J. Basic. Appl. Sci. Res., 1(12)3466-3474, 2011

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Study of Aquatic and Semi-Aquatic Plants of Aquatic Ecosystems of Siahrud-e Rudbar Protected Area is in N. Iran and Bioaccumulation of Heavy Metals by these Plants

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ABSTRACT

The aquatic and semi-aquatic flora of the Siahrud-e Rudbar Protected Area was investigated in the year 2008. A total of 192 plant specimens were collected and 60 species belonging to 38 genera and 26 families were identified. Of these, no one species are endemic to Iran. *Polygonum thymifolium*, *Equisetum palustre* and some species of Genera of Cyperus, Juncus and Lemna were the most abundant plants species in this study. Three families, Cyperaceae, 10 species, Polygonaceae, 6 and Juncaceae with 5 species, were largest families, respectively.

The phytogeographical affinities of the species were as follows: pluriregional 41%, euro-siberian 27%, iran-turanian 13%, iran-turanian & euro-siberian 12% and cosmopolite7%. The biological form rates of the species are as follows: hemocryptophyte (43%), cryptophyte (38%) and therophyte (18%), respectively. Also 3 (5%) species are in the IUCN list. Floating aquatic plants and semi-aquatic plants are the major categories, as a key species played an important role in aquatic ecosystems of region, in the accumulation of heavy metals and thus the richness of the plants species, about 700 species, can help.
KEY WORDS: Bioaccumulation, Emersed, Floating, IUCN, Siahrud-e Rudba, Submerged plants.

INTRODUCTION

Aquatic ecosystems, including ecosystems, saltwater, brackish and freshwater ecosystems are. Aquatic habitat for a total of ¾ Earth's surface are included, of which, about 98 percent of salt water ecosystems and the remaining 2% belong to freshwater ecosystems. Plants have adapted to different habitats. They are mostly terrestrial, but some of them lived in their water habitat. Aquatic plants are a natural part of any aquatic ecosystem into account. Types of animals as food or a place to hide is used. They refined the ecological balance of ecosystems and play an important role (Lanet al., 2010). Biological filter, they are irreplaceable role in maintaining aquatic ecosystems play. The spontaneous growth of aquatic plants and habitats are divided into five categories that include: Algae, floating plants, submerged plants, marginal plants and emerged plants.

Algae, phytoplanktons are tiny and large. Some floating plants by rhizome and roots attached to the bed sediments. Relatively large leaves of these plants are widespread in surface water. Absorb water and minerals from the seabed, but in air gas exchange takes place. Some floating plants also lacked roots و can absorb water and minerals directly from water this done. Most of floating Plants had significantly higher growth rate and between aquatic plants are painful. The genera Lemna, Wolffia and Nymphaea are of this category. Immersed completely immersed in water and flowers, they just might be in surface or out of the water. The roots of these plants have a role in stabilization of the plant and material is often absorbed by the adventitious roots. Plants such as Ceratophyllum and Potamogeton are in this place. Emersed plants in the coastal area to a certain depth of water have been developed. Usually the roots and lower parts of the plants in water and mud have been established. Foliage and flowers, they are above the water surface. This is the kind of vegetation such as Sagittaria.

Depending on how water and their habitats, marginal plants to be expanded. Plants such as Juncus, Cyperus, Phragmites have this one. Research shows that aquatic ecosystems, a high capacity to store nutrients, such as phosphor in during of aquatic plants growth. Some aquatic plants can absorb organic compounds and minerals within the water and reduce pollution. In addition, aquatic plants can absorb toxic metals and dangerous cadmium, nickel, mercury, phenols, and carcinogens are, so that they can absorb and concentrate. In recent years, heavy metal uptake by aquatic plants, mainly of interest is located. Recent studies have demonstrated that aquatic plants can store large amounts of heavy metals in their tissues (Arts

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et al., 2008). Submerged aquatic plants are the most important plants in the ecosystems that such areas have a monitoring role in the structure and function. They are important concentrations of heavy metals (Thiebaut et al., 2010). Species of Potamogeton in water ecosystems around the world are growing, are the pioneers of Phytoremediation, as compared most of plants species contaminated water, colonies are fast (Lilitet al., 2006). Phytoremediation efficient and effective way to remove heavy metals, which in recent years much attention has been located. The definition of plant and microbial communities associated with them in order to disable or eliminate pollution of the environment. The strategies that are used to protect the environment by means of plants, which have been called Phytotechnologies that, Phytoremediation is a part of it.In this strategy, plants for treatment, reliability and control of pollution or contaminated places are used (Prasad, 2007). Jose (2009) and colleagues found the aquatic plant *Azolla caroliniana*, 93 % of the mercury-contaminated water in a 12-day period, the draws. Studies have demonstrated that aquatic plants play an important role in the food chain and consequently are in life (Penget al., 2008). Absorbed through roots and leaves are considered two basic methods of heavy metals absorb in aquatic plants. Aquatic plants absorb toxic elements are in a different capacity. Reports indicate that plants can absorb heavy metals in the act of choice. In the past two decades, studies have shown that *Lemna minor* plant can absorb large amounts of cadmium and researchers from the plant to absorb cadmium in surface water use. This plant is a good option for the purposes of phytoremediation, because it grows rapidly and easily harvest takes place. According to studies Khellaf & Zerdaoui (2009), aquatic plants can absorb the pesticides and modify them as useful. Aquatic plants such as *Lemna minor*, *Elodea Canadensis* high capacity for doing the show. Among heavy metals, chromium, copper, zinc and nickel are less toxic than iron and aluminum. Due to the indiscriminate destruction of vegetation due to construction of housing and factories, and the resulting increase in household and industrial waste entering the water, the necessity of this research is justified. Wastewater and industrial plants, large amounts of heavy metals are urban households. Studied area, "Siahrud-e Rudbar protected area" is located in Guilan province, 35 km NE of Rudbar between 49° 32′-49° 51′ E and 36° 44′-36° 54′ N (Fig. 1). The region was declared a protected area in 1999, and to date no floristic study had been done.

The total area is 28,289 hectares, including 5000-6000 hectares of closed forests with the remainder as pasture or agronomic lands. The altitude of the area ranges between 220-2220 m, with a mean annual precipitation and temperature of 800 mm and 14°C, respectively. The climatic characteristics of the study area were estimated according to an ombrothermic evaluation of data from the Manjil and Pasikhan meteorological stations (Fig. 2). Approximately 10 months are “wet” months, with the remaining two (June and August) considered “dry” months. The coldest months are January and February with a minimum temperature of 2.8 and 2.3°C, respectively. The hottest months are June and July with a maximum temperature of 18.1°C and 19.6°C respectively. This temperate humid climate is clearly reflected in the flora and vegetation of the study area.The purpose of this study identify important aquatic plants, aquatic ecosystems and their importance in the removal of Siahrud-e Rudbar protected area river pollution is given the key role in maintaining the fauna and flora area, with a solution that we can prevent their extinction.

MATERIALS AND METHODS

To gather and introduced aquatic species in the Siahrud-e Rudbar, field operations and sampling was done in the years 2007 and 2008. To this end, during the growing seasons, plants, referring to the region, Aquatic ecosystems from all parts of the region were sampled. To collect emersed plants and plants that are growing on the shore of a selective sampling method was used. for samples immersed plants, from instruments used furcated. Handle nets were used to collect floating plants. The plants were then washed by water to disinfect and clean the plastic containers were cleaned with water. Materials and tools needed for drying the pressed board, cardboard and paper drying the paper. After complete drying, the samples were attached on herbarium glossy paper and then transferred to Farabi herbarium (FAR) of Tarbiat Moallem University, Tehran, Iran, to identify their work done. On aquatic species were found in Phytoremediation. Life forms of plants based on the system Raunckiaer (Zohary, 1969a) were determined. Geographical distribution of plant species based on vegetative areas divided by Leonard and White (1991) took place.

RESULTS

In the study a total of 192 plant specimens were collected and 60 species belonging to 38 genera and 26 families were identified and the life of their affiliation to the water and soil. Table 1 List of plant species with the biological and phytogeographical affinities they are shown. Table 2 Shows, Plants species for phytoremediation of heavy metals (Prasad et al., 2001, 2006).

Three families, Cyperaceae, 10 species, Polygonaceae, 6 and Juncaceae with 5 species, were largest families, respectively.Geographical distribution of plant species in the region showed that pluriregional species 41% the highest and cosmopolite with 7%, the lowest percentage in the geographical are allocated to (Fig. 3). Investigation showed that the biological form of hemicryptophytes with 26 species (43%) ranked first, cryptophytes 23 species (38%) ranked second and therophytes with 11 species (18%) is allocated to the next rank (Fig. 4). Also 3 (5%) species are in the IUCN * list (Tab. 3).

DISCUSSION

192 plant specimens were collected from the study area. A total of 26 families, 38 genera and 60 species were identified (see Tab.1). Studies show that, with a diversity of aquatic species in the study area is relatively good. Species that are abundant in the area can be *Equisetum palustre*, *Iris pseudacorus*, *Sparganium erectum* and *Typha turcomanica* noted that a high percentage of aquatic plant species make up the region. Most aquatic plants, pond and wetlands area show a high density. Species such as *Lemna minor*, and *Potamogeton natans* surface of the pool area are fully covered.

Geographic distribution of aquatic plant species protected area suggests that the Siahrud-e Rudbar pluriregional species with the 41%, highest, and cosmopolite species with the 7%, lowest percentage of its geographical distribution have. Plants have several strategies for dealing with toxic chemicals in the environment surrounding the show includes: Phytoextraction, Rhizofiltration, Phytostabilisation, Phytodegradation, Phytovolatilization are (Fig. 5).

Phytoextraction plants that do have a high capacity to absorb metal contaminants in the extremities are no symptoms of poisoning. Plants are capable of more than 100 milligrams of Cd, 1000 mg kg of Pb, Cu and Co and 10,000 mg per kg of Zn and Ni in its shoot to save, hyperaccumulator plants are considered. These values are 10 to 500 times more than the normal plants. In Rhizofiltration, terrestrial and aquatic use plants with lower concentrations of the pollutants or sediments are concentrated in the roots. This method is particularly suitable for industrial sewage, agricultural runoff and acid mine drainage is used. Phytostabilisation using the root power, mobility and accessibility of pollutants in the soil decreases.
Phytovolatilization, plants absorb pollutants from the soil and then evaporates into the atmosphere and the transpiration transfer. In Phytodegradation, plants with their metabolism, transport, degradation, stability and sublimation compound emissions, helping to remove contaminants from soil and groundwater. In this method, organic compounds are broken down into simpler molecules that can be inserted into plant tissue. Phytoremediation by various aquatic plants isn't similar in different ecosystems. Aquatic plants due to having different characteristics haven't the same function and absorption of heavy metals in the act of choice. pH has an important role in this regard. Studies show that plants absorb zinc, copper and lead an active act, but the metal cadmium in Floating plants are more effective. Emersed plants with big roots in the ability of metals in soils and sediments are consolidated.

One of the obstacles to commercial implementation of phytoremediation, how the consumption of infected plants. After harvest, contamination of soil by the plant decreased, but the amount of biomass produced is dangerous. Burning and gas production techniques for producing electrical energy and heat that can be extracted from infected plants. This recycling of energy by burning (in the closed space) biomass or natural gas production could be a high economic value because it can not be used as fodder or fertilizer.

In general we can say the first step towards the introduction of plants that are able to remove pollutants; Identify plants and their tolerance to high concentrations of toxic metals are that can we choose the best plant varieties can help to remove these toxic compounds.

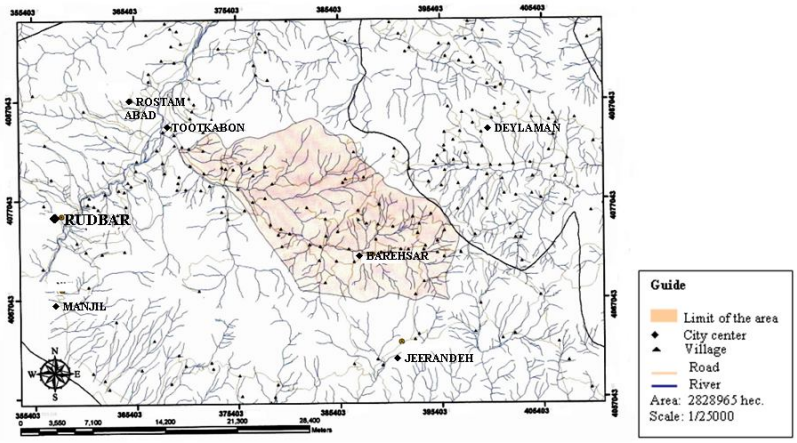
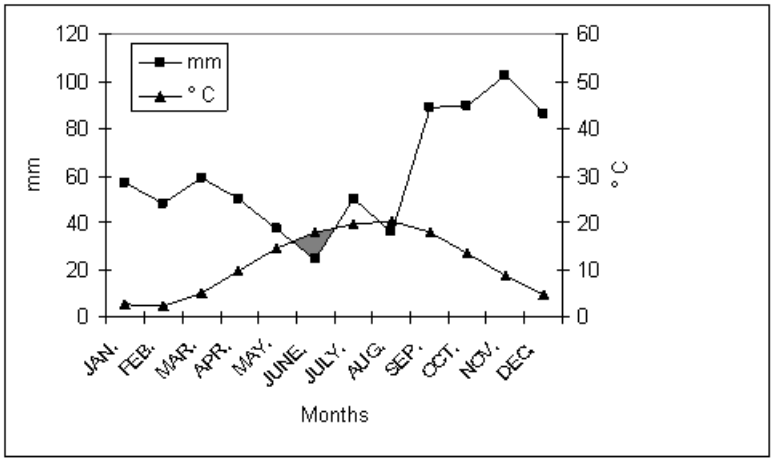


Figure1. Map of study area.



Dry month Precipitation month

Figure 2. Ombrothermic climatic diagram of area

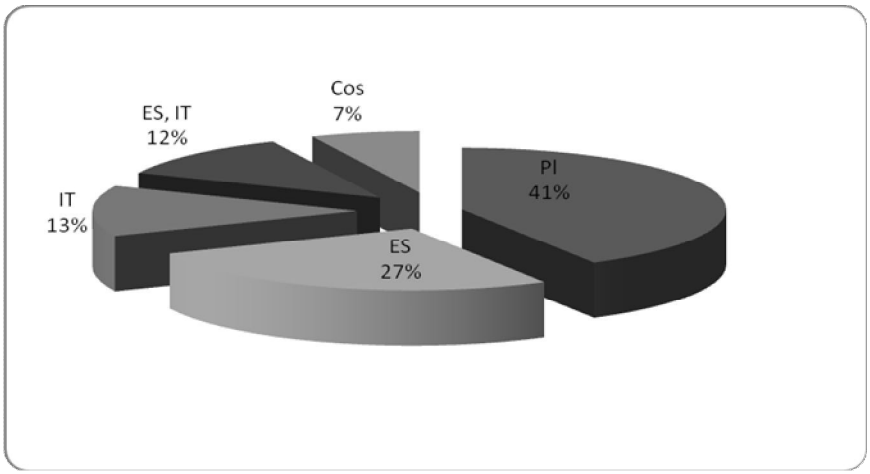


Figure 3. Geographic distribution of aquatic plants in the study area.

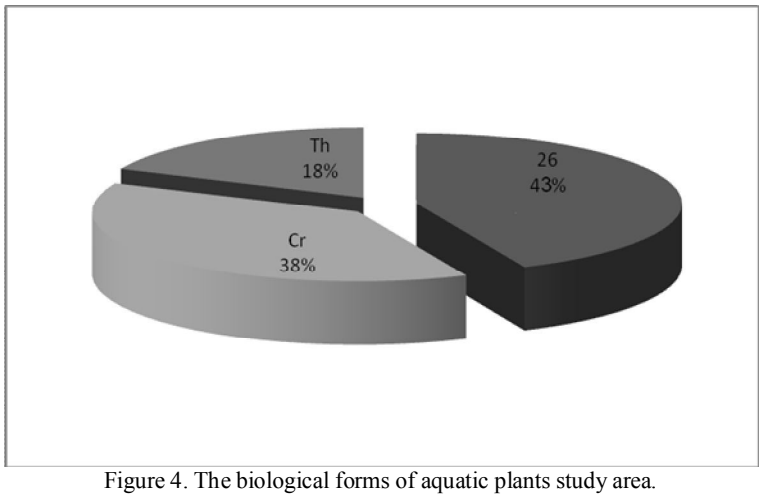


Figure 4. The biological forms of aquatic plants study area.

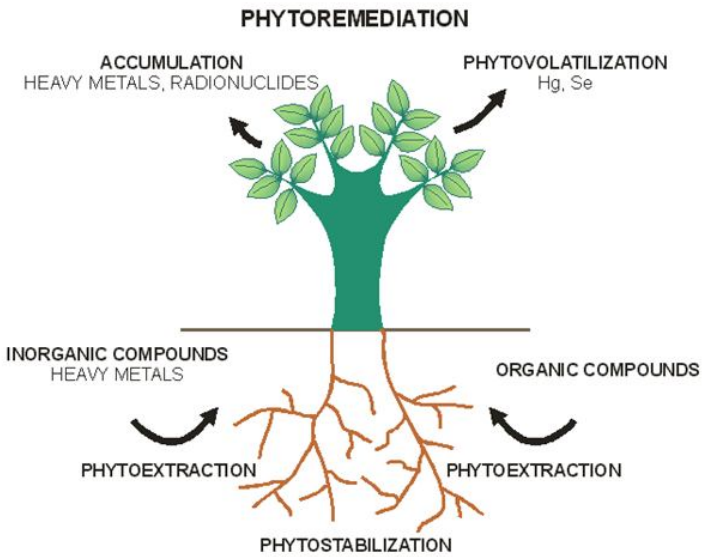


Figure 5. Schematic picture of Plants strategy for phytoremediation.

Table1. Biological form and choro type of aquatic and semi-aquatic plants species in Siahrud-e Rudbar protected area.
Life Form: Cr = Cryptophytes, He = Hemicryptophyte, Th = Therophyte.
Chorotype: ES = Euro-Siberian, Pl = Pluriregional, Cos = Cosmopolitan, IT = Irano-Turanian.

Row	Species	Family	Biological Form	Chorotype
1	*Equisetum palustre*	Equisetaceae	Cr	**ES**
2	*Bellis perenis*	Asteraceae	He	**Pl**
3	*Petasites hybridus*	Asteraceae	Cr	**ES**
4	*Tussilago farfara*	Asteraceae	Cr	**ES**
5	*Myosotis caespitosa*	Asteraceae	He	**ES**
6	*Nasturtium officinale*	Brassicaceae	He	**Pl**
7	*Symphyandra odontocepala*	Campanulaceae	He	**ES**
8	*Ceratophyllum submersum*	Ceratophyllaceae	Cr	**Pl**

9	*Geranium montanum*	Geraniaceae	He	**ES**
10	*Hippuris vulgaris*	Hippuridaceae	Cr	**Cos**
11	*Mentha longifolia*	Lamiaceae	He	**Pl**
12	*Perilla frutescens*	Lamiaceae	Th	**ES**
13	*Lythrum hyssopifolia*	Lythraceae	Th	**ES**
14	*Lythrum salicaria*	Lythraceae	He	**Pl**
15	*Epilobium algidum*	Onagraceae	He	**IT**
16	*Epilobium hirsutum*	Onagraceae	Cr	**Pl**
17	*Epilobium minutiflorum*	Onagraceae	He	**Pl**
18	*Oxalis corniculata*	Oxalidaceae	Th	**Pl**
19	*Plantago lanceolata*	Plantaginaceae	He	**Pl**
20	*Plantago ovata*	Plantaginaceae	He	**Pl**
21	*Polygonum hydropiper*	Polygonaceae	Cr	**ES**
22	*Polygonum hyrcanicum*	Polygonaceae	Th	**ES**
23	*Polygonum orientale*	Polygonaceae	He	**IT**
24	*Polygonum patulum*	Polygonaceae	Th	**IT**
25	*Polygonum persicaria*	Polygonaceae	Th	**Pl**
26	*Polygonum thymifolium*	Polygonaceae	Cr	**IT**
27	*Anagalis arvensis*	Primulaceae	Th	**Cos**
28	*Lysimachia dubia*	Primulaceae	Th	**ES, IT**
29	*Potentilla reptans*	Rosaceae	He	**Pl**
30	*Veronica persica*	Scrophulariaceae	Th	**Pl**
31	*Veronica polita*	Scrophulariaceae	Th	**Pl**
32	*Phyla nodiflora*	Verbenaceae	He	**Pl**
33	*Alisma lanceolatum*	Alismataceae	He	**Pl**
34	*Alisma Plantago - aquatica*	Alismataceae	He	**ES, IT**
35	*Blysmus compressus*	Cyperaceae	He	**ES**
36	*Carex divulsa*	Cyperaceae	He	**ES, IT**
37	*Carex grioletii*	Cyperaceae	He	**ES**
38	*Carex melanostachya*	Cyperaceae	He	**ES**
39	*Carex pendula*	Cyperaceae	He	**Pl**
40	*Cyperus fuscus*	Cyperaceae	Cr	**Pl**
41	*Cyperus rotundus*	Cyperaceae	Cr	**Pl**
42	*Eleocharis palustris*	Cyperaceae	He	**ES**
43	*Fimbristylis miliacea*	Cyperaceae	Cr	**ES, IT**
44	*Schoenoplactus lacustris*	Cyperaceae	He	**ES**
45	*Cynodon dactylon*	Poaceae	He	**Pl**
46	*Poa annua*	Poaceae	Th	**ES, IT**
47	*Juncus acutus*	Juncaceae	Cr	**ES, IT**
48	*Juncus articulatus*	Juncaceae	Cr	**Pl**
49	*Juncus fontanesii*	Juncaceae	He	**Pl**
50	*Juncus inflexus*	Juncaceae	Cr	**Pl**
51	*Luzula forsteri*	Juncaceae	He	**Pl**
52	*Iris pseudacorus*	Iridaceae	Cr	**ES**
53	*Lemna minor*	Lemnaceae	Cr	**Cos**
54	*Lemna trisulca*	Lemnaceae	Cr	**Cos**
55	*Potamogeton natans*	Potamogetonaceae	Cr	**Pl**
56	*Potamogeton lucens*	Potamogetonaceae	Cr	**IT**

57	*Potamogeton oblongus*	Potamogetonaceae	Cr	**IT**
58	*Sparganium erectum*	Sparganiaceae	Cr	**ES, IT**
59	*Typha latifolia*	Typhaceae	Cr	**IT**
60	***Typha turcomanica***	**Typhaceae**	**Cr**	**IT**

Table 2. Plants species for Phytoremediation of heavy metals (Prasad et al., 2001, 2006).

Row	Plants species	Toxic Metals
1	*Azolla fililiculiodes*	**Cr, Ni, Zn, Fe, Cu, Pb**
2	*Azolla pinnata*	**Cd, Cr, Zn**
3	*Bacopa monnieri*	**Hg, Cr, Cu, Cd**
4	*Carex juncell*	**Cu, Pb, Zn, Co, Ni, Cr, Mo, U**
5	*Carex rostrata*	**Cu, Pb, Zn, Co, Ni, Cr, Mo, U**
6	*Ceratophyllum demersum*	**Cd, Cu, Cr, Pb, Hg, Fe, Mn, Zn, Ni, Co, andradionuclides**
7	*Cynodon dactylon*	**As, Cd, Cu, Pb, Hg, Mo, Ni, Se, Zn**
8	*Cyperus eragrostis*	**Cd, Cu, Pb, Zn**
9	*Echhornia crassipes*	**As, Cd, Co, Cr, Cu, Al, Ni, Pb, Zn, Hg, P, Pt, Pd, Os, Ru, Ir, Rh**
10	*Elodea canadensis*	**Zn, Cu**
11	*Elodea densa*	**Hg, methyl-Hg**
12	*Eriocaulon septangulare*	**Hg, Pb, Cd, Fe**
13	*Hydrilla verticillata*	**Hg, Fe, Ni, Pb**
14	*Hygrophila onogaria*	**Hg, methyl-Hg**
15	*Isoetes lacustris*	**Cu, Pb**
16	*Juncus effuses*	**As, Se, Zn, Ni, Pb, Cd, Cr, Hg**
17	*Lemna minor*	**Mn, Pb, Ba, B, Cd, Cu, Cr, Ni, Se, Se, Zn, Fe**
18	*Ludwigia natans*	**Hg, methyl-Hg**
19	*Mentha aquatica*	**Cd, Zn, Cu, Fe, Hg**
20	*Myriophyllum aquaticum*	**Se**
21	*Myriophyllum spicatum*	**Cd, Cu, Zn, Pb, Ni, Cr**
22	*Najas marina*	**Cd, Fe, Pb, Mn**
23	*Nuphar luteum*	**Cu, Ni, Cr, Co, Zn, Mn, Pb, Cd, Hg, Fe**
24	*Nymphoides germinate*	**Cd, Cu, Pb, Zn**
25	*Pistia stratoites*	**Cu, Al, Cr, P, Hg**
26	*Polygonum amphibium*	**Cd, Cu, P, Pb**
27	*Potamogeton communis*	**Ni, Cr, Co, Zn, Mn, Pb, Cd, Cu, Hg, Fe**
28	*Potamogeton nattenuatum*	**Cd, Cu, Pb, Zn**
29	*Ranunculus aquatilis*	**Mn, Pb, Cd, Fe**
30	*Ruppia maritime*	**Mn, Pb, Cd, Pb, Fe, Se**
31	*Salvinia acutes*	**Mn, Pb**
32	*Scirpus lacustris*	**Cr**
33	*Spirodela polyrrhiza*	**Cr**
34	*Typha domingensis*	**Cd, Cu, Pb, Zn**
35	*Typha latifolia*	**Ni, Cr, Co, Zn, Mn, Pb, Cd, Cu, Hg, Fe**
36	*Vallisneria americana*	**Cd, Cr, Cu, Ni, Pb, Zn**
37	*Vallisneria spiralis*	**Hg**
38	***Wolfia globosa***	**Cd, Cr**

Table 3. Aquatic plants on the IUCN list in the study area.

Row	Species	Rank
1	*Geranium montanum*	UV
2	*Mentha longifolia*	LR
3	***Polygonum hyrcanicum***	LR

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