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Benthic macro-invertebrates diversity as bio indicator of water quality of Godawari River in province no. 3, Lalitpur, Nepal

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Abstract
Bio monitoring is a method of using living organisms to determine the environmental condition and clean freshwater is an important natural resource for human need. A study on macro invertebrate diversity and water quality parameters were conducted in Godawari River of Lalitpur, State Number 3 of Nepal. The Godavari Spring, found 500 metres from the Botanical Gardens' main gate, is also well worth a look. Sampling was conducted on July 2018 and five sampling stations (S-1, S-2, S-3, S-4 and S-5) were selected and the distance between stations was 75 metres. Three replicates for both water quality sample and benthic macro invertebrates were collected for each sampling station. Results indicated good water quality based on WQI and A total of 1 phylum, 2 classes, 6 order, 25 families, and 1558 individuals were successfully sampled and recorded. The presence of Hydropsychidae, Baetidae, and Chironomidae with a high abundance of the families shows the potential to be used as biological indicators of a clean ecosystem. The analysis showed that the average value of Shannon Diversity Index, H' (0.28) indicates that the distribution of macro invertebrates was uniform between stations. The correlation test showed that the WQI has a strong relationship with the diversity indices involved.

Keywords: Macro invertebrates, benthic, water quality, bio-indicator, Godawari River, Nepal

1. Introduction
In any aquatic ecosystems, rivers get strongly influenced by the surrounding environment. Water quality of a river is influenced by several parameters like land use, settlement patterns, farming, and industrial activities around that river [1]. Studying macro invertebrate diversity is one of the most effective and inexpensive ways to estimate the ecological quality of the waters [2]. For instance, measurement of the physical and chemical properties of water can also be utilized to estimate its quality but such measurements cannot exactly represent the actual state of the waters [3]. Therefore it is necessary to combine physical, chemical, and biological evaluation along with other monitoring methods to provide a comprehensive picture of environmental water quality [4]. Biological monitoring using macro invertebrates has been found accurate and advantageous compared with using other organisms because macro invertebrates are extremely sensitive to organic pollutants, widely distributed, and easy and economical to sample [5].
Benthic macro invertebrates live at the bottom of the freshwater habitat substrates such as river for at least part of their life cycle and their sizes range between 200 to 500 μm [6]. Benthic macro invertebrate is a good bio-indicator based on the biological monitoring agent specified by Hellawell [7], which is easy to identify, easy to sample, and having a cosmopolitan distribution. Godawari River lies in the southern town in Godawari Municipality in Lalitpur District in the Bagmati Zone of State No 3 Nepal. The river is situated 11 km east of Lalitpur's, Lagankhe and 14 kms south of Kathmandu lies the Botanical Gardens of Nepal at Godavari Nepal.

Fig 1: Showing Godawari river of Lalitpur district in state number-3

With its rushing rivers and shady meadows it is a popular picnic spot and birds watching as well as dating spot among the teenagers and time spending area for family as well. It also has a notable collection of orchids, cactii and ferns found in this area. A quiet path leads to the Godavari Kunda, a spring where the sacred water of the Godavari River pours from the mountains can be found. A huge festival takes place at the Godawari temple once every 12 years in the autumn season pilgrims from around the country participate in the fair which named as Maha kumbhamela. From Bhadra 1st 2072 here 12 years Godawari Maha Mela is started and last for whole one month so if you planning to tour Godawari then this month may be best time to visit Godawari and take shower insacred water of Godawari Kunda. In year 2014 Dec, Nepal Government merged five Village Development Committees including Godawari to create Godawari Municipality in Nepal. In 2011, it had a population of 15,572 in 1,825 individual households in this region. It is one of the popular hiking destinations in Nepal for its rich wildlife and splendid environment. Within Nepal, Godawari is also famous for its botanical garden where different plants, birds and trees can be found.

Clean freshwater is one of the main and most important sources of living organisms [8]. Apart from water resources, freshwater including rivers play an important role as habitats, food sources, transportation, energy and recreational resources for life. Rivers are also a lotic habitat that is flowing water environment [9]. According to a report released by Ministry of Natural Resources and Environment, Godawari's community worry on water quality deterioration because of human activity and garbage disposal.

Thus, a study of benthic macro invertebrate's diversity was carried out as no previous studies have been conducted in Godawari River. Hence, this study aims to determine the water quality based on the water quality index (WQI) and also determines the diversity and abundance of benthic macro invertebrates. In addition, analysis from this study recognized certain families of macro invertebrates as a bio-indicator agent.

2. Materials and Methods

2.1 Study sites

Fig 2: Godawari River Showing in Satellite Map indicating the sample sites

The Godavari Spring, found 500 metres from the Botanical Gardens' main gate, is also well worth a look. This freshwater spring spouting ice-cold water from the Gadavari River is reputed to have been created when the Buddhist Mystic Padmasambhava struck a rock (In order to demonstrate that the ultimate truth is clear and will fulfill the people's thirst); unsurprisingly, the spring is a popular Hindu and Buddhist pilgrimage site. Those with more energy will enjoy a hike to the top of Phulchowki, the highest hill in the Kathmandu valley, to take in the views and a small Buddhist shrine at the summit. Sampling was conducted on July 2018 and five sampling stations were selected starting from upriver to downriver and the distance between stations is 75 metres. Three replicates for both water quality sample and benthic macro invertebrates were collected for each sampling station.

2.2 Benthic macro invertebrates

Benthic macro invertebrates were sampled after the sampling of water quality. A Surfer's net was placed in the water facing the water flow and the area inside the quadrate was disturbed for 3-5 minutes. The samplings of benthic macro invertebrates at each of the five stations were done in triplicate. Samples trapped in the net were transferred to a tray for cleaning. Samples then were filtered to remove impurities and transferred into a labelled plastic sample

containing 70% ethanol. In the laboratory, the samples were sorted from substrates and debris using forceps and white background tray. Benthic macro invertebrates were then transferred into the bottles containing 70% ethanol. The identification of benthic macro invertebrates was done under stereo microscope and using the reference books such as Merritt and Cummins [10], Throp & Covich [11], Yule & Yong [12] and Suren A.M., (1994) [13].

2.3 Water quality parameters

There are six main parameters which are emphasized in this study namely pH, dissolved oxygen, biological oxygen demand (BOD5), chemical oxygen demand (COD), ammoniacal nitrogen (NH3-N) and total suspended solid (TSS). These parameters are used in calculation of Water Quality Index (WQI). In situ parameters were taken by using YSI Pro Series multi probe parameter reader. The parameters are temperature, pH, dissolved oxygen and conductivity. Ex situ parameters such as biological oxygen demand (BOD5), chemical oxygen demand (COD), ammoniacal nitrogen (NH3-N) and total suspended solid (TSS) are done in the laboratory. All samples were preserved with ice (<4 °C) before being taken to laboratory for analysis. COD was measured using reactor digestion method, while ammoniacal nitrogen was measured using Nessler's Method [14] (APHA, 1992). TSS analysis was done using gravimetric method [15] (HACH, 2007) and 1 Litre of water was used since the water was clear.

3. Results and Discussions

The total number of individuals sampled was 1558 individuals (Table 1). In general, there are four dominating orders which are Trichoptera, Diptera, Ephemeroptera, and Coleoptera from Class Insecta of phylum Arthropoda. According to Albert *et al*., [16] (2008) Hydropsychidae is a family of Trichoptera order that do not have any case and this family traps food by constructing nets. This family tends to inhabit moderate to fast flowing waters with stable substrata such as rocks, boulders, or submerged logs. Next, Chironomidae is the second most represented family in the sample. Chironomidae is one of the important aquatic insects which have a high density and diversity (Merrit, 1984) [17]. Cranston (2004) [18], mentioned that Chironomidae are extremely important ecologically due to their abundance and diversity and presence in lotic and lentic habitat. Although Chironomidae known as tolerant family [19] (Ahmad *et al*., 2013), previous studies showed Chironomidae also recorded [20]. Three main genera dominating Chironomidae population in sample are *Microtendipase* spp, *Polypedilum* spp., and *Cricotopus* spp. According to Rosenberg [21], though Chironomidae is a pollution resistant organism, these three genera are usually found in sandy substrate areas and are among the only genera that can only live in a clean area.

Small invertebrates are functionally important in many terrestrial and aquatic ecosystems [22]. In freshwater sediments, benthic invertebrates are diverse and abundant, but they are often patchily distributed and relatively difficult to sample, especially when they live in deep subsurface sediments. Thus, the species richness and functional importance of freshwater benthic invertebrates generally go unnoticed until unexpected changes occur in ecosystems.

Unanticipated changes in freshwater ecosystems are often due to alterations in the complex connections among sediment-dwelling species and associated food webs [23] or to disturbances, such as floods or drought [24], that alter the species composition of the benthos. In addition, benthic species can themselves constitute a disturbance, such as when they transmit diseases. For example, certain benthic invertebrate species serve as parasite-transmitting vectors; if these invertebrates increase in abundance in river sediments, they may spread a lethal disease to trout, causing trout populations to decline [25]. Fish kills may also occur because of increased accumulation of nutrients, which cause formation of toxic algal blooms, deoxygenation of deeper, density-stratified waters, and high concentrations of ammonia or hydrogen sulfide [26].

Table 1: Total number of benthic macro invertebrates by different stations (S) of Godawari River

Family	S1	S2	S3	S4	S5	Total
Astacidae	4	4	4	4	4	20
Atyidae	4	4	4	4	4	20
Baetidae	55	11	1	51	36	154
Chironomidae	151	173	132	153	186	795
Cossidae	0	0	0	1	0	1
Dytiscidae	12	0	1	1	0	14
Elmidae	8	0	1	1	1	11
Ephemerellidae	4	0	1	1	0	6
Gyrinidae	0	0	1	3	5	9
Heptageniidae	6	0	1	1	1	9
Hydrophilidae	6	0	1	1	1	9
Hydropsychidae	76	12	64	41	62	255
Leptoceridae	3	0	0	2	0	5
Leptophlebiidae	3	3	9	5	0	20
Palaemonidae	4	4	1	0	0	9
Perlidae	13	19	17	15	6	70
Perlodidae	2	0	2	1	0	5
Philopotamatidae	1	0	0	2	0	3
Phryganeidae	2	0	1	1	0	4
Psychomyiidae	3	3	2	1	0	9
Pteronarcyidae	2	0	0	2	0	4
Scirtidae	1	0	1	1	0	3
Sericostomatidae	3	8	2	1	0	14
Siphlonuridae	2	0	2	2	0	6
Tipulidae	49	14	19	18	3	103
Total	414	255	267	313	309	1558

Benthic macro invertebrates burrow deeply into layered sediments and accelerate nutrient cycling. Burrowing bivalves, crayfish, tubificid worms, and aquatic insect larvae mix the sediments, aerate deeper layers of sediments, and increase rates of recycling of macronutrients (Nitrogen, phosphorus, and organic carbon) and micronutrients (trace elements) by bioturbation and fecal production. Mysid shrimp, amphipods, and gastropods enhance microbial growth and nutrient cycling through their mixing of surface sediments and breakdown of organic detritus.

Table 2: Average value of physico-chemical parameters by different stations (S) of Godawari River

Parameter	S-1	S- 2	S- 3	S-4	S-5	Mn±SE
Temperature (˚C)	25.3±0.12	25.3±0.12	25.2±0.12	23.5±0.12	23.4±0.12	24.54±0.12
Conductivity (µS/cm)	47.13±0.07	45.34±0.13	46.17±0.12	47.11±0.07	47.33±0.17	46.62±0.11
pH	6.96±0.17	6.97±0.11	6.94±0.13	6.93±0.18	6.63±0.01	6.96±0.18
Flow (m/s)	1.38±0.91	1.75±0.17	1.38±0.35	1.32±0.01	1.38±0.31	1.42±0.31
DO (mg/L)	6.04±0.21	6.25±0.13	6.65±0.18	6.71±0.08	6.37±0.21	6.44±0.08
TSS(mg/L)	0.47±0.85	0.97±0.25	0.79±0.21	0.28±0.85	0.97±0.45	0.66±0.15
BOD_5(mg/L)	2.47±0.23	2.29±0.66	2.21±0.26	2.55±0.23	2.34±0.25	2.37±0.26
COD(mg/L)	0.01±0.06	0.09±0.16	0.19±0.16	0.02±0.27	0.28±0.04	0.11±0.14
NH_3N(mg/L)	0.05±0.05	0.04±0.05	0.04±0.05	0.06±0.02	0.03±0.03	0.04±0.03

Table 2 shows the average value of physico-chemical parameters for Godawari River. The average values of each parameter are dissolved oxygen (DO) 6.44±0.08 mg/L, pH 6.96±0.18, temperature 24.54±0.12˚C, conductivity 46.62±0.11 µS/cm, flow 1.42±0.31 (m/s), and total suspended solid (TSS) 0.66±0.15 mg/L. Based on physico-chemical parameters data for Water Quality Index, (BOD_5, COD, pH, NH_3N, TSS, and DO), one-way ANOVA test were conducted, and the results showed that all the data had no significant difference ($p < 0.05$).

Correlation test was conducted to analyse the relationship between benthic macro invertebrates and water quality. Results show that Shannon diversity index has a positive and strong correlation with WQI ($r = 0.846$, $p = 0.07$). According to Ahmad *et al*, [27] (2002), in general, most diversity indices will indicate changes in value based on WQI value changes. This is because theoretically, diversity index has a positive relationship with the water quality index (WQI).

4. Conclusion

Based on the results of the study, it can be concluded that Sungai Kisap has good water quality and classify in Class I based on Malaysia Water Quality Index (WQI). Sungai Kisap also has a high diversity and abundance of benthic macro invertebrates. Families such as Hydropsychidae (Trichoptera), and Chironomidae (Diptera) are able to serve as biological indicators for clean river ecosystems.

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