

USE OF WATER HYACINTH AS AN ECOFRIENDLY MANAGEMENT PRACTICE IN CONTROLLING EUTROPHICATION

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ABSTRACT : The present study was carried out in a perennial lentic water body locally known as Santhi jheel located at Nadia District, West Bengal. It is a large stagnant water body which receives rain water runoff, agricultural runoff etc., making the water body eutrophic. This natural water body is being utilized for extensive fish culture. The macrophytes mainly *Eichhornea* sp. are put along all the margins, as a management strategy to control the eutrophication. The study was aimed to understand the connection between resource use, methods of culturing and environmental impacts. Different physico-chemical properties of water like temperature, pH, DO, COD, BOD, NH₃, NO₂, NO₃, PH₄ and biomass, total nitrogen, phosphorus, potassium of *Eichhornia* sp. were analysed for a period of one year. The results showed that the water body is slightly alkaline in nature which is a favorable condition for aquaculture. The nutrients present in water were in the order of K>N>P, whereas in *Eichhornia* sp. the order was N>K>P. The biomass of the plant was high in summer and similarly the nutrients accumulation was also high in summer. It reveals that, the excess accumulation of nutrients due to agriculture runoff and additional fish feed of the water body can be avoided through *Eichhornia* sp. The proper management of water hyacinth in natural water bodies helps in recycling of nutrients and materials. Extensive aquaculture along with low-tech, low cost and ecofriendly technology like phytoremediation is advisable for the better utilization of natural resources, as it helps to reduce resource inputs and environmental adverse effect.

Key words : Phytoremediation, wet lands, nutrient studies, water hyacinth.

INTRODUCTION

Wetlands are one of the most productive ecosystems comparable to tropical evergreen forests in the biosphere and play a significant role in the ecological sustainability of a region. West Bengal is rich with natural and man-made wetlands, both freshwater and brackish water. Total wetland area of the state has been estimated at 10.49 lakh ha (freshwater area: 5.89 lakh ha, estuarine area: 2.5 lakh ha and brackish water area: 2.1 lakh ha), excluding paddy fields. Amongst these ecological types, freshwater wetlands, such as, pond, pool, beel, baor, haur, jala, doba, daha, dighi, sagar, sayar, etc., are distributed widely all over West Bengal. And amongst these freshwater wetlands, people are especially concerned with smaller water bodies, shallow marshes and lowland depressions like dobas, jheels, jalas, paddy fields and roadside nullahs those offer suitable sites for fishing small indigenous fishes, shrimps etc (Mousumi and Nandi, 2015). These wet lands are one of the important fishery resources. Managed as community resources, nearly half

of the *beels* are located in the districts of 24 Parganas, Murshidabad, Hooghly and Nadia (Sinha, 2000). This system will be of special significance as it will improve the socio-economic status of weaker rural fisher community.

But at the same time these wet lands are cradles of biological diversity that provide the water and productivity upon which countless species of plants and animals depend for survival. The health of the environment decides the diversity and productivity of the systems. Therefore, for sustaining the diversity of fish, and for sustainable management of the fish culture, it is important to know the factors controlling the quality of the lake systems which helps to follow rational management methods for preventing any further rural economic loss and biodiversity (Prasad *et al*, 2009).

In this connection few studies have been carried out regarding the use of waterhyacinth for the management of water quality under natural or controlled conditions (Penfound and Earle, 1948).

The presence of water hyacinth may enhance water quality due to their ability to absorb excessive loads of nutrients (Rommens *et al*, 2003). Large aggregations of *Eichhornia crassipes* rapidly remove nitrogen and phosphorus from the water column (McVea & Boyd, 1975). But, attempts to manage the water hyacinth in small impoundments or lakes, which are utilized for fish culture are scanty. So, the present study has been carried out to study the use of water hyacinth as a management strategy which provides baseline information to understand the connection between resource use, methods of culturing and environmental impacts for better utilization of these wetlands.

MATERIALS AND METHODS

Water body selected for the present study is a Jheel named as Shanti Jheel which is partially connected to "Mathura beel". The water body covers a length of about 1 km. and the depth may rise upto 1.5 to 2 m during monsoon season. The water body is unique in its type having the agricultural fields and human settlements surroundings it, thus contributing varied qualities of sediment and water. It is a perennial water body where extensive fish culture is being practiced by putting water hyacinth at margins of the jheel as a management strategy.

From the water body compound samples for water sample and macrophytes were collected randomly in labeled and clean containers once in a month for one year and were analysed. Collection, preservation and analysis of physico-chemical properties of water like temperature, pH, turbidity, dissolved oxygen, total alkalinity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate-nitrogen, ammonia-nitrogen & phosphate-phosphorus of water was done according to the standard methods of APHA (1998). Compound macrophyte samples were collected by 1 m² wooden frame. The collected samples were washed, extra water was drained and wet weight was taken on spot by standard balance. Then the samples were brought to the laboratory for the analysis of dry weight, total nitrogen (AOAC, 1995) and phosphorus (Tandon, 1995).

RESULTS AND DISCUSSION

The physical and chemical attributes of water are the critical components of a water body. Some physical and chemical parameters were measured in the Santhi jheel in the present study (Table 1).

Temperature is one of the most important ecological factors, which controls the physiological behaviour and distribution of organisms (Moundiotiya *et al*, 2004). In the present findings, water temperature of the water body

showed maximum values during summer and minimum in winter. The water temperature ranged from 15.06 ± 0.057 to $34.33 \pm 0.057^\circ\text{C}$ in the jheel. The range of temperature affirmed tropical character of the study area and also corresponded with the earlier observation of Sharma and Hussain (1999) and Sharma (2000). Variations observed in water temperature may be due to inflow of water from the surrounding areas, seasonal influence and also due to fluctuation in atmospheric temperature.

One of the most important index of water quality is the water pH, which expresses the intensity of acidity or alkalinity. pH value obtained during the study period was within the acceptable limit, which was slightly alkaline (8.10 ± 0.10) to neutral (7.30 ± 0.12) during winter and pre-monsoon which is comparable to the results of Sugunan *et al* (2000) and Paria & Konar (2000). Higher pH value is normally associated with the high photosynthetic activity in water (Hujare, 2008) and pH ranging between 6.09 and 8.45 is ideal for supporting aquatic life forms (Buttner *et al*, 1993).

Turbidity ranging from 28.53 ± 0.25 (May) to 20.40 ± 0.20 NTU (December) was recorded in the Jheel and this range is generally desirable in fish ponds (Boyd, 1982). The agricultural runoff and domestic waste water which are rich in nutrients should increase the turbidity in the water body. But, the presence of aquatic macrophytes reduces the turbidity of water body (Scheffer, 1999). The present findings are in agreement with the observations of Chandrasekhar and Jafer, (1998).

Dissolved oxygen being essential for many metabolic processes (Ahmed, 1995) showed variation in the study area, recorded from 7.40 ± 0.12 (January) to 6.00 ± 0.20 ppm (May) which is optimum for fish production. Similar ranges of dissolved oxygen levels were reported by Pathak (1990) and Rana *et al* (1996) from beels of West Bengal. Wahlquist (1970), observed that the mean dissolved oxygen concentration was similar in both ponds with or without water hyacinths. Whereas, King and Smith (1947) recorded much lower dissolved oxygen concentration in small ponds filled with water hyacinth. Based on the above studies, it can be stated that, only the higher biomass of water hyacinth causes depletion in dissolved oxygen concentration in the water body.

Total alkalinity determines the buffering capacity or ability to neutralize acid. Alkalinity above 100 ppm is classified as high productive and those with <50 ppm are oligotrophic (Anonymous, 2005; Meera and Nandan, 2010). The maximum and minimum values for the jheel were recorded as 196.67 ± 1.05 (May) and 146.00 ± 2.00

ppm (July), which indicates that, the water body is highly productive. These findings are comparable to the reports of Sugunan *et al* (2000).

According to Adakole (2000) the BOD of unpolluted waters remains <1.00 ppm; moderately polluted within 2.0-9.0 ppm and heavily polluted waters >10.0 ppm. During the present study the BOD₅ of jheel varied from 13.70±0.10 (July) to 11.70±0.12 ppm (December) and can be stated that, the water body is heavily polluted. Ajibade *et al* (2013) reported gradual decrease in BOD and COD concentrations of sewage when treated with more water hyacinth. As the BOD concentration is more in the jheel, biomass of water hyacinth may be managed in required quantity to reduce BOD and COD levels of the jheel.

Chemical oxygen demand of the jheel is higher than the BOD ranging from 38.67±1.15 (July) to 26.33±0.58 ppm (December). Similar values of BOD and COD were reported from a beel of West Bengal (Bandyopadhyaya and Das, 1998).

Ammonia-nitrogen is the by-product from protein metabolism excreted by fish and bacterial decomposition of organic matter. Ammonia-nitrogen of the jheel were fluctuating between 0.198±0.001 (May) to 0.171±0.100 ppm (December). But, sub-lethal effects like reduced growth, poor feed conversion and reduced disease resistance may occur in the fish at 0.1 to 0.3 ppm of ammonia-nitrogen (EIFAC, 1973; Robinette, 1976).

Nitrate-nitrogen is relatively nontoxic to fish and not cause any health hazard except at exceedingly high levels (>90ppm) (Stone and Thomforde, 2004). Santhosh and Singh (2007) described the favourable range of 0.1 to 4.0 ppm in fish culture water. The nitrate-nitrogen concentration of the present water body varied in between 0.077±0.001 (August) and 0.044±0.001 (May), which is lower than the favourable range. Several workers have opined nitrate-nitrogen fluctuations differently. According to Schwoerbel (1987), nitrate-nitrogen level will be always higher in oligotrophic water bodies than in high productive wetlands, which indicates the Santhi jheel as high productive wetland.

Almost all of the phosphorus present in water is in the form of phosphate and it is an essential nutrient for increasing the aquatic productivity. Bhatnagar *et al* (2004) suggested that, the 0.05-0.07 ppm of phosphate-phosphorus is optimum and productive for fish culture. Excess concentration of phosphorus may lead to eutrophication. Phosphate-phosphorus of the selected water body varied from 0.201±0.001 (July) to 0.169±0.002 (May), which is near to excessive (>0.2

Table 1 :

Param- eters Months	Temp °C	pH	Turbidity NTU	DO ppm	Total alkalinity ppm	BOD ppm	COD ppm	NO ₃ -N ppm	NH ₃ -N ppm	PO ₄ -P ppm
JUL	30.83±0.057	7.83±0.057	27.23±0.251	6.56±0.321	146.00±2.000	13.73±0.115	38.66±1.154	0.076±0.001	0.186±0.001	0.201±0.001
Aug.	29.96±0.057	7.70±0.100	26.56±0.321	6.53±0.152	151.66±1.527	13.40±0.200	36.00±1.000	0.077±0.001	0.182±0.001	0.198±0.0005
Sept.	29.10±0.100	7.66±0.057	25.33±0.230	6.40±0.200	156.00±2.000	13.46±0.115	36.66±1.527	0.071±0.001	0.180±0.001	0.196±0.001
Oct.	27.33±0.057	7.56±0.057	24.90±0.100	6.36±0.351	161.66±1.527	12.66±0.115	28.00±1.000	0.065±0.001	0.175±0.001	0.194±0.001
Nov.	20.33±0.057	7.43±0.057	24.16±0.152	6.86±0.115	162.33±2.081	12.06±0.115	27.66±0.577	0.058±0.002	0.174±0.001	0.190±0.0005
Dec.	18.40±0.100	7.40±0.100	20.40±0.200	7.20±0.200	165.33±2.309	11.73±0.115	26.33±0.577	0.057±0.001	0.171±0.001	0.186±0.0005
Jan.	15.06±0.057	7.36±0.115	23.20±0.200	7.46±0.115	174.00±2.000	12.13±0.115	28.66±1.154	0.054±0.001	0.177±0.001	0.185±0.001
Feb.	22.20±0.100	7.56±0.057	24.36±0.152	7.13±0.115	186.00±2.000	12.80±0.200	29.66±2.081	0.053±0.001	0.182±0.002	0.180±0.001
Mar.	26.46±0.115	7.80±0.100	26.66±0.152	6.73±0.115	192.66±1.154	13.33±0.115	32.00±2.000	0.051±0.001	0.186±0.0005	0.173±0.001
Apr.	30.40±0.100	7.93±0.057	27.40±0.360	6.20±0.200	194.66±1.154	13.53±0.115	32.66±2.309	0.046±0.002	0.195±0.001	0.172±0.002
May	34.33±0.057	8.10±0.100	28.53±0.251	6.00±0.200	196.66±1.054	13.66±0.115	34.66±2.309	0.044±0.001	0.198±0.001	0.169±0.002
Jun.	32.33±0.057	8.00±0.100	26.30±0.100	6.33±0.305	175.33±1.154	13.70±0.100	37.33±1.154	0.075±0.001	0.193±0.001	0.191±0.001

Table 2 :

Param Months	Wet weight Kg/m ²	Dry weight g/m ²	Total nitrogen %	Phosphorus %
Jul.	2.43±0.658	152.03±6.047	2.486±0.150	0.403±0.005
Aug.	2.14±0.475	137.26±6.299	2.220±0.200	0.366±0.011
Sept.	1.86±0.055	112.76±3.563	2.066±0.115	0.346±0.011
Oct.	1.12±0.055	98.10±2.851	2.066±0.057	0.326±0.011
Nov.	1.41±0.066	119.06±1.401	2.133±0.115	0.350±0.010
Dec.	1.81±0.225	169.60±15.649	2.113±0.115	0.380±0.010
Jan.	3.16±0.104	204.13±3.330	2.220±0.100	0.390±0.010
Feb.	4.54±0.050	208.06±11.271	2.266±0.115	0.396±0.015
Mar.	3.80±0.045	216.23±0.550	2.466±0.115	0.420±0.010
Apr.	3.01±0.045	219.33±1.361	2.866±0.115	0.430±0.010
May	3.78±0.045	224.90±3.764	3.133±0.115	0.443±0.005
Jun.	3.00±0.061	205.53±8.746	2.800±0.200	0.420±0.020

ppm) concentration for lake production (Moyle, 1946).

Ammonia-nitrogen, nitrate-nitrogen and phosphate-phosphorus levels of the selected water body are indicating that, the water body is highly productive and the ranges of ammonia-nitrogen and phosphate-phosphorus are above the desirable levels for fish culture. Even though water hyacinth is employed to maintain the water quality as it has a high nutrient uptake rate compared to other macrophytes (Rodríguez-Gallego *et al*, 2004); reduction in nutrient concentrations in a water body depends on the extent of cover and density of the plant (Pinto-Coelho & Greco, 1999).

Dry and Wet weight and nutrition status of water hyacinth

There is potential for water hyacinth to provide phytoremediation in highly eutrophic systems (Rodríguez-Gallego *et al*, 2004). During the present study wet weight, dry weight, total nitrogen and phosphorus of the plant was analysed to understand the nutrient removal capacity of plant from water column (Table 2).

Some studies revealed that, the bioaccumulation of nutrients in the water hyacinth are showing the positive correlation with the biomass of the plant and nutrient load in the water (Poulami *et al*, 2015). During the present study the wet weight and dry weight of the water hyacinth varied in between 3.78±0.045 (May) to 1.123±0.055 kg/m² (October) and 224.90±3.76 (May) to 98.10±2.85 g/m² (October) respectively. Sugunan *et al* (2000) also recorded similar plant biomass in the beels of West Bengal. Maximum weight of the plant was recorded during summer and minimum during winter. Similar fluctuations in biomass was reported by many workers (Sinha and Jha, 1997; Collier *et al*, 1999)

The fantastic ability of absorbing nutrients of the

water hyacinth was studied by several workers like Surat and Singh (1980) & Mohan and Hosetti (1998). A positive correlation of nitrogen and phosphorus between habitat waters and water hyacinth plant tissues were observed (Boyd and Vickers, 1971). Total nitrogen and phosphorus of the plant ranged from 3.13±0.12 (May) to 2.07±0.058% (October) and 0.44±0.005 (May) to 0.326±0.011% (October) respectively. With increasing biomass of the plant, the amount of nutrients absorbed by the plant also increased (Ajibade *et al*, 2003). The nutrients present in water were in the order of K>N>P, whereas in *Eichhornia* sp. the order was N>K>P. The biomass of the plant was high in summer and similarly the nutrients accumulation was also high in summer.

CONCLUSION

The present results revealed that, even though water hyacinth is employed to maintain the water quality (Rodríguez-Gallego *et al*, 2004); still nutrient concentrations in the water body was higher than the desirable levels as the potential to significantly reduce nutrient concentrations in a water body depending on the extent of cover and density (Pinto-Coelho and Greco, 1999). But, the net benefits of a phytoremediation approach would also depend on other impacts by water hyacinth. Thick and large water hyacinth mats may alter the physico-chemical properties of water which may cause negative impact on the water body. From the present study it is concluded that, the utilization of this plant for phytoremediation is not being practiced properly in the wetlands. So, it is stated that, the studies on the management of the extent of cover and density of water hyacinth are very much required to improve fish production as well as to safe guard the biodiversity of the wetland.

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