International Research Journal of Environment Sciences ISSN 2319–1414
Vol. **3(8),** 26-35, August **(2014)** *Int. Res. J. Environment Sci.*

Biomonitoring in Lentic Ecosystems of Irongmara, District Cachar, Assam, India, with Special reference to Aquatic Insect community

Barman Bijita, Gupta Priti, Choudhury Dharitri, Dalal Arpita and Gupta Susmita
Department of ecology and Environmental science, Assam University, Silchar-788011, INDIA

Available online at: www.isca.in, www.isca.me
Received 20th June 2014, revised 15th July 2014, accepted 18th August 2014

Abstract

This paper represented a preliminary three months data on the aquatic insect diversity of two ponds, one private property pond and one community pond of Irongmara village, district Cachar, Assam. The communitypond (pond1) was characterized by market and household waste disposal site and the privatepond (pond2) was characterized by a community fishery. A total of 16 families belonging to 5orders from pond 1 and 9 families belonging to 4 orders from pond 2 were recorded. The insect order Diptera was found to be abundant and dominant in pond1, while in pond2 the order Hemiptera was found more abundant and dominant. Dissolved oxygen of water on pond1 was found very low with high Free-CO_2 and Electrical Conductivity while in pond2 the dissolved oxygen was found in good concentration with low Free-CO_2 and Electrical Conductivity. Different biomonitoring scores were computed to see the water quality of the ponds and statistical analyses were done to find the relationship of environmental variables with insect density and family richness. The present study compared the water quality of the two types of ponds and concluded that the authorities, management and users should come forward with protective measures to save the ponds from deterioration.

Keywords: Aquatic insects, hemiptera, diptera, pond, environmental variables.

Introduction

A pond is a natural or man-made standing water bodysmaller than a lake and contains shallow water with marsh, aquatic flora and fauna. A pond is a feature of many landscapes and it contribute the mass of regional freshwater biodiversity[1,2]. Though they are small in size, they are rich in biodiversity and often act as biodiversity ‘‘hot spots’’ within the region or landscape[2]. The pond system also shows greater variation in biotic and environmental variables than rivers and lakes[3].

Major changes in environmental variables in a pond by anthropogenic activityinclude mainly changes in physical habitat and changes in chemical properties of the water. Habitat changes include water level decreases, increase of sedimentation, and decrease of depth. Change in water quality of pond includes eutrophication and toxic chemicals concentration increase. Aquatic insects were used as new tool to monitor these environmental impacts and changes in water.Because of their importance in nutrient cycling, inresponding to the changes in the environmental factors of waterand pollution sensitivity they are used widely as biomonitoring agent[4-7].

The study area Irongmara village has increasing trend of construction of buildings by draining and filling the house hold ponds or community ponds which have been serving the locality so long. The village with increasing population is also facing tremendous problem of solid waste disposal where often ponds are used as disposal site. Again there are many fishery ponds which are less subjected to pollutants or solid waste disposals. Taking all these facts into account, two ponds of Irongmara, one from market area and another fishery pond from residential area were selected to evaluate their water quality status using aquatic insects. It is thought thata few ponds which are still there in the urban setup are to be conserved for the betterment of the residents of that area.

Material and Methods

Study area: The Cachar district has an altitude of 26 – 27 m above MSL and $24^0 8'$- $25^0 8'$ N latitude; $92^0 15'$ - $93^0 15'$ East Longitude. Irongmara, a village developed into township is very close to Assam University campus, Silchar, Cachar. Mean annual rainfall of this area is 2954 mm (Data recorded at Silcoorie Metrological Station).The temperature regime of the area shows that the maximum temperature ranges from 35.23^0C to 27.12^0C. The minimum temperature ranges from 25.53^oC to12.2^oC. Two ponds from the village, one community pond (pond1) and one private property pond (pond 2) were selected for this study. Thepond1is the common property of people staying in the area and the pond 2 is the private property of a villager. The descriptions of the sites of the two ponds are given in the table-1.

Aquatic insect and Water quality: Two sampling sites, site 1 and site 2 from pond 1, and site 3 and site 4 from pond 2 were selected. The study was conducted during January to April, 2014 with five visits at each pond in regular intervals. Aquatic insects with three replicates from each site were collected by kick method with a circular net (mesh size 60µm) for a unit of time[8,9]. Three drags constituted a sample. Collected insects were immediately sorted and preserved in 70% alcohol. They were later identified using a Moticstereo zoom Microscope and Magnus stereozoom Microscope with the help of standard keys[10-14]. Water from the same sites were collected in replicates and water parameters like air temperature (AT), water temperature (WT), transparency (TR), pH, electrical conductivity (EC), dissolved oxygen (DO), free carbon dioxide (F-CO_2), total alkalinity (TA), nitrates and phosphates were estimated with standard methods[15,16].

Data Analyses: Average Score Per Taxon (ASPT) and Biological Monitoring Working Party (BMWP) were calculated followingstandard literature[17]. The BMWP score is obtained by summing the individual scores of all families present. Score values for individual families reflect their pollution tolerance[18]. The Average Score per Taxon (ASPT) is calculated by dividing BMWPscore by the total number of scoring family. Stream Invertebrate Grade Number- Average Level (SIGNAL) scoring system for macroinvertebrate was calculated[19]. Statistical analyses were done using software SPSS 16.

Results and Discussion

Aquatic Insect and their relationship with water variables: Several studies in the water quality and aquatic insects were done in India and also Barak Velly[20-23]. The present study revealed the aquatic insect orders and families recorded from two different ponds. All total5 orders and20 families were recorded from the two ponds. Five orders viz., Hemiptera, Odonata, Ephemeroptera, Diptera and Coleoptera from pond1 and four orders- Hemiptera, Odonata, Diptera, and Coleoptera from pond 2 were recorded. 16 families were recorded from pond 1and 9 families from pond 2. Five families were found common in the two ponds (table-2 and 3). In pond 1, the total number of insects was found to be highest in site 2, visit 2 and lowest in site 2 visit 4. In site 3 of pond 2, the total no. of insects was found to be highest in visit 4 and lowest in visit 2 (figure-2).

Table-1
Morphometry and description of the two ponds

POND	GPS Location		Area (m^2)	Vegetation	Type
Pond 1	Site 1	24°41′15.67’’ N 92° 44′33.25′′ E	783	Tree line, Grasses, Shrubs (*Mangiferaindica,* areca nut,*Combretumpilosum, Cynodondactylon, Psidiumguajava, Alocasiamacorrhiza, Hibiscus rosa-sinensis,* etc.)	Domestic disposal pond
	Site 2	24°41′15.74’’N 92° 44′33.65’’E			
Pond 2	Site3	24° 41′17.75′′N 92° 44′17.55′′E	1482	Trees, Bamboo clump, shrubs (*Solanammyriacanthum, Cleome gynandra, Cynodondactylon, Melastomamalabathricum,* etc.)	Fishery
	Site 4	24° 41′16.96’’N 92° 44′16.92’’E			

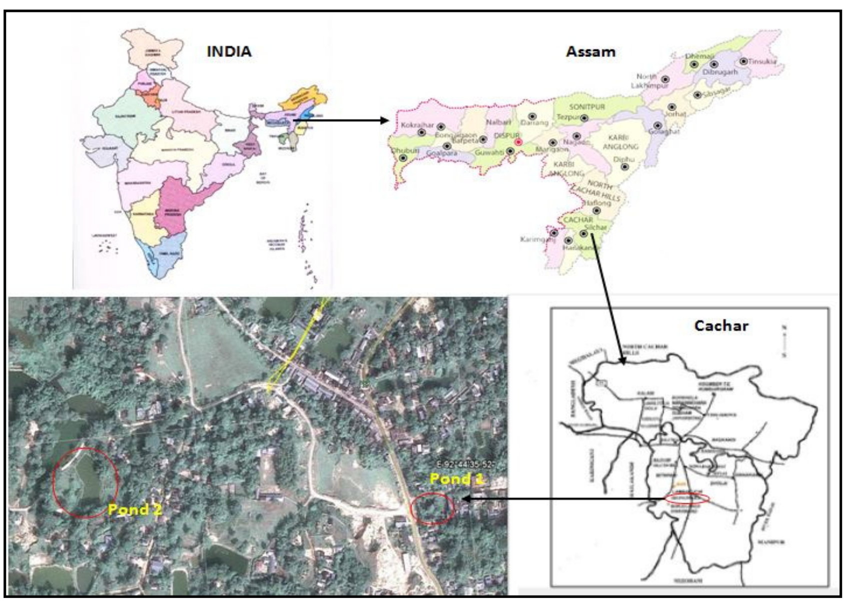

Figure-1
Map of India showing position of Assam followed by Map of Assam showing the Cachar district followed by map of Cachar showing Irongmara village followed by satellite imaginary of Irongmara village showing the two studied ponds

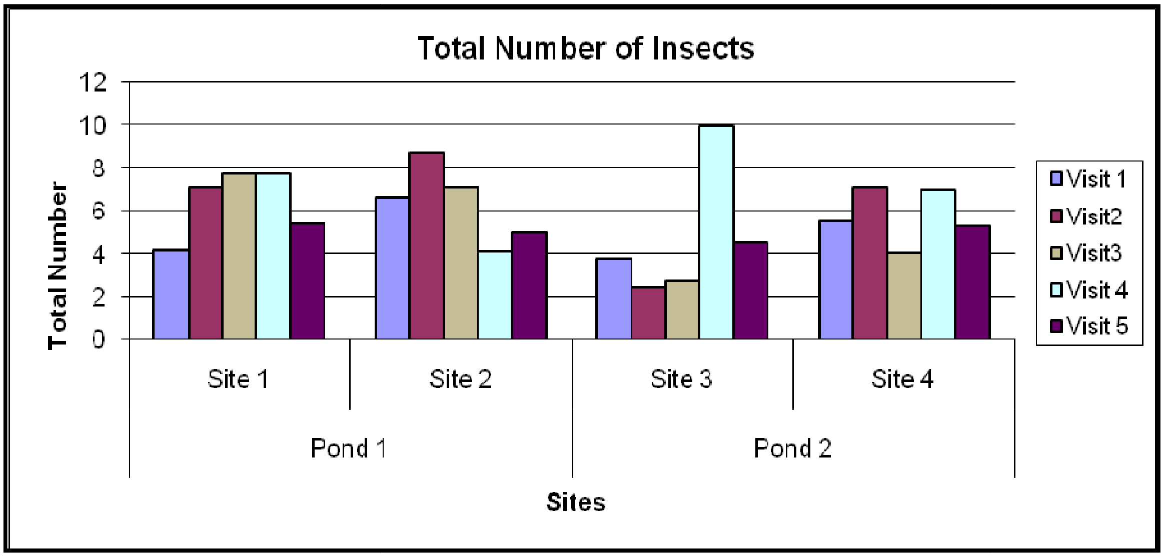

Figure-2
Total number of aquatic insects in different sites of two ponds in different visits

Table-2
Distribution of different aquatic insect familiesin the two sites of Pond 1 during five visits

Order	Family	Site 1					Site 2				
		V 1	V 2	V 3	V 4	V 5	V 1	V 2	V 3	V 4	V 5
Hemiptera	Naucoridae	+	-	-	-	-	-	-	-	-	-
	Gerridae	+	-	-	-	-	-	-	-	+	-
	Vellidae	+	+	+	+	+	-	+	+	+	+
	Mesoveliidae	-	-	+	-	-	-	+	-	-	-
	Corixidae	+	+	-	-	-	+	-	-	-	-
	Aphididae	-	-	-	+	+	+	-	-	+	-
Coleoptera	Elmidae	+	-	-	-	-	-	-	-	-	-
	Dytiscidae	+	-	-	+	-	-	-	-	-	-
	Hydraenidae	-	-	+	-	-	+	-	-	+	-
	Hydrophilidae	-	-	+	+	-	-	-	-	+	-
	Noteridae	-	-	-	-	-	-	-	-	+	+
Diptera	Chironomidae	+	+	-	+	+	+	+	+	+	+
	Culicidae	+	-	-	+	-	+	-	-	+	-
	Simuliidae	-	-	-	-	-	+	-	-	-	-
Odonata	Coenagrionidae	+	+	-	+	-	+	+	-	+	-
Ephemeroptera	Baetidae	-	-	-	-	-	+	-	+	-	-

Table-3
Distribution of different aquaticinsect families in the two sites of Pond 2 during five visits

Order	Family	Site 1					Site 2				
		V 1	V 2	V 3	V 4	V 5	V 1	V 2	V 3	V 4	V 5
Hemiptera	Gerridae	+	+	+	+	+	+	+	+	+	+
	Veliidae	-	+	-	+	+	-	+	+	+	+
	Hydrometridae	-	-	+	-	-	-	-	-	-	-
	Notonectidae	-	-	-	+	-	-	-	-	-	-
Coleoptera	Chrysomelidae	+	-	-	-	-	-	-	-	-	-
	Stephylinidae	-	-	-	+	-	-	-	-	-	-
Odonata	Coenagrionidae	-	-	+	+	-	+	-	-	-	-
Diptera	Chironomedae	+	+	+	-	+	+	+	+	+	+
	Culicidae	-	-	-	-	-	+	+	+	-	+

In both the sites of pond 1, the density of Hemiptera was found to be highest in all the visits, while density of Odonata was found lowest in site 1, visit 4 (figure- 3). In site 3, pond 2 order Diptera showed highest density in visit 1 and visit 3 followed by Hemiptera. In rest of the visits Hemiptera had highest density followed by Diptera. In site 4 the density of order Hemiptera was found to be highest in all the visits except visit1 where Diptera had high density (figure-4). At pond 1, site2, the density of aquatic insects showed significantpositive correlation with DO and significantnegative correlation with nitrates (table-4). At pond 2 site3, density of insect showed significant positive correlation with depth, whereassignificant negative correlation with pH and phosphates (table-5).

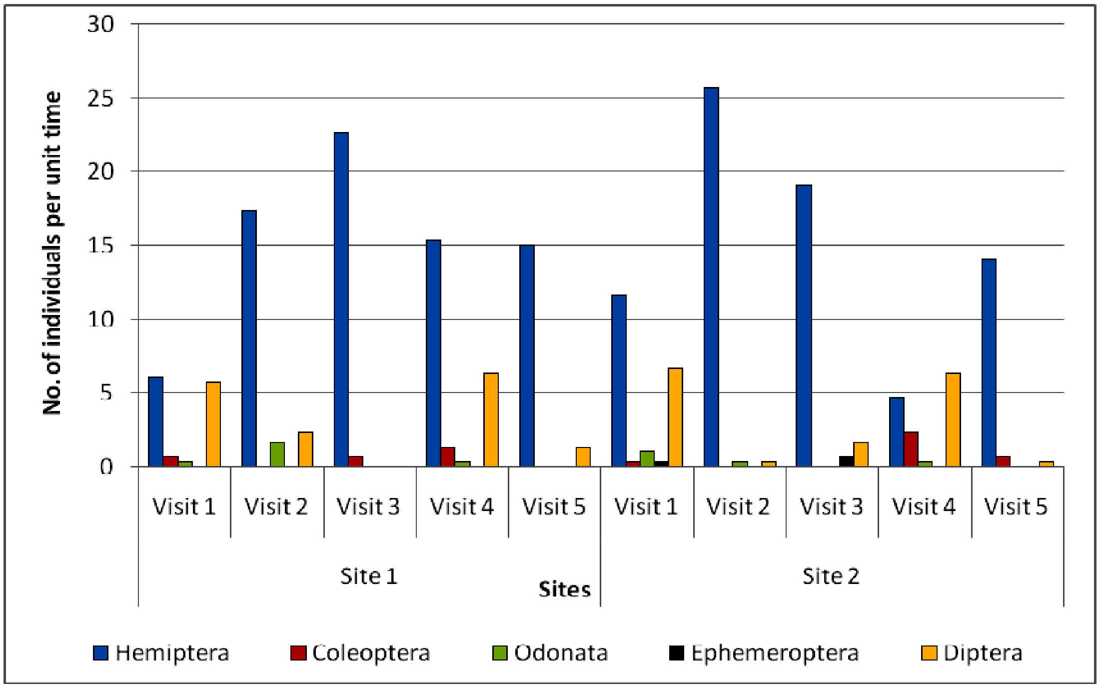

Figure-3
Density of different orders of aquatic insects in two sites of Pond 1 during five visits

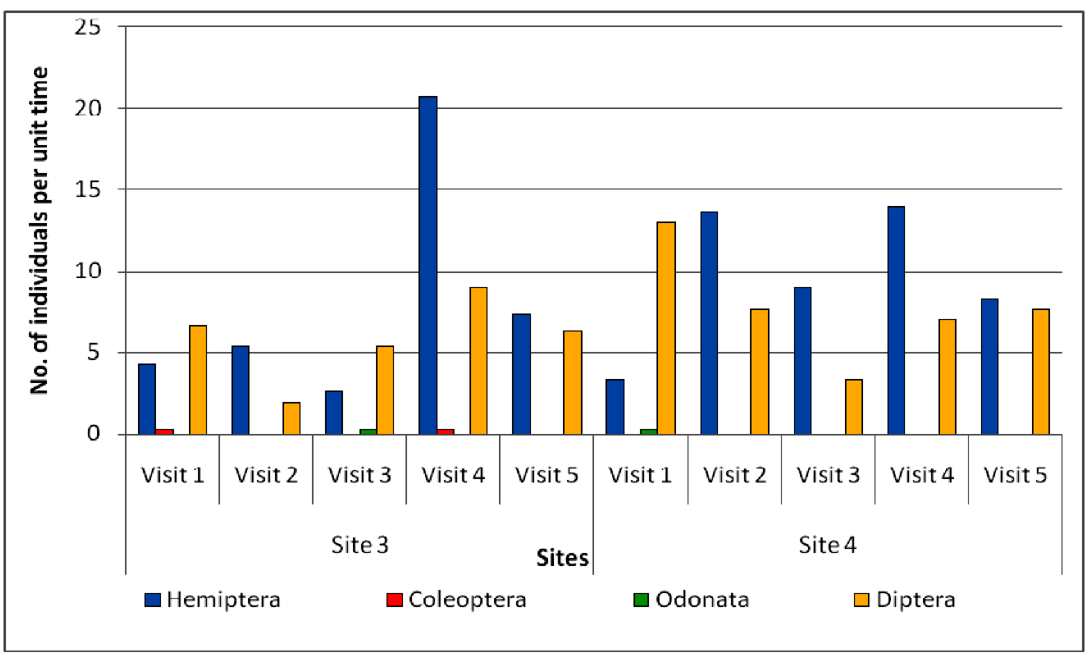

Figure-4
Density of different orders of aquatic insects in two sites of Pond 2 during five visits

Table-4
Significant Pearson's Correlation coefficient matrix of different physico-chemical parameters with insect family richness and insect density in Pond 1

Sites		**Depth (cm)**	**Air temperature (°C)**	**Water temperature (°C)**	**Transparency (cm)**	**Dissolved Oxygen (mgl^{-1})**		**Total Alkalinity (mgl^{-1})**	**Nitrates (mgl^{-1})**
Site 1	Water temperature (°C)	0.525*	0.885**	-	-	-	-	-	-
	Dissolved Oxygen (mgl^{-1})	-0.824**	-	-	-	-	-	-	-
	Free-CO_2 (mgl^{-1})	-	-0.808**	-0.761**	-	-	-	-	-
	pH	-	-	-	-0.515*	-	-	-	-
	Total Alkalinity (mgl^{-1})	0.856**	-	-	-	-0.661**	-	-	-
	Electrical Conductivity (mS/cm)	0.895**	-	0.527*	-	-0.814**	-	0.691**	-
	Nitrate (mgl^{-1})	0.668**	-	0.663**	-	-0.583*	-	0.551*	-
Site 2	Transparency(cm)	-0.524*	-	-	-	-	-	-	-
	Dissolved Oxygen (mgl^{-1})	-	-	-	0.853**	-	-	-	-
	Free-CO2(mgl^{-1})	-	-	-0.638*	-	-	-	-	-
	Total Alkalinity(mgl^{-1})	-	-	-	-0.519*	-0.625*	-	-	-
	EC (mS/cm)	-	-	-	-0.636*	-	-	-	-
	Nitrate(mgl^{-1})	-	-	-	-0.930**	-0.852**	-	0.538*	-
	Phosphate(mgl^{-1})	-	-	0.829**	-	-	-0.702**	-0.526*	-
	Density(no./unit time)	-	-	-	-	0.660**	-	-	-0.561*

*. Correlation is significant at the 0.05 level (2-tailed), **. Correlation is significant at the 0.01 level (2-tailed).

Table-5
Significant Pearson's Correlation coefficient matrix of different physico-chemical parameters with insect family richness and insect density in Pond 2

		Depth (cm)	**Air tempe-rature (°C)**	**Water tempe-rature (°C)**	**Dissolved Oxygen (mgl^{-1})**	**Free-CO_2 (mgl^{-1})**	**pH**	**Electrical Conductivity (uS/cm)**	**Phosphat (mgl^{-1})e**	**Density (no./unit time)**
Site 3	Air temperature(°C)	-0.693**	-	-	-	-	-	-	-	-
	Water temperature(°C)	-	0.716**	-	-	-	-	-	-	-
	pH	-0.742**	-	-	-	-	-	-	-	-
	Electrical Conductivity(mS/cm)	-	-	-	0.565*	-	0.542*	-	-	-
	Nitrate(mg/l)	-0.551*	0.650**	-	-	-	0.631*	-	-	-
	Phosphate(mg/l)	-	-	-	0.565*	-	-	0.678**	-	-
	Density(no./unit time)	0.578*	-	-	-	-	-0.521*	-	-0.559*	-
	Family richness	-	-	-0.577*	-	-	-	-	-	0.628*
Site 4	Water temperature (°C)	-	0.884**	-	-	-	-	-	-	-
	Total Alkalinity (mgl^{-1})	-	-	-	-	0.603*	-	-	-	-
	EC(mS/cm)	-	0.836**	0.685**	-	-	-	-	-	-
	Nitrate(mgl^{-1})	-	-	-	-	-	0.593*	-	-	-
	Phosphate(mg/l)	-	-	-0.603*	-	-	-	-	-	-

*. Correlation is significant at the 0.05 level (2-tailed).**. Correlation is significant at the 0.01 level (2-tailed).

In pond 1 site 1, the relative abundance of family Veliidae was found highest followed by Aphidae and Chironomidae in all the visits except visit 1, where Corixidae was relatively abundant than others. In site 2, Corixidae and Chironomidae were found equally abundant in visit 1, while in the rest of the visits the relative abundance of family Veliidae was found highest than that of other families (figure- 5). In pond 2 site 3, family Chironomidae was found relatively high in abundance in visits 1,3,5 and Gerridae was highly abundant in visits 2, 4. In site 4, Chironomidae in visits 1,5 and Gerridae in visits 2,3,4 were found relatively more abundant than others (figure- 6).

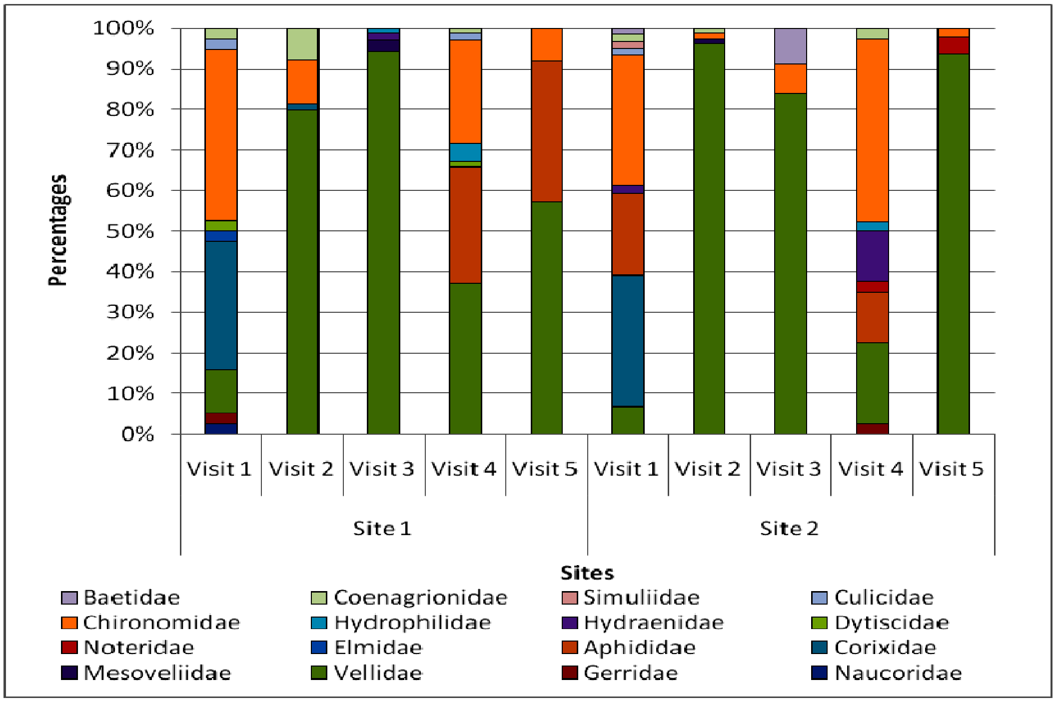

Figure-5
Relative abundance of aquatic insect families in two sites of Pond 1 during five visits

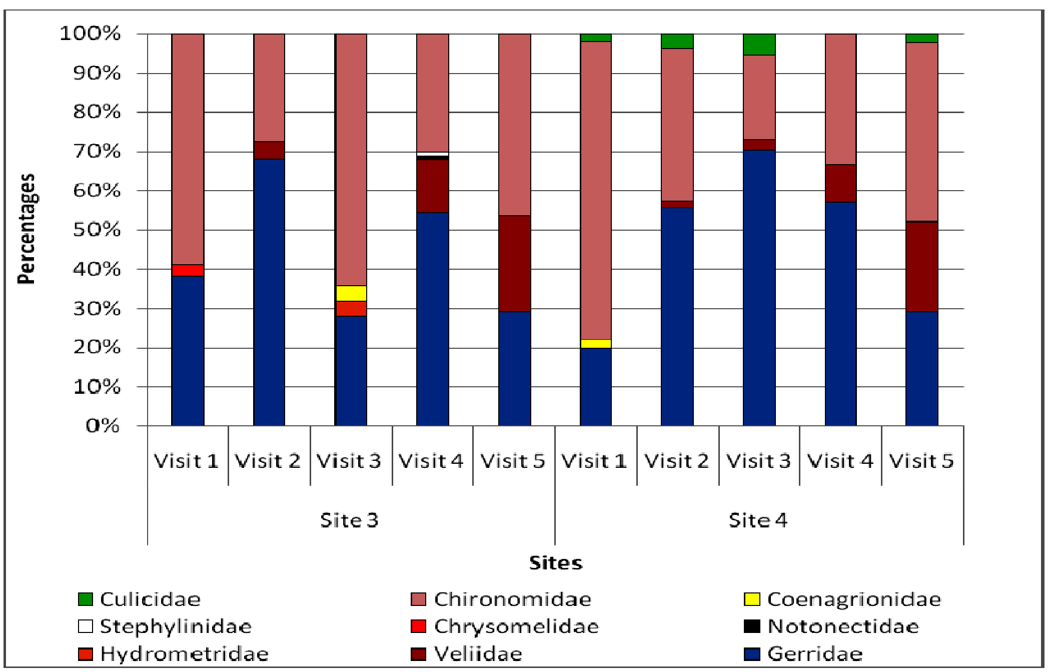

Figure-6
Relative abundance of aquatic insect families in two sites of Pond 2 during five visits

Abundance and density of families belonging to the orders like Hemiptera, Coleoptera and Diptera throughout the study period in both the ponds indicated that only stronger and tolerant ones were able to survive. Patraet al. also found the high abundance of Hemiptera, Coleoptera and Diptera in the Santragachi Jheel Lake, West Bengal, India[24].

Physico-chemical variables of water: The composition and concentration of physico-chemical variables of water vary seasonally, daily or even hourly. The composition and distributions of organisms and the physico-chemical properties of water of any aquatic system are related to each other and also influenced by each other[25].

The physico-chemical properties of water of pond 1 and pond 2 are represented in the table-6 and table-7 respectively. The pH of pond 1 ranged from 6.89 to 7.74 and pond 2 ranged from 6.04 to 7.8. The pH range of both the ponds was much comparable with the results of previous study on 5 shallow ponds of Barak valley, Assam, North East India which revealed the pH range of 6.33 to 7.43[26]. Various biological activities in a system change the pH of water. The EC of water represents the availability of free ions such as nitrates, chlorides and bicarbonates in the water[25]. In the present study, the range of EC at pond 1 was 0.36 $mScm^{-1}$ to 0.49 $mScm^{-1}$ and the range at pond 2 was 0.0482 $mScm^{-1}$ to 0.106 $mScm^{-1}$. The EC of pond 1was found higher than pond 2 in all the sites and visits. Thus at pond 1 the input of organic and inorganic waste may be the cause of high EC[27].

Table-6
Physico-chemical properties of water of two sites of Pond 1 during five visits (Mean ±SD)

Water variables	Site 1					Site 2				
	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Depth (cm)	11.5± 1.32	11.33± 1.04	11.5± 0.79	20.56± 5.50	27.36± 1.02	38±3	37.66± 2.08	36.33± 3.78	45.83± 5.55	41.4± 9.3
Air temperature (°C)	19±2	25.33± 1.52	24.33± 0.57	23.66± 1.52	25±1	24.13± 4.22	26.66± 1.15	24±1	25.66± 0.57	24.66± 0.57
Water temperature (°C)	16.33 ± 1.52	20.33± 1.52	21.33± 1.15	21.33± 1.15	22.33± 0.57	16.33± 1.52	22.33±1.15	21.33±1.52	23±1	21.33± 0.57
Transparency (cm)	8.08± 1.77	7.66±1.65	8.06± 1.53	7.96± 1.59	7.26± 0.41	30.66± 2.92	28.3± 3.46	36.33± 2.51	8.76± 1.05	6.46± 0.404
Dissolved oxygen (mgl^{-1})	0.7±0.2	0.8±0.1	0.8±0.1	0.38± 0.07	0.26± 0.26	0.5±0.1	0.866± 0.057	0.86± 0.05	0.15± 0.25	0±0
Free CO_2 (mgl^{-1})	22.66 ± 1.52	8.66± 5.77	8±1	9.33± 0.57	11±2	11.66± 1.52	8.66± 0.057	7.33± 0.57	8.33± 0.577	9.66± 1.52
pH	7.766 ± 0.064	7.55± 0.317	7.76± 0.06	7.56± 0.14	7.71± 0.26	6.89± 0.59	7± 0.101	7.87± 0.03	7.50± 0.179	7.74± 0.06
Total alkalinity (mgl^{-1})	92.66 ± 2.08	90±7.81	94.33±0.57	96.33±3.78	132.66 ± 3.05	118.33±16.25	95± 2.64	93.33± 0.57	103±5.56	131.3± 1.52
Electrical conductivity (mS/cm)	0.36± 0.009	0.366± 0.02	0.37±0.01	0.48±0.01	0.48± 0.003	0.433± 0.086	0.417± 0.067	0.38± 0.005	0.491± 0.004	0.461± 0.02
Nitrate (mgl^{-1})	0±0	0±0	0.3±0.12	0.355± 0.03	0.372± 0.01	0±0	0±0	0.036± 0.037	0.376± 0.05	0.499± 0.01
Phosphate (mgl^{-1})	0.084 ± 0.051	0.391± 0.019	0.02± 0.009	0.41± 0.008	0.262± 0.01	0.065± 0.034	0.475± 0.01	0.44± 0.06	0.382± 0.01	0.358± 0.05

Table-7
Physico-chemical properties of water of two sites of Pond 2 during five visits (Mean ±SD)

Water variables	Site 3					Site 4				
	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5	Visit 1	Visit 2	Visit 3	Visit 4	Visit 5
Depth (cm)	34±3.60	36±2.64	37±2	44±2.64	43.33±4.04	30.66±1.52	32±2.64	30±3.60	48.6±3.21	32±2
Air temperature (°C)	29.33±0.57	25.66±0.57	25.33±0.57	23.3±0.57	22.66±1.52	28.33±3.05	24.33±0.57	25±1	24±1	23±1
Water temperature (°C)	24±2.64	23±1	23.33±0.57	21.3±0.57	19.33±1.52	25±1	21.33±0.57	22±1	21.3±0.57	19±1
Transparency (cm)	25.16±2.56	26.33±2.34	26.33±1.52	26.3±2.30	26.96±4.27	25.83±1.89	27.33±1.52	26±1.73	27.7±1.58	25.3±1.21
Dissolved oxygen (mg l^{-1})	4.75±0.56	6.08±0.58	5.42±0.01	5.34±0.127	5.21±0.11	5.16±0.152	5.33±0.15	5.53±0.05	5.36±0.320.57	5.53±1.25
Free-CO_2(mgl $^{-1}$)	4±1	4.33±1.52	4.66±1.15	4.33±1.52	5.33±0.57	4.33±0.57	5±1	3.66±0.50	4.33±0.57	4.66±1.57
pH	6.93±0.37	7.41±0.13	6.69±0.53	6.28±0.17	6.43±0.20	6.64±0.11	7.86±0.06	6.39±2.08	6.04±0.30	6.32±0.035
Total alkalinity ($mgl^{-1)}$	19±10.1	18.66±0.57	16±1	16.33±0.57	28±1	20.6±2.51	23±1	18.33±4.34	20±1	25.33±1.52
Electrical conductivity (mS/cm)	0.0508±15.9	0.10743±2.90	0.1064±6.92	0.06066±0.30	0.0482±1.92	0.08823±40.95	0.0799±5.99	0.07593±4.34	0.0629±1.51	0.05246±2.65
Nitrate ($mgl^{-1)}$	2.61±0.13	2.52±0.40	0.32±0.06	0.011±0.011	1.006±0.28	0.62±0.36	0.89±0.07	0.46±0.03	0.537±0.05	0.62±0.04
Phosphate ($mgl^{-1)}$	0.095±0.009	0.394±0.05	0.39±0.01	0.005±0.005	0.33±0.019	0.02±0.02	0.42±0.05	0.39±0.03	0.091±0.02	0.35±0.03

The range of DO at pond 1 was 0.15mg l^{-1} to 0.86mg l^{-1} and pond 2 was 4.75mg $l^{-1}$to 6.08mgl^{-1}. Verylow DO concentration at pond 1 could be due to very low penetration of sunlight due to disposal of waste and growth of *Lemna* sp. which covered the pond. This facilitated more amount of organic matter decomposition instead of photosynthesis. Again the remaining amount of oxygen dissolved in water might have been utilized by the macrophytes. At pond 2 range of concentration of DO was relatively high. Range of F-CO_2 of pond 1 (7.33mg l^{-1} to 22.66mg l^{-1}) was much higher than pond 2 (3.66mg l^{-1} to 4.66mg l^{-1}).A very high concentration of F-CO_2 in water of pond1 could be due to higher respiration of aquatic biota, more decomposition of organic matter and low photosynthesis[25].

Phosphates ranged from 0.02 mg l^{-1} to 0.47 mg l^{-1} at pond 1 and 0.005 mg l^{-1} to 0.42 mg l^{-1} at pond 2.Phosphate concentration is generally low at Barak Valley as revealed in the previous study on nine different ponds[28]. The range of nitrates at pond 1 was 0.03mg l^{-1} to 0.499 mg l^{-1} and at pond 2 was 0.01mg l^{-1} to 2.61 mg l^{-1}. However, at both the ponds the nitrates concentration was within the permissible limit of WHO[29]. In the industrial area of river Kapila, India, 2.6 mgl^{-1} of nitrate was recorded by Smitha[30].

Biomonitoring Scores: BMWP score ranged from 54 (pond 1, site 2) – 23 (pond 2, site 2) (table-8). Based on distribution and abundance of an individual family the BMWP Score values were computed to that family which again reflects their pollution tolerance. High BMWP scores mean pollution intolerant families, while low scores mean pollution tolerant families[18]. The maximum value of BMWP score in pond 1, site 2 indicated relatively better water quality in that site. Table-8 shows the ASPT scores of the two ponds. Highest score was recorded at site 4 of pond 2 (5.75), whereas lowest score was recorded in site 1 of pond 1(4.78). A high ASPT usually characterizes clean sites. Disturbed sites generally have low ASPT values and do not support many high scoring taxa[18].In SIGNAL score index, the macro-invertebrate families were computed by a 'grade number' between 1 and 10. The pollution tolerant families have a low grade number and sensitive to pollution families have a high number. Highest SIGNAL score was recorded in site 4 of pond 2 (4) whereas lowest score was recorded in site1of pond 1(2.25) (table-9).

Table-8
BMWP and ASPT Scores of four sites of two ponds studied

Ponds	Sites	BMWP scores	No. of families	ASPT scores
Pond 1	Site 1	43	9	4.78
	Site 2	54	11	4.9
Pond 2	Site 3	28	5	5.6
	Site 4	23	4	5.75

N.B: BMWP score, 0-16=Poor water quality; 17-50=Moderate water quality; 51-100=Good water quality; 101-150=High water quality; 151+=Very high water quality (Source: Mandaville 2002). ASPT Value : >6= Clean water, 5-6= Doubtful quality, 4-5 = Probable moderate pollution, <4 = Probable severe pollution (Source: Mandaville 2002).

Table-9
SIGNAL Score of the two ponds along with its water quality status

Ponds	Sites	SIGNAL Score	Water Quality status (Source: Gooderum and Tsyrlin 2002)
Pond 1	Site 1	2.25	Severe pollution
	Site 2	2.28	Severe pollution
Pond 2	Site 3	2.73	Severe pollution
	Site 4	4	Moderate pollution

Conclusion

Due to globalization and industrialization all the fresh water systems of urban areas are under threat. This study finds that even a small village converted to township is showing the sign of degradation of its fresh water systems.Hence there is a need for proper management. The authorities and management should come forward with protective measures to save the ponds from deterioration with the help of the municipalities, local peoples and NGOs.

Acknowledgement

The authors are thankful to the Head, department of Ecology and Environmental Science, Assam University, Silchar, India for providing laboratory facility and the owner of the fishery pond for giving permission to collect samples.

References

1. Williams P., Whitfield M., Biggs J., Bray S., Fox G., Nicolet P. and Sear D., Comparative biodiversity of rivers, streams, ditches and ponds in an agricultural landscape, *Biol Cons.,* **115,** 329–341**(2004)**
2. Scheffer M., van Geest G.J., Zimmer K., Jeppsen E., Sondergaard M., Butler M.G., Hanson M.A., Declerck S. and De Meester L., Small habitat size and isolation can promote species richness: second-order effects on biodiversity in shallow lakes and ponds, *Oikos*., **112,** 227–231 **(2006)**
3. Davies B.R., Developing a Strategic Approach to the Protection of Aquatic Biodiversity, PhD thesis, Oxford Brookes University **(2005)**
4. Rosenberg D.M and Resh V.H. (eds.), Freshwater biomonitoring and macroinvertibrates, Chapman and Hall, NewYork, 488 **(1993)**
5. Carter J.L. and Resh V.H., After site selection and before data analysis: sampling, sorting, and laboratory procedures used in stream benthic macroinvertebrate monitoring programs by USA state agencies, *J. N. Am. Benthol. Soc.,* **20 (2001)**
6. Balachandran C., Dinakaran S., Alkananda B., Boominathan M. and Ramachandra T.V., Monitoring aquatic macroinvertebrates as indicators for assessing the health of lakes in Bangalore, Karnataka, *International Journal of Advanced Life Sciences (IJALS)*, **5(1)**, 19-33 **(2012)**
7. Bae Y.J., Kil H.K. and Bae K.S., Benthic Macroinvertebrates for Uses in Stream Biomonitoring and Restoration, *KSCE Journal of Civil Engineering*, **9(1)**, 55-63 **(2005)**
8. Macan T.T. and Maudsley R., The insects of the stony substratum of Windermere, *Trans. Soc.Br.Ent*., **18**, 1-18 **(1968)**
9. Brittain J.E., Studies on the lentic Ephemeroptera and Plecoptera of Southern Norway, *Norskent. Tidsskr.*, **21**, 135-151 **(1974)**
10. Kumar A., Descriptions of the last instar larvae of odonata from the Dehra DunValley (India), with notes on biology I (Suborder: Zygoptera), *Orient Insects.,* **7**, 23–61 **(1973)**

11. Bal A. and Basu R.C., Insecta: Hemiptera: Mesovelidae, Hydrometridae, Velidae and Gerridae, In: State Fauna Series 3: Fauna of West Bengal, Part 5, Zoological Survey of India, Calcutta, 511–534 **(1994a)**

12. Bal A. and Basu R.C., Insecta: Hemiptera: Belostomatidae, Nepidae, Notonectidae and Pleidae, In: State fauna series 5: Fauna of West Bengal, Part 5, Zoological Survey of India, Calcutta, 535–558 **(1994b)**

13. Bal A. and Basu R.C., Insecta: Hemiptera: Corixidae, Veliidae, Mesoveliidae, Nepidae, Notonectidae and Gerridae. In: State fauna series 10: Fauna of Manipur, (Part 2), Zoological Survey of India, Kolkata, 625 **(2004)**

14. Westfall M.J. and Tennessen Jr K.J., Odonata, In: An introduction to the aquatic insects of North America, Merrit, R.W and Cummins (ed) Kendell/ Hunt Publishing Company Dubuque , Iowa 164-211 **(1996)**

15. Michael P., Ecological Methods for Field and Laboratory Investigation, Tata Mc. Graw-Hill publishing Company Ltd. New Delhi, 434 **(1984)**

16. APHA, Standard methods for the Examination of Water and Wastewater, 19th Edn. Published by American Public Health association,1015, fifteen street NW Washington, D.C. 20 R.C.0015 **(2005)**

17. Mandaville S.M., Benthic Macroinvertebrates in Freshwaters-Taxa Tolerance Values, Metrics, and Protocols. Soil and Water Conservation Society of Metro Halifax.http://lakes.chebucto.org/H-1/tolerance.pdf. **(2002)**

18. Sivaramakrishnan K.G., Composition and Zonation of Aquatic Insect Fauna of Kaveri and its Tributaries and the Identification of Insect Fauna as Indicator of Pollution, D.O.E. Project Number 22/18/89-Re. **(1992)**

19. Chessman B., SIGNAL 2 – A Scoring System for Macro-invertebrate (‘Water Bugs’) in Australian Rivers, Monitoring River Heath Initiative Technical Report no 31, Commonwealth of Australia, Canberra **(2003)**

20. Shivayogimath C.B, Kalburgi P.B, Deshannavar U. Band Virupakshaiah D.B.M., Water Quality Evaluation of River Ghataprabha, India, *I Res. J. Environment Sci*., **1(1)**, 12-18 **(2012)**

21. Farshad H. and Venkataramana G.V., Impact of Physico-Chemical Parameters of Water on Zooplankton Diversity in Nanjangud Industrial Area, India, *Int. Res. J. Environment Sci*., **1(4)**, 37-42 **(2012)**

22. Kumar A., Studies on Qualitative and Quantitative Abundance of Aquatic Entomofauna in Glacial fed Mountainous Goriganga River ofKumaun Himalaya Uttarakhand, India, *Int. Res. J. Environment Sci*., **3(4)**, 51-63 **(2014)**

23. Gupta S., Dey S. and Purkayastha P., Use of Aquatic Insects in Water quality assessment of Ponds around two Cement Factories of Assam, India, *Int. Res. J. Environment Sci*., **2(7),** 15-19 **(2013)**

24. Patra A., Santra K.B. and Manna C.K., Limnologcal Studies Related o Physico-Chemical Characteristics of Water of Santragachi and JoypurJheel, W.B., India, *Our Nature.,* **8**, 185-203 **(2010)**

25. Bhat M.M., Yazdani T., Narain K., Yunus M. and Shukla R.N., Water Quality Status of Some Urban Ponds of Lucknow, Uttar Pradesh, *Journal of Wetlands Ecology,* **2**, 67-73 **(2009)**

26. Buragohain K. and Gupta S., Chlorophyll dynamics of *Euglena* infested ponds in Barak Valley, Assam, North East India, *Eco.Env.& Cons*., **16(2),** 133-137 **(2010)**

27. Wright R., Seasonal variation in water of a West African river (R. Jong in Sierra Leone), *Revue d’ Hydrobiologie Tropicale*, **15(3)**, 193-199 **(1982)**

28. Bhuiyan J.R and Gupta S., A comparative hydrobiologicalstudy of a few ponds of Barak Valley, Assam and their role as sustainable water resources, *J.Environ.Biol*., **28(4)**, 799-802 **(2007)**

29. WHO, Guidelines for Drinking Water Quality, vol.**1**, Recommendations,World Health Organization, Geneva, 130 **(2011)**

30. Smitha, Ajay D. and Shivashankar P., Physico Chemical Analysis of the Freshwater at River Kapila, Nanjangudu Industrial Area, Mysore, India, *Int. Res. J. Environment Sci.,* **2(8)**, 59-65 **(2013)**