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Assessing the Impact of Anthropogenic Activities on the Relative Density of Macroinvertebrates in a Hill Stream Located in Western Himalaya, District Solan, Himachal Pradesh, India

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ABSTRACT: Macroinvertebrates act as bioindicators and can be used for biomonitoring freshwater aquatic habitats. Therefore, the present study has been conducted to study the variations in relative densities of macroinvertebrates on moving from a pristine to anthropogenically impacted area in three selected study sites *i.e.* Barog, Bajhol and Deothal in District Solan, Himachal Pradesh and monthly sampling was done during August, 2014 to July, 2016. Maximum dipterans were recorded from Bajhol sampling site, which received agriculture runoff, industrial effluents and domestic sewage and their presence indicated pollution at this site. The least polluted site was Barog sampling site as indicated by maximum density of ephemeropterans. Deothal sampling site harboured less relative density of dipteran and ephemeropteran individuals as compared to other two study sites, but had maximum density of trichopterans.

Keywords: Macroinvertebrates, hill streams, anthropogenic, density, Western Himalaya, India.

INTRODUCTION

Anthropogenic activities have greatly affected freshwater biodiversity habitats, which have perturbed the ecological balance and resulted in loss of aquatic biodiversity (Jewitt, 2002; Hassan *et al.,* 2005). Freshwater bodies such as streams and rivers, which support high species diversity and density of biota are among the most endangered ecosystems worldwide (Armitage *et al*., 1983). The health of a stream can be determined using macroinvertebrates as they act as bio indicators and play an important role in the food chains of aquatic systems (Bode and Novak, 1995). The overall health of a stream is linked to the density, diversity, distribution and population of its benthic macroinvertebrates (Callisto *et al.*, 2007). The present study was hence carried to study the variations in relative densities of macroinvertebrates on moving from a pristine to anthropogenically impacted area.

MATERIALS AND METHODS

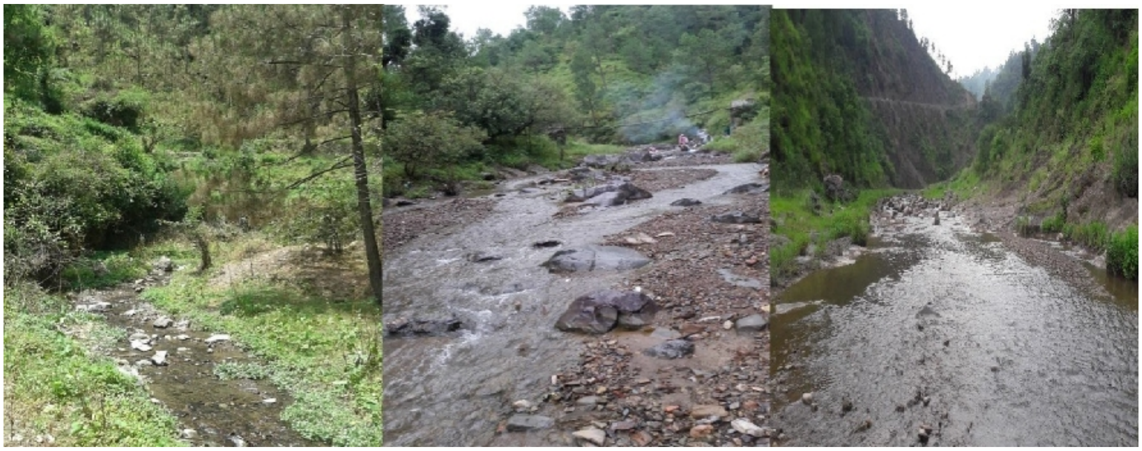
A. Study area

The present study was carried out on a stream of the Giri watershed. It is located in the mid Himalayas forming part of Shivalik ranges and drains in the vicinity of Solan City, District Solan, Himachal Pradesh, India. Three sampling sites were selected for the present studies (Fig. 1). The selection of these sites was based on the criteria of varied inputs of pollutants along the course of the stream. Monthly sampling was done for a period of two years during August, 2014 to July, 2016. Five replicates were taken from each sampling site.

(A) Barog: The study section was a small riffle close to the source of stream. It was located 300 metres from Barog railway station and 7 kilometres from Solan City at an altitude of 1529 metres and lies between30.5327 N and 77.0454 E. The stream was exposed to little anthropogenic activities like collection of potable water by the villagers and sparse cattle grazing.

(B) Bajhol: It was located about 14 km from Solan city on Oachghat-Kumarhatti state highway near Shoolini University. It is located at an altitude of 1120 m. The stream receives various other streams with pollutants, domestic sewage and industrial effluents

(C) Deothal: It was located at an altitude of 978 metres, about 20 km from Solan and 5 km from Oachghat on way to Narag. It lies between 30.53 N and 77.0937 E. The stream section was half a kilometre from a stone query and stone crusher, and fringed with sparse vegetation of bushes and grasses. The stream was exposed to various anthropogenic activities, *viz.* bathing, agriculture and stone quarry run off, water uplift for irrigation, fishing and removal of sand, stones, and gravel.



(A) (B) (C)

Fig. 1. Three sampling sites of stream near Solan, Himachal Pradesh during the study period 2014-2016- (A) Barog, (B) Bajhol (C) Deothal.

B. Macroinvertebrate Sampling

Benthic macroinvertebrates were sampled at monthly intervals over a period of two years during August, 2014 to July, 2016. Quantitative samples were taken using Surber's sampler (25 × 25cm, 625cm^2 area; mesh opening of cloth 0.4mm) (Fig. 2), which was operated by the method as given by Welch, 1948. On each occasion, five replicates of samples were obtained, which were considered satisfactory for normal quantitative studies (Dudgeon and Richardson, 1988). Sampling was carried out starting from the last sampling point on the downstream area towards the upper points. Macroinvertebrates were preserved in 4-8% formalin/ 70% ethyl alcohol. They were sorted out and identified up to species and generic/family level as morpho species. Olympus Magnus stereo microscope was used for identification of macroinvertebrates. Photographs were taken using Olympus phase contrast microscope with image analysis system (Fig. 3). The identification of the macroinvertebrates was carried out by one of the authors (JMJ), a former taxonomist of Zoological Survey of India, with the help identification keys as given in Hynes (1961), Kapur and Kriplani (1963), Ward and Whipple (1966), Hickin (1967), Kumar (1973), Kumar and Prasad (1981) and Dutta (1992). Identification of *Simulium* and odonate larvae were confirmed by M. Dutta and A. Kumar, former taxonomists of Zoological survey of India, respectively.

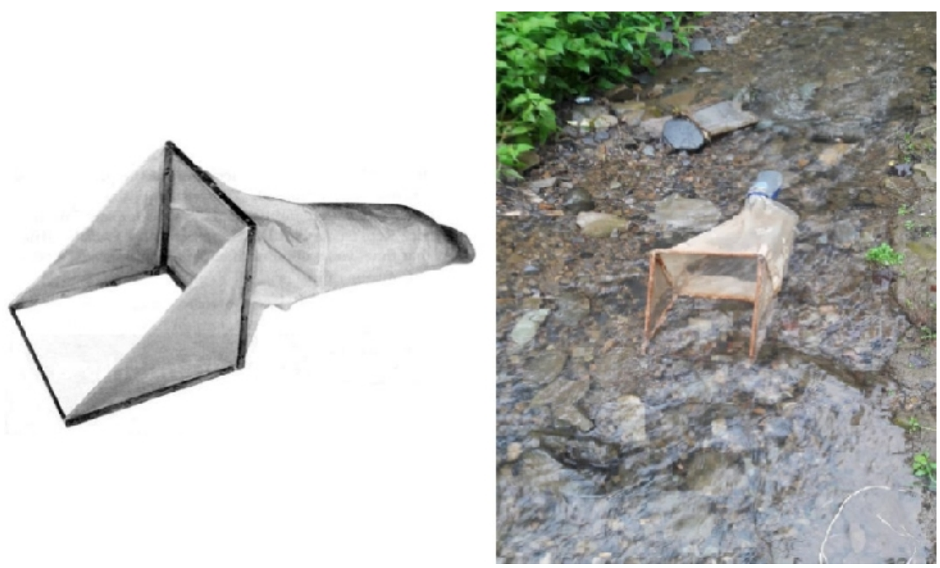


Fig. 2. Macroinvertebrate sampling using Surber's sampler.

Fig. 3. Figure displaying various macroinvertebrates under microscope: A- *Baetis* sp. B- *Caenis* sp. C- *Cryptochironomus* sp. D- *Tabanus* sp. E- *Agapetus* sp. F- *Cheumatopsyche* sp.

RESULTS AND DISCUSSION

The macro invertebrate assemblage in the stream under study was dominated by insect taxa which was in consistent with other mountain streams in the world (Hynes, 1970). Among insects, Ephemeroptera was most predominant, followed by Diptera and Trichoptera. Relative density recorded for Ephemeroptera at all three sampling sites *i.e.* Barog (71.29%), Bajhol (52.95%) and Deothal (40.03%) during two years of study in 2014-16 (Table 1).

According to Nautiyal *et al.* (2015), the streams across the Western Himalayas are typically rich in Ephemeroptera, Trichoptera and Diptera, as also elsewhere in other mountainous streams in the world (Hynes, 1970; Winterbourn and Ryan, 1994).

The sequence of their dominance, however, varied regionally depending upon riparian vegetation, land use systems, altitude, geology and physicochemical parameters of stream (Singh and Nautiyal, 1990; Julka*et al*., 1999; Habib and Yousuf, 2012; Sharma and Dhanze, 2012; Nautiyal *et al*., 2015; Singh *et al*., 2016). Plecoptera and Coleoptera can be locally abundant in some Himalayan streams (Julka *et al*, 1999; Habib and Yousuf, 2012). Higher relative abundance of Ephemeroptera was primarily due to better tolerance capacity of its constituent species not only with respect to pollution but also adjustment to changing physicochemical matrices in running waters and having diverse feeding habits (Hilsenhoff, 1998; Mackie, 2001; Habib and Yousuf, 2012).

Table 1: Relative density of macroinvertebrate groups at three sampling sites during 2014-2016.

Group	Relative density (%)		
	Barog (%)	**Bajhol**	**Deothal**
Ephemeroptera	71.29	52.95	40.03
Diptera	15.95	43.53	27.27
Trichoptera	11.27	0.96	31.81
Coleoptera	0.56	0.07	0.19
Odonata	0.63	0.13	0.12
Plecoptera	0.01	0.00	0.00
Hemiptera	0.00	1.93	0.36
Others (Crustacea, Turbellaria, Hirudinea)	0.13	0.09	0.02

Diptera was the second most dominantat Barog (15.95%) and Bajhol (43.53%), whereas at Deothal, Trichoptera was the most dominant with a relative density of 31.81%. Higher densities of Diptera are attributed to their adaptation to extreme environmental conditions and great diversity (William and Feltmate, 1992). The trichopteran larvae are adapted to live in a wide range of aquatic habitats and their maximum diversity occurs in cool waters. Non-insect groups (Crustacea, Turbellaria and Hirudinea) had very low relative densities. They together constituted 0.13%, 0.09% and 0.02% of total collected macroinvertebrates at Barog,Bajhol and Deothal sampling sites respectively.

The most common families were Baetidae (Ephemeroptera), Chironomidae (Diptera), Hydropsychidae (Trichoptera) and Elmidae (Coleoptera) and these families predominated streams in different parts of the tropics (Jacobson *et al*., 2008). Most of them tolerated wide range of environmental variations (Vannucchi, 2017). The Plecoptera, highly pollution intolerant group, declined sharply, while it wasnot encountered during the second year of sampling. They have been recognized as the first EPT (Ephemeroptera, Trichoptera, Diptera) taxa to disappear when pollution begins to occur (Fore *et al*., 1996). The dominance of Chironomidae at Bajhol could be attributed to its great colonizing capacity and tolerance to various levels of organic pollution (Kaul and Pandit, 1981). Dominant families at Deothal were Hydropsychidae and Chironomidae. Both these groups prefer silty substrates because of their functional food habits; chironomids are collector gatherers and hydropsychids are collector filterers (Cummins, 1979). Henriques-Oliveira and Nessimian (2010) and Vannucchi *et al*. (2017) correlated occurrence and predominance of the Baetidae, Chironomidae and Hydropsychidae to their tolerance of a wide range of environmental variations.

Top-ranked species or morpho species were: *Baetis* sp. 1 (39.38%) at Barog followed by *Baetis* sp. 2 (16.33%) and *Caenis* sp. (10.67%); *Caenis* sp. (40.10%) at Bajhol followed by *Cryptochironomus* sp. 1 (30.43%) and *Baetis* sp. 1 (10.31%); *Cheumatopsyche columnata* (31.67%) at Deothal followed by *Baetis* sp. 1 (20.77%) and *Cryptochironomus* sp. 1 (16.64%) (Table 2). Highpopulation of pollution tolerant taxa at Bajhol namely *Cryptochironomus* spp. and *Caenis* sp. could be related to high level of pollution leading to low level of dissolved oxygen.

Table 2: Relative density of macroinvertebrate taxa at three sampling sites during 2014-2016.

Taxa	Relative density (%)		
	Barog	**Bajhol**	**Deothal**
(A). Ephemeroptera			
Baetidae			
Baetis sp.1	39.38	10.31	20.77
Baetis sp.2	16.33	0.81	6.69
Baetiellatuberculata	0	0	0.05
Caenidae			
Caenis sp.1	10.67	40.10	4.73
Heptageniidae			
Ecdyonurus sp.1	3.25	1.64	2.15
Ecdyonurus sp.2	0.01	0	0
Epeorus sp.	0.02	0	0
Ephemerellidae			
Ephemerella sp.	1.62	0.03	0.89
Leptophlebiidae			
Euthraulus sp.	0.03	0.06	4.73

	Relative density (%)		
Taxa	**Barog**	**Bajhol**	**Deothal**
(B). Trichoptera			
Hydropsychidae			
Cheumatopsyche columnata	9.97	0.91	31.67
Glossosomatidae			
Agapetus triangularis	1.27	0.04	0.09
Philopotamidae			
Chimarra aberrans	0.01	0	0.05
Lepidostomatidae	0.01	0.01	0
(C). Diptera			
Chironomidae			
*Cryptochironomus*sp.1	4.42	30.43	16.64
*Cryptochironomus*sp.2	4.21	4.61	2.83
*Cryptochironomus*sp.3	2.28	5.50	2.95
Pentaneura sp.	3.10	1.73	1.94
Pseudochironomus sp.	0.06	0.63	0.66
Tabanidae			
Tabanus sp.	0.36	0.13	0.45
Tipulidae			
Hexatoma sp.	0.07	0	0.09
Antocha sp.	0.29	0.14	1.48
Simuliidae			
Simulium himalayense	0.45	0.36	0.04
Simulium ghoomense	0.06	0.03	0
Simulium rufibasis	0.09	0	0
Simulium digitatum	0.09	0	0
Ceratopogonidae			
Atrichopogon sp.	0.44	0	0.18
Dixidae			
Dixa sp.	0.01	0	0
Rhagionidae			
Atherix sp.	0.01	0	0.02
(D). Coleoptera			
Elmidae	0.54	0.07	0.18
Haliplidae	0.01	0	0
Hemiptera			
Micronecta sp.	0	1.93	0.36
(E). Odonata			
Epallagidae			
Bayadera indica	0.13	0	0
Gomphidae			
Burmagomphus sp.	0.51	0.12	0.12
Libellulidae	0	0.02	0.03
(F). Plecoptera			
Nemouridae			
Nemoura sp.	0.01	0	0
(G). Crustacea			
Potamidae			
Himalayapotamon sp.	0.01	0	0
(H). Platyhelminthes			
Turbellaria	0.06	0.03	0.02
(I). Hirudinea			
Glossiphoniidae			
Alboglossiphonia sp.	0.06	0.03	0

Sharma (1999) and Sawhney (2004) also linked increase in pollution tolerant Chironomidae midges to decline in DO levels in lower Himalayan streams of Jammu and Kashmir.

CONCLUSION

This study has provided a broad perspective of macroinvertebrate density of a perennial stream flowing in the vicinity of Solan town in Himachal Pradesh and western Himalayas, constituent of Himalayan Biodiversity Hotspot. The present study reveals that high relative density of dipterans at Bajhol indicates pollution at this site as compared to Barog and Bajhol. The least polluted site was Barog as indicated by maximum density of ephemeropterans. Deothal sampling site harboured less relative density of dipteran and ephemeropteran individuals as compared to other two study sites, but had maximum density of trichopterans. Biomonitoring is a tool which should be used to study the environmental condition of water bodies. Proper measurements should be taken for the abatement of pollution.

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REFERENCES

Armitage, P.D., Moss, D., Wright, JF., Furse, M.T. (1983). The performance of a new biological water quality score based on macroinvertebrates over a wide range of unpolluted running-water sites. *Water Research.* **17**: 333–347.

Bode, R.W., Novak, M.A. (1995). Development and application of biological impairment criteria for rivers and streams in New York State. Biological Assessment and Criteria. Lewis Publishers, Boca Raton, FL. 97-108.

Callisto, M., GonçalvesJr, J.F., Graça, M.A. (2007). Leaf litter as a possible food source for chironomids (Diptera) in Brazilian and Portuguese headwater streams. *Revista Brasileira de Zoologia*. **24**(2): 442-8.

Cummins, K.W., Klug, M.J. (1979). Feeding ecology of stream invertebrates. *Annual Review of Ecology and Systematics.* **10**(1): 147-72.

Dutta, M. (1992). Contribution to the knowledge of the blackfly fauna (Diptera: Simulidae) of Himachal Pradesh, India. *Proc. Zool. Soc., Calcutta*. **45**(1): 39-52.

Fore, L.S., Karr, J.R., Wisseman, R.W. (1996). Assessing invertebrate responses to human activities: evaluating alternative approaches. *Journal of the North American Benthological Society*. **15**(2): 212-31.

Habib, S., Yousuf, A.R. (2012). Benthic macroinvertebrate community of Yousmarg streams (Doodganga stream and Khanshah Manshah canal) in Kashmir Himalaya, India. *Journal of Ecology and the Natural Environment.* **4**(11): 280-9.

Hassan, R., Schole, R., Ash, N. (2005). Ecosystems and human well-being: current state and trends. Island press, Washington DC. **1**: 917.

Henriques-Oliveira, A.L., Nessimian, J.L. (2010). Aquatic macroinvertebrate diversity and composition in streams along an altitudinal gradient in Southeastern Brazil.; *Biota Neotropica.* **10**(3): 115-128.

Hickin, N.E. (1967). Larvae of British Trichoptera, Hutchinson and Co., London. pp- 476.

Hilsenhoff, W.L. (1998). A modification of the biotic index of organic stream pollution to remedy problems and to permit its use throughout the year. *Great Lakes Entomology*. **31**: 12.

Hynes, H.B. (1970). The ecology of running waters. Liverpool: Liverpool University Press.

Jacobsen, D., Cressa, C., Mathooko, J.M., Dudgeon, D. (2008). Macroinvertebrates: composition, life histories and production. *Tropical stream ecology*. 65-105.

Hynes, H.B. (1961). The invertebrate fauna of a Welsh mountain stream. *Archiv fur Hydrobiologie.* **57**(3): 344-88.

Jewitt, G. (2002). Can Integrated Water Resources Management sustains the provision of ecosystems goods and services? *Physics and Chemistry of the Earth.* **27**: 887-895.

Julka, J.M., Vasisht, H.S., Bala, B. (1999). Distribution of aquatic insects in a small stream in Northwest Himalaya, India. *Journal-Bombay Natural History Society.* **96**: 55-63.

Kaul, V., Pandit, A.K. Benthic communities as indicators of pollution with reference to wetland ecosystems of Kashmir. In Proceedings of the WHO Workshop on Biological Indicators and Indices of Environ-mental Pollution.(AR Zafar, KR Khan, MA Khan and G. Seenayya, eds.). Cent BdPrevCont Water Poll./Osmania University, Hyderabad, 1981, India, 33-52.

Kapur, A.P., Kripalani, M.B. (1963). The mayflies (Ephemeroptera) from the North-Western Himalaya. *Rec. Indian Mus.,* **59**(1&2): 183-221.

Kumar, A. (1973). Descriptions of the last instar larvae of Odonata from the Dehradun valley (India), with notes on Biology. II. (Suborder: Anisoptera). *Oriental Insects*. **7**: 291-331.

Kumar, A., Prasad, M. (1981). Field ecology, zoogeography and taxonomy of the odonatan of western Himalaya, India. *Rec. Zool. Surv. India, Occ.* **20**: 1-118

Mackie, G.L. (2001). Applied Aquatic Ecosystem Concepts. Kendall/Hunt Publishing Company. 744.

Nautiyal, P., Mishra, A.S., Semwal, V.P. (2015). Spatial Distribution of Benthic Macroinvertebrate Fauna in Mountain Streams of Uttarakhand, India. *In Aquatic Ecosystem: Biodiversity, Ecology and Conservation*. 31-51.

Sharma, I., Dhanze, R. (2012). Evaluation of macrobenthic fauna in hill stream environment of Western Himalaya, India. *Journal of Threatened Taxa*. **4**(9): 2875–2882.

Singh, D., Ahmed, R., Gupta, S., Bartwal, M., Joshi, M., Bhandari, M.S. (2016). Physicochemical profile and benthos of River Giri up and downstream Giri Barrage in Renuka, Sirmour (Himachal Pradesh). *International Journal of Scientific Research*. **5**(3): 57-62.

Singh, H.R., Nautiyal, P. (1990). Altitudinal changes and the impact of municipal sewage on the community structure of macrobenthic insects in the torrential reaches of the river Ganges in the Garhwal Himalaya (India). *Acta Hydrobiologia*. **32**(314): 407–421.

Vannucchi, P.E., Peralta-Maraver, I., Tierno de Figueroa, J.M., López-Rodríguez, M.J. (2017). Dynamics of the macroinvertebrate community and food web of a Mediterranean stream. *Journal of Freshwater Ecology*. **32**(1): 223-239.

Ward, H.B., Whipple, G.C. (1966). Fresh water Biology-second edition, edited by Edmonsdon, W.T. John Wiley and sons, Inc, New York.

Welch, P. S. (1948). Limnological methods.

Williams, D.D. (1992). Feltmate, B.W. Aquatic insects. Cab International.

Winterbourn, M.J., Ryan, P.A. (1994). Mountain streams in Westland, New Zealand: benthic ecology and management issues. *Freshwater Biology*. **32**(2): 359-73.