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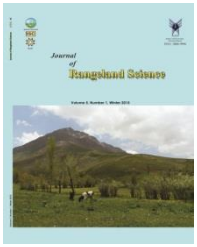

Research and Full Length Article:

Study of the Morphometric Characteristics of Nebkhas and the Amount of Accumulated Sand in *Nitraria schoberi* Type in Mighan Playa Arak, Iran

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Abstract. Phytogenic mounds (nebkhas), which are formed by shrubs, are common phenomena in arid and semiarid landscapes and play important roles in preventing soil erosion and nutrient loss. *Nitraria schoberi* is one of the important indigenous plant species of Mighan playa that can not only protect itself against wind erosion but also reduce sediment removal and can form nebkha phenomenon. This study aims at examining the role of *Nitraria schoberi* in controlling wind erosion (nebkha formation), and its morphometric relation with the accumulated sand in marginal dune land of Mighan playa, Arak, Iran. This study performed at an area of one hectare. In order to analyze the morphometric characteristic of nebkhas and the amount of sand accumulated in this vegetative type, parameters including length, width and height of the nebkhas and the canopy cover of nitre bushes were measured separately. The results reveal that *Nitraria schoberi* can stabilize 1576 m^3h^{-1} in average that is a remarkable number, considering the dimensions of the nebkhas and can prevent soil erosion. The results also showed significant correlation between the dimensions of nebkhas with large diameter, small diameter, plant canopy cover diameter and canopy area and total height of the plant (from the plain level) ($P<0.01$).

Key words: *Nitraria schoberi*, Wind erosion, Nebkha, Mighan playa

Introduction

Erosion is a phenomenon by which soil materials are transported by agents like water and wind (Bybordi, 2003). Wind erosion may bring along some materials and result in covering the plants with the wind blown materials. Generally, wind erosion not only causes removal of soil, but it also damages agricultural products, hedges, structures and highways. (Tengberg and Chen, 1998; Hesp and McLachlan, 2000). Nebkha is an Arabic word used for soil dunes made of wind sediments deposited around a plant and is formed in different environments like longitudinal hills, lowlands and highlands, on the surface of strata and near pools (Tengberg and Chen, 1998). The main elements comprising nebkha include sand, sludge and silt and can be found in active and inactive forms (Ahmadi, 2008). Among the factors influencing the height of nebkhas, vegetation parameters (canopy cover, density etc.), roughness and degree of slope can be mentioned. The difference between the dimensions of nebkhas may be related to the morphological features of the plant (Tengberg, 1995). Nebkhas are formed when the vegetation in desert area limits the removal of sands but does not stop it completely. Therefore, an amount of sand is deposited around bushes during storm and moisture of the earth stabilizes some parts of the sand. Gradually, by growth of the plants and their aerial parts, the hills will grow in height accordingly. Nebkhas develop only in areas with high level of wind activities and with underground water supplies confined in a specific point (Wang *et al.*, 2007). Formation of nebkhas by the plants results in physical changes in the soil, for example increase in heat, ventilation, enrichment of nutriments, especially Nitrogen in the growing place of the plants (Manu, 1994 and 1998). The cause of nebkha formation is controlled by factors like increase in wind energy or reduction of rainfall (Wang *et al.*, 2004).

Height classification of nebkhas is based on the growth characteristics of the species which could be classified nebkhas in short, medium and tall groups, thus nebkhas shape can be categorized according to the coral shape of the plant, in to individual and branched off groups. Generally, based on the growth types, nebkhas can be classified into tree, shrub, bush and herb, and the characteristics of the growing forms of the species can represent vertical and horizontal dimensions of the nebkha and generally its volume, (Langford, 2000). The height of nebkhas can vary from some decimeters to several meters and its length may be from 1 to 10 m. It has to be mentioned that individual plants should be more than 10 to 15 cm in height in order to be able to control the sands. If the sand particles do not have adhesiveness (in other words do not have clay and sludge elements), their dimensions will change by variance in wind speed (Wang *et al.*, 2006). By increasing in the amount of sediments, plants continue growing up in order to prevent being buried. The growth will go on as long as the plant root is connected to the underground water supplies, but whenever there is a downfall in the level of the water, this connection will break, and destruction of nebkha will start which will result in death of the nebkha. Aged and permanent nebkhas play a major role in changing the level of underground water sources, sewage, evaporation and distillation and controlling the wind sediments in the area (Pourkhosrovani *et al.*, 2009). The aims of this study were to investigate *Nitraria schoberi* roles in quantitative deposition of sand, and investigation of the relationship between morphometric characteristics in Nitraria and the amount of sand accumulated on Nebkha.

Materials and Methods

Case study

Mighan playa (Fig. 1) is located in the center of Iran at 15th km of the northeast of Arak city; its area is 120 km^2 and is situated at 49º42′00″ E and 34º21′30″ N. The type of *Nitraria schoberi* covers an area of 299.5 ha. The average altitude is 1650 m above sea level, the average of long-term rainfall based on the nearest synoptic station (Arak) is 210 mm and the annual average of temperature is 14.8°C. (Torangzar *et al.*, 2011) The soil texture of study area is Sandy-Loam and the main vegetation types of Mighan playa marginal lands are (Torangzar *et al.*, 2011):

1. *Halocnemum strobilaceum,*
2. *Nitraria schoberi,*
3. *Puccinellia bulbosa,*
4. *Halocnemum strobilaceum/Aeluropus littoralis,*
5. *Halocnemum strobilaceum/Salsola incanescens,*
6. *Salsola incanescens,*
7. *Halimione verrucifera /Aeluropus littoralis,*
8. *Limonium iranicum,*
9. *Aeluropus littoralis*

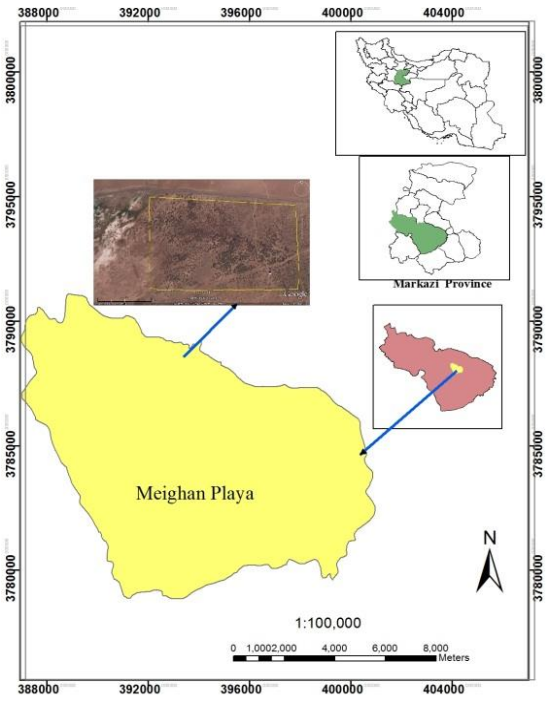

Fig. 1. Geographical location of Mighan playa in Markazi province, Iran

Plant material (*Nitraria schoberi*)

Nitraria schoberi belongs to Zygophyllaceae family which is resistant dryness. *Nitraria schoberi* is a thorny wooden shrub growing up to 1.5 m and its canopy cover diameter sometimes reaches to 2 m^2 (Fig. 2) with a low dispersion, it grows in saline and humid areas along playas in northeast, northwest and especially central habitats of Iran and Turan (Toranjzar *et al.*, 2011).

Fig. 2. A view of *Nitraria schoberi* type in Mighan playa

Data collection

In this study, several parameters including plant height, canopy cover diameter, nebkha height, basal diameter, nebkha dimensions, and plant dimensions were measured. First, considering the average conditions of the region, 1 ha area was specified for the nebkhas, and geographical coordinates of the area was determined by GPS.

Then, the characteristics of 30 nebkhas were separately measured including the morphometric characteristics and the amount of accumulated sand of *Nitraria schoberi* plant parameters such as, length, width and height of the nebkhas and vegetation canopy cover. Five soil samples were taken to the laboratory to measure their specific weights (cylindrical method) and tape measure was used for the measurements. Figure 3 shows the calculation method of nebkha and vegetation canopy cover parameters such as length, width, height. (Equation 1) which is the calculation formula of cone volume was used to calculate the volume of the nebkhas (Hesp and McLachlan, 2000).

$$V = \pi r^2 \times \frac{h}{3} \quad \text{(Equation 1)}$$

Where:
V= nebkha volume
π= 3.14

$$r = \frac{(\text{Width} + \text{Length})}{4}$$

h= nebkha height

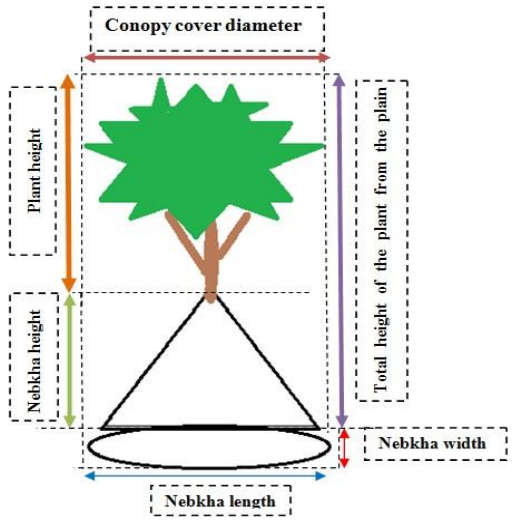

Fig. 3. Calculation method of the measured parameters (Wang *et al.*, 2007)

Taking the soils sampled for pedology experiments into consideration, the soil of the region was recognized as loamy and sandy. Thus the special weight of the soil entrapped by the species was calculated considering the soil texture of the region. Apparent specific weight of the soil was obtained as (Equation 2), (Ibn Jalal and Shafaei, 1990).
Specific weight of the soil of the region was equal to 1.6 g/cm^2.

$$Pb = \frac{Ms}{Vt} \quad \text{(Equation 2)}$$

Where
P_b= apparent specific weight
M_s= weight of solid particles (ton)
V_t= total volume of the soil (m^3)
The following equation was used to calculate vegetation canopy cover diameter (Equation 3):

$$Canopy\ cover\ diameter = \frac{\text{large diameter+smal diameter}}{2} \quad \text{(Equation 3)}$$

The variation of the measured parameters in both nebkhas and species studied were analyzed. Descriptive statistics as mean, standard deviation and standard error were measured through SPSS18 software. Finally the relationship between the traits and factors related to nebkhas and vegetation factors were estimated using Pearson correlation.

Results

Sum of stabilized soil

As mentioned in Materials and Methods, the *Nitraria schoberi* type covers an area of 299.5 ha in Mighan playa (2.68% of the total desert) (Toranjzar *et al.*, 2011).
The results of 30 individual nebkhas volume are presented in Table 1. The sum of nebkhas volume ∑(Vt) were calculated in one ha as (Equation 4).

$$\sum(Vt) = 1576\ m^3 ha \quad \text{(Equation 4)}$$

Then, the weight of the stabilized soil in *Nitraria* sp. nebkhas was calculated using (Equation 5) as follows:
Ms= 1.6 × 1576 = 2521.6 ton/ha (Equation 5)
Accordingly, *Nitraria* sp. had stabilized about 755219 ton soil in an area of 299.5 ha using (Equation 6).
Sum of stabilized soil =299.5 × 2521.6 =755219 ton (Equation 6)

Table 1. Measured parameters of *Nitraria schoberi* nebkhas

No.	$V = r^2\pi \times h/3$	No.	$V = r^2\pi \times h/3$	No.	$V = r^2\pi \times h/3$
1	39.61	11	20.10	21	21.43
2	1.34	12	77.51	22	31.66
3	5.87	13	13.96	23	64.31
4	127.7	14	48.72	24	91.32
5	20.73	15	133.52	25	55.36
6	14.54	16	8.17	26	51.92
7	27.37	17	44.48	27	56.52
8	108.8	18	117.78	28	9.50
9	0.08	19	34.16	29	216.3
10	0.00	20	20.59	30	110.52

Descriptive statistics

The summary of descriptive statistics of the traits studied of 30 *Nitraria schoberi* nebkhas and the mean of the nebkhas is shown in Table 2. The results reveal that in average, *Nitraria schoberi* had stabilized 42.5 m^3 soils around its limbs.

Table 2. Descriptive statistics of the variables under the study area

Variation	Standard Deviation	Mean	Standard Error	Minimum	Maximum	Variance
Nebkha Length (m)	9.766	14.45	1.783	0.0	20.00	95.38
Nebkha Width(m)	5.44	8.95	0.994	0.0	15.00	29.65
Nebkha Height (m)	0.724	1.49	0.132	0.0	2.80	0.524
Nebkha Volume (m^3)	122.25	42.5	27.79	0.0	176.36	14945.25
Plant Great Diameter(m)	9.62	13.08	1.75	2.50	40.00	92.70
Plant Short Diameter (m)	4.6	7.78	0.84	2.30	24.00	21.18
Plant Height (m)	0.315	1.16	0.054	0.50	2.00	0.100
Canopy Cover Diameter (m)	6.93	10.43	1.26	2.40	32.00	48.07
Canopy Cover Area (m^2)	128.26	60.24	22.54	4.52	303.8	16450.62
Plant Height (m)	0.89	2.65	0.162	0.70	4.50	0.79

Correlation between traits

One of the aims of this study was to identify the relationship between traits and factors related to nebkhas and vegetation factors. Correlation coefficient between the traits was calculated and the results are presented in Table 3.

The results indicate that there was a positive relationship between nebkha volume and length, width and height of the nebkha; also, large diameter, small diameter and vegetation canopy cover diameter and area of the canopy cover and total height of the plant (from the plain ground) ($P<0.01$). The nebkha volume had positive correlation with vegetation canopy cover area and vegetation canopy cover diameter ($P<0.01$). However, it had no significant relationships with plant height.

Table 3. The correlation between traits of plant and nebkha properties

Variations	Canopy Cover	Plant Height	Plant Length	Plant Width	Plant Height	Canopy Diameter	Nebkha Length	Nebkha Width	Nebkha Height
Plant height	0.37*								
plant length	0.94**	0.44*							
Plant width	0.93**	0.52**	0.88**						
plant height	0.27^{ns}	0.65**	0.05^{ns}	0.19^{ns}					
Canopy diameter	0.96**	0.48*	0.98**	0.94**	0.10^{ns}				
Nebkha length	0.89**	0.53**	0.97**	0.87**	0.18^{ns}	0.96**			
Nebkha width	0.78**	0.58**	0.75**	0.86**	0.22^{ns}	0.81**	0.76**		
Nebkha height	0.45*	0.94**	0.52**	0.54**	0.36*	0.54**	0.58**	0.63**	
Nebkha volume	0.93**	0.51**	0.84**	0.90**	0.07^{ns}	0.88**	0.81**	0.86**	0.62**

ns, *and**= No Significant difference and Significant difference at 5% and 1%, respectively

Discussion and Conclusion

Nitraria schoberi is used as one of the best stabilizing plants in these habitats that due to the existence of sand dunes cannot provide required moisture for the growth of other species, (Toranjzar *et al.*, 2011). The stem of this plant can vastly grow on the ground and by developing adventitious roots along with the growth of sand dunes continues to live and in addition to reproduction, brings about its stabilization.

Morphometric results of the nebkhas including various types of species indicate that in general, the higher plant morphological characteristics like canopy size and plant height, the greater amount of wind sediments could entrapped by the plant and the nebkha will be larger (Wang *et al.*, 2003; Zhang *et al.*, 2011; Maghsoudi *et al.*, 2012 and Pourkhosravani *et al.*, 2009).

Therefore, taking the aforementioned results into consideration, it can be concluded that due to its shrub growth type, *Nitraria schoberi* has been able to hold a significant relationship between nebkha dimensions and canopy size and the area of vegetation canopy cover and plant height (from the plain level) ($P<0.01$). Considering the obtained results and morphological indices of *Nitraria sp*. plant, this plant has got an important role in the heights of nebkha hills because as much as it is longer and bigger, it can entrap more sands and create bigger sand dunes (Maghsoudi *et al.*, 2012); as a result, it plays its role in nebkha formation, development of prolific areas, prevention of soil destruction and reduction of nutrients (Zhang *et al.*, 2011). Therefore, as most of the sand dunes along lakes and playas have high saltiness, *Nitraria schoberi* can be one of the best stabilizing plants in such habitats.

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بررسی ویژگی‌های مورفومتری نبکاها و مقدار ماسه تجمع یافته در تیپ گیاهی قره‌داغ (*Nitraria schoberi*) در کویر میقان، اراک

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چکیده. نبکاهای فیتوژنیک که تو سط درختچه‌ها ایجاد می شوند، پدیده‌ای معمول در چ شم اندازهای خشک و نیمه‌خشک محسوب می‌گردند و نقش مهمی در جلوگیری از فرسایش و هدر رفت مواد مغذی خاک ایفا می‌نمایند. یکی از گونه‌های بومی گیاهی مهم کویر میقان اراک که نه تنها می تواند خود را در برابر فرسایش بادی حفظ کند بلکه تا حد زیادی جابجایی رسوبات منطقه را هم کاهش داده و پدیده نبکا را تشکیل دهد، گونه قره داغ (*Nitraria schoberi*) می‌باشد. این تحقیق با هدف برر سی نقش گیاه قره داغ در کنترل فر سایش بادی (تشکیل نبکا) و رابطه مورفومتری آن با ماسه تجمع یافته در ارضی ماسه‌ای حاشیه کویر میقان اراک در سطح ۱ هکتار انجام گرفت. به منظور برر سی ویژگی‌های مورفومتری نبکاها و مقدار ما سه تجمع یافته در این تیپ گیاهی، پارامترهایی چون طول، عرض و ارتفاع نبکاها و تاج پوشش گیاهی هر کدام به صورت مجزا مورد اندازه‌گیری قرار گرفت. نتایج ن شان داد که گونه قره‌داغ بطور میانگین قادر به تثبیت مقدار ۱۵۷۶ مترمکعب خاک در هکتار می‌با شد که با توجه به ابعاد نبکاهای ت شکیل شده رقم قابل توجهی بوده و باعث جلوگیری از فر سایش خاک می شود. همچنین نتایج حاکی از وجود همب ستگی بین حجم نبکا با قطر بزرگ، قطر کوچک، قطر تاج پو شش گیاه و م ساحت تاج پوشش و ارتفاع کلی گیاه (از سطح دشت) در سطح احتمال ۱٪ بود.

کلمات کلیدی: قره داغ، فرسایش بادی، نبکا، کویر میقان