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The sodium sulfates dominance in soil as a result of anthropogenic and climate interactions in Segzi desert plain at the east of Esfahan, Iran

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Key words: Gypsic Haplosalids, Gypsic Aquisalids, Secondary sodium sulfate, Wind erosion.

Abstract

The soil control against wind erosion in Segzi is very important because of strategic location of this area that it is nearby some industrial estates. The soils with a soil moisture regime of aridic and a soil temperature regime of thermic, were classified as Gypsic haplosalids subgroups. The soil subgroups of the soils have changed to Gypsic Aquisalids after leaching with agriculture surplus water in winter. The natural system of [Halite, Gypsum] in the soils has changed to secondary system of [Mirabillite, Calcium chloride] after soil leaching for salt melioration in winter. In this research after using chemical and physical, micro morphology and Thermal analyses were resulted that the major factor in wind erosion of the soils in Segzi is secondary sodium sulfate evaporates of thenardite and so mirabillite. And so for control of wind erosion was resulted to return in primary salt system with adding $CaCl_2$ in soil for melioration.

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Introduction

Because of wind erosion potentials in Segzi plain this research was defined for study of soil chemical variability to control salt systems in the soils for soil stability against wind erosion. Segzi (Sagzi) plain is one of the eastern intensive wind erosion centers of Esfahan city.

Therefore, soil stabilization and reinforcement of vegetation to restore the plantation to control wind erosion is a priority for combat desertification center of Esfahan natural recourses department. In this area, irrigation with recycled wastewater and sewage of Esfahan for preserving aquifers underground were done. Although according to Ayers and Westcot (1985) and Boll *et al.* (1986) using refined wastewater in irrigation, depending on geographical region can be either beneficial or harmful. Abedi-Kupai *et al.* (2000), in a study of the effects of sprinkler irrigation with treated wastewater on the soil surface were investigated. The results showed that the use of wastewater result in, reducing soil salinity (electrical conductivity of saturated soil paste extract). On the other hand, Hassan-Oghli *et al.* (2006) examined how changes in the electrical conductivity of the soil saturation as a result of irrigation with domestic wastewater and effluent showed that the use of waste water for irrigation and the cultivation of vegetables for two years, electrical conductivity of saturated soil increase in comparison with control. But Ansarinejad *et al.* (2010), in his investigation using wastewater found significant effect on increasing the rate of soil permeability in comparison with the use of well water.

They showed and reported a positive effect of the wastewater for reclamation of Segzi vegetation and so they expressed that the use of wastewater for irrigation of saline and alkaline soils, has a significant impact on the plant growth. They observed a significant plant cover vitality and plant seedlings on the studied area. Movahedian and Afioni (2006), after the research on the effect of industrial wastewater and sewage sludge on soil properties, were observed that in all experimental treatments, the concentrations of heavy metals have been increased in 0 to 20 cm surface depth of the soils. According to Narimanian and Ansarinejad (2012) the segzi area has a mean annual rainfall of 99.6 mm and a potential annual evapotranspiration of 2210 mm. The combat desertification activities were created in the area from 1358 years for the area about 12,000 hectares by dry land forest planting with Haloxylon. Kovda (1973) showed that some salts can be more stable in cold weather but some others do not. Akhavan Ghalibaf(2002) and Akhavan Ghalibaf and Koohsari (2007) showed that shallow ground water containing sulfate ions in the presence of salts of sodium chloride, result in increasing of sodium sulfate concentration in soil surface , which is capable of causing Solonchaks with sulfate type. So it is able to create the kind of bloated salty desert.

Material and methods

The studied area located 35km east of Esfahan with a geographical coordinate interval; from 51° 58' E to 52° 3' E and from 32° 42' N to 32° 47' N. This area located on reversal alluvial that tertiary geological depositions with gypsiferous marls (MPm) have outcrops in the northern parts (Assefi, 1976, fig. 1).

The soil sampling with grid method was done in spring and summer of 2013. The routine chemical and physical analyses were done on the soils. Some soil crumbs from surface horizon of sample profiles were prepared for micro morphology study with hardening in resin and taking thin section from them. A surface sample of the soils was prepared for SEM analysis with VEGA 3 TESCAN instrument, from Czech Republic. From evaporates on the soils thermo analyses were done with Bahr STA 503 instrument from Germany. Calculation of the salinity parameters was done with Russian method of V.A. Kovda and its modified method in Pankova *et al.* (1996). The soil extractions were done from 1:5 soil and water extracts and so according to American soil salinity laboratory, (Soil survey staff, 2010) in saturated soil pastes.

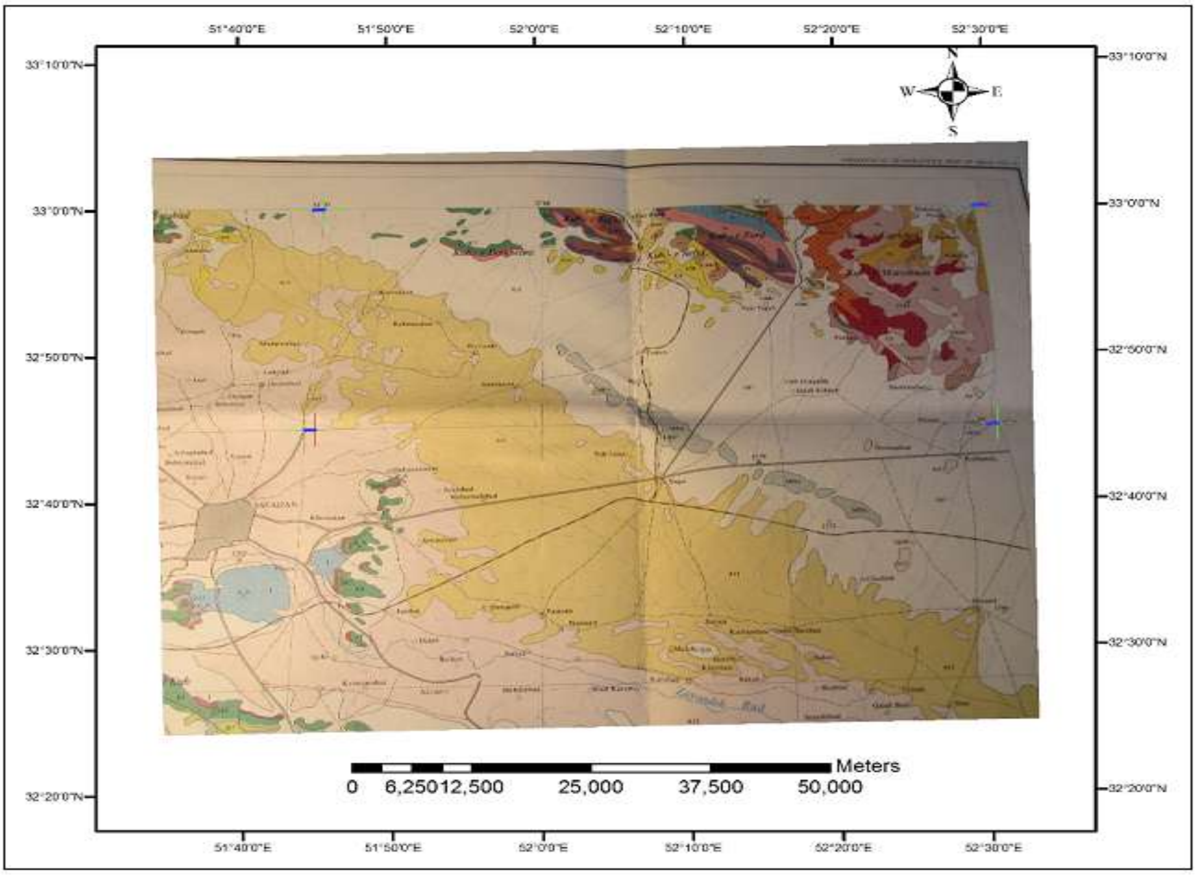

Fig. 1. The gypsiferous marls (MPm) in the north of the researched area on the geological map of Esfahan with scale of 1:250000.

Results

The results of ion's contents from soil extract of 1:5 soil and water were shown in table. 1.

In table. 2 Some of chemical properties of the profiles were shown and in table. 3 the ion contents in soils from saturated paste were shown. In fig. 2 was shown thermal analysis results for diagnostic and research on crystal-chemical properties of evaporate salts in the soils. In figures 3 and 4 (left one) were shown the results of thin section observation with polarized microscope and electron scanner microscopy on gold covered soil samples respectively. In fig. 4 (right) was shown an electron microscopy for comparison with Segzi samples.

Discussion

The anion types of the both waters sources from local ground water in summer and from refined sewage water in winter are Sulfate-Chloride with a relation of chloride per sulfate equal to 1.5. The ground water show magnesium Cation type and refined waste water is calcium one. The soils have a light texture of sandy loam in surface and a medium to heavy texture of sandy clay loam to silty clay loams in sub surface horizons. From the granulometry analyses from sand fractions of the soil resulted in a low similarity between horizons in a profile there for they showed a lithological discontinuity in all of profiles. According to geological map of Esfahan (Fig. 1) The soils have formed on the old alluvial and related to the granulometry can be resulted that the soils have the same origin with upper terraces of river alluvial of Zayanderood river where it's valley located 24km south of researched area. From the salinity type's analyses in 1:5 soil and water extracts resulted in the soils of the both sample profiles are Solonchaks and because of increasing salinity in the surface horizons, they are Hydromorphic ones with Gypsiferous Solonchaks (Table 1 and 2).

Table 1. Ion contents in 1:5 soil and water extracts and some salinity parameters in Russian method.

		(meq/100gr) Anions			Cations (meq/100gr)						
Horizon	Depth (cm)	SO_4^{2-}	Cl^-	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-/SO_4^{2-}	$Na^+/(Ca^{2+}+Mg^{2+})$	%Total Soluble Salts
		Profile 1									
A_z	0-30	40.4	5.0	0.4	35.0	0.02	7.0	13.5	0.12	1.7	3.2
IIB	30-80	11.4	3.0	0.6	26.0	0.01	1.5	4.0	0.26	4.7	1.4
IIIC	80-120	28.5	2.0	0.2	19.5	0.01	1.5	15.5	0.07	1.1	2.1
		Profile 2									
A_z	0-40	36.3	4.0	0.4	30.0	0.01	9.0	16.0	0.11	1.2	3.0
IIB	40-55	14.2	3.0	0.4	20.0	0.01	5.0	14.5	0.21	1.0	1.5
IIIC	55-100	19.4	1.0	0.6	50.5	0.01	1.5	16.5	0.05	2.8	2.4

Table 2. Some of the chemical and physicochemical parameters in soil samples.

Horizon	Depth (cm)	pH(1:1)	EC, dS/m (1:5)	$\%CaSO_4.2H_2O$	$CaCO_3\%$	%O.M.
				Profile 1		
A_z	0-30	8.01	10.8	3.01	21.5	0.91
IIB	30-80	8.08	5.89	3.69	38.5	1.21
IIIC	80-120	7.73	5.51	1.28	15.0	0.6
				Profile 2		
A_z	0-40	8.01	9.82	7.2	33.0	1.18
IIB	40-55	7.91	7.19	1.83	42.0	1.23
IIIC	55-100	6.93	3.63	1.6	41.0	1.23

In table 3 has shown some chemical and physical properties from saturated soil paste which are with high SAR and EC. So these soils can be classified as Typic Aquasalids in profile 1 and Gypsic Aquisalids in profile 2 (Soil survey staff, 2010). Salinity types in the profiles are sulfate anion type ($Cal^-/SO_4^{2-}<0.2$) and Magnesium Sodium Cation type ($2>Na^+/(Ca^{2+}+Mg^{2+}>1)$ and $Mg^{2+}>Ca^{2+}$) (Table1, 2 and 3).

Table 3. Ion contents in saturated soil paste extracts and some salinity parameters.

		Anions (meq/l)			Cations (meq/l)						
Horizon	Depth (cm)	SO_4^{2-}	Cl^-	HCO_3^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	SAR	*pH*	EC, dS/m
					Profile 1						
A_z	0-30	658.3	332.0	1.6	900.0	4.9	36.0	51.0	136.5	*8.21*	73.7
IIB	30-80	430.2	92.0	1.8	300.0	4.3	9.0	48.0	56.2	*8.27*	25.3
IIIC	80-120	265.6	48.0	1.4	80.0	4.3	15.0	44.0	14.7	*7.80*	19.5
					Profile 2						
A_z	0-40	576.8	274.0	2.2	600.0	3.4	38.0	82.0	77.5	*8.14*	64.5
IIB	40-55	151.9	104.0	1.4	340.0	4.3	18.0	46.5	59.9	*8.26*	29.2
IIIC	55-100	265.1	30.0	1.4	160.0	2.1	16.0	37.5	30.9	*8.02*	9.52

According to Fig. 2 in the thermogram, endotherms of 100° C and 150° C for Gypsum are absent. But can be seen 118 ° C, 470 ° C and 874 ° C ones. Smykatz-Kloss (1974), introduced the endotherms of 147 ° C, 215 ° C, 245 ° C and 890° C for Thenardites. Doner and Lynn (1992) reported endotherms of 100 ° C and 548 ° C for Bloedite. Visible lack of endotherms in the range of 215 ° C or less demonstrate endotherms of 147 ° C as 118 in Segzi sample and an more quantity of 470° C instead 245° C one could be related to the exotherm extensive organic material between 200 and 400 ° C. Endotherm of 874 ° C, is more closed to the 890° C which provided by Smykatz-Kloss (1974) for Thenardites and it is far more related to endoterm of 548 ° C related to Bloedite. In the thin section from harden crumb (Fig. 3) can be seen filamentous Mirabilite minerals which sampling and preparation was done in cold season (early spring).

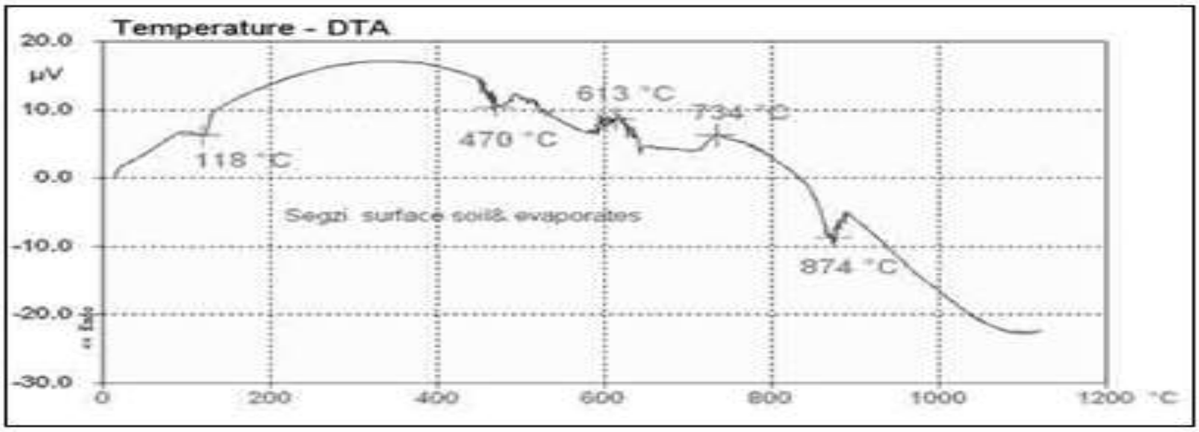

Fig. 2. Thermogram of surface soil and evaporates in Segzi.

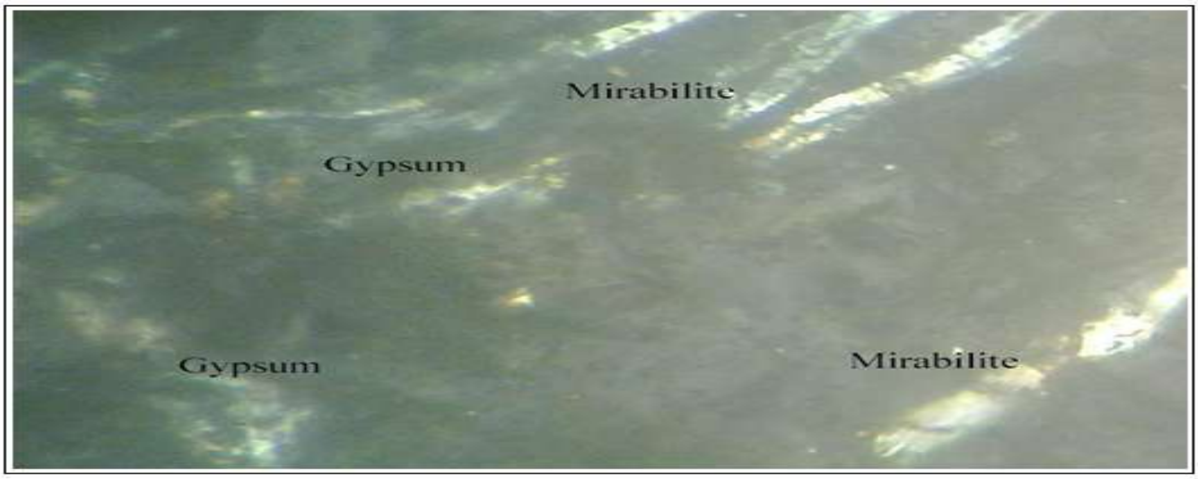

Fig. 3. Thin section under polarized microscope with II Nikole (40×).

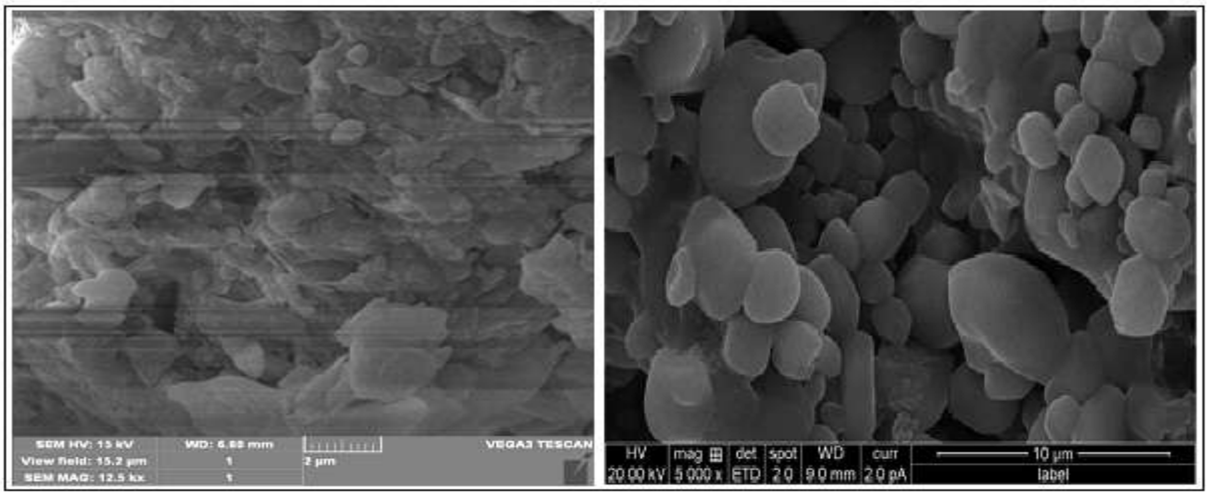

Fig. 4. ESM image from Segzi evaporates (Left) and from Vidya and Lakshminarasappa (2014) (Right).

The ESM image from Segzi evaporates at summer period of sampling when the soil surface temperature was above 27° C has shown in fig. 4 (Left). For compression, this image has a similar shape with Thenardite image from Vidya and Lakshminarasappa (2014) (Fig. 4, right).

Conclusion

The soils in researched area because of influence of gypsonous deposits from geological periods of tertiary (Neogenes) soil salinity systems in soil have formed in initial salinity system of [Halite, Gypsum]. The Mediterranean climatic regime of precipitation and anthropogenic soil leaching with winter surplus sewage water in winter has changed the initial salinity system to [Mirabillite, Calcium chloride, Halite] because of low solubility of sodium sulfates in cold season. In Fig. 5 have shown the umberothermic curve of Esfahan that has a Mediterranean moisture regime.

In summer the salinity systems of [Mirabillite, Calcium chloride, Halite] have changed to [Tenardite, calcium chloride, Halite] Na_2SO_4, $CaCl_2$, NaCl, because of dry climate and dehydration of Mirabilites in warm season. In winter or rainfall season with cold weather again the salinity system return to Mirabilite types . These process can be shown in equation1.

$CaSO_4.2H2O$ (Gypsum) + 2NaCl+ 8 H_2O $CaCl_2$ + $Na_2SO_4.10H_2O$ (Mirabilite) [1]

Also irrigation with surplus refined sewage water for revival of desert shrubs result in change salinity types from sodium chloride to sodium sulfate with extreme wind erodibility in Segzi areas. For control wind erodibility and increasing stability of soil surface was proposed to add a part of lost calcium chloride to soil surface according to equation 2.

Because of high salinity of the soils the amounts of calcium chloride were calculated only for maximum 1cm of soil surface. In fig. 6 were shown the plate for test of wind erodibility (left) and wind simulator that in Yazd university (Right). these were made for measuring wind erosion in three wind speed according to table 4.

calcium chloride Ton/ha =0.0555(Na^+ - Cl^-) meq/100gr.soil × h (cm) × ρ_b (gr/cm^3) [2]

(ρ_b (gr/cm^3): Bulk density of soil in A horizon, h (cm): Depth of A Horizon).

The statistical test showed significant difference between non treatment soils and treatment soils with calcium chloride solutions. In the field suitable time can be selected from climatic characteristic of the region. The favorite time depend to sufficient high temperature for solubility of sodium sulfates and existence of minimum moisture in the last rainfall season. For example in Esfahan region in can be at early summer and in Yazd in middle spring.

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