SABKHAT AND HALOPHYTES IN KUWAIT

SAMIRA A. S. OMAR, RAAFAT F. MISAK &
SHABBIR A. SHAHID

Kuwait Institute for Scientific Research, P.O. Box 24885, 13109 Safat, Kuwait

Abstract
The distribution of sabkhat in Kuwait is described. Studies carried out by the Kuwait Institute for Scientific Research regarding soils and vegetation of sabkhat showed that most soils are aquisalids. The major part of the coastal sabkhat were classified under the order of *Aridisols* and the suborder *salids*, which were further recognised mainly as *gypsic aquisalids* and to a minor extent as *typic aquisalids*. To a minor extent sabkhat were also mapped as *torriorthents*. Five major plant communities were identified in the sabkhat of Kuwait. These are: *Nitraria resuta, Tamarix aucheriana, Zygophyllum qatarense, Halocnemum strobilaceum* and *Seidlitzia rosmarinus*. Since the sabkhat of Kuwait are threatened by different anthropogenic activities conservation measures were necessary. These are shortly described together with recommendations for future research concerning the subject.

INTRODUCTION

In Kuwait, sabkhat with their picturesque features constitute one of the most common landforms along the coastal plains and in some inland areas. In the past years the Kuwait Institute for Scientific Research has carried out intensive soil and vegetation surveys in sabkhat environments. In this paper some of these results will be presented.

Barth & Böer (eds.), SABKHA ECOSYSTEMS, 71-81

SABKHA DISTRIBUTION

Sabkhat in Kuwait cover about 10% of the country area (about 1800 km²). Geographically they are differentiated into coastal sabkhat (about 7% of the country) and inland sabkhat (about 3% of the country area). The coastal sabkhat are distributed in the northern coastal plain which includes the western coast of the Khor As Sabiyah and Bubiyan Island (Fig. 1). Moreover, coastal sabkhat occur at the northern coast of Kuwait Bay and along the southern coastal plain (Julayah - Az Zour strip) (Fig. 1). These coastal sabkhat are developed as a result of the intersection between the highly saline groundwater table (resulting from sea water intrusions) and the low ground surface. Wetting and drying of these surfaces are very common throughout the year.

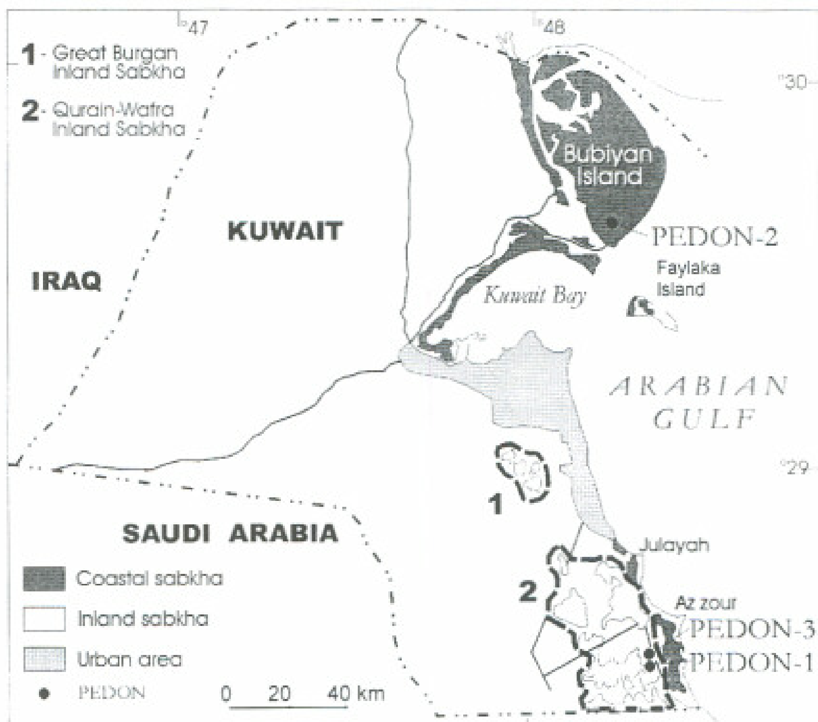

Figure 1. Map of Kuwait showing the geographic distribution of sabkhat and the location of soil pedons 1-3.

Morphologically, lithologically, geochemically and biologically the coastal sabkhat are highly variable. In the northeastern part of the country the sabkhat are dominated by laminated silt and clay with a high gypsum content. The fine sediments are derived mainly from the Shatt Al Arab. The elevation of the sabkhat at the northeastern part is around 4 m above sea level and the groundwater table is between 2 and 3 m below the surface level. In Kuwait Bay the sabkha is dominated by fine to medium sand with high salt content. The average groundwater level is at a depth of around 145 cm at Bahra (central part of Kuwait Bay). The sabkhat along the southern coastal plain are composed of sands, carbonate grains and evaporites. The average groundwater table is located at a depth of about 120 cm at Nuwassib sabkha (extreme southern part).

In the southern coastal plain, and at local parts of Kuwait Bay, the seaward (Gulfward) side of the coastal sabkhat are skirted by off shore bars, oolitic ridges and aeolian accumulations. In the northern coastal plain and the majority of Kuwait Bay, the sabkhat are not separated from intertidal flats.

Along the coastal sabkhat, a wide variety of micro-landforms are prominent. These include aeolian features (nabkhas, sand sheets, deflational depressions and soft and hard yardangs), fluvial forms (rills, gullies and alluvium cones) and evaporitic salt crusts.

The inland sabkhat occupy the floors of enclosed depressions. During heavy rain storms, the runoff water from the surrounding higher terrain accumulates forming water ponds (30-50 cm depth, 0.5 - 2 km² area). The inland sabkhat are scattered within the Great Burgan oil field (south of Kuwait City), and around Qurain area (see Fig. 1). The sabkhat constitute depressions of different sizes. Generally the long axis of one of these sabkhat attains about 3 km in NW-SE direction with a width ranging between 0.5-2 km. The depressions are in their central parts up to 3 m lower than the surrounding terrain. Their ground elevation varies between 47-58 m above sea level.

The inland sabkhat of Qurain-Wafra cover a wide area in comparison with those of the Great Burgan oil field. The long axis of these sabkhat attains about 4 km in NW-SE direction with a width varying between 0.5 and 1.5 km. The depressions here are in their central parts up to 6 m lower than the surrounding area. The rims of the sabkhat are cut by shallow and short rills which drain into the sabkha floors. One of the sabkhat at the northwestern part of Qurain-Wafra receives surface runoff by a wadi (Khar Al-Qurain) which extends around 5 km into surrounding terrain to the west. This fact would classify the landform as a playa. But since it's origin seems to be purely deflational and the drainage into the wadi is only that of a very small area, we still define it as a sabkha.

Gunatilaka & Mwango (1987) studied the sabkhat at the southeastern part of Qurain-Wafra. They stated that the sabkhat are made up of quartz, calcite and gypsum. Regarding the origin of the inland sabkhat, it seems that they were developed as a result of the intersection with shallow groundwater bodies in Quaternary sand and gravel beds. Strong winds in the past excavated these depressions.

SOIL CHARACTERISTICS

The soils of the state of Kuwait have been mapped at a scale of 1:100.000 (KISR 1999) using the soil classification system of the United States Department of Agriculture (Soil Survey Staff, Soil Conservation Service 1994). The soil profiles were described as per Soil Survey Manual (Soil Survey Division Staff 1993). Most sabkhat are mapped as *aquisalids* (Soil Survey Staff, Soil Conservation Service, 1994). The *aquisalids* have a salic horizon and water table fluctuations within one meter from the soil surface. The sabkha sites at the islands are close to the sea level and therefore, seawater intrudes to these areas, evaporates and salts are concentrated to form marine evaporites. The major part of the coastal sabkhat were classified under the order of *Aridisols* and the suborder *salids*, which were further recognised mainly as *gypsic aquisalids* and to a minor extent as *typic aquisalids* (Soil Sruvey Staff, Soil Conservation Service 1994). The salinity levels are very high and even halophytes rarely establish. To a minor extent sabkhat were also mapped as *torriorthents*.

The chemical and physical characteristics of two representative pedons are shown in tables 1 and 2. The morphologies of the soil families are given in table 3. The location of pedons as described in table 3 is shown in figure 1.

The pH was measured of the soil saturated paste, and the electrical conductivity of the soil saturation extract obtained under vacuum from the saturated soil paste (Richards 1954). The soil saturation extract was analysed for solution chemistry (soluble anions and soluble cations). The cation exchange capacity was determined by saturating the soil exchange complex with 1M sodium acetate (pH 8.2) solution, followed by ethanol washing, and displacing the Na with 1N (pH 7) ammonium acetate solution. The displaced Na was measured by atomic absorption spectrophotometer. Gypsum was measured by acetone precipitation method, and calcium carbonate by calcimeter method. In the field $CaCO_3$ was measured through effervescence test (fizzing reaction caused when carbonate mineral is treated with acid). For all the above measurements, methods as described by the United States Department of Agriculture (USDA 1996) were used.

In table 1 the slightly to moderate alkaline pH values of all the layers can be attributed to the presence of "halite" (NaCl) in dominant form throughout the profiles. The relatively higher values of SAR in both the pedons are attributed to the higher concentrations of Na compared to Ca and Mg in the saturation extract.

Analytical data for the particle size distribution is presented in table 2. It is apparent that pedon 1 is sandy in texture throughout the profile, pedon 2 is loam (0-40cm) and sandy loam (40-100 cm). The total percent loss (soluble salts, gypsum and carbonates) is maximum in pedon 2 (decomposition of calcareous shells and calcium carbonates). Total clay is maximum in pedon 2. This is due to the deposition of fresh material through tidal coverage. More detailed information on occurrence of different soil units is given in the soil survey of the State of Kuwait (KISR 1999).

Table 1. Analytical properties of the representative pedons.

Horizon	Lower Depth (cm)	pHs	ECe dS/m	Na	K	Ca	Mg	HCO_3	Cl	SO_4	SAR	CEC	SP	Gypsum	$CaCO_3$
				(…………me/l…………						)	(mmoles/$^{0.5}$)	(me/100g)	(………%……)		(%eq.)
PEDON 1: Gypsic Aquisalids, sandy, mixed, hyperthermic (236057 mE 3173153 mN Zone 39)															
Akz	2	7.4	358	1247	253	78	101	0.65	1600	74	131	0.88	17.2	10	4
Bkz	25	8.0	64	571	37	89	77	0.09	674	87	63	1.45	17.6	3	6
Bkyz1	60	7.9	46	345	13	70	41	0.14	381	74	46	1.79	21.6	14	5
Bkyz2	90	7.9	31	240	9	59	31	0.10	258	75	36	2.07	26.0	14	7
Bkyz3	120	7.8	44	437	18	93	54	2.51	504	90	51	1.60	22.0	5	9
PEDON 2: Typic Torriorthent, sandy, skeletal, carbonatic, hyperthermic (229140mE 3280949 mN zone 39)															
A	25	8.2	8	51	1.5	38	9	1.64	48	49	11	7.19	33.9	37	29
C1	40	7.4	29	188	1.7	51	16	0.88	242	45	32	6.26	36.0	8	53
C2	70	7.6	28	163	1.8	47	18	0.59	200	60	28	5.00	41.0	3	55
C3	100	7.6	27	144	1.6	48	17	0.78	180	58	25	4.36	20.0	4	56

pHs = pH of saturated soil paste; ECe = Electrical conductivity of soil saturation extract; SAR = sodium adsorption ratio; CEC = cation exchange capacity; SP = saturation percentage

Table 2. Physical characteristics of the representative pedons.

Horizon	Lower Depth (cm)	Total Clay <.002	Total Silt .002-.05	Total Sand .05-2	Silt Fine .002-.02	Silt Coarse .02-.05	Sand VF .05-.10	Sand F .1-.25	Sand M .25-.5	Sand C .5-1	Sand VC 1-2	TPL	Coarse Fraction F 2-5	Coarse Fraction M 5-20	Coarse Fraction C 15-75
		(……% of < 2mm (carbonate free)……)										% of < 2mm	(…% of < 75 …)		
PEDON - 1: Gypsic Aquisalids, sandy, mixed, hyperthermic (236057 mE 3173153 mN Zone 39)															
Akz	2	1.3	2.5	96.2	1.9	0.6	7.8	20.0	26.8	28.4	13.2	22.5	0	0	0
Bkz	25	0.5	3.8	95.7	2.7	1.1	8.5	22.1	30.4	26.9	7.8	9.3	0	0	0
Bkyz1	60	2.6	3.1	94.3	1.3	1.8	11.5	25.8	32.6	18.5	5.0	23.2	0	0	0
Bkyz2	90	2.0	5.9	92.1	2.6	3.3	11.7	30.5	34.6	12.9	2.4	23.9	0	0	0
Bkyz3	120	1.2	3.8	95.0	2.9	0.9	8.0	30.7	47.8	7.5	1.0	14.5	0	0	0
PEDON - 2: Typic Torriorthent, sandy, skeletal, carbonatic, hyperthermic (229140mE 3280949 mN zone 39)															
A	25	24.9	33.0	42.1	20.6	12.4	26.2	8.7	6.1	1.1	0.0	53.7	8	3	0
C1	40	20.7	42.1	37.2	23.4	18.7	24.5	5.5	5.5	1.1	0.6	64.0	25	16	0
C2	70	14.8	11.8	73.4	7.4	4.4	6.8	8.3	15.4	27.5	15.4	66.8	33	20	0
C3	100	11.8	15.4	72.8	10.4	5.0	6.5	9.5	14.8	23.5	18.3	66.7	33	31	0

TPL = total pretreatment loss; VF = very fine; F = fine; M = medium; C = coarse; VC = very coarse

Table 3. Morphological properties of representative pedons.

Horizon	Lower depth (cm)	Munsell color dry	Munsell color moist	Texture#	Structure†	Consistence‡	Effervescence§	Lower¶ boundary
PEDON 1: Gypsic aquisalids, sandy, mixed, hyperthermic (236057 mE 3173153 mN Zone 39)								
Akz	2	2.5Y 6/4	2.5Y 5/3	cs	m	vfr	ste	as
Bkz	25	2.5Y 6/4	2.5Y 5/3	cs	m	vfr	ste	as
Bkyz1	60	2.5Y 6/4	2.5Y 5/3	s	m	vfr	ste	cw
Bkyz2	90	2.5Y 7/4	2.5Y 5/3	s	m	vfr	ste	cw
Bkyz3	120	2.5Y 7/4	10YR 5/4	s	m	fi	ste	-
PEDON 2: Typic torriorthents, sandy, mixed, hyperthermic (229140mE 3280949 mN zone 39)								
A	25	2.5Y 7/3	2.5Y 5/3	l	wtp	fr	ste	gw
C1	40	10YR 5/2	10YR 6/2	gcs	m	fi	vie	gw
C2	70	10YR 5/2	10YR 6/2	gcs	m	fi	vie	dw
C3	100	10YR 5/2	10YR 6/2	gcs	m	fi	vie	-
PEDON 3: Typic aquisalids, sandy, mixed, hyperthermic (235999 mE 3173123 mN zone 39)								
Az	5	2.5Y 6/4	10YR 5/3	s	m	fr	se	cs
Bkz	25	2.5Y 6/4	2.5Y 5/3	s	m	vfr	ste	cs
Bk1	60	2.5Y 6/3	2.5Y 5/3	s	m	vfr	ste	cw
Bk2	90	2.5Y 7/3	2.5Y 5/3	cs	m	vfr	ste	cs
Bk3	120	2.5Y 7/3	2.5Y 5/3	cs	m	l	vse	-

Texture abbrev. l = loam; s = sand; cs = coarse sand; gcs = gravely coarse sand
† Structure abbrev. m = massive; wtp = weak thick platy
‡ Consistence moist abbrev. l = loose; fr = friable; vfr = very friable; fi = firm
§ Effervescence abbrev. vse = very slightly effervescent; se = slightly effervescent; ste = strongly effervescent; vie = violently effervescent
¶ Lower boundary abbrev. as = abrupt smooth; cw = clear wavy; cs = clear smooth; gw = gradual wavy; dw = diffuse wavy

HALOPHYTES IN SABKHA ENVIRONMENTS

Halophytes are widespread in low lying lands that have been waterlogged and salt affected by surface and sub-surface flooding. Their cells maintain a higher osmotic potential to prevent water loss. The roots can withstand low oxygen levels without losing control over ion uptake. Some halophytes develop root air channels and adventitious roots, which can assist them in surviving under sabkha conditions. Some absorb salts while others lose salts via leaf tissues.

Five major plant communities are identified in the sabkhat of Kuwait. These are: *Nitraria resuta, Tamarix aucheriana, Zygophyllum qatarense, Halocnemum strobilaceum* and *Seidlitzia rosmarinus*. Associated species are: *Aeluropus lagopoides, Aeluropus littoralis, Frankenia pulverulenta, Bienertia cycloptera, Cressa cretica, Aizoon canariense, Aizoon hispanicum* and *Mesembryanthemum nodiflorum*. The site locations of these plant communities are shown in Fig. 2.

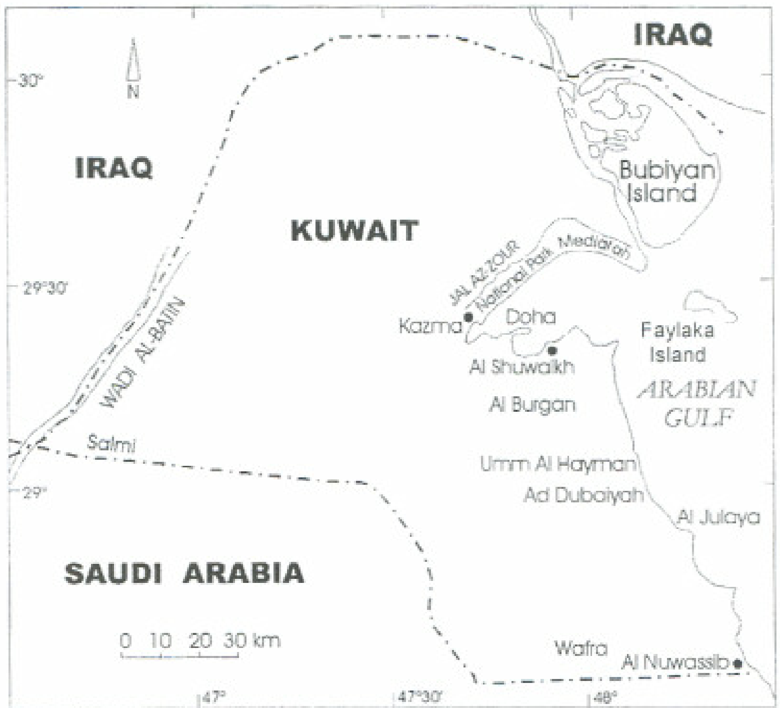

Figure 2. Map of Kuwait showing sites of halophytes in sabkha environments.

Nitraria resuta (Forssk.) Aschers. (Qhardaq or Qharqad)
The seeds of this shrub can be easily germinated in pots and the plant can be also reproduced by tissue culture technique. This was successfully accomplished by KISR in 1999. The shrub is found in the coastal areas of the National Park of Kuwait, Kazma, Mediarah, As Subiyah, Al-Nuwaseeb-Wafra and Al Khiran.

Tamarix aucheriana (Decne.) baum (Athl)
This shrub grows in saline grounds at sabkha edges. It is found in Doha, Ad Dubaiyah and Al Burgan.

Zygophyllum qatarense Hadidi (harim)
This shrub is found along the coastal zones in the north and south of Kuwait. It occurs also inland in saline grounds at sabkha edges.

Halocnemum strobilaceum (Pall.) M.B. (Thullayth)
This shrub grows on mudflats which are periodically submerged by sea-water along the coastal line in the north and south of Kuwait.

Seidlitzia rosmarinus Ehrenb. Ex. Bge. (Shinan, Ushnan)
This shrub grows in few locations on islands and off shores along the coast in the north. It also occurs in the Al Shuwaikh area.

Associated species:
Aeluropus lagopoides (L.) Trin. Ex. Thwaites (Ikrish)
This perennial grass is commonly found in Kazma, Umm Al Hayman and Al-Khiran.

Aeluropus littoralis (Goauan) Parl. (Sheraib, Ikrish)
This perennial grass occurs occasionally in the east of Kuwait and was reported in Kazma.

Frankenia pulverulenta L. (Mulaih, Abuthurayb)
This annual herb is common in sabkha areas with Tamarix shrubs, at Ad Dubaiyah, Al Khiran, Al Shuwaikh and Doha.

Bienertia cycloptera Bunge (Golleman)
This annual herb is found in low saline lands in Ad Dubaiyah, Al Shuwaikh, Doha and the National park coastal zone.

Cressa cretica L. (Shuwayla Nadwa)
This short herb is common in sabkhat in Al Nuwassib, Doha, As Subiyah and the National park of Kuwait.

Aizoon canariense L. (Hudq)
This herb is found in scattered localities near sabkha areas, i.e. Ad Dubaiyah, Al Shuwaikh and Doha

Aizoon hispanicum L. (Mullayh)
This annual herb appears in coastal areas on hard desert soils and sometimes in inland areas.

Mesembryanthemum nodiflorum L. (Qasool)
This succulent herb is found in sandy shores in the south and north of Kuwait.

MEASURES FOR CONSERVING SABKHA ECOSYSTEMS IN KUWAIT

The sabkha ecosystems in Kuwait are threatened by activities and processes like excessive grazing, off road driving (Fig. 3), oil pollution (with reference to the Gulf war 1991), dumping and sand encroachment. KISR carried out several studies to assess the impacts. Therefore measures for conservation of sabkha ecosystems were necessary. As a result of that many areas in Kuwait were set aside to protect the fragile habitats. The following areas were allocated for their importance in respect to vegetation and wildlife:
Doha-Sulaybikhat Bay, Jahra Pond, the National Park of Kuwait and the Botanical Garden and Eco Park at the coastal zone of Sulaybikhat Bay near Doha.

Figure 3. Sabkha soil affected by off road vehicle use in Ad Dubaiyah.

RECOMMENDATIONS

Because knowledge of sabkha ecology is very limited the following research studies should be carried out as the next step towards a better understanding the processes:

- The seasonal variations of the water table which has an impact on the vigor and growth of sabkha plants.

- Monitoring of soil salinity in order to understand the salinity build up problem in sabkhat.
- Study of the mechanism by which the watertable and logging influence root growth and performance of *Nitraria resuta* and *Tamarix aucheriana*.
- Study the sand dynamics of mobile sand.
- Study of microbial activities in sabkhat. The type of microbes surviving under severe salinity may have valuable benefit that is worth investigating.
- Wildlife such as birds, reptiles and insects that survive in sabkha areas as their niche need to be identified.
- The impact of salinity on different seeds of native plants needs to be investigated in order to understand the mechanism by which plants propagate under saline conditions. Tissue culture techniques are recommended for multiplication of sabkha plants, particularly species that are under pressure.
- Study of plant adaptation and mutation. The mechanisms by which plants resist salinity needs further research and assessment.
- Grazing impact and sand encroachment need to be surveyed and assessed.

References

Gunatilaka, A. & Mwango, S. 1987. Continental sabkha pans and associated nebkhas in Southern Kuwait, Arabian Gulf. Desert sediments: Ancient and Modern. *Geological Survey Special Publication* 35: 187-203.

KISR 1999. Soil Survey for the State of Kuwait. 5 Volumes. AACM International: Adelaide, Australia.

Richards, L.A. 1954. Diagnosis and Improvement of Saline and Alkali Soils. United States Salinity Laboratory Staff, Handbook No. 60.

Soil Survey Division Staff. 1993. Soil Survey Manual. United States Department of Agriculture. Handbook No. 18. U. S. Govt. Print. Office, Washington, DC.

Soil Survey Staff, Soil Conservation Service. 1994. Keys to Soil Taxonomy-6th Edition. United States Department of Agriculture. U. S. Govt. Print. Office, Washington, DC.

USDA. 1996. Soil Survey Laboratory Methods Manual. Soil Survey Investigation Report No. 42. Version 3.0. United States Department of Agriculture. U. S. Govt. Print. Office, Washington, DC.