A Study of Comparative Purification Efficiency of Two Species of *Potamogeton* (Submerged Macrophyte) In Wastewater Treatment

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Abstract- In the balancing of lake ecosystem macrophytes play a very important role. They have capacity to improve the water quality by absorbing nutrients with their effective root system and hence as Biofilters. Attempt was made in which samples of two *Potamogeton* species viz. *Potamogeton crispus* and *Potamogeton pectinatus* were collected during December 2008 to April 2009 from three different sites of Upper Lake of Bhopal. The nutrients including the phosphorus, potassium and sodium in the plants were analysed and found to be high. Significant correlations in phosphorus, potassium and sodium levels were apparent between the tissues of two *Potamogeton* species which were related to their life forms and to the limnological characteristics of the lake. The objective of the study was to know the comparative purification efficiency of two species of *Potamogeton* in wastewater treatment i.e. in reducing the nutrient content of the water. Purification of water through macrophytes is a good example of purification of water with natural means. Results indicated that both species were capable of improving water quality by reducing nutrient concentrations. But *Potamogeton crispus* rather than *Potamogeton pectinatus* was found more potent in improving the quality of lake water.

Index Terms- Macronutrients, *Potamogeton crispus, Potamogeton pectinatus,* Upper Lake, Wastewater, Water quality.

I. Introduction

Freshwater aquatic macrophytes grow naturally in water bodies polluted by nutrient loading from urban and agricultural activities. Accumulation of nutrients in an aquatic ecosystem leads to eutrophication resulting into massive growth of the macrophytes and weeds. Main cause of nutrient accumulation is rapid urbanization and anthropogenic pressure. Storm water runoff and discharge of sewage into the lakes are two common ways through which various nutrients enter the aquatic eco-system, resulting into the death of those systems [1]. The washing of large amount of clothes by dhobis and laundry workers, continued entry of domestic sewage and death and decay of macrophytes are posing pollution problems and hence an imbalance in the dynamics of water quality. The water quality issues regarding lakes everywhere is of great concern. Eutrophication of a water body signifies the aging of a lake. It is caused by the accumulation of nutrients, sediments, silt and organic matter in the lake from the catchment area. Macrophytic vegetation plays an important role in maintaining the ecosystem of a lake. Various types of macrophytes viz. emergent, free floating, submerged are generally observed in an aquatic ecosystem where they play a very important role in improving the quality of water since later is a prime natural resource, a basic human need and a precious natural asset.

Among the principal characteristics of macrophytes is their ability to accumulate nutrients and accelerate nutrient loading in the environment. Many aquatic plants utilize these nutrients and produce large amount of biomass which can be used for some beneficial purposes. The concept of using aquatic plants for treating wastewater is giving the attention of local and state agencies in various parts of the U.S.A. Submerged macrophytes especially *Potamogeton* species play a key role in aquatic food webs by providing substrate for epiphytes [2] and invertebrate colonization [3] , as well as providing a forage source and refugia for fish. Nutrient compositions of four submerged macrophytes were analyzed and it was concluded that variation in nutrient content was a function of the age of the species tested [4, 5].

Increasing efforts have been made in the study of chemical composition of aquatic macrophytes with emphasis on different aspects including the possibility of commercial exploitation of the plants [6], their seasonal changes in chemical composition [7], their role in nutrient accumulation, balance cycling within the ecosystem [8], and the effects of nutrient enrichments on these plants [9]. These results demonstrated, amongst other things that the chemical compositions of the plants varied according to species, the time of the year, and the site in which they are found. It has been, for example, reported that the distribution of two *Potamogeton* species was differentially affected by changes in the lake stage over a 20 year period in six interconnected shallow water lakes in the Netherlands [10].

Macrophytes absorb a wide range of macronutrients in the ambient environment including phosphorus, sodium and potassium etc and subsequently accumulate them in their tissues. They serve as tools for lake management [11]. A number of studies have demonstrated that a large reservoir of nutrients can accumulate in aquatic macrophytes in lake ecosystems [12, 13, 14]. Phosphorous compounds generally constitute the most important limiting nutrients in freshwater lakes [15, 16]. By determining the concentration of macronutrients (Na, P and K) in the tissues of two *Potamogeton* species originating from sites undergoing human impact, the aim of our study was to compare the nutrient removal efficiency of the two species and to establish the role of these plants in improving the water quality.

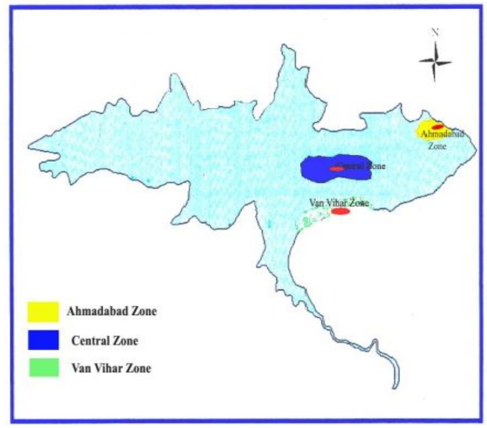
II. MATERIAL AND METHODS

Upper Lake, locally known as “Bada Talab”, is the oldest man-made lake of India (77º 18'-77º 24' E, 23º 13'-23º 16' N) and is surrounded by Vanvihaar National Park on the south, human settlements on the east-north and agricultural fields on the west. It was constructed by Raja Bhoj in 11^{th} century by constructing an earthen dam across the river Kolans. It is a source of drinking water to urban populations and miscellaneous purposes viz., aesthetic, recreational, industrial purposes etc.

Submerged plant biomass samples of the two *Potamogeton* species were collected from the three sites of the lake viz, Ahmadabad site, (Longitude 77˚ 22' 51. 2" and Latitude 23˚15'31.0"), Central site (Longitude 77˚ 22' 07. 9"and Latitude 23˚ 15' 05. 4") and Vanvihaar site (Longitude 77˚ 21' 45. 01" and Latitude 23˚ 14' 27. 05") after a duration of every two months from December 2008 to April 2009. For the identification of plants important works like Water plants of world [17], Marsh plants of India & Burma [18] and other relevant literature were consulted.

Potamogeton crispus commonly known as curly pondweed is an aquatic herb with branched compressed somewhat dichotomous stem. It is found in sub- littoral and sometimes in pelagic zone of the lake and is one of the most dominant species. It was frequently found at all sampling stations at almost all the occasions. Its highest density was recorded at Ahmadabad site. On the other hand, *Potamogeton pectinatus* commonly called as Sago pondweed has filiform rather profusely branched stems**.** It is commonly found in sub-littoral zones of lake. It prefers to grow in waters with moderately rich nutrient content. During study it was reported at Vanvihaar and Central sites, which are relatively low in nutrient content. However, its maximum density was noticed at Vanvihaar site.

After collections, the samples were brought to the laboratory in polythene bags and ice boxes, where they were washed with water several times and then with 0.2% detergent solution to remove any waxy coating and adhering soil particles. Subsequently, they were washed with 0.1N HCL to remove metallic contamination and lastly with deionised water to wash the previous two solutions. The two species of *Potamogeton* were then dried separately in an oven at 60˚C for 48 hours. Dried samples were homogenized and ground to yield fine powder. A standard procedure for water and aquatic plants was used to prepare plant material for chemical analysis [19, 20]. The grinded samples were digested by following tri-acid and di-acid digestion procedure. Lastly, processed samples were analysed for the contents of sodium, potassium and phosphorous. The total phosphorous was assayed spectro-photometrically by Ammonium- Vavnadate- Molybdatye method while as the sodium and potassium was determined flame-photometrically.



Map of Upper Lake showing three sampling sites.

Site-I (Ahmadabad site)

Site-II (Central site)

Site-III (Vanvihaar site)

Potamogeton crispus

Potamogeton pectinatus

III. RESULTS

Plants absorb nutrients from the soil/sediments and lake water. Different plants have affinity with particular nutrients and such nutrient elements are absorbed by the plant and retained in the particular part of the body. The results of the investigation show that in the biomass of *Potamogeton crispus* (which occupies the shallowest regions of the lake [21]) there are differences between particular investigated main nutrients. In order to see the role and participation of *Potamogeton crispus* in the cycling of nutrients in the Upper Lake we calculated the quantity of investigated main nutrients in the course of December 2008 to April 2009.

The maximum sodium values of *Potamogeton crispus* (0.64%) was reported at Ahmadabad site as compared to other two sites. In *Potamogeton pectinatus* the maximum sodium value was reported both at Ahmadabad site (0.59% -man made pollution) and at the Vanvihaar site (0.60%-natural pollution) with little variations, as compared to the Central site (0.35% -no pollution). Potassium belongs to the group of major macronutrients and is responsible for plant growth, namely primary production. According to the results, the concentration of potassium in *Potamogeton crispus* (1.90%) was higher than in *Potamogeton pectinatus* (1.83%). It was also found that the concentration of potassium in both the plant species was higher at Ahmadabad site. Similarly the average stock values of phosphorus in the biomass of *Potamogeton crispus* was higher (0.42%) than that of the *Potamogeton pectinatus* (0.36%). Moreover, the minimum concentration of phosphorous in both the plants was recorded at the Central site (0.35%- 0.38%). Results also indicated that the concentration of phosphorous was at minimum in the late winter (December) and increased towards the end of growing season (April). The content of Na, K and P in two macrophytes of Upper Lake is given in the Tables 1&2 below:

Table 1: Variation in % Na, K and P values in *Potamogeton crispus*

Macronutrients\ Site	Ahmadabad site	Central site	Vanvihaar site
% Sodium (Na)	0.64	0.44	0.44
% Potassium (K)	1.9	1.43	1.5
% Phosphorus (P)	0.42	0.38	0.41

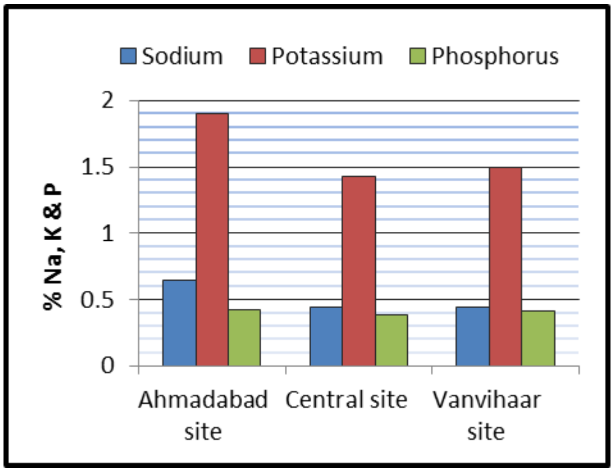


Fig. 1: Variation in % Na, K and P values in *Potamogeton crispus*

Table 2: Variation in % Na, K and P values in *Potamogeton pectinatus*

Macronutrients\ Site	Ahmadabad site	Central site	Vanvihaar site
% Sodium (Na)	0.59	0.35	0.6
% Potassium (K)	1.83	1.5	1.26
% Phosphorus (P)	0.36	0.35	0.36

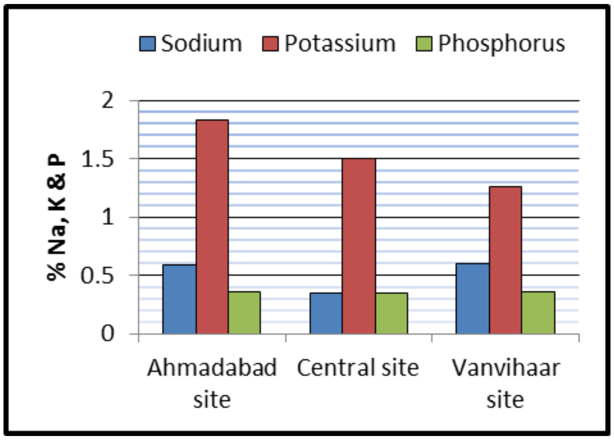


Fig.2: Variation in % Na, K and P values in *Potamogeton pectinatus*

IV. DISCUSSION

Differences in the chemical composition of the two species of *Potamogeton* were probably related to their life forms & to the limnological characteristics of the lake. Submerged and floating macrophytes are rich in phosphorous [22]. The results showed that *Potamogeton crispus* and *Potamogeton pectinatus* which are both submerged plants have the highest concentration of phosphorous and many other nutrients such as sodium and potassium in their biomass. The maximum sodium value (0.64%) in *Potamogeton crispus* at Ahmadabad site was due to the fact that at this site there was man-made pollution on account of the entry of sewage into the lake from the catchment area that brought a lot of nutrients such as Na, K, and P along [23]. In *Potamogeton pectinatus* the high concentration of sodium was not only reported at Ahmadabad site but also at the Vanvihaar site. Vanvihaar site was naturally polluted firstly because of surface runoff and secondly there was dense growth of macrophytes, which upon natural death and decomposition added a great concentration of nutrients to the lake water and sediments. In general, submerged and floating leaved macrophytes are more quickly decomposed while floating and emergent species have slower decomposition rates [24, 25]. Macrophytic plants can directly recycle phosphorous from the sediments via, root uptake, incorporation into tissues and subsequent senescence [26, 27, 28]. They can indirectly recycle phosphorous from sediment via, increasing pH of water column through photosynthetic activities. The concentration of both phosphorous and potassium were also reported to be very high in *Potamogeton crispus* than in the *Potamogeton pectinatus* at Ahmadabad site on account of the above mentioned facts. The minimum value of phosphorous in the month of December (Late winter) and the maximum value of phosphorous in the month of April (end of growing season) were also reported [15]. Occurrence of dense growth of macrophytes at Ahmadabad and Vanvihaar sites than at the Central site was probably due to the availability of more nutrients. A phosphorous content of 3.5 to 5.6 mg g^{-1} (mean 4.9) in *Potamogeton maackianus* was reported earlier [29] which also supports our results. Sediments have a far larger reserve of nutrients than the lake water, and during the growing season more phosphorous is taken up by *Potamogeton* species than enters lake water from the inflows, certainly indicates that the sediments are the principle source for the plants. The very large biomass of this plant (*Potamogeton*) means next to the sediments the macrophytes have the largest reserve of nutrients. Results indicated that both species were capable of improving water quality by reducing nutrient concentration. Since, the level of estimated nutrients was comparatively found high in *Potamogeton crispus*, it became evident from our results that *Potamogeton crispus* has comparatively more nutrient accumulation capacity and hence purification efficiency than *Potamogeton pectinatus* [30].

V. CONCLUSION

A comprehensive research work, that included both field and laboratory components, was done with the view to know the comparative purification efficiency of two species of *Potamogeton* in wastewater treatment *i.e.* in reducing the nutrient content of the water. The two plants were collected thrice from three different sites of Upper Lake of Bhopal. The results of the investigation showed that Upper Lake was receiving enough nutrients particularly sodium, potassium and phosphorous etc. at the Ahmadabad site from the catchment area. It also showed a significant variation of element concentrations in two *Potamogeton* species. *Potamogeton crispus* rather than *Potamogeton pectinatus* was found more potent in improving the quality of lake water.

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