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RESEARCH ARTICLE

AQUATIC INSECTS AS BIO-INDICATOR OF WATER POLLUTION – A STUDY ON LOWER STRETCH OF BAHINI RIVER, GUWAHATI, ASSAM, NORTH EAST INDIA

***Biman Kumar Sarma and Binode Kumar Baruah**

Department of Zoology, Cotton University, Guwahati, India

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ABSTRACT

The Bahini River (about 14 – 16 Km) located in the south east corner of Guwahati City. This study is a part of bio-monitoring programme using aquatic insect as bio-indicator species of the lower stretch of Bahini River during 2010 – 2012. The study revealed the presence of 8 genera of aquatic insects belonging 7 families and 3 orders. Biological Monitoring Working Party score and Bio-sensitivity Assessment (BSA) index were calculated to find out the status of the water quality of lotic ecosystem.

INTRODUCTION

The biological species especially aquatic insects play an important role for assessment of water quality. Aquatic insects used as a bio indicator reveal the presence of the pollutants by the occurrence of typical symptoms or measurable responses, and is therefore more quantitative. These organisms or communities of organisms deliver information on alternation in the environment or the quantity of environmental pollutants by changing in one of the following ways: physiologically, chemically or behaviorally. According to Peck *et al.* (1998), the bio indicators are: a) Respond quickly to environmental changes; b) Have few generations per year; c) Are easily sampled and identified; d) Show high sensitivity for detecting early changes in their geographical area; e) Provide information without interruption of the extent damage caused by environment alteration or pollution. Freshwater ecosystems are under increasing pressure from various kinds of disturbances (Tachet *et al.,* 2003). This particular disturbed situation threatens both aquatic living resources and human population (Ramade, 2002). To tackle this threat water quality systems were set up and to preserve biodiversity and use macro invertebrates as indicators (Armitage *et al.,* 1983; Rosenberg and Resh, 1993; Wright *et al.,* 1995; Williams and Smith, 1996; Clarke *et al.,* 2002). Aquatic insects often make good bio-indicators because they are present in some capacity in almost every type of habitat and many are habitat specialists (Lewis and Gripenberg, 2008). The present study was designed to carry out investigation on the diversity of aquatic insects of Bahini River. This will help to understand the applicability of aquatic insects as biological tool to monitor water pollution. Studies on aquatic insects as bio-indicator of water pollution in India were also reported by Subramanian and Sivaramakrishnan (2007), Sarma and Chowdhary (2011) and Barman and Gupta (2015). This study seeks to investigate the aquatic insect communities, their distribution in different seasons and their role as bio-indicator of water of the Bahini River.

****Corresponding author:*** **Biman Kumar Sarma,**
Department of Zoology, Cotton University, Guwahati, India.

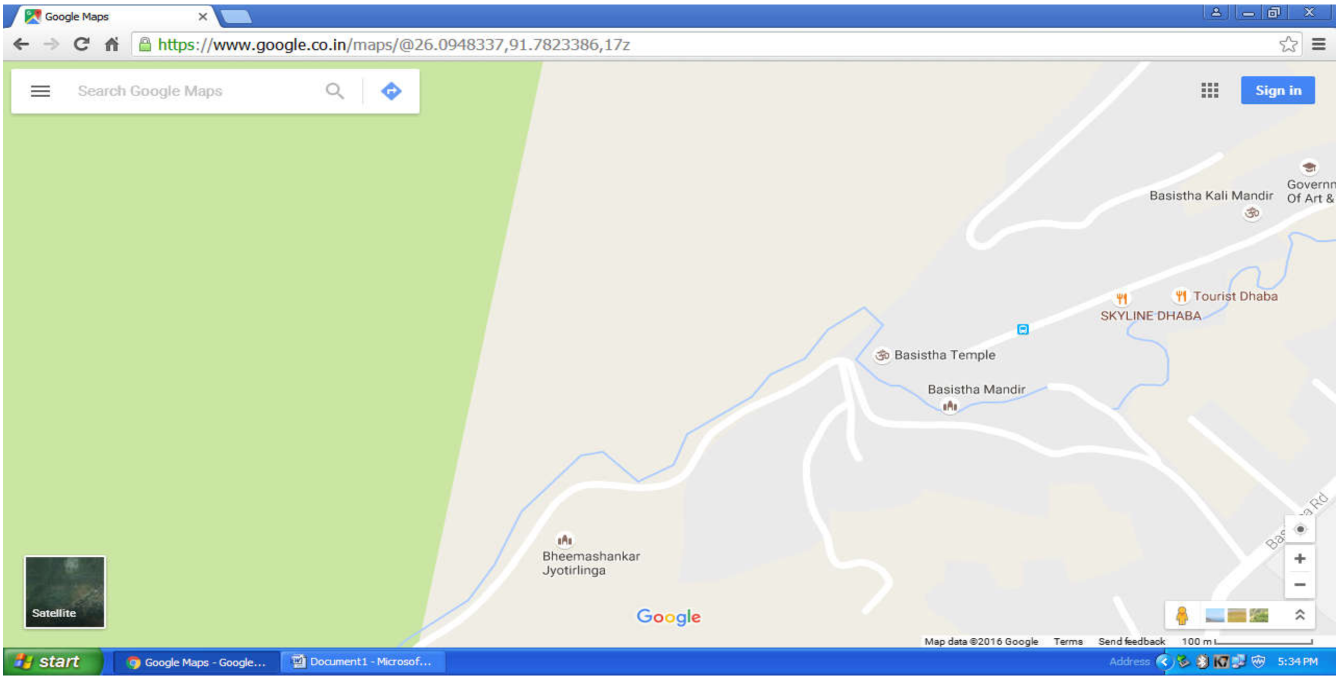
MATERIALS AND METHODS

Study area

Guwahati, the capital of Assam and the gateway to Northeast India, is situated on the south bank of the Brahmaputra River towards Southeastern side of Kamrup district. The geographical area is located above 26 10' N of Equator and 92 49' E of Greenwich. The city is situated on an undulating topography with varying altitudes of 49.5 m to 55.5 m. The flatness of the plain is broken in the southern margin by the Meghalaya plateau. The central part of the city area also has small hillocks like Sarania Hill (193 m), Nabagraha Hill (217 m), Nilachal Hill (193 m) and Chunsali Hill (293 m). Apart from hilly tracts, the city is also covered by swamps, marshes and small water bodies like Deepar Beel, Barsola Sarusala and

Dighali Pukhuri. The boundary of the Guwahati Municipal Corporation (GMC) extends from the Brahmaputra River in the north, Basistha grant in the south, Khanyan River in the west and Khanapara hills in the east. Bahini river (about 14 – 16 Km) located in the south east corner of Guwahati City. This streams originating from the hills of Meghalaya, which becomes the river Basistha and Bahini/ Bharalu flowing by southern part of the city.

Map – 1. Location of Bahini River



Collection of Insect Fauna

Aquatic insects were collected from May, 2010 to April, 2012 for two years, covering four seasons Monsoon (June-August), Post-monsoon (September-November), winter (December-February) and Pre-monsoon (March-May) of year. Sampling was standardized by restricting the collection of aquatic insects from 10 m^2 area for one hour. Within the sampling area, aquatic insects were searched in all the possible substrata and collected from bedrocks, boulders, cobbles, leaf litter and dead wood. In stretches of river where the water flows with little turbulence over gravel and sand, physical nature permits to use nets. Aquatic insects were sampled by taking three, one minute kick-net samples (mesh opening: 180 µm; area 1m^2). The kick-net was held against water current and an area of 1 m^2 in front of the net is disturbed for one minute (Subramanian and Sivaramakrishnan, 2007). After collection, organisms were washed and scrubbed from the larger substrate materials, concentrated by use of a No. 30 U.S. Standard sieve and were preserved in 70% ethyl alcohol. In the laboratory the organisms were sorted from the finer residual debris by elutriation and hand picking from white enamel pan and transferred to fresh preservative. The surface and bottom water insects were preserved in 70% ethyl alcohol for identification. The insects were identified upto family level to calculate the Saprobic score of the wetlands during the different seasons of the study period and to calculate the Bio-Sensitivity index value of the wetlands. Further, insects were identified upto genus level to evaluate the Diversity score of the wetlands during different seasons of the study period.

Identification of insects

Under the binocular dissecting microscope and binocular compound microscope the taxonomic identification of both surface and bottom sample was performed following the works of Needham and Needham (1962), Edmondson (1959), Pennak (1978), Pillai (1986), Tonapi (1980), Croft (1986), Triplehorn and Norman (2005), Subramanian and Sivaramakrishnan (2007). Each taxon of the collected sample was recorded and enumerated. Two methods for biological water quality evaluation have been adopted, Sequential comparison for diversity score and the Biological Monitoring Working Party (BMWP) for the saprobic score. The combination of the range of saprobic score with the diversity score indicates the ecological health of the water body.

Saprobic score (BMWP): This methodology involves inventory of the presence of benthic macro-invertebrate fauna up to the family level. All possible families having saprobic indicator value are classified on a score of 1-10 according to the preference for saprobic water quality (Table.1). The saprobic scores of all the families are registered and averaged to produce BMWP score (Akolkar *et al*., 2001).

Diversity score (Sequential Comparison Index or SCI): This methodology involves pair wise comparison of sequentially encountered individuals and the difference of the two benthic animals up to the species level. The diversity is the ratio of the total number of different animal species (runs) and the total number of organisms (of all species) encountered. The ratio of diversity has a value between 0 and 1 (Dutta *et al*., 2001, Zwart *et al*., 1994). For biological water quality evaluation, the diversity of the benthic animals is compared with the saprobic score with the help of BWQC (Biological Water Quality Criteria) (Table 2).

A comprehensive water quality index based on species diversity and sensitivity. BSA (Biosensitivity Assessment) index based on the works Gautam (2001) in Rihand Sagar Reservoir.

Bio-Sensitivity Index: - Σ (Total number of individual from particular family × sensitivity value of the family) ÷ Total number of collected individuals.

Diversity Index $\overline{H} = \sum P_1 \log_2 P_1$

Where, $P_1 = N_1 / N$, $N_1 =$ Number of Individuals in each group.

$N =$ Total number of individuals in the sample

Shanon Weiner Index	Diversity Index
>3.5	10
3.0 – 3.5	8
2.5 – 3.0	6
2.0 – 2.5	4
< 2.0	2

BSA Index = (Bio-sensitivity Index + Diversity Index)

On the basis of BSA Index, the water quality can be classified on given below-

Water quality class	BSA Index
Very good	>8
Good	6 – 8
Medium	4 – 6
Vulnerable	< 4

Olive's theory (1976) on correlation of Diversity index (d) and water quality:

Diversity index (d)	Condition
>3	Water of high quality and harbor less than 20% polluted tolerant species.
1 – 3	Moderate pollution and harbor wide range in percentage of pollution tolerant species.
<1	Water of poor quality and harbor 90% pollution tolerant form.

The Shanon Weiner equation is the commonly used index for water quality index but BSA Index includes both Sensitivity Index and Diversity index, hence recently are more reliable.

RESULTS AND DISCUSSION

The study of aquatic insects analysis of Bahini River (Lower Stretch) is presented in Table.3 and 4. The aquatic insect communities comprised of 8 genera and 7 families of which three genera belong to Order Coleoptera, three to Order Hemiptera and two to Order Diptera. With maximum number of families, Order Hemiptera was representing 24% of the total aquatic insects in this wetland (Fig.1a). Diptera was the quantitatively most dominating group representing 51% of the total insect population of this lotic ecosystem. Diptera was represented by two familis viz., Culicidae and Chironomidae constituting 67% and 33% of this order respectively (Fig.1b). Coleoptera was represented by two families viz., Hydrophilidae and Gyrinidae constituting 57% and 43% each respectively (Fig.1c). Hemiptera was represented by 3 families viz., Gerridae, Vellidae and Nepidae constituting 37%, 34%, 29% respectively (Fig. 1d). Order Diptera was dominated during the entire study period except monsoon season and the post monsoon season of 2011-12 (Fig.2a and 2b). The Saprobic score and diversity score of Bahini River (Lower Stretch) is presented in Table.5. The minimum Saprobic score value (4.5) was attributed to winter 2010-11 and 2011-12 respectively. During the rest of the study period the Saprobic score followed a linear trend (5.0-5.2). The diversity score ranged from (0.13-0.66). The maximum value was recorded during monsoon 2010-11 and the minimum value was recorded during winter 2011-12. The Bio Sensitivity Assessment (BSA) index value of Bahini River was recorded 5.35 and 5.75 during 2010-11 and 2011-12 respectively (Table.6). The water quality class of Bahini River was good during the entire study period. The diversity index value was recorded 1.71 during 2010-11 and 1.74 during 2011-12 (Table.6), which indicated water of moderate pollution. In Bahini River (Lower Stretch), Coleoptera was dominated by the family Hydrophilidae indicating more pollution in the stream. Khan and Ghosh (2001) reported that Hydrophilidae beetles inhabit shallower and polluted regions of water bodies with abundant macrophytes and feed on detritus, algae and decaying matter. Similarly, Sharma *et al*., (1993) showed that coleopterans were able to survive with much diversity in stressed conditions because they do not depend on dissolved oxygen of their environment. The relatively more abundance or dominance of families Gerridae and Veliidae of Order Hemiptera in the lotic ecosystem could be due to their modified body structure. These known skaters who stay on the surface of water can walk on the surface of water and can utilize atmospheric variables without totally depending on water. They were found in relatively less polluted water. The dominancy of the families Gerridae and Veliidae in Bahini River (Lower Stretch) during the study period indicated pollution of water. Naranjo *et al*., (2010) recorded the dominancy of the families Gerridae and Veliidae in their study of aquatic and semiaquatic Hemiptera in high altitudinal stream systems of Cuba where water was polluted. The dominance of Diptera in the lower stretch of Bahini River during the study period suggested that the water quality of these water bodies were polluted. These water bodies receives huge amount of polluted water through a network of drains systems from the surrounding areas. Sensitive species gradually eliminated during unfavorable condition, resulting in an insect community structure noticeably different from undisturbed site. The declined density of intolerant aquatic insect taxa at lower stretch of Bahini River indicated that either there is a continuous flow of contaminants into the water body or contaminants get accumulated and magnified due to stagnant water. Dipterans such as Chironomidae were indicative of poor water quality from various anthropogenic activities (Yakub, 2004) and dominated in heavily organically polluted water bodies (Ali *et al*., 2003). Doisy and Rabeni (2001) also agreed with that the abundance of Chironomidae was related to the amount of detritus present in water. The Saprobic score value 4.5 was also recorded during winter season of entire study period from Lower Stretch of Bahini river. Dipterans in the aquatic system occur mostly at the benthic zone of streams and rivers. The bottom sediment usually contains most of the pollutants introduced into an aquatic system and reflects the level of pollution in a system. Pollution occurring from sewage and other sources adds organic matter that provides food for these pollution tolerant benthic Dipteran species.

Table 1. Biological Monitoring Working Party (BMWP) score of Dighali Pukhuri

Taxonomical Group	Taxonomical families	BMWP score
Hemiptera	Gerridae	5
Veliidae		
Nepidae		
Coleoptera	Gyrinidae	5
Hydrophilidae		
Diptera	Culicidae	5
Chironomidae		2

Table 2. Biological Water Quality Criteria (BWQC)

S.No.	Taxonomic groups	Range of saprobic score (BMWP)	Range of diversity score	Water quality characteristic	Water quality class	Indicator colour
1	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Diptera	7 and more	0.2-1	Clean	A	Blue
2	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Odonata, Diptera	6-7	0.5-1	Slight pollution	B	Light Blue
3	Ephemeroptera, Plecoptera, Trichoptera, Hemiptera, Odonata, Crustacea, Mollusca, Polychaeta, Coleoptera, Diptera, Hirudinea, Oligochaeta	3-6	0.3-0.9	Moderate pollution	C	Green
4	Mollusca, Hemiptera, Coleoptera, Diptera, Oligochaeta	2-5	0.4 and less	Heavy pollution	D	Orange
5	Diptera, Oligochaeta and No animals	0-2	0-0.2	Severe pollution	E	Red

(Source: CPCB, 1999)

Table 3. Seasonal fluctuations of Aquatic insect species recorded in Lower Stretch of Bahini River during 2010-11

Order/Genus	Monsoon	Post-monsoon	Winter	Pre-monsoon	Total
Order- Diptera					
Family: Culicidae					
Culex sp.	00	03	21	13	37
Family: Chironomidae					
Chironomous sp.	00	07	11	05	23
Order- Coleoptera					
Family: Gyrinidae					
Dineutus sp.	02	01	04	09	16
Family: Hydrophilidae					
Hydrophilus sp.	00	01	07	04	12
Helochares sp.	01	05	00	03	09
Order- Hemiptera					
Family: Veliidae					
Microvelia sp.	00	02	03	05	10
Family: Gerridae					
Geris sp.	00	03	01	07	11
Family: Nepidae					
Laccotrephes sp.	00	01	02	06	09

Table 4. Seasonal fluctuations of Aquatic insect species recorded in Lower Stretch of Bahini River during 2011-12

Order/Genus	Monsoon	Post-monsoon	Winter	Pre-monsoon	Total
Order- Diptera					
Family: Culicidae					
Culex sp.	00	03	31	19	53
Family: Chironomidae					
Chironomous sp.	00	06	07	09	22
Order- Coleoptera					
Family: Gyrinidae					
Dineutus sp.	05	01	04	03	13
Family: Hydrophilidae					
Hydrophilus sp.	00	01	05	03	09
Helochares sp.	03	04	00	01	08
Order- Hemiptera					
Family: Veliidae					
Microvelia sp.	00	03	02	06	11
Family: Gerridae					
Geris sp.	00	05	02	05	12
Family: Nepidae					
Laccotrephes sp.	00	02	02	05	09

Table 5. Bio-monitoring of Lower stretch of Bahini River during 2010-2012

Year	Seasons	Sabrobic Score	Diversity Score	Biological water quality class	Biological water quality
2010-2011	Monsoon	5.0	0.66	C	Moderate pollution
	Post-monsoon	5.2	0.34	C	Moderate pollution
	Winter	4.5	0.14	D	Heavy pollution
	Pre-monsoon	5.2	0.15	C	Moderate pollution
2011-2012	Monsoon	5.0	0.25	C	Moderate pollution
	Post-monsoon	5.2	0.32	C	Moderate pollution
	Winter	4.5	0.13	D	Heavy pollution
	Pre-monsoon	5.2	0.15	C	Moderate pollution

Table 6. Shannon – Weiner index and BSA index for Bahini River during 2010 – 2012

Year	Total Numbers of Individuals	Total Numbers of Species	Shannon – Weiner index	Bio-sensitivity index	BSA index	Water quality class
2010-2011	127	8	1.71	3.35	5.35	Medium
2011-2012	137	8	1.74	3.75	5.75	Medium

Fig.1a. . Relative abundance of the Orders of aquatic insects in Bahini River(Lower stretch) of Guwahati City.

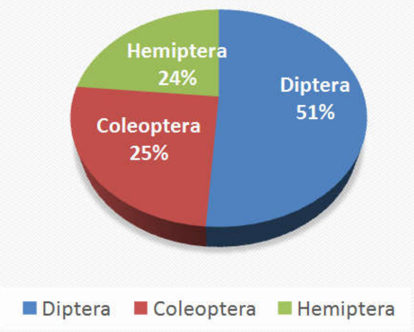


Fig.1b. Relative abundance of the families of Order of Diptera in Bahini River(Lower stretch) of Guwahati City.

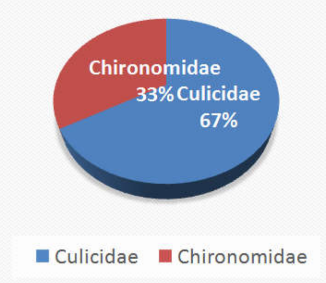
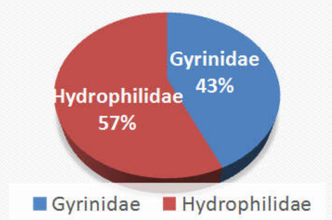
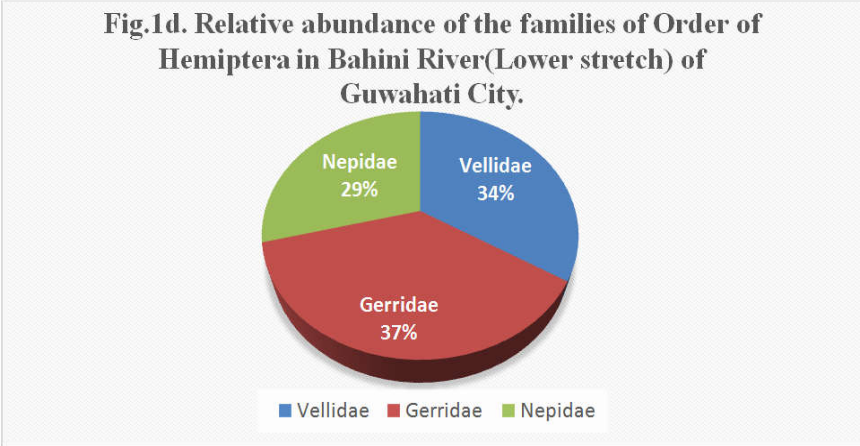
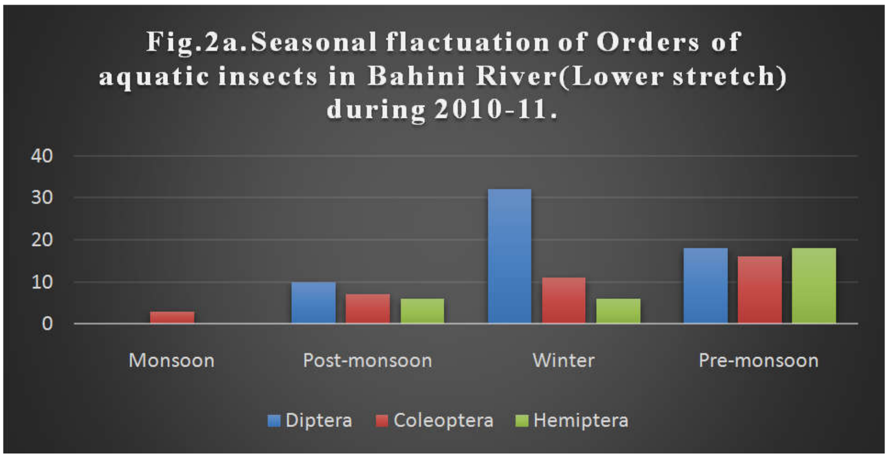
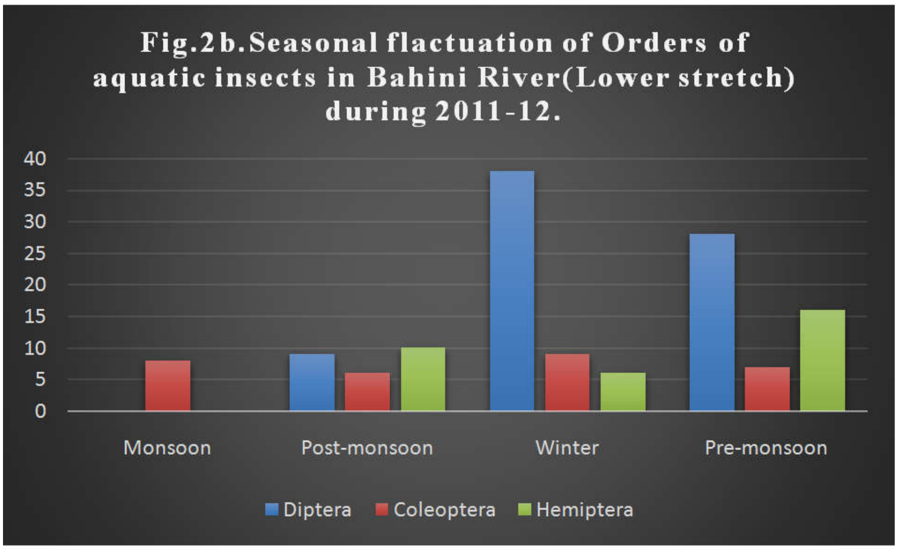


Fig.1c. Relative abundance of the families of Order of Coleoptera in Bahini River(Lower stretch) of Guwahati City.









According to Olive's (1976), theory on correlation of diversity index and water quality, the diversity index value less than 1 indicate water of poor quality and harbor 90% pollution tolerant form, diversity index value greater than 3 indicate water of high quality and harbor less than 20% polluted tolerant species and intermediate value indicates moderate pollution and harbor wide range in percentage of pollution tolerant species. Bahini River was recorded between 1 – 2, which indicated the water quality of these wetlands were moderately polluted and abundance of aquatic insect species were maximum. The Bio-sensitivity Assessment (BSA) index value is a combination both bio-sensitivity inex and diversity index. Bio-sensitivity index value based on BMWP scores.

The BSA index value in between 4 – 6 indicate medium quality of water which was recorded in Bahini River during the study period. The present study clearly showed that aquatic insects can be used effectively and accurately to assess water quality to any wetland ecosystem. Hence with application of different pollution index viz. BMWP score and BSA index, aquatic insect community determine the water quality states of wetland.

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