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[Short Communication]

Distribution and abundance of high aquatic plants in the Gorganroud River, the Caspian Sea basin, Iran

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ABSTRACT
The distribution and abundance of high aquatic plants in the Gorganroud River was examined at five stations in four seasons (20 samples) over one year period during 2009-2010. We identified 21 species of aquatic plants from 21 genera, belonging to 9 families. These species were determined as 3 halophytic species (14.2%) and 18 high aquatic plants (85.7%).The highest species diversity was observed at Khajenafas, Aq qala and Chargoli stations(17, 13 and 11 species) respectively, The highest biomass of high aquatic plants were recorded in summer (for Inspection and Chargoli stations 11.5 and 10.1 $g.m^{-2}$, respectively) and autumn (for the station of Inspection was 8.5 $g.m^{-2}$ dry weight). The most dominant species were different in the investigated stations. At station 1 species *Tamarix kotschyi*, at station 2 species *Juncus acutiflorus*, at station 3 species *Hordeum murinum hudson*, at station 4 species *Salicornia europaea L* and at station 5 *Juncus acutiflorus* species were dominated.

Keywords: *High aquatic plants, Gorganroud River, Biomass*

INTRODUCTION
High aquatic plants play an essential role in the function of the ecosystems of shallow lakes and rivers. These plants are involved in several feed-back mechanisms that tend to keep the water clear even in relatively high nutrient loadings (Moss, 1990) and therefore crucial for the shallow water areas. Rivers are among the most dynamic and complex ecosystems playing a major role in a landscape biodiversity. They are highly sensitive to the nutrients, which influence the primary producers at most. Increasing human activities, particularly urbanization, agriculture, and industry increase eutrophication. Freshwater high aquatic plants are fundamental to the structure and functioning of lowland river habitats (Baatrup-pedersen & Rills, 1999). Rooted high aquatic plants have an important role related to energy flow, nutrient cycling, and sedimentation processes. They improve water quality, directly through oxygenation and nutrient recycling, and indirectly by providing surface for water-purifying algae, fungi and bacteria(Holmes, 1984). High aquatic plants provide food and shlter for aquatic invertebrates and fish. In addition, macrophyte stands have been reported to notably affect lake nutrient status, renewed suspantion of bottom material and water turbidity (James & Barko 1990, Sand-Jensen & Borum 1991, Horppila & Nurminen 2001). The quantitative role of high aquatic plants in river ecology is closely linked to their areal distribution and biomass, which in turn is a synergy of various environmental factors(Duarte *et al*. 1986, Middelboe & Markager 1997).

They have tremendous capacity of absorbing nutrients and other substances from the water (Boyed, 1970) and hence brings the pollution load down. It is found to be most effective in removal of BOD, COD, nitrogen, phosphorus, organic carbon, suspended solids, phenols, pesticides, heavy metals etc from waste water (Gupta, 1982).

MATERIALS AND METHODS

Study area

This study was performed from April 2009 through March 2010, by seasonally sampling of high aquatic plants of Gorganroud River. Gorganroud River basin is established in the north of Iran at the northern hillside of Alborz Mountains, Golestan province, southeast of the Caspian Sea. The study area was a part of Gorganroud River, located between 05427460 E- 3700744N and 05359984E-3658516N (Table1) in the Gharn abad catchment (Fig. 1).

Table 1. Location of the sampling stations in Gorganroud during 2009-2010.

Station	Location	Latitute	Longitude	Distance from Estuary(Km)
1	Aq qala	05427460	3700744	49.67916
2	Khajenafas	05405792	3659765	10.54746
3	Charghli	05402936	3659231	6.85222
4	Inspection	05401423	3658686	3.30272
5	Estuary	05359984	3658516	-

Fig 1. Sampling stations along the Gorganroud River 2009-2010.

Methods of sampling and analysis high aquatic plants

Aboveground, living biomass of dominant species of high aquatic plants assessed seasonally at discrete sampling stations along the study area by limnological method using a 50×20 cm plot in each station in three repetitions. Plotting was performed in randomized manner. After plotting, all the high aquatic plants were cut. Upon return to laboratory, blades of high aquatic plants sampled from each quadrate were identified and sorted by species and repackaged as sub-samples that were thereafter analyzed separately .If any high aquatic plants blades appeared dead or senescent; they were removed and not computed. Each sorted group was then briefly sprayed with distilled water to remove sediment and patted to surface dryness with absorbent toweling. After appropriate transformation wet weights of samples were measured, dried at 105°C for 24 h or until a constant weight was attained, and re-weighed. Dry weights were considered to be the primary unit of biomass (Patrick Center for Environmental Research).

After species identification and biomass computation, for investigation and comparison between four seasons and five stations evaluated MSTATC software. In additional all maps including land use, site and area study were preformed as GIS (geographical information system) program. All graphs for high aquatic plants were prepared using Excel (Microsoft Office, 2010).

RESEULTS AND DISCUSSION

Distribution and abundance of high aquatic plants

The number of species in this part of the River stretch in the sampling stations ranged from 3 to 21. The species that occurred in great abundance were found in a variety of habitats from riffles to rivers, exhibiting different habits, with regard to abiotic conditions.

Species were distributed to ecological types including 3 Halophytic species (14.3%) and 18 (85.7%) high aquatic plants species. The reason for lack of hydrophytes plants in the study area could be associated with the large amount of wood which tend to be settled on the bottom, to interfere for absorbing minerals and water turbidity by plants and then to decrease process of photosynthesis.

Table 2. Existing Species of high aquatic plants in the Gorganroud River during 2009-2010

Row	Family	Genus	Species	Ecological type	Station				
					1	2	3	4	5
1	*Asteraceae*	*Sonchus*	*S.oleraceus L.*	II	+	+	-	-	+
2	*Asteraceae*	*Silybum*	*S.marianum(L.)Gaertner*	II	-	+	-	-	-
3	*Asteraceae*	*Helianthus*	*H. annus L.*	II	-	-	-	-	+
4	*Asteraceae*	*Artemisia*	*A. bsinthium L.*	II	-	+	-	-	-
5	*Asteraceae*	*Centaurea*	*C. virgata(lam).*	II	-	-	-	+	-
6	*Asteraceae*	*Inula*	*I. salicina L.*	II	-	-	+	-	-
7	*Chenopodiaceae*	*Suaeda*	*S. maritime (L.)Dumort*	II	+	+	-	-	-
8	*Chenopodiaceae*	*Salicornia*	*S. europaea L.*	I	-	-	-	+	+
9	*Chenopodiaceae*	*Atriplex*	*A. tatarica L.*	II	+	+	+	-	-
10	*Chenopodiaceae*	*Chenopodim*	*C. album L.*	II	+	+	+	+	-
11	*Juncaceae*	*Juncus*	*J. acutiflorus (Ehrh).*	I	-	+	+	+	+
12	*Malvaceae*	*Malva*	*M. sylvestris L.*	II	-	+	+	-	-
13	*Papilionaceae*	*Alhagi*	*A. camelorum Fisch*	II	+	+	+	-	-
14	*Papilionaceae*	*Melilotus*	*M. officinalis (L.)Desr.*	II	+	+	-	-	-
15	*Poaceae*	*Hordeum*	*H .murinum hudson*	II	+	+	+	-	-
16	*Poaceae*	*Lophochloa*	*L.phleoides(vill.)Reichenb*	II	+	+	-	-	-
17	*Poaceae*	*Lolium*	*L. perenne L.*	II	+	+	+	-	-
18	*Poaceae*	*Phragmites*	*P.australis(Cav.)Trin.Ex Steud.*	I	+	+	+	+	+
19	*Polygonaceae*	*Rumex*	*R. acetosella L.*	II	+	+	+	+	-
20	*Polygonaceae*	*Polygonum*	*P. hyrcanicum Rech. f.*	II	+	+	-	+	-
21	*Tamaricaceae*	*Tamarix*	*T. kotschyi (Bunge.).*	II	+	+	+	-	-

Note: "1" Aq qala, "2" Khajenafas, "3" Charghli, "4" Inspection, "5" Estuary, "+" presence, "-" absent; I - helophyte, II – mesophyte

Phragmites australis and Juncus acutiflorus were found mainly in the shallow parts . *Tamarix kotschyi (Bunge), Rumex acetosella* (L.), *Hordeum murinum* (Steud.) , *Silybum masianum, Lolium perenne* (L.), *Juncus acutiflons* (Ehrh.) were found mainly in the shore of River.

Lolium perenne (L.), *Hordeum murinum (Steud.), Lophochloa phleoides* (vill.), were more frequent and abundant in the first half of the River, while *Salicornia herbacea* (L.) Only were found in the second half of the River and *Juncus acutiflorus (*Ehrh.) *and Phragmites australis* found in the second half of the River in a greater abundance than the first half.

High aquatic plants biomass were high in all zones, as might be expected during summer at the late period of the growing season.

At station 1 *Hordeum glaucum* (Steud.) and *Lolium perenne* (L.) had the highest abundant in spring, while *Tamarix kotschyi* (Bunge.) and *Atriplex tataricu* had the highest abundant in summer respectively. *Tamarix kotschyi* (Bunge.) had the highest abundant in autumn, while the amount of *Rumex acetosella* (L.) increased with decreasing temperature in winter.

At station 2, *Juncus acutiflons* (Ehrh.) had an incremental growth in the three seasons of year and it had highest abundant between all the species. This station was infertile in the winter approximately.

At station 3 *Lolium perenne* (L.) *and Juncus acutiflons* (Ehrh.) had highest abundant and *Lolium perenne* (L.) more abundant than *Juncus acutiflons* (Ehrh.). *Hordeum glaucum* (Steud.) and *Juncus acutiflons* (Ehrh.) were the abundant species in summer. The amount of high aquatic plants in this station was very low in autumn and winter.

At station 4 a low amount of high aquatic plants [*Juncus acutiflons* (Ehrh.)] were found in spring. *Salicornia* was most in summer,

while *Juncus acutiflons* (Ehrh.) was most in autumn. In winter only a low amount of *Juncus acutiflons* (Ehrh.)was observed.
At station 5 only four species were found. *Juncus acutiflons* (Ehrh.) and *Phragmites australiss* had higher abundance in spring respectively, while *Phragmites australiss*, *Salicornia herbacea* (L.),and *Herlianthus annus* were most in summer respectively. Finally in autumn and winter *Phragmites australiss* had highest abundance than the other species.
Looking at the high aquatic plants' charts, the diversity of high aquatic plants was found to be decreased from station 1 to station 5. Increasing salinity and changing in chemical – physical factors in this part (station 5) may be the reasons for that because station 5 was situated at the same level as estuary and water of the River might be influenced by brackish water of the Caspian Sea.

Biomass of High aquatic plants
As shown in Table 3 that biomass of the aquatic plants was significantly affected by season (P = 0.0123), station (P = 0.0000) and their interaction (P = 0.0001).

Table 3. Variance analysis for biomass based on stations and seasons.

Source	DF	SS	MS	F	P
Season	3	0.0002	0.00001	6.197	**0.0123**
Error	8	0.00008	0.000002	18.8219	
Station	4	0.00009	0.00001	8.7418	**0.0000**
Season*Station	12	0.0004	0.000008	4.6365	**0.0001**
Error	32	0.00003	0.000001		
Total	59	0.001			

Split-plot design, n=3.

Higher biomass was found at stations 3 and 4 during summer (0.0115 and 0.0101 kg/m^2, respectively as well as station 4 during autumn (0.0085 kg.m^{-2}) ($P<0.05$) (Table 5).
Higher biodiversity of high aquatic plants was found at stations 1, 2 and 3 (14, 14 and 15 species), while it reduced at stations 4 (7 species) and 5 (4 species) (Figs. 23-25). On the other hand, dominant species varied in different stations. In station 1, the most dominant species was *Tamarix kotschyi* (Fig. 2). Greatest biomass at station 1 is observed in summer. This may be due to the increase in water temperature and the speed of a number of processes (dilution, assimilation, sedimentation, etc.), which increases the amount of nutrients required for the growth of high aquatic plants.

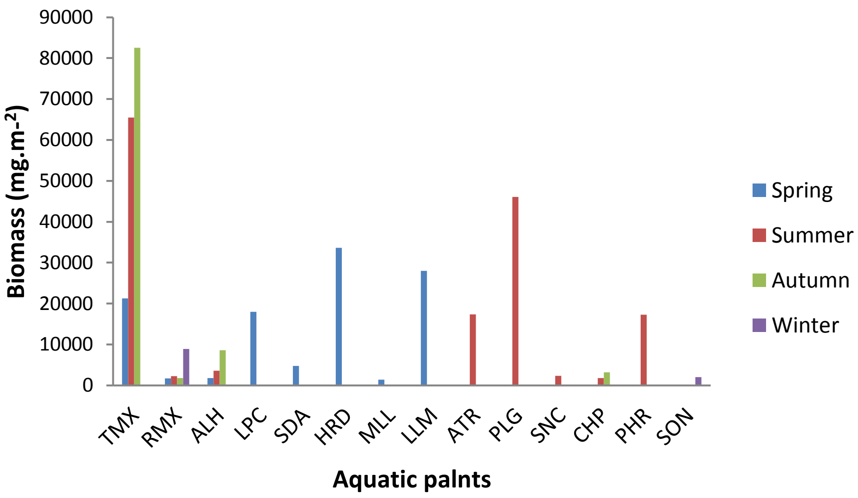

Fig 2. Change in biomass of different aquatic plants species in station 1 during seasons (TMX. - *Tamarix*, RMX. – *Rumex*, ALH. – *Alhagi*, LPC.- *Lophochloa*, SDA - *Suaeda*, HRD – *Hordeum*, MLL – *Melilotus*, ATR – *Atriplex*, PLG – *Polygonum*, SNC – *Sonchus*, CHP - *Chenopodium*, PHR - *Phragmites*, SON – *Sonchus)*

At station 2 (Fig. 3) the highest biomass was observed in summer. Aquatic plants in the study area play a role as habitat, shelter, food and spawning ground for many fish such as carp (*Cyprinus carpio*), and also play a significant role in protecting fish from predators too.

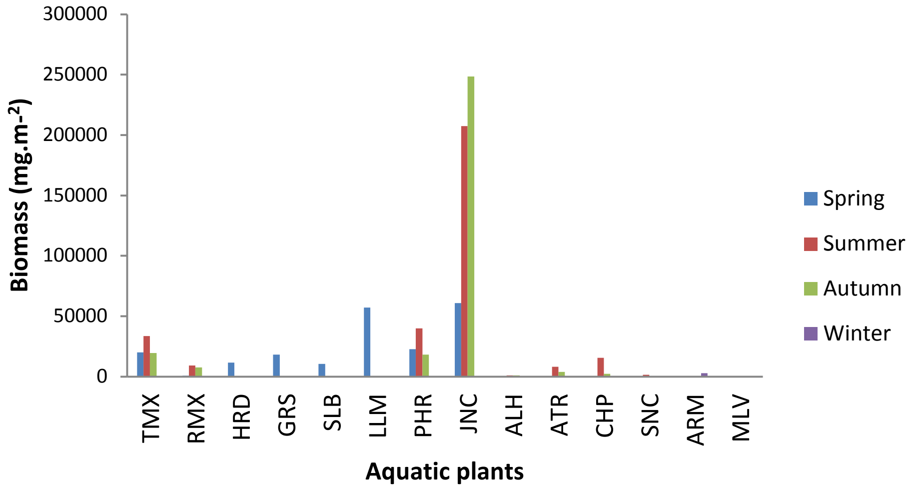

Fig 3. Change in biomass of different aquatic plant species at station 2 in different seasons (TMX. - *Tamarix,* RMX. – *Rumex,* HRD – *Hordeum,* SLB – *Silybum,* LLM – *Lolium*, PHR - *Phragmites,* JNC – Juncus, ALH. – *Alhagi*, ATR – *Atriplex*, CHP - *Chenopodium,* SNC – *Sonchus,* ARM - *Artemisia*, MLV – *Malva)*

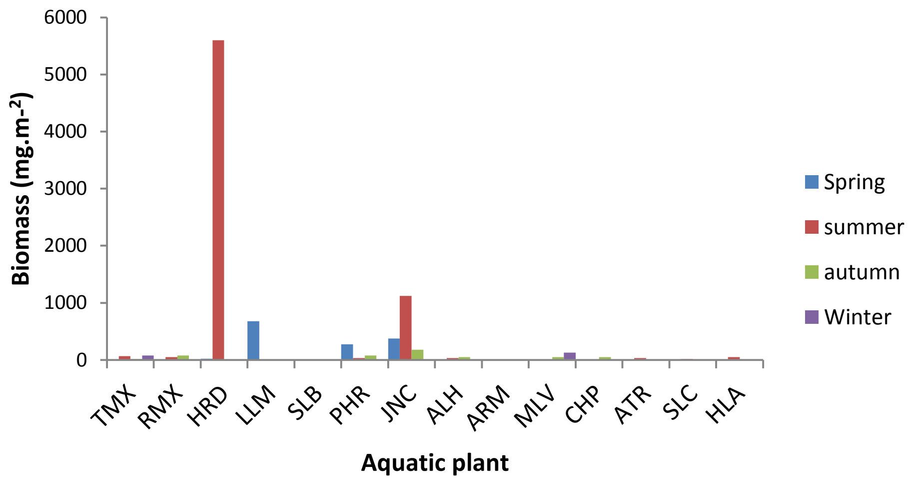

Fig 4. Change in biomass of different aquatic plants species at station 3 in different seasons (TMX. - *Tamarix,* RMX. – *Rumex,* ALH. – *Alhagi*, PHR - *Phragmites,* JNC – *Juncus,* HRD – *Hordeum,* LLM – *Lolium,* SNC – *Sonchus,* ATR – *Atriplex,* INL – *Inula,* PLG – *Polygonum,* CHP - *Chenopodium,* MLV – *Malva)*

Human impact on biodiversity of high aquatic plants became more pronounced in the second half of the 20th century. As a result, new macrophyte communities (especially underwater plants) began to appear, and floating plants were decreased. Destructive activities on the macrophyte vegetation can reduce spawning ground so that, result changes in carp (Talevski *et al*, 2002).

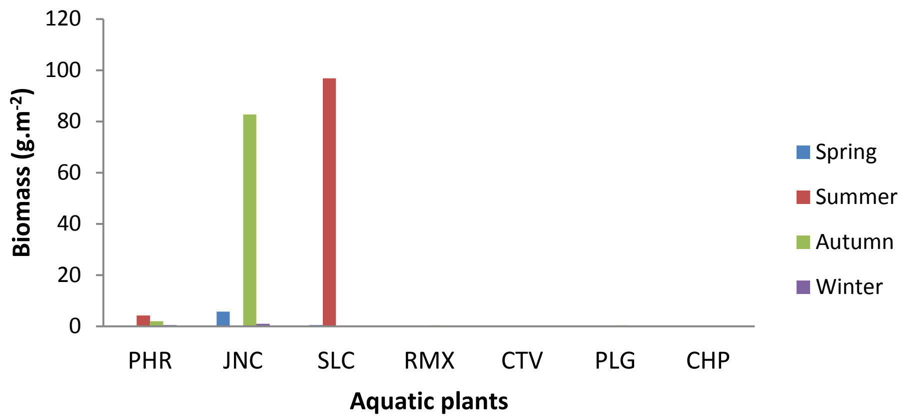

Fig. 5. Change in biomass of different aquatic plants species in station 4 during seasons
PHR - *Phragmites,* JNC – *Juncus*,RMX. – *Rumex,* PLG – *Polygonum,* CHP - *Chenopodium* --*Salicornia*, SLC.

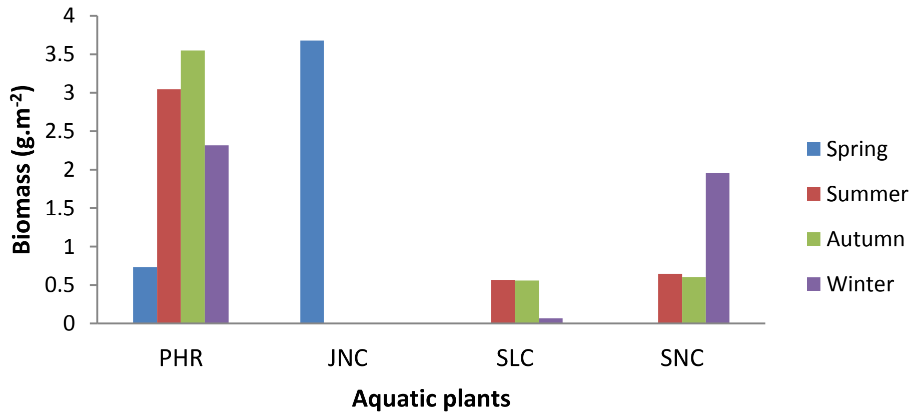

Fig 6. Change in biomass of different aquatic plants species in station 5 during seasons

Fig. 7 shows the interaction between station and season in the case of aquatic plants biomass. While stations 1 and 5 showed no marked fluctuations in aquatic plants biomass during different seasons, stations 3 and 4 showed one and two peaks, respectively. At the station 3, a marked peak was seen in summer, in which the biomass was nearly 4-40 folds higher than the other seasons.

However, at station 4, there were two peaks in summer and autumn, in which the biomass reached nearly 14-50 folds higher than the other two seasons. Trend at station 2 was not remarkable, however marked increase in biomass values was found in spring, summer and autumn compared to winter respectively. There were no significant differences in the case of plants biomass between the other stations and seasons (Table 4).

In the case of the seasons, higher values were found in summer (0.0053 kg.m^{-2}) which was significantly higher than in spring and winter (.0.0014 and 0.0002 kg.m^{-2}) respectively (Table 4).

In August, amounts and biomass of high aquatic plants were high at all stations.

Values of aquatic plants biomass in autumn were not significantly different than in summer and spring, but were significantly higher than in winter. There was no significant difference between the values in spring and winter. In the case of the stations, higher values were found at stations 4 and 3 (0.0048 and 0.0041 kg.m^{-2}, respectively) but were not significantly different compared to station 2 (0.002 kg.m^{-2}). However they were significantly higher than at stations 1 and 5 (0.0009 and 0.0004 kg.m^{-2}, respectively). There was no significant difference between station 1, 2 and 5 (Table 5).

Apart from stations, the highest biomass belonged to summer, while winter had a lower biomass than the other seasons (Table 4). Amount of total biomass at station 3 in summer was higher than the other stations in the other seasons (Table 6).

Table 4. Biomass (kg.m^{-2}) of the aquatic plants in different seasons

	Spring	Summer	Autumn	Winter
Biomass	0.0014±0.0011^{bc}	0.0053±0.0058^{a}	0.0029±0.0036^{ab}	0.0002±0.0002^{c}

Table 5.Biomass (kg. m^{-2}) of the aquatic plants in different stations

	Station 1	Station 2	Station 3	Station 4	Station 5
Biomass	0.0009±0.0007^{b}	0.002±0.0015^{ab}	0.0041±0.005^{a}	0.0048±0.006^{a}	0.0004±0.0002^{b}

Table 6. Biomass (kg.m^{-2}) of the aquatic plants at different stations in various seasons

	Spring	Summer	Autumn	Winter
Station1	0.0011±0.0008^{b}	0.001561±0.0007^{b}	0.00096±0.0004^{b}	0.0001±0.00004^{b}
Station2	0.0020±0.0006^{b}	0.0031±0.0009^{b}	0.0030±0.0013^{b}	0.00003±0.000004^{b}
Station3	0.0030±0.0012^{b}	0.0115±0.0015^{a}	0.0015±0.0003^{b}	0.0003±0.00003^{b}
Station4	0.0006±0.0002^{b}	0.0101±0.0088^{a}	0.0085±0.0048^{a}	0.0001±0.000095^{b}
Station5	0.0004±0.0001^{b}	0.0004±0.0001^{b}	0.0004±0.0002^{b}	0.0004±0.0002^{b}

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توزیع و فراوانی گیاهان آبزی رودخانه گرگانرود، حوضه دریای خزر، ایران

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چکیده

توزیع و فراوانی گیاهان آبزی رودخانه گرگانرود در پنج ایستگاه در چهار فصل (20 نمونه) درطی سال 2010- 2009 مورد بررسی قرار گرفت. ما 21 گونه از گیاهان آبزی از 21 جنس متعلق به 9 خانواده را شناسایی کردیم. 3 گونه از این گونه‌ها Halophytic (14/2٪) و 18 گونه High aquatic plant (85/7 ٪) تعیین شدند. بیشترین تنوع گونه در ایستگاه خواجه نفس، آق قلا و چارقلی (17، 13و 11 گونه) به ترتیب، بیشترین بیوماس گیاهان آبزی در تابستان (ایستگاه بازرسی و چارقلی 11/5 و 10/1 گرم بر مترمربع به ترتیب) و در پاییز برای ایستگاه بازرسی با وزن خشک 8.5 گرم برمترمربع) ثبت شد.گونه های غالب در ایستگاه های مورد مطالعه متفاوت بودند. در ایستگاه 1 گونه *Tamarix kotschyi* ، در ایستگاه 2 گونه *Juncus acutiflorus* ، در ایستگاه 3 گونه‌های *Hordeum murinum hudso*، در ایستگاه 4 گونه *Salicornia europaea L.* ، در ایستگاه 5 گونه *Juncus acutiflorus* غالب بودند.

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