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Full Length Research Paper

Total lipid content in macrophytes of Wular lake, A Ramsar site in Kashmir Himalaya

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The purpose of this study was to evaluate total lipid content in 15 fresh water macrophytes belonging to four ecological groups and examining the possible variations between the studied periods. The samples were obtained from nine sites throughout the Wular lake, during March to December 2011, spelling four seasons with determinations of lipid content of the aquatic macrophytes. No gross differences in the lipid content, which in general ranged between 1 to 7.6% fresh weight, was observed in the various macrophytic species, however, with a clear pattern between seasons. Results of the investigation revealed that emergents and submergeds presented greater concentration of total lipids when compared with free floating and rooted floating macrophytes. There was a tendency to higher concentrations of total lipids in the tissues of submerged macrophytes (*Ceratophyllum demersum* and *Potamogeton crispus*) in the early autumn season (peak growth period) suggesting that this period presents better conditions to *Ceratophyllum demersum* and *Potamogeton crispus* development in the Wular lake.

Key words: Aquatic macrophytes, ecological groups, total lipids, *Ceratophyllum demersum*, *Potamogeton crispus,* peak growth period.

INTRODUCTION

Freshwater plants are much less studied; in so far their total lipids are concerned, although their role in the life of water ecosystems is equally important (Pandit and Qadri, 1986; Banerjee and Matai, 1990; Rozentsvet et al., 1995; Goncharova et al., 2004; Kostetsky et al., 2004; Esteves and Suzuki, 2010). The macrophytes are a potential source of food and fodder for humans and bovine population, besides serving as a base of aquatic food-chain (Tardío et al., 2005; Rahman et al., 2007; Hasan and Chakrabarti, 2009; Swapna et al., 2011; Smith, 2011). In most freshwater systems they are important components of food web dynamics (Madsen, 2009; Smith, 2011). It is well-known that many plants, e.g. Algae (Cherepanov, 1981; Nelson et al., 2002) and lichens (Stefanov, 1988) can change their lipid contents, as well as other lipid characteristics, for instance, their fatty acid composition, under the influence of the environmental conditions (Koskimies and Nyberg, 1987; Roslin, 2001; Rajasulochana et al., 2002).

In view of this, we collected all our macrophytic samples during four seasons, including the period of the most active vegetation from nine sites located within the largest freshwater body of the Indian Subcontinent, Wular lake, a Ramsar site of international importance, in order to evaluate the total lipid content of water plants belonging to different ecological groups and examining the possible variations between the studied periods.

MATERIALS AND METHODS

Wular lake, the largest freshwater lake in the Indian subcontinent is a shallow one (open water area 24 km^2), located 34 Km north-west of Srinagar city on the Kashmir valley between 34° 16' and 34° 20'

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Table 1. Aquatic plants with scientific, common names and flowering season, that were collected from the Wular lake for the evaluation of total lipids.

S/N	Scientific name	Common name	Flowering period
1.	*Azolla sp.*	Water velvet	May-September
2.	*Ceratophyllum demersum*	Horn wort	May-September
3.	*Hydrocharius dubia*	Frogbit	July-September
4.	*Lemna minor*	Duckweed	March-September
5.	*Myriophyllum verticillatum*	Water milfoil	June-August
6.	*Nymphaea mexicana*	Water lily	August-September
7.	*Nymphoides peltatum*	Yellow floating heart	June-September
8.	*Polygonum amphibium*	Water knotweed	August-September
9.	*Potamogetan crispus*	Curly- leaf pondweed	April-June
10.	*Phragmites australis*	Common reed	July-August
11.	*Polygonum hydropiper*	Water pepper	July-October
12.	*Potamogetan natans*	Pondweed	July-September
13.	*Salvinia natans*	Water fern	May-September
14.	*Trapa natans*	Water-chestnut	June-October
15.	*Typha angustata*	Cattails	June-July

Table 2. Showing general geographical features of nine sampling sites.

Site	Code	Latitude	Longitude
Saderkote	I	34° 39' 19" N	74° 47' 8.8" E
Vintage	II	34° 21' 56.9" N	74° 39' 42.0" E
Kulhama	III	34° 22' 53.0" N	74° 39' 11.5" E
Laherwalpora	IV	34° 23' 47.4" N	74° 35' 9.1" E
Ashtung	V	34° 24' 3.8" N	74° 32' 41.7" E
Kuinus	VI	34°23' 0.3" N	74°32' 0.8" N
Watlab	VII	34°21' 29.4" N	74° 31' 48.2" N
Ningal	VIII	34°17' 74.31" N	74°31' 29.8" N
Makhdomyari	IX	34°20' 39. 2" N	74°34' 52.2" N

N latitude and 74° 33' to 74° 44' E longitude. The lake is mono basined, elliptical in shape and is of fluviatile origin, formed by the meandering of River Jhelum. Its altitude is 1580 m (a.s.l) and its depth, on average, 3.6 m throughout length, reaching 5.8 m at its deepest point. The major inflows to Wular lake are Jhelum, Madumati and Erin. The lake plays a significant role in the hydrographic system of Kashmir valley by acting as a huge reservoir and absorbs high annual flood of River Jhelum. The largest freshwater shallow lake in 1990 has assumed the status of Ramsar Site, a Wetland of International Importance.

This study of total lipids in macrophytes of the Wular lake was carried out, from March 2011 to December 2011.The samples of fifteen aquatic plants (Table 1) were selected according to their availability and collected from nine sampling locations within the Wular lake, in order to determine the total lipid content of these macrophytes (Table 2 and Figure 1). The plants were harvested in a lush, green condition using quadrants of 0.25 m^2 in an area (Westlake, 1965; 1971) from different areas within each stand to form three representative samples for each species. The harvested materials were placed in polyethylene bags and transported to the laboratory where they were cut to include only leaves and shoots. These were then washed thoroughly and moisture was drained before being analyzed for total lipid content. Total lipids were estimated using standard methods (Knight et al., 1972). The estimation of total lipids is based on the principle that, "In the presence of concentrated H_2SO_4 and phosphovanillin, lipids produce a colored complex, which absorbs maximally at 540 nm. The readings are compared with the color developed with standard olive oil, which also undergoes this type of reaction and helps in finding the concentration of total lipids". The concentration of total lipids was calculated using the following formula:

$(A_T – A_B) / (A_S – A_B) \times 500$

A_T = Absorbance of test sample.
A_B = Absorbance of blank.
A_S = Absorbance of standard.

RESULTS AND DISCUSSION

The results of seasonal changes in the total lipids of fresh water macrophytes are given in Table 3. They demonstrate certain similarities as well as differences in

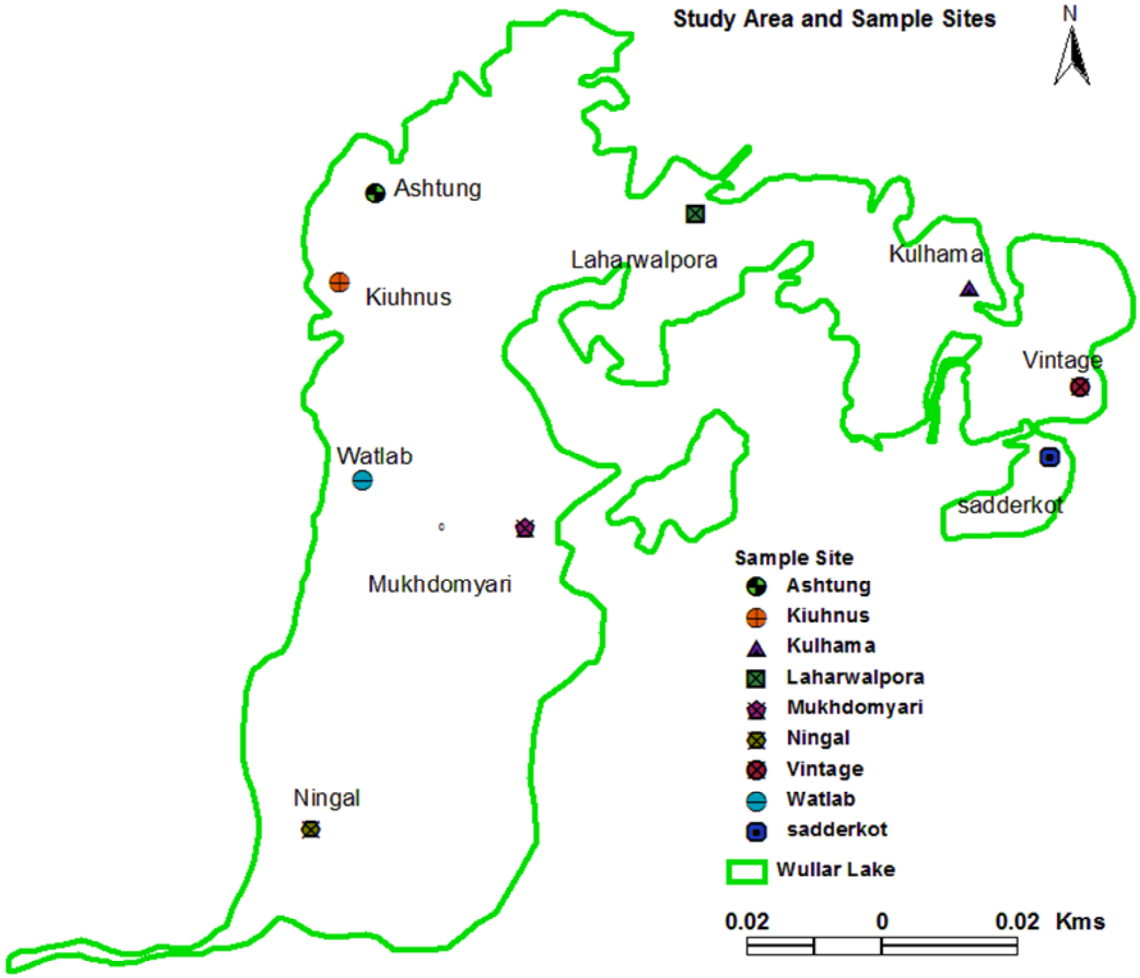

Figure 1. Area and sampling stations.

the total lipids among these macrophytes. Total lipids accumulated in the studied macrophytes amounted to 1.0 to 7.6% of fresh weight. The high lipid content (1.4 to 7% fresh weight) was noted for emergent macrophytes, *Typha angustata, Myriophyllum verticillatum* and *Phragmites australis.* Among these emergent macrophytes *M. verticillatum* seems to accumulate higher content of lipids (2.1 to 7.2% fresh weight) over the entire period of growth. *M. verticillatum* has also been reported to be very efficient in the uptake of many plant nutrients from the sediments and thus helping in pollution abatement (Pandit, 1984). The submerged macrophytes represented in our study by two species namely *Potamogeton crispus* and *Ceratophyllum demersum,* had lipid content (1.2 to 7.6% fresh weight) closer to free floating macrophytes, *Lemna minor* and *Azolla* sp. Among the floating –leaved macrophytes *Trapa natans* gained superiority over the other 5 species in so far as the high proportion of lipid content is concerned. This is in consonance with the findings of Pandit and Qadri (1986) who also reported higher levels of lipids in case of *T. natans.* However, these figures were similar to those reported for aquatic plants growing in tropical regions (Banerjee and Matai, 1990). Three species had lipid content on mean value basis above 4% while submerged plants had values below 4%. Aquatic plants have been reported to contain 1.18 to 5.42% total lipid content (Boyd, 1968).

Since aquatic macrophytes are known to differ widely in their chemical composition depending upon species, season and location (Annon, 1984). Though, no gross differences in the total lipid content were observed in the various ecological groups. Yet significant differences in the total lipids of these macrophytes with a distinct pattern between the seasons were observed. More or less similar results were registered by Mini (2003) and Arathy (2004) in various aquatic as well as riparian vegetations. Fluctuations noticed in the concentration of lipid in the different genera may be due to the changes in the environmental factors that might have influenced the vegetative growth and development including availability of nutrients, allochthonous materials as well as variation

Table 3. Seasonal variation in total lipids* (% fresh weight) from macrophytes of Wular lake.

Plant	Species	Spring (March-May)	Summer (June-August)	Autumn (September-November)	Winter (December -February)	Mean	S.D	C. V
Emergent	*Myriophyllum verticillatum L.*	3.6	5.9	7.2	2.1	4.7	2.28	4.86
	Phragmites australis	3.2	5.2	6.6	1.8	4.2	2.12	5.05
	Typha angustata	2.8	4	6	1.4	3.55	1.95	5.49
Rooted – floating	*Trapa natans L.*	2.9	4.9	6.3	2	4.03	1.94	4.82
	Potamogeton natans L.	2.2	3	4.4	1.6	2.8	1.21	4.33
	Nymphea mexicana L.	2	3.2	4.5	1.4	2.78	1.37	4.94
	Polygonum amphibium	2	3.2	3.6	1.7	2.63	0.92	3.5
	Hydrocharis dubia	1.8	2.2	3.7	1.2	2.23	1.07	4.79
	Nymphoides peltatum	1.4	1.8	3.3	1.2	1.93	0.95	4.94
	Polygonum hydropiper	1	1.2	2.2	0.7	1.28	0.65	5.1
Submerged	*Potamogeton crispus L.*	2	3.2	7.6	1.2	3.5	2.85	8.15
	Ceratophyllum demersum L.	1.8	2.8	7.1	1.4	3.28	2.62	7.99
Free floating	*Azolla* sp.	2.2	4.2	5.6	1.4	3.35	1.91	5.69
	Lemna minor L.	2	4	5.2	1.8	3.25	1.64	5.03
	Salvinia natans	2.1	3.6	4.2	1.1	2.75	1.41	5.13

*Average results based on three analyses.

in the efficiency of lipid accumulation among the plants.

Lipids can readily be used by many organisms, which constitute a major source of energy in the aquatic environment with a high recycling rate (Stable, 1977). The total lipids presented the highest variance among the studied periods with the significant increases for C *demersum* and *P. crispus* (about 4 times each) in the early autumn season experiencing frequent rains. These differences indicate an acceleration of productive metabolic activity during this period and/or higher consumption of this organic compound during the dry period. The significant increases in the lipid content (about 5 times) have also been reported for *C. demersum* in the rainy season (Esteves and Suzuki, 2010). The increase in total lipid content of submerged macrophytes in this season is probably related to the decrease in conductivity values and alkalinity as a consequence of the largest inflow and accumulation of fresh water from catchment (Esteves and Suzuki, 2010). Also, Haroon et al. (2000) and Nelson et al. (2002) mentioned that this may be because of the reduction in the levels of proteins and carbohydrates. Under this condition, more photosynthetic intermediates can be utilized in the synthesis of lipid molecule. The tendency to accumulate higher concentration of total lipids in the tissues of submerged macrophytes in this period, suggests that this period presents better conditions to the development of these macrophytes.

Conclusions

The obtained data testify to the fact that despite the morphological differences between the examined water plants, no significant difference in their total lipids was observed. The concentration of total lipids fluctuated in aquatic macrophytes during their growth season, this may be related to temporal variations and spatial distribution. The submerged macrophytes (*C. demersum* and *P. crispus*) gained superiority over the other species in so far as the accumulation of high proportion of total lipids is concerned during the peak growth period.

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