Sustainability and Biodiversity Conservation

Macrophytes and their Nutrient content analysis- a study of Dal Lake, Kashmir

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Abstract

The nutrient analysis of some macrophytes like *Typha angustata*, *Phragmites australis*, *Azolla* sp., *Nulembo nucifera*, *Potamogeton natans*, *Trapa natans*, *Potamogeton lucens*, *Ceratophyllum demersum* and *Myriophyllum verticillata* belonging to different life-form classes was carried out in the present study. In general, the nutrient content like moisture content, ash content, crude protein, crude fiber, and lipids varies from 86-94%, 8-29%, 13-22%, 1-21%, and 1-5% respectively with highest values during summer months which is the peak growing season of these macrophytes. The highest value of moisture content was found in the case of Azolla sp. (94.60 ±0.26) whereas the lowest content was found in the case of *Nelumbo nucifera* (86.04±0.60). The highest ash content was observed in the case of *Myriophyllum verticillatum* (29.31±1.20) while the lowest ash content was observed in *Nelumbo nucifera* (8.00±1.20). The highest value of crude protein was recorded in *Azolla* sp. (22.15±0.40) and the lowest was recorded in *Myriophyllum verticillatum* (13.01±0.05). Crude fiber shows the highest value in *Ceratophyllum demersum* (21.00±6.74) and the lowest in *Typha angustata* (1.80±0.18). lipid shows the highest range in *Ceratophyllum demersum* (5.96±0.14) and lowest in *Trapa natans* (1.00 ±0.15). The nutrient analysis shows species specificity and spatial and temporal variation. The finding of the present study suggests that these macrophytes have great importance in day-to-day life and can be used as a potential source of food for humans, feed for fishes, fodder for bovine animals, and as fertilizers for flowering gardens, horticulture fields, floating gardens and agriculture fields.

Keywords: Nutrient analysis, peak growth season, species specificity, temporal variation

Introduction

Aquatic weeds grow in a continuous supply of water and are also known as aquatic plants or these are the plants that are at least present in soils that are covered with water during a major part of the growing season (Penfound, 1956; Cook et al. 1974; Mitchell, 1974). Aquatic macrophytes play important roles in the freshwater ecosystem and are known as photosynthetic organisms of freshwater habitats (Wetzel, 2011). Aquatic weeds have a big contribution to nutrient cycling in lakes ponds and other waterways. The presence of aquatic weeds in water bodies determines Physico-chemical properties and nutrients availabilities of

Waterbodies (Pompêo & Moschini-carlos, 2003). According to Gupta (2001) the abundant growth rate of macrophytes in lakes, ponds, and other waterways have perceived as a nuisance over the years rather than as a resource because they block waterways, cause eutrophication, block canals and increase water-borne diseases. The limited growth of macrophytes is very useful to water bodies in maintaining water quality and provides food and shelter for aquatic organisms but their abundant growth damage the water bodies by covering the surface. In the recent past, different researchers studied that macrophytes can be used as a food source for livestock and in medicine (Naghma & Sarwat, 2005, Deepa, et al. 2009; Shah et al. 2010). Macrophytes are known as a good source of food and fodder for humans, aquatic herbivores, and farm animals and are also used as fertilizer like mulch and compost manure, green manure, ash, etc. for the production of food crops, apple gardens, flowering beds, etc besides serving as a base of the aquatic food chain (Hasan & Chakrabarti, 2009; Tardío et al. 2005; Rahman et al. 2007; Swapna et al. 2011). The knowledge of the chemical composition of macrophytes is most important in order to evaluate the food potential and estimation of their nutritional value (Chapman, 1950; Hawkins & Hartnoll, 1983). Metabolic activities like photosynthesis, growth rates, and level of proximate nutrient constituents are greatly influenced by abiotic factors such as light, temperature, sediment composition, and water chemistry (Koskimies & Nyberg, 1987; Roslin. 2001, Rajasulochana et al. 2002) thus necessitating the determination of biochemical ingredients of the tissues produced under each ecological condition. Growth rate, morphology, photosynthesis, chlorophyll composition, lipids & protein composition, and reproduction are affected by both light and temperature (Chambers, 1982; Barko, et al. 1986; Nekrasova, et al. 2003; Ronzhina, 2004; Robledo, and Freile-pelegrin, 2005). The present study aims to determine the nutrient content like protein, fiber, ash, and lipids content of some aquatic macrophytes.

The use of macrophytes as food for humans, animals, and aquaculture purposes is based on their high nutritive value arising from the richness of biochemical constituents such as moisture, proteins, fiber, lipids, ash, etc. The major biochemical compounds, *viz.,* proteins, fiber, ash, and lipids act as the energy-yielding nutrients that provide the energy required by the human and animal bodies to enable the body to perform all body functions (Rather, Nazir, 2015). Lipids are the principal dietary sources of energy and are the nutrients responsible for energy production in our bodies. The body’s requirement for amino acid nitrogen and specific amino acids are derived from proteins. The energy derived from lipids affects protein requirements because it spares the use of protein as an energy source. To use expensive dietary protein efficiently and to reduce requirements for it to a minimum, it is necessary to ensure adequate provision of energy from non-protein sources such as lipids

Table1. Macrophytes with scientific name, common name, and flowering season were collected from Dal Lake for the proximate nutrient analysis.

Plants	Scientific name	Common name	Flowering period
Emergents	*Typha Angustata*	Cattails	June-July
	Phragmites Australis	Common reed	July-August
	Azolla sp.	Mosquito fern	July-August
Rooted Floating	*Nelumbo nucifera*	Lotus	July-September
	Potamogetan natans	Pondweed	July-September
	Trapa Natans	Water chestnut	July-September
Submerged	*Potamogetan lucens*	Shining pondweed	May-September
	Ceratophyllum demersum	Horn wort	May-September
	Myriophyllum verticillatum	Whorled water milfoil	September-November

Materials and method

In The present study, the material was collected from their natural habitat from the 3 basins (I Hazratbal basin, II Nishat basin, III Gagribal basin) of Dal Lake for a period of five months from June to October (Fig. 1). The selection was made considering the abundance of macrophytes at the sampling sites and the easiness for recognition and collection. Nine species of macrophytes belonging to three different systematic forms of emergents, rooted with floating leaves and submerged were chosen for the present study (Table 1).

Study area

Once Dal Lake was 7.44 km long, about 3.5 km broad, and 22 km^2 but presently it is only 10.4 km^2 because of anthropogenic pressure of the population living in the vicinity, formation of floating gardens, land masses, and marshes.

Dal lake is an urban valley lake and is multi-basined. It is probably of fluvial origin having been formed from the ox-bows of the river Jhelumprobably originated from the River Jhelum. Dal is divided into four basinslike Hazratbal, Boddal, Gagribal, and Nagin. Dal lake is situated in the heart of Kashmir valley in Srinagar city at an altitude of 1586 m above sea level between 34°5'–34°9' N latitude and 74°49'–74°52' E longitude. The valley of Kashmir exists between the lesser and Greater Himalayas characterized by numerous aquatic ecosystems of great ecological and economic importance. The freshwater bodies of the Kashmir Himalayas are the big sources of drinking water, irrigation, navigation, fishery, agriculture, socioeconomic development, and recreation. However, in recent decades, the ecosystem of these water bodies changed drastically due to the heavy anthropogenic pressures, discharge of large quantities of waste from human settlement which results in the shrinking of lake surface area, and deterioration of water quality which results from the enormous growth of macrophytes and eutrophication of Dal Lake.

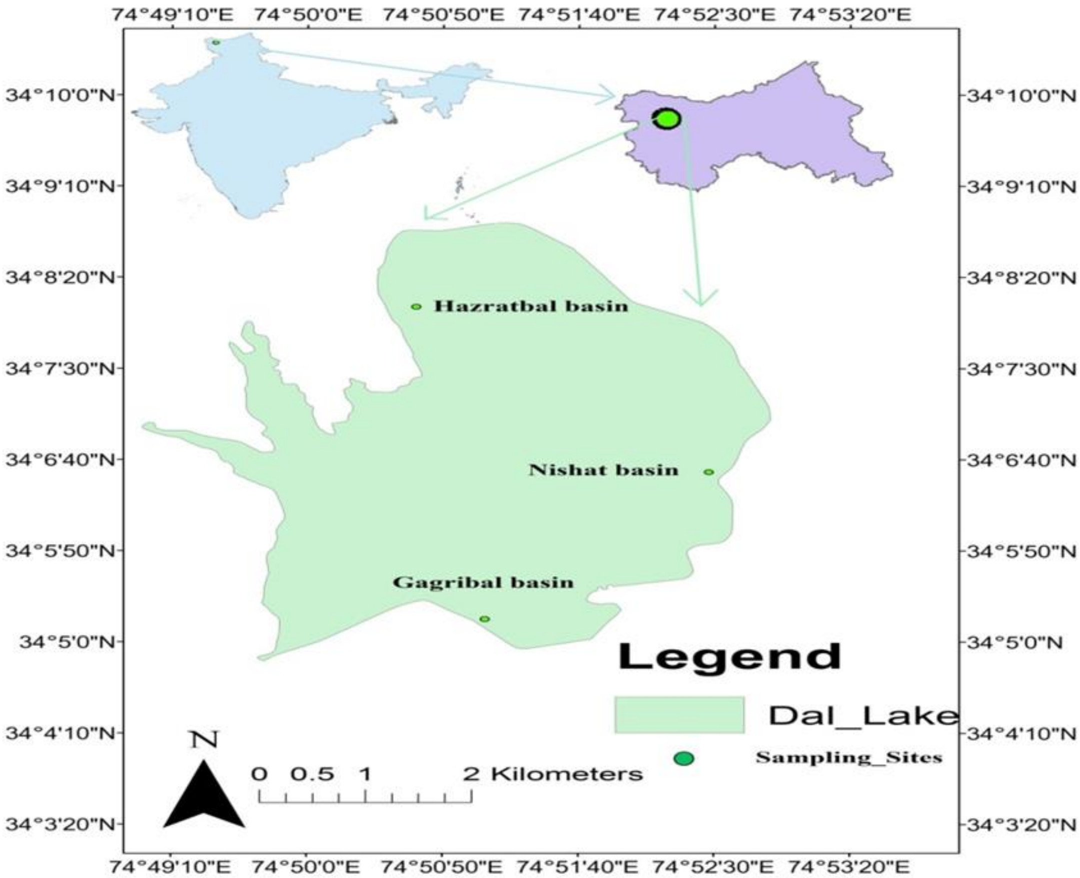

Figure 1. Study area and sampling sites

Table 2. Geographical features of sampling sites

Site	Code	Latitude	Longitude
Hazratbal basin	I	34° 08′ 03.8″ N	74° 50′ 40.1″ E
Nishat basin	II	34° 06′ 33.1″ N	74° 51′ 05.5″ E
Gagribal basin	III	34° 05′ 12.5″N	74° 52′40.0″ E

Weed analysis

The Macrophytes were identified and picked from their nature with the help of tools with proper care so that there is no damage to the sample. All the samples collected were washed and cleaned thoroughly with water. The samples were put in eco-friendly polybags and transported to the laboratory for further treatment i.e., they were incised to include only leaves and shoots and sorted out. The plant material was then again washed thoroughly to render it free of mud, periphytic growth, crustaceans, etc. The washed Macrophytic materials were kept in plastic containers at room temperature and air dried for some days up to analysis.

Total Moisture

The wet sample materials were taken in pre-weighed dry Petri dishes for determining the moisture content of the samples and then weighed again. After this, they were kept in an oven at 105˚C for 24 hours or till the constant weight was obtained (Hart & Fisher, 1971). Now the dried samples were taken out of the oven and placed on desiccators. The weight of the samples was again taken after 30 minutes and the difference in weight was calculated. The results were found by using the following formulae and expressed as the percentage moisture of the content.

$$\textbf{Moisture [\%]} = \frac{\text{Wet weight of sample[g]} - \text{Dry weight of sample [g]}}{\text{Wet Weight of the sample [g]}} \times 100$$

Total ash

For the analysis of ash content, the samples were ground to fine powder form using mortar and pestle. The samples were weighted in clean pre-weighted silica crucibles. Now, the samples placed in crucibles were put in a muffle furnace at 650 ˚C for 4-6 hours till the residue turns to white color [26]. After this, the samples were placed in desiccators for about 20-30 minutes to cool down and weighed again. To calculate the amount of ash, the difference in weights of the samples was calculated by using the following formulae and was expressed as a percentage of ash.

$$\textbf{Total Ash [\%]} = \frac{\text{Weight of Ash[g]}}{\text{Weight of sample [g]}} \times 100$$

Crude protein

In order to determine the crude protein content in the moisture-free samples obtained by the Kjeldahl method [26] was used. The value of Nitrogen so obtained was multiplied by 6.25 to get the appropriate protein value of the samples.

Crude fiber

Acid-base digestion method was used to calculate the crude fiber content of the sample [26]. The remains of the samples were ignited after digestion at 500 º C in a muffle furnace for 3 hours.

$$\textbf{Crude Fibre [\%]} = \frac{\text{Weight of dry residue} - \text{Weight of ash residue}}{\text{Weight of sample}} \times 100$$

Lipids

In order to determine the lipid content, the method of Floach [27] was used and the result was expressed in the percentage of the weight of the sample analysed.

$$\textbf{Crude Lipid [\%]} = \frac{\text{Weight of extract}}{\text{Weight of sample}} \times 100$$

Table 3. Nutrient content analysis of selected Microphytes of Dal Lake

Plant Name	Moisture (%)	Ash (%)	Protein (%)	Fiber (%)	Lipid (%)
Typha angustata	86.06±0.59	9.91±1.30	19.56±0.52	1.80±0.18	1.90±0.40
Phragmites australis	90.06±0.60	10.2±1.40	18.60±0.49	2.00±0.20	1.6±0.40
Azolla sp.	94.60±0.26	14.60±6.20	22.15±0.40	15.10±0.30	2.00±0.25
Nelumbo nucifera	86.04±0.60	8.00±1.20	17.50±0.51	2.00±0.16	1.90±0.32
Potamogetan natans	89.22±0.68	11.20±2.10	15.80±0.29	12.90±0.66	1.10±0.14
Trapa natans	91.24±0.60	10.90±2.20	16.82±0.30	12.30±0.62	1.00±0.15
Potamogetan lucens	87.00±1.10	20.99±2.10	14.00±0.13	20.95±0.70	3.00±0.06
Ceratophyllum demersum	91.30±0.20	23.97±3.60	21.99±0.24	21.00±0.74	5.96±0.14
Myriophyllum verticillatum	92.08±1.00	29.31±1.20	13.01±0.05	11.93±0.30	2.04±0.09

Results and discussion

The present study revealed profound variations in the moisture content, ash content crude protein crude fiber, and lipids among nine different aquatic weeds chosen for three study sites. The data of proximate nutrient content analysis of the weeds is presented in Table 3.

Moisture content

The results from the analysis revealed that the moisture content of macrophytes was found in the range of 86-94%. The highest value of moisture content was found in the case of Azolla sp. (94.60 ±0.26)followed by *Myriophyllum verticillatum* (92.08±1.00)whereas the lowest content was found in the case of Nelumbo nucifera (86.04± 0.60). [35] The highest moisture content was found in emergent followed by rooter-free floating.

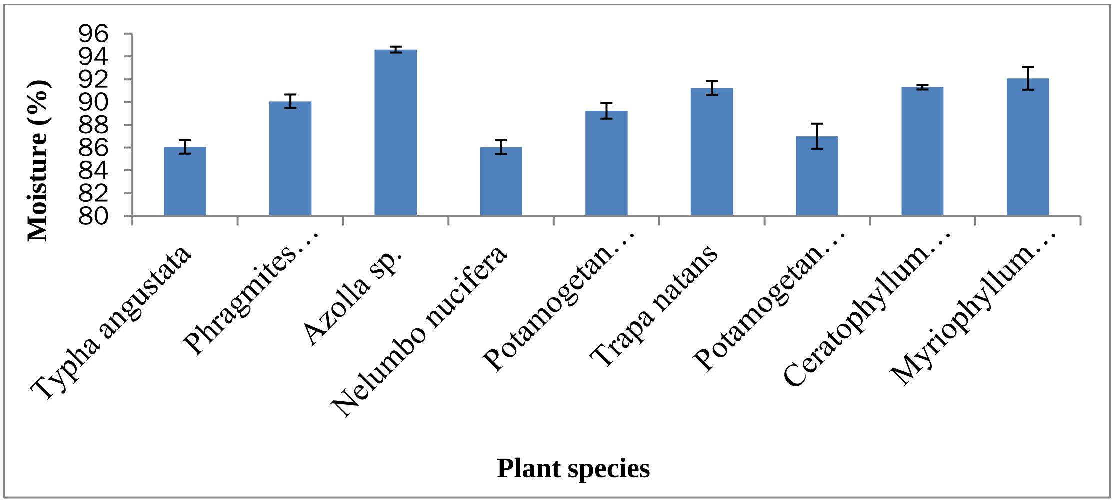

Figure 2. Moisture content in different species

Ash content

The ash content is the amount of inorganic substance that remains after the complete combustion of the biomass. The ash content was found to be in the range of 8-29% and the ash content of submerged plants was found to be higher as compared to emergent or floating types. *Myriophyllum verticillata* has shown the highest ash content (29.31±1.20). The lowest ash content was observed in the case of Nelumbo nucifera (8.00±1.20) followed by *Typha angustata* (9.91±1.30). It is found that the component of aquatic plants and terrestrial plants are closely similar (Fig. 3).

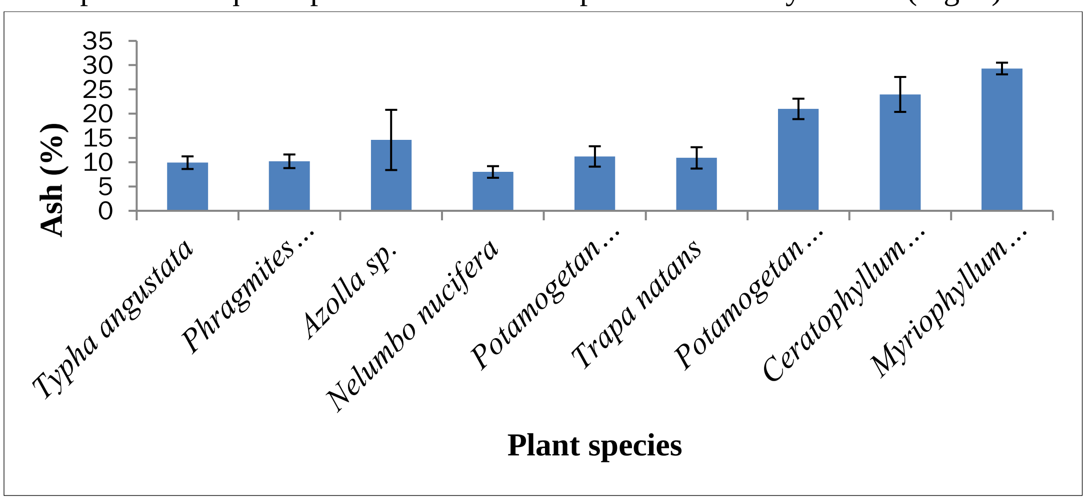

Figure 3. The ash content in different target species

Crude fiber and protein

In the current study, the value of crude proteins ranges from 13.01-22.15%which may be a result of micro-habitat in the sampling sites. In the present study crude protein percent of aquatic weeds shows a slight variation in growth period but depicts higher during peak growing season (Fig. 4). The protein content varies in the same plant at different sites because of physiochemical properties.

The growth of plants causes the formation of new tissues which increase the protein content. The highest value of crude protein was recorded in Azolla sp. (22.15±0.40) and followed by (21.99±0.24) and the lowest was recorded in *Myriophyllum verticillatum* (13.01±0.05). More or less similar results were registered by [34,35]. Crude fiber shows the highest value in *Ceratophyllum demersum* (21.00±6.74) and the lowest in *Typha angustata* (1.80±0.18). In order to maintain buoyancy, the macrophytes show a lower fiber content than the plants that live on land.

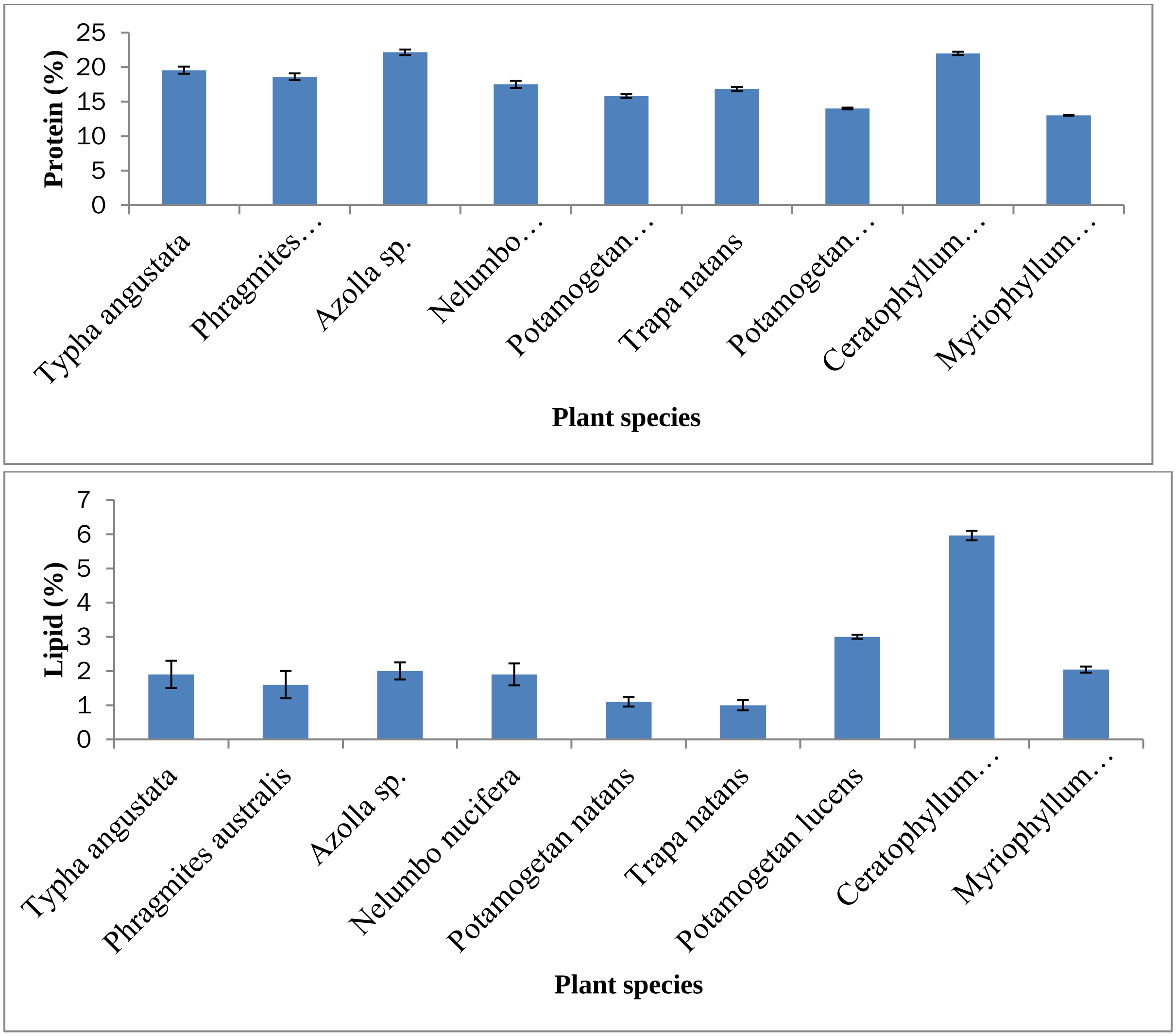

Figure 4. Protein and lipid content of the studied plant species

The maximum lipid percentage at all sites was found highest in the case of *Ceratophyllum* demersum(5.96±0.14)followed by *Potamogetan lucens* (3.00 ±0.06)and lowest in Trapa natans (1.00 ±0.15). It has been found that the differences in the proximate composition of plants could be attributed to different processing techniques, differences in soil chemistry plant species type, and variations in climate (Conforti et al. 2008). During the month of September means, the peak growing season from June to September the lipid content shows a higher percentage. The highest value was recorded in the case of submerged plants that show they have a good efficiency of up taking many plant nutrients from sediment (Pandit, Qadri,1986). During the rains in the early autumn season, the *Ceratophyllum demersum* shows a significant increase in lipids by higher consumption of organic compounds during the dry periods or it may be due to the reduced level of carbohydrates and proteins (Haroon, et al. 2000; Nelson et al. 2002; Esteves & Suzuki, 2010; Prasannakumari, Gangadevi, 2012, Subzar, et al. 2019) (Fig. 5).

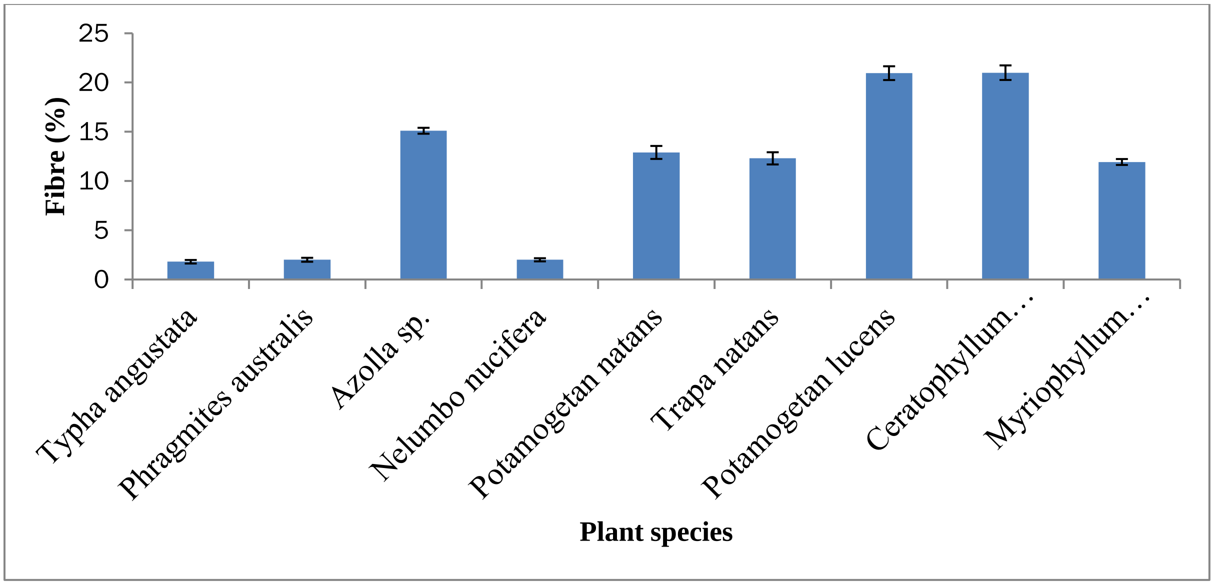

Figure 5. Fibre content of the studied species

Aquatic macrophytes play an important role in freshwater ecosystems and are known as photosynthetic organisms of freshwater habitats. It was recorded that the variation in different nutrients of macrophytes may be due to the harvesting method, environmental conditions, anthropogenic activities, temperature, and soil composition. The present study reveals that the higher accumulation of different nutrients like protein, lipids, fiber, etc. in macrophytes closer to land plants can be used as an alternative source of food for humans, food and fodder for animals, and feed for fishes as they have good nutrient value.

Considering the fact that an increase in population is a challenging task for scientists to meet the demands of food for the growing population. With the increase in population growth, unsustainable use of natural resources and urbanization, there is a continuous decrease in land under the use of agriculture and food production which results in increasing the shortage of food security worldwide. COVID-19 now doubles the rate of acute hunger by putting an additional130 million people at risk of suffering acute hunger by the end of 2020. Macrophytes can be used as an alternative source of food for a tremendously increasing population and it can help in reducing the food demand of the increasing population. Macrophytes also provide food for aquatic herbivores, such as fishes, turtles, rodents, and manatees. Besides macrophytes can be used as fertilizer (mulch and manure, ash, green manure, compost, biogas slurry). Macrophytes can play a big role in the future if they can be utilized properly.

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