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An investigation of the physico-chemical parameters and zooplankton abundance in Bagmati River near Pashupatinath Temple, Kathmandu, Nepal

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Abstract
Physico-chemical parameters and abundance of zooplankton in Bagmati River Near Pashupatinath Temple, Kathmandu, Nepal were studied. In the present investigated 5 groups of zooplankton were namely copepod, rotifer, cladocera, ostracoda and crustacean larvae. It was demonstrated that their prevalence percentages (%) in the culture systems were 53%, 37%, 7%, 1.3% and 1.7% respectively. Zooplankton was dominated by copepods which showed more or less two peaks in August (949 individuals/L) and in October (867 individuals/L). Rotifer and copepod were about perennial while one genus Cypris of ostracod was found only in August. Three genera of copepod namely Diaptomus, Cyclops and Mesocyclops were identified in the study area of which Diaptomus and Mesocyclops were more or less dominant while four genus of which Brachionus and Filinia under rotifer and Daphnia and Diaphanosoma under cladocera were also found during the study period. The physico-chemical parameters and the zooplankton abundance showed some interrelationships which are helpful to understand the seasonal and spatial variation of zooplankton population.

Keywords: Zooplankton, river, copepod, rotifer, cladocera, ostracoda and crustacean larvae

1. Introduction

Aquatic ecosystems are known to support work to range of organism. Among these zooplanktons are the free floating and microscopic animal found in aquatic ecosystem. The zooplanktons are important for fishes as they are used as source of food. Zooplanktons are playing important role in biomonitoring of water pollution [1]. The Zooplanktons are classified in various groups viz. Cladocera, Copepoda, Rotifer and Ostracoda etc. The study of zooplankton is necessary to evaluate the fresh water reservoir in respect to their ecological and fishery status [2]. Zooplankton community community fluctuates according to physicochemical parameter of the environment, especially Rotifer species change with biotic factors [3]. The abundance and assemblage composition of zooplanktons are depending upon the dominance of water birds, fish, macroinvertebrates and their food preference [4]. On the similar line Jafari *et al* [5] studied the zooplankton diversity and compositions are correlated to the physicochemical environment of the Haraz River. Zooplanktons are heterotrophic in nature and play important role in food web by link primary producers to higher trophic level. The Zooplankton abundance was declines due to connection with redistribution number of individual in a water body less possibilities to stay in eutrophic zone where photosynthesis occurs [6]. Zooplanktons are important in nutritive level, temperature, and pollution used to determine the health of an ecosystem [7].

The Bagmati River is the principal river of the Bagmati Basin in central Nepal. The Bagmati river basin is a medium sized river basin with a catchment area of 3700 km2 at the Nepal India Border. It extends between $20^0 42'$ to $27^0 50'$ north latitude and $85^0 02'$ to $85^0 58'$ east longitude. It originates from the Shivapuri hills in the Mahabharata range of mountains and flows down south into the Terai plains before crossing the Indo Nepal border. The Kathmandu valley comprises of 15% of the of the basin area in Nepal. The basin can be divided into three parts; the upper Bagmati basin comprising of theKathmandu valley plus the upper Nakhkhu khola and Dakshinkali area, the Middle Bagmati basin comprising of the remainder of the basin in the hills including the Kulekhani khola; andthe lower Bagmati basin comprising of the basin in the Terai, plus some tributaries whichoriginate in the Shiwaliks.

The river, fed by springs and monsoon rainfall, originates in the north of Kathmandu Valley (the capital of Nepal) and drains across the Mahabharat Range to the Gangetic plain. The Basin transacts three distinct latitudinal physiographic zones (Mountain, Siwalik and Terai) of the Nepal Himalayas. Hard rock geological formations at the Basin headwaters stand out as a resistant ridge complex compared to the weak and fragile rock formations at the middle stretches of the Basin. The Bagmati Basin currently faces several serious environmental and ecological challenges. Urbanization and industrialization of the Basin headwaters at Kathmandu contributed to water quality deterioration with regional consequences on the aquatic ecosystem and on the health of the downstream sub-basin's user groups. Increasing population pressure on the fragile mountain slopes has also resulted in the rapid degradation of the natural resources. From the earlier work on the zooplanktons, it appears that studies have been done on the seasonal variation and zooplankton diversity thus the present investigation was carried out in Bagmati River near Pasupainah Temple, Kathmandu, Nepal.

In Nepal, limnological studies of lotic and lentic water bodies were conducted after 1960. Löffler [8] explored physico-chemical and biological aspects of 24 high altitude lakes (4500-5600m asl) of Nepal. Since then over 150 publications on limnology of lakes were conducted until 2010 [9]. Some study presented a bathymetric map [10], comparative study on limnology of three major lakes of Pokhara valley with major focus on physico-chemical parameters and nutrient loads [11]. Also, other researchers [12-17] did different aspects of limological studies of the Lake Rupa. Most of them were focused on studying seasonal variations on physico-chemical parameters and or biological parameters like planktons, macrophytes, aquatic weeds and fish species as separate factors.

2. Materials and Methods

2.1 Sampling area and sampling design

Pashupatinath is the most important temple dedicated to god Shiva. Every year this temple attracts hundreds of elderly followers of Hinduism. They arrive here to find shelter for the last several weeks of their lives, to meet death, be cremated on the banks of the river and travel their last journey with the waters of the sacred river Bagmati, which later meets the holy river Ganges. Hinduists from every corner of Nepal and India are arriving here to die. Thus, this work was conducted near one of the most sacred Hindu temples of Nepal-Pashupatinath Temple which is located on both banks of Bagmati River on the eastern outskirts of Kathmandu. The samples were collected at 30 days interval from June 12th to December 10th, 2015. Three representative samples were collected to increase accuracy of the result.

2.2 Plankton collection and preservation

Zooplankton samples were collected in monthly intervals at 10.30 am on each sampling date by conical shaped monofilament nylon net (Plankton net). The mesh size of the plankton net was 90 µm and the diameter of the net at mouth was 30 cm. Samples were collected from pelagic waters of the ponds from different parts of the river. Sixty litters of pelagic water from 6 different parts of the river were passed through the plankton net with the help of a plastic pan of 5 liter capacity. The water was passed down through the net and the plankton condensed at the lower end of the plankton net then it was collected into a glass test tube and fixed firmly (Welch, 1948). After collection, the plankton materials were transferred into glass bottles and preserved with Lugol's solution. About 250 ml samples of plankton were preserved with 1.5 ml Lugol's solution. After preservation, the plankton samples were carried out to the Fisheries and Aquaculture Research Laboratory, Department of Zoology at Amrit Campus, Tribhuvan University, Kathmandu for further analyses.

2.3 Plankton identification

Zooplankton cells were enumerated under a light microscope by using Sedgwick-Rafter cell. Recognition of species is a matter of experience. Thus, a series of pencil and ink drawing on postcards of the species of the observed were prepared to identify the organisms. Identifications were done following [18-22].

2.4 Classifications and identifying characters of observed zooplankton

Mesocyclops and *Cyclops* were identified by using the characteristics given by Todd [21] while *Diaptomus, Daphnia, Diaphansoma, Filinia, Brachionus and Cypris* were identified according to Charles [22]. Characteristics of zooplankton according to different scientists are given below.

A. Mesocyclops

Key to the genera: It has a characteristic appearance; with a streamlined cephalosome bearing four free thoracic segments and short but heavily setose antennae. The first urosome segment the sixth thoracic segment is somewhat rounded and carries two obvious lateral spines on each side [21].

Phylum	:	Arthropoda
Class	:	Crustacea
Order	:	Cyclopoida
Family	:	Cyclopoidae
Genus	:	*Mesocyclops*

B. Cyclops

Key to the genera: They have the articulation between cephalosome and urosome, not between the sixth thoracic and first abdominal segments, but between the fifth and sixth thoracic segments. This gives cyclopoids the appearance of a long slender urosome and the antennules are usually shorter than is typical of calanoids [21].

Phylum	:	Arthropoda
Class	:	Crustacea
Order	:	Cyclopoida
Family	:	Cyclopoidae
Genus	:	*Cyclops*

C. Diaptomus

Key to the genera: The genus *Diaptomus* is characterized by the beautifully streamlined torpedoshaped cephalosome, five free thoracic segments and extremely long antennules, which bear three large setae two backward and one forward pointing at their tips [22].

Phylum	:	Arthropoda
Class	:	Crustacea
Order	:	Calanoida
Family	:	Diaptomidae
Genus	:	*Diaptomus*

D. Daphnia

Key to the genera: Its size is less than three mm. Head armour dorsally prolonged and compressed laterally. Dorsal body wall takes the form of folds that cover the body and limbs one each side, thus forming a sort of bivalve shell. The head however remains uncovered and free. The valves of the shell are firmly grown to each other dorsally, and there is no hinge [22].

Phylum	:	Arthropoda
Class	:	Crustacea
Order	:	Cladocera
Family	:	Daphnidae
Genus	:	*Daphnia*

E. Diaphanosoma

Key to the genera: Body long with transparent open valve. Eye pigment black, filling end of the head. Color somewhat yellowish. No rosterm. Reflexed antenna does not reach up to the posterior margin of the valve. Pastabdominal claw with the basal spines no anal spines [22].

Phylum	:	Arthropoda
Class	:	Crustacea
Order	:	Cladocera
Family	:	Sididae
Genus	:	*Diaphanosoma*

F. Cypris

Key to the genera: They have a single eye and the two are most easily distinguish from each other by the structure [22].

Phylum	:	Arthropoda
Order	:	Ostracoda
Family	:	Cypidae
Genus	:	*Cypris*

G. BRACHIONUS

Key to the Species: Anteromedian spines have broad base, posterior spines are often present, lorica is smooth and transparent; appears as one piece [22].

Phylum	:	Rotifera
Class	:	Monogononta
Order	:	Ploima
Family	:	Brachionidae
Genus	:	*Brachionus*

H. Filinia

Key to the Species: Has spine lets on the bristles in the summer in the Great Lakes [22].

Phylum	:	Rotifera
Class	:	Monogononta
Order	:	Flosculariaceae
Family	:	Filinidae
Genus	:	*Filinia*

2.3 Counting

The quantitative enumeration of the zooplankton was carried out with the help of a Sedgwick-Rafter (S-R) counting cell which is 50 mm long, 20 mm wide and 1 mm deep. Before filling the SR cell with sample, the cover glasses were diagonally placed across the cell and then samples were transferred with a large bore pipette so that no air bubbles in the cell covers were formed. The S-R cell was let stunned for at least 15 minutes to settle zooplankton. Then plankton on the bottom of the S-R cell was enumerated by compound microscope. By moving the mechanical stage, the entire bottom of the slide area was examined carefully. To achieve a random sampling, each time 3 fields were examined for each sample and an average of the counts had been recorded. The organisms thus counted, were expressed as cells per liter (cells) of the sample. From each sample 20 cells counts in 3 slides have been made to achieve random counts and an average of the counts has been recorded. Number of plankton (Zooplankton) in the S-R cell was derived from the following formula.

$$No./ml = \frac{C \times 1000\, mm^3}{L \times D \times W \times S}$$

Where, C = Number of Organisms Counted; L = lengthof each strip (S-R cell length) in mm; D = depth of a strip (whipple grid image width) in mm; S = number of strips counted. The number of cells per mm was multiplied by a correction factor to adjust the number of organisms per liter [23].

2.4 Physicochemical parameters

The physicochemical parameters such as temperature, transparency, pH, free carbon dioxide (CO2), dissolve oxygen (DO), alkalinity, hardness and salinity were measured during the study period. Similarly, total alkalinity, total hardness, nitrates and phosphates were also analyzed following the standardized methods outlined in [23-24].

2.5 Statistical analysis

Correlation and regression between various water quality parameters and abundance were done using Microsoft Office Excel 2003 and SPSS 20.

3. Results

3.1. Zooplankton diversity and abundance

Both the diversity and abundance of zooplankton were identified through the present study.

3.2. Diversity of zooplankton

Zooplankton population was composed of the numbers of copepod, rotifer, cladocera, ostracoda and different crustacean larvae. A total of 8 genera were recorded from the study area. Among them 3 belonged to copepod, 2 to rotifer, 2 to cladocera, 1 to ostracoda and others crustacean larvae. *Brachionus and Filinia* belonged to rotifer. *Brachionus* was found in perineal while the genus *Filinia* was observed only in November. *Diaptomus, Cyclops and Mesocyclops* were under the group of copepod of which *Mesocyclops* was dominant. Two genera namely *Diaphanosoma* and *Daphnia* were observed belong to cladocera while only *cypris* was found under the group of ostracod.

3.3. Abundance of zooplankton

The zooplankton showed a seasonal as well as monthly variation both qualitative and quantitatively. In the present study 5 groups of zooplankton were observed these are rotifer, copepod, cladocera, ostracod and crustacean larvae. During the study period, copepod was dominant in the months of June, July, August and October and represented as 77%, 72%, 80%, and 90% respectively while rotifer was dominant in the months of September, November and December and represented as 62%, 84%, and 54% respectively of total zooplankton. Ostracod was found only in the month of August. The maximum total zooplankton abundance (18%) was found in the month of November and minimum (10%) in the month of June. These showed that there is no significant variation of total zooplankton among different months.

3.4. Correlations of total zooplankton abundance with different water quality parameters

Zooplankton abundance was positively correlated with pH, DO, salinity while negative correlations were noticed with temperature, transparency, free carbondioxide and alkalinity. Total zooplankton had significant positive correlation with pH and salinity that means pH and salinity affect the total zooplankton greatly but the study showed that the number of total zooplankton per litter may change inversely for changing the temperature, transparency, free carbondioxide and alkalinity of the water.

3.5. Physico-chemical Parameters

Variations in physico-chemical parameters at all the sampling sites of Bagmati River during the study period. The Physico-chemical Parameters such as surface water temperature (minimum 18 ºC to maximum 28 ºC), pH (7.3 to maximum 7.8), free carbon dioxide i. e. CO_2 (minimum 12 mg/L to maximum 24 mg/L), dissolve oxygen i. e. DO (minimum 4.3 to maximum 6.8), alkalinity (minimum 148 $CaCO_3$/L to maximum 261 $CaCO_3$/L), salinity (minimum 6 ppt to maximum 15 ppt) and transparency (minimum 18 cm to maximum 25 cm) were measured during the study period. We recorded the highest and lowest concentrations of both Nitrates and Phosphates in same study periods during June and September respectively. Nitrate concentrations were ranged between 0.17 mg/L-0.55 mg/L whereas the phosphates concentration varied between 0.006 mg/L to 0.025 mg/L. Also, total hardness fluctuated between 33mg/L to 75 mg/L.

4. Discussion

During the present study, a distinct fluctuation of zooplankton population in different months as well as seasons was observed during july to December, 2015. Altogether five groups of zooplankton were observed namely copepod, rotifer, cladocera, ostracoda and crustacean larvae. Among them, the percentages of copepod, rotifer, cladocera, ostracoda and crustacean larvae in the culture system were 53%, 37%, 7%, 1.3% and 1.7% respectively. The zooplankton was dominated by copepods which showed more or less two peaks in August (949 individuals/L) and in October (867 individuals/L). Rotifer and copepod were about perennial while one genus *Cypris* of ostracod was found only in August. Three genus of copepod namely *Diaptomus*, *Cyclops* and *Mesocyclops* were identified in the study area of which *Diaptomus* and *Mesocyclops* were more or less dominant while four genera of which *Brachionus* and *Filinia* under rotifer and *Daphnia* and *Diaphanosoma* under cladocera were also found during the study period. Similar observations were noted by George [25], Krishnamoorthi and Visweswara [26], Michael [27], Islam and Aziz [28], Naser [29], Ali *et al.*, [30], Banu *et al.*, [31], Chowdhury *et al*., [32] and Jana and Sengupta [33] in various habitats.

The bulk of the zooplankton consisted of rotifer, cladocera, copepod and crustacean larvae. The zooplankton showed its peak (November and December) in winter. Such peak was recorded by Menon *et al.*, [34] from a fish pond at Mymenshing. George [35] observed maximum population of zooplankton in November, January and April to September and the major pulse was in June with 1179 units/L was observed in different habitats.

Rotifer was second dominant (41% of total zooplankton) group among the zooplankton. The highest population (1137 units/L) was found in November and lowest (21 units/l) in August. Resemble finding was made by Krishnamoorthi and Visweswara [26] in Gandisagar tank in India. Islam *et al* [36], found the highest abundance of rotifer was in the month of December and the lowest in September. The peak in winter might be due to the favorable conditions of physico-chemical parameters and the availability of nutrients in the pond. During the present study, relevant Co-efficient of correlation showed rotifers had a highly significant relationship with pH (r = 0.820) and DO (r = 0.630). A significant relationship has also been observed with salinity (r = 0.447). An inverse relationship was seen in case of water temperature (r = -0.71), alkalinity (r = -0.22) and free CO2 (r = -217). Rotifers feed on phytoplankton to a great extent [26]. During the winter season, due to higher degree of photosynthesis, number of phytoplankton increased and in turn resulted in the higher production of nutrients of rotifers which might result in flourish of rotifers during winter season. Though the photoperiod was shorter in winter yet photosynthesis increased due to clear sky. Winter was supposed to be positive for plankton growth [37] and [38]. But Roy *et al* [39] reported that the rotifer population prolonged in summer and decrease in the monsoon, probably due to water movement and increased in the post monsoon. The abundance of rotifers was comparatively lower in winter. During study period the genus *Branchionus* was observed perennial which support the report of George [35], Das and Bhuiyan [40], Islam *et al.*, [36], Chowdhury *et al.*, [41] from different habitats in different condition.

Copepod was the dominant group (59%) among the zooplankton during study period. The highest density 714 (units/L) was found in August and lowest 199 (units/L) in November when pH values were found 7.2 and 7.8 and DO values were recorded 5.0 mg/L, 5.83 mg/L respectively. Copepod was totally absent in September. More or less two peaks were evident in August and October. Resemble finding was made by Krishnamoorthi and Visweswara [26] in Gandisagar tank in India in different condition. During the present study, relevant Coefficient of correlation showed copepod had a significant relationship with water temperature (r =0.262), free CO2 (r =0.144) and inversely related with pH (r = -0.829), DO (r = -0.387) and alkalinity (r = -0.117). Noticed that copepod had no relationship with salinity (r = -0.009) and hardness (r = -0.013). Roy *et al* 2008 observed a peak in the copepod populations in October and other peaks in December and July when pH values were found 8.4, 8.5 and 7.6 and DO values were recorded 5.52 mg/L, 5.61 mg/L and 5.75 mg/L. Islam *et al.* [36] observed copepod were highly abundant in monsoon and post monsoon.

Cladocera contributes 7% of the total zooplankton. The highest density 348 (units/L) was found in September and lowest 55 (units/L) in July. The members of cladocera were very poor in number.This group showed irregular pulses during the study period. Irregular pulses of cladocerons were also reported by Smyle [42] and Straskrba [43], Islam *et al* [44] in different conditions. Islam *et al.* [44] reported that the irregular pulses of cladocerans might have been caused by different duration of life span of different genus. Life span of various genera depends upon various physico-chemical factors. During the study period cladocerans were only found in the month of July, August and September. Among them highest peak was observed in September. Roy *et al* [45] reported that the cladocerans had their peak in monsoon and summer. The winter population was very poor. During the present study, relevant Coefficient of correlation showed cladocerans had a significant relationship with water temperature (r =.304), pH (r =.490) and DO (r =.314). An inverse relationship was seen in case of transparency (r =.630), free CO2 (r =.630), alkalinity (r =.630) and salinity (r =.630). It is found that cladocerans had no relationship with hardness. During field observation, the abundance of crustacean larvae was higher in the months of June, July and August while it was totally absent during the rest of the study period. Crustacean larvae showed positive correlation with temperature and free CO_2. During this study a comprehensive observation on the physico-chemical parameters and the zooplankton abundance and diversity has been made in a shrimp farm which was semi-intensive.

The abundance of zooplankton not only depends on season but also different water quality parameters. Nayar [46] pointed out that pH and dissolve organic content of water influence the abundance of rotifer population, where water temperature played a positive role. A significant relationship has also been observed with salinity (r = 0.447). An inverse relationship was seen in case of water temperature (r =-0.71), alkalinity (r = -0.022) and free carbon dioxide (CO2) (r = -217). Islam *et al*., 1974) reported the absence of *Brachionus* from acidic waters, while George (1964) reported the absence of *Brachionus* from water above pH 8.5. Lower pH value below 5 is regardless as adversive to the aquatic organisms [47]. *Brachionus* is characteristic of higher alkalinity reported by Michael [48].

5. **Conclusion**

The physico-chemical parameters and the zooplankton abundance showed some interrelationships. These relationships are helpful to understand the seasonal and spatial variation of zooplankton population. The plankton is considered to be the best index of the biological productivity and the nature of aquatic habitat. In semi intensive shrimp culture the growth of the individuals not only depends on the supplementary feed but also on the production of plankton. From the present study it is found that the zooplankton abundance varies seasonally and it showed direct or indirect relationships with the physico-chemical parameters. The peak of zooplankton population in winter may be due to the less rainfall, comparatively high dissolve oxygen (DO) content, low free carbon dioxide and high pH. During the present study, relevant Co-efficient of correlation showed total zooplankton had a highly significant relationship with pH (r =0.820) and DO (r =0.630).

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