

Macrophytes of Tehri Dam Reservoir, Garhwal Himalaya, India

Ashok K. Agarwal • Govind S. Rajwar*

Department of Botany, Government Post Graduate College, Rishikesh – 249201, India Corresponding author: * raiwares@hotmail.com

ABSTRACT

One hundred and seventy six species of macrophytes (154 herb, 14 shrub and 8 tree species) belonging to 58 families of angiosperms were recorded in the present study on macrophytes of Tehri Dam reservoir in Garhwal Himalaya during 2003-2005. All species were herbs. The family Asteraceae was the most dominant among the macrophytes consisting of 25 species. The second largest family was Papilionaceae with 16 species followed by Poaceae with 14 species. The largest genus was *Ageratum* with 4 species. *Cyperus, Euporbia, Sida, Crotalaria* and *Ranunculus* had 3 species each. Twenty genera consisted of 2 species each and all other genera had one species each. Comparatively, fewer macrophytes appeared in July and August, showing thinner growth, while maximum growth was recorded in December and January.

Keywords: macrophytes, Tehri dam reservoir, aquatic ecosystem, Garhwal Himalaya

INTRODUCTION

Macrophytes are large plants including aquatic angiosperms, water ferns, mosses and large algae e.g., *Chara* and *Entero-morpha*. They are sensitive indicators of water quality and conditions of their habitats. They are affected by a wide variety of environmental factors including geology, land form and pollution. Careful study of macrophyte community can provide valuable information about the habitat conditions and conversely, a first hand knowledge of the habitat can enable reasonable prediction of the expected type of vegetation.

Rech et al. (2006) and Sand-Jensen and Søndergaard (2006) described the distribution and production of aquatic macrophytes in Southern Michigan Marl Lake, USA and Lake Kalgaard, Denmark respectively. The macrophytes are well known to antagonise the planktonic population of a lake by either shade effect due to surface area coverage or by high growth rate, resulting in nutrient deficiency. The floating and emergent vegetation in the lake results due to successional changes and relishes a higher nutrient status (Sharma and Singhal 1988). Oosterberg et al. (2000) described the ecological gradients in Danube Delta, Romania. They concluded that the concentration of various chemical characteristics increased in shallow water region and in promixity with the salt water. Aquatic macrophytes act as indicators of various physical and chemical characteristics in an aquatic body (Seddom 2006).

Macrophytes determine the overall ecosystem physiognomy, indicating the degree of pollution, hence they are responsible for their immense role in biogeochemical cycling of nutrients (Hutchinson 1975; Wetzel 1983). Species richness, temperature, resource quality and environmental perturbations affect the development of aquatic macrophytes (De Stasio *et al.* 2009; Hladyz *et al.* 2009; McKie *et al.* 2009)

The large multipurpose Tehri Dam has two main catchments of the rivers Bhagirathi and Bhillangana draining into its reservoir. Both these rivers originate in the glaciers of the higher Himalayan region and flow through deep gorges, dense forests and habitation alike. The source of river Bhagirathi is Gaumukh, while the Bhilangana originates from the comparatively smaller Khatling glacier. It is a fresh water reservoir on the course of Bhagirathi and Bhilangana rivers. The Tehri dam, after completion, has a height of 260.5 m, which is the highest earth rockfill dam in Asia.

The present study was conducted with the objective of recording the macrophytes along the banks of the Tehri dam to study their flowering and fruiting periods.

MATERIALS AND METHODS

The study area is located at 30° 23' N latitude, 78° 29' E longitude and 635 m altitude. The collection of plant samples was done up to 5 m width from the banks of the Tehri dam reservoir. The climate of the study area is tropical monsoon with three distinct seasons. The atmospheric temperature ranged between a minimum of 5°C in December and January, and maximum of 37°C in June during the study period. The maximum rainfall (230 mm) occurred in July whereas the humidity ranged from 47% (May) to 92% (January).

Flowering plants constituted exclusively the category of macrophytes in the present study. Macrophytes were observed and collected monthly. They were pressed, dried and mounted on herbarium sheets by standard methods and were deposited in the herbarium of the Department of Botany, Government Post Graduate College, Rishikesh (Jain and Rao 1977). Details about their growth habit and flowering and fruiting periods were recorded. The identification of plants was done by consulting regional floras (Gaur 1999) and by consulting the herbaria of the Forest Research Institute (FRI) and Botanical Survey of India (BSI), Northen Circle, Dehradun.

RESULTS AND DISCUSSION

Macrophytes recorded in the present study included mainly herbs. One hundred and seventy six species (154 herb, 14 shrub and 8 tree species) of angiosperms belonging to 58 families were recorded along the banks of the Tehri dam reservoir. The Asteraceae family was dominant among macrophytes, consisting of 25 species. The second largest family was Papilionaceae with 16 species followed by Poaceae with 14 species; Scrophulariacae and Lamiaceae had 10 and 8 species, respectively. Brassicaeae had 6 species. The families Acanthaceae, Amaranthaceae, Cyperaceae, Malvaceae, Solanaceae consisted of 5 species each and the family Polygonaceae had only 4 species. Caryophyllaceae, Euphorbiaceae, Ranunculaceae, Rubiaceae, Urticaceae had

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58 ('henopodiaceae ('henopodium murale I Herb November February December	•
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60CleomaceaeCleome gynandra L.HerbJune-AugustOctober-E	December
61 Commelinaceae Commelina benghalensis L. Herb July-August September	er-November
62 Commelinaceae Murdannia nudiflora (L.) Brenan. Herb August-September October-N	November
	r-December
64 Convolvulaceae <i>Ipomoea purpurea</i> (L.) Roth. Herb July-August September	
65 Cucurbitaceae <i>Coccinea grandis</i> (L.) Voigt Climber July-August October-E	
	r-December
5 1	
68 Cyperaceae Cyperus niveus Retz. Herb April-July July-Augu	
69 Cyperaceae Cyperus rotundus L. Herb Whole Year Whole Year	
70 Cyperaceae <i>Eleocharis atropurpurea</i> (Retz.) Kuntz. Herb August-September October-N	
71 Cyperaceae Eriophorum dichotoma (L.) Vahl. Herb July-September October-N	
72 Dioscoreaceae <i>Dioscorea belophylla</i> (Prain) Voigt ex Haines. Climber July-August September	r-October

No. Identified) Family	Species	Habit	Flowering Period	Fruiting Period
3	Dioscoreaceae	Dioscorea bulbifera L.	Climber	August-September	October-November
4	Euphorbiaceae	Euphorbia hypericifolia L.	Herb	July-September	September-November
5	Euphorbiaceae	Euphorbia geniculata Ortega	Herb	June-July	August-September
	Euphorbiaceae		Herb	July-November	December-February
6	Fumariceae	Euphorbia peplus L.		2	2
7		Fumaria indica (Haussk.) Pugsley	Herb	December-February	March-May
8	Geraniaceae	Geranium ocellatum Camb.	Herb	January-March	October-November
9	Hydrocharitaceae	<i>Hydrilla verticillata</i> (L.f.) Royle	Herb	September-November	October-December
0	Hydrocharitaceae	Vallisneria spiralis L.	Herb	-	-
1	Juncaceae	Juncus bufonius L.	Herb	March-August	April-September
2	Lamiaceae	Ajuga bracteosa Wall. ex Benth.	Herb	Whole Year	Whole Year
3	Lamiaceae	Ajuga macrosperma Wallich ex Benth.	Herb	February-April	May-June
4	Lamiaceae	Colebrookea oppostifolia Smith	Shrub	January-March	April-May
5	Lamiaceae	Leucas cephalotes (Roth.) Sprengel.	Herb	July-August	September-November
6	Lamiaceae	Leucas lanata Benth.	Herb	May-August	September-October
7	Lamiaceae	Micromeria biflora (BuchHam.ex D.Don) Benth.	Herb	March-August	September-October
8	Lamiaceae	Nepeta hindostana (Roth) Haines	Herb	March-April	May-June
9	Lemnaceae	Spirodela polyrhiza (L.) Schleiden	Herb	May-June	July-August
0	Linaceae	Reinwardtia indica Dumort.	Shrub	December-February	March-May
1	Lythraceae	Woodfordia fruticosa (L.) Kurz	Shrub	February-April	June-August
2	Malvaceae	Malva parviflora L.	Herb	July-August	October-November
3	Malvaceae	Malvastrum coromandelianum (L.) Garcke	Herb	December-March	July-November
4	Malvaceae	Sida acuta Burm.f.	Herb	July-September	May-July
5	Malvaceae	Sida cordata (Burm.f.) Borss.	Herb	Whole Year	Whole Year
6	Malvaceae	Sida cordifolia L.	Herb	Whole Year	Whole Year
7	Meliaceae	Toona ciliata Roemer	Tree	March-May	June-August
8	Menispermaceae	Cissampelos pareira L.	Climber	March-July	August-October
9	Mimosaceae	Acacia catechu (L.f.) Willd.	Tree	May-August	September-December
00	Mimosaceae	Albizia lebbeck (L.) Willd.	Tree	April-August	October-December
01	Moringaceae	Moringa oleifera Lam.	Tree	March-May	June-August
02	-	0 1		Whole Year	Whole Year
	Nyctaginaceae	Boerhavia diffusa L.	Herb		
03	Nyctaginaceae	Mirabilis jalapa L.	Herb	August-September	October-November
04	Orchidaceae	Epipactis veratrifolia Boiss.	Herb	February-March	April-May
05	Oxalidaceae	Oxalis corniculata L.	Herb	Whole Year	Whole Year
.06	Papaveraceae	Argemone mexicana L.	Herb	Whole Year	Whole Year
.07	Papaveraceae	Argemone ochroleuca Sweet	Herb	December-February	March-June
08	Papilionaceae	Abrus precatorius L.	Herb	March-May	June-August
.09	Papilionaceae	Abrus vaginalis (L.) DC.	Herb	July-August	September-December
10	Papilionaceae	Campylotropis stenocarpa (Klotzsch) Schindler	Shrub	December-March	August-November
11	Papilionaceae	Crotalaria albida Heyne ex Roth.	Herb	Whole Year	Whole Year
12	Papilionaceae	Crotalaria calycina Schrank	Herb	July-August	October-November
13	Papilionaceae	Crotalaria medicaginea Lam.	Herb	August-September	October-December
14	Papilionaceae	Desmodium gangeticum (L.) DC.	Herb	March-April	October-December
15	Papilionaceae	Desmodium triflorum (L.) DC.	Herb	March-April	August-September
16	Papilionaceae	Erythrina suberosa Roxb.	Tree	March-May	June-August
17	Papilionaceae	Indigofera heterantha Wall. ex Brandis	Shrub	March-May	June-August
18	Papilionaceae	Lathyrus sativus L.	Herb	February-April	May-July
19	Papilionaceae	Lathyrus sphaericus Retz.	Herb	February-March	April-June
20	Papilionaceae	Medicago lupulina L.	Herb	December-March	April-June
21	Papilionaceae	Medicago polymorpha L.	Herb	October-December	March-May
22	Papilionaceae	Melilotus alba Medikus ex Desr.	Herb	February-April	September-December
23	Papilionaceae	Vicia sativa L.	Herb	December-March	April-June
23	Poaceae	Echinochloa colonum (L.) Link	Herb	July-September	August-October
24 25		<i>Apluda mutica</i> L.		• •	Whole Year
	Poaceae	1	Herb	Whole Year	
26 27	Poaceae	Bothriochloa pertusa (L.) A. Camus	Herb	March-June	July-September
27	Poaceae	<i>Chrysopogon serrulatus</i> Trin.	Herb	July-September	October-November
28	Poaceae	Cynodon dactylon (L.) Pers.	Herb	Whole Year	Whole Year
29	Poaceae	Echinochloa colonum (L.) Link	Herb	Whole Year	Whole Year
30	Poaceae	Imperata cylindrica (L.) Raeuschel.	Herb	March-June	July-September
31	Poaceae	Lolium temulentum L.	Herb	November-January	February-March
32	Poaceae	Phalaris minor Retz.	Herb	February-April	May-June
33	Poaceae	Polypogon fugax Nees ex Steud.	Herb	February-March	April-May
34	Poaceae	Setaria glauca (L.) P. Beauv.	Herb	Whole Year	Whole Year
35	Poaceae	Setaria verticillata (L.) P. Beauv.	Herb	July-August	September-October
36	Poaceae	Poa annua L.	Herb	January-May	March-June
37	Poaceae	Digitaria setigera Roth.	Herb	August-October	September-Novembe
38	Polygalaceae	Polygala arvensis Willd.	Herb	March-July	August-October
38 39		Rumex nepalensis Sprengel.	Herb	•	August-October
	Polygonaceae			April-August	•
40	Polygonaceae	Persicaria capitala BuchHam.ex D.Don	Herb	April-July	August-October
41	Polygonaceae	Persicaria hydropiper (L.) Spach	Herb	June-August	September-October
42	Polygonaceae	Polygonum plebijum R. Br.	Herb	November-February	March-June
43	Portulacaceae	Portulaca oleracea L.	Herb	June-August	October-December
44	Potamogetonaceae	Potamogeton natans L.	Herb	April-May	June-July

No. Identified	Family	Species	Habit	Flowering Period	Fruiting Period
145	Ranunculaceae	Ranunculus sceleratus L.	Herb	February-November	October-December
146	Ranuculaceae	Ranuculus muricatus L.	Herb	December-February	March-May
147	Ranunulaceae	Ranunculus arvensis L.	Herb	December-February	March-May
148	Rhamnaceae	Ziziphus mauritiana Lam.	Shrub	May-July	September-December
149	Rubiaceae	Galium aparine L.	Herb	February-April	September-December
150	Rubiaceae	Oldenlandia corymbosa L.	Herb	March-May	October-December
151	Rubiaceae	Spermadictyon suaveolens Roxb.	Shrub	August-September	October-December
152	Rutaceae	Murraya koenigii (L.) Sprengel.	Shrub	March-May	August-November
153	Scrophulariaceae	Buchnera hispida Buch. Ham. ex D.Don.	Herb	July-October	August-November
154	Scrophulariaceae	Lindernia crustacea (L.) F.V. Mueller	Herb	March-August	September-November
155	Scrophulariaceae	Mazus pumilus (Burm.f.) van Steenis.	Herb	March-August	September-October
156	Scrophulariaceae	Mazus surculosus D.Don.	Herb	February-September	August-October.
157	Scrophulariaceae	Veronica anagallis-aquatica L.	Herb	February-September	August-October.
158	Scrophulariaceae	Antirrhinum orontium L.	Herb	December-March	April-May
159	Scrophulariaceae	Bacopa monieri (L.) Penell	Herb	June-August	September-October
160	Scrophulariaceae	Lindenbergia indica (L.) O. Kuntze.	Herb	September-October	November-December
161	Scrophulariaceae	Lindernbergia parviflora (Roxb.) Haines	Herb	October-December	January-March
162	Scrophulariaceae	Scoparia dulcis L.	Herb	Whole Year	Whole Year
163	Solanaceae	Datura stramonium L.	Herb	December-March	April-May
164	Solanaceae	Nicotiana plumbaginifolia Viv.	Herb	March-July	August-November
165	Solanaceae	Physalis minima L.	Herb	July-August	September-October
166	Solanaceae	Solanum nigrum L.	Herb	Whole Year	Whole Year
167	Solanaceae	Solanum viarum Dunal	Shrub	Whole Year	Whole Year
168	Tamaricaceae	Tamarix dioica Roxb.ex Roth.	Shrub	February-April	May-August
169	Tiliaceae	Grewia optiva J.R. Drumm.	Tree	Whole Year	Whole Year
170	Tiliaceae	Triumfetta rhomboidea Jacq.	Herb	May-July	October-Decmeber
171	Urticaceae	Boehmeria playtyphnylla D.Don	Herb	August-November	December-January
172	Urticaceae	Urtica ardens Link	Herb	August-September	October-November
173	Urticaceae	Urtica dioica L.	Herb	September-December	January-March
174	Verbenaceae	Lantana camara L.	Shrub	Whole Year	Whole Year
175	Violaceae	Viola canescens Wallich ex Roxb.	Herb	February-April	August-November
176	Zygophyllaceae	Tribulus terrestris L.	Herb	June-August	October-December

3 species each. Apiaceae, Balsaminaceae, Caesalpiniaceae, Chenopodiaceae, Commelinaceae, Convolulaceae, Dioscoreaceae, Hydrocharitaceae, Mimosaceae, Nyctanginaceae, Papaveraaceae and Tiliaceae each had 2 species. The remaining 29 families were monotypic showing the presence of only one species each in the study area.

The largest genus recorded was Ageratum consisting of 4 species, whereas the second largest genus with 3 species each were Cyperus, Euporbia, Sida, Crotalaria and Ranunculus. The genera consisting of 2 species each were Bidens, Gnaphalium, Sonchus, Impatins, Chenopodium, Ipomoea, Dioscorea, Ajuga, Leucas, Argemone, Abrus, Desmodium, Lathyrus, Medicago, Stelaria, Persicaria, Mazus, Linderbergia, Solanum and Urtica. All other genera were monospecific. The habit and periods of flowering and fruiting of macrophytes appear in **Table 1**. There was variation in these periods for different species.

The reservoir ecosystem is a highly integrated ecologically complex system where the role of macrophytes is important in maintaining the ecological balance. During the present investigation the macrophytes growing along the banks of the reservoir were studied. Since the reservoir is newly created, free-floating macrophytes are absent. Aquatic macrophytes play a pivotal role in the primary productivity of a river ecosystem. Bilgrami and Dutta Munshi (1979) observed that biomass was directly related to productivity. They also observed that biomass was maximum at the centre where primary productivity was greater and it was maximum where productivity was lower. The sampling of macrophytes was year round to record macrophytes of all seasons. Comparatively, fewer macrophytes appeared in July and August with thinner growth; most appeared in December and January (Table 1).

The successful growth and distribution of the important macrophyte species which are distributed regularly throughout the year may be attributed to a number of interacting physico-chemical characters of water and sediments. The effect of seasonality and plant diversity on the productivity of some freshwater macrophytes has been established by DeBusk et al. (1981). They described that productivity of some macrophytes increased with more plant diversity and during the months showing maximum litter. Fitzsimons and Vallejos (1986) recorded the growth of water hyacinth, Eichhornia crassipes in middle Parana River, Argentina. In a stream field experiment, McKie et al. (2009) showed that pollutants and other environmental perturbations and species richness affected the development of aquatic macrophytes in lakes; more the environmental perturbations and species richness, more is the growth and productivity of aquatic maceophytes. The litter decomposition in a stream increased with the increase in functional leaf traits and biodiversity (Schindler and Gessner 2009). Lakes and reservoirs show high decomposition of organic matter and release of carbon dioxide and methane into the atmosphere causing regulation of carbon cycling and climate of ecosystems (Tranvik et al. 2009).

The present reservoir is a newly formed one; therefore, biomass accumulation is still in the initial stage. After accumulation and degradation of biomass in coming decades, macrophytes, particularly submerged, rooted and freefloating ones, may start to grow on it.

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