Nepalese Journal of Biosciences **5(1): 31-38 (2015)** https://doi.org/10.3126/njbs.v5i1.41728

Wetland vegetation of Biratnagar, Nepal

Bhabindra Niroula and Sasinath Jha
Department of Botany, Post Graduate Campus, Tribhuvan University
Biratnagar, Nepal
E-mail: niroulab@ gmail.com

Abstract

In total, 128 species of aquatic macrophytes (angiosperms 120, pteridophytes 6, bryophyte 1 and alga 1) were recorded among which 37 species were helophytes, 35 tenagophytes, 37 hyperhydates, 6 epihydates, 5 vittates, 1 rosulate and 5 pleustophytes on the basis of growth form. Based on the frequency of occurrence 2% were abundant, 12% frequent, 76% occasional and 10% scarce. Seven macrophyte communities were recorded on the basis of habitat. These were: 1. deep water submerged associes; 2. shallow water submerged associes; 3. Floating- leaf form associes; 4. free floating-leaf form associes; 5. Amphibious-marsh associes; 6. moist meadow associes; and 7. dry mud associes.

Key words: Aquatic macrophytes, growth forms, use potential

Introduction

Wetlands have high ecological, socio-economic and cultural significance (Mitsch and Gosselink 2000). They harbor different species of flora and fauna and many ethnic groups are dependent on wetlands for their livelihoods. Nepal's wetlands are continuously being lost to agriculture, human settlement and urbanization as well as from water pollution by domestic sewage, industrial effluents and agricultural runoffs. Growing environmental pollution has caused eutrophication of many ponds, lakes and rivers (GON, 2014). These are the most threatened ecosystems and are disappearing at an alarming rate because of poor understanding of their values (IUCN/ Nepal 1992). As the wetland vegetation is the essential components of aquatic ecosystems, status and wealth of information is inevitable for wetland restoration.

Biratnagar township (lat N 26^0 20', long E 87^0 16'; alt 72 m msl) is a part of the Indo-Gangetic flood plain. It has alluvial soil and tropical monsoonic climate with average annual rainfall 1348 mm and average annual air temperature 22 ºC. It is bordered by Keshaliya river in the west and Singhia river in the east and possesses several derelict depressions usually inundated during rainy season. Besides these perennial water bodies it has numerous seasonal wetlands such as irrigational canals, ditches along the roadsides, manmade ponds and deep water paddy fields. The present study aims to highlight the species composition, growth forms, communities, and human use potential of wetland macrophytic flora of Biratnagar township.

Materials and Methods

Wetland vegetation of Biratnagar was observed for two years from January 2011 to December 2012. The specimens of the aquatic macrophytes were collected manually at monthly intervals. They were recorded, tagged and pressed to prepare herbaria. The plants were identified as per Hooker (1872-1897), Cook (1996) and Siwakoti and Varma (1999). The identified specimens were confirmed by making crosschecks with the specimens housed at the herbarium Centre, University Department of Botany, T.M. Bhagalpur University, Bhagalpur, India. The specimens are deposited at Regional Herbarium Centre, Post Graduate Campus, T.U., Biratnagar, Nepal.

The nomenclature of plants is based on Hara *et al.* (1978-1982) and Press *et al.* (2000). Growth form categories of the plants were determined as per Cook (1996). The frequency of occurrence of each species was recorded as abundant (++++), frequent (+++), occasional (++) and scarce (+) on the visual basis. Uses of the plants were determined either through interviews with local people or with the help of standard literature (Anonymous 1948-1976, Banerjee 1995, Bala and Mukherjee, 2007, GON 2007). Growth form categories of the plants were determined as per Cook (1996) as follows:

A. Plants not physiologically bound to water but tolerating longer periods of submergence: **Helophytes**
B. Plants physiologically bound to water at least part of the generative cycle:
1. Plants with the juvenile phase submerged in or floating on water and the adult phase (flowering) phase terrestrial: **Tenagophytes**
2. Plants rooted in the substrate with all photosynthetic parts submerged:
(a) Leaves borne in rosette: **Rosulate**
(b) Leaves arranged along elongated stems: **Vittates**
3. Plants with photosynthetic parts in contact with air:
(a) Plants free floating on the surface, not attached to or penetrating the substrate: **Pleustophytes**
(b) (b) Plants with roots penetrating the substrate:
(i) Leaves and/or stems floating on but not arising above water surface: **Epihydates**
(ii) Leaves and / or stems emerging above the water surface: **Hyperhydates**

Results and Discussion

Species composition: The aquatic macrophytes showed diversity in floristic composition. Altogether 128 species of aquatic macrophytes with 92 genera belonging to 45 families were recorded from the wetlands of Biratnagar township. They comprised 120 species of angiosperms (dicots 54 and monocots 66); pteridophyte 6, bryophyte 1 and macroalga 1 (Table 1). Among the families of angiosperms, the dominant ones in number of species included: poaceae (27), Cyperaceae (17), Asteraceae (9), Polygonaceae (6), Lythraceae and Scrophulariaceae (4), amaranthaceae, Apiaceae, Araceae, Commelinaceae and Pontederiaceae (3). The dominance of grasses and sedges corresponded with the findings of Dangol *et al.* (1986), Shrestha (1996) and Niroula and Singh (2011). The dominance of monocots over dicots by species count but reverse case by number of families approached the study of Satyanarayan (1962) Shrestha (1996), and Niroula and Singh (2011). Seventy-six percent plant species were occasional, 12% frequent, 10% scarce and 2% abundant in occurrence. *Colocasia esculenta*, *Eichhornia crassipes* and *Oryza sativa* were abundant while *Aeschynemone asper*, *Ammania auriculata*, *Cyperus pilosus*, *Leptochloa chinensis*, *Schoenoplectus juncoides*, *Smithia ciliata* and *Utricularia exoleta* were scarce aquatic macrophytes.

Table 1. Taxonomic composition of wetland macrophytes.

Taxa	Macroalgae	Bryophyta	Pteridophyta	Dicotyledonae	Monocotyledonae	Total
Families	1	1	6	23	14	45
Genera	1	1	6	39	45	92
Species	1	1	6	54	66	128

Growth forms: Seven growth forms of aquatic macrophytes were recorded in wetland areas of Biratnagar township. Number of species in each growth forms were: helophytes (37) = hyperhydates (37) > tenagophytes (35) > epihydates (7) > vittates (6) > pleustophytes (5) >

rosulates (1). Emergents (helophytes, tenagophytes, and hyperhydates) had the highest contribution in comparison to submerged (vittates, rosulates), rooted floating – leaved (epihydates), and free – floating (pleustophytes) species. Percentage contribution of seven growth forms of macrophytic vegetation at Biratnagar township is shown in figure 1. Upadhyay *et al.* 2011 recorded four growth form categories: emergent (13), floating leaved (6), free floating (5) and submerged (4) from the selected wetland habitats of Biratnagar township. In the present work there was also a general decreasing trend in diversity of aquatic macrophytes from shore line to the centre of the water bodies. The dominance of emergents can be attributed to the edge effect of ecotone (Odum, 1971).

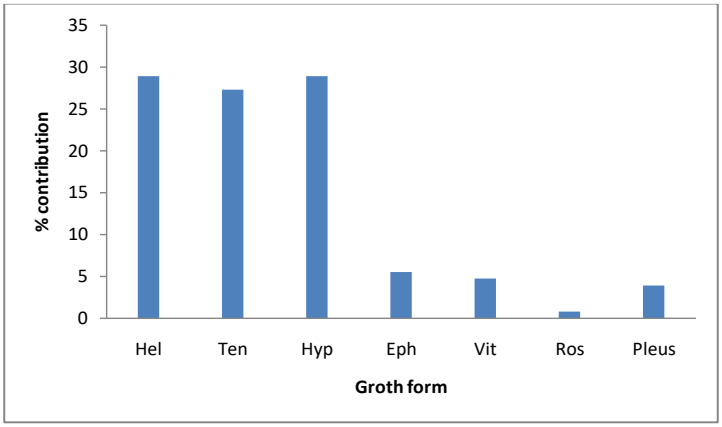

Figure 1. Growth forms distribution of wetland vegetation in the study area.

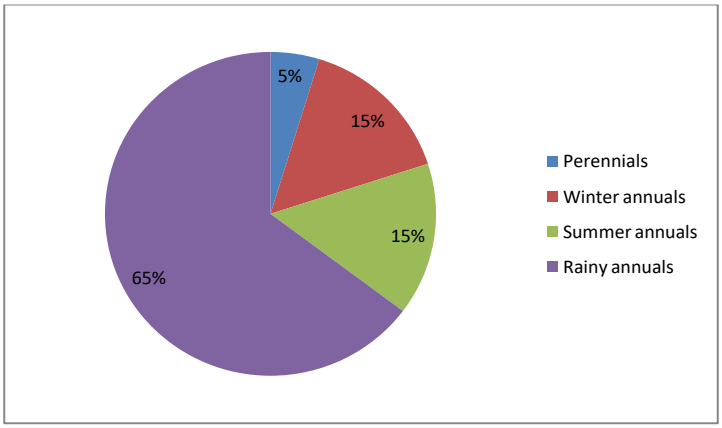

Figure 2. Habits of aquatic macrophytes in the study area.

Seasonal distribution: There was seasonal variation in the occurrence of different growth forms and species composition. Helophytes, tenagophytes and hyperhydates (mostly grasses and sedges); epihydates and rosulates were dominant in the rainy season. Most pleustophytes (free floating) *Azolla imbricata*, *Lemna aequinoctialis*, *Spirodella polyrhiza* and *Pistia stratioites*); few tenagophytes (*Hygrophila polysperma*, *Rumex dentatus*, *Sagittaria trifolia* and *Veronica anagallis-aquatica*);

hyperhydate (*Ranunculus scleratus*) and vittates (*Chara schweinitzii*, *Utricularia* spp.) were the common winter species. Dominant aquatic macrophytes of summer season were: *Alternanthera philoxeroides*, *Marsilea minuta*, *Monochoria hastata*, *Oenanthe javanica*, *Panicum psilopodium*, *Sacciolepis interrupta* (hyperhydates); *Colocasia esculenta*, *Hemarthra compressa*, *Polygonum barbatum*, *Spilanthes iabadicensis* (tenagophytes) and *Potamogeton crispus* (vittate). *Acorus calamus*, *Arundinella benghalensis*, *Canna indica*, *Colocasia esculenta*, *Crinum asiaticum*, *Saccharum spontaneum*, *Typha angustifolia*, *T. elephantina*, *Vetiveria zizanoides* were perennial aquatic macrophytes. Percentage occurrence of winter, summer, rainy annuals and perennial aquatic macrophytes are given in fig 2.

Association of macrophytic communities: Wetland vegetation was characterized into following communities as per their habitat conditions.

1. Deep water submerged associes (vittates): *Hydrilla verticillata*, *Ottelia alismoides*.
   Habitat: Depth and turbidity of water affecting the penetration of light, a silty substratum and little biotic disturbance.
2. Shallow water submerged associes (vittates): *Chara schweinitzii*, *Potamogeton crispus*.
   Habitat: a hard bottomed clayey/silty substratum with transparent shallow water depth.
3. Floating – leaf form associes (epihydates): *Nymphaea pubescens*, *Sagittaria guyanensis*, *Ipomoea aquatica*.
   Habitat: minimum biotic disturbance, very gradual change in the level of water and a substratum of loose mud.
4. Free floating – leaf form associes (pleustophytes): *Azolla imbricata*, *Lemna minor*, *Spirodela polyrhiza*, *Pistia stratiotes*, *Eichhornia crassipes*.
   Habitat: minimum water disturbances, shallow to deep stagnant water at winter season and substratum of a loose mud.
5. Amphibious – marsh associes (helophytes, tenagophytes and hyperhydates):
   (a) *Typha angustifolia* and *Cyperus* spp. in the permanent clayey/silty bottomed permanent waters.
   (b) *Alternanthera philoxeroides, A. sessilis*, *Echinocloa colona*, *Marsilea minuta* in the temporary waters.
   (c) *Hygrophila auriculata*, *Eleocharis acutangula*, *Cyperus esculentus*, *Fimbristylis miliacea* etc. on a clayey substratum.
   (d) *Paspalidium punctatum*, *Sacciolepis interrupta*, *Ludwigia perennis*, *Arundinella bengalensis*, *Polygonum* spp. inundated for a long period and a substratum of an organic brown mud and stiff clay.
   (e) *Ranunculus scleratus*, *Rumex dentatus* sometimes *Veronica anagallis-aquatica*, loose bottomed organic clayey soil with gradual decreasing water levels.
6. Moist meadow associes (helophytes, tenagophytes): *Cynodon dactylon*, *Panicum psilopodium*, *Paspalum scrobiculatum*, *Cyperus iria*.
   Habitat: gradually slopping moist substratum.
7. Dry mud associes (helophytes): *Polygonum plebeium*, *Grangea maderaspatana*, *Sphaeranthus indicus*, *Cotula hemisphaerica*, *Gnaphalium polycaulon*.
   Habitat: drying clay, moderate grazing.

Macrophytic communities with their associes in the wetlands of Biratnagar were in agreement with Misra (1976) in the Varanasi on the bank of river Ganga.

Uses of aquatic plants: Aquatic macrophytes were observed to be useful in the local socio-economy, religion, culture, and ecology. Use category of wetland plants occurring at Biratnagar township is given in Table 2. They were observed to play substantial roles are as: feed for livestock (41 species), edible/pot herb (23 species), fish poison (2 species), green manure/compost (10 species), genetic resource breeding stock (3 species), handicrafts/thatch and cordage (9 species), insecticides (3 species), medicinal (30 species), and religious (5

species). Other uses included: dyes-*Eclipta prostrata, Polygonum hydropiper*; aquarium plant-*Ceratophyllum demersum, Hydrilla verticillata*; spawning/nesting habitats and feed for aquatic invertebrates/waterfowls - *Nymphaea pubescens*, *Nymphoides* spp., *Potamogeton crispus*, *Saccharum spontaneum* ; fire wood/hedge plant-*Ipomoea carnea*.

In genral, native aquatic flora is being outcompeted by invasive alien species such as *E. crassipes, A. philoxeroides, I carnea* ssp. *fistulosa, M. micrantha* and P. *stratiotes.* On the other hand, wetlands are disappearing at an alarming rate due to unplanned development of the township.

Table 2. List of aquatic macrophytes of Biratnagar with growth forms, frequency of occurrence

S,N	Growth form/species	Family	Freq.	Uses
	Helophytes			
1.	*Alternanthera paronychioides* St. Hil	Amaranthaceae	++	-
2.	*A.sessilis* (L.) DC.	Amaranthaceae	++	F
3.	*Ammania baccifera* L.	Lythraceae	++	-
4.	*Caesulia axillaris* Roxb.	Asteraceae	++	M
5.	*Centella asiatica* (L.) Urb.	Apiaceae	++	M
6.	*Coix lacryma-jobi* L.	Poaceae	+	M
7.	*Commelina benghalensis* L.	Commelinaceae	+++	M
8.	*C. paludosa* Blume	Commelinaceae	+	F
9.	*Cotula hemispherica* (Roxb.) Wall. ex C. B. Clarke	Asteraceae	++	C
10.	*Crinum asiaticum* L.	Amarylidaceae	++	-
11.	*Cynodon dactylon* (L.) Pers.	Poaceae	+++	M/FO
12.	*Cyperus compressus* L.	Cyperaceae	++	FO
13.	*C. iria* L.	Cyperaceae	+++	FO/M
14.	*Diplazium esculentum* (Retz.) Sw	Athyriaceae	++	F
15.	*Eclipta prostrata* (L.) L.	Asteraceae	++	F/M/R
16.	*Eqisetum diffusum* D. Don	Equisetaceae	++	M
17.	*Eragrostis unioloides* (Retz.) Nees ex Steudel	Poaceae	++	FO
18.	*Gnaphalium polycaulon* Pers.	Asteraceae	++	-
19.	*Grangea maderaspatana* (L.) Poiret	Asteraceae	++	C
20.	*Hydrocotyle sibthorpioides* Lam.	Apiaceae	+	-
21.	*Ischaemum rugosum* Salisb.	Poaceae	++	FO
22.	*Kyllinga brevifolia* Rottb.	Cyperaceae	+++	FO
23.	*Lindernia antipoda* (L.) Alston	Scrophulariaceae	++	-
24.	*L. ciliata* (Colsm.) Pennell	Scrophulariaceae	++	F
25.	*L. crustacea* (L.) F. Muell.	Scrophulariaceae	++	-
26.	*Lippia nodiflora* (L.) Rich.	Verbenaceae	++	F/M
27.	*Meniscium proliferum* (Retz.) Sw	Thelypteridaceae	++	-
28.	*Mikania micrantha* Kunth	Asteraceae	+++	-
29.	*Murdania nudiflora* (L.) Brenan	Commelinaceae	++	FO
30.	*M. vaginata* (L.) Brueckns	Commelinaceae	+	FO
31.	*Oxystelma esculentum* (L. f.) Sm. Hara	Asclepiadaceae	++	M
32.	*Polygonum. plebeium* R. Br.	Polygonaceae	++	M
33.	*Rorippa benghalensis* (DC.) Hara	Brassicaceae	++	-
34.	*Saccharum spontaneum* L.	Poaceae	++	FO/GR/M

35.	*Setaria pallidefusca* (Schumach.) Stapf & C. E. Hubbard	Poaceae	++	FO
36.	*Sphaeranthus indicus* L.	Asteraceae	++	M/IN
37.	*Typha. elephantina* Roxb.	Typhaceae	+	HC
	Tenagophytees			
1.	*Acorus calamus* L.	Araceae	++	M/IN
2.	*Aeschynemone asper* L.	Fabaceae	+	HC
3.	*Ammania auriculata* Willd.	Lythraceae	+	FO
4.	*Canna indica* L.	Cannaceae	++	FO
5.	*Ceratopteris thalictroides* Brongn	Parkeriaceae	++	F
6.	*Colocasia esculenta* (L.) Schott	Araceae	++++	FO
7.	*Cyperus corymbosus* Rottb.	Cyperaceae	+	HC
8.	*C. differmis* L.	Cyperaceae	++	-
9.	*Echinochloa colona* (L.) Link	Poaceae	++	FO
10.	*E. stagnina* (Retz.) Nees ex Steudel	Poaceae	++	FO
11.	*Fimbristylis littoralis* Gaud.	Cyperaceae	++	FO
12.	*F. miliacea* (L.) Vahl	Cyperaceae	++	FO
13.	*F. schoenoides* (Retz.) Vahl	Cyperaceae	+	FO
14.	*Floscopa scandens* Lour.	Commelinaceae	++	FO
15.	*Hemarthria compressa* (L. f.) R. Br.	Poaceae	++	FO
16.	*Hygrophila polysperma* (Roxb.) T. Anders	Acanthaceae	++	-
17.	*Isachne dispar* Trin.	Poaceae	++	FO
18.	*Leptochloa chinensis* (L.) Nees	Poaceae	+	FO
19.	*Ludwigia perennis* L.	Onagraceae	+++	M
20.	*Marchantia palmata* Nees	Marchantiaceae	++	Soil binder
21.	*Mariscus compactus* (Retz.) Druce	Cyperaceae	++	-
22.	*Melochia corchorifolia* L.	Sterculiaceae	++	-
23.	*Paspalum scrobiculatum* L.	Poaceae	++	FO/M
24.	Polygonum barbatum (L.) Hara	Polygonaceae	++	M
25.	*Polygonum hydropiper* L.	Polygonaceae	+++	FP
26.	*Rotala indica* (Willd.) Koehne	Lythraceae	++	-
27.	*R. rotundifolia* (Buch.-Ham. ex Roxb.) Koehne	Lythraceae	++	-
28.	*Rumex dentatus* L.	Polygonaceae	+++	C
29.	*Sagittaria trifolia* L.	Alismataceae	++	F
30.	*Scleria parvula* Steudel	Cyperaceae	++	FO
31.	*Smithia ciliata* Royle	Fabaceae	+	FO
32.	*Sphenoclea zeylanica* Gaertn.	Sphenocleaceae	++	F
33.	*Spilanthes iabadicensis* A. H. Moore	Asteraceae	++	M
34.	*Veronica anagallis-aquatica* L.	Scrophulariaceae	++	-
35.	*Vetiveria zizanioides* (L.) Nash	Poaceae	++	HC/FO
	Hyperhydates			
1.	*Alternanthera philoxeroides* Griseb	Amaranthaceae	+++	C/F
2.	*Arundinella bengalensis* (Sprengel) Druce	Poaceae	++	FO
3.	*A. nepalensis* Trin.	Poaceae	++	FO
4.	*Brachiaria mutica* (Forsskal) Stapf	Poaceae	++	FO
5.	*Butomopsis latifolia* (D. Don) Kunth	Butomaceae	++	-
6.	*Cyperus esculentus* L.	Cyperaceae	++	HC

7.	*C. pilosus* Vahl	Cyperaceae	+	-
8.	*Echinochloa crus-galli* (L.) Beauvois	Poaceae	++	FO
9.	*Eleocharis acutangula* (Roxb.) Schultes	Cyperaceae	++	FO
10.	*E. atropurpurea* (Retz.) Kunth	Cyperaceae	++	FO
11.	*Eriocaulon cinereum* R. Br.	Eriocaulaceae	++	FO
12.	*Hydrolea zeylanica* (L.) Vahl	Hydrophyllaceae	++	-
13.	*Hygrophila auriculata* (Schumach.) Heine	Acanthaceae	+++	M
14.	*Hymenachne pseudointerrupta* C. Mueller	Poaceae	++	M
15.	*Ipomoea carnea* Jacq.subsp. *fistulosa* (Mart. ex Choisy) D. F. Austin	Convolvulaceae	+++	FO
16.	*Leersia hexandra* Swartz.	Poaceae	++	FW/H/IN
17.	*Ludwigia octovalvis* (Jacq.) Raven	Onagraceae	++	FO/GR
18.	*Marsilea minuta* L.	Marsileaceae	++	-
19.	*Monochoria hastata* (L.) Solms.	Pontederiaceae	++	F
20.	*M. vaginalis* (Brum.) Kunth	Pontederiaceae	++	C
21.	*Oenanthe javanica* (Blume) DC.	Apiaceae	++	M
22.	*Oryza rufipogon* Griff.	Poaceae	+	F
23.	*O. sativa L.*	Poaceae	+++++	FO/GR
24.	*Panicum paludosum* Roxb.	Poaceae	+	FO
25.	*P. psilopodium* Trin.	Poaceae	++	F/FO
26.	*Paspalidium punctatum* (Brum.) A. Camus	Poaceae	+++	FO
27.	*Paspalum distichum* L.	Poaceae	++	FO
28.	*Polygonum glabrum* Willd.	Polygonaceae	++	FO
29.	*P. lapathifolium* L.	Polygonaceae	+	FO
30.	*Ranunculus scleratus* L.	Ranunculaceae	++	FP
31.	*Rorippa nasturtium-aquaticum* (L.) Hayek.	Brassicaceae	++	FP
32.	*Sacciolepis indica* (L.) Chase	Poaceae	++	M
33.	*S. interrupta* (Willd.) Stapf	Poaceae	++	F
34.	*Schoenoplectus grossus* (L. f.) Palla	Cyperaceae	++	FO
35.	*S. juncoides* (Roxb.) Palla	Cyperaceae	++	FO
36.	*S. mucronatus* (L.) Palla	Cyperaceae	+	F/HC
37.	*Typha angustifolia* L.	Typhaceae	++	HC
	Epihydates		++	HC
1.	*Euryle ferox* Salisb.	Nympheaceae	++	HC
2.	*Ipomoea aquatica* Forssk.	Convolvulaceae	++	F/R
3.	*Ludwigia adscendens* (L.) Hara	Onagraceae	++	F
4.	*Nymphaea pubescens* Willd.	Nympheaceae	++	-
5.	*Nymphoides hydrophyllum* (Lour.) Kuntze	Gentianaceae	++	F/R
6.	*Sagittaria guyanensis* Kunth	Alismataceae	++	M
7.	*Trapa natans* var. *bispinosa* (Roxb.) Makinno	Trapaceae	++	F
	Vittates			
1.	*Ceratophyllum demersum* L.	Ceratophyllaceae	++	F/R
2.	*Chara schweinitzii* A. Braun	Characeae	++	M
3.	*Hydrilla verticillata* (L. f.) Royle	Hydrocharitaceae	++	IN
4.	*Potamogeton crispus* L.	Potamogetonaceae	++	C
5.	*Utricularia aurea* Lour.	Lentibulariaceae	++	M
6.	*U. exoleta* R. Br.	Lentibulariaceae	+	M

	Rosulates			
1.	*Ottelia alismoides* (L.) Pers.	Hydrocharitaceae	++	F/M
	Pleustophytes			
1.	*Azolla imbricata* (Roxb.) Nakai	Azollaceae	+++	C/FO
2.	*Eichhornia crassipes* (Mart.) Solms.	Pontederiaceae	++++	C
3.	*Lemna minor* L.	Lemnaceae	+++	M
4.	*Pistia stratiotes* L.	Araceae	+++	C/M
5.	*Spirodela polyrhiza* (L.) Schleiden	Lemnaceae	+++	C

(++++ = abundant, +++ = frequent, ++ = occasional, + = scarce) and uses (C = compost, F = food, FO = fodder, FP = fish poison, FW= fire wood, GR = genetic resource, HC = handicraft, M = medicinal, R = religious, IN =insecticidal).

Acknowledgements

We are thankful to the Head, Department of Botany, Post Graduate Campus, T.U. Biratnagar, Nepal for lab facilities. One of the authors (BN) is grateful to the Tribhuvan University for the Ph.D. study leave and the University Grants Commission, Nepal for the research fellowship.

References

Anonymous (1948 – 1976): *Wealth of India: raw materials* (I-X), CSIR, New Delhi.

Bala, G. and A. Mukherjee (2007): Useful plants of wetlands in Nadia district, West Bengal. *Geobios* **34 (4):** 253 - 256.

Banerjee, M. L. (1995): Some edible and medicinal plants from east Nepal. *J. Bomb. Nat. Hist.Soc.* **53:** 153 - 155.

Cook, C.D.K. (1996): *Aquatic and wetland plants of India*. Oxford University Press, Oxford-New York-Delhi.

Dangol, D.R., S.B. Gurung and I. Bhattarai (1986): Lowland rice weeds at the Agronomy Farm, IAAS, Rampur, Chitwan, Nepal. *J. Inst. Agric. Anim. Sc*. **7:** 01-12.

GON (2014): Nepal National Biodiversity Strategy and Action Plan 2014-2020. Government of Nepal, Ministry of Forests and Soil Conservation, Singhadurbar, Kathmandu, Nepal.

GON(2007). *Medicinal plants of Nepal*. Government of Nepal, Ministry of Forests and Soil Conservation Department Plant Resources, Thapathali, Kathmandu, Nepal.

Hara, H. and L.H. Williams (1979): *An enumeration of the flowering plans of Nepal* Vol. 2. British Museum (Nat. Hist.), London.

Hara, H., A.O. Chater and L.H. Williams (1982): *An enumeration of the flowering plants of Nepal* Vol.3. British Museum (Nat. Hist.), London.

Hara, H.W., T. Stearn and L.H. Williams. 1978. *An enumeration of the flowering plants of Nepal* Vol. 1.British Museum (Nat. Hist.), London.

Hooker, J.D. (1872-1897): *The flora of British India,* 7 volumes L. Reeve, London.

IUCN/Nepal (1992). *Wetlands management programme*. A project Document. IUCN/ Nepal.

Misra, R. (1976): Seasonal dynamics and aquatic weeds of the lowlying lands of the mid- Ganga plains. In: *Aquatic weeds in South East Asia.* (eds.) C.K. Varshney and J. Rzoska, R. W. Junk, Hague. pp. 103-106.

Mitsch, W. J. and J. G. Gosselink (2000): *Wetlands.* John Wiley and Sons, Inc. New York, Chichester, Weinhelm, Brisbane, Singapore, Toronto.

Niroula, B. and K.L.B. Singh. 2010. Contribution to aquatic macrophytes of Biratnagar and adjoining areas, eastern Nepal. *Ecoprint* **17:** 23-34.

Press, J.R., K.K. Shrestha and D.A. Sutton (2000): *Annonated checklist of the flowering plants of Nepal.* The Natural History Museum, London.

Siwakoti, M.and S.K. Varma (1999): *Plant diversity of eastern Nepal*/*Flora of plains of eastern Nepal*. Bishen Singh Mahendra Pal Singh. Dehra Dun (India). P. 491.

Upadhyay, B.P., S. Jha, U. Koirala and B. Niroula (2011): Inventory of ten auatic habitats of Biratnagar township, Nepal. *GEOBIOS* **38:** 283-288.