Asian Journal of Water, Environment and Pollution, Vol. 7, No. 2, pp. 83-87.

Scientific Note

Limiting Effect of Some Toxic Heavy Metals on Zooplankton Diversity in Freshwater Lake Ecosystem at Sahebbundh, Purulia, West Bengal

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Received August 27, 2007; revised and accepted September 23, 2009

Abstract: Environmental monitoring of inland water bodies is needed for proper introspection of the structural and functional responses of freshwater ecosystem vis-à-vis status of biological components. Above endeavour have been initiated by periodic monitoring of both biological and physico-chemical parameters of a freshwater lake at Sahebbundh, Purulia, West Bengal, which is located at 23°29′42″ N latitude and 86°21′37″ E longitude. Water of this 63-acre lake is widely used for drinking purposes during summer months. But the water body has become a target of several anthropogenic interferences like garage activities, biomedical wastes, disposed sewage, etc., which can potentially hamper the health of the freshwater lake ecosystem. In all 28 species of zooplanktons are recorded from the lake, including some which are reported to be indicator of thermal pollution. Among the heavy metals the study concentrates upon Pb^{2+}, Cr^{3+} and Cd^{2+}. A remarkable change of community dynamics of the zooplankton reflected by diversity fluctuations is observed particularly in those areas with anthropogenic activities including introduction of biomedical wastes, garage activities etc. Interestingly the toxic heavy metal is very high in those spots with direct human interferences. The level of Pb^{2+} is much higher in those sites in comparison to the other two heavy metals, i.e. Cr^{3+} and Cd^{2+}. The Pb^{2+} is obviously a direct contribution from anthropogenic garage activities, which is established from our findings.

Key words: Toxic metal, zooplankton, diversity, freshwater, ecosystem, anthropogenic interference, limiting effect.

Introduction

Environmental monitoring of inland water is needed for proper understanding of structural and functional responses of freshwater ecosystem vis-à-vis status of biological components. Above endeavour have been initiated by periodic monitoring of both biological and physico-chemical parameters of a freshwater lake at Sahebbundh, Purulia, West Bengal, which is located at 23°29′42″ N latitude and 86°21′37″ E longitude. Water of this 63-acre lake is widely used for domestic as well as drinking purposes especially during summer months. It is also a visiting place for migratory birds. The lake is also being used for recreational and cultural purposes throughout the year. So it is an important wetland ecosystem for its biological diversity, aesthetic beauty and multipurpose features. There are a number of interferences like biomedical wastes, disposed sewage, garage activities etc. The present study will help to assess the degree of deterioration of the lake.

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Materials and Method

The main objective of the field study is to have a clear understanding of several physico-chemical and biological aspects of the lake ecosystem with respect to topography, infrastructure and surrounding activities. The samplings were carried out throughout a year in the predetermined sampling sites of the above-mentioned lake. The ten sampling sites were chosen on the basis of the introduction of wastes, concrete embankment or large amount of anthropogenic activities. The surface water of the lake was collected using water sampler and taken to the laboratory following APHA (1992) and EPA guidelines for their preservation. The analyses of the physico-chemical parameters were carried out following standard method mentioned in APHA (1992). The water samples for analysis of heavy metals were digested using HNO_3 and $HClO_4$. The digested samples were measured in Atomic Absorption Spectrophotometer (Varian SpectrAA 55). For the study of zooplankton diversity 50 litres of water was filtered from each abovementioned sites by a zooplankton net (No. 20) and preserved in 70% alcohol. They were identified following standard literature (Needham and Needham, 1962; Tonapi, 1980; Battish, 1992). A Sedgwick-rafter counting cell was used for quantitative analysis and their abundance was expressed as number of individuals per litre. Shannon-Wiener diversity index was also calculated following Krebs (1985).

Some statistical operations like principal component analysis and cluster analysis were performed using Multi Variate Statistical Package (MVSP 32) software.

Results and Discussion

In the current study we have recorded 28 zooplankton species in this rain-fed Lake Ecosystem. Mostly we have found groups of zooplanktons comprising Rotifera, Cladocera and Copepoda. As observed, the Shannon Wiener diversity index (Krebs, 1985) (Table 1) is pretty high throughout the year and the same is well supported by Figure 1. As described earlier we have classified sample sites on the basis of their interferences as well as distinctive characters. Interestingly as depicted site 6 has shown immense peculiarity so far as diversity of zooplankton is concerned. Decreased diversity level of this site consistently was observed throughout the year. Site no. 8 also follows the similar observations as depicted from site 6. The downfall of the diversity of site nos. 6 and 8 might not be correlated with that of change in physico-chemical parameters. Further investigation with some toxic metals i.e. Pb, Cr, and Cd has led to draw some clue about the change in the level of zooplankton diversity (Urech, 1979).

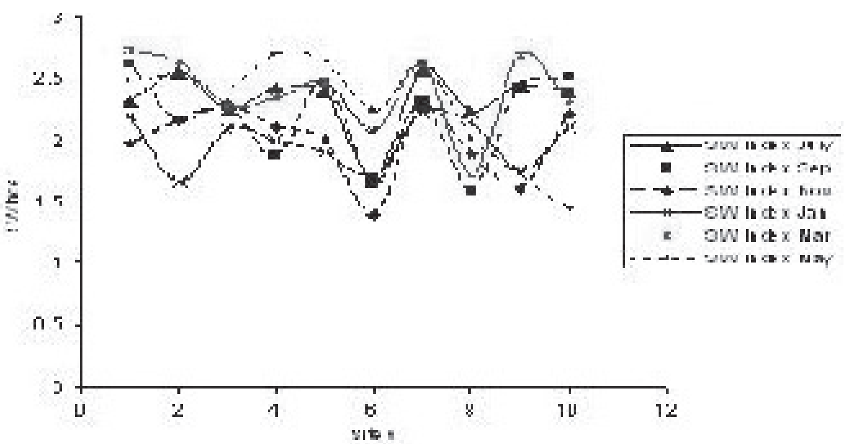

Figure 1: Seasonal variation of SW Index along sites.

Table 1: Variation of SW Index along the lake

Site	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
SW index July	2.31	2.55	2.25	2.42	2.39	1.7	2.57	2.24	2.44	2.4
SW index Sep	2.62	2.16	2.28	1.87	2.48	1.64	2.32	1.6	2.43	2.51
SW index Nov	1.98	2.16	2.29	2.11	2	1.39	2.27	1.89	1.61	2.21
SW index Jan	2.19	1.66	2.09	2	1.9	1.71	2.22	2.14	1.76	2.11
SW index Mar	2.73	2.63	2.28	2.34	2.48	2.07	2.61	1.72	2.69	2.32
SW index May	2.49	2.52	2.43	2.7	2.64	2.24	2.62	2.02	1.72	1.44

From our observation, we have seen that the abovementioned heavy metals were present throughout the lake and from all of our 10 sampling sites we have recorded these heavy metals (Tables 2, 3 and 4). But an interesting variation may lead to some remarkable conclusion. By nature sites 6 and 8 were characterized with the several anthropogenic interference: a source with heavy metal inclusion from garage, biomedical wastes etc. (Rodriguez et al., 2001; Haertling, 1989). Sites 6 and 8 are with a remarkably high toxic metal concentration (Figures 2, 3 and 4), which might be the

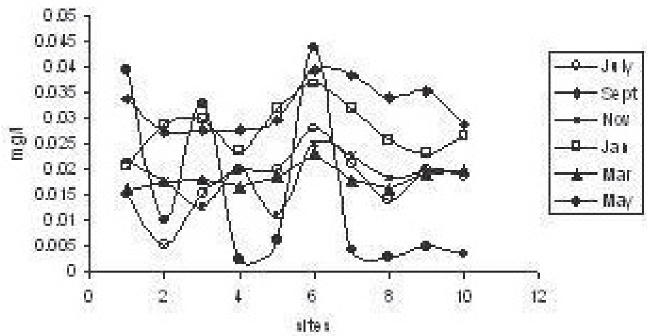

Figure 2: Variation of lead (ppm) along the lake.

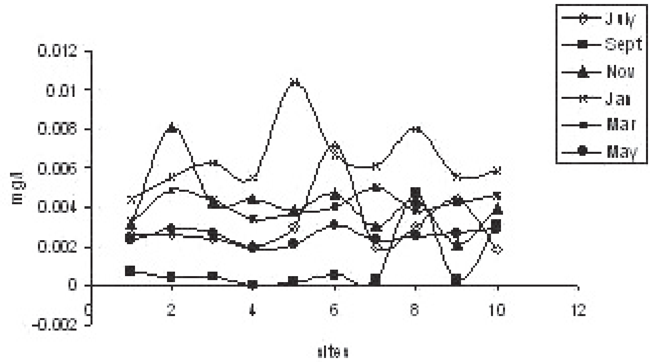

Figure 3: Variation of chromium (ppm) along the lake.

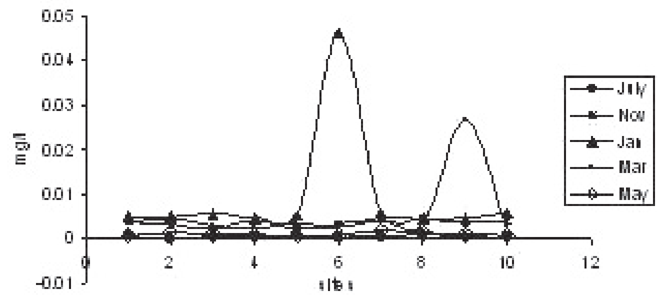

Figure 4: Variation of cadmium (ppm) along the lake.

Table 2: Variation of lead along the lake

Pb/Sites	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
July	0.015	0.0052	0.0152	0.01972	0.0199	0.0278	0.0211	0.01391	0.0199	0.0186
Sept	0.0337	0.0272	0.0275	0.02766	0.0295	0.0393	0.0383	0.0339	0.0352	0.0287
Nov	0.02165	0.01764	0.01268	0.01994	0.01095	0.02495	0.02259	0.0183	0.01972	0.01943
Jan	0.0206	0.02875	0.02966	0.02348	0.03174	0.03657	0.03174	0.02575	0.02298	0.02643
Mar	0.01593	0.01751	0.01787	0.01663	0.018495	0.02311	0.01777	0.01606	0.01897	0.01967
May	0.0393	0.01	0.0328	0.0025	0.0062	0.0436	0.0043	0.0028	0.0049	0.0034

Table 3: Variation of chromium along the lake

Cr/Sites	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
July	0.0026	0.0026	0.0024	0.002	0.003	0.00712	0.002	0.003	0.0044	0.00184
Sept	0.0007	0.0004	0.00044	0.00002	0.0002	0.00052	0.0003	0.0047	0.0003	0.0031
Nov	0.00314	0.00807	0.00424	0.00442	0.00389	0.00469	0.00304	0.00438	0.00211	0.00398
Jan	0.0044	0.00556	0.00625	0.00551	0.01038	0.006655	0.00613	0.00797	0.00559	0.00587
Mar	0.00328	0.00485	0.00436	0.00341	0.003695	0.004045	0.00499	0.00386	0.00425	0.00463
May	0.0023	0.0029	0.0027	0.0019	0.0021	0.0031	0.0023	0.0025	0.0027	0.0029

Table 4: Variation of cadmium along the lake

Cd/Sites	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
July	0.0007	BDL	0.0004	0.00053	0.0007	0.0002	0.0005	0.0008	0.0005	0.00027
Nov	0.00378	0.00312	0.00225	0.00392	0.002225	0.00332	0.0046	0.00443	0.00366	0.00397
Jan	0.00495	0.00483	0.00555	0.00465	0.005305	0.04611	0.0057	0.00452	0.00461	0.00566
Mar	0.00395	0.00436	0.00307	0.00248	0.00327	0.002535	0.00404	0.00334	0.02665	0.00271
May	0.0007	0.0014	0.0009	0.0008	0.0007	0.0008	0.0019	0.0013	0.0009	0.0007

reason for limiting the diversity of zooplanktons in these two particular sites (Tolunen et al., 2006). We have also tried to find out the vulnerability of these three toxic metals in relation to the zooplankton diversity. From PCA (Figure 5) we have found that Pb and Cd are very much responsible to limit the community structure irrespective of sampling site position (Smolyakov et al., 2004; Gama-Flores et al., 2006). But on the contrary Cr has almost no significant effect as such. It seems interesting to see that, between Pb and Cd, Pb is shown to have more forceful effect on the diversity level. The source of Pb is quite detectable and its high level of occurrences is justified because Pb could be originating from the leaded fuel in the industries and the chemicals used in manufacture of drugs that may contain Pb-organo compounds (Muwanga et al., 2006).

Above conclusion is also supported from the Cluster Analysis (Figure 6). From the cluster analysis it can be

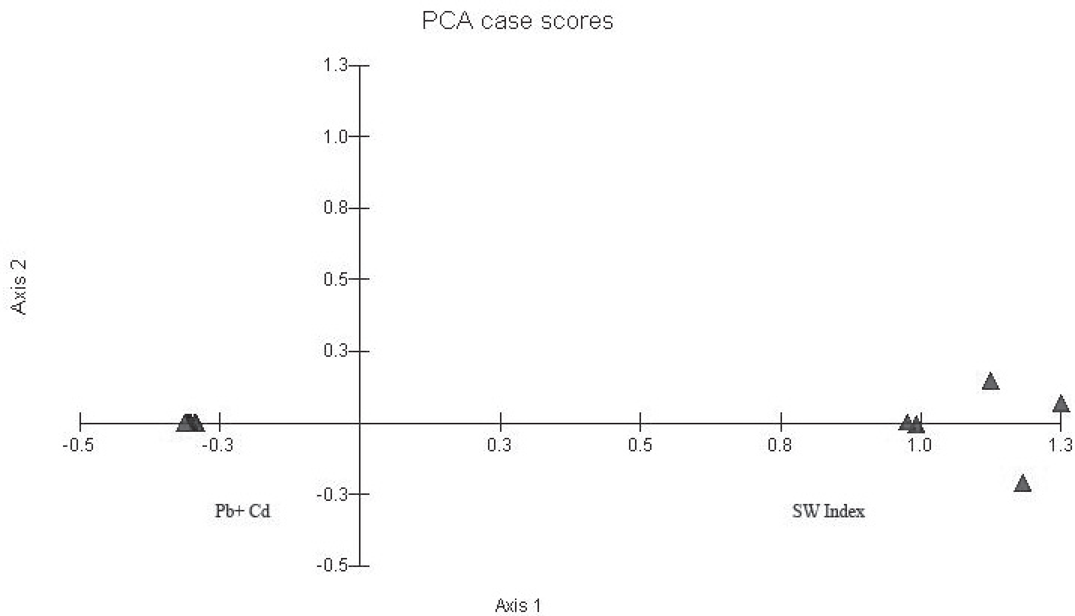

Figure 5: Principal component analysis of metals and planktons along the lake.

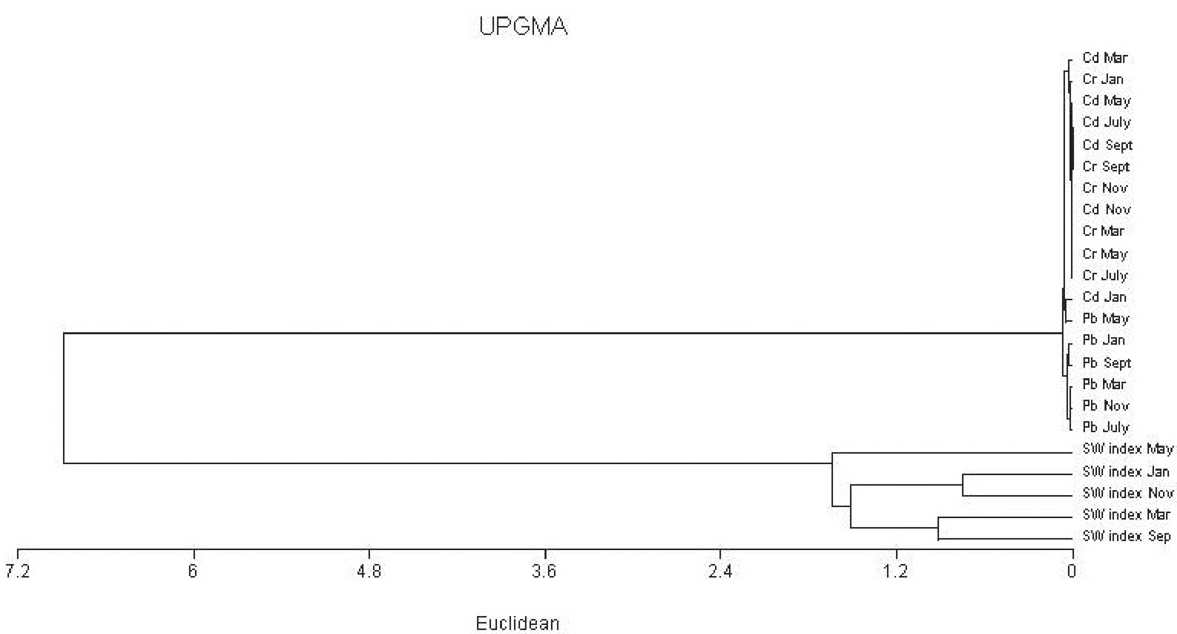

Figure 6: Cluster analysis metals and planktons along the lake.

observed that the diversity index in the month of September is closely related with that of March. This can also be same for the month of January and November (Bergen et al., 2001). The diversity index in the month of May is also related to all of them but it maintains some distance substantiating its exclusiveness caused due to the climatic condition (Drake, 2005; Primicerio et al., 2007). It is also clear from Figure 6 that the metal Pb irrespective of season makes a close cluster. Only Cd in the month of January has become close to them. The Cd and Cr content of the lake are almost evenly related to each other forming another cluster. Finally we can conclude that all the three toxic metals limit the diversity of the zooplankton species only in those sites of the abovementioned ecosystem where the anthropogenic interference is maximum. Among the three toxic metals the effect of Pb is established to be greatest from our findings.

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