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Biomonitoring of zooplankton to assess the quality of water in the nagpokhari of Kathmandu valley

Sunil Ram Vaidya

Department of Zoology, Tribhuvan University, Patan Multiple Campus, Lalitpur, Nepal

Abstract
Zooplanktons are heterogeneous assemblage of minute floating animal forms found in water. They may bear some locomotory structures but are not capable of propelling against the water currents. They usually act as primary consumers and constitute an important link between primary producers (phytoplankton) and higher consumers like carnivore fish in aquatic food chain. The zooplankton mainly consume primary producer and form the major food source for tertiary consumers. Certain species of zooplanktons are used as bio indicators of water quality. The estimation of plankton analysis helps in explaining the cause of color, turbidity, presence of odor, taste and visible particles in water. Thus, the present study deals with the role of biological parameter especially zooplankton community and its trophic status to assess water quality of four selected area in the Nagpokhari of Kathmandu Valley. Pollution status of pond was assessed on the basis of the Palmer's Pollution Index, Shannon Wiener Index and physico-chemical parameters. A total of 10 genera belonging to 3 groups of zooplankton were identified from the pond. Different patterns of dominance and sub-dominance of species along with physico-chemical quality observed confirms the pollution status of the pond.

Keywords: Zooplankton, Kathmandu, Palmer's Pollution Index, Shannon Wiener Diversity Index

1. Introduction
Fresh water zooplankton is an important biological component in aquatic ecosystems, whose main function is to act as a primary and secondary links in the food chain and they play a vital role in energy transfer of aquatic ecosystems [1]. Zooplanktons are the most valuable indicator of tropic status than generally has been realized, since they are larger and easier to identify than phytoplankton [2]. Zooplanktons can also be used as "bioindicators" for water pollution studies, because their occurance, vitality and responses, change under adverse environmental conditions [3]. Biological monitoring is valuable method used in conservation studies to protect and preserve the biological integrity of natural ecosystem, which includes preventive measures. Bioindicators of pollutants are useful in predicting the level and degree of the pollutants before the effects of the pollutants starts, which caused large proportions [4]. Study of these organisms is generally linked to the use of mathematical distribution [5] of these organisms in the communities to which the bio-indicator species belong [6].
Water is liquid compound and descends from the cloud as rain. It covers 71 percent of the earth's surface in form of rivers, lake and seas [7] and is useful for life survival and existence of man, all animals and plants. Water is one of the most impotent available substances on the earth. The survival and quality of human life depends up on the availability of fresh water. The aquatic animal's life directly or indirectly depends on water quality status [8]. Qualitative and quantitative analysis of different groups of organisms have led to establishment of bio-indicators, indices and systems which can be used to assess the pollution and trophic status of water bodies. Different indices [9] have been developed based on the tolerance of algae to the pollution levels [10]. Presently biomonitoring [11] and indices [12] have become an integral part of water quality assessment and forms part of many water pollution studies.
Nepal has over 6,000 rivers and streams. They support aquatic biodiversity such as fish, crab and snail species. The Nepali rivers which flow down south generated an estimated fish yield of about 25 thousand metric tonnes in 2011-12, employing about 0.6 million people, mostly women. However, planned and ongoing hydro-power dams, diversion of river waters for irrigation, and intensive farming with rampant use of pesticides will likely reduce fish yield in hilly areas and southern wetlands and endanger fish species, with implications for food and nutritional security. Kathmandu, a valley covering an area of 665 KM^2 of three districts, Kathmandu, Lalitpur, and Bhaktapur, lies at 1,300 masl and is located between latitudes 27°32'13" and 27°49'10" north and longitudes 85°11'31" and 85°31'38" east. The valley is surrounded by the Mahabharata mountain range on all sides with the highest altitude being 2,831 m. The climate is subtropical, temperate and cool-temperate, with four distinct seasons: spring from March to May; summer from June to August; autumn from September to November; and winter from December to February [13] (ICIMOD *et al.* 2007). Thus, this study deals with assessment of water quality status of 4 selected areas of Nagpokhari situated in the heart of Kathmandu using Shannon Wiener Diversity Index (SWDI) and Palmer's Pollution Index (PPI) values based on qualitative and quantitative analysis of zooplankton community and physicochemical quality of water. SWDI gives accurate value of population diversity and is applied to a large extent by limnologists.

2. Materials and Methods
The influence of pollution on the abundance of major zooplanktons like Rotifera, Cladocera and Copepod were investigated at polluted and non-polluted regions at Nagpokhari of Kathmandu Valley. The water samples were collected for physicochemical analysis from 3 different regions for 6 months (June to December 2014). The water samples were collected in

the acid washed five liter plastic containers, at early Morning 10 a.m to 12 a.m in the fourth week of every month. Separate samples were collected for DO in 250 ml. BOD bottles. The Physicochemical variations of water like DO, Temperature, pH, conductivity and total hardness were recorded. DO was fixed at the stations itself water and air temperatures were recorded with thermometer; pH was examined with the help digital pH meter in laboratory. The conductivity was recorded with the help of digital conductivity meter. The standard methods used for water analysis were according to APHA [15] in the Laboratory/Dept. of Zoology at Patan Multiple Campus, Tribhuvan University, Lalitpur. The subsurface water was sieved through plankton net no. 25 and was transferred to 200 ml plastic containers for preservation in 4% formalin solution. The formalin fixed plankton samples were centrifuged at 1500 to 2000 rpm for 8-12 min. The zooplanktons were settled at bottom, the upper water was siphoned out and diluted to concentration in such a way that they could be easily counted individually under compound binocular microscope and zooplanktons were measured and multiplied with dilution factors using Sedgwick rafter cell [14, 10, 15].

The analysis was done with the help of Sedgwick's rafter cell. The supernant water was siphoned out and the settled planktons were enumerated by 'Sedgwick-Rafter Cell' method. Identification of zooplanktons species was performed under microscope by using keys and Sladecek pollution indicator index, standard References [16]. The pollution indicator species were identified according to the standard list of pollution tolerant zooplankton index by Sladecek pollution indicator index [17].

3. Result and Discussion

Zooplankton is an important component of ecosystem; they act as primary and secondary links in the food chain [18]. The zooplankton communities are influenced by biological interactions, predation and interspecific competition for food resources [19, 20]. Zooplankton have long been used as indicator of eutrophication [21, 22]. Zooplankton constitutes the food source of organisms. It plays an important role in aquaculture, including being an indicator that determines water quality, pollution, and the state of eutrophication [23]. For understanding the health of water bodies, zooplanktons are useful as these are very sensitive to pollutants and as they act as bio indicator of water bodies.

Knowledge of the zooplankton communities and their population dynamics is a major requirement for better understanding of life processes in a fresh water body since eutrophication influences both the composition and productivity of zooplanktons [24]. Zooplankton communities are very sensitive to environmental changes and thus are of considerable potential value as water quality indicators [25]. In the present study the zooplankton were identified according to guidelines given by Ward and Wipple [4]; Ruttner-Kolisko [26]; Koste [27]; Victor and Fernando [28]; Seghal [29] and found Rotifera, Cladocera and Copepoda dominate the zooplankton population of Nagpokhari (Table 1).

The utility of zooplankton in accessing the water quality at population level was done by several workers The role of zooplankton in assessing water quality at population level had been reported by [30] (Trivedi, 2000); [31] Reddy (2002); [32] (Altaf and Muthupriya, 2002); [33] (Hiware and Ugale, 2003); [34] (Sharma, 2004); [35] (Raut *et al.* 2006); [36] (Pandit *et al.* 2007); [37] (Bhagat and Meshram, 2007); [38] (Patil *et al.* 2008); [39] (Mulani *et al.* 2009); [40] (Rajgopal *et al.* 2010); [41] (Verma *et al.* 2011) [42] (Rankhamb and Raut, 2012); [43] (Sivalingam *et al.* 2013); [44] (Shailendra Sharma *et al.* 2013).

Table 1: Quantitative Analysis of Zooplankton in Nagpokhari of Kathmandu in 2014

S. No	Month wise sampling	No of Zooplankton count/m^3	% Composition			Shannon Wiener Diversity Index
			Cladocera	Rotifera	Copepoda	
1	March	9750	62	15	23	2.2
2	April	10500	42	29	31	2.3
3	May	12750	24	23	54	2.6
4	June	8250	9	27	67	2.2
5	July	6750	11	33	56	2.5
6	August	11250	21	47	32	2.8
7	September	9179	23	47	30	2.6
8	October	6798	21	33	46	2.9
9	November	7645	31	23	51	2.8
10	December	6234	13	12	75	2.1

Water pollution is a phenomenon that is characterized by the deterioration of its quality as a result of various human activities. Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture are causing heavy and varied pollution in aquatic environment leading to deterioration of water quality and hence depletion of aquatic biota [45] (Khan *et al.* 2012). Surface water quality depends not only on natural processes like precipitation inputs, erosion, and weathering of crustal material, etc. but also on anthropogenic influences like urban, industrial, and agricultural activities [46] (Ravikumar *et al.* 2013). Therefore, scientific study needs to review strategies for conservation and better utilization of lakes [46] (Nikitaraj, 2012). In the present investigation (Table 2) maximum air temperature value recorded in Summer was 32 ^{0}C in june with seasonal mean value as 29 ^{0}C and minimum temperature value recorded in winter in October was 20 ^{0}C in December with seasonal mean temperature value as 23.25 ^{0}C. In the present investigation maximum water temperature value recorded in Summer was 32.50 ^{0}C in June with seasonal mean value as 25.87 ^{0}C and minimum water temperature value recorded in winter in was 19 ^{0}C in December with seasonal mean water temperature value as 24.25 ^{0}C. Maximum values of air and water temperatures were recorded in summer and minimum values of temperature were recorded in winter.

Similar types results were attributed by few workers at different water bodies are as Trivedi [30]; Reddy [31]; Altaf and Muthupriya [32]; Hiware and Ugale [33]; Sharma [34]; Raut *et al.* [35]; Pandit *et al.* [36]; Bhagat and Meshram [37]; Patil *et al.* [38]; Mulani *et al.* [39];

Dirican. [47]; Rajgopal *et al.* [40]; Sanyogita [48], Verma *et al.* [41], Shinde [49], Rankhamb and Raut, [42]; Sivalingam *et al.* [43]. Similarly maximum pH value recorded in summer was 8.61 with seasonal mean value as 8.4 and minimum pH value recorded in winter in October was 7.25 with seasonal mean value as 7.64. Similar types of results were attributed by Trivedi [30]; Reddy [31]; Altaf and Muthupriya [32]; Raut *et al.* [35]; Pandit *et al.* [36]; Bhagat and Meshram [37]; Patil *et al.* [38]; Verma *et al.* [41], Rankhamb and Raut, [42]. Maximum conductivity recorded in Monsoon was 2132 µm in August 2010 with seasonal mean value was 1996.25 µm value and minimum conductivity recorded in winter in December was 1080 µm with seasonal mean value 1227.25 µm. Electric conductivity showed high significant positive relationship with water temperature. Similar types of results were recorded by few workers as; Rajgopal *et al.* [40]; Sanyogita [48], Verma *et al.* [41], Shinde [49], Sivalingam *et al.* [43].

Table 2: Physicochemical estimation of Nagpokhari of Kathmandu in 2014

Months/Parameters	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Atm. Temp.	23	25	32	33	34	28	27	28	26	25
Water Temp.	18	20	24	29	30	23	22	21	19	18
pH	8.12	8.17	8.33	8.52	8.61	8.41	8.33	7.99	7.43	7.25
Conductivity	910	1100	1245	1478	1677	1890	2109	2132	1854	1643
D. Oxygen	6.5	6.3	6.8	6.83	7.18	7.13	7.28	7.43	7.58	7.73
T. Hardness	144	108	100	91	116	121	124	128	131	138

Dissolved oxygen (DO) is one of the most important and limiting parameter of water quality assessment which maintains aquatic life. It regulates the metabolic processes of aquatic organisms. In the present investigation maximum DO value recorded in winter was 9.1 mg/l in Dec.2014with seasonal mean 8.81 mg/l as and minimum DO value recorded in summer in June was 6.3 mg/l with seasonal mean value 7.12 mg/l. as 7.64. Similar types results were attributed by Lower DO in summer may be due to high temperature and low solubility of oxygen in water consequently affecting the BOD Rao *et al.* [50]. With the progress of winter, DO increase to its highest value which may be due to circulation by cooling and draw down of DO in water Hunnan [51]. Water hardness is commonly defined as the sum of the polyvalent cat ions dissolved inwater. The most common cat ions are calcium and magnesium; although iron and manganese may contribute. In present investigation maximum T. hardness value recorded in winter was 144 mg/l in Dec. 2014with seasonal mean 136 mg/l as and minimum T. hardness value recorded in summer in June was 90 mg/l with seasonal mean value 98.5 mg/l. In the present work Maximum values of TH were recorded in winter and minimum were recorded in summer. Salve and Hiwre [52] and Shinde *et al.* [49] reported that TH high in winter low in summer and monsoon season.

4. Conclusion

Thus in the present investigation it is very clear that water body is polluted as from the zooplankton analysis out of 22 recorded species 19 are Bio- indicator. Different zooplankton pollution indicator species groups from Cladocera, copepod and Ostracoda were found to polluted condition of Nagpokhari pond. This shows domination of rotifers which can be attributed with the high degree of pollution. The zooplankton found in, high pollution stress, acid stess, heavy metal stress, eutrophication stress, thermal stress, alkaline stress conditions etc. clearly indicates that water body shows moderately polluted condition.

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