Water Quality Monitoring Using Aquatic Insects Hemiptera And Coleoptera

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Abstract

The biodiversity of aquatic insect communities in a given ecosystem often reflect the environmental conditions (Rosenberg & Resh, 1993). High Biotic Index (B1) values are associated with the adverse impacts of organic pollution. Low FBI or B1 values indicate that the macroinvertebrate community is not impacted by organic pollution. The present study indicates higher anthropogenic disturbance in S2 than other sites. More intolerant genera and species in each family predominate in clean streams, whereas more tolerant genera and species predominate in polluted streams. The SIGNAL scores obtained in the three study sites (Si. S3 and S4) using different families belonging to the order Hemiptera and Coleoptera indicated that the level of water pollution is similar. S2 with a score of 6.5 indicates that water is slightly more polluted compared to other three sites. Higher Average Score Per Taxa (ASPT) score and lower SIGNAL score indicates higher anthropogenic disturbance in P. The sum of Biological Monitoring Working Party (BMWP) score of Si, S3 and S4 is .55, 50, 50 respectively, which signifies that the water bodies are moderately polluted whereas in S2 where the value is 40 signifies little higher impact of pollution.

Key words: Aquatic Hemiptera, Coleoptera and Aquatic ecosystem in Meghalaya

1. Introduction

Biologists have been studying the effects of human activities on aquatic systems and organisms for decades but their findings have been translated into methods suitable for monitoring the quality of water bodies relatively recently. It has been recognised as a vital component for an integrated assessment of water quality (Hellawell, 1986). Use of aquatic insects as biomonitor provides important insights into changes in water and habitat quality (Rosenberg & Resh, 1993). These changes are valuable in demonstrating the effects of anthropogenic disturbances in the aquatic ecosystems. Numerous taxa of aquatic insects groups have been used as biological parameter to know the ecological status of aquatic systems. There are several studies focused on the physical attributes and biotic assemblages in freshwater river, stream, pond, lake ecosystems and examined the species-habitat relationship in order to develop reliable predictable biotic organisms to assess the habitat condition (Gomi et al & Richardson 2002; Heino, 2009). Some species are known to have particular requirements with regard to nutrients, water quality, substrate components and the structure of vegetation. Once these are defined, it is desirable to determine the effectiveness of the tolerant and intolerant species (Hellawell, 1986). The benthic organisms serve as bio exposed to different kinds of environmental pollution as they are constantly pollutants in lakes and streams and those pollution sensitive benthic insects are used as biological indicators (Morse et al., 1994). Benthic invertebrate communities respond to changes in physical and chemical conditions of the bottom sediment and integrated impact over a period of time change the abundance and distribution of benthic fauna. Benthic aquatic insects express long term changes in water and habitat quality rather than instantaneous conditions (Resh et al.,1979; Halse et al., 2002; Duran et al., 2003). Change in aquatic group mainly insects (abundance) were observed and analysed with changing conditions in the water systems which directly reflected environmental changes (New, 1984).

In India researchers have carried out intensive investigations on benthic organisms. (Shivramkrishnan et al., 2000; Khan & Ghosh, 2001; Saha et al., 2007; Malik et al., 2010; Sharma & Agarwal, 2012; Zade & Sitre, 2012). Aquatic systems of different gradation of disturbances were monitored in relation to its faunal diversity to develop the concept of bioindicator. Documentation of rare and endemic aquatic insects, indicator species provide biological information essential to estimate the degree of environmental impact and its potential dangers for other living organisms (Kondratieff & Baumann, 2002).

Aquatic insects are widely used to estimate the chemical or nutrient content of water, which is important in determining the health of an aquatic ecosystem. The deteriorating aquatic systems result in loss or change in the diversity of invertebrates. Johnson & Gage, (1997) studied the biotic communities in streams in relation to different water parameters and detected a number of adverse impact of polluted water to those communities.

BMWP The Biological Monitoring Working Party) is a procedure defining score for measuring the biological quality of rivers using species of macro- invertebrates as indicators. Keawkhao (2007) reported that the Biological Monitoring Working Party (BMWP) score and further Average Score Per Taxa (ASPT) represent the biological component of the aquatic ecosystems. BMWP, and ASPT are used to find out the

Family Biotic Index Index (FBI) (Hilsenhoff, 1988). The biotic index is widely used by organizations of the Environment Agency.

Recently many techniques, protocols, and indices have been developed to monitor water quality changes, using species composition diversity and functional organisation of aquatic insects (Hilsenhoff, 1988; Plafkin et al., 1989; Lenat, 1993). These factors are important in demonstrating the effect of anthropogenic disturbance on different water system. Hsu and Yang (1997) pointed out that Hilsenhoffs family level biotic index was a reliable method for assessing water quality of the Keelung River in Northern Taiwan. Biological monitoring is generally applied to compare historical and contemporary data which can provide insights into how benthic communities have responded to long term anthropogenic changes in a s ecosystem or its catchment (Grubaugh & Wallace, 1995).

Monitoring aquatic ecosystem is complex and is the result of rapid changes in physical, chemical and biological characters (Smith et al., 2007). However, organisms living in the affected areas might be good indicator of quality of the water body and overall integrity of the environment (Wright & Center, 1984; Karr, 1999). To estimate the degree of pollution in the study sites, the value of Biotic Index (BI) were determined for each water system using a relative pollution tolerance organism. Polluted sites were identified based on the BMWP biotic index adapted for the region (Dominguez & Fernandez, 1998).

The BMWP Score of each family is assigned as a tolerance score varying from 1 to 10. Tolerance with a value of 10 is for organisms which are very sensitive pollution (Bode et al., 1996, 1997). The results are then compared with the reference table of Hilsenhoff, 1988 to assess water quality. The total BMWP score following the least tolerant to pollution species group are assigned a high score and the highly tolerant group are assigned low scores (Mustow, 2002).

2.Materials and Methods

3.Collection of aquatic insects

The aquatic insects per unit time were collected monthly using insect net (mesh size own; diameter 30cm; depth 15cm). Insects were collected by sweeping the pet over the water surface or by disturbing the bottom and side substrates. After collection, the insects were transferred to a white tray where preliminary separation of Hemipteran and Coleopteran were made from each site. The insect samples were preserved in vials containing 5% formalin solution and different indices are calculated following different formulae.

4. Calculation of biomonitoring indices

The formula for calculating the ASPT or Biotic Index is:

$$\text{ASPT or BI} = \frac{\text{Sum of BMWP score of all families in a site}}{\text{Total number of families present in the site}}$$

BMWP score Tolerance value of each family is taken from the table value of (Hilsenhoff., 1988). Typically ranged 0-10 with 0 representing highly intolerant organism and 10 highly tolerant species (Lenat., 1993).

The scores for ten families in the present studies are given in (Table1). Water quality interpretation based on ASPT scores is given in (Table 2). Interpretation of level pollution based on sum BMWP score is given in (Table 3).

Table 1: To allocate the Biotic Score to the aquatic Hemiptera and Coleoptera Hilsenhoff (1987-88)

Order			
	family	**Species indications**	**BMWP score**
Hemiptera	**Gerridae**	**Tolerant species**	**5**
			5
			5
			5
	Corixidae	**Tolerant species**	**5**
	Nepidae	**Tolerant species**	**5**
	Veliidae	**Tolerant species**	**5**
	Aphelocheidae	**Tolerant species**	**5**
Coleoptera	**Dytiscidae**	**Tolerant species**	**5**
		Tolerant species	**5**
		Tolerant species	**5**
		Tolerant species	**5**
		Tolerant species	**5**
		Tolerant species	**5**
	Anthicidae	**Tolerant species**	**5**
	Gyrinidae	**Tolerant species**	**5**
	Hydrophilidae	**Tolerant species**	**5**

Table 2: Water quality based on ASPT score.

ASPT score	Water Quality	Degree of organic pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
7.51-8.50	Very Poor	Severe

Table 3: Sum of Biological Monitoring Working Party (BMWP) score interpretation

Sum bmwp score	Interpretations	Sum of BMWP score	Interpretations
0-10	Heavily polluted	71-100	Clean and slightly impacted
11-40	Polluted or impacted	>100	Unpolluted/ unimpacted
41-70	Moderately impacted	-	-

The overall BMWP for all the sites is the sum of all scores of esch family present at that site.

*Values greater than 100 are associated with clean water water body, while heavy polluted ones, score less than 10.

SIGNAL stands for "Stream Invertebrate Grade Number- Average level". It is simple scoring systems for macro-invertebrates. SIGNAL 2 score can be calculated with or without. abundance weighing. SIGNAL Scores can be interpreted using the following

Table 5). (Chessman & Grown 1997; Chessman, 2003)

Table 4: Calculation of SIGNAL 2 score for the study sites. Wf= Weight factor

$$\text{Signal score} = \frac{\text{Total of grade x Weight factor}}{\text{Total of weight factor}}$$

Table 5: SIGNAL SCORE interpretation data

SIGNAL SCORE	Interpretation
0-7	Suggest Pollution
>20	Suggest good habitat and water s quality

WEIGHT TABLE	
Number of specimens	**Weight factor**
1-2	**1**
3-5	**2**
6-10	**3**
11-20	**4**
>20	**5**

5. Results

The BMWP (tolerance value according to Hilsenhoff, 1988) score of Hemiptera and Coleoptera in present study is given in Table (6).

The BMWP, ASPT, SIGNAL score of S1, S2, S3, S4 for study period of three years is given Table (11). The ASPT score indicated that the water quality is good with slight organic pollution.

Table 6: BMWP score and Average score per taxa (ASPT) in different sites during the three years study period

Order	BMWP							
	S1		S2		S3		S4	
	Family	BMWP	Family	BMWP	Family	BMWP	Family	BMWP
Hemiptera	Gerridae	5	Gerridae	5	Gerridae	5	Gerridae	5
	Gerridae	5	Gerridae	5	Gerridae	5	Gerridae	5
	Nepidae	5	Nepidae	5	Nepidae	5	Nepidae	5
	Notonectidae	5	Notonectidae	5	Notonectidae	5	Notonectidae	5
	Veliidae	6	Veliidae	6	Veliidae	6	Veliidae	6
	Aphelocheidae	10	Aphelocheidae		Aphelocheidae	10	Aphelocheidae	10
Coleoptera	Dytiscidae	5	Dytiscidae	5	Dytiscidae	5	Dytiscidae	5
	Anthicidae	5	Anthicidae	5	Anthicidae	5	Anthicidae	5
	Gyrinidae	5	Gyrinidae	5	Gyrinidae	5	Gyrinidae	5
	Hydrophilidae						Hydrophilidae	
Total	10	55	8	40	9	50	9	50
ASPT		5.5		5		5.5		5.5

Table 7: SIGNAL score in S1 during the three years study period

Order	S1 (3years)				
Hemiptera	Family	SIGNAL 2 sensitiviy grade	No. of Species	WF	Grade
	Gerridae	5	4	2	11
	Gerridae	5	1	1	7
	Corixdae		2	1	8
	Nepidae	5	1	1	7
	Notonectidae	5	1	1	8
	Veliidae	6	1	1	12
	Aphelocheida	10			
Coleoptera	Dytiscidae	5			11
	Anthicidae	5			7
	Gyrinidae	4			6
	Hydrophilidae	5			7
Total					84
SINGNAL SCORE					7

Table 8: SIGNAL score in S2 during the three years study period

Order	S2(3years)				
	Family	SIGNAL 2 sensitivity grade	No of Spicies	WF	Grade XWF
Hemiptera	Gerridae				
		5	4	2	11
	Corixidae	5	4	2	11
		5	2	1	8
	Nepidae				
	Notonectidae	5	1	1	7
Coleoptera	Veliidae	6	1	1	8
	Dytiscidae	5	4	2	11
	Anthicidae	5	1	1	7
	Gyrinidae	4	1	1	6
Total					69
SIGNAL					6.3

Table 9: SGNAL Score in S3 during the three years study period

Order	S3 (3years)				
Hemiptera	Family	SIGNAL2 sensitivity grade	No. of Species	WF	Grade XWF
	Gerridae	5	4	2	11
	Corixidae	5	1	1	7
	Nepidae	5	1	1	7
	Notonectida	5	1	1	7
	Veliidae	6	1	1	8
	Aphelochei Ridae	10	1	1	12
Coleoptera					
	Dytiscidae	5	4	2	11
	Anthicidae	5	1	1	7
	Gyrinidae	4	1	1	6
Total				11	76
SIGNAL					6.9

Table 10: SIGNAL Score in S4 during the three year study period

Order	S4(3 Years)					
	Family	SIGNAL 2 sensitivity grade		No of species	WF	Grade XWF
	Gerridae	5		4	2	11
	Corixidae	5		4	1	11
	Nepidae	5		2	1	8
	Notonectidae	5		1	1	7
Hemiptera	Veliidae	6		1	1	8
	Aphelocheidae	10		1	1	12
	Dytiscidae	5		4	2	11
Coleoptera	Gyrinidae	4		1	1	6
	Hydrophilidae	5		1	1	7
Total					12	81
SIGNAL						6.75

Table 11: BMWP, ASPT, SIGNAL score of S1, S2, S3, S4 for three years study period

SITES	Type of water body	Biological Monitoring Working Party(BMWP) score	Sum of Biological Monitoring Working Party (BMWP) score interpretation	Average Score Per Taxa (ASPT)	Biotic Index Water quality (Degree of organic pollution)	SIGNAL SCORE2	Interpretation data
S1	Pond	55	Moderately impacted	5.5	Good with some organic pollution	7	Suggest pollution
S2	Stream	40	pollution impacted	5		6.3	
S3	Riffle	50	Moderately impacted	5.5		6.9	
S4	Stream	50	Moderately impacted	5.5		6.75	

6: Discussion

Species vary in their degree of tolerance and the effect of water pollution reduced the species diversity (Rosenberg and Resh, 1993). In the present study, the BMWP tolerance value score of most of the Hemiptera and Coleoptera calculated according to (Hilsenhoff., 1988) score is 5 except for Orectochilus sp, which is regarded as least tolerant has score of 4, others species are regarded as tolerant of score above 5 and Aphelocheires sp, has a score of 10 which is regarded as highly tolerant species.

High Biotic Index (BI) values are associated with the adverse impacts of organic Low FBI or BI values indicate that the macroinvertebrate community is not by organic pollution. The present study indicates higher anthropogenic disturbance S2 than other sites. More intolerant genera and species in each family dis urinate in clean streams, whereas more tolerant genera and species predominate in polluted streams.

The SIGNAL scores obtained in the three study sites (S1, S3 and S4) using different families belonging to the order Hemiptera and Coleoptera indicated that the level of water pollution is similar. S2 with a score of 6.3 indicates that water is slightly more polluted compared to other three sites. Higher Average Score Per Taxa (ASPT) score and lower SIGNAL, score indicates higher anthropogenic disturbance in S2.

Thus FBI and SIGNAL score are important to indicate the amount of perturbations in aquatic ecosystem, using insect as indicators. The biodiversity of aquatic insect communities in a given ecosystem often reflected the environmental conditions (Rosenberg & Resh, 1993). In the present study, a comparison of FBI in all the sites shows that the higher FBI value in S I, S3, S4 and lower SIGNAL score in S2 indicated that water is more polluted in S2 compared to Sl, S3, S4. The more polluted sites indicate the present of more tolerant taxa and less polluted sites support more intolerant taxa. The sum of Biological Monitoring Working Party (BMWP) score of S1, S3, S4 is 55,50,50 respectively which signifies that the water bodies are moderately polluted whereas in S2 where the value is 40 sides little more higher impact of pollution.

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