© 2016 IJSRSET | Volume 2 | Issue 6 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Identification and Quantification of Aquatic Macrophytes with Ecological Indices in the Damodar River

Ruma Banerjee, Apurba Ratan Ghosh

Department of Environmental Science, University of Burdwan, Golapbag, West Bengal, India

ABSTRACT

A study was conducted to analyze the aquatic macrophytes with the help of ecological indices along the stretch of the Damodar river from Dishergarh to Barsul, Burdwan West Bengal, India. Twenty five aquatic macrophytes were collected from sixteen sampling sites of the river Damodar to determine their density, frequency, abundance, diversity (Shannon diversity), evenness, species richness (Margalef species richness). The objective of the study was (i) to identify the macrophytes present in the 16 different sites in the river Damodar and (ii) to quantify the aquatic macrophytes with the help of some ecological indices. The aquatic plants were identified up to species level. The average of diversity index, species richness and eveness of aquatic macrophytes in the Damodar river were 0.75, 20.0 and 0.25 respectively. Physicochemical parameters showed an average of pH (7.76), alkalinity (210.45 mg/l), conductivity (310 µS/cm), nitrate (NO_3^-) (1.62 mg/l) and phosphate (PO_4^{3-}) (0.15 mg/l) in the sixteen sampling sites. Shannon diversity index showed minimum number of representative species under 14 families. Species richness index was moderate to high representing the enriched participation of habitat species. The study revealed that the most abundant species was *Vallisneria spirdis* may be due to its invasive nature and rate of dispersal.

Keywords : Aquatic macrophytes, species richness, diversity, ecological indices, Damodar River

I. INTRODUCTION

Rivers are composite aquatic systems flourished by intensive spatiotemporal dynamicity of the biotic and abiotic entities. The river Damodar is the prominent tributary of the holy river Ganges, and also the synergistic life-line of the dwellers of Rarh Bengal Delta. The river Damodar originates from the lava capped Khamarpet hill adjacent to Rajruppa and rushes a path of about 540 km penetrating the river Hooghly. The river Barakar meets to the river Damodar in the vicinity of Disergarh, Asansol, India. The Damodar is seasonal and flood prone mainly on account of different seasons, which are physiographic and meteorological in nature. River is the most dynamic and complex representative of lotic freshwater ecosystem playing a vital role in biodiversity. Macrophytes are aquatic plants, growing in or near water that are emergent, submerged or floating. Freshwater macrophytes are the basis of the structure and functioning of river habitats [1]. Rooted aquatic macrophytes have a positive role in energy flow, nutrient cycling, and sedimentation processes. They directly improve the water quality through oxygenation process and nutrient cycling as well as provide surface for water-purifying algae, fungi and bacteria indirectly [2].

According to Thomaz et al., 2008 [3] the study related to aquatic macrophytes, and their ecology, were few in number before the 1960s. Taxonomically aquatic macrophytes are closely resembled to terrestrial plants, but are aquatic phanerogams, living in a completely different environment. A few factors control the variability of macrophyte vegetation in different rivers. Most frequent and dynamic factors are the hydrological (water depth and flow velocity), geographical (distance from source, river connectivity, catchment area) and chemical factors (water conductivity, nutrients) [4]. The range to which macrophytes will affect the river system by their interaction in physical, chemical and biological processes depends mainly on density and species composition. Macrophytes increase the retention time of river water by flow reduction, [5] that may induce sedimentation of fine particles with associated

nutrients, heavy metals or organic pollutants [6]. In the study it was flourished that macrophyte community may very well indicate nutrient concentrations of the river water, even if macrophyte communities are mainly structured by parameters other than nutrient concentrations. On this account, the macrophyte species composition and abundance were analyzed.

The aim of the study was to identify all the representative species of collected macrophytes from the stretch of the Damodar river under study. The indentified macrophyte species were fashioned under consecutive families to gain their taxonomic rank. The identified plant species were ecologically analyzed by some quantitative attributes like density, frequency, abundance, Shannon diversity index, species richness index, evenness index and Margalef diversity index to shape their communities as well as biodiversity in the river Damodar. As the river is a lotic system, the composition of the collected species as well as the community distribution may vary with seasonal cycle. Growth of aquatic macrophytes depends mainly on nutrient composition of the water system. In the study, the physicochemical parameters like pH, alkalinity, conductivity, nitrate (NO_3^-) and phosphate (PO_4^{3-}) of river water as the representatives of nutrient level were analyzed.

II. METHODS AND MATERIAL

Geographical Location of the Study Area

The study area comprises of a large stretch of the Damodar river in West Bengal starting from the Disergarh up to Barsul at Burdwan. This river stretch is tided by the Raniganj and Asansol coal belt and is the representative portion under the Damodar Valley Corporation. The study area lies under 23°12'42.93"N latitude and 87°50'49.79"E longitude to 23°41'6.69"N latitude and 86°49'21.55"E longitude. A total number of twenty five plant species native to the study area considered as the aquatic macrophytes that were collected from the sixteen sampling stations (Table 1) in the peak of the vegetation season (june to august) in the year 2011. The twenty five members of macrophyte community were the representatives of 14 taxonomic families. Though the riverine environment is a lotic system, collection of samples in quadrate method as like as the terrestrial community is not possible in all the cases. For that reason the sixteen sampling sites were treated as sixteen cases or representatives of aquatic and marginal individuals of different macrophyte species. Different attributes like population density, frequency, abundance, Species richness [7], Shannon diversity [8], evenness [9] and Margalef diversity index [10] were calculated to assess the community structure and to interpret the macrophyte predominant zones of the river Damodar under the study area. Several environmental variables like pH, electrical conductivity, alkalinity, nitrate (NO_3^-) and phosphate (PO_4^{3-}) were estimated [11] to correlate environmental attributes of the river water with macrophyte community.

Measurement of Diversity

The type of diversity used here is α- diversity which is the diversity of species within a community or habitat. The diversity index was calculated by using the Shannon – Wiener diversity index (1949) [8].

Diversity index = $H' = -\sum Pi \ In \ Pi$

where $Pi = S / N$

S = number of individuals of one species

N = total number of all individuals in the sample

In = logarithm to base e

Measurement of Species Richness

Margalef's index was used as a simple measure of species richness [10] (Margalef, 1958).

Margalef's index = $(S - 1) / In \ N$

S = total number of species

N = total number of individuals in the sample

In = natural logarithm

Species richness is a measure of the number of species found in a sample. This particular measure of species richness is known as D, the Menhinick's index [7] (Menhinick, 1964).

$D = s / \sqrt{N}$

where s equals the number of different species represented in sample, and N equals the total number of individual organisms in sample.

Measurement of Evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used [9] (Pielou, 1966).

$e = H / In \ S$

H = Shannon – Wiener diversity index

S = total number of species in the sample

Table 1: Description of sampling sites in the study area

Sl. No.	SITES	SITE DESCRIPTION
1	Dishergarh	Coal mines area and confluence point of river Barakar
2	Chinakuri	Coal mines area and discharge point of Thermal power plant
3	Dihika	Discharge point of IISCO
4	Hirapur Pump Stn	Industrial area
5	Burnpur	Industrial area
6	Narayankuri	Coal mines and discharge point of Nunia nala
7	Mejhia	Coal mines and industrial area
8	Srirampur	Discharge point of Singran nala
9	Pursa	Industrial area
10	Durgapur Barrage	Dam area
11	Majher Mana	Discharge point of Tamla nala
12	Dhobi Ghat	Industrial effluent and sewage cntamination
13	Silampur	Agricultural area
14	Sillaghat	Agricultural area
15	Gohogram	Agricultural area
16	Barsul	Agricultural area

Table 2. Identification and quantification of aquatic macrophytes

Sl. No.	Family	Scientific Name	Growth form	Frequency	Density	Abundance
1	Hydrocharitaceae	Hydrilla verticillata	so	50(43.75-56.25)	64 (55.63-72.56)	128.57(113.44-145.13)
2		Vallisneria spirdis	sr	50 (37.5-62.5)	71.71 (58.31-92.25)	144.08(129.13-155.50)
3	Ceratophyllaceae	Ceratophyllum demersum	sfl	35.42 (31.25-37.5)	15.27 (6.75-25.00)	43.22(18.00-66.67
4	Potamogetonaceae	Potamogeton pectinatus	s	14.58 (6.25-25)	0.96 (0.25-2.25)	5.33(3.0-9.0)
5		Potamogeton crispus	s	58.33 (56.25-62.5)	21.29 (6.44-39.94)	35.49(11.44-63.90)
6	Araceae	Spirodela polyrhiza	fll	20.83 (6.25-31.25)	7.52 (0.50-11.380	29.05 (8.00-42.75)
7		Pistia stratiotes	fll	60.42 (50-75)	16 (9.13-20.25)	26.12 (18.25-33.11)
8	Lemnaceae	Lemna minor	fl	60.42 (50-68.75)	79.42 (18.25-119.19)	123.72 (36.50-173.72)
9	Salviniaceae	Salvinia cucullata	fl	41.67 (18.75-56.25)	9.40 (2.69-14.00)	20.74 (14.33-24.89)

10		Azolla sp.	fl	29.17 (18.75-50)	13.10 (9.38-19.94)	47.74 (39.88-53.33)
11	Pontederiaceae	Eichhornia crassipes	fl	73.28 (56.25-82.35)	35.60 (26.56-51.56)	47.82 (32.79-63.46)
12	Alismataceae	Sagittaria monteidvensis	e	33.33 (25-43.75)	4.69 (3.63-5.94)	14.16 (13.57-14.50)
13		Sagittaria sagitifollia	e	20.83 (6.25-31.25)	0.40 (0.19-0.50)	2.20 (1.60-3.00)
14	Polygonaceae	Polygonum barbatum	e	27.08 (12.5-37.5)	4.46 (1.44-6.44)	15.59 (11.50-20.60)
15		Polygonum globosum	e	18.75 (6.25-25)	0.44 (0.13-0.88)	2.25 (1.25-3.50)
16	Cyperaceae	Scirpus articulatus	e	16.67 (6.25-25)	1.15 (0.63-1.56)	7.86 (6.25-11.00)
17		Eleocharis palustris	e	52.08 (50-56.25)	20.25 (15.81-24.94)	39.02 (31.63-49.88)
18		Eleocharis dulcis	e	16.67 (12.5-25)	1.35 (1.19-1.56)	9.25 (4.75-12.50)
19		Scirpus maritimus	e	6.25 (0-12.5)	0.15 (0.0-0.31)	1.50 (0.0-2.50)
20		Cyperus sp	e	29.17 (18.75-37.5)	4.21 (1.88-7.44)	14.50 (6.0-19.83
21	Marsileaceae	Marselia minuta	sf	18.75 (6.25-25)	1.54 (0.81-2.50)	8.28 (4.33-10.50)
22	Characeae	Nitella sp	s	8.33 (6.25-12.5)	0.29 (0.06-0.63)	3.0 (1.0-5.0)
23		Chara sp	s	16.67 (6.25-25)	0.40 (0.06-0.75)	2.17 (1.0-4.0)
24	Aponogetonaceae	Aponogeton natans	s	10.42 (6.25-18.75)	0.88 (0.06-2.44)	5.33 (1.0-13.0)
25	Trapaceae	Trapa bispinosa	sf	25 (12.5-37.5)	3.73 (1.38-7.94)	15.92 (5.0-31.75)

(s=submersed, so=submersed obligate, sr=Submersed spreaded with runner, sfl=submersed free floating, sf=submerged with floating leaf, fl=floating, e= emergent)

Table 3. Macrophytes and environmental matrices (mean and range)

Macrophyte variables	Short code	Range
Species richness	N	20 (7-50)
Shannon diversity	H	0.75 (0.03-1.75)
Evenness	J	0.25 (0.02-0.50)
Margalef index	d	3.95 (3.75-4.85)
Environmental variables	Unit	Range
pH		7.76 (7.18-8.56)
Electrical Conductivity	µS/cm	310 (170-610)
Alkalinity	mg/l	210.45 (108.63-272.52)
Nitrate (NO_3^-)	mg/l	1.62 (0.06-5.92)
Phosphate (PO_4^{3-})	mg/l	0.15 (0.08-0.45)

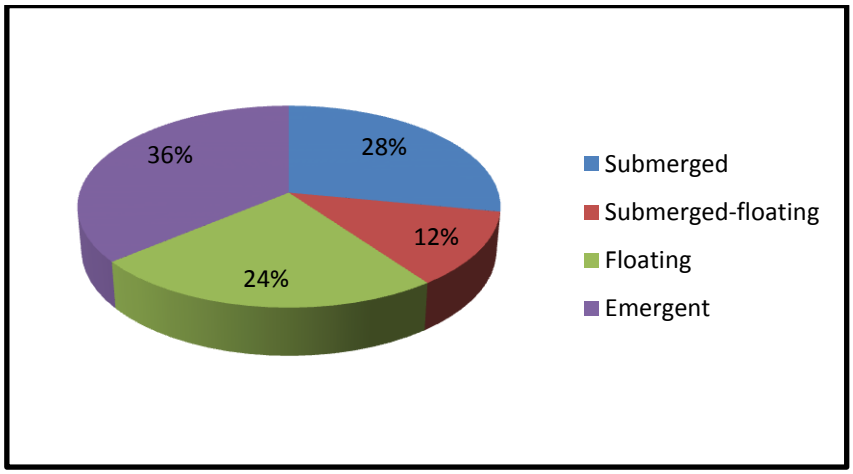

Figure 1. Pie diagram of percentage of different growth forms of aquatic macrophytes

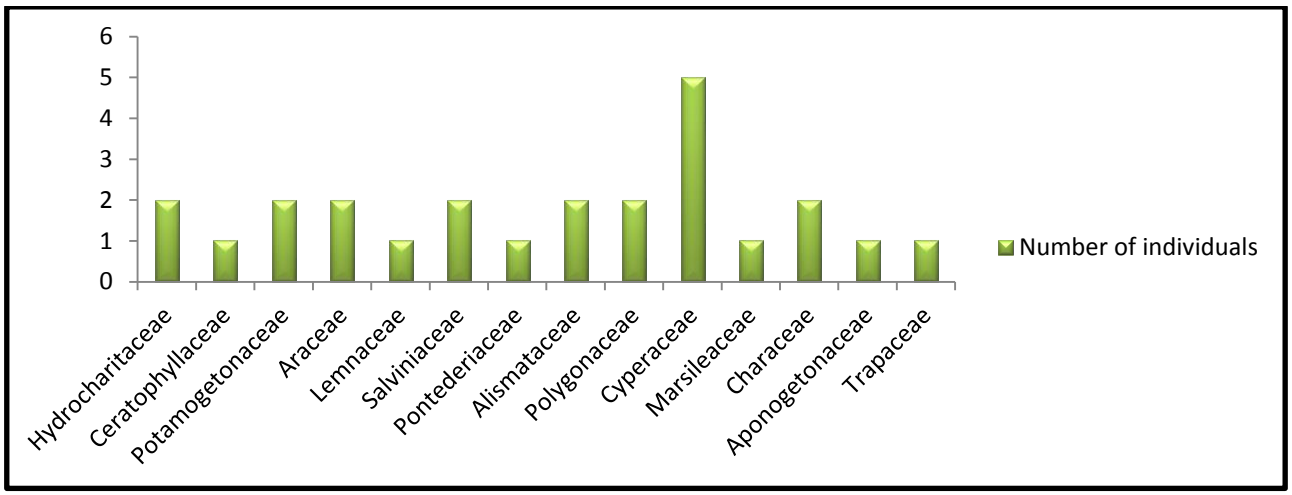

Figure 2. Number of individuals of each family of macrophytes

III. RESULTS AND DISCUSSION

In the research work twenty five different species of aquatic macrophytes under 14 families were recorded from the Damodar river under study, which have included six floating, ten submerge and nine emergent species (Fig. 1). Submerged macrophytes were predominant (Table 2) in the study area (*Hydrocharitaceae* family), together with emerged and floating taxa. Number of individuals of each family of macrophytes is represented in Fig. 2. The most abundant taxa in the river Damodar was Hydrocharitaceae. The most common species of the family Hydercharitaceae found were *Vallisneria spirdis*, *Hydrilla verticillata and Lemna minor* of lemnaceae family, all of which are native to the rivers of the Bengal belt. Among all the collected macrophytes, *Lemna minor* (family - Lemnaceae) was highly densed (density- 79.42) representative of the Damodar river. The most frequent (73.28 per cent) species was *Eichhornia crassipes*, which is a member of the family Pontederiaceae (Table 2). Diversity indices vary among all the sampling sites from 0.03 to 1.75, where the species richness index varies from 7 to 50 between the sixteen sampling stations. Margalef diversity index followed a range of 3.75 to 4.85 and Evenness index varies from 0.02 to 0.50 (Table 3) that supports the study of macrophyte matrix of rivers in North- Central Poland [12].

This study indicated that the average diversity index, species richness and eveness of aquatic macrophytes in the Damodar river were 0.75, 20.0 and 0.25 (Table 3) respectively that supports the finding of Dabgar *et al.*, (2011) [13] in some wetlands of Gujrat. The biodiversity (diversity index, species richness and evenness) of aquatic macrophytes in the Damodar river is mainly due to the rich nutrient condition in this area. Aquatic macrophyte plays an important role in maintaining the ecological balance by nutrient

recycling [14]. Aquatic vegetation plays an important role for the existence of aquatic fauna in a community as it provides the main source of food and energy. The outcome of the present study notes the association of submerged species with water depth and its certain qualities. Emergent species grow mainly in the periphery of the river. Submerged species were also commonly present where water depth is low. This work was an attempt to describe some aspects of biodiversity of aquatic macrophytes of the lotic environment of the river Damodar. The biodiversity (diversity index, species richness and evenness) of aquatic macrophytes in the Damodar river exhibited mainly due to the nutrient rich condition in this area as physicochemical parameters like phosphates, nitrates etc. play an important role for their growth and community distributions as they are the sources of food. The occurrence of a rich and diversified flora in some parts of the river may be indicative of some unpleasant condition of water quality.

The present study was conducted for a quantative investigation of macrophytes and physicochemical properties of the river water. During the investigation, 25 different species of macrophytes were recorded from the study area. While the number of submerged and emergent species was almost same, the number of floating species was recorded six in number and it might be vary because of the flow and velocity of the river. Shannon diversity index (0.75) showed moderate and species richness index (3.05) showed the high range of value. Various anthropogenic activities like development of commercial fisheries, excessive growth of invasive aquatic weed (*Eichhornia crassipes*), point and nonpoint sources of polluted water gradually degrading the river water quality status. Growth of *Eichhornia crassipes* in an excessive range can be concluded as bioindicator of degrading water quality of the river. Fluctuation of physico-chemical parameters is primarily destroying the diversity, density, abundance, richness as well as evenness of the aquatic macro flora.

IV. CONCLUSION

The river macrophyte species composition revealed the predominance of herbs. The identified taxa constitute 36% of the emergent, 28% submerged, 24% floating and 12% submerged floating plants. In the upper stretches of the Damodar under study the aquatic vegetation has vital role in restoring aquatic habitats and stream functions. The downstream has fragmented vegetation and requires conservation process. The dynamicity of river water seems to have a direct effect on occurrence and difference in plant species diversity in the river channel. The average value of Shannon diversity index was low to moderate that showed minimum number of representative species under 14 families. The Species richness index was moderate to high representing the enriched participation of habitat species. The most abundant species was *Vallisneria spirdis* may be due to its invasive nature and rate of dispersal. *Lemna minor* was highly densed in some of the sampling sits because they are rapidly growing plants. Other major invasive plant *Eichhornia crassipes* was most frequently found among all the sampling stations because of its free floating nature. Though the river is a dynamic system it maintains its water quality in a homeostatic system. A lot of further works are essential in this regard and further periodic sampling is necessary to monitor the ecological status of aquatic macro flora. Furthermore, this work may lead to the development of standard monitoring procedures that will flourish the value in assessment of the environmental stability of the river regime.

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