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A study of Macro-Invertebrates of Bagmati River, Kathmandu, Nepal

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Abstract
In this study, the diversity and seasonal variation of benthic macro-invertebrates of Bagmati River, Kathmandu, Nepal was studied in 2007 to 2010. Five stations were selected and sampled seasonally and investigated for benthic macro-invertebrates community structure using basic statistical measurement of abundance and diversity indices to characterize the benthic macro-invertebrates. The species richness, evenness and diversity of the benthic macro-invertebrates in the study area were high and typical of a tropical fast-flowing freshwater river. Taxa belonging to 5 invertebrate groups were recorded: insect nymphs/larvae (18 taxa), Oligochaete worms (3 taxa), leeches (3 taxa), snails (2 taxa) and bivalves (1 taxon). Altogether 27 taxa were identified from five sampling sites of Bagmati River. Their population remarkably declined from Gokarna to Chovar. The test indicated that the abundance of Dipterans and Ephemeroptera at station 3, 4 and 5 respectively were the source of the significant ($p<0.05$) difference.

Keywords: diversity, macro-invertebrates, Bagmati river, Kathmandu valley, Nepal

1. Introduction
Benthic macro-invertebrates are organism over 1mm in size and these include bottom dwellers. Benthic macro-invertebrate fauna often referred to as bottom fauna. Benthic macro invertebrates are the organisms that live underwater in streams and rivers, lack of a backbone, and can be seen by the naked eye [1]. There are different types of macro invertebrates such as dragonfly larvae, mosquito larvae, water fleas, beetles and snails. Some of these are sensitive to pollution whereas others can live in much polluted waters [2]. Benthic macro-invertebrates are most commonly used tool in biomonitoring. They are invertebrates that inhabit the bottom substrates such as sediments, rocks, snags and aquatic plants, of aquatic habitats for at least part of their life cycle [3]. There are several advantages of using benthic macro-invertebrates for assessing water quality. Aquatic benthic macro invertebrates are diverse group of animals. They are important food source for aquatic predators such as fish, amphibians and birds. Benthic macro invertebrates exist within a certain range of environment and as such, their adjustments with polluted and clean water also vary [4]. The presence of some specific species of benthic invertebrates is an indicator of clean, unpolluted water, while some other species thrive well in polluted water. Due to these characteristics, macro-invertebrates are commonly used to evaluate the ecological integrity of streams and as indicators of water quality assessment [5].
Benthic macro-invertebrates are largely non-mobile. Their life-span is long enough to allow elucidation of temporal changes caused by disturbances, whilst short enough to ensure observation of recolonisation patterns following such a disturbance. These organisms are also easy to sample and identify. Benthic macro-invertebrates therefore, act as continuous monitors of the water they inhabit [6], enabling long-term analysis of both regular and intermittent discharges, variable concentrations of pollutants, single and multiple pollutants, and synergistic or antagonistic effects. The use of biota as indicators of stress in the ecosystem has proven successful and indices based on macro-invertebrates assemblages have proven to be useful measures of river health and are widely applied today [7]. Apart from their use as long term indicators of water quality, benthic macro-invertebrates have attracted a lot of interest among biologists in view of their importance in food chain of fishes and other vertebrates [8]. These organisms play a vital role in the circulation and recirculation of nutrients in aquatic ecosystems. They constitute the link between the unavailable nutrients in detritus and useful protein materials in fish and shellfish. Most benthic organisms feed on debris that settle on the bottom of the water and in turn serve as food for a wide range of fishes [9]. The aim of the present study is to provide some baseline information on the composition, distribution, taxa richness, general diversity and dominance of the benthic macro-invertebrates in the river and also to assess the quality of the water using benthic macro-invertebrates as bio-indicators.

2. Materials and methods
2.1 Study site
The study has been conducted in the Bagmati River, Kathmandu Valley, that lies in the central region of the Mahabharat hills. It is located between 27°32’13” and 27°49’10”N latitudes and 85°11’31” and 85°31’38”E longitudes. Sampling sites at Bagmati River were selected randomly**.** Five sites were selected on the basis of differences in substratum, topography, abiotic and biotic factors and water pollution.
Site 1. Gokarana: It is located near the Gokarna village east of Gokarna temple from where Bagmati river enters in the valley. There are few local residents and no visible point

sources of pollution besides human activities like washing and bathing. It extends about 17-18 km. from the source i.e. Baghdwar. The substratum is composed of fixed rocks, stones, gravels and dirty sand.

Site 2. Bagmati bridge: It is located after the Bagmati bridge near the Tilganga Eye Hospital, about 21km from the source. The water is contaminated with the ash of cremated human bodies. The substratum is composed of pebbles, coarse and fine sand with silt. Before reaching the Bagmati bridge the river receives the effluents from small carpet industries of Boudnath and Chabhil and also the untreated sewage of this part of the city, thereafter, the river receives more than fifteen sewage, household outlets, a lot industrial wastes, cremation left outs, and huge piles of solid wastes damaging the aquatic environment.

Site 3. Shankhmul: It is located just before the confluence of Manohara and Bagmati. Here the anthropogenic activities are higher than the site no.1. The site receives huge amount of effluent from sewages being surrounded by dense human population. Human activities like collection of sand from the river bed and waste disposal are common here. The flow rate of water becomes slower than site no. I. The substratum is composed of sand, silt and a variety of disposables. This site is approximately 26 km. away from source.

Site 4. Teku: It is located near the Bagmati Bridge. There are series of temples and human residences on the north bank of river but on the south bank a few human settlements and agriculture land are situated. Effluents from carpet factories, other small factories as well as untreated sewage of Thapathali, Teku and Kopundole are poured here. Activities like bathing and washing are performed aptly. The river is about 6-7 meters wide, flow rate is low and substratum is composed of muddy sand and disposables.

Site 5. Chovar: It is often regarded as the gorge of river as the outlet to the valley, located near the Ganesh temple (Shidhi Binayak Mandir). The famous Mahendra cave is also situated on the western bank of river. It is about 32 km south from the source. Human activities like washing, bathing clothes and fishing (only during rainy season) were observed. The substratum is composed of muddy sand, silt and gravel.

2.2 Biological sampling

Estimation of the habitat composition

Before sampling, the site protocol-especially the estimation of the coverage of habitats was completed. If the estimation of the coverage of habitats needed to be corrected, e.g. due to hardly visible parts of the river bed, this was done during the sampling procedure. After sampling, the estimated coverage of substrates was revised for accuracy and completeness. Based on the habitats listed, the coverage of all habitats in the river channel with at least 5% cover was recorded to the nearest 5% interval. The presence of other habitat less than 5% was indicated by cross.

Quantitative sampling

A Multi-Habitat Sampling (MHS) [10] is considered as fundamental requisite of multi-metric assessment approaches that evaluate the ecological status of rivers. A sample in MHS includes 20 sampling units taken from all habitat types at the sampling site, each with a share of at least 5% coverage. A total of 20 samples were taken and a single composite was prepared.

An AQEM/STAR net sampler with 500 micron mesh size was used for sampling. This sampler was specially developed for multi habitat sampling and preferred than surber sampler because it reduces the amount of sediments in a sample and hence the time for sorting. The net is attached to rectangular metal frame of size 25x25 square cm. the opening of the net was placed opposite to the flow of the river vertically on the stream bed. The substrate was disturbed by hands up to varying depths depending upon the sampled substrate in order to dislodge the animals from the substrate.

2.3 Sample processing

Samples were transferred from the net to sample container and preserved in 4% formalin to cover the sample completely immediately after collection. This form of fixation is important to prevent carnivores, particularly stone flies, beetles and caddis larvae from eating other organism. Forceps were used to remove the organisms from the dip of net. The sample container was closed tightly. The sample was stored cool. Site location was placed outside of the container with date.

2.4 Laboratory methods

Samples were kept for at least a week to allow the specimens to fix in the formaldehyde solution. After that the sample was thoroughly washed in different mesh size and transferred into different white enameled tray for sorting. The specimens were sorted and kept in different petri-dish. The sorted biological specimen was identified up to family level by referring to various identifications keys [11]

3. Results

The results on the examinations of water for benthic fauna are given below. Taxa belonging to 5 invertebrate groups were recorded: insect nymphs/larvae (18 taxa), Oligochaete worms (3 taxa), leeches (3 taxa), snails (2 taxa) and bivalves (1 taxon). Insect nymphs/larvae were predominantly present in the Bagmati River and its tributaries. In particular, the blood worms (midge larvae, Chironomids) were recorded at all five sampling sites. Midge larvae are regarded as pollution-tolerant macro-invertebrate species [12]. Their presence in the aquatic habitats combined with the absence of pollution sensitive species, i.e. mayflies (Ephemeroptera) and stoneflies (Plecoptera), reflected the poor water quality of river. These were recorded in Gokarna (site no.1) only.

Altogether 27 taxa were identified from five sampling sites of Bagmati River (Table 1). Their population remarkably declined from Gokarna to Chovar. The taxa were *Acroneuria sp. (*Perlidae), *Alboglossiphonia heteroclite* (Lnnaeeus, 1761), *Alboglossiphonia weberi* (Blanchard, 1897), Aeshnidae, Amblemidae, Ampullariidae, Apataniidae, Ancylidae, *Allonais paraguayensis* (Michaelsen, 1905); *Amynthas corticis* (Kienberg, 1867); *Allonais inaequalis* (Stephenson, 1911); *Asiaticobdella birmanica punyamataensis* n, sp., *Asiaticobdella birmanica birmanica* (Blanchard, 1894) *Asiaticobdella fuscolineta* (Moore, 1924); *Baetis sp.* (Baetidae), *Baetiella sp.* (Baetidae), *Barbronia wemeri* (Blanchard, 1897), *Barbronia nepalensis meghalayaensis* n.

sp.; *Barbronia nepalensis nepalensis* n.sp.; *Barbronia wemeri* (Blanchard, 1897); Calamoceratidae *Calicneuria sp.* (Perlidae), Calamoceratidae, *Caridina cf. nilotica; Capniidae*; *Dendrodrilus rubidus* Savigny, 1826, *Dero cooperi* Stephenson, 1932, *Dero dorsalis (*Ferroniere, 1899), *Dero digitata* (Muller, 1773) etc.

4. Discussion

Aquatic benthic macroinvertebrates are diverse group of animals. They are important food source for aquatic predators such as fish, amphibians and birds. Benthic macroinvertebrates exist within a certain range of environment and as such, their adjustments with polluted and clean water also vary. The presence of some specific species of benthic invertebrates is an indicator of clean, unpolluted water, while some other species thrive well in polluted water. Due to these characteristics, macro invertebrates are commonly used to evaluate the ecological integrity of streams and as indicators of water quality assessment [13]. Distribution, density and biomass of benthic organisms depend upon the physico chemical characteristics of water, the nature of sediments or substratum, biological complexes such as food, predation and other factors. Changes in presence/absence, numbers, morphology, physiology or behavior of these organisms can indicate that the physical and/or chemical conditions are outside their preferred limits. Presence of numerous families of highly tolerant organisms usually indicates poor water quality [14]. The macroinvertebrates are sensitive to organic pollution, thermal impact, substrate alternation and toxic pollution of lakes, reservoirs, rivers, streams and other water bodies. The qualitative and quantitative changes in the benthic population have also been used as pollution indices [15].

Arora *et al.* [16] have pointed out that the bottom dwellers are important indicators of pollution. Among the benthos, sludge worm (Oligochatea and Annelida), blood worms, (diptera, insects and insect larvae) and several mollusks indicate the condition of the river, although the status of mollusks is said to be uncertain. It is clear that the counts of mollusks, sludge worms and blood worms show a definite pattern of fluctuation at different sites according to the intensity of pollution. The number of sludge worm and blood worms is also reduced correspondingly with the decline in the counts of mollusks. Highest number of sludge worms and blood worms has been recorded at sites V while that of mollusks at site I, both of which represent opposite water conditions. These conditions have a direct bearing on the benthos. The same conditions of bottom-fauna have been recorded by Motwani *et al.* [17] in river Sone.

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