The Pharma Innovation Journal 2018; 7(7): 162-168

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(7): 162-168

www.thepharmajournal.com
Received: 15-05-2018
Accepted: 21-06-2018

Sanghamitra Konar
(A). Assistant Teacher, Kaligram Girls High School, Burdwan, West Bengal, India
(B). Research Scholar, Department of Zoology, University of Burdwan, West Bengal, India

Correspondence
Sanghamitra Konar
(A). Assistant Teacher, Kaligram Girls High School, Burdwan, West Bengal, India
(B). Research Scholar, Department of Zoology, University of Burdwan, West Bengal, India

Estimation of water quality of different types of Ponds of Burdwan, West Bengal, India through distribution and abundance of larval chironomidae in relation with physicochemical characteristics of water

Sanghamitra Konar

Abstract
The present investigation was done to evaluate the status of water quality of selected ponds of Burdwan area in terms of density and abundance of chironomid population in correlation with physico-chemical parameters of water. Seven physico-chemical water quality parameters were measured in four selected sites along with density and abundance of Chironomid population. Humidity, Dissolved Oxygen content showed significant seasonal variation among the four studied sites. The total alkalinity, phosphate, nitrate value of water samples significantly varied in the four studied sites at different seasons throughout the study period.

Keywords: Physico-chemical parameters, diversity, seasonal variations, adundance, Chironomid population

1. Introduction

Water is the universal solvent on world. Of the total amount of global water only 2.4 per cent is situated on terrestrial region. From this amount only a little amount can be utilized as fresh water. The available fresh water to man is hardly 0.3 to 5 per cent of the total supply and therefore its judicious use is imperative. Though ponds and lakes are the principle forms of inland standing surface water, important to men, fishes, aquatic-birds, growth in population, industries and advanced agricultural practices in our country. They are became a threat to those ecosystem which were continuously used. Population explosion, industrialization and urbanization created problems of water pollution. Direct effluent discharges, agricultural run off, domestic sewage an oligotrophic water body most often contain complex mixtures of contaminants which may made new compounds due to breakdown and transformation processes and hence contribute to the complexity of the total toxic burden. By the employment of chemical and physical measurements only, the synergistic effect of pollution on its biotic community may not be fully and easily assessed. In general biological indicators provide a potential for direct observation of the overall effect of environmental contaminants by virtue of their role in aquatic ecosystems (Warwick, 1988) [1].

The Chironomidae family, one of the main member of the benthic community, is very diversified and abundant, and adversely distributed (Oliver, 1971; Coffman and Ferrington, 1996) [2, 3] and can subsist in a wide range of water qualities (Saether, 1979; Lindergaard, 1995; Real *et al*., 2000; Higuti *et al*., 2005) [4-7]. Several studies have revealed that physical and chemical factors strongly influence the composition and abundance of chironomids (Oliver, 1971; Botts, 1997; Callisto, 1997) [8, 9]. These properties make them potential indicator in determining water for the presence of pollution. Chironomids are one of the most abundant macro-invertebrate group and they often account for the majority of aquatic insects in freshwater environments (Epler, 2001) [10]. The larval stage that belongs to the family Chironomidae in lentic to lotic water is the longest period of life cycles of these insects. These are sometimes called 'bloodworms' because of their bright red colour. Polluted water apparently favours their multiplication and emergence but relatively clean water can also support their breeding (Kar *et al*, 2011) [11]. Due to adaptation capability and ecological ability of larvae to extreme environmental conditions of temperature, pH, salinity, depth, flow velocity and productivity, they can be found in many different aquatic environments (Armitage *et al*., 1995) [12].

Also, species composition of chironomid assemblages differs qualitatively and quantitatively among microhabitats, and larvae are highly selective in their choice of a site (Maasri *et al.*, 2008) [13]. Larval chironomids are used as indicators in biological classification of inland water reservoirs by their abundance in unit area of bottom and species compositions (Kırgız, 1988) [14]. Chironomid populations are subject to changes in physicochemical conditions and input of nutrients (Lim, 1990) [15] and their abundance patterns are also influenced by the available larval food, particularly the deposition of organic matter and detritus on the bottom (Galdean *et al*., 2000) [16]. Therefore, the objectives of this investigation includes assessment of the differential response of chironomid population in relation to physico-chemical characteristics of water in and around Burdwan.

2. Material and Methods

2.1 Study Area

Site-I represents an agricultural pond is located adjacent to paddy field, at Kaligram. The main sources of this pond are run off from paddy fields and rain water. This water body is surrounded by paddy fields.

Site-II is represented by domestic sewage canal resulting from domestic sewage of Kaligram and adjoining areas.

Site-III represents a waste canal is located near cast iron factory, at Palitpur. The main sources of this canal are industrial effluents from many cast iron factories of Palitpur.This canal contains coal ash, acids, toxic chemicals and liquid byproducts.

Site-IV represents a pond located at Burdwan University, Golapbag Campus, resulted from rain water and ground water.

2.2 Sampling of water samples

Water samples were collected from the four sites for a period of three year from January 2013 to December 2015. The water samples were collected with the aid of samplers. Various physico-chemical parameters of water samples were measured following the standard methods of APHA (1998) [17].

2.3 Determination of physical parameters

pH was recorded using a portable pen pH meter (Hanna®, Mauritius). Light intensity is measured by using Digital Lux Meter (LX-101). Humidity is measured by hygrometer.

2.4 Determination of chemical parameters

Alkalinity (APHA 2320B) was measured using acid–base titrimetry. Phosphate was estimated using spectrophotometric method. Nitrite (APHA 4500 NO−2 B) and nitrate nitrogen were estimated by acid treatment followed by spectrophotometry. DO was determined using Winkler's method on the site itself. All the reagents used for the analysis were analytical reagent grade. The quality assurance and quality procedure were also used as described in APHA 1998.

2.5 Determination of Chironomid larval population density

To determine chironomid larval population density, three 15×15×15 cm Ekman dredge samplers were used for sampling at each sampling site (Kar *et al.*, 2011). These benthic samples were washed through a 0.35-mm pore screen and the retained material identified and counted using standard methods (Ali *et al.*, 1977; Ali and Baggs, 1982) [18, 19].

2.6 Statistical Analysis

The data obtained on the physicochemical parameters were subjected to correlation analysis (Zar 1999) [20]. Correlation index, was used to determine whether there were any correlation between the limnological parameters and number of individuals or not (Kar *et al*. 2011). The major objective of the present work was to assess water quality by using Chironomid larval population or factors (Manly 1994) [21].

3. Results & Discussions

The water parameters for detection of water quality for 3 years (from January 2013 to December 2015) of four different study sites were presented in Tables 1, 2, 3 and 4 respectively.

Table 1: Physico-chemical analysis of water (site- 1).

Parameters	**Premonsoon**	**Monsoon**	**Postmonsoon**
LI(x100Lux)	695.12±0.15	850.30±0.15	579.13±0.15
Humidity	37.20±0.15	47.39±0.15	28.29±0.15
Alkalinity (mmol/l)	0.50±0.10	0.54±0.10	0.64±0.10
Phosphate (ppm)	0.24±0.15	0.19±0.15	0.23±0.15
Nitrate (mg/l)	0.02±0.15	0.02±0.15	0.02±0.15
Soil pH	7.3±0.15	7.0±0.15	7.2±0.15
DO(mg/l)	8.79±0.10	3.60±0.10	7.53±0.10

Table 2: Physico-chemical analysis of water (site- 2).

Parameter	**Premonsoon**	**Monsoon**	**Postmonsoon**
LI(x100Lux)	805.26±0.15	760.35±0.15	619.33±0.15
Humidity	35.4±0.15	69.8±0.15	33.1±0.15
Alkalinity(mmol/l)	1.30±0.10	1.40±0.10	1.11±0.10
Phosphate(ppm)	10.26±0.15	5.40±0.15	10.46±0.15
Nitrate(mg/l)	0.03±0.15	0.04±0.15	0.04±0.15
Soil pH	7.5±0.15	7.7±0.15	7.2±0.15
DO(mg/l)	6.67±0.10	4.87±0.10	5.28±0.10

Table 3: Physico-chemical analysis of water (site- 3)

Parameter	**Pre Monsoon**	**Monsoon**	**Post Monsoon**
LI(x100Lux)	719.75±00	543.11±0.0	239.01±20
Humidity	40.1±0.15	79.7±0.15	59.04±0.15
Alkalinity(mmol/l)	0.75±0.15	0.75±0.15	2.75±0.15
Phosphate(ppm)	10.27±0.15	10.17±0.15	10.07±0.15
Nitrate(mg/l)	0.60±0.10	0.63±0.10	0.53±0.10
Soil pH	7.2±0.15	7.1±0.15	7.0±0.15
DO(mg/l)	2.42±0.15	1.53±0.15	2.40±0.15

Table 4: Physico-chemical analysis of water (site- 4)

Parameter	Premonon	Monsoon	Postmonsoon
Li(X100lux)	575±0.20	327±0.20	270±0.20
Humidity	50.27±0.10	68.9±0.10	49.9±0.10
Alkalinity(Mmol/L)	2.18±0.15	2.25±0.15	1.30±0.15
Phosphate(Ppm)	5.33±0.10	5.23±0.10	1.10±0.10
Nitrate(Mg/L)	0.13±0.10	0.14±0.10	0.13±0.10
Soil Ph	7.9±0.15	8.0±0.15	7.8±0.15
Do(Mg/L)	4.50±0.10	2.31±0.10	5.02±0.10

Note: All the values were reported in mean ±standard deviation. means of three replicates were taken.

In the present investigation, light intensity gradually decreased from premonsoon to monsoon and then postmonsoon for last three study sites. But at study site 1 light intensity highest during monsoon. The range of light intensity was found to be higher in site I and II in comparison to site III and IV. (Table – 1-4).

Humidity values ranged between 28.29% to47.39% in site 1, 33.10% to 69.80% in site 2, 40.1% to 79.7% in site 3 and

49.9% to 68.9% in site 4. Humidity was maximum in months of monsoon among all four study areas and minimum in months of post-monsoon among the studied sites I,II and IV where at study site III humidity is minimum during premonsoon (Table-1-4).

Total alkalinity showed a accending trend from premonsoon to monsoon and then postmonsoon for site I. In site III, the level of total alkalinity was significantly higher during post-monsoon period. For Site-II and Site-IV the level of total alkalinity showed considerable fluctuation among the different seasons throughout the investigation period. Site-III reflected significantly higher measurements of total alkalinity in comparison to the other studied sites. (Table-1-4).

Phosphate content in water samples showed considerable variation among the four studied sites. Minimum level of phosphate content was found to be in case of site-I through out the study period. There is no such variation in the level of phosphate content of water samples in site III. There is significant reduction in the phosphate content of water samples during monsoon for site-II. Lower level of phosphate content was recorded during post-monsoonal period for site IV. The phosphate level fluctuates throughout the whole study period for site-IV (Table- 1-4)

The nitrate concentration of water of all the study sites showed significant fluctuation throughout the study period. Higher level of nitrates in water samples were recorded for site –III and minimum level were recorded for site-I and II. (Table -1-4)

There is a decline in dissolved oxygen concentration in monsoon in all the four sites. (Table-1-4). In the present investigation, low abundance and distribution of larval chironomids were reported in site I and site III, highest values were recorded for site II and IV respectively.

Number of chironomid population were found to higher during the postmonsoon for study sites I,III &IV and site II indicating the dense population of chironomid larva throughout the study period.

Table 5: Correlation between different physico-chemical factors of water and chironomid larvae in site-I at different season:

Agri Pre Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	0.756	1.0					
DO	0.999	0.961	1.0				
Nitr	0.945	1.000	0.961	1.0			
Hum	-0.150	-0.465	-0.201	-0.465	1.0		
Alk	-0.839	-0.971	-0.866	-0.971	0.664	1.0	
Chiro	-0.945	-1.000	-0.961	-1.000	0.692	0.154	1.0

Agri Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil Ph	1.0						
Water Phos	0.866	1.0					
DO	-0.721	-0.971	1.0				
Nitr	0.500	0.866	-0.651	1.0			
Hum	-0.058	0.449	-0.651	0.836	1.0		
Alk	-0.115	0.397	-0.606	0.803		1.0	
Chiro	0.277	0.721	-0.866	0.971	0.943	0.923	1.0

Agri Post Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil Ph	1.0						
Water Phos	0.786	1.0					
DO	0.387	-0.266	1.0				
Nitr	0.655	0.982	-0.444	1.0			
Hum	0.797	1.0000	-0.248	0.978	1.0		
Alk	0.189	-0.459	0.979	-0.619	-0.442	1.0	
Chiro	-0.996	-0.839	-0.302	-0.721	-0.849	-0.099	1.0

Table 6: Correlation between different physico-chemical factors of water and chironomid larvae in site-II at different season:

Dom Pre Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil Ph	1.0						
Water Phos	0.640	1.0					
DO	0.866	0.938	1.0				
Nitr	0.500	0.986	0.866	1.0			
Hum	-0.891	-0.919	-0.999	-0.839	1.0		
Alk	-0.739	-0.991	-0.977	-0.953	0.964	1.0	
Chiro	0.910	0.901	0.995	0.814	-0.999	-0.952	1.0

Dom Pond Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	0.663	1.0					
DO	0.982	0.792	1.0				
Nitr	1.000	0.663	0.982	1.0			
Hum	-0.603	-0.997	-0.743	-0.603	1.0		
Alk	0.693	0.999	0.817	0.693	-0.993	1.0	
Chiro	0.891	0.931	0.961	0.891	-0.899	0.945	1.0

Dom Post Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	-0.987	1.0					
DO	-0.778	0.665	1.0				
Nitr	0.945	-0.986	-0.529	1.0			
Hum	-0.966	0.995	0.590	0.708	1.0		
Alk	-0.866	0.773	0.988	-0.655	0.708	1.0	
Chiro	-0.910	0.830	0.968	-0.724	0.772	0.995	1.0

Table 7: Correlation between different physico-chemical factors of water and chironomid larvae in site-III at different season:

Ind Pre Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil Ph	1.0						
Water Phos	-0.991	1.0					
DO	1.000	-0.991	1.0				
Nitr	0.954	-0.985	0.954	1.0			
Hum	0.986	-0.956	0.986	0.891	1.0		
Alk	-0.803	0.875	-0.803	-0.945	-0.693	1.0	
Chiro	-0.911	0.957	-0.911	-0.993	-0.830	0.977	1.0

IND MON	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	0.756	1.0					
DO	-0.737	-0.115	1.0				
Nitr	-0.971	-0.577	0.878	1.0			
Hum	-0.825	-0.253	0.990	0.936	1.0		
Alk	-0.904	-0.404	0.955	0.980	0.987	1.0	
Chiro	-0.866	-0.327	0.976	0.961	0.997	0.997	1.0

Ind Post Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	0.756	1.0					
DO	-0.052	-0.693	1.0				
Nitr	1.000	0.756	-0.052	1.0			
Hum	-0.715	-0.998	0.736	-0.715	1.0		
Alk	0.896	0.968	-0.490	0.896	-0.951	1.0	
Chiro	-0.866	-0.982	0.545	-0.866	0.969	-0.998	1.0

Table 8: Correlation between different physico-chemical factors of water and chironomid larvae in site-IV at different season:

Con Pre Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	-0.786	1.0					
DO	-0.945	0.945	1.0				
Nitr	1.000	-0.786	-0.945	1.0			
Hum	-0.881	0.985	0.987	-0.881	1.0		
Alk	-0.998	0.825	0.964	-0.998	0.910	1.0	
Chiro	-0.918	0.967	0.997	-0.918	0.996	0.942	1.0

Con Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	0.982	1.0					
DO	-0.945	-0.866	1.0				
Nitr	0.993	0.997	-0.901	1.0			
Hum	1.000	0.978	-0.952	0.991	1.0		
Alk	0.998	0.968	-0.964	0.984	0.999	1.0	
Chiro	0.982	0.929	-0.990	0.954	0.986	0.992	1.0

Con Post Mon	Soil pH	Water Phos	DO	Nitr	Hum	Alk	Chiro
Soil pH	1.0						
Water Phos	-0.933	1.0					
DO	0.500	-0.778	1.0				
Nitr	-0.756	0.470	0.189	1.0			
Hum	-0.611	0.855	-0.991	-0.056	1.0		
Alk	0.693	-0.906	0.971	-0.052	-0.994	1.0	
Chiro	0.679	-0.897	0.975	-0.032	-0.996	1.000	1.0

(*ALK-Alkalinity, PHOS-Phosphate, NITR-Nitrate, DO-Dissolved oxygen,Chiro- Number of chironomid larvae)

From the correlation study, it is observed that humidity was positively correlated with larval abundance at first two season but at post monsoon it is negatively correlated. Soil pH was negatively correlated with larval population at all three season. In Control pond, DO, Soil pH were negatively correrated with larval population at Post-Monsoon. At Monsoon, DO was negatively correlated with abundance of Chirinomids. Humidity, water phosphate, nitrate were negatively correlated with no. of Chironomida at post Monsoon. Alkalinity was positively correlated with larval population at all three season of Control pond.

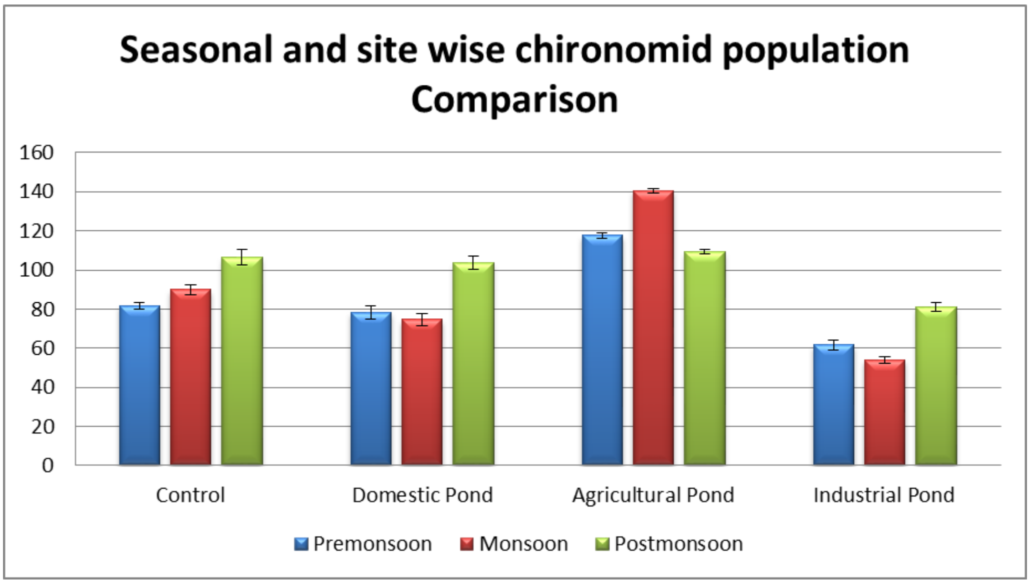

Fig 1: Abundance of Chironomid larvae within four sites in monthly variation.

Table 9: Principal component analysis (2 components counted) for physico-chemical parameters of water in site- I, II, III, IV

	PC 1	**PC 2**
Soil pH	-0.00254	0.004638
Water PO	-0.11461	-0.09332
DO	0.050857	-0.06297
Nitrate	-0.00611	-0.00111
Humidity	-0.40682	0.82303
Alkalinity	-0.00945	0.008137
No.of Chironomids	0.89755	0.40719
Eigenvalue	693.67	193.799
% of Variance	69.256%	19.349%

PC-1 explain 69.256% of varience with Eigen value 693.67.Where, PC-2 explain 19.349% of variance with Eigen value 193.799. As, PC 1 & 2 show most of the varience then rest of the varience is plotted against PC 1 & 2. No. of Chironomids very significantly loaded in factor 1 where humidity are significantly loaded in factor 2.Except, No. of Chironomids and DO other components are inversely correlated against PC 1. In PC 2 DO, nitrate and water phosphate are inversely correlated and rest of the components correlate directly.

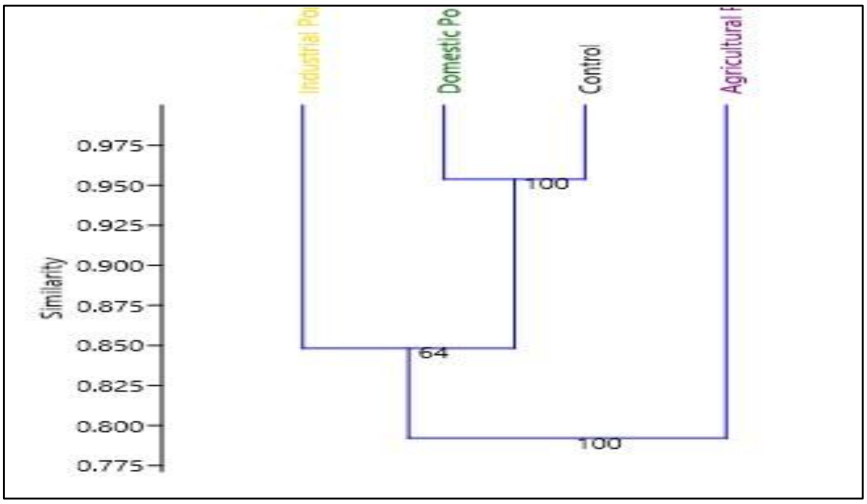

Fig 2: Sang Dendrogram of different type of ponds with Chironomid abundance

In this paper, I use Bray Curtis similarity index and hierarchical paired group (UPGMA) performed by 1000 boot-strap. Here, it is shown that single cluster formed between domestic & control pond for Chironomid abundance with 0.950 similarity.Industrial pond connects with domestic & control pond cluster with showing similarity 0.850. Here, agricultural pond is outgroup. It connects industrial pond showing least level of similarity for chironomid abundance and cluster of Domestic & Control pond distantly related with it. Then, it is concluded that Domestic and Control show similar type of Chironomid abundance which has least similarity with Industrial pond. But, Chironomid abundance of agricultural pond is rather different.

4. Conclusion

In this present survey temperature showed significant level of seasonal variation. The alkaline nature of water samples of the four studied areas indicate towards the anthropogenic influence in terms of on-farm inputs as well as industrial and domestic discharges as well as due to the buffering capacity of water. (Datta *et al.*, 2009) [23] ; Kar *et al.* (2011). pH in surface waters remained alkaline throughout the study period at four study sites with maximum value during the post monsoon and summer seasons and the minimum during monsoon. Generally, its seasonal variations attributed to factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, low primary productivity, reduction of salinity and temperature, and decomposition of organic matter (Paramasivam and Kannan, 2005; Bragadeeswaran *et al.*, 2007; Kar *et al.*, 2011) [24, 25]. The recorded high summer pH might be due to the influence of high biological activity (Govindasamy *et al.*, 2000) [26] and due to the occurrence of high photosynthetic activity (Sridhar *et al.*, 2006; Saravanakumar *et al.*, 2008) [27, 28].

Light intensity value of the present investigation reflected the effect of different seasons on the four studied sites under the present investigation. Higher level of humidity were recorded during monsoonal period for all the four studied sites due to higher evaporation rate from the surface water bodies during the pre-monsoonal period and subsequent increase in the moisture content in the atmosphere during the monsoonal period. Lower level of humidity were seen during post monsoonal period reflecting lower evaporation rate from the water bodies and therefore lower level of moisture content in the atmosphere.

Higher alkalinity during summer months were recorded which may be attributed towards the increased photosynthesis in the algal blooms resulting into the precipitation of carbonates of calcium and magnesium from bicarbonates causing higher alkalinity. Similar observations were made by Kulshrestha *et al.*, 1992 [29] and Kar *et al.*, 2011.

Higher level of phosphate content during pre-monsoon and monsoon for site –II for agricultural activities and other domestic anthropogenic activities (Tepe *et al.*, 2005) [30]. The addition of super phosphates applied in the agricultural fields as fertilizers and alkyl phosphates used in households, as detergents can be other sources of inorganic phosphates during the season (Bragadeeswaran *et al.*, 2007). The post-monsoonal low value could be attributed to the limited flow of freshwater, high salinity and utilization of phosphate by phytoplankton (Rajasegar, 2003) [31]. The variation may also be due to the processes like adsorption and desorption of phosphates and buffering action of sediment under varying environmental conditions (Rajasegar, 2003).

The recorded highest monsoonal nitrate value could be through oxidation of ammonia form of nitrogen to nitrite formation (Rajasegar, 2003). The recorded low values during non-monsoon period may be due to its utilization by phytoplankton as evidenced by high photosynthetic activity (Rajaram *et al.*, 2005; Bragadeeswaran *et al.*, 2007; Kar *et al.*, 2011) [32].

DO has inverse relationship with temperature. As the temperature was slightly lower during monsoon and winter months the dissolve oxygen content was found to be higher in water samples of the studied sites. (Datta *et al.*, 2009). The higher water temperature may result in decline of dissolved oxygen concentration of water.

Seasonal differences in the density and abundance could be explained by the different amounts of allochthonous material entering these systems (Kar *et al.*, 2011). Increased input of allochthonous matter makes a decline in organism density.

The higher values of chironomid larva during the winter and post winter period may be attributed towards increase in nutrient inputs and organic materials, primarily domestic sewage, agrochemicals which increased the amount of benthic surface area by increasing the three dimensional aspect of the four study sites and by providing an increase in food supply for the chironomids (Friemouth *et al.*, 1994; Kar *et al.*, 2011) [33].

As the population of chironomids were higher in site I were significantly higher through out the study period it therefore indicates towards higher nutrient enrichment and organic material concentration.and therefore the water quality of study site I is deteriorating at fast rate due to anthropogenic inputs where Site II, III and IV were less vulnerable with respect to deterioration of water quality due to anthropogenic influence (Kar *et al.*, 2011). The density of chironomid population in site II, III and IV were least may be due to water pH, presence of toxic substances along with low nutrient inputs.

From the overall experiment it can be decided that impairment of the water quality of the studied sites has contributed significantly towards distribution and abundance of chironomid population among different seasons. Among the study sites the water quality of site I is deteriorating at fast rate in compare to other study sites. Therefore, abundance of chironomid population shows considerable promise towards indicating the status of water parameters of four study areas in Burdwan, West Bengal India.

5. Acknowledgements

I am thankful to Dr. U. Mazumdar, Assistant Professor, Department of Zoology, Hoogly Womens College, West Bengal, India for providing meaningful suggestions. I am indebted to the Head, Department of Zoology, The University of Burdwan West Bengal for laboratory facilities.

6. References

1. Warwick WF. Morphological deformities in Chironomidae (Diptera) larvae as bioindicators of toxic stress. in: M.S. Evans (ed.). Toxic contaminants and ecosystem Health. A Great Lake focus. Wiley and Sons, New York: 1988, 281-320.
2. Oliver DR. Life history of the Chironomidae. Ann. Rev. Ent., 1971; 12:211-230.
3. Coffman WP, Ferrington LC jr. Chironomidae. In: R.W. Merritt & K.W, 1996.
4. Saether OA. The influence of eutrophication on deep lake benthic invertebrate communities. Prog. Wat. Tech. 1980; 12:161-180.
5. Lindergaard C. Classification of water-bodies and pollution. In: Armitage P, Cranston PS and Pinder LCV. (eds). The Chironomidae: biolgy and ecology of non-biting midges. London: Chapman and Hall: 1995, 385-404,
6. Real M, Rieradevall M, Prat N. Chironomus species (Diptera: Chironomidae) in the profundal benthos of Spanish reservoirs and lakes: factors affecting

distribution patterns. Freshw. Biol., 2000; 43(1):1-18.
7. Higuti J, Zviejkovski IP, Takahashi MA, Dias VG. Chironomidae indicadora de estado trófico em reservatórios. In:Rodrigues, L., Thomaz, S.M., Agostinho, A.A. and Gomes, L.C. (eds).Biocenosesem reservatórios: Padrões espaciais e temporais. São Carlos: Rima: 2005,137-145,
8. Botts PS. Spatial pattern, patch dynamics and successional change: chironomid assemblages in a Lake Erie coastal wetland, Freshw. Biol., 1997; 37(2):277-286.
9. Callisto M. Larvas bentônicas de Chironomidae (Diptera: Insecta) em quatro ecossistemas lóticos amazônicos sob influência das atividades de uma mineração de bauxita. Anais do 8 Seminário Regional de Ecologia: 1997, 89-98,
10. Epler JH. Identification manual for the larval Chironomidae (Diptera) of North and South Carolina. NC Dept. Environ. Nat. Res., Raleigh, NC: 2001, 526,
11. Kar D, Banerjee, Arnab, Palit, Debnath. Assessment of water quality of some selected sites of Durgapur Industrial belt,West Bengal, India through distribution and abundance of Chirinimidae in relation with physicochemical characteristics of water. International Journal of Lakes and Rivers, 2011; 4(2):177-198.
12. Armitage P, Cranston PS, Pinder LCV. Chironomidae – Biology and ecology of non-biting midges. *Chapman & Hall, London*. 1995, 572.
13. Maasri A, Fayolle S, Gandouin E, Garnier R, Franquet E. Epilithic chironomid larvae and water enrichment: is larval distribution explained by epilithon quantity or quality? J. N. Am. Benthol. Soc., 2008; 27(1):38-51.
14. Kırgız T. A preliminary study on Chironomidae Larvae in Lake Gala (in Turkish). IX. National Biology Congress, Cumhuriyet Univ., Fen Edebiyat Faculty, Biology Department, Sivas: 1988, 11,
15. Lim RP. Effects of pesticides on the aquatic invertebrate community in rice fields. In: Proceedings of the International Conference on Tropical Biodiversity. In Harmony with Nature, 12-16 June 1990, Kuala Lumpur, Malaysia: 1990, 336-352,
16. Galdean N, Callisto M, Barbosa FAR. Lotic ecosystems of Serra do Cipo, Southeast Brazil: water quality and a tentative classification based on the benthic macroinvertebrate community. Aquat. Ecosys. Hlth. and Manage. 2000; 66:545-552.
17. American Public Health Association (APHA). Standard methods for the examination of water and wastewater (20th ed.) Washington, DC: American Public Health Association, 1998.
18. Ali A, Mulla MS, Federici BA, Pelsue FW. Seasonal changes in chironomid fauna and rainfall reducing chironomids in urban flood control channels. Environ. Entomol. 1977; 6:619-622.
19. Ali A, Baggs RD. Seasonal changes of chironomid populations in a shallow natural lake and in a man-made water cooling reservoir in central Florida. Mosq. News, 1982; 42:76-85.
20. Zar JH. Biostatistical analysis. The Edn. Prentice Hall, Englewood Cliffs, New Jersey, USA, 1999.
21. Manly BFJ. Multivariate statistical methods: A primer II ed. London, UK: Chapman and Hall, 1994.
22. Datta JK, Layek S, Banerjee A, Mondal NK, Gupta S. Physicochemical characterization of water quality of eutrophied surface water body and ground water around the field crop research station, Burdwan, West Bengal. Asian J. water Environ. and Poll., 2009; 7(3):69-75.
23. Paramasivam S, Kannan L. Physico-chemical characteristics of Muthupettai mangrove environment, Southeast coast of India. Int. J. Ecol. Environ. Sci., 2005; 31:273-278.
24. Bragadeeswaran S, Rajasegar M, Srinivasan M, Kanagarajan U. Sediment texture and nutrients of Arasalar estuary, Karaikkal, southeast coast of India. J. Environ. Biol., 2007; 28:237-240.
25. Govindasamy C, Kannan L, Azariah J. Seasonal variation in physico-chemical properties and primary production in the coastal water biotopes of Coromandel Coast, India. J. Environ. Biol. 2000; 21(1):1-7.
26. Sridhar R, Thangaradjou T, Kumar SS, Kannan L. Water quality and phytoplankton characteristics in the Palk Bay, southeast coast of India. J Environ. Biol., 2006; 27:561-566.
27. Saravanakumar A, Rajkumar M, Serebiah JS, Thivakaran GA. Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat. J Environ. Biol., 2008; 29:725-732.
28. Kulshrestha SK, George MP, Saxena R, Johri M, Shrivastava M. Seasonal variations in the limnochemical characteristics of Mansarovar reservoir of Bhopal. In Aquatic Ecology (Mishra S. R. and Saksena D. N.Eds.), Ashish Publishing House, New Delhi: 1992, 275-292.
29. Tepe Y, Türkmen A, Mutlu E, Ate A. Some Physicochemical Characteristics of Yarseli Lake, Hatay, Turkey. Tur. J. Fisheries and Aqua. Sci, 2005; 5:35- 42.
30. Rajasegar M. Physico-chemical characteristics of the Vellar estuary in relation to shrimp farming. J. Environ. Biol. 2003; 24:95-101.
31. Rajaram R, Srinivasan M, Rajasegar M. Seasonal distribution of physico-chemical parameters in effluent discharge area of Uppanar estuary, Cuddalore, South-east coast of India. J Environ. Biol. 2005; 26:291-297.
32. Freimuth P, Bass D. Physicochemical Conditions and Larval Chironomidae (Diptera) of an Urban Pond. Proc. Okla. Acad. Sci. 1994; 74:11-16.