even nektonic organisms. The zooplankton are important food for fishes as this indicates nutritive level of an aquatic ecosystem [2]. The main function of fresh water zooplankton being an important biological component in aquatic ecosystems is their primary and secondary links in the food chain [3]. They belong to three groups: (i) Phylum Rotifera (ii) Phylum Protozoa (iii) Class Crustacea which is composed of order like *Cladocera* and subclasses *Copepoda* and *Ostracoda.* The general state of water body is reflected from its zooplankton community and its other related components [4]. The zooplankton forms a major link in the energy transfer at secondary level in aquatic biotopes. They occupy an intermediate position in aquatic food webs between autotrophs and heterotrophs. The study of zooplankton is necessary to evaluate the fresh water reservoirs in respect to their ecological and fishery status [5]. Zooplankton have good nutritional value and are a rich source of Omega-3-fatty acids [6]. They are excellent bioindicators of environmental conditions because they are sensitive to change in water quality. Zooplankton are important in nutritive level, temperature, and pollution. They are used to determine the health of an ecosystem [7].
In aquatic ecosystems, the diversity of zooplankton depends mainly on the physico-chemical parameters of water [8]. The zooplankton community especially rotifer species fluctuates with biotic factors [9]. Rotifers are the natural trophic link between alga and zooplanktivorous predators such as fish [10]. The connections between fish fauna and their development in their habitat can be established by evaluation of phytoplankton and zooplankton together [11]. Any alteration in the environment leads to the change in the plankton communities in terms of tolerance, abundance, diversity and dominance in the habitat. Zooplankton play an important role in biomonitoring of water pollution [12]. The higher rates of phytoplankton production is correlated with an increase in organic pollution which leads to zooplankton communities of higher biomass. In tropical and temperate climates, seasonal qualitative fluctuations in

planktonic population in water body usually occur [13]. Cladocerans are apparently more sensitive for certain toxic substances and changes in the water quality than rotifers [14]. Massive industrialization, urbanization, excessive utilization of pesticides in agriculture is the reason that threatens aquatic ecosystem and human beings [15]. Pollution of water bodies by different sources will result in drastic changes in zooplankton potential of the ecosystem. Thus, the present study was aimed to study the seasonal zooplankton diversity in polluted water of Buddha Nullah, Ludhiana

2. Materials and Methods

2.1 Collection of Water Samples

In the study area, five different sites were selected for zooplankton collection from stretch of Buddha Nullah. Samples were collected from Machhiwara (upstream), Buddhewal, Jamalpur, Sunder Nagar and Walipur Kalan (downstream) at periodic interval (April, June, July and December 2015).

2.2 Zooplankton Sampling

The zooplanktons were collected using plankton net having mesh size 60µm. This net is in the form of a truncated cone with the lower narrow end. Wide end of the cine is sewed above an iron ring with constituting mouth of the net, while the lower end of the bolting cloth sleeve carries a graduated plastic tube (15ml). Plankton net acts as a filter. A mug of 500ml capacity water was taken and about 25 times the water was filtered out. The zooplankton were trapped and collected in the plastic tube and later were preserved. The concentrated zooplankton samples were carefully transferred to another container. Then 5% of formalin was added to samples for settled down zooplankton and solution was kept 24 hours undisturbed. Formalin acts as both fixative and preservative. Zooplanktons were identified by using stereomicroscope and keys of zooplankton [16].

3. Results and Discussion

3.1 Rotifers

In the present study, the rotifers had a higher diversity in the summer months but a lower value in December (Table 1). The Rotifera group comprises of 3 main genera, such as *Brachionus* sp, *Trochosphaera* sp, *Polyarthra* sp. *Brachionus* sp., which is an indicator of organic pollution was present throughout the year. *Brachionus* species were very common in temperate and tropical waters that indicated the alkaline nature of water [17]. The population of rotifers was rich in summer and poor in winter probably due to high population of bacterial species and organic matter of dead and decaying vegetation. So, the polluted spots i.e. Jamalpur, Sunder Nagar and Walipur showed rich diversity of rotifers. The range of water temperature between 13.5 °C to 32 °C was reported to be very suitable for growth of planktonic species [18]. The domestic sewage increased the nitrogen and phosphorous load in water bodies which resulted in increase in the zooplankton, algal blooms, and phytoplankton composition [19]. Rotifers respond very quickly to environmental changes than other planktonic species. The rotifers were dominant in municipal and industrial discharges while copepods and cladocerans were less abundant [20]. It was suggested that the increase in diversity of zooplankton were indication of the healthier environmental condition while low diversity suggested fewer species dominance probably due to sewage environmental stress [21]. Thus, the rotifers are globally recognized as pollution indicator organisms in the aquatic environment [22].

Table 1: Seasonal zooplankton (Rotifer) diversity at different spots of Buddha Nullah

S.No.	Months / Genus	Season wise sampling			
		April (2015)	June (2015)	July (2015)	December (2015)
Rotifers (Machhiwara)					
1	*Polyarthra* sp.	+	-	-	+
2	*Trochospaera* sp.	++	+	-	-
3	*Brachionus* sp.	-	-	+	+
Rotifers (Buddhewal)					
1	*Polyarthra* sp.	-	+	-	-
2	*Trochosphaera* sp.	+	-	++	+
Rotifers (Jamalpur)					
1	*Polyarthra* sp.	-	+	++	-
2	*Trochosphera* sp.	-	+	-	+
3	*Brachionus* sp.	+	++	+	-
Rotifers (Sunder Nagar)					
1	*Polyarthra* sp.	++	+	+	-
2	*Trochosphaera* sp.	+	+	++	-
3	*Brachionus* sp.	+	-	+	+
Rotifers (Walipur)					
1	*Polyarthra* sp.	-	-	+	-
2	*Trochosphaera* sp.	+	+	-	-
3	*Brachionus* sp.	+	-	++	-

+ = presence, - = absence, ++ = maximum occurrence.

3.2 Cladocera

The data (Table2) on cladocera during different months of the year at different spots depicts their maximum diversity throughout the present study. The moderate population in summer month may be due to higher growth of Rotifers. The genus cladocera was represented by *Simocephalus* sp, *Moina brachiata, Daphnia* sp., *Ceriodaphnia* sp., and *Alonella* sp. However, in the wetlands of Jharkhand [23], cladocerans were abundant from March to June and were either absent or present in very negligible numbers during the rest of months. The maximum diversity of cladocera during winter season may be due to favourable temperature and availability of food, nanoplankton, suspended detritus. The physico-chemical factors like DO, water temperature and turbidity

also play crucial role in diversity & density of cladocerans [24]. But decline in the number of cladocerans during summer months may be due to predation by fish and higher competition between cladocerans and other groups of zooplankton [25]. However, the cladoceran richness was also reported higher in summer and minimum in winter [26, 27].

Table 2: Seasonal zooplankton (Cladocera) diversity at different spots of Buddha Nullah

	Months / Genus	Season wise sampling			
Cladocera (Machhiwara)		**April (20115)**	**June (2015)**	**July (2015)**	**December (2015)**
1	*Alonella* sp.	-	-	++	-
2	*Daphnia* sp.	++	-	-	-
3	*Ceriodaphnia* sp.	+	-	-	++
4	*Moina brachiata*	+	++	-	+
	Cladocera (Buddhewal)				
1	*Alonella* sp.	-	-	++	+
2	*Daphnia* sp.	-	+	-	++
3	*Semocephalus* sp.	+	++	-	+
4	*Moina brachiata*	-	-	+	+
Cladocera (Jamalpur)					
1.	*Daphnia* sp.	+	-	++	+
2	*Ceriodaphnia* sp.	-	+	-	-
3	*Moina brachiata*	+	-	+	+
Cladocera (Sundar Nagar)					
1	*Daphnia* sp.	+	-	+	-
2	*Alonella* sp.	-	+	-	-
3	*Moina brachiata*	+	+	+	-
Cladocera (Walipur)					
1	*Alonella* sp.	-	-	+	-
2	*Daphnia* sp.	+	+	+	+
3	*Moina brachiata*	+	-	+	-

+ = presence, - = absence, ++ = maximum occurrence.

3.3 Copepoda

In the present study, the diversity of copepod at different spots during different months of the year was recorded (Table 3). The maximum diversity of copepods was observed in summer months (June and July) and lower in winter (December). Thus, copepod's positive correlation with temperature indicated their better development during warm period. The major factors that inhibit the distribution of copepods might be discharge of effluents into water, rainfall and decreased abundance of phytoplankton species due to turbidity. The dominance of these species of zooplankton may be due to pre-dominance of blue-green algae at highly polluted spots of Buddha Nullah. Temperature was most important factor that affects the copepods density and diversity. Their production increased with increase in temperature. This may be due to the fact that the higher temperature increased the biochemical & biological activities and increased the production of microorganisms. Copepods take much time to build up their population than rotifers and other zooplankton. However, once dominant, they continue to dominate the habitat [28]. However, the high density of copepod was observed during October because the water temperature and availability of food to organisms affected the copepod population in summer [29]. The rise in atmospheric temperature caused enhancement in the evaporation rate and the positive correlation of copepods with temperature indicated their better development in warm periods after winter [30].

Table 3: Seasonal zooplankton (Copepods) diversity at different spots of Buddha Nullah

S.no.	Months / Genus	Season wise sampling			
Copepoda (Machhiwara)		**April (2015)**	**June (2015)**	**July (2015)**	**December (2015)**
1	*Acanthocyclops* sp.	+	-	-	-
2	*Cyclops muller*	+	++	-	-
3	*Cyclops* sp.	-	+	-	+
4	*Eucyclops* sp.	-	+	++	-
Cpepoda (Buddhewal)					
1	*Cyclops muller*	+	-	+	+
2	*Cyclops* sp.	-	+	-	++
3	*Eucyclops* sp.	-	++	+	-
Copepoda (Jamalpur)					
1	*Acanthocyclops* sp.	-	+	+	-
2	*Cyclops muller*	+	-	-	+
3	*Cyclops* sp.	-	-	++	-
4	*Eucyclops* sp.	-	+	-	+
Copepoda (Sunder Nagar)					
1	*Acanthocyclops* sp.	+	++	-	-
2	*Cyclops muller*	-	-	-	+

3	*Cyclops* sp.	-	+	++	-
4	*Eucyclops* sp.	+	-	++	-
Copepoda (Walipur)					
1	*Acanthocyclops* sp.	-	-	+	-
2	*Cyclops muller*	+	-	+	-
3	*Cyclops* sp.	-	+ +	+	+
4	*Eucyclops* sp.	+	-	-	++

+ = presence, - = absence, ++ = maximum occurrence.

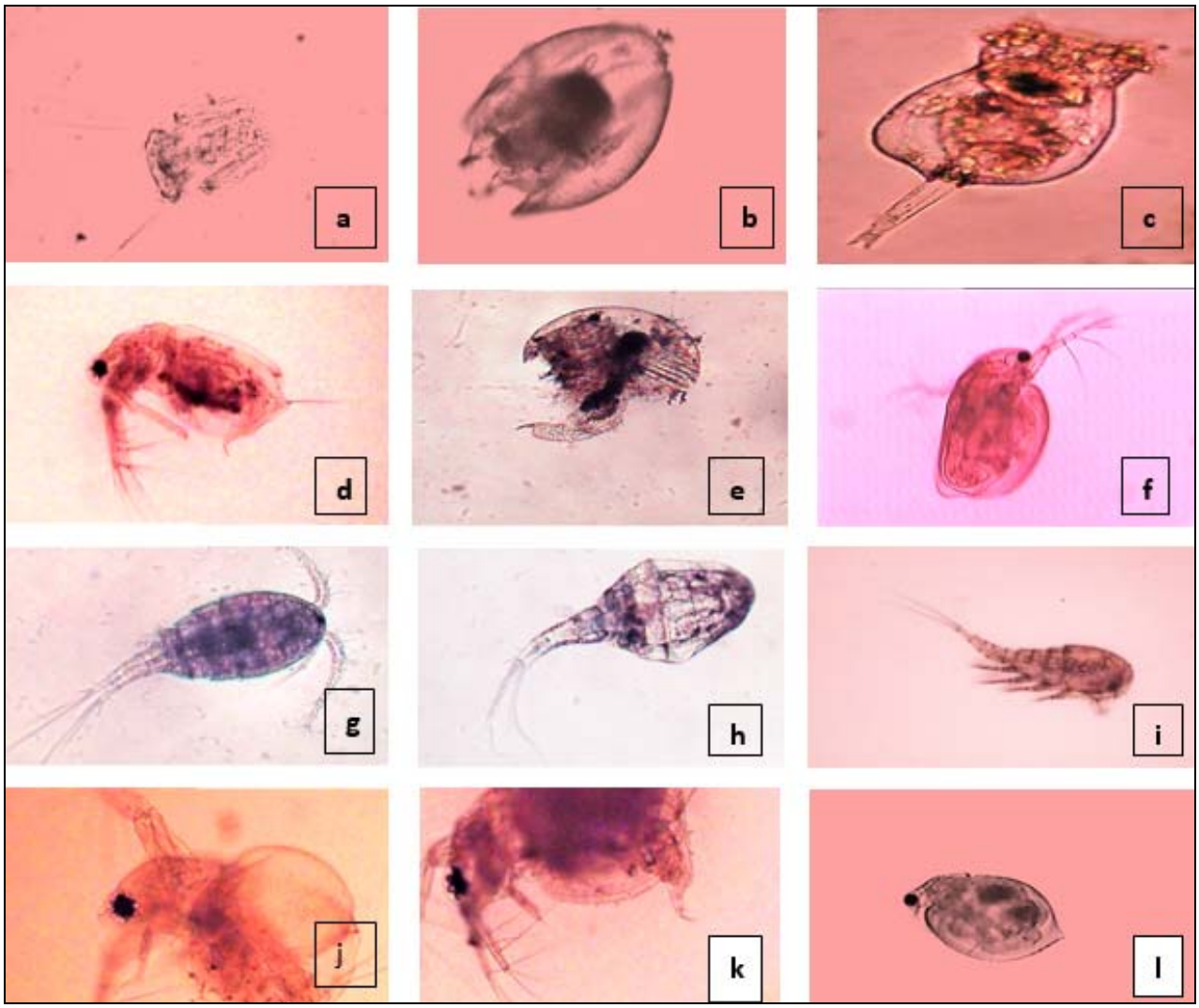

Fig: Different indentified zooplankton **a)** *Polyarthra* sp. **b)** *Brachionus* sp. **c)** *Trochosphaera* sp. **d)** *Moina* sp. **e)** *Alonella* sp. f) *Simocephalus sp*. **g)** *Cyclops muller* **h)** *Eucyclops* sp. **i)** *Cyclops* sp. **j)** *Moina brachiata* k) Posterior body of moina brachiata **l)** *Ceriodaphnia* sp.

4. Conclusion

Seasonal variations of zooplankton diversity in polluted water of Buddha Nullah showed that mainly two phylums (Rotifera and Crustacea) were found from the waste water. Among rotifers, *Polyarthra* sp and *Trochospaera* sp. were found in summer seasons at all the spots while *Brachionus* sp. was found at all the downstream polluted spots (*viz*, Jamalpur, Sunder Nagar and Walipur) during summer months. Among crustaceans, the species of copepods and cladocerans were found throughout the period of sample collection at non-polluted upstream spots (such as Machhiwara and Buddhewal). So, the pollution indicator species of rotifers from polluted spots describes the higher levels of organic pollution and eutrophication at downstream spots of Buddha Nullah.

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