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International Journal on Environmental Sciences

International Journal on Environmental Sciences 10 (1) : 18-23, ***January-June 2019***
ISSN No.: 0976-4534; NAAS Rating **3.06**

ROLE OF *AZOLLA PINNATA* IN CONSERVATION STRATEGY OF A LAKE SYSTEM

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Research Paper

Received: **13.02.2019** Revised: **20.02.2019** Accepted: **07.03.2019**

ABSTRACT

Azolla pinnata was introduced in an experimental chamber containing Dal Lake water in Dal Lake of Srinagar (Jammu and Kashmir). The *in situ* experimentation which was carried out for two consecutive years revealed that the macrophytes have capacity to uptake biologically important nutrients such as 'N' and 'P' but simultaneously it enriches the system by way of sporulation and senescence. The species can only be employed for Conservation strategy of the Dal Lake water once its harvesting from the system is well planned.

Keywords: *Azolla pinnata*, nitrogen and phosphorus uptake, enrichment and senescence.

INTRODUCTION

Azolla pinnata, a pteridophyte, is a free floating water fern belonging to the family Salviniaceae. It is commonly found in tropics and subtropics. It grows naturally in stagnant water of drains, canals, ponds, rivers marshy habitats and lakes. Due to the presence of Anabaena in the cavity of *Azolla* leaves, it can fix high amount of atmospheric nitrogen[1] The contribution of nitrogen from the plant into the soils is 60-80 kg N/ha/ season [2]. It is commonly used as fertilizer in cultivation of various crops [3-5]. It is a potential feed for the live stock[6-7]. The species being basically tropical seems to have infested temperate waters on account of biodiversity shift.

The purpose of our study was to evaluate the role of Azolla pinnata in conservation strategy of a lake system.

Methodology

The present research work was conducted along lake bank close to the Hazratbal basin of the Dal lake. Experimental chamber (3ft x4ft x 4ft) was employed for the purpose .The chamber was washed with dilute HCl and then rinsed with double distilled water. 12-15 inches of lake sediment was put in the chamber and then 3/4th of it was filled with lake water. A suitable aliquot from water, sediment and macrophyte was analysed at the start of the experiment and considered as initial reading. The analysis was carried out following the methods as outlined in [8-12].

RESULTS AND DISCUSSION

Variation in nitrogen and phosphorus in ambient waters in experimental chamber having *Azolla pinnata* is represented in Table1.

In the first year (2008-2009) the experiment lasted for 302 days. On day 1, the concentration of nitrogen in the water was 1016µg/l which decreased to 925µg/l on 50th day of the experiment (Spring), depicting a decrease in nitrogen concentration by 9 %.On 140th day (Summer),nitrogen concentration increased to 1295µg/l depicting an increase in nitrogen concentration by 28%. However, on 226th day

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(Autumn), a decreased value of 1148µg/l was recorded, showing a percent decrease of 11% from summer value. Further, on 302nd day of the experiment (winter), the value of nitrogen got increased to 1255µg/l showing percent increase of 8.5% from autumn value. During second year of the study period (2009-2010), the experiment lasted for 308 days. In the beginning of the experiment (day1), the concentration of nitrogen in the water was 985µg/l, which decreased to 879µg/l, on the 50th day (spring), depicting a decrease in nitrogen concentration by 11 %. On 135th day (summer), nitrogen increased to 1397µg/l (37% increase). However, on 222nd day (autumn) a decreased value of 1079µg/l was recorded (23% decrease). Further, on 308th day (winter) the value of nitrogen recorded was 1227µg/l (12%) increase from autumn value.

With respect to phosphorus during the first year of study (2008-2009), it has been observed that on day 1 of the experiment the phosphorus concentration was 390µg/l, which increased to 437µg/l on 50th day of the experiment (spring), depicting an increase in phosphorus concentration by 12%.On 140th day (summer) phosphorus concentration decreased to 411µg/l depicting a decrease in phosphorus concentration by 6%. However on 226th day (Autumn) onwards there was increase in concentration up to the end of the experiment (302 days), winter, when an increased value of 600µg/l was recorded, depicting a total percent increase of 31.5% (Table 1). During second year (2009-2010) in the beginning of the experiment (day1) the concentration of phosphorus was 450µg/l which decreased to 388µg/l on 50th day of the experiment (spring) depicting a decrease in phosphorus concentration by 14%. From summer (135th day onwards) up to 308th day (winter), the value of phosphorus recorded an increasing trend and a maximum value recorded was 1089µg/l (winter) showing a percent increase of 64%.

Table 1: Seasonal Variations in nitrogen and phosphorus content in chamber containing *Azolla pinnata.*

Sl. No.	Parameters	2008-2009					2009-2010				
		Initial Day 1	Spring 50 day	Summer 140 day	Autumn 226 day	Winter 302 day	Initial Day 1	Spring 50 day	Summer 135 day	Autumn 222 day	Winter 308 day
1	Nitrogen (µg/l)	1016	925	1295	1148	1255	985	879	1397	1079	1227
	(%) increase/ decrease		-9	28	-11	8.5		-11	37	-23	12
2	Phosphorus (µg/l)	390	437	411	499	600	450	388	648	696	1089
	(%) increase/ decrease		12	-6	18	31.5		-14	40	7	64

The values of nitrogen in chamber containing *Azolla pinnata* were very high. It is a nitrogenous fern as N2_ fixing cyano bacteria (of Nostoc- Anabena group) living in the cavity of *Azolla* leaves can fix high amount of atmospheric nitrogen. The nitrogen fixing potential of the association is recognized as a nitrogen source, thereby increasing the amount of nitrogen in water chamber. Singh [13] stated that the species is a common bio fertilizer employed in the rice fields.

Further, a significant seasonal trend was observed in the nitrogen content of the chamber during both the years, spring and autumn values being comparatively low (Table1) in comparison to the high summer values.

Phosphorus concentration in the water containing *Azolla pinnata* was also high during the present investigation (Table1). This is because *Azolla pinnata* imparts high phosphorus to the water as also reported by Rivaie *et al*., (2013). Toledo and Penha (2011) revealed that the species has low potential for improving the quality of the input.

Nutrient uptake by the macrophytes was also studied. In the first year (2008-2009) the experiment lasted for 308 days. In the beginning of the experiment (day1), the concentration of nitrogen in the plant was 1.225 mg/g which increased to 1.829 mg/g and 2.622 mg/g on the 50th day (spring) and 140th day (summer)

respectively, depicting an increase in uptake by 33% and 53.2% respectively (Table 2) However on 222nd day (autumn) a decreased value of 0.625mg/g was recorded, showing a percent decrease of 76.1 % from summer value. Further, on 308th day of the experiment (winter), the value of nitrogen got further reduced to 0.254 mg/g, showing a percent decrease of 59.3 from the autumn value. During the second year of investigation (2009-2010), the experiment lasted for 308 days again. On the day 1, the concentration of nitrogen in the plant was 0.254 mg/g which increased to 1.92 mg/g and 2.253 mg/g on the 50th day (spring) and 135th day (summer), depicting an increase in uptake by 86.70% and 88.7 % respectively. However, on 222nd day (Autumn),a decreased value of 0.856 mg/g was recorded, depicting a percent decrease of 62% from summer value. Further, on 308th day of experiment (winter), the value of nitrogen got further reduced to 0.206 mg/g, showing a percent decrease of 76 % from autumn value (Table 2).

Table 2: Experimental details of nutrient uptake by *Azolla pinnata*.

Sl. No.	Parameters	2008-2009					2009-2010				
		Initial Day 1	Spring 50 day	Summer 140 day	Autumn 222 day	Winter 308 day	Initial Day 1	Spring 50 day	Summer 135 day	Autumn 222 day	Winter 308 day
1.	Nitrogen (mg/g)	1.225	1.829	2.622	0.625	0.254	0.254	1.92	2.253	0.856	0.206
	(%) increase/ decrease		33	53.2	-76.1	-59.3		86.7	88.7	-62	-76
	Phosphorus (mg/g)	0.709	1.115	1.826	0.506	0.203	0.203	1.226	1.908	0.556	0.097
2	(%) increase/ decrease		36.4	61.1	-72.2	-59.8		83.4	89.3	-70.8	-82

With respect to phosphorus, the concentration during the first year of study on day 1 was 0.709mg/g which increased to 1.115 mg/g and 1.826 mg/g on 50th day of experiment (spring) and 140th day (summer) respectively, depicting an increase in uptake by 36.4% and 61.1% respectively. However, on 222nd day (Autumn) a decreased value of 0.506 mg/g was recorded, registering a percent decrease of 72.2% from summer value. Further, on 308th day of the experiment (winter), the value of phosphorus got further reduced to 0.203 mg/g showing a percent decrease of 59.8% from autumn value (Table 2).During the second year (2009-2010) the experiment lasted for 308 days. In the beginning of the experiment (day 1), the concentration of phosphorus in the plant was 0.203mg/g which increased to 1.226 mg/g and 1.908mg/g on 50th day of the experiment (spring) and 135th day (summer) respectively, depicting an increase in uptake by 83.4% and 89.3% respectively. However, on 222nd day (autumn) a decreased value of 0.556mg/g was recorded, depicting a percent decrease of 70.8% from the summer value. Further on 308th day of the experiment (winter), the value of phosphorus got further reduced to 0.097 mg/g showing a percent decrease of 82% from the autumn value. It has been observed that the maximum uptake of nitrogen and phosphorus was recorded during summer, which is growing period for the plant.

The die back role of the species under consideration was also studied so as to evaluate the levels of enrichment on the arrival of senescence and long decaying processes thereafter (Table3)

Table 3: Percentage of nutrient back release of *Azolla pinnata* in lake water.

Experimental plant	2008-09	2009-10	2008-09	2009-10
	162 days N%	173 days N%	173 days P%	162 days P%
Back release (%)	90.0	90.8	88.8	94.9

The plant released back 90% and 90.8% of nitrogen during the first and second year respectively, while release back of phosphorus was 88.8% and 94.9% respectively for 2008-2009 and 2009-2010 (Table3)

Decaying of *Azolla pinnata* supplies an additional amount of nitrogen and phosphorus to the sediment. That *Azolla pinnata* releases marked amount of Nitrogen and phosphorus to the substrate has also been reported by Singh and Singh (1990) and Choudhary and Kennedy (2004).

Studies on Nurtient trends in sediments containing *Azolla pinnata* (Table 4) depicted that the concentration of Nitrogen in the sediment on the day 1 was 1.035 mg/g which increased to 1.854 mg/g on 50th day showing an increase by 44%.On 140day (Summer), 1.965mg/g of Nitrogen was recorded showing an increase in nitrogen by 5.6% from Spring. However, on 226th day (autumn) an increased value of 2.122 mg was recorded showing a percentile increase of 7.6% from summer value. Further, on 302ndday of the experiment (winter) the value of nitrogen in the sediment increased to 2.225 mg/g, recording 5 percent increase from autumn value. During the second year (2009-2010), the experiment lasted for 308days, with respect to nitrogen. At day1, the concentration of nitrogen in the sediment was 2.225 mg/g which decreased to 2.166mg/g and 1.949 mg/g on 50th Day and 135th day respectively, depicting a decrease in nitrogen by 3% and 10% respectively. However, on 222nd day (au tumn), an increased value of 2.22mg/g was recorded (12% increase). Further on 308th day (winter) the value of nitrogen got further increased to 2.3mg/g showing a percent increase of 3.5% from autumn value.

Table 4: Nutrient trends in sediments containing *Azolla pinnata.*

Sl. No.	Parameters	2008-2009					2009-2010				
		Initial Day 1	Spring 50 day	Summer 140 day	Autumn 226 day	Winter 302 day	Initial Day 1	Spring 50 day	Summer 135 day	Autumn 222 day	Winter 308 day
1.	Nitrogen (mg/g)	1.035	1.854	1.965	2.122	2.225	2.225	2.166	1.949	2.22	2.3
	(%) increase/ decrease		44	5.6	7.6	5		-3	-10	12	3.5
2.	Phosphorus (mg/g)	0.903	1.226	1.175	1.982	1.996	1.996	1.854	1.725	2.006	2.155
	(%) increase/ decrease		26	-4	40.7	1		-7	-7	14	7

With respect to phosphorus, it has been observed that on day1 of the experiment (during 2008-2009), the phosphorus concentration was 0.903 mg/g, which increased to 1.226 mg/g, depicting an increase by 26% on 50th day of the experiment (spring). On 140th day (summer), a value of 1.175mg/g was recorded, depicting a decrease by 4%. However on 226th day (autumn), an increased value of 1.982mg/g was recorded showing a percent increase by 40.7% in comparison to the summer value. Further, on 302nd day (winter), the value of phosphorus got further increased to 1.996 mg/g showing percent increase by 1% from the autumn value. During the second year of the study (2009-2010), the experiment lasted for 308 days. In the beginning of the experiment (day1), the concentration of phosphorous in the sediment was 1.996 mg/g which decreased to 1.854 mg/g and 1.725 mg/g on 50th and 135th day showing percent decrease by 7% each. However, on 222nd day (autumn), an increased value of 2.006 mg/g was recorded (14% increase). On 308th day of the experiment (winter), the value of phosphorous got further increased to 2.155 mg/g showing percent increase of 7% from autumn value.

Sediments have an important role to play in Lake Metabolism. The enrichment of bottom sediments is a function of external loading and an autochthonous build up [18].Autochthonous build up ultimately leads to macrophyte regenerations through a feedback loop linking macrophyte decomposition and translocation and dissolution from bottom sediments[19-21]. In the present investigation it has been observed that maximum values of nitrogen and phosphorus in the

sediment were recorded in Autumn-winter. This is due to the release back of the nutrients by the decaying plant during this period. *Azolla pinnata* is a seasonal plant and as temperature starts declining during autumn-winter, the nutrients are released in appreciable quantity.

Macrophytes play an important role in balancing aquatic systems and have capacity to improve water quality by absorbing various nutrients, ('N' and 'P' in particular). Basic function of macrophyte based treatment system is to assimilate, concentrate and to store contaminants on short term basis. *Azolla pinnata* being seasonal has quick turn over and early senescence and release back of nutrients is alarmingly tremendous. However, on the other hand, it is equally efficient enough to trap the nutrients. This quality of plant, can be cashed once its harvest is planned well in time so that the surplus nutrients stored in the form of nutrient pump inside the macrophyte are got rid off. Since the plant propagates mainly through the spores and the spores have been seen to retain nutrients, therefore, the timing of the spore formation will also have to be considered during harvesting so as avoid nutrient enrichment through release of nutrients from spores as well. Further, *Azolla pinnata* being seasonal has quick turnover, its planned harvesting can therefore be useful in conservation strategy of the polluted Dal Lake. Besides this, the plants harvested thus, can serve as cattle food, green manure and for biogas production.

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