International Journal of Ecology and Environmental Sciences 45 (3): 00-00, 2019
ISSN: 2320-5199 (Online)

Short Communication

Community Features of Benthic Macroinvertebrates and Bioassessment of the Stretch of Bhagirathi River Impacted by Maneri Bhali Stage I Hydroelectric Project

[1]SANDEEP KUMAR AND [2] PRAKASH NAUTIYAL

Department of Zoology and Biotechnology, HNB Garhwal University (A Central University) Srinagar 246174, Uttarakhand, India
[1] sandeepkgu@gmail.com; [2] pn.mahaseer@gmail.com
* Corresponding author

ABSTRACT

Benthic macroinvertebrate community was studied in a stretch of Bhagirathi River (stations S2and S3) starved of its flow due to Maneri Bhali stage I Hydroelectric project andcompared with that in the upstream (station S1) with natural hydrological regime. Mean water temperature increased while current velocity and DO decreased from S1 to S3. The benthic density decreased significantly in the downstream station. Single benthic assemblage found at S1 indicated the stable ecosystem while varying types of assemblages at S2 and S3 depict the perturbance. Biological Monitoring Working Party Score indicated moderately impacted to polluted and polluted to heavily polluted water quality at S2 and S3 respectively as compared to moderate water quality at S1. LIFE score indicated moderate to fast-flow conditions at S1, slow to moderate at S2 and varying flow conditions at S3 during lean season. CCA separated three stations with different characteristic taxa associated with different environmental variables. Current velocity, pH and dissolved oxygen explained maximum of the variance in assemblage in CCA plot. The study indicates that urgent measures are required to improve the ecological health and integrity of the stretch deprived of its natural hydrological regime.

Key Words: Bhagirathi river; Macroinvertebrate assemblage; BMWP; LIFE; CCA

INTRODUCTION

Bhagirathi is the source tributary of the holy Ganga in the Indian Himalayan Region. Currently four HEPs are functional on ca. 130 km stretch of this river (Maneri to Devprayag) since commissioning of Maneri Stage I in 1984. Currently the river is deprived of discharge from Maneri to Dharasu, modified into a reservoir from Dharasu to Tehri/Koteshwar and carries regulated flow until Devprayag. The understanding of the consequences of a modified ecological state is of great concern to guide the decision makers on water resource. This study is restricted to the discharge-starved stretch (Maneri to Uttarkashi) and examines state of the benthic macro-invertebrate community that contributes to ecosystem processes, deriving energy from both detritus and photo-synthetic algae (Cummins 1974). Benthic macro-inverterates are widely used to assess the hydrological stress (Jalon et al. 1994), and freshwater biomonitoring (Rosenberg and Resh 1993). Past studies on benthic communities in relation to HEP focussed only on stations immediately upstream and downstream of the dam (Nautiyal et al. 1988, Singh et al. 1994 and Rajvanshi et al. 2012).

MATERIAL AND METHOD

Three sampling stations were selected in the confines of Maneri-Bhali Stage I; S1 3 km upstream of the Maneri dam, S2 5 tablekm downstream of the Maneri with meager discharge and S3, ca. 1 km below Stage I Power

House (PH) at Tiloth (left bank, Uttarkashi). Station S1 is the free-flowing section having natural flows and hence a reference site. Station S3 receives regulated flow from Tiloth PH. The slopes are forested (pine) with grasses along the lower slopes at S1 and S2. Villages occur in the vicinity of S1 and S2, Uttarkashi town at S3.

Sampling and Analysis

The river was sampled at monthly intervals from November 2016 to October 2017. Physical and chemical characteristics were determined using standard methods (APHA 1995). The riffle-pool-riffle sequence was sampled at each station with the help of D-frame kick net sampler (mesh size 500µm) to obtain the macro-invertebrate community. Ten replicates were obtained at each station (6 in riffle and 4 in the pool). The macro-invertebrate fauna was resolved at family level using standard keys (Edmondson 1959), and counted to obtain total density and percentage composition at each station. Non-parametric analyses of variance Kruskal-Wallis test was performed to assess the significant difference in median density. Bioassesssment of the river was carried out using Biological Working Monitoring Party score (BMWP). Lotic Invertebrate Index for Flow Evaluation (LIFE) scores (Extence 1999) was obtained to link the benthic macroinvertebrate data to prevailing flow regimes. Canonical Correspondence Analysis (CCA) was performed using CANOCO software for window 4.5 with the total set of samples to know the distribution and association of macroinvertebrate assemblages with the environmental variable and station.

RESULT AND DISCUSSION

Among physicochemical parameters, mean dissolved oxygen (DO) and current velocity (CV) decreased from S1 to S3, while mean water temperature (WT) and transparency (T) increased from S1 to S2 and slightly declined at S3. When compared to the past studies (Nattiyal et al. 1988 and Singh et al. 1994) the mean WT (^oC) has increased from 10.5 to 11.4 at S2, 10.1 to 11.4 at S3 while it increased from 9.8 to 10.4 at S1. Mean DO decreased from 8.6 to 7.3 mg l^{-1} at S3, 9.2 to 8.5 at S1, CV (cm s^{-1}) has decreased from 150 to 74 at S2 and 182 to 75 at S3. Median density (indiv. m^{-2}) of benthic macroinvertebrates decreased from S1 to S3 and differed significantly, p=0.0394 between stations respectively. Median density exhibited peak during December at S1 and registered gradual decline from February onwards to register a fall in July and August. However, after attaining peak (February) the density abruptly declined at S2 and S3. The mean density (indiv. m^2) has decreased from 22- 1611 to 0- 922 at S2, 20-1240 to 0- 261 at S3. However, when S1 was compared with 32 km upstream station mean WT increased from 9.8 to 10.4 and mean density increased from 82-1117 to 0-1400. The Baetidae and Heptagenidae consistently occurred at S1. In contrast to S1 the assemblage varied from month to month especially during the lean season (December-May). Two assemblages figured prominently (Baetidae-Chiro-nomidae; Chironomidae- C. red worm) at S3. It augurs that S2 is the most disturbed stretch as it has highest number of assemblages in a year attributed to varying flow. S3 is also disturbed as evidenced from blood worms forming assemblage. Baetidae prevails at S3 because of resurrected flow. Besides, Baetidae scores low in BMWP which indicate organic pollution. The plecoptera in the assemblage was absent at S2.

The BMWP score indicated moderately impacted community at S1, moderately impacted to polluted or impacted at S2 and polluted or impacted condition throughout the year and heavily polluted during few months at S3 (Table1). The polluted water quality was attributed to the sewage influx and wastes generated from rituals at Uttarkashi. LIFE score indicated moderate to fast-flow conditions at S1 as compared to slow to moderate flow conditions at S2 during most of the months. Since the sub dominant taxa (Chironomidae) have no score group the LIFE flow category at S3 was found to be of varying type. CCA eigen value of 1, 2, 3, and 4 were 0.19, 0.114, 0.076, 0.062 respectively. The matrix environmental correlation for four axes was strong (i.e. 0.85, 0.77, 0.87, and 0.67 respectively). Conditional effect showed high lambda value for three variables Current velocity (0.16; p=0.01), pH (0.14; p=0.004) and DO (0.1; p=0.002) were significant at $p<0.05$ and account for 31 % of the variations in the distribution of macroinvertebrate assemblages. CCA separated the samples in different quadrants associated with particular environmental variables. Blepharo-ceridae, Athericidae, Leptoceridae, Simuliidae, Hepta-genidae were positively correlated to CVR, pH while chironomidae red worm (CRW) and Chironomidae were located in negative association with these parameters. Tipulidae, Hydropsychidae, Limnephillidae, and Ephemerillidae, were correlated with carbon dioxide (CO_2), Total hardness (TH) and Total alkalinity (TA) in other axis.

Significantly different density, fragmented occur-rence of the assemblage, polluted water quality, slow to

moderate and varying flow conditions at S2 and S3 depicted through BMWP and LIFE scores respectively reveals perturbed state of the stretch. Variation in assemblage and density were due to major environmental factors (CVR, pH, and DO) reflected by CCA plot. Distribution of macroinvertebrate families and samples in different ordination in CCA triplot and indicates lack of similarity in the riverine ecosystem within 17 km. Moreover, the increase in WT, decrease in CVR and DO, decrease in benthic density at S2 and S3 and absence of order Plecoptera (clean water indicator) in the fauna at S2 between 1985-2018 was the notable change observed during the study. Apart from this, regular occurrence of the dominants and subdominants, moderate water quality, constant flow conditions indicates the stability in the river ecosystem and semi-natural condition at S1.

ACKNOWLEDGEMENTS

The financial assistance (NET-JRF) granted by CSIR to first author (SK) is sincerely acknowledged. We thank the head of Department of Zoology and Biotechnology for providing laboratory facilities.

Author Contributions: SK and PN conceived and designed the study; SK carried out the field work; SK identified the samples, analyzed the data and applied statistics under supervision of PN. SK and PN prepared the manuscript.

REFERENCES

APHA 1995. Standard Methods for the Examination of Water and Wastewater American Public Health Association Washington DC. Xxx pages??

Cummins, K.W. 1974. Structure and function of stream ecosystems. Bioscience 24 : 631-641.

De Jalon, D.G.; Sanchez, P. and Camargo, J.A. 1994. Downstream effects of a new hydropower impoundment on macrophyte, macroinvertebrate and fish communities. Regulated Rivers: Research & Management 9: 253-261.

Edmondson, W.T. 1959. Freshwater Biology. 2nd edn. John Wiley, New York. Xxx pages??

Extence, C.A.; Balbi, D.M. and Chadd, R.P. 1999. River flow indexing using British benthic macroinvertebrates: a framework for setting hydro-ecological objectives. Regulated Rivers: Research & Management 15: 545-574.

Nautiyal, P.; R.C. Pokhriyal,; A. Gautam,; D.C. Rawat and Singh H.R. 1988. Maneri dam on the river Bhagirathi-A lacustrine environment in the making. pp.175-182. In: S.K. Kulshreshta,; U.N. Adholia,; O.P. Jain and Bhatnagar, A. (eds.) Proceedings of the national symposium on Past, Present, and Future of Bhopal Lakes. Shaheen Printers, Bhopal.

Rajvanshi, A.; Arora, R.; Vinod, B;, Sivakumar, K.; Sathyakumar, G.S.; Rawat, G.S.; Johnson, J.A.; Ramesh, K.; Nandkishore, D. and Maletha, A. 2012. Assessment of the cumulative impacts of Hydropower projects on aquatic and terrestrial biodiversity in Alaknanda and Bhagirathi Basins, Uttarakhand. Wildlife Institute of India, Technical Report. 203 pages

Rosenberg, D.M. and Resh, V.H. 1993. Introduction to freshwater biomonitoring and benthic macroinvertebrates. p. 1-9. In: Rosenberg DM, Resh VH (eds). Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall: New York

Singh, H R,; Nautiyal, P.; Dobriyal, A.K.; Pokhriyal, R.C.; Negi, M.; Baduni, V.; Nautiyal, R,; Agarwal, N.K.; Nautiyal, P. and Gautam, A. 1994. Water quality of the river Ganga (Garhwal Himalayas). Acta Hydrobiologia 36: 3-11.

Table 1. Monthly variations in percentage composition of benthic macroinvertebrate taxa forming assemblage (Dominants, Subdominants, physicochemical parameters, median density (indiv. m^{-2}), BMWP scores LIFE flow category at three stations; BMWP score 0-10 Heavily impacted, 11-40 polluted or impacted and 40-70 moderately impacted. MF-Moderate to Fast flow, SM- Slow to moderate, F- Fast and R- Rapid)

S1	N	D	J	F	M	A	M	J	J	A	S	O	Mean±SE
Baetidae	**56**	**76**	**45**	**33**	**38**	**46**	**36**	**69**			42	46	
Heptageniidae	15	7.1	17	25	24	40	58	25		100	42	37	
WT (°c)	10.2	7.5	5.1	6.4	7.2	11.1	13.2	16.3	13.7	13	12	9.5	10.4±0.9
DO (mg l^{-2})	8.6	8.56	9.8	8.9	8.4	8.6	8.5	7.8	8.2	8.7	8.1	7.9	8.5±0.15
CVR (cm s^{-2})	65	61	62	65	67	71	91	103	103	107	105	101	83±5.6
Median density	150	**544**	439	522	539	256	67	28	0	0	56	139	
BMWP													
LIFE Category	M-F	M-F	M-F	S-M	S-M	S-M	M-F	M-F			F	F	
S2													
Baetidae	**33**	2.6	30	16	6.3	**35**	**67**	**62**			**68**	**33**	
Heptageniidae	22	11	3.8				12	38			15	50	
Chironomidae	13	17	24	14	35		17						
Hydropsychidae	17	31	23	34		24	14				4.9	13	
Limnephillidae	8	18		25	17	3.4	2.4				2.4		
WT (°c)	10	5.4	8.9	6.7	7	12.3	14.5	19.2	16.4	11.6	12	12.9	11.4±1.18
DO (mg l^{-2})	8.3	9.6	7.1	8.2	8.1	8.2	7.9	7.3	7.6	8.6	7.6	6.2	7.8±0.24
CV (cm s^{-2})	56	41	40	44	51	68	89	101	103	105	101	100	74±7.8
Median density	228	**256**	167	189	144	100	39	11	0	0	39	144	
BMWP													
LIFE Category	S-M	S-M	M-F	S-M	S-M	S-M	S-M	R			M-F	M-F	
S3													
Baetidae	**62**	**57**	**58**	**45**	**24**	**44**	**63**	**25**				**60**	
Chironomidae	24	35	14	17	40	22	13	12				40	
C. red worm	-	-	16	19	30	29	13	7					
WT (°c)	9.2	5.4	8.5	7.4	8	13	14	19.1	15.7	14.5	11.3	11.5	11.4±1.14
DO (mg l^{-2})	8.3	9.3	6.9	7.1	6.9	7.1	7.2	6.9	6.93	8.1	7.2	6.3	7.3±0.23
CV (cm s^{-2})	58	40	54	58	42	62	101	103	102	103	99	87	75±7.3
Median density	111	**300**	89	50	67	56	33	0	0	0	0	11	
BMWP													
LIFE Category	M-F	M-F	F	S-M	S-M	F	F	F			F	F	

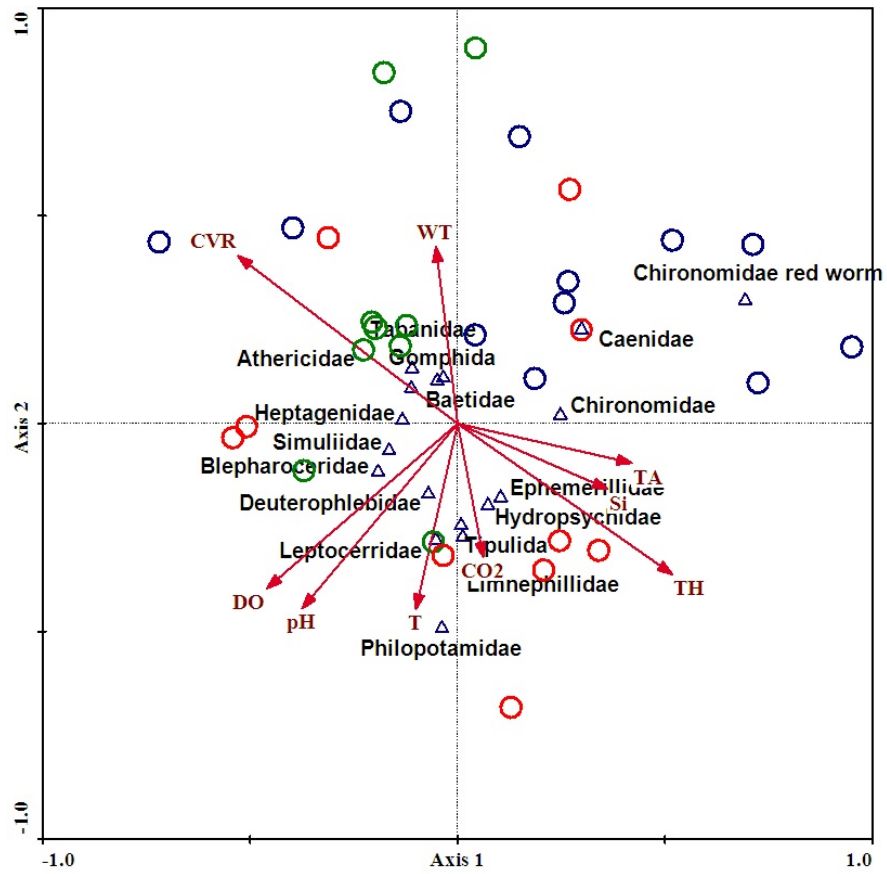

Figure 1. CCA triplot showing association of macroinvertebrate taxa to environmental variables and monthly samples from each station. (S1-O, S2-O, S3-O)

Figure has not been cited in the text

Received xx xxxxxxxx 2019
Accepted xx xxxxx 2019