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## Seasonal Variation of Benthic Macro Invertebrates from Tons River of Garhwal Himalaya Uttarakhand

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**Abstract:** Present investigation was carried out to assess the seasonal variation of benthic macro-invertebrates from the Tons river, a tributary of Yamuna River in Garhwal Himalaya, Uttarakhand during December, 2007 to November, 2009. The seasonal benthic diversity was correlated with various physico-chemical parameters which documented that the macrobenthic diversity is mostly regulated by the dissolved oxygen in the water while temperature and free CO<sub>2</sub> were found to be inversely correlated with the benthic fauna. Maximum diversity of benthos was reported at the upstream site ('H' 0.204) during the winter season while it was recorded minimum during the rainy season at all the sites. Maximum diversity is reported during the winter season at all the sites. The benthic fauna is represented by three phylum, 4 classes and 10 orders with Insecta emerging as the most dominant class. Maximum genera were reported from midstream site as it acts as ecotone between upstream and downstream.

**Key words:** Benthos, Garhwal Himalaya, seasonal variation, river

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### INTRODUCTION

The benthic macro invertebrate community contributes immensely to the functioning of the stream/river ecosystem. It serves not only as a major source of food for fishes but also helps in processing relatively large amounts of organic matter. Further, they are more of resident nature because they are not as mobile as fishes so as to exhibit avoidance behavior. Owing to their bottom dwelling habit, they are better indicators of changes in the system because all extraneous matter coming into the system tends to settle on the bottom. Abundance and distribution of macro benthos has affected by various physical and chemical condition of the water body such as depth, current of the water organic contents of the sediments, contaminations of bed sediments environment, toxicity of sediments and rapid sedimentation have appear to causes shifts towards lower abundances of macro benthic species (Pearson, 1970). The benthic macro invertebrates are the animals inhabiting the sediment or living on or in other available bottom substrate of freshwater, estuarine and marine ecosystem (APHA, 1998). The distribution of aquatic macroinvertebrate species and communities is controlled by a variety of environment factors such as habitat characteristics (Peeters and Gardeniers, 1998), good indicator of water quality conditions (Resh, 1995; De Shone, 1995), sediment quality (Chapman *et al.*, 1976),

sediment grain size (Tolkamp, 1980) and by biological factors such as competition and predation. The present study was aimed to know the seasonal variation, percentage composition and diversity of the benthic macroinvertebrate community of the Tons river of Uttarakhand state India.

### MATERIALS AND METHODS

Samples were collected from the three selected sites (upstream, midstream, downstream) located on the river during December, 2007 to January, 2009. Each site was extended for about 6.5 km along the river and included a variety of habitats such as pools, run, sandy bottoms, rocky riffles and vegetated areas. The aquatic insects and other benthos were collected by enclosing one square meter of river bottom with square meshed cloth. The bottom stones, gravel and sand were upturned to dislodge the benthic life. Each animal was collected with the help of forceps and brush and were preserved in 5% formalin for the identification. For the identification of benthic fauna, the standard references like Ward and Whipple (1959) and APHA (1998) were consulted. Parameters like DO, pH, Water temperature, Air temperature were measured on the spot and for the other parameters samples were brought to the lab and analyzed with standard methods APHA (1998).

**Statistical analysis:** Species diversity was calculated using Shannon's diversity index and percentage occurrence of benthic fauna was calculated as:

$$\text{Species occurrence (\%)} = \frac{\text{No. of individuals of each species}}{\text{Total No. of individual of all species}} \times 100$$

**RESULTS**

During the present investigation, random sampling of zoo-benthos was carried out and a total 31 benthos were recorded, belonging to three phylum, 4 classes and 10 orders with Insecta emerging as the most dominant class. The most abundant order having maximum genera were coleoptera and odonata with 5 genera followed by

ephemeroptera and hemiptera (4 genera), plecoptera and trichoptera (3 genera), Diptera and Decapoda (2 genera) and Megadrilacea and Arhynchobdellida with one each. Species composition and seasonal variation in benthos is documented in Table 1-3. Percentage composition of species of benthic fauna is represented graphically in Fig. 1.

Site-II was dominated by a total number of 29 genera with class insecta emerging as the most dominant group having 24 genera (82.75%) followed by class Malacostraca with 2 genera and class Clitellata and Gastropoda with one genus each. Since site-II acts as an ecotone between sites-I and site-III, the benthos concentration was recorded maximum at this site. A total of 26 genera were recorded at site-III with class insect

Table 1: Species composition and seasonal variation of benthic fauna recorded from Tons river during December, 2007 to Nov., 2009 at site-I

Taxa	Months																									
	Winter		Summer				Monsoon				Winter		Summer				Monsoon		Winter							
	D 2007	J 2008	F	M	A	M	J	J	A	S	O	N	D 2008	J 2009	F	M	A	M	J	J	A	S	O	N 2009		
<b>P- Annelida</b>																										
<b>C- Clitellata</b>																										
<b>O- Megadrilacea</b>																										
<i>Earthworm</i> sp.	+	-	+	-	++	-	+	++	#	#	-	-	+	+	+	-	-	-	+	++	++	++	-	-	-	
<b>O- Arhynchobdellida</b>																										
<i>Leech</i> sp.	-	-	+	++	++	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	++	
<b>P- Mollusca</b>																										
<b>C- Gastropoda</b>																										
<i>Lymnaea</i> sp.	+	-	-	+	-	-	-	-	+	-	+	+	-	-	-	-	+	-	-	-	++	++	-	+	+	
<b>P- Arthropoda</b>																										
<b>C- Malacostraca</b>																										
<b>O- Decapoda</b>																										
<i>Crab</i> sp.	+	-	+	++	-	++	-	-	+	-	+	+	-	-	+	++	-	++	-	-	-	+	-	-	+	
<b>C- Insecta</b>																										
<b>O- Coleoptera</b>																										
<i>Cybister</i> sp.	-	-	-	-	-	-	-	-	-	-	-	++	++	++	++	-	+	+	-	-	-	-	-	-	-	
<i>Hydrophilus</i> sp.	#	++	#	-	-	-	+	-	-	+	+	++	#	++	-	-	-	-	-	-	+	-	-	-	#	
<b>O- Diptera</b>																										
<i>Culex</i> sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	
<i>Anopheles</i> sp.	-	-	+	+	+	+	-	-	-	-	-	-	-	-	++	+	-	++	-	-	-	+	-	-	+	
<b>O- Ephemeroptera</b>																										
<i>Baetis</i> sp.	++	-	++	+	-	+	-	-	-	+	+	++	++	-	++	+	-	-	-	-	-	+	+	-	++	
<i>Caenis</i> sp.	+	+	+	+	-	-	-	-	-	++	++	+	-	-	+	+	-	-	+	-	-	-	++	-	+	
<i>Ephemerella</i> sp.	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	+	-	-	+	
<i>Heptagenia</i> sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	
<b>O- Hemiptera</b>																										
<i>Gerris</i> sp.	+	+	++	+	-	-	-	-	+	++	-	+	+	-	++	++	-	-	-	+	++	++	-	-	+	
<i>Hydrometra</i> sp.	+	+	-	-	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	+	
<i>Plea</i> sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	
<i>Ranatra</i> sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	+	-	-	-	
<b>O- Odonata</b>																										
<i>Cordulia</i> sp.	+	-	+	+	-	-	-	-	-	-	-	+	+	++	-	-	++	-	-	-	-	-	-	-	-	
<i>Hagenis</i> sp.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	-	-	-	
<i>Macromia</i> sp.	+	-	-	-	-	-	-	-	-	+	+	+	+	-	-	+	-	-	+	-	-	+	-	-	+	
<i>Enallagma</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	+	-	-	-	
<b>O- Plecoptera</b>																										
<i>Alloperla</i> sp.	+	-	+	+	-	+	-	-	+	-	+	+	-	+	+	-	-	-	-	-	-	+	-	-	+	
<i>Isoperla</i> sp.	+	+	+	+	-	-	-	-	-	+	+	+	+	-	-	+	+	+	-	-	-	-	-	-	+	
<b>O- Trichoptera</b>																										
<i>Glossosoma</i> sp.	+	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	+	+	-	-	+	
<i>Neuroclipsis</i> sp.	+	-	-	+	-	+	+	-	-	-	-	+	-	-	++	-	+	++	-	-	++	++	-	-	+	
<i>Rhyacophila</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	+	

P: Phylum, C: Class, O: Order, -: Absent, +: Recorded, ++: Abundant, #: Dominant

Table 2: Species composition and seasonal variation of benthic fauna recorded from Tons river during December, 2007 to Nov., 2009 at site-II

Taxa	Months																								
	Winter		Summer				Monsoon				Winter		Summer				Monsoon		Winter						
	D 2007	J 2008	F	M	A	M	J	J	A	S	O	N	D 2008	J 2009	F	M	A	M	J	J	A	S	O	N	2009
<b>P- Annelida</b>																									
<b>C- Clitellata</b>																									
<b>O- Megadrilacea</b>																									
<i>Earthworm</i> sp.	+	+	+	-	-	-	+	#	#	++	-	-	+	+	-	-	-	+	-	#	++	#	-	-	
<b>O- Arhynchobdellida</b>																									
<i>Leech</i> sp.	-	-	+	-	+	-	+	-	-	-	-	+	-	+	-	-	++	++	-	-	#	-	-	-	+
<b>P- Mollusca</b>																									
<b>C- Gastropoda</b>																									
<i>Lymnaea</i> sp.	+	-	++	+	-	++	-	-	-	+	-	+	+	+	++	-	-	-	-	-	-	-	-	-	-
<b>P- Arthropoda</b>																									
<b>C- Malacostraca</b>																									
<b>O- Decapoda</b>																									
<i>Crab</i> sp.	++	-	+	+	-	++	-	-	-	++	-	+	+	-	-	-	+	++	-	-	-	-	++	+	
<i>Prawn</i> sp.	-	+	-	-	+	-	+	+	-	-	-	+	+	-	-	+	-	+	-	-	-	+	-	-	-
<b>C- Insecta</b>																									
<b>O- Coleoptera</b>																									
<i>Cybister</i> sp.	+	+	+	+	-	-	-	-	-	-	-	+	+	+	-	+	-	-	-	-	-	-	+	+	
<i>Dystiscus</i> sp.	++	++	+	+	-	-	-	-	+	+	-	-	++	++	-	-	-	-	-	-	+	-	-	-	-
<i>Hydrocanthus</i>	+	-	-	-	-	+	-	-	+	-	+	-	-	-	-	-	+	-	-	-	-	-	+	-	
<i>Hydrophilus</i> sp.	++	-	-	-	+	-	+	-	-	-	-	++	-	-	++	-	+	-	-	-	-	+	-	+	
<b>O- Diptera</b>																									
<i>Anopheles</i> sp.	+	-	+	+	-	++	++	-	-	++	-	+	+	+	-	-	-	+	+	-	+	+	-	+	
<b>O- Ephemeroptera</b>																									
<i>Baetis</i> sp.	+	++	#	#	+	+	+	+	-	-	-	+	+	+	+	+	-	+	-	-	+	-	+	+	
<i>Caenis</i> sp.	+	#	+	+	#	-	-	-	-	+	+	#	#	+	+	-	+	+	+	+	-	-	+	-	
<i>Ephemerella</i> sp.	+	-	-	+	-	-	+	+	-	+	-	-	+	+	+	-	-	-	-	-	-	-	+	+	
<i>Heptagenia</i> sp.	-	-	-	-	-	+	-	-	+	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	
<b>O- Hemiptera</b>																									
<i>Gerris</i> sp.	++	-	++	++	-	-	-	-	-	-	++	++	++	+	+	+	-	+	++	-	-	++	-	-	
<i>Hydrometra</i> sp.	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+	-	-	+	-	
<i>Plea</i> sp.	+	-	+	-	-	-	-	-	-	-	-	+	+	-	-	+	-	+	-	-	-	-	+	+	
<i>Ranatra</i> sp.	+	-	+	+	+	-	-	-	+	-	+	+	-	-	-	+	-	-	-	-	+	-	-	+	
<b>O- Odonata</b>																									
<i>Cordulia</i> sp.	-	-	++	++	-	-	-	-	-	-	+	+	+	-	+	+	-	-	+	-	-	-	+	+	
<i>Hagenis</i> sp.	-	-	-	+	-	+	-	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	+	+	
<i>Macromia</i> sp.	+	+	-	+	-	-	+	-	+	-	-	+	+	+	+	+	-	-	-	-	+	-	-	-	
<i>Enallagma</i> sp.	+	-	+	+	-	-	-	-	-	+	-	+	+	+	+	+	-	-	-	+	-	+	-	-	
<i>Lestes</i> sp.	-	-	++	-	-	+	-	-	-	-	-	-	+	-	-	+	+	++	-	-	-	-	++	+	
<b>O- Plecoptera</b>																									
<i>Alloperla</i> sp.	++	#	#	+	+	-	-	+	-	-	+	+	++	++	+	+	++	-	-	-	-	-	-	+	
<i>Isoperla</i> sp.	+	++	-	-	-	-	+	-	-	-	+	+	-	-	++	+	-	-	-	-	-	+	-	+	
<i>Neoperla</i> sp.	+	-	-	+	-	-	-	-	-	-	-	+	+	-	+	+	-	-	-	-	-	-	-	-	
<b>O-Trichoptera</b>																									
<i>Glossosoma</i> sp.	+	-	+	+	-	-	+	-	-	+	+	+	+	+	+	+	-	-	-	+	-	-	-	-	
<i>Neuroclipsis</i> sp.	++	+	++	+	-	-	-	+	++	-	-	+	-	-	+	-	+	-	-	-	+	-	+	+	
<i>Rhyacophila</i> sp.	-	-	-	-	+	+	-	-	-	+	-	-	-	-	-	+	+	-	+	+	-	-	-	-	

P: Phylum, C: Class, O: Order, -: Absent, +: Recorded, ++: Abundant, #: Dominant

with most number of genera (21 genera, 80.76%), followed by class Malacostraca with 2 genera and Gastropoda and Clitellata with one genus each. A total of 25 genera of benthos have been recorded from site-I. The most abundant group recorded was Insecta with a total number of 21 genera (84%) followed by classes Clitellata, Gastropoda and Malacostraca with one genus each. Among phylum Annelida, Earthworm sp. was dominant at all the sites and was recorded maximum during monsoon and post monsoon season while *Leech* sp. was recorded occasionally. In case of phylum Arthropoda, crab sp. was

recorded in abundance almost at all the sites whereas prawn sp. was recorded only at sites-II and III with restricted distribution. These were collected maximum during winter season.

The phylum Mollusca was represented by *Lymnaea* sp. only and was recorded occasionally though it showed maximum abundance during certain months.

Among phylum Arthropoda, class Insecta and order Coleoptera, the *Hydrophilus* sp. was dominant only at site-I while it was recorded in abundance at sites-II and III. *Amphizoa* sp. was reported only at site-III while

Table 3: Species composition and seasonal variation of benthic fauna recorded from Tons river during December, 2007 to Nov., 2009 at site-III

Taxa	Months																									
	Winter		Summer				Monsoon				Winter		Summer				Monsoon		Winter							
	D 2007	J 2008	F	M	A	M	J	J	A	S	O	N	D 2008	J 2009	F	M	A	M	J	J	A	S	O	N	2009	
<b>P- Annelida</b>																										
<b>C- Clitellata</b>																										
<b>O- Megadrilacea</b>																										
<i>Earthworm</i> sp.	+	-	+	-	-	-	+	+	#	#	-	-	+	+	+	-	+	-	-	+	++	+	-	-	-	
<b>O- Arhynchobdellida</b>																										
<i>Leech</i> sp.	-	-	-	+	-	-	-	-	+	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	+	
<b>P- Mollusca</b>																										
<b>C- Gastropoda</b>																										
<i>Lymnaea</i> sp.	+	+	-	++	-	+	-	-	-	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	
<b>P- Arthropoda</b>																										
<b>C- Malacostraca</b>																										
<b>O- Decapoda</b>																										
<i>Crab</i> sp.	+	+	-	++	-	+	-	-	-	-	+	+	+	+	-	+	-	+	-	-	-	-	+	-	+	
<i>Prawn</i> sp.	-	-	-	-	-	-	+	-	-	-	-	+	-	+	-	-	-	+	-	-	-	-	-	-	+	
<b>C- Insecta</b>																										
<b>O- Coleoptera</b>																										
<i>Amphizoa</i> sp.	-	+	-	-	-	+	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	+	
<i>Cybister</i> sp.	+	++	+	-	-	-	-	-	-	-	-	++	-	+	++	-	-	-	-	-	-	-	++	-	+	
<i>Dystiscus</i> sp.	+	-	-	-	+	-	-	+	-	-	-	+	-	-	-	-	+	-	+	+	-	-	-	-	+	
<i>Hydrocanthus</i>	+	+	-	-	-	-	+	-	+	-	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	
<i>Hydrophilus</i> sp.	-	-	-	+	-	+	-	-	+	+	-	-	++	-	++	+	-	+	-	-	-	++	-	-	+	
<b>O- Diptera</b>																										
<i>Culex</i> sp.	+	-	++	+	-	+	-	-	+	-	-	+	+	-	-	-	+	++	-	-	-	+	+	+	+	
<i>Anopheles</i> sp.	+	+	-	+	-	+	++	+	-	+	-	-	+	+	-	-	++	+	-	-	-	-	-	-	-	
<b>O- Ephemeroptera</b>																										
<i>Baetis</i> sp.	#	#	++	+	-	++	-	-	-	+	+	+	+	#	#	+	-	-	-	-	-	+	++	+	+	
<i>Caenis</i> sp.	+	++	+	+	+	-	-	-	-	+	+	+	+	+	-	+	-	-	-	-	-	+	+	+	+	
<i>Ephemerella</i> sp.	+	-	-	+	-	-	-	+	-	+	++	+	+	-	++	+	-	-	-	-	-	+	+	+	+	
<b>O- Hemiptera</b>																										
<i>Gerris</i> sp.	++	-	++	++	-	+	-	-	+	+	-	++	++	++	++	++	-	++	++	-	-	-	-	-	+	
<i>Hydrometra</i> sp.	+	+	-	+	-	-	+	-	-	-	+	+	+	-	-	-	-	-	-	+	-	-	+	-	-	
<i>Ranatra</i> sp.	-	-	+	+	-	-	-	-	+	+	-	+	+	-	+	+	+	+	-	-	+	+	-	-	-	
<b>O- Odonata</b>																										
<i>Macromia</i> sp.	++	-	+	++	-	-	-	-	-	-	+	+	+	-	+	+	+	-	-	-	-	+	-	-	-	
<i>Lestes</i> sp.	+	-	++	+	-	-	-	-	-	++	-	+	+	-	+	+	-	+	-	-	++	++	-	-	-	
<b>O- Plecoptera</b>																										
<i>Alloperla</i> sp.	++	-	++	+	-	-	-	-	-	+	-	+	+	+	-	+	+	-	+	-	-	-	-	-	-	
<i>Isoperla</i> sp.	+	++	++	+	-	-	-	-	-	-	-	+	-	-	+	+	-	+	-	-	-	+	-	+	+	
<i>Neoperla</i> sp.	+	-	-	+	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	+	-	-	+	-	-	
<b>O- Trichoptera</b>																										
<i>Glossosoma</i> sp.	#	++	#	-	+	-	+	-	-	-	-	+	-	#	#	+	-	-	-	-	+	-	-	-	-	
<i>Neuroclipsis</i> sp.	+	-	+	-	-	-	-	-	-	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	
<i>Rhyacophila</i> sp.	+	+	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	+	+	+	

P: Phylum, C: Class, O: Order, -: Absent, +: Recorded, ++: Abundant, #: Dominant

*Cybister* sp. was recorded in abundance at all the sites. *Dystiscus* sp. was found abundant at site-II whereas it was found occasionally at site-III and was absent at site-I. *Hydrocanthus* sp. was reported occasionally at sites-II and III while it was absent at site-I. All the species of order coleoptera showed maximum distribution during winter season. In case of order Diptera, *Culex* sp. showed abundance at site-III and was reported occasionally at site-I but was found absent at site-II while *Anopheles* sp. was reported abundant at all the study sites. They do not show any fixed trend of distribution though maximum species were collected during monsoon and post monsoon months. Among Ephemeroptera, *Baetis* sp. was dominant at sites-III and II and was abundant at site-I.

*Caenis* sp. was dominant at site-II and abundant at sites-III and I, respectively. At site-III, *Ephemerella* sp. was abundant while *Heptagenia* sp. was absent. *Ephemerella* sp. and *Heptagenia* sp. both were found occasionally at sites-II and I. Among order Hemiptera, *Gerris* sp. was abundant at all the sites. *Hydrometra* sp., *Ranatra* sp. and *Plea* sp. were reported occasionally at all the sites except for *Plea* sp. which was found absent at site-III. Hemiptera order showed maximum species distribution during winter and post monsoon season. In case of Odonata, *Cordulia* sp. was found abundant at sites-I and II but was absent at site-III. *Hagenis* sp. and *Micromia* sp. were recorded occasionally at sites-I and II. At site-III, *Macromia* sp. was found abundant while

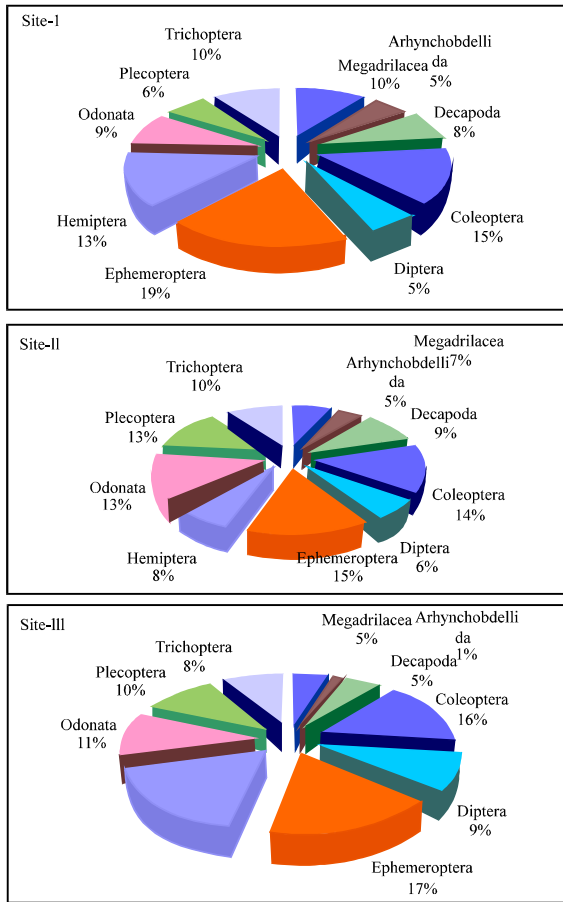


Fig. 1: Percentage occurrence of benthic fauna recorded from the study sites

*Hagenis* sp. was absent. *Enallagma* sp. was found occasionally at sites-I and II but was found absent at site-III while *Lestes* sp. was abundant at sites-II and III but found absent at site-I. Species of Odonata group showed maximum occurrence during winter and post monsoon season.

Among Plecoptera, *Alloperla* sp. was found dominant at site-II and abundant at site-III but rare at site-I while *Isoperla* sp. was recorded in abundance at sites-II and III and rare at site-I. *Neoperla* sp. and *Isoperla* sp. were found occasionally at sites-II and III but were absent at site-I. Almost all the species of this order showed maximum abundance during winter season with *Alloperla* sp. being more abundant during the month of April, 2009. *Neuroclipsis* sp. of order Trichoptera was abundant at sites-I and II and was found rarely at site-III. *Rhyacophila* sp. was found occasionally at all the sites while *Glossosoma* sp. was reported dominant at site-III but rare at sites-I and II. At site-I, maximum species were recorded during summer and post monsoon season. At

site-II, *Neuroclipsis* sp. showed maximum abundance in winter season while other two species did not showed any fixed trend of distribution. At site-III, *Glossosoma* sp. showed maximum abundance during winter and post-monsoon season.

Percentage occurrence of the orders investigated during the study was also calculated where order Ephemeroptera was emerged as the most dominant order at all the sites followed by Coleoptera. Minimum percentage occurrence was documented for the order Arhynchobdellida at all the sites.

Diversity index of benthic fauna ranged between ('H') 0.000-0.204 at site I, ('H') 0.126-0.201 at site II and ('H') 0.1-0.202 at site III. The maximum diversity index was reported in September, 2009 as ('H') 0.204 and minimum in July, 2008 as ('H') 0.000 at site I. At site II, maximum diversity index was reported in February, 2008 as ('H') 0.201 and minimum in July, 2009 as ('H') 0.126 and it was recorded maximum in December, 2007 as ('H') 0.202 and minimum in June, 2009 as ('H') 0.1 at site III. Benthos showed negative co-relation with air temperature at site-II (-0.659\*\*) and site-III (-0.682\*\*) and with water temperature at site-III (-0.577\*\*) and partial negative co-relation with water temperature at site-II (-0.488\*). At all the sites benthos showed positive co-relation with dissolved oxygen with values of 0.752\*\* and 0.682\*\* at sites-II and III respectively. The partial co-relation was observed at site-I (0.427\*). Partial negative co-relation was observed at site-II (-0.447\*) and III (-0.436\*) between benthos and free CO<sub>2</sub>.

## DISCUSSION

During the present investigation, it was observed that at almost all the sites the maximum species were recorded during winter period when temperature is usually low and the amount of dissolved oxygen is more. Thus it can be concluded that air temperature, water temperature, dissolved oxygen and free CO<sub>2</sub> have direct influence on benthos distribution and abundance. During the present investigation, it was observed that high dissolved oxygen and low temperature are positively co-related with rich benthic density and other biotic communities. The present findings favors the concept given by Dobriyal *et al.* (1999) and Pande and Mishra (2000) where they studied the different streams and rivers of Doon valley and reported that the dissolved oxygen values were more in winter season and play a significant role in the production of biota.

According to Hynes (1970), insects are the most important group in analyzing diversity and abundance in running water. This is in confirmation with the present

observations where class insecta emerged as the most dominant group influencing the biotic diversity in the river. This was also supported by the works of Serrano *et al.* (1998); Bueno *et al.* (2003) and Ribeiro and Uieda (2005). Maximum diversity of benthic fauna was documented from the upstream and midstream section of the river which may be due to slowing down of current velocity in the midstream and presence of different microhabitats in that stretch as documented by Takeda *et al.* (1997) and Oliveira and Froehlich (1997) who reported that heterogeneity of rocky substrate supported higher richness and mean diversity of species by favoring of the formation of diverse microhabitats. Peeters *et al.* (2000), Pires *et al.* (2000) and Boyero and Bosch (2004) also reported that current velocity and substratum are the two main physical factor affecting the distribution of lotic macroinvertebrate.

A positive relation was found between the benthic diversity and dissolved oxygen at all the sites during the present investigation which is in accordance to the findings of Joshi *et al.* (2007) who reported maximum benthic diversity during winter season when the amount of dissolved oxygen is more and the temperature is low. Negi (2008) studied the Hinval stream of Garhwal region and reported 29 genera of benthic fauna belonging to 7 orders. The most abundant order recorded was Ephemeroptera (11 genera), followed by Plecoptera, Coleoptera, Diptera with 4 genera each, Trichoptera, Odonata with 2 genera each and Megaloptera with 1 genus. Sharma *et al.* (2008) studied the macroinvertebrate diversity at two sampling sites of Ninglad stream (an important tributary of river Kosi) and collected a total of 36 families of macroinvertebrates. At site-I, 13 families were identified belonging to Oligochaetes, Hirudinea, Odonata, Coleoptera, Trichoptera, Diptera and annelida order. The percentage abundance of the insecta and non-insecta was found as 97.17 and 2.83% respectively. Among benthic population, aquatic insects were the most dominating group of Diptera comprising 5 families. At site-2, 31 families of macro invertebrates were found belonging to the Ephemeroptera, coleoptera, trichoptera, odonata, lepidoptera, diptera and annelida. The percentage abundance of insect population recorded by them was 96.84%, while non-insects population was 3.15%. Hazarika and Goswami (2009) studied the freshwater ichthyofauna of Guwahati, Assam and reported 27 species of aquatic insects belonging to 23 genera, 14 families and 5 orders in association with 15 species of aquatic macrophytes. Of all the orders Hemiptera tops the list with highest number of associated taxa followed by Coleoptera, Odonata, Ephemeroptera and Diptera.

## CONCLUSION

The present study was initiated with an objective to assess the benthic macroinvertebrate community of Tons river of Uttarakhand State, India. On the basis of present study maximum diversity of macroinvertebrate was reported at site-II followed by sites III and I this may be due to high altitude at site- I. The class insecta emerges as most dominant macroinvertebrate in all the study sites and maximum diversity of macroinvertebrate was recorded during winter season. Ephemeroptera was emerged as the most dominant order in percentage composition at all the sites followed by Coleoptera. Minimum percentage occurrence was documented for the order Arhynchobdellida at all the sites.

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