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Distribution of macrophytes in urban traditional water reservoirs of Imphal (Manipur), India

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Abstract

The paper reports on the macrophyte’s composition and their phytosociological aspects in Imphal's urban traditional water reservoirs. The vegetation types are described and floristically characterized. It is observed that all the macrophytic species occurred in intermixed mats of submerged, free-floating, rooted with floating leaves and marginal, amphibious groups and not in clear-cut zones of the above groups. These observed species were classified into five categories depending on their growing habits.

A totally submerged *Utricularia* and an emergent *Alternanthera*, *Jussiaea*, and *Echinochloa*, were recorded from the marginal regions of the TWRs. Only one species, *Alternanthera* was common in all three study sites. Six other species (*Echinochola stagnina*, *Eichhornia*, *Hydrilla verticillata*, *Salvinia cucullata*, *Pistia stratiotes*, and *Lemna perpusilla* were recorded in two sites, and the rest five (*Nymphoides*, *Jussiaea repens*, *Echinochola colonum*, *Utricularia*, and *Azolla pinnata*) were found in one site only. Four types of life forms are documented amongst the 12 macrophytic species based on the position and degree of protection to perennating organs during the adverse season. Similarly, there is a total of 8 types of growth forms. In all, the percentage composition of different life forms of macrophytes is given as the errant vascular hydrophytes contributed (50%) to the total macrophytes, followed by therophytes (33.3%), and geophytes and hemicrytophytes with (8.3%) respectively. Finally, aquatic macrophytes indicate the mechanisms behind community shifts that is of considerable importance in the management and the establishment of good ecological status for urban TWRs and other community ponds and its services.

Keywords:-Phytosociology, aquatic, macrophytes, TWRs, life forms, growth forms.

Introduction

Imphal is the central valley of Manipur state. Geographically, Imphal is located at an elevation of 800 m. above the mean sea level, between $93^{\circ}\,01'\,48''$ E and $94^{\circ}\,46'\,04''$ E longitude and $23^{\circ}\,49'\,48''$ N and $25^{\circ}\,40'\,48''$ N latitude (**fig.1**). Mean temperature in the area varies from 5.3°C to 29.5°C and average annual rainfall ranges from 1250 mm to 2700mm. The climate in the western part of the state is tropical, whereas the rest of the state observes a sub-tropical climate with distinct summer, winter, and rainy seasons. Historically, many canals and water reservoirs were dug out at many places for irrigation purposes as well as for community use during the reign of King Khagemba (1629-30 A.D.). Many traditional water reservoirs (TWRs) were also dug out for socio-cultural activities like the boat race festival (Heikru-Hidongba) and Lai- Loukhatpa (Sanctity of God and Goddess). This festival is performed annually to bring prosperity to the state. Water from traditional water reservoirs is served as Holy water for the celebration of traditional God and Goddess (Local deity). The unique lifestyles and traditions of the local human population have also made it one of the primary tourist destinations in Imphal. Three urban traditional water reservoirs (TWRs) are undertaken as study sites for the investigation of macrophytic vegetational composition at monthly intervals for one year before their complete embankment. It comprises the floristic composition and life form analysis of the plants. Hence, phytosociological studies are necessary for the proper understanding of the structure and dynamics of vegetation (Ambasht, 1990).

Aquatic plants those who are photosynthetically active parts remain permanently or at least for several months each year submerged in water or floating onto the water's surface (Singh, 2006). In general, these represent plants that are found in and around the water bodies.

The aquatic plant community or macrophytes comprises a diverse group of macrophytic organisms including angiosperms, ferns, mosses, liverworts, and some freshwater macroalgae that occur seasonally or in permanently wet environments. Aquatic macrophytes are also indicators of pollution and nutrient level. Submerged macrophytes play a key role in the ecology of shallow, alkaline, clear water, lakes, where they form an extensive and diverse littoral community with numerous associated invertebrates, fish, and birds (Jeppesen *et al.*, 1998), while the cover and biomass of submerged macrophytes and their role in lake metabolism are largely predictable from the lake area, basic configuration, and nutrient loading (Gasith and Hoyer, 1998).

Further, they play an important role in the structuring and functioning of aquatic freshwater systems (Jeppesen et al., 1998; Timms and Moss, 1984; James and Barko, 1994) and are especially important for in-lake nutrient cycling and for stabilizing a clear water state in nutrient-rich lakes (Phillips et al., 1978; Scheffer et al., 1993). In shallow lakes, the submerged macrophytes can suppress algal growth and enhance water clarity through a number of mechanisms, including nutrient competition (Phillips et al., 1978) or the release of allelopathic substances toxic to algae (Gross et al., 2007).

Recently, a few studies including phytoplankton and aquatic macrophyte composition and abundance have been conducted in some lakes and reservoirs in Myanmar (Ballot et al., 2020; Mjelde et al., 2021; Mjelde and Ballot, 2016; Mjelde et al., 2018). The present investigation was, therefore, undertaken to study the species composition and vegetation analysis along their phytosociological aspects of different aquatic macrophytes in the urban TWRs.

Materials and Methods

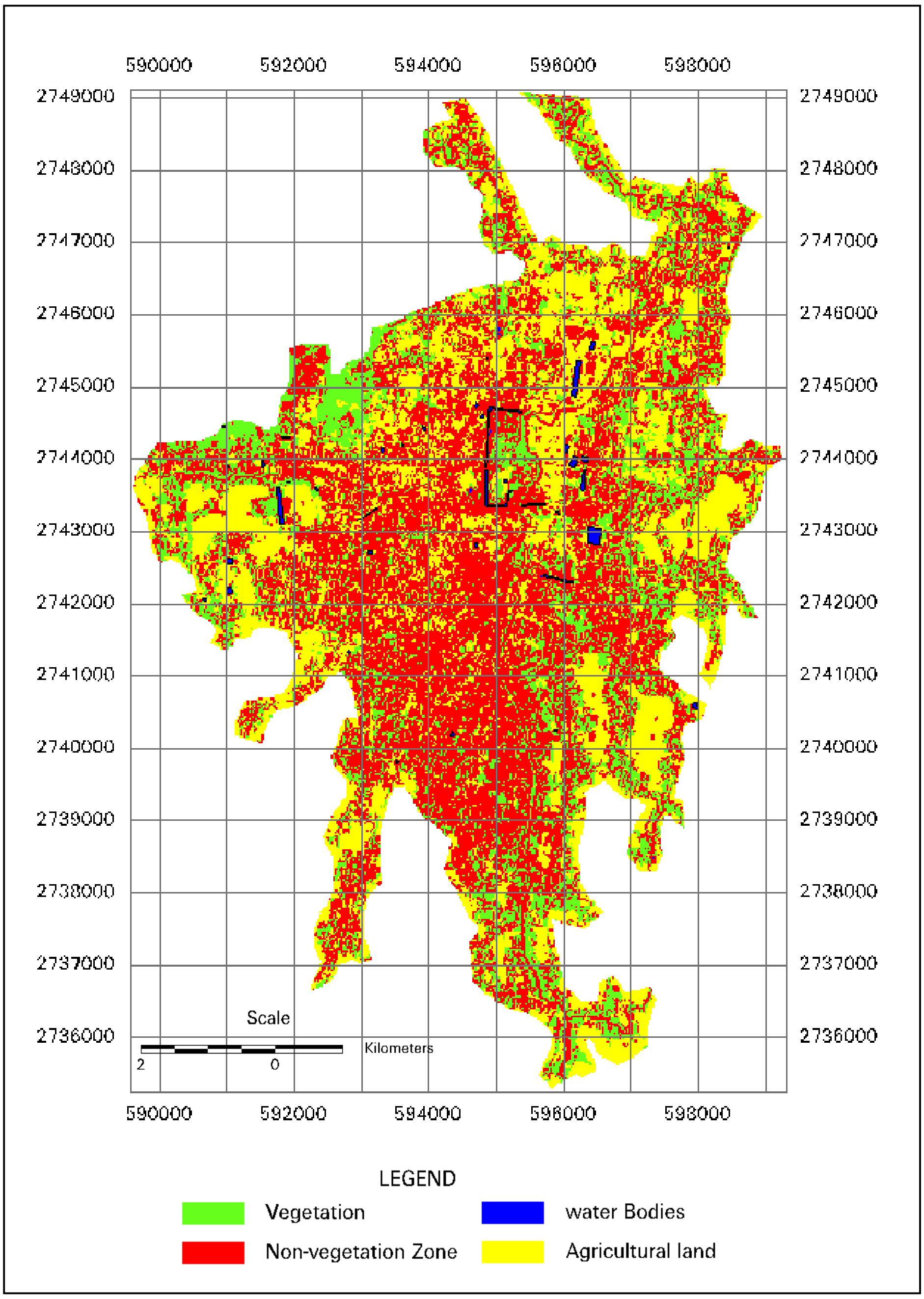
The three urban TWRs chosen for the study are unique and are located at the heart of Imphal city, close to public places, and characterized by anthropogenic impact. These TWRs are utilised for meeting the water requirement of the population in the vicinity during water scarcity. The monthly survey was done by the quadrat method for exploring the distribution of aquatic macrophytes.

A satellite map of study sites (TWRs) was generated from IRS-IC LISS III, 2003 data and presented in **fig 2.**

The site I Kanglapat is located at the center of the city and sandwiched by the Imphal and Nambul rivers. Geographically, located between 24° 48′ 51.64″ N and 93° 56′ 21.66″ E. The approximate area covered by site –I is 60,532 m^2 (IRS-IC LISS III, Dec.2003). The mean depth of this study site is 164 cm. The local population that depends on this water reservoir is approximately 15,000 people. Site II,

Bijoy Govinda Thangapat is situated 2 kilometers southwest of Kanglapat, covering an area of 3,674 m^2 (IRS-IC LISS III, 2003) and a mean depth of 151 cm. It is located between 24° 48′ 3.44″ N and 93° 55′ 11.24″ E. Approximately 14,000 people depend on this site. The third site, **Wangkhei Thangapat** is situated 2 kilometers from south-east Kanglapat and located between 24° 47′ 38.93″ N and 93° 56′ 46.10″ E. It has an area of 9,923 m^2 (IRS-IC LISS III, 2003). The mean depth of this site is 130cm and about 8353 people inhabit this area.

Figure 1: Map of Imphal Valley for Urban Macrophyte Distribution



DATA SOURCE: IRS LIS III (2003), IRS PAN, SOI Toposheet

MAP PROJECTION: UTM, Zone 46SPHEROID: WGS84

DATUM: WGS84UNIT: METERS

Figure 2.: Map showing the land use land cover of the study area.

Results and Discussion

In the present study, it is observed that all the macrophytic species occurred in intermixed mats of submerged, free-floating, rooted with floating leaves and marginal, amphibious groups and not in clear-cut zones of the above groups. Overall, there were 12 species belonging to various plant groups with seven dicotyledonous species and three monocotyledons. Two species of Pteridophytes (*Azolla, and Salvinia*) were also recorded. But, all three sites were different in a number of species. Site-I of TWRs possessed 8 species, Site-II recorded 5 species and Site-III had 7 species. Out of the total 12 macrophytic species recorded in all three study sites, family Salviniaceae and Poaceae contributed 2 species each while families Amaranthaceae, Pontenderiaceae, Hydrocharitaceae, Onagraceae, Nymphaeceae, Utriculariaceae, Araceae and Lemnaceae contributed one species each. These observed species were classified into five categories depending on their growing habits. *Nymphoides indicum* is a rooted plant with floating leaves, whereas *Salvinia, Azolla, Pistia, Lemna,* and *Eichhornia* are free floating in

nature. A totally submerged *Utricularia* and an emergent *Alternanthera, Jussiaea,* and *Echinochloa*, were recorded from the marginal regions of the TWRs. Only one species, *Alternanthera* was common in all three study sites. Six other species (*Echinochola stagnina, Eichhornia, Hydrilla verticillata, Salvinia cucullata, Pistia stratiotes* and *Lemna perpusilla* were recorded in two sites and the rest five (*Nymphoides, Jussiaea repens, Echinochola colonum, Utricularia,* and *Azolla pinnata*) were found in one site only. (**Table 1**).

The morphological and ecological characteristics of macrophytes recorded in the present study are summarised in table 2.

Four types of life forms are documented amongst the 12 macrophytic species based on the position and degree of protection to perennating organs during the adverse season (Raunkiaer, 1934). They are Therophytes, Errant Vascular Hydrophytes, Geophytes and Hemicryptophytes (**Table 3**). A greater number of species (6) belongs to Errant Vascular Hydrophytes (*Azolla pinnata, Pistia stratiotes, Lemna perpusilla, Salvinia cucullata, Utricularia flexuosa),* whereas Hemicryptophytes and Geophytes were represented only by *Hydrilla* and *Nymphoides* respectively. Growth forms of all the 12 species of macrophytes depending upon the relationship of plants with their substratum have been categorized as per the conditions laid down by Hogeweg and Brenkert (1969). Accordingly, there are total 8 types of growth forms namely Nymphaeids (1 species), Rhizopleustohelophytes (2 species), Helophytes (2 species), Lemneids (2 species), Magnolemnids (2 species), Parvopotamids (1species), Eichhorniids (1 species) and Utriculariids (1 species).

Under the growth form Nymphaeids, only one species was recorded, i.e., *Nymphoides indicum* which are rooted and exhibit submerged forms with floating leaf blades having long petioles. Rhizopleustohelophytes comprises *Alternanthera* and *Jussiaea* only which are represented emergent habitat and the stem of the plants is just below the surface of the water and produce aerial leaves. Helophytes (*Echinochloa colonum, Echinochloa stagnina)* are represented by emergent habitats. Lemneids were represented by 2 species (*Azolla* and *Lemna)* that are free floating and the body cannot be differentiated into leaves and stems. Magnolemnids comprise two species (*Pistia* and *Salvinia)* which are free-floating types having stoloniferous habit forms. Parvopotamids had one species (*Hydrilla)* only which is represented by a submerged form with a long stem and undissected leaves. Eichhorniids is also represented by one species (*Eichhornia crassipes)* and this plant had the habit of free-floating or rooting in soft partly organic bottom sediment, leaves emergent (at least the greater part of leaf and petiole), Stoloniferous rosettes with floating to emerged petiolate leaves. Utriculariids (*utricularia flexuosa)* are also represented by free-floating, never rooting, submerged, finely dissected leaves, and emerged inflorescence.

The percentage composition of different life forms of macrophytes is given in (Table 4). In all,

the errant vascular hydrophytes contributed (50%) to the total macrophytes, followed by

therophytes (33.3%), and geophytes and hemicryptophytes (8.3%) respectively.

Table 1. Macrophytic species and their families in the TWRs of study sites

[+ = Present; – = Absent]

S. No.	Macrophytic Species	Plant Family	Site I	Site II	Site III
1.	*Alternanthera philoxeroides* (Mart) Griseb	Amaranthaceae (Dicot)	+	+	+
2.	*Azolla pinnata* R.Br.	Salviniaceae (Pteridophyte)	+	-	-
3.	*Echinochloa colonum*. (Linn), Link	Poaceae (Monocot)	-	+	-
4.	*Echinochloa stagnina* Retz.	Poaceae (Monocot)	+	-	+
5.	*Eichhornia crassipes* (Mart.) Solms.	Pontenderiaceae (Dicot)	-	+	+
6.	*Hydrilla verticillata* (Linn f) Royle	Hydrocharitaceae (Monocot)	+	-	+
7.	*Jussiaea repens* Linn	Onagraceae (Dicot)	+	-	-
8.	*Lemna perpusilla* Torr.	Lemnaceae (Dicot)	-	+	+
9.	*Nymphoides indicum* (Linn) Kuntz.	Nymphaeaceae (Dicot)	+	-	-
10.	*Pistia stratiotes* Linn	Araceae (Dicot)	-	+	+
11.	*Salvinia cucullata* Roxb.	Salviniaceae (Pteridophyte)	+	-	+
12.	*Utricularia flexuosa* Vahl.	Utriculariaceae (Dicot)	+	-	-
	Total		**8**	**5**	**7**

Table . The morphological and ecological characteristics of macrophytes recorded.

Sl no.	Plant name	Description
1	***Alternanthera philoxeroide***	Plant commonly grows in wet and marshy places. Prostate herbs adpressed to the ground, leaves shortly stalked green, smooth, inflorescence white in colour. Native to South America. It is a good fodder, increases the flow of milk in the cattle. Also used against night blindness, Iron content very high, plant may be used as a salad (Ambasht, 1968) [2].
2	***Azolla pinnata***	It is free floating minute sized pteridophyte, quite common in ponds, lakes and rice fields. Root and stem are very poorly developed. Leaves are the most characteristic and well developed parts which do most of the function. They are reddish in colour and pinnately arranged. Plant regenerates mostly by fragmentation and covers the whole surface of the water body. Leaves have a pocket in which a cynobacterial species (Blue-Green Alga)- *Anabaena azollae* is found as an endophyte. Due to the presence of this BGA, the plant acts as an excellent biofertilizer and enhances the capacity of nitrogen fixation in rice fields. It is used fresh as green forage and as poultry feed; rich in protein, minerals and carotene (Ambasht, 1968).
3	***Echinochloa stagnina***	It is a common herb at the margin of ponds and lakes. Lower lemmas and upper glumes equally acute or cuspidate, nutritious, quick-growing fodder grass, relished by cattle.
4	***Echinochloa colonum***	An annual growing in small tufts upto 60cm, high slender, erect or geniculately ascending, branched mostly in the lower part only, glabrous and smooth. Leaf-blades glabrous, rarely with some minute hairs on the blades, linear from a scarcely contracted base, tapering to a slender acute point. A valuable fodder grass at all stages.
5	***Eichhornia crassipes***	It is commonly known as water hyacinth. It is a free floating aquatic herb, very common in large sized, old ponds and tanks. The stem is short and bears a large tuft of pinkish adventitious roots ventrally, immersed in water. Petiole long, green, spongy and swollen, plant floats on water due to it. Growth is very fast, inflorescence bluish in colour, radical leaves dorsally emerging out of water. The lamina is thick, fleshy and ovate-rhomboid in outline. The plant multiplies vegetatively by offsets. They are water purifier as they can absorb heavy metals present in water (Gopal, 1976).
6	***Hydrilla verticillata***	Fresh water plants forming large masses; stem slender, 1feet and more long, with fibrous roots, much branched, flaccid, with long or short internodes, often rooting from the nodes; branches with

		a short sheating leaf at the base.
7	***Jussiaea repens***	It is floating or creeping plant in semi aquatic conditions when floating, stem is supported by vesicles, flowers white in colour. This species is common in ponds and canals. Plant is used as a constituent of poultice used for ulcers and skin complaints.
8	***Nymphoides indicum***	Aquatic herbs floating or creeping; stem erect or runner like, or resembling petioles. Leavess alternate, orbicular, elliptic or ovate, deeply cordate, entire or obscurely drenate. Flowers white or yellow.
9	***Salvinia cucullata***	It is a free floating water fern, quite common in fresh water ponds. There are usually three leaves at each node. Two of them are normal and covered by papillate hairs while the third one on the ventral side is transformed into a bunch of fibrous roots which remain immersed in water. True roots are missing in this plant.
10	***Utricularia flexuosa***	It is an insectivorous plant and commonly known as Bladder-wort. It is a submerged aquatic plant, often found in standing water, lacking in nitrogenous salts. The plants are rootless, with slender stem which bears finely divided leaves. Some of the ultimate leaf-segments are modified into peculiar bladder-like structures, borne on small stalks. These bladders are meant for catching insects. Flowers are borne on long racemes, projecting above the water.
11	***Pistia stratiotes***	It is an aquatic floating weed, stem is stoloniferous, bearing rosettes of roundish, spathulate or obcordate cuneate leaves, the outer of which lies on the water while the inner stands erect. Offsets grow out from the leaf axils which give rise to new vegetative plants. Clusters of adventitious roots rise ventrally at each node and grow down into the water
12	***Lemna perpusilla***	Commonly known as duckweed. It is a small, free-floating, fresh water herb. Commonly found on the surface of still waters of ponds. The plant shows no differentiation into distinct stem and leaves. The plants is reduced to an oblong, flat, globose thallus, consisting of 2-5 green fronds, bearing a number of ventrally growing adventitious roots. Capable of thriving in foul waters. To some extent, it can absorb organic and inorganic substances present in water. It is usually introduced in Carp nurseries as it destroys algae and promotes growth of zooplanktons.

Table 3. Life forms of various macrophytic species based on position and degree of protection of the perennating organs of the study sites (after Raunkiaer, 1934)

No.	Macrophytic Species	Position and degree of protection to perennating organ during the adverse season	Life-form
1.	*Alternanthera philoxeroides*	Survives the adverse season in form of seeds. The plants produce flowers and seeds in favourable season	Therophytes
2.	*Echinochloa colonum*		
3.	*Jussiaea repens*		
4.	*Echinochloa stagnina*		
1.	*Azolla pinnata*	The plants survive the unfavourable conditions in the form of vegetative parts like stolon. In favourable condition they grow fast by vegetative means.	Errant Vascular Hydrophytes
2.	*Eichhornia crassipes*		
3.	*Lemna perpusilla*		
4.	*Pistia stratiotes*		
5.	*Salvinia cucullata*		
6.	*Utricularia flexuosa*		
1.	*Nymphoides indicum*	The buds are in variably buried in the soil or substratum such as the bulbs and rhizomes	Geophytes
1.	*Hydrilla verticillata*	Perennating buds are present just under the surface of soil and remain protected there, Buds may also be present at soil surface but they are never exposed; they remain concealed under the dead leaves and twigs.	Hemicryptoph ytes

Table 4. Life Form classification of the aquatic macrophytic species in urban TWRs. (after Ellenberg and Mueller- Dombois, 1967 and Mueller-Dombois and Ellenberg, 1974).

<table>
<tr><th>Life forms composition (%)</th><th>Name of species</th><th>No.of species</th><th>Percentage</th></tr>
<tr><td rowspan="4">Th</td><td>Alternanthera philoxeroides</td><td rowspan="4">4</td><td rowspan="4">33.3%</td></tr>
<tr><td>Echinochloa colonum</td></tr>
<tr><td>Jussiaea repens</td></tr>
<tr><td>Echinochloa stagnina</td></tr>
<tr><td rowspan="6">EVH</td><td>Azolla pinnata</td><td rowspan="6">6</td><td rowspan="6">50%</td></tr>
<tr><td>Eichhornia crassipes</td></tr>
<tr><td>Lemna perpusilla</td></tr>
<tr><td>Pistia stratiotes</td></tr>
<tr><td>Salvinia cucullata</td></tr>
<tr><td>Utricularia flexuosa</td></tr>
<tr><td>G</td><td></td><td>1</td><td>8.3</td></tr>
<tr><td>H</td><td></td><td>1</td><td>8.3</td></tr>
</table>

(Abbreviation: Th= Therophytes, G= Geophytes, H= Hemicryptophytes, EVH= Errant Vascular Hydrophytes).

Conclusion

The present study indicates that the richness of macrophytes plays an important role in maintaining a clear water state and stability of the ecosystem in the urban traditional water reservoirs (Sayer et al., 2010; Liu et al., 2020), adding knowledge regarding the consequences of increasing pressures, mainly nutrient load from growing human population, establishments for settlement and land use on the urban TWRs and its services in the area. It is concluded that aquatic macrophytes indicate the mechanisms behind community shifts that is of considerable importance in the management and the establishment of good ecological status for urban TWRs and other community ponds and their services.

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