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Effect of Dredging on the Macrozoobenthos of Hazratbal Basin in the Dal Lake Srinagar Kashmir, India

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Abstract

In order to assess the effect of dredging on macrozoobenthos community, study was carried out in the Hazratbal Basin of Dal Lake from August 2010 to January 2011. The results showed strongly significant differences ($P<0.05$) between control site and the site which was sampled after dredging operation. The significant differences were also found between pre-dredging and post-dredging ($P = 0.004$), while as, there were no significant differences between control site and pre-dredged site ($P = 0.191$). Altogether 6 taxa were observed at post dredged site in comparison to the pre-dredged (9 taxa) and the control site (10 taxa). At control site, molluscans were found to be the dominant group (1255 ind/m^2) followed by annelida (1110 ind/m^2) and diptera (330 ind/m^2), There were six taxa were shared both sites (control, impact sites) and one taxa *Erpobdella octoculata* of annelida was only restricted to control site. The abundance of most taxa were significantly higher at control and pre-dredged site. Three species (*Lymnea stagnalis, Radix auricularia and Radix ovata)* were completely eliminated after dredging operation. A cluster analysis showed that macrozoobenthic communities revaealed 90% similarity levels between control site and pre-dredged site. After dredging similarity level was greatly declined and was recovered 76% after six months of dredging.

Keywords: Macrozoobenthos, dredging effects,Hazratbal Basin, Dal Lake.

1. Introduction

Disturbance in ecological term is an event that has profound impact on ecosystem and its resources (Pickett and White 1985). There are various disturbances which are continuously taking place at different levels in lake ecosystem. The dredging operations are long established human induced disturbances in lakes and rivers and are responsible for making change the environmental features of the water bodies (Pranovi *et al*., 1998). Previous studies show that species spectrum of aquatic biota including fish, shellfish and benthic invertebrates depict alteration after dredging processes (Taylor and Salomon 1968, Kenny and Rees, 1996; Lewis *et al*., 2001). In the past different researchers have investigated the impact of dredging on macrozoobenthos and have shown decreased diversity and density in macrobenthic community (Bemvenuti, *et al*., 2005, Johnson and Nelson, 1985; Palmer, *et al*., 2008). In addition, studies have pointed out lower diversity indices in the post dredging period in comparison to undisturbed area (Szymelfenig *et al*., 2006). Considering the important role of the benthic fauna in the secondary production of aquatic systems, any kind of impact upon the macrobenthos may seriously harm the ecology and economy of the aquatic ecosystem, limiting its ability to function as a nursary area (Bemvenuti *et al*., 2005).

In the last 50 years, there has been drastic changes in urban lakes of Kahmir Himalya including Dal Lake. Due to cultural eutrophication, the Dal has got silted up and consequently shrunk in size. A lake conservation plan was devised for the Dal Lake in 1980s and as per the plan dredging of the peripheral areas of the Hazratbal, Nishat and Gagribal basins was started in late 1990s' with the aim of improving the aesthetic value of the inshore area.

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In order to have a first hand information on the impact of dredging on different aquatic communities in this water body , a lake wide study has been initiated in 2010 and shall continue till 2013 . In the present communication an attempt has been made to assess the impact of the dredging programme in the lake on the macrobenthic community (important link in the food cain) living on the soft bottom in Hazratbal Basin of the Dal Lake based on the data procured from August, 2010 to January, 2011.We predicted that dredging will decrease the species diversity and density of macrozoobenthos in the areas where dredging operation was carried out. In addition, we assumed that there could be dominance of somes species after dredging operation (Figure 1-3).

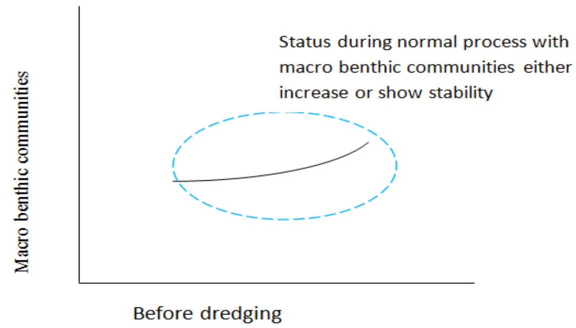

Figure 1. Hypothetical concept showing macro benthic growth before the start of dredging operation

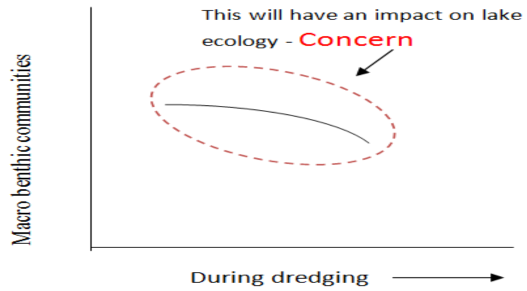

Figure 2. Hypothetical concept showing the impact of dredging on macro benthic communities

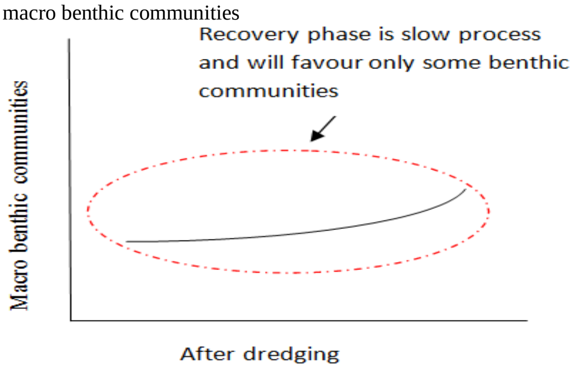

Figure 3. Hypothetical concept showing recovery phase after dredging

2. Materials and Methods

2.1. Study area

Dal Lake is a Himalayan urban lake, located in the heart of Srinagar (34°18′ N latitude and 74°9′ 1E longitude) at an average altitude of 1583 m. Dal Lake comprises of four basins viz. Hazratbal Bod-Dal, Gagribal and Nageen. A perennial inflow channel known as Telbal Nallah enters the lake from the north in its Hazratbal basin. Another inlet, Bot Kol, also joins in the Hazratbal basin, just west to Telbal stream. The water from this catchment area inclusive of water input from a high altitude lake called Marsar Lake besides this the springs present within the lake basin are also a permanent water source to the lake.

2.2. Sampling design

In order to assess the impact of dredging operation on macrobenthos, two sites (Figure 4) were selected one in the area which was planned to be dredged (called site 1) and the other in the area which was not to get directly impacted by the dredging (called site 2). Ekman dredge (15 × 15 cm^2) was used to collect three replicate samples at each site. The unaffected site was sampled on monthly basis for the period August 2010 to January 2011. The site selected for dredging was first sampled before one week of dredging activity and then resampled after 1 day, 3 days, 6 days, 10 days, 20 days, 35 days, 50 days, 70 days, 3 months and 6 months of the dredging activity. The sampling continued till some macrobenthic recovery at the site was observed. In the field, samples were packed in polybags and immediately transferred to laboratory. In the laboratory the samples were carefully washed through 0.55mm mesh screen and preserved in 4% formalin. The sub-samples were stained with Rose Bengal, hand sorted under stereomicroscope and identified by using standard works on macrobenthos (Pennek, 1978; Milligan, 1997; Brinkhurst, 1971; Edmondson, 1959).

2.3. Univeriate Measures of Community Structure

Univariate measures includeded: total anundance (N), number of taxa (S), dominance (D), Shannon-Wiener diversity indexwhich was calculated by using base-e logarithms (H'), Simpsons diversity index (1-D), d= Margalf's species richness index and J'= equitability, these measures were calculated by using PAST programme. The significance of differences between before/after dredging and control sites was tested using One-way analysis of variance (ANOVA).

2.4. Multivariate analysis of community structure

Non-parametric multivariate techniques were used to measure similarity matrices. The similarity between the sites were calculated by means of Bray-Curtis index by using Bio Diversity Pro Satstical software.

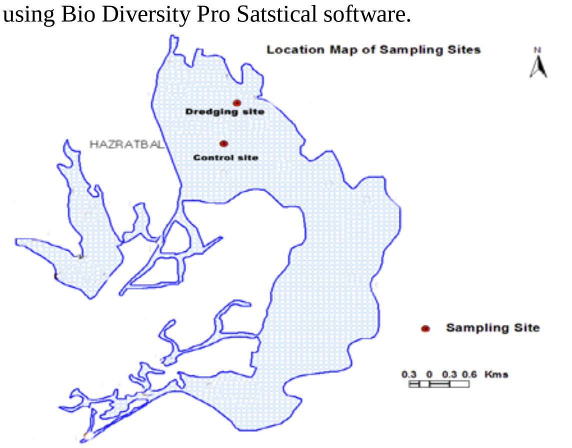

Figure 4. Map of Dal lake showing sampling sites in Hazratbal basin.

3. Results

A total of 10 taxa of macrozoobenthos were recorded at site 2, of which 4 were annelids, 5 molluscs and 1 dipteran. A similar species structure was recorded at site prior to dredging, there being a total of 9 taxa (3 belonged to annelida, 5 to mollusca and 1 to diptera). After the dredging of the site was performed only 6 taxa were observed in the samples from the area (3 belonged to annelida, 2 mollusca and 1 diptera). 3 species of mollusca (*Lymnea stagnalis, Radix auricularia* and *Radix ovate*) were completely missing from the area (site 1) after dredging (Table 1).

All the diversity indices were higher at site 2 throughout the study and at site 1 during pre-dredging period in in comparison to site 1 during post-dredged period (Table 2). No benthic organism was observed at site 1 during the dredging. This position continued 6 days of dredging. The early colonizers included annelids such as, *Tubifex tubifex* and *Limnodrillus hoffmiesteri* which reappeared in the area after 10th day of dredging. The same trend was observed up to one month after dredging. The total abundance and species richness showed increased recovery rate from 2nd month of dredging and reached to maximum richness on the 5th and 6th month after dredging (Figure 5). As per our observation 9 taxa were found before dredging operation and recovered to the level of 66.6% after 6 month of dredging. It can be presumed that total (100%) recovery will be attained after 1 year. Interestingly, three species of molluscan (*Lymnea stagnailis, Radix ovate* and *Lymnea auricularia*) were eliminated during the process of dredging and were not recovered even after 6 months of recovery phase.

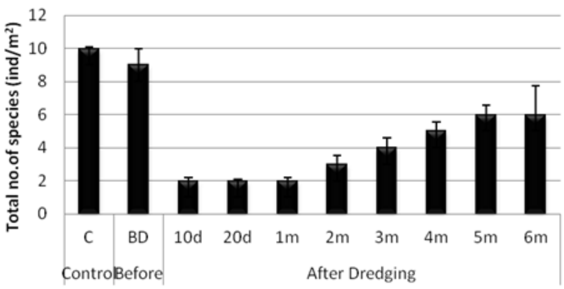

Figure 5. Graph depicts variation in species number at control, before dredging and decreasing trend after initial stages of dredging and then shows gradual increase in number of species (S) ind/m^2 along with standard errors.

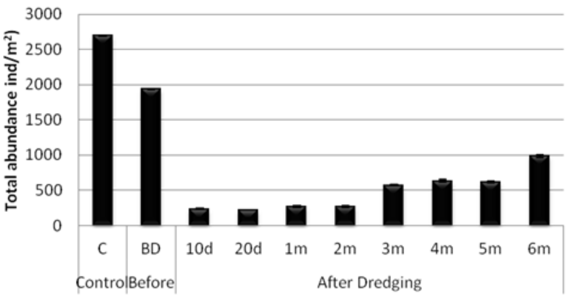

Figure 6. Graph depicts variation in total abundance at control site, before dredging and decreasing trend after initial stages of dredging and then shows gradual increase in abundance along with standard errors

It was observed during present study that the density of some species such as, *Tubifex tubifex, Limnodrillus hoffmiesteri* and especially *Chironomus* sp. increased after the dredging process, while, molluscs like *Lymnea stagnalis, Radix ovata* and *Lymnea auricularia* were affected by the dredging operation. Interestingly, *Sphaerium* sp. (belonging to Molluscan group) was observed after 4 months of dredging.

Significance of differences between before/after dredging and control sites were tested using One-way analysis of variance (ANOVA) was used to measure the significance of differences between before/after dredging and with control site. The results showed strongly significant (P<0.05) differences between control site and the site which was sampled after dredging operation. The significant differences were also found between pre-dredging and post-dredging (P = 0.004), while as, there were no significant differences between control site and pre-dredged site (P = 0.191). No significant differences (P >0.05) were found between Margalf's index with diversity (H') and equitability (J').

Cluster analysis revealed that after 5 months of dredging macrozoobenthos fauna showed maximum similarity with samples taken before dredging and with control site. As it is depicted in the dendrogram (Figure 7) that samples taken after 5th and 6th month of dredging were grouped in upper cluster with samples taken at pre-dredged and at the control site showed highest similarity level (76%). However, the similarity level between control site and pre-dredged site was 83%.The middle clusters contains samples which were taken after 10th day to 3rd month of dredging showed less similarity level in terms of macrozoobenthos fauna with control site and samples taken before dredging.

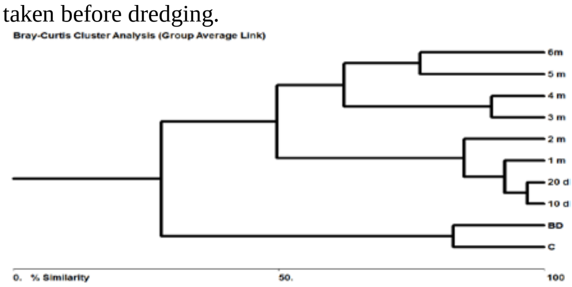

Figure 7. Cluster analysis of samplings of control site, before dredging, after 10, 20 days, 1, 2,3, 4,5 and 6 months of dredging.

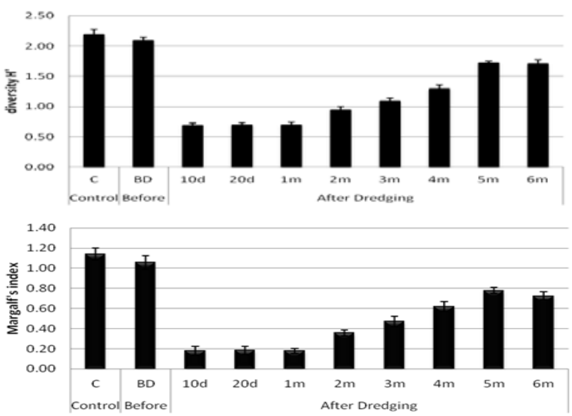

Figure 8. Graph depicting the variations in Shannon – Wiener (H') and Margalf's species index (d) of macrozoobenthos community with stanadard errors during study period in Hazratbal basin of Dal lake.

Table 1. Species composition per m^2 recorded during the present study at control site(C), before dredging (BD), during dredging (DD) and after 1, 3, 6, 10, 20 days and 1, 2, 3, 4, 5 and 6 months after dredging.

	Taxa/species														
S.NO		**C**	**BD**	**DD**	**1 d**	**3 d**	**6 d**	**10 d**	**20 d**	**1 m**	**2 m**	**3 m**	**4 m**	**5 m**	**6m**
	ANNELIDA														
1	*Tubifex tubifex*	405	330	0	0	0	0	105	105	135	90	135	150	120	315
2	*Limnodrillus hoffmeisteri*	480	390	0	0	0	0	135	120	135	150	335	320	165	195
3	*Branchiura sowerbyii*	180	180	0	0	0	0	0	0	0	0	60	45	75	120
4	*Erpobdella octoculata*	45	0	0	0	0	0	0	0	0	0	0	0	0	0
	MOLLUSCA														
5	*Sphaerium sp.*	330	120	0	0	0	0	0	0	0	0	0	30	90	135
6	*Lymnea columella*	315	335	0	0	0	0	0	0	0	0	0	0	45	90
7	*Lymnea stagnalis*	225	90	0	0	0	0	0	0	0	0	0	0	0	0
8	*Radix ovata*	180	150	0	0	0	0	0	0	0	0	0	0	0	0
9	*Radix auricularia*	205	180	0	0	0	0	0	0	0	0	0	0	0	0
	DITERA														
10	*Chironomus* sp.	330	165	0	0	0	0	0	0	0	30	45	90	120	135

Table 2. The values of macrozoobenthos diversity indices at control, before dredging and after 10, 20 days, 1, 2, 3, 4, 5 and 6 months of dredging. S =No. of species, N = total abundance, D = Dominance, H'= Shannon diversity, 1 – D = Simpson index, d = Margalf's species richness index and J' = equitability.

Indices	C	BD	10 d	20 d	1 m	2 m	3 m	4 m	5 m	6 m
Taxa_S	10	9	2	2.00	2.00	3.00	4.00	5.00	6	6
Individuals -N	2695	1940	240	225.00	270.00	270.00	575.00	635.00	615	990
Dominance_D	0.12	0.14	0.51	0.50	0.50	0.43	0.41	0.34	0.19	0.20
Shannon_H	2.19	2.09	0.69	0.69	0.69	0.94	1.09	1.30	1.72	1.70
Simpson_1-D	0.88	0.86	0.49	0.50	0.50	0.57	0.59	0.66	0.81	0.80
Margalef	1.14	1.06	0.18	0.18	0.18	0.36	0.47	0.62	0.78	0.72
Equitability_J	0.95	0.95	0.99	1.00	1.00	0.85	0.79	0.80	0.96	0.95

Table 3. Detailed similarity matrix of Cluster analysis between different intervals of samplings with control site, pre and post dredging.

	C	**BD**	**10 d**	**20 d**	**1 m**	**2 m**	**3 m**	**4 m**	**5 m**	**6m**
C	*	82.87	16.35	15.41	18.21	18.21	35.17	38.14	37.16	53.73
BD	*	*	22.01	20.78	24.42	24.42	45.71	49.30	48.12	66.53
10 d	*	*	*	96.77	94.12	88.24	58.90	54.86	56.14	39.02
20 d	*	*	*	*	90.91	84.85	56.25	52.33	53.57	37.04
1 m	*	*	*	*	*	83.33	63.91	59.67	57.63	42.86
2 m	*	*	*	*	*	*	63.91	59.67	61.02	42.86
3 m	*	*	*	*	*	*	*	90.08	65.55	55.59
4 m	*	*	*	*	*	*	*	*	72.00	62.77
5 m	*	*	*	*	*	*	*	*	*	76.64
6 m	*	*	*	*	*	*	*	*	*	*

4. Discussion

The present study revealed significant changes in the macrozoobenthos community of Hazratbal basin of Dal lake with dredging activities. The diversity of macrozoobenthos was found to be greatest at control and pre-dredged site in comparison to the post-dredged site. A similar development after dredging process has been reported by Jamar and Mejuto (1988). The present data reveals that dredging operation leads to significant changes in macrozoobenthos in terms of species composition, density and diversity.

The main reason for reduction of abundance, diversity and species composition in benthos of Hazratbal Basin could be because of the fact that dredging operation has disturb the microhabitats of these communities. The findings of this study fully coincide with the observation of earlier researchers who studied the impacts of dredging on benthic communities (Oliver and Slattery, 1976 and Johnson and Nelson, 1985). We have noted during present study period that after dredging the sediment structure was fine as compared to before dredging, when sediment was mixed with a lot of organic matter and other material like wood debris etc. The fine sediments may become favourable for early colonizers such as *Tubifex tubifex* and *Limnodrillus hoffmeisteri*. These two species also showed increasing trend in species richness and diversity (H') (Table 1.). The colonization of two species of annelid group may be due to transportation of larvae and adults from the water column, and post-settlement movement of juvenile and adult life-stages across the sediment. The results from our study correspond very well with the findings of Guerra-Garcia *et al.* (2003). It has been also reported that earlier colonists generally have similar life history patterns which include similar kind of habitat and high larval availability (Bolam and Rees, 2003).

The data shows that the number of species starts recovering 20 days after dredging, but the diversity (H') and Margalf's index of richness (d) continue declining until 2 months of dredging (Figure 6) could be due to strong increase in abundance of some species such as, *Tubifex tubifex* and *Limnodrillus hoffmeisteri*. These species remain in open areas during dredging process where they grow up in large populations and recover immediately after dredging. When areas are depopulated through dredging operations, some opportunistic species usually have a good chance of building up large population in such 'open spaces (Guerra-Garcia, *et al.*,2003).This short-term change is reflected by the abundant increase of opportunistic species (Grassie and Sanders, 1973; Lopez-Jamer and Mejuto,1998; Van Dalfsen *et al*., 2000).

It was observed in the present study that *Tubifex tubifex*is the only species which shows 99% recovery after 6 months of dredging. Similar studies were also reported by Lu and Wu (1998). It was also observed from the present study that *Tubifex tubifex*, *Limnodrillus hoffmeisteri* and*Chironomus* sp. were more abundant after dredging than other taxa.

In connection with the molluscan community, the present study has shown that these communities are more impacted by dredging activity in Hazratbal basin. In addition most taxa of mollusca got eliminated after dredging. Further it was observed during present investigation that only two taxa such as, *Sphaerium* sp. and *Lymnea collumela* recovered after dredging. The recovery time of macrobenthic communities after this type of disturbance depends on the spatial scale, the hydrodynamic conditions, the bottom grain size and the structure of the community affected by the disturbance (Kaiser and Spencer, 1996; Pranovi *et al.*, 1998).

5. Conclusion

Present study reveals that dredging is responsible for short-term changes in macrozoobenthos community structure which include effects on species richness, diversity and reduction of benthic habitat. The Annelida group was showed rapid recovery followed by diptera and molluscs. In fact, dredging operation initially disturbs the macrozoobenthos of lake, but it should be carried at small-scale in selected areas. The dredging of whole lake bed is dangerous for lake biodiversity. So, the lake authorities should operate dredging operation in lake as per environmental goals and should, however, avoid operating it from engineering point view.

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