# Water quality assessment of Ninglad stream using benthic macroinvertebrates☆

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**Abstract**

Ninglad stream of city Bhowali, Uttarakhand (India) was chosen to assess the impact of organic pollution from the city on the water quality and the dilution/self-cleansing effect of further joining of tributaries as river flows and traverse a course of 8 km from the city Bhowali to d/s of Kainchi temple. The present paper reports the sampling, pre-identification and complete identification of macroinvertebrates together with measurement of physico-chemical parameters and calculation of % abundance of families of various macroinvertebrates taxonomic groups, identified upto family level, from both the sites. The water quality was assessed using Nepalese biotic score system as well as national sanitation foundation water quality index. A comparison of both the system revealed the same water quality classes indicating the complete applicability of NEPBIOS as a tool for assessment of ecological status of stream & rivers in Hindu-Kush Himalayan (HKH) region. However, the development of a bio-assessment tool for India is being developed because different macro-invertebrate taxa is available in different parts of the country. The taxonomic keys based on macro-invertebrate taxa being developed for HKH region in particular and for India in general will be a valuable tool for assessing the water quality of stream & rivers in minimum time and with least cost in comparison to physico-chemical methods needing much time and costly equipment. [Life Science Journal. 2008; 5(3): 67 – 72] (ISSN: 1097 – 8135).

**Keywords:** biomonitoring; bioindicator; Nepalese Biotic Score; average taxon; per taxon; NSFWQI

## 1 Introduction

The biomonitoring is used to measure the response of aquatic communities to anthropogenic stressors like energy source, water quality, habitat quality, flow regimes and biotic interactions. The toxic substances, urban influences, sedimentation and flow regulation are some of the stressors that impact the water quality considerably. The benthic macroinvertebrates have been found as the most common faunal assemblages for bioassessment and provide more reliable assessment of long term ecological changes in the quality of aquatic system compared to its rapidly changing physico-chemical characteristics. Well developed water quality monitoring programs involve the measurement of physical, chemical and biological parameters and provide valuable information on the impact of water quality on the benthic macroinvertebrates which respond differentially to biotic and abiotic factors in their environment and consequently, the structure of macroinvertebrate has long been used as bio-indicators to assess the water quality of a water body[1–2]. Numerous biotic index systems have been developed each assigning the numerical scores to specific "indicator" organisms at a particular taxonomic level. The presence/absence, numbers (% abundance), morphology, physiology or behavior of these indicator organisms can significantly predict the physico-chemical conditions defining the status of given water body at a given location e.g. the presence of numerous families of highly tolerant organisms is usually an indication of poor water quality[3–8]. The advantage of macroinvertebrates as bio-indicators inhabiting the lakes, reservoirs, rivers, streams and other water bodies are that they are visible to unaided eyes and can be retained by a sieve having a mesh size of 500 μm pore diameter, have sedentary and long life span and are significantly sensitive to organic pollution, thermal pollution, substrate altera-

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tion and toxic substances. The qualitative and quantitative changes in the benthic communities have also been used as a tool for checking pollution through the use of indices[6–7]. Sharma *et al* (2006), have conducted the bioassessment of Behta River with benthic macroinvertebrates using Nepalese Biotic Score (NEPBIOS) and National Sanitation Foundation Water Quality Index (NSFWQI) system to see the impact of slaughter house located on the bank of river.

In view of the above, the present paper attempts to assess the water quality of Ninglad stream at two station and to further test the validity / applicability of NEPBIOS by NSFWQI.

## 2 Materials and Methods

### 2.1 Sampling site

The Ninglad stream, an important tributary of river Kosi, is located in subtropical pine forest ecoregion in Nainital District of Uttarakhand state (Figure 1). Total catchments area of the Ninglad stream is about 22.20 km$^2$. Two sampling sites were chosen for water quality assessment, one at upstream and another at down stream of Kanchi Temple.

The details of both the sites are given as below:

Station 1: Down stream of city Bhowali: The global positioning system (GPS) informations of the site in terms of longitude, latitude and altitude are 79º30'42", 29º23'24" and 1631 m respectively. The stream carries the effluents of the Bhowali city and consists of large amount of suspended particles. The foam is easily detectable and the riverbed and the river banks are characterized by huge amount of waste (including slaughter house waste). Average stream width is 3.5 m, mean depth 8 cm and mean current velocity 35 cm/s.

Station 2: Eight km d/s of city Bhowali d/s Kainchi Temple: The GPS informations of the site in terms of longitude, latitude and altitude are 79º30'30", 29º25'44" and 1300 m respectively. Average stream width is 10 m, mean depth 25 cm and mean current velocity of 40 cm/s. The water carries small amount of foam and suspended solids.

### 2.2 Method

A sample consists of 20 sub-samples each of 0.25 m × 0.25 m collected from all microhabitat types. The sam-

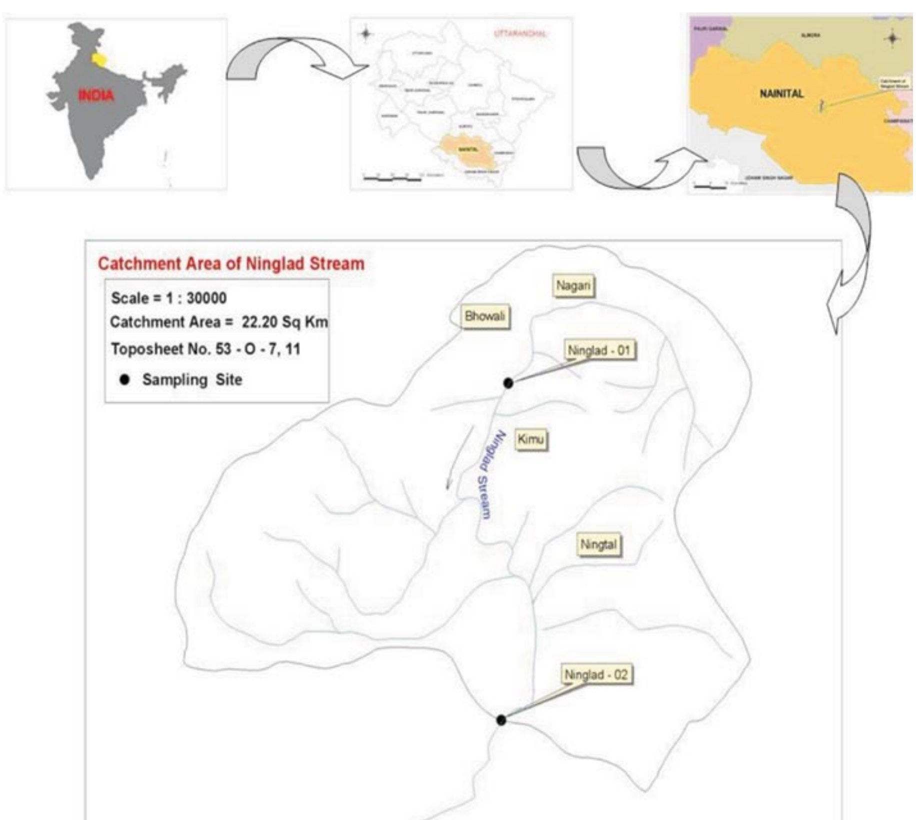


**Figure 1.** Location map of Ninglad Stream in district Nainital

pling was done using for 1.25 $m^2$ stream bottom area using net of 500 µm mesh size for collecting the macroinvertebrates. Each pickable large boulder or cobble in the area was picked up and organisms washed vigorously by hand into the net. Finally, the substrate with smaller boulders was disturbed by kicking by feet 3 – 4 times such that the organisms are collected into the net. The organisms were carefully picked up from the net and finally preserved immediately in 80% ethanol or 4% formaldehyde solution.

The macroinvertebrates so collected were sorted and identified to operational taxonomic level i.e. upto family level using regional keys in the laboratory and microscope for identifying the fauna[8,9,11–13]. The samples were collected in plastic container and analyzed for physico-chemical parameters using standard methods[14] and the results are reported in Table 1. The samples for microbiological examination were collected in sterilized & dried non-reactive Borosilicate glass bottles.

## 3 Results and Discussion

The physico-chemical microbiological parameters as reported in Table 1 were used for computing NSFWQI to assess the water quality classes.

The NSFWQI, being used since long for the development of standards, testing of products and certification services in the area of public health, safety and protection of the environment, calculates mathematically a single value from the weightage computed for various parameters. The index is rated from 0 to 100 to rate the water quality with 100 being the highest possible score representing excellent water quality and 0 – 25 as the bad quality. Table 2 gives the index rating for different water quality classes.

It is found that NSFWQI at station 1 has been calculated as 69, which is indicative of water quality class III (moderately polluted) while at station 2, it is 80 representing water quality class II (good quality). Regarding the biological parameters, the common and dominant families of macroinvertebrates of each group found are given in Table 3 and NEPBIOS[15] has been calculated using NEPBIOS keys. Figures 2 & 3 give % abundance of macroinvertebrates at station 1 & 2 respectively.

NEPBIOS biotic index system has been developed based on the Nepalese taxa and calculated average score per taxon (ASPT)[15]. The ASPT results of station 1 & 2 are shown in Figures 2 and 3 respectively. Based on the presence of macroinvertebrates families, the water quality has been calculated using NEPBIOS as per procedure described in our earlier paper[10].

On the basis of NEPBIOS, the macroinvertebrates species present in the samples of the station 1 shows water quality class III while the species present in the samples of the station 2 indicated the water quality class II. This

**Table 1.** Physico-chemical and biological parameters measured at sites

| Parameters | Units | Station 1 | Station 2 |
|---|---|---|---|
| Pre-classification class | | II | II |
| Estimated discharge | L/s | 19.6 | 199.39 |
| Temp. (Water) | °C | 16 | 20.8 |
| Temp.(Air) | °C | 15.7 | 19.6 |
| pH | | 8.1 | 7.3 |
| Conductivity | µS/cm | 212 | 129 |
| Turbidity | NTU | 1.16 | 0.61 |
| Oxygen content | mg/L | 8.68 | 7.76 |
| % Saturation of oxygen | | 89.5 | 100.8 |
| Alkalinity ($CO_3^{2-}$) | mmol/L | 91.4 | 68.4 |
| Total Hardness | mmol/L | 109 | 69.7 |
| Chloride | mg/L | 28.7 | 12.8 |
| Ammonium | mg/L | 0.1 | 0 |
| Nitrite | mg/L | 0.056 | 0.008 |
| Nitrate | mg/L | 1.5 | 1.2 |
| Ortho-phosphate | µg/L | 570 | 240 |
| Total phosphate | µg/L | 660 | 380 |
| BOD5 | mg/L | 6.2 | 1.1 |
| *E.coli* | *n*/100 ml | 1600 | 500 |
| TDS | ppt | 0.11 | 0.15 |
| NSFWQI | | 69 | 80 |
| Water quality class as per NSFWQI | | III | II |
| NSFWQI range | | 50 – 70 | 70 – 90 |

**Table 2.** NSFWQI

| Water quality | NSFWQI | WQ class |
|---|---|---|
| Excellent water quality | 91 – 100 | I |
| Good water quality | 71 – 90 | II |
| Medium or average water quality | 51 – 70 | III |
| Poor water quality | 26 – 50 | IV |
| Bad water quality | 0 – 25 | V |

improvement in water quality from station 1 to station 2 can be attributed to the large number of small tributaries meeting the main stream and to the self purification ability of water from station 1 to station 2.

During the study at Ninglad stream, a total of 36 families of macroinvertebrates were found. At station 1, 13 families were identified belonging to Oligochaetes, Hirudinea, Odonata, Coleoptera, Trichoptera, Diptera and an-

**Table 3.** % Abundance and NEPBIOS scores of benthic macroinvertebrates community

| S. No. | Taxonomic group | Family | | Station 1 | | | Station 2 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | No. of individual | % of abundance | NEP-BIOS | No. of individual | % of abundance | NEP-BIOS |
| 1. | Annelida | 1 | Turbellaria | | | | 16 | 2.40 | |
| | | 2 | Dugesiidae | | | | 1 | 0.15 | |
| | | 3 | Lumbricidae | 9 | 1.10 | | 3 | 0.45 | 3 |
| | | 4 | Tubificidae | 13 | 1.60 | 1 | | | |
| | | 5 | Salifidae | 1 | 0.12 | | 1 | 0.15 | 3 |
| 2 | Ephemeroptera | 6 | Baetidae | | | | 294 | 44.14 | 7 |
| | | 7 | Caenidae | | | | 17 | 2.55 | 6 |
| | | 8 | Ephemerellidae | | | | 2 | 0.30 | 7 |
| | | 9 | Ephemeridae | | | | 11 | 1.65 | 6 |
| | | 10 | Heptageniidae | | | | 53 | 7.96 | 7 |
| | | 11 | Leptophlebiidae | | | | 1 | 0.15 | 10 |
| 3. | Odonata | 12 | Gomphidae | | | | 1 | 0.15 | 4 |
| | | 13 | Aeshnidae | 1 | 0.12 | | | | |
| | | 14 | Libellulidae | 12 | 1.47 | 6 | | | |
| 4. | Colleptera | 15 | Psephenidae | | | | 4 | 0.60 | 7 |
| | | 16 | Dytiscidae | 27 | 3.31 | 4 | | | |
| | | 17 | Elmidae | 1 | 0.12 | 8 | | | |
| | | 18 | Ecnomidae | | | | 1 | 0.15 | 6 |
| | | 19 | Glossosomatidae | | | | 1 | 0.15 | 7 |
| | | 20 | Goeridae | 1 | 0.12 | 9 | 3 | 0.45 | 9 |
| | | 21 | Hydropsychidae | | | | 14 | 2.10 | 6 |
| | | 22 | Hydroptilidae | | | | 2 | 0.30 | 6 |
| | | 23 | Lepidostomatidae | | | | 4 | 0.60 | 10 |
| | | 24 | Leptoceridae | | | | 1 | 0.15 | 10 |
| | | 25 | Odontoceridae | | | | 2 | 0.30 | 5 |
| | | 26 | Psychomyiidae | | | | 2 | 6 | |
| | | 27 | Rhyacophilidae | | | | 2 | 0.30 | 8 |
| | | 28 | Uenoidae | | | | 3 | 0.45 | 10 |
| 6 | Lepidoptera | 29 | Pyralidae | | | | 3 | 0.45 | 8 |
| | | 30 | Chironomidae | 6 | 0.74 | 1 | 1 | 0.15 | 1 |
| | | 31 | Limoniidae | 9 | 1.10 | 8 | 72 | 10.81 | 8 |
| | | 32 | Muscidae | 97 | 11.90 | | | | |
| | | 33 | Simuliidae | 631 | 77.42 | 7 | 137 | 20.57 | 7 |
| | | 34 | Tabanidae | 7 | 0.86 | | 3 | 0.45 | |
| | | 35 | Pediciidae | | | | 4 | 0.60 | |
| | | 36 | Ceratopogonidae | | | | 7 | 1.05 | |

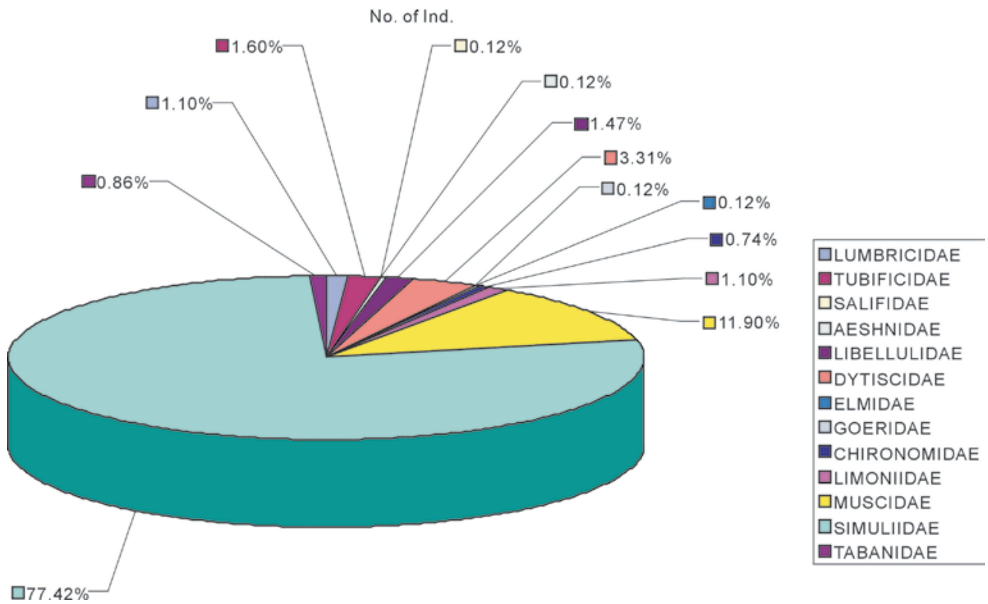


**Figure 2.** % Abundance of benthic macroinvertebrates communities at station 1

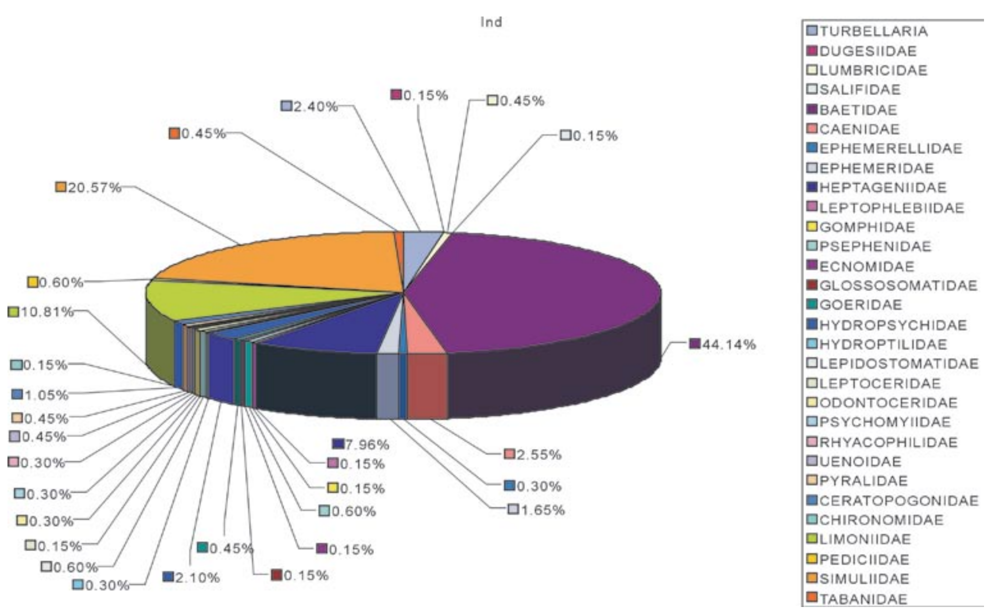


**Figure 3.** % Abundance of benthic macroinvertebrates communities at station 2

nelida, out of which the insects population belong to the order Odonata, Coleoptera, Trichoptera and Diptera, while non-insects population belong to group Annelida. The % abundance of the insecta and non-insecta was found as 97.17% and 2.83% respectively (Figure 2). Among benthic population, aquatic insects were the most dominating group of Diptera comprising 5 families. Most of these larval fauna are reported to be tolerant to varied aquatic environments[16–17]. About 92.02% of total insects population of Odonata and Coleopteran comprise two families each and Tricoptera one family only. Similarly, the Oligochates and Hirudinea are represented by two familes only.

At station 2, 31 families of macroinvertebrates were found belonging to the groups Ephemeroptera, Coeleoptera, Trichoptera, Odonata, Lepidoptera, Diptera, Annelida. The % abundance of insect population has been found as 96.84%, while non-insects as 3.15% (Figure 3). The insect population belonged the order of Ephimeroptera, Coleoptera, Trichoptera, Odonata, Lepidoptera and Diptera. The bio-assessment of water quality using macroinvertebrates and physico-chemical analysis yielded the same water quality classes i.e. class III (moderately polluted) at station 1 and water quality class II (good) at station 2. This shows that there is good similarity between these two score systems indicating that bio-assessment based on macro-invertebrates may prove to be a perfect tool for evaluating the ecological status of streams and rivers, once the taxa keys are developed on the basis of availability of macro-invertebrates taxa. The study indicates that these insects have the capability to adopt to varied aquatic environments due to their structural organization and physiology[18–19]. Success of application of NEPBIOS to these sites is attributed to the fact that the sites falls in the same ecoregions i.e. subtropical pine forest ecoregion available in India & Nepal. The development of assessment tool based on the taxa keys of HKH region (Indian part) in particular and India in general is being developed for application in wider perspective as the different population of macroinvertebrates has been found at many places.

## 4 Conclusion

The study concludes that stations 1 & 2 at Ninglad stream have been found to have water quality class III & II respectively assessed on the basis of macro-invertebrates using NEPBIOS & NSFWQI. The improvement in quality from class III (u/s) to class II (d/s) is attributed to the large number of tributaries mixing in the way as well as self purification feature of the stream. Finally, it is concluded that NEPBIOS may be suitably used as a quick and economical tools for assessing the ecological status of the streams & rivers compared to the measurement of physico-chemical parameters which is not only costly but much time consuming also. Further the development of an assessment tool for HKH region in particular and India in general is being developed due to the availability of different macroinvertebrate population in various parts of the country.

## References


1. Hynes HBB. The Ecology of Running Water. University of Toronto Press. 1972; 555.
2. Reynoldson TB, Schloessor DB, Manny BA. Development of benthic invertebrate objective for mesotrophic great lakeswaters. J Great Lakes Res 1989; 15: 669 – 86.
3. Hynes HBN. Historical Perspective and Future Direction of BIOLOGICAL Monitoring of Aquatic Ecosystem. In: Loeb SL, Spacic A (Eds). Biological Monitoring of Aquatic Systems. Lewis Publishers, BOCA Paton, FL. 1994.
4. Flotemersch JE, Blocksom K, Hutchens JR, Autrey BC. Development of a standardized large river bio-assessment protocol (lr-bp) for macroinvertebrate assemblages river. Research & Applications 2006; 22: 775 – 90.
5. Goethals P, De Nidr Pauw. Development of a concept for integrated ecological river assessment inassessment in Flanders, Belgium. J Limnology 2001; 60: 7 – 16.
6. Dhillon SS, Bath KS, Mander G. Invertebrate fauna of fresh water bodies existing in and around Patiala. Journal of Environment and Pollution 1995; 2: 163 – 7.
7. Tyagi P. Occurrence of benthic macroinvertebratres families encountered in River Hindan in Uttar Pradesh (India). J Zool India 2006; 9(1): 209 – 16.
8. Needham JC, Needham PR. A Guide to the Study of Fresh-water Biology. Reiter's Scientific and Professional Books, Washington, D.C. USA 1988.
9. Pennak, Robert W. Fresh-water Invertebrates of the United States: Protozoa to Mollusca. 3rd Ed. John Wiley and Sons, New York, USA. 1989; 628.
10. Sharma MP, Sharma S, Goel V, Sharma P, Kumar A. Water quality assessment of Behta River using benthic macro-invertebrates. Life Science J 2006; 3(4): 68 – 74.
11. Tonapi GT. Fresh Water Animals of India: An Ecological Approach. Oxford and IBH Publishing Co., New Delhi, India. 1980; 341.
12. Williams DD, Feltmate BW. Aquatic Insects. C.A.B. International, Wallingford, Oxford. 1992; 358.
13. Merrit RW, Cummins KW (Eds). An Introduction to the Aquatic Insects of North America. 2nd Edn. Kendall / Hunt Publishing Company, Dubuque 1984.
14. American Public Health Association. Standard Method For the Examination of Water and Waste Water. 20th Edn. New York, USA 1998.
15. Sharma S. Capacity Building in Community Water Quality Assessment in the Jhikhu Khola Watershed in Kaverpalanchok District of Nepal. In: Proceedings of Introduction of NEPBIOS Methods in Surface Water Quality Monitoring. Organized by International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal during May 2 – 4; 2000.
16. Bath KS, Kaur S. Aquatic insects as bio-indicators at Harike Reservoir in Punjab-India. Indian Journal of Environmental Science 1997; 2: 133 – 8.
17. Sharma S. Biodiversity of Litteral Benthic Organisms and Their Trophic Releationship With Shore Birds and Fishes in Sirpur Lake Indore Madhya Pradesh, India. M.Sc. Thesis, Devi Ahilya University, Indore 2003; 278.
18. Kumar A. Role of species diversity of aquatic insects in the assessment of population in Wetlands of Santhal Parganas (Bihar). J Environment and Pollution 1994; 1(3&4): 117 – 20.
19. Malhotra YR, Gupta K, Khajuria A. Seasonal variation in the population of macro-zoobenthos in relation to some physico-chemical parameters of Lake Mansar, India. J Freshwater Biol 1990; 2: 123 – 8.