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AQUATIC FLORA OF VARIOUS FRESH WATER BODIES OF DISTRICT CHARSADDA, KHYBER PAKHTUNKHWA, PAKISTAN

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ABSTRACT

This study was conducted during summer 2014, to investigate the aquatic plants from various fresh water bodies of District Charsadda, Pakistan and pin point the major aquatic weeds particularly the invasive ones. A total of 36 plants species were collected from different water bodies at various sites and a variety of habitats. The plant specimens were properly identified through the flora of Pakistan and by consulting renowned taxonomists in the University. The collected plants were classified in to different groups and subgroups according to their growth habit, habitats, type of water body, life cycle and their position with respect to the water surface. About 30.60 % of the aquatic plants were associated with streams and river banks, 27.70 % to drainage ditches and stagnant water conditions, 19.50 % to irrigation channels and fresh water ponds and 22.20 % to wetland and marshy places, respectively. Regarding the life cycle of the hydrophytes, 35 % of them were annual and 65% were perennial plants. Regarding to their position with the water surface, 11% were free floating, 14% anchored floating, 61% emergent and marshy plants and 9% submerged plants. On the basis of availability and abundance scale 25% were common, 22.20 % rare, 16.6 % abundant and infrequent each, 8.5 % very rare, 5.6 % very abundant plants and 2.7 % very common and occasional plants each, respectively. While on the basis of growing habits 80 % were herbs, 12% shrubs, 6 % tree and 2% filamentous algae. Only a few plants like Nasturtium officinale etc. used as pot herb while Typha for making ropes, mats, baskets and blinds. Persicaria hydropiper Michx. was the most poisonous weed while Eichhornia crassipes (Mart.) Solms., Pistia stratiotes L., Phragmites australis L. and Typha latifolia L. were the most problematic weeds and were abundant almost in all habitats and in almost all water bodies surveyed.

Key words: Aquatic flora, fresh water bodies, Pakistan, survey, weeds.

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INTRODUCTION

District Charsadda is located between 34° and 34°-38` N latitude and 71°-28` and 71°-53` E longitudes and lies in of the Khyber Paktunkhwa and is bounded by district Malakand on the North, Mardan in and East, Nowshera in the South and district Peshawar and Mohmand Agency in the South. The total area of district Charsadda is 996 km^2. Most of the residents are farmers, cultivating their own or rented land, growing almost all crops that can grow there like tobacco, canola, sunflower, wheat, sugarcane, maize, sorghum, melons, water melons, fodder and forages and a number of fruits and vegetables.

There is a network of water channels throughout the district from the main canal coming from river Munda, which starts from Chitral and northern areas of Pakistan, flowing towards Afghanistan, and re-enters to Pakistan through Mohmand Agency and finally enters in to the Indus River. Beside the irrigation channels other types of water bodies like rivers, streams, lakes, dams, marshes and wetlands are also abundant throughout the district. Most of the water bodies are rich in native hydrophytes but recently invasive aquatic plants are also noted flourishing and spreading throughout the area. For example *Eichhorrnia crassipes*, *Pistia stratiotes*, *Lemna, Typha, Sagitaria* and *Hydrilla* have been collected from the various water bodies of the study area. These and several other hydrophytes are very important when growing in or near water bodies if in equilibrium with the ecosystem. Their normal growth is beneficial in so many ways in terms shelter for wildlife, regulating and recycling nutrients in the ecosystem, acting as a source of O_2 for aquatic fauna and in controlling soil erosion on the shoreline and river banks. These plants are a source of food for the herbivorous animals particularly the aquatic ones. Wild rice, water chestnut, Chinese water chestnut (*Eleocharis dulcis*), water lilly (*Nelumbo nucifera*), *Typha alatifola* etc. are used as a food (Hutchinson, 1975).

Aquatic plants belong to three main botanical categories i.e. (a). Algae (may be unicellular, filamentous or higher plant like) (b). Pteridophytes and (c). Angiospermic plants. The aquatic angiosperms grow in diverse conditions, conferring numerous benefits as well as harms to the water body and concerned ecosystem. Wetlands are the sanctuaries of biodiversity in terms of aquatic plants. The richness of aquatic plants in wetlands could be measured by the numbers and diversity of fauna present there, which is a yardstick if animals are more, then the area is rich in plant resources (Chamber 2008). This

richness of aquatic flora in various fresh water bodies is analyzed through Shannon's diversity index (H'), and Pielou's evenness index (J'). In normal conditions aquatic flora provides natural protection against extreme floods, storage of freshwater and improves the water quality through nutrients extraction; a process called phyto-remediation. They providing a spawning habitat for fish and amphibians and offering shelter and nesting for birds (Mitsch and Gosselink, 2000). Wetlands and especially peat lands provide a net sink of CO_2 (Bobbing *et al*., 2006).

On the other hand abundance of aquatic plants make them undesirable and change their status to aquatic weeds which is a threat to fresh waters and act as a source of water pollution, unfavorable climatic changes, water logging, eutrophication, acidification, extinction of native flora, lowering biodiversity and disturbing of natural ecosystem (Chambers *et al.,* 2008). Invasive aquatic weeds reproduce mostly vegetatively and also have suitable seed dispersal mechanisms which make them better survivors. Their luxuriant and thick growth on the water surface support certain invasive small animal's to walk on it and live it (Anderson, 2003), but their presence prove a barrier for the native fauna and make them endangered and finally extinct (Lancar and Krake, 2002). The infested rivers and streams are a big threat in terms of flood as the weeds biomass slows down water flow, causing siltation, decreased the water carrying capacity, cause water logging and increase the width of the streams. Infestation of water channels creates problems in irrigation (Richardson and Jowett, 2005).

The areas where the water table is high and water logging is prevalent due to less soil gradient and poor drainage system the rain water, sewages and waste water remain standing and create stagnant ponds where floating aquatic weeds i.e. water hyacinth, water lettuce and duck weeds flourish well. Emergent weeds like Typha and common reed are also common (Kitamura *et al*., 2006). Keeping in view the importance of water for agriculture, livestock, and other requirements of the common public and the threats to these water bodies from hydrophytes and invasive aquatic weeds the present study were carried out with the objectives to know the aquatic flora and the weed infestation in the study area, and to evaluate the presence of invasive weeds in various water bodies of the study area.

MATERIALS AND METHODS

A field study was conducted in the various fresh water bodies of District Charsadda for the native as well as introduced/ invasive noxious aquatic weeds. All water bodies including irrigation channels, rivers, ponds, wetland habitats dams, water logged conditions, lakes,

drainage ditches, stagnant water bodies and streams were studied during a search for aquatic flora. The study was carried out during summer, May to October, 2014, in various places of the district Charsadda-Pakistan. During the study aquatic plants were searched, collected and photographed at various location and different water bodies present in the study area. Plant collection kit included a field notebook, permanent and water resistant marker/ pencil, measuring tape, meter rod, scissor, knife, plant digging tools, plastic bags, rough newspapers, plant presser), lifesaving jackets, swimming kit, plant collection rake, tags and digital camera with built-in GPS properties etc.

Aquatic plants Collection method

Various fresh water bodies of district Charsadda were surveyed for plants collection. The area was explored for different water bodies and different aquatic plants species. The plant specimens were collected in a scientific and standard way used for the collection of aquatic flora. Larger plants were collected in several folds of rough news paper, kept flat and pressed at the site of plant collection and before bringing to the plant collection laboratory. The news paper was changed to remove excess of moisture. During plant collection the following data were taken on collection date, location of plant, plant habitat, water body type, infestation of area and growing habit of plant. Any other prominent visual observation related to the soil, plant, water body, water type or environment was also noted.

Permanent Preservation

Plants were preserved by using standard preservation procedures, pasted on particular herbarium sheets and the specimens were deposited in the herbarium of Department of Weed Science, The University of Agriculture Peshawar, for study and research for the help of students and researchers in the concerned field.

RESULTS AND DISCUSSION

Various locations of the District Charsadda were visited several times from May to October, 2014. It was observed that most of the irrigation channels, streams, rivers, rice fields and ponds were found severely infested with noxious native as well as invasive aquatic weeds. The unchecked growth of aquatic weeds caused the sedimentation, which reduced the water carrying capacity of the water body particularly of irrigation canals and water channels, damaged their structure, caused seepage of water, reduced the quality of the water which might have an impact on the normal growth of crops as well as related fauna. Eutrophication, water logging, and poor drainage system further aggravated the weeds problem of areas having already high water table. These conditions further promoted the infestation of

floating weeds such as *Eichhornia crassipes*, *Pistia stratiotes* and *Salvinia molesta* (Table-2). *Typha latifolia*, *Alternanthera philoxeroides*, *Cyperus* species, being emergent weeds flourish well on the banks of channels, lakes and stagnant ponds (Table-4). Various water bodies had a variety of macrophytes communities such as floating weeds, free floating weeds, emergent weeds and submerged weeds (Fig. 1). The growth, biomass production, other characteristics of aquatic weeds, all depend upon the flow, depth and kind of the water body and nutrient availability in the water etc. On the bases of life cycle most of the plants were perennial with small percentage of annuals. The perennating parts of the aquatic perennials make them a bit difficult to manage than annuals. Aquatic plants found in the study area were mostly herbs, followed by shrubs, a few trees and rarely filamentous algae excluding microscopic algae.

The change in climate and receding of water also effects the growth and frequency of certain species of the plants. During the survey study various kinds of the aquatic plants are observed ,some are emergent, some are anchored floating, some are free floating ,and some are live in water as well as terrestrial. *Typha latifolia* and *Sagittaria* were observed as emergent condition in standing water, and stagnant ponds, with a great density, covering the whole surface of the ponds. Apart from these water bodies *Typha latifolia* were also found in water logging, the bank of some irrigation channels, and the area which is permanently covered with water. The free floating weeds such as *Marsilea* and water hyacinth were observed in ponds and lakes at highest density. *Alternantra sessilis* was observed floating and anchored to the hydrosoil in a different water bodies such as water channels, stagnant water, streams and marshy places. *Vallisneria* and *Chara zeylancia*, *Anabeana* spp (blue green algae), *Najas minor*, *Hydrilla*, *Elodia*, *Scripus* and some filamentous algae were observed in a submereged state in fresh water steams and standing water, and the soil permanent covered with a thin film of water (Table-1). *Potamogeton, Marsilea quadrifoliata,* and *Mersilia minuta* were found rooted to the hydrosoil and floating on the surface of the water bodies almost in shallow clear and slow moving waters in most of the conditions (Table-3). *Typha latifolia* ,*Pragmites communis, Plantago Cyperus, difformis* L., *Ipomea carnea* and *Alternanthera philoxeroides*, *Sagittaria latifolia*, *Nasturtium officinale*, *Eclipta alba*, *Equisetum, Mentha spicata*, *Canna indica* were observed in emergent form in the different location of water, such as ponds, river banks, irrigation channels, fisheries and water logged areas. *Cyperus fuscus* L., *Cyprus strigosus* L., *Scripus* ssp., *Fimbristylis bisumbellata* (forssk), *Apluda mutica* L, *Equisetum arvense* were observed in a marshy places and shallow habitats (Table-4). Among these aquatic plants *Potamogeton*

suboblongus and *Persicaria hydropiper* L. were the most poisonous weed while *Typha latifolia, Chara zeylancia, Naustersium officinales, Pistia stratioties, Eichhornia crassipes* L, were the most invasive and problematic weeds in all type of water bodies. Only a few plants like *Nasturtium officinale* were used as pot herb while *Typha* was used for making ropes, mats, baskets and blinds. *Persicaria hydropiper* Michx. was the most poisonous weed while *Eichhornia crassipes* (Mart.) Solms., *Pistia stratiotes* L., *Phragmites australis* and *Typha latifolia* L. were the most problematic weeds found abundantly in almost all water bodies of the study area.

These findings are supported by the following researchers who worked on various aspects of aquatic weeds. For example: Yan *et al.* (2001) worked on alien invasive aquatic weeds and concluded that significant damages to native flora, ecosystems and biodiversity have been done by theses weeds and suggested to manage the menace of these weeds through enhancing awareness, documentation of invasive species, strengthening co-operation, legislation, regulations and monitoring. Similarly they reported that the consequences of invasive aquatic weeds as a menace for hindering the delivery of ecosystem goods and services to people is a less explored area of plant sciences (Richardson & Van Wilgen, 2004) is also in line with our work. Moreover, Abbasi *et al*. (1990) worked on the utilization of common aquatic weeds for the CH_4 production and reported that natural stands of *Salvinia*, would produce energy (CH_4) @ 10^8 Kcal ha^{-1} $year^{-1}$. Aquatic weeds can also be utilized as feed for fish and poultry as being richer in minerals and proteins than some of the terrestrial forages (Lodge, 1991) which is also one of our suggestion in this paper.

In terms of the stability and balance of aquatic eco-system, aquatic plants are important components of many freshwater bodies unless and until they remain in equilibrium with that system. But when they exceeds the limit they becomes undesirable or weeds which might be due to some natural and anthropogenic influences as plants vary greatly in their responses to changes or biological stresses (Lacoul & Freedman, (2006). Similarly in terms of establishment of invasive aquatic plants Chambers et al. (2008) reported that many of the threats to fresh waters consequently result from a reduction in the biodiversity of that ecosystem which may subsequently affect the faunal diversity of aquatic ecosystems and culminate at the establishment of exotic species, at the expense of native species. While according to Dukes & Mooney, (1999) plant invasion is a major threat to biodiversity and an important element of global change.

Aquatic plants range from emergent plant to fully submerged species. Some plants although not fully aquatic, grow on the banks of water

bodies may be termed as water loving plants. The zonation and occurrence of aquatic plants at various positions with respect to the water surface on a vertical scale depends on anatomy, physiology, morphology, competition and adaptations etc. of the plants as discussed by Spence, (1982).

In terms of chemical weed control of aquatic weeds the herbicides has a direct effect on the overall flora and fauna, but the indirect effect of the dead biomass of aquatic weeds should not be ignored. Similarly the mechanically harvested biomass must be removed from the aquatic body by a more efficient and economical method to avoid its effects on water quality, related flora and fauna, intended use of water and water flow (Brooker & Edwards, 1975). Similarly the most expected climate change could significantly aggravate problems of invasive weeds and therefore work on these aspects must be the part of planning and management frameworks (Richardson & Van Wilgen, 2004).

Aquatic weeds categorization on basis of Plant Types

The aquatic weeds were grouped in study area on the basis of their position from water surface and it was evident from the data that 67% emergent aquatic weeds, 14 % were anchored floating aquatic weeds, 11% free floating aquatic weeds and 8% were submerged aquatic weeds as indicated in the Fig. 1.

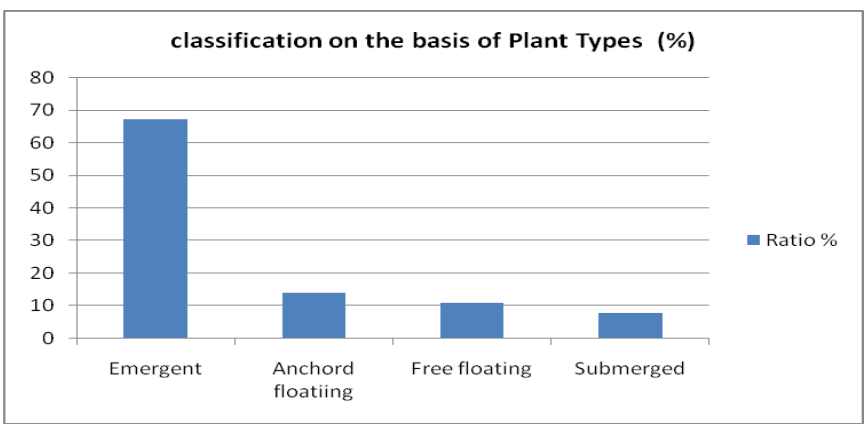

Figure 1. Aquatic weeds categorization on basis of Plant Types.

Aquatic weeds classification on the basis of Life Cycle

On the basis of life cycle, the aquatic weeds were classified and the data showed that there were 65 % perennial aquatic weeds as compared to the 35% annual aquatic weeds with zero percentage of the biennial aquatic weeds as illustrated from the Fig.2.

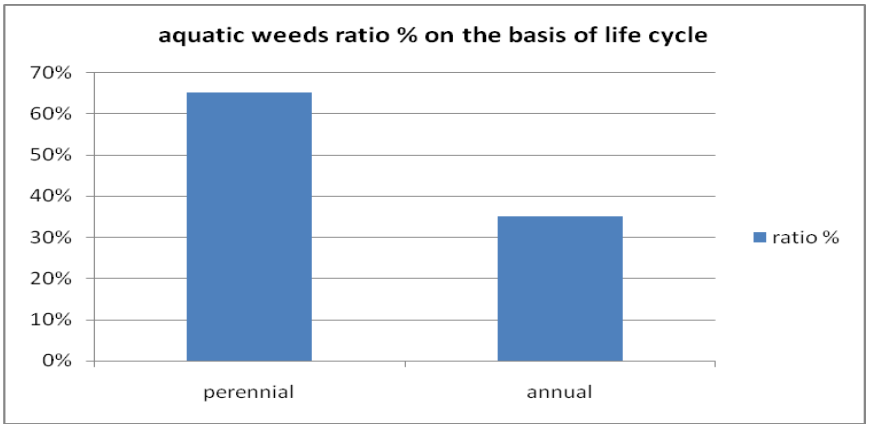

Figure 2. Aquatic weeds classification on the basis of Life Cycle.

Aquatic weeds classification on basis of Growing Habits in District Charsadda:

The aquatic weeds categorization on the basis of growing habits in study area revealed that there were 80 % herbaceous weeds, 12 % shrubby or shrub like aquatic weeds like *Ipomea carnea* and 6 % trees and only 2 % filamentous aquatic weeds present in the study area as presented in the Fig. 3.

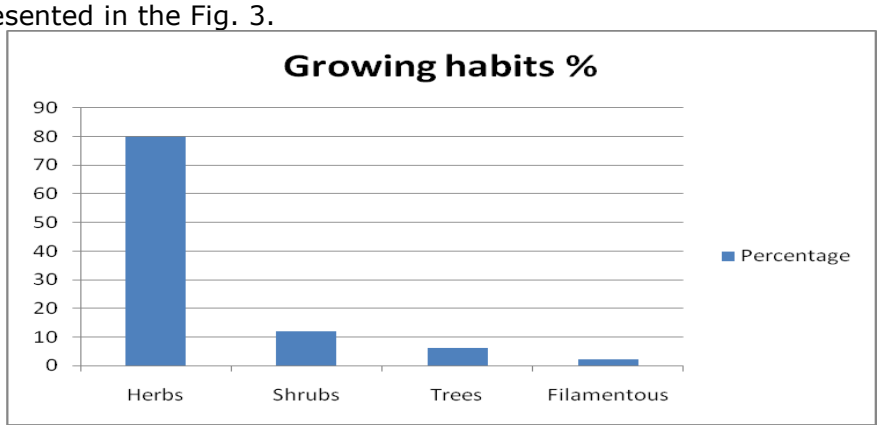

Figure 3. Aquatic weeds classification on basis of Growing Habits in District Charsadda

Table -1. List of submerged aquatic weeds collected from the study area of District Charsadda, Pakistan.

S. No.	Botanical name	English name	Family	Life cycle	Plant type	Habitat	Plant height	Growing habit	Water type	Water depth	Avail-ability
1	*Caretophylum demursum*	common hornwort	Ceratophyllaceae	A	S	Irrigation channels	1 feet	Spreading herb	Drain water	1 feet	Rare
2	*Spirogyra* spp.	Filamentous algae	Zygnemataceae	A	S	Fresh water ponds	5 feet	Filamento-us	Fresh water	2 feet	Commo n
3	*Hydrilla verticillata*	Hydrilla	Hydrocharitaceae	P	S	Water streams	0	Spreading herb	lakes and ponds	Variable	Rare

Table -2. List of free floating aquatic weeds from the study area (District Charsadda)

S. No.	Botanical name	English name	Family	Life cycle	Plant type	Habitat	Plant height	Growing habit	Water type	Water depth	Avail-ability
1	*Eichhornia crassipus*	Water hyacinth	Pontederaceae	P	F.F	Stagnant ponds	1 feet	Spreading herb	Fresh water	1 feet	Abunda nt
2	*Pistia stratiotes*	Water lettuce	Araceae	P	F.F	Stagnant water ponds	> feet	Spreading herb	Drain water	2 feet	Very rare
3	*Lemna minor* L.	common duckweed	Araceae	P	F.F	Stand water and ponds	0	Spreading herb	Drain water	2 feet	Rare
4	*Lemna azolla* L.	Duck weed	Lemnaceae	A	F.F	Stagnant Pond	1cm	Spreading herbs	3 feet Hard water	2 feet	Abunda nt

Table-3. List of anchored floating aquatic weeds from the study area (District Charsadda).

S. No.	Botanical name	English name	Family	Life cycle	Plant type	Habitat	Plant height	Growing habit	Water type	Water depth	Avail-ability
1	*Jussiaea repens*	Ledwigia	Onagraceae	P	A.F	Marshy land	3 feet	Spreading shrubs	2 feet fresh water	1 feet	Occasional
2	*Marsilea Quadrifoliata*	Water clover	Marsileaceae	P	A.F	Stagnant Pond	8 inch	herb Spreading	Hard water	4 feet	Very common
3	*Mersilia quardifolia*	water clover	Marsileaceae	A	A.F	Water channels	0	Spreading herb	Wet land	0.25-50 ft	Infrequent
4	*Mersilia minuta*	Water clover	Marsileaceae	A	A.F	Water channels	0	Spreading herb	above water or submerged	0 feet	Rare
5	*Potamogeton natans*	Floating leaf pondweed	Potomogentaceae	A	A.F	Water streams	0	Spreading herb	Drain water	1.5m	Infrequent

Table-4. List of emergent and Marshy aquatic weeds from the study area (District Charsadda)

S.No.	Botanical name	English name	Family	Life cycle	Plant type	Habitat	Plant height	Growing habit	Water type	Water depth	Avail-ability
1	*Typha elephantina*	Elephant grass	Typhaceae	P	E	Marshy	3 feet	Erect herb	Drain water	> feet	Abundant
2	*Typha latifolia* L.	Broad leaf Cattail	Typhaceae	P	E	Stagnant Ponds	6 feet	Erect herb	Salty & hard	2 feet	Very Abundant
3	*Phragmites australis*	Common reed	Poaceae	P	E	Stream banks	8 feet	Erect shrub	Salty & hard	1 feet	Very Abundant

4	*Pasphalam conjugantum*	Buffalo grass	Poaceae	A	E	All water bank	1 feet	Erect herb	Drain +fresh	> feet	Abundant
5	*Echinocloa colonum*	Barnyard grass	Poaceae	A	E	Stream and channels	3 feet	Erect herb	Fresh water	> feet	Rare
6	*Persicaria hydropiper*	Water Pepper	Polygonaceae	A	E	Stream banks	2 feet	Erect herb	Drain +fresh water	> feet	Common
7	*Alternanthera philoxeroides*	Alligator weed	Amaranthaceae	A	E	River banks	2 feet	Spreading herb	Fresh water	> feet	Abundant
8	*Canna indica*	Indian shot	Cannaceae	P	E	Marshy + Stream banks	5 feet	Erect herb	Drain +fresh water	1 feet	Infrequent
9	*Canna americanallis*	Bengal tiger	Cannaceae	P	E	River banks	6 feet	Erect herb	Drain +fresh water	1 feet	Infrequent
10	*Eclipta alba*	Bhringaraj	*Asteraceae*	A	E	Stream banks	1 feet	Erect herb	Fresh water	> feet	Common
11	*Salix alba*	White willow	Salicaceae	P	E	Wet areas along water	tree	Tree	lakes and streams	Water & wet area	Common
12	*Cyperus difformis*	Variable flatsedge	Cyperaceae	A	E	Marshy	3 feet	Herb	Moist and rice field	< feet	Very rare
13	*Cyperus* sp.	Sedges	Cyperaceae	A+P	E	Marshy	2 feet	Herb	stand or slow water	0.5 meter	Infrequent
14	*Fimbristylis bisumbellata*	Bubani	Cyperaceae	A	E	Marshy	2.5 feet	Herb	Marshy places	0.5-1 m	Common

15	*Scirpus mucronatus*	Bog bulrush	Cyperaceae	P	E	Drain + Marshy	4 feet	Herb	Terrestrial and shallow water	3 meter	Infrequent
16	*Scirpus triqueter*	Deergrass	Cyperaceae	A	E	Drain + Marshy	5 feet	Herb	stands water along rivers	3 meter	Common
17	*Cyperus iria*	Rice flatsedge	Cyperaceae	A	E	Marsh, Rice field	2 feet	Herb	Wet and dry land of rice	8-60 cm	Rare
18	*Nasturtium officiale*	Nasturtium	Brassicaceae	P	E	Drains water	5-15 cm	Herb	Dirty streams	2-3 inch	Abundant
19	*Sagittaria trifolia* L.	Arrow head leaves	Alismataceae	P	E	Stagnant water banks	1.5 feet	Herbs	Drain water	1 feet	Very rare
20	*Adiantum radianum*	Maidenhair Fern	Pteridaceae	P	E	Water banks	0.5 feet	Erect +herb spreading	Marshy places	0	Rare
21	Dryopteris spp.	Male fern	Dryopteridaceae	P	E	Wet lands	2 feet	Erect+ herb spreading	Marshy places	0	Common
22	*Salix tetrasperma*	Willow tree	Salicaceae	P	E	River bank	12 feet	Erect tree	2 feet Fresh	3 feet	Common
23	*Ipomea aquatic*	Water spinach	Convolulaceae	P	E	Stream Banks	6 feet	shrub Spreading	2 feet Fresh water	3 feet	Common
24	*Commelina diffusa*	Spreading day flower	Commelinaceae	A	M	Stream banks	1.5 feet	Spreading herb	Fresh water	> feet	Rare

Aquatic weeds categorization on the basis of abundance scale or their Availability:

In the categorization of the aquatic weeds on the basis of availability of the plants the *Common* aquatic weeds were 25%, *Rare* aquatic weeds 22%, the *Abundant* aquatic weeds 17%, *Infrequent* aquatic weeds were 17%, while the *Very Rare* were only 8%. Similarly the *Very abundant* aquatic weeds were found 6%, but the *Very common* aquatic weeds as well as the *Occasional* aquatic weeds both had the same percentage i.e. each 2% in the study area as given in Fig. 4.

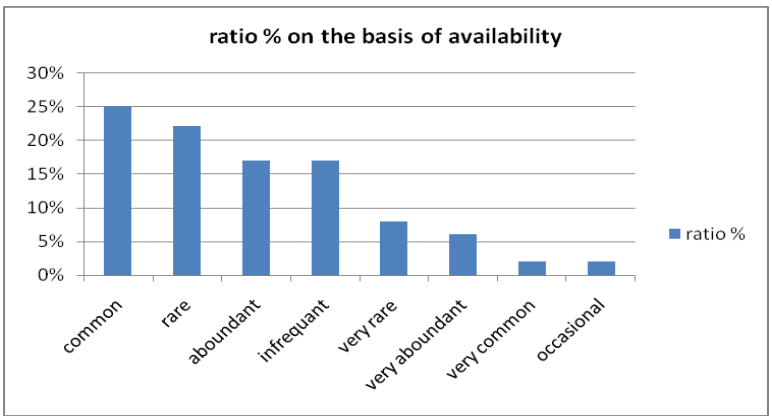

Figure 4. Aquatic weeds categorization on the basis of abundance scale or their Availability

CONCLUSION

Most of the water bodies in District Charsadda were found severely infested with noxious native as well as invasive aquatic weeds causing sedimentation, reduced water carrying capacity and resulting destructive water body structure, seepage, lowered water quality. Water logging and weak drainage system further promoted weed infestation. In this study the collected aquatic plants were classified in to different groups and subgroups according to their growth habit, habitats i.e. and the type of water body, life cycle and their position with respect to the water surface. Moreover, the uses, edibility and the phyto-toxicity/ noxiousness were also pointed out. On the bases of our study and observations it is recommended that further studies should be designed to investigate in details various aspects of individual water body and weed regarding the severity of their infestation, economic impact on agriculture, fisheries and water body. The utilization of weeds for the benefits of the society should also be undertaken. Moreover, economical and eco-friendly management strategies should be devised for the weeds declared as noxious and invasive.

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