

مجلة جامعة الملك عبدالعزيز: العلوم الهندسية ، م ١٤ ع ١٠٤ ص ١-١٠٤ بالعربية ، ص ١-١٤٢ بالإنجليزية (١٤٢٢-١٤٢٤هـ / ٢٠٠٢-٢٠٠٣م)  
رديف ١٠٤٧ - ١٣١٩



# مجلة جامعة الملك عبد العزيز العلوم الهندسيّة

المجلد ١٤ العدد ٢

١٤٢٢-١٤٢٤هـ

٢٠٠٢-٢٠٠٣م

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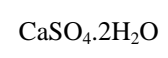
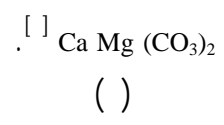
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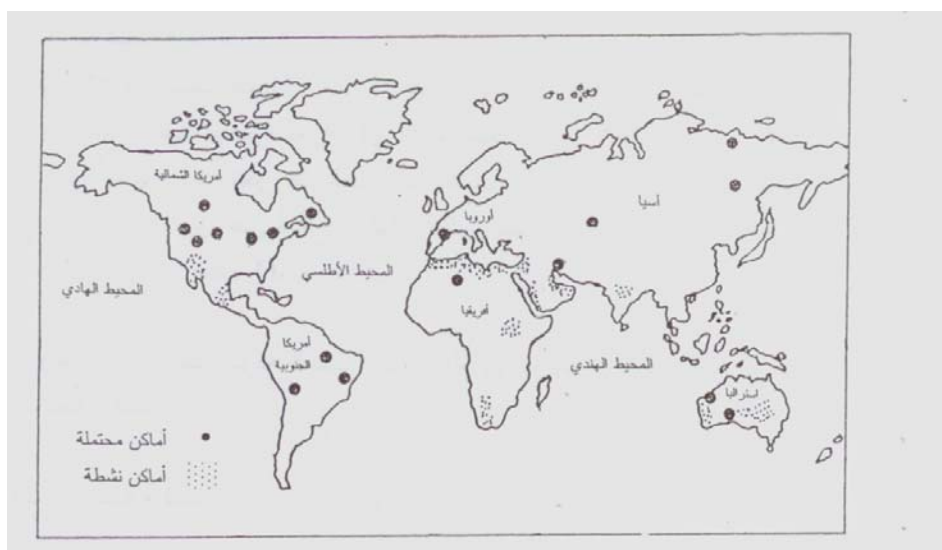
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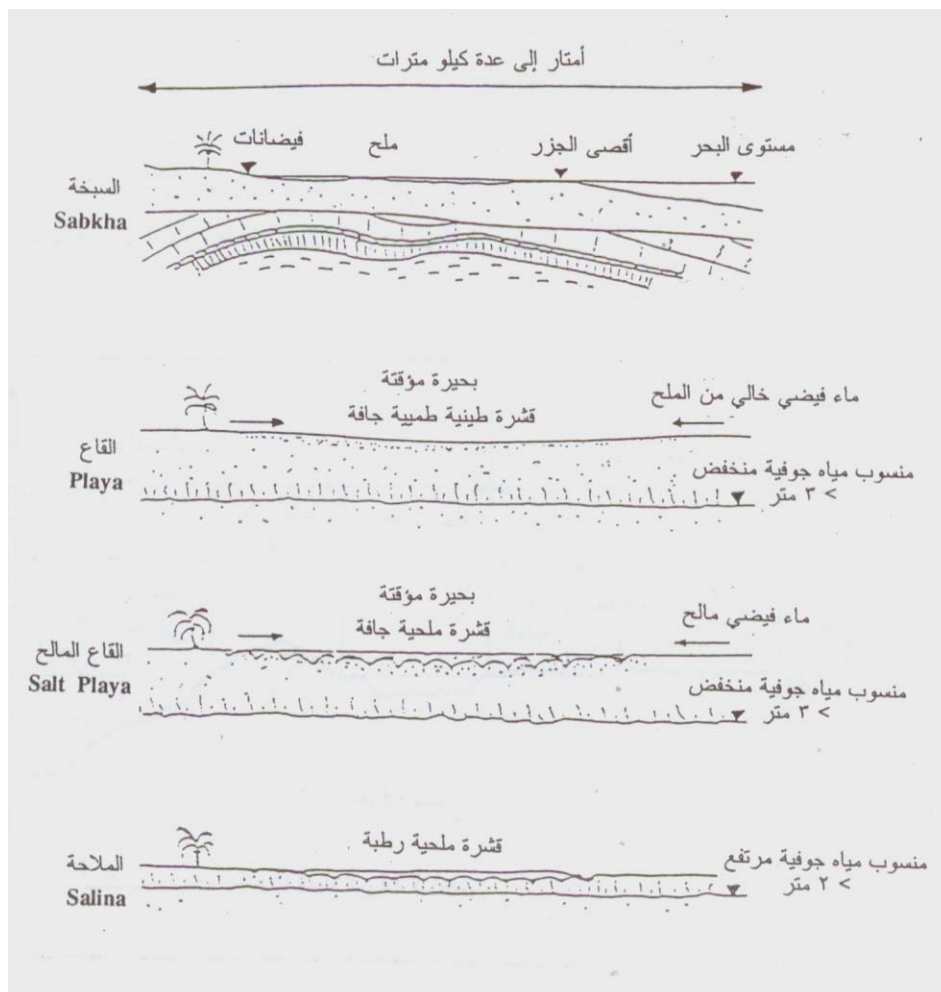
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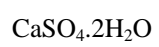
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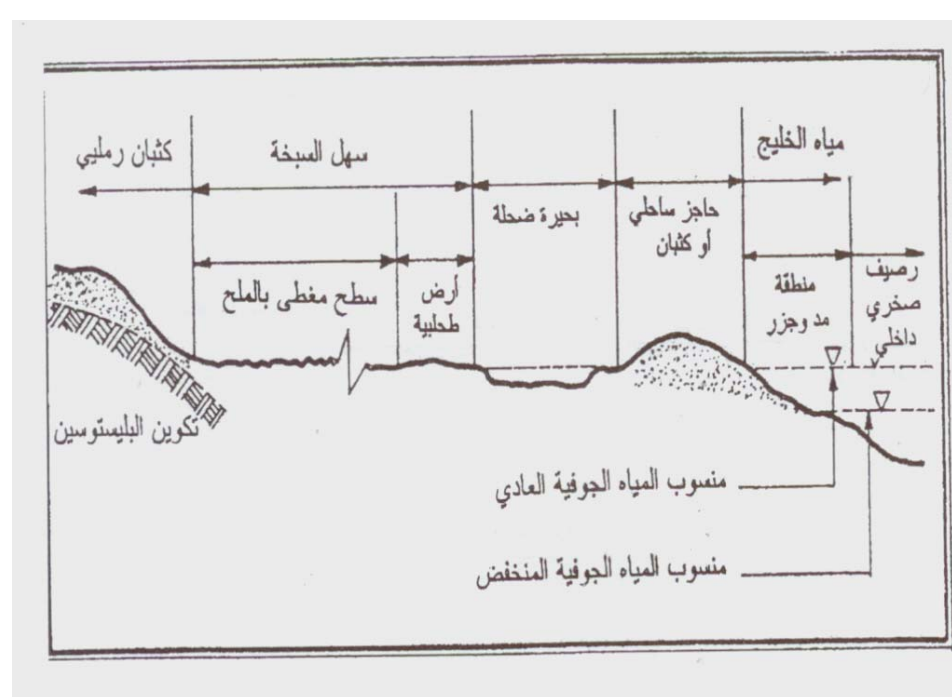
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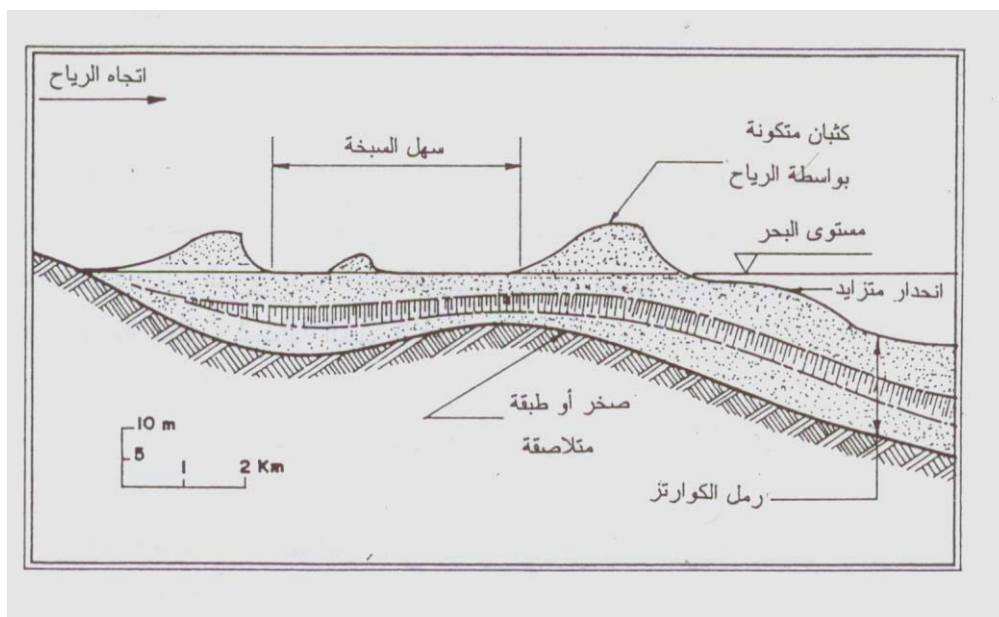


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(CaSO<sub>4</sub>)

(NaCl)

(SrSO<sub>4</sub>)

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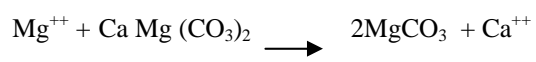
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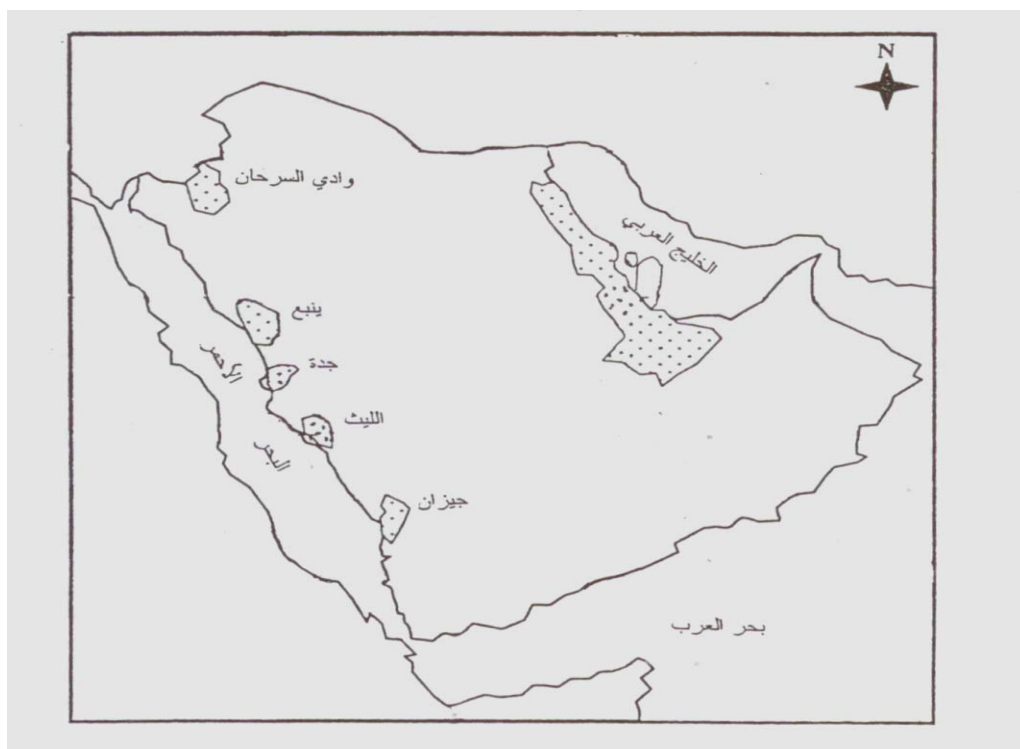
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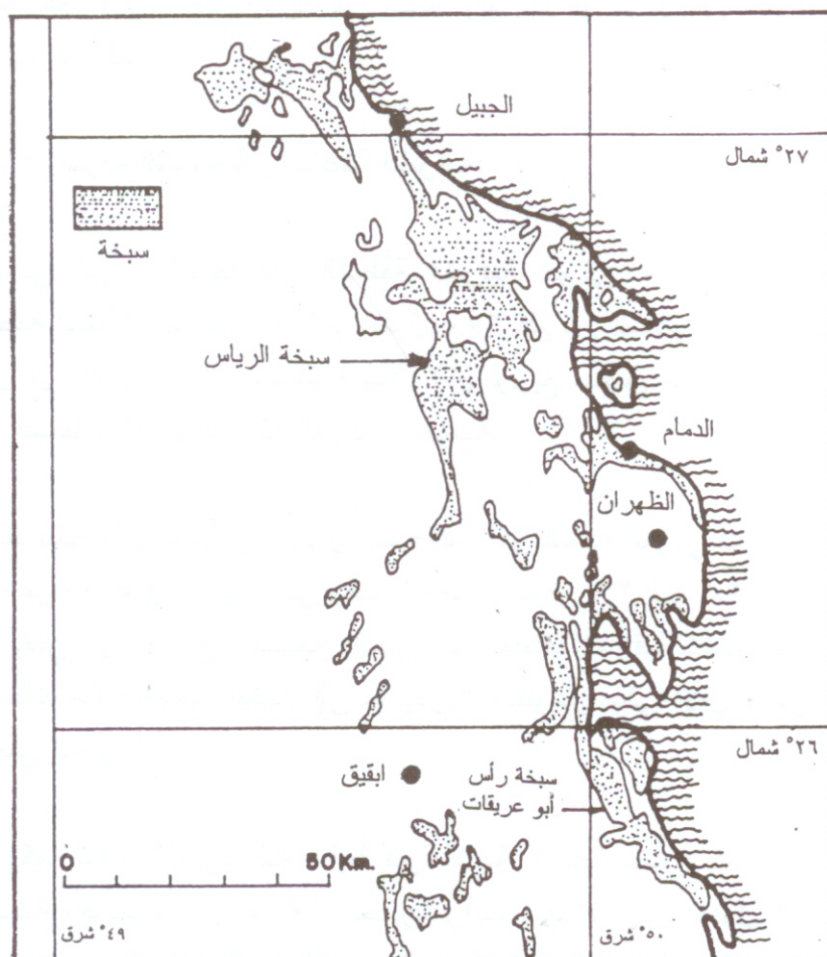
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,	,	(So <sub>4</sub> ) <sup>--</sup>

<i>I</i>	<i>I</i>	(HCO <sub>3</sub> ) <sup>-</sup>
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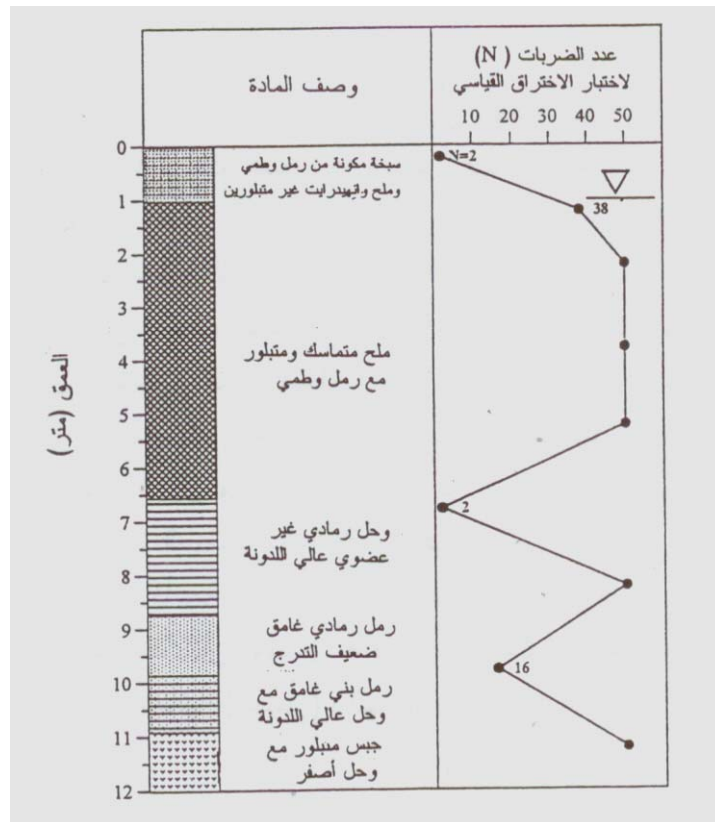
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A-4	ML			,	,		-	-		
A-2-4	SM	,		,	,		-	-		
A-2-4	SM	,		,	,		-	-		
A-3	SP	,		,	,		-	-	,	
A-2-4	SM	,		,	,		-	-	,	
A-2-4	SM	,		,	,		-	-	,	
A-4	SM	,		,	,		-	-		
A-2-4	SM	,		,	,		-	-		
A-6	CL			,	,	,	,	,		
A-4	ML	,		,	,		-	-		
A-3	SP-SM	,		,	,		-	-	,	
A-3	SP-SM	,			,		-	-		
A-2-4	SM	,		,	,		-	-		
A-4	ML-CL			,	,	,	,	,		

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AASHTO	Unified	W <sub>opt</sub> at CBR <sub>max</sub> (%)	CBR <sub>max</sub>	W <sub>opt</sub> (%)	γ <sub>d max</sub> (g/cm <sup>3</sup> )				#	
A-2-4	SM	,		,	,		-	-		
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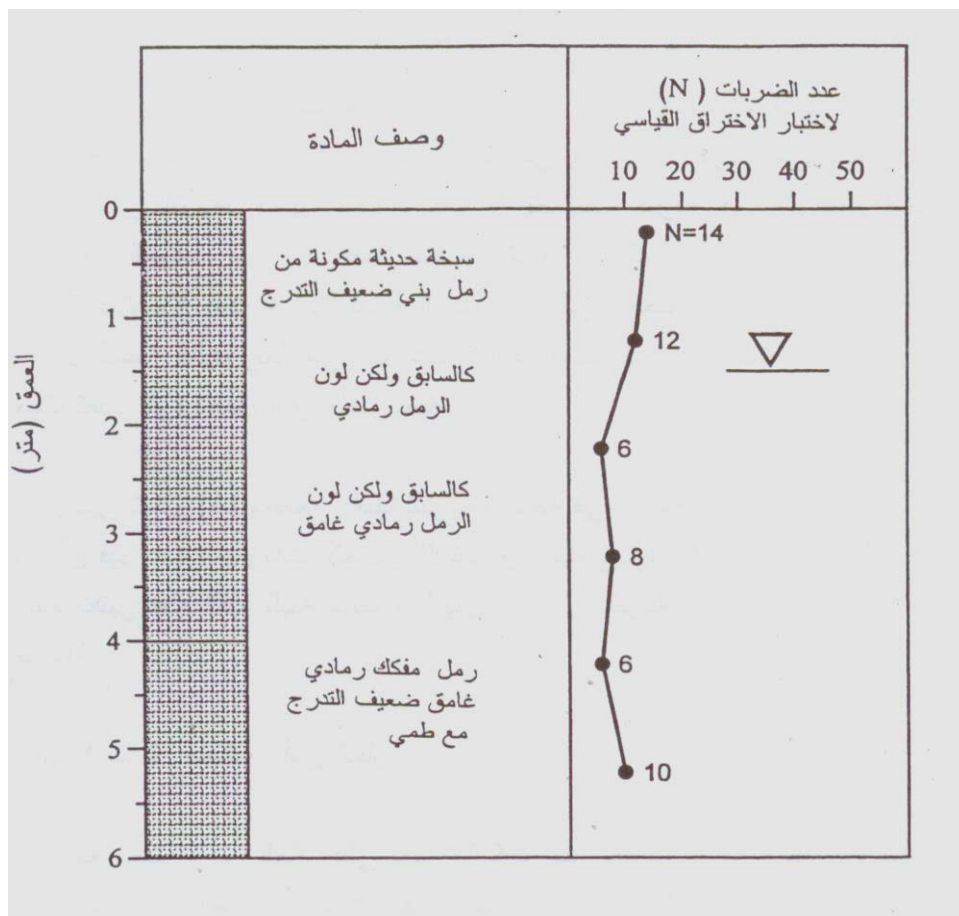
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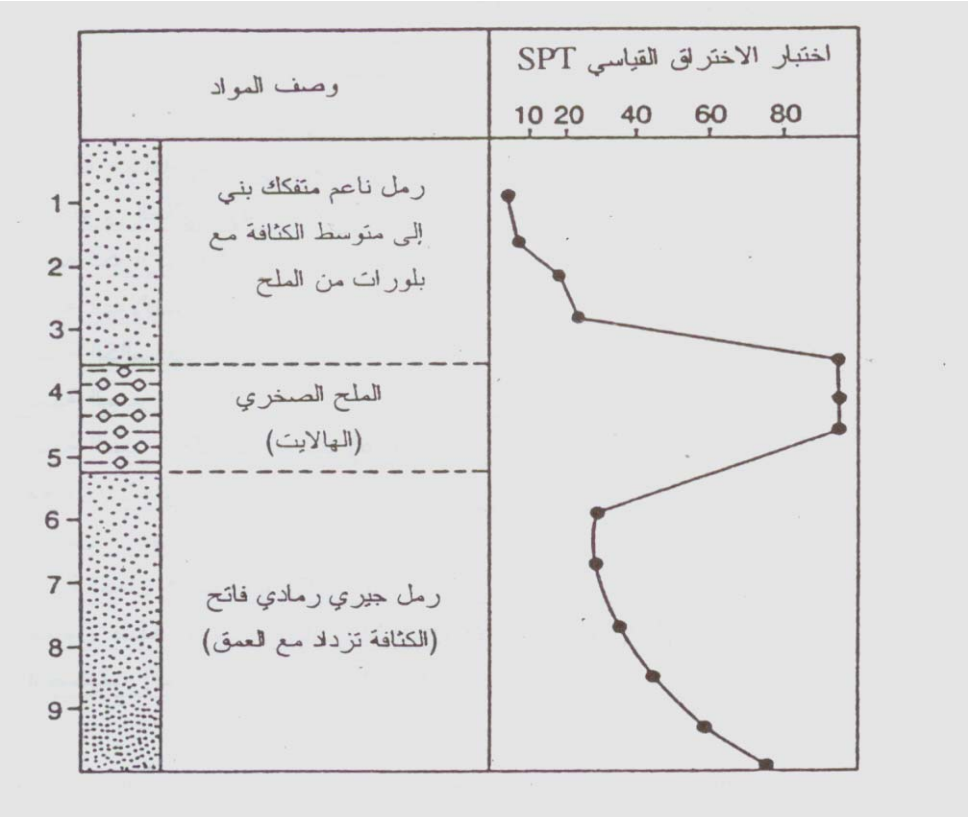
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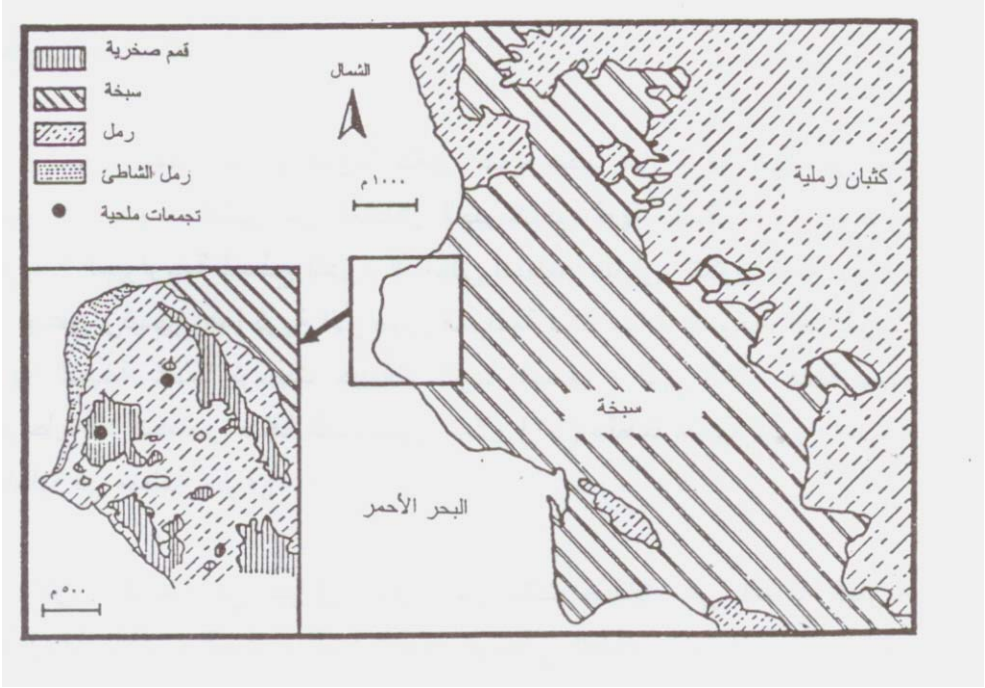
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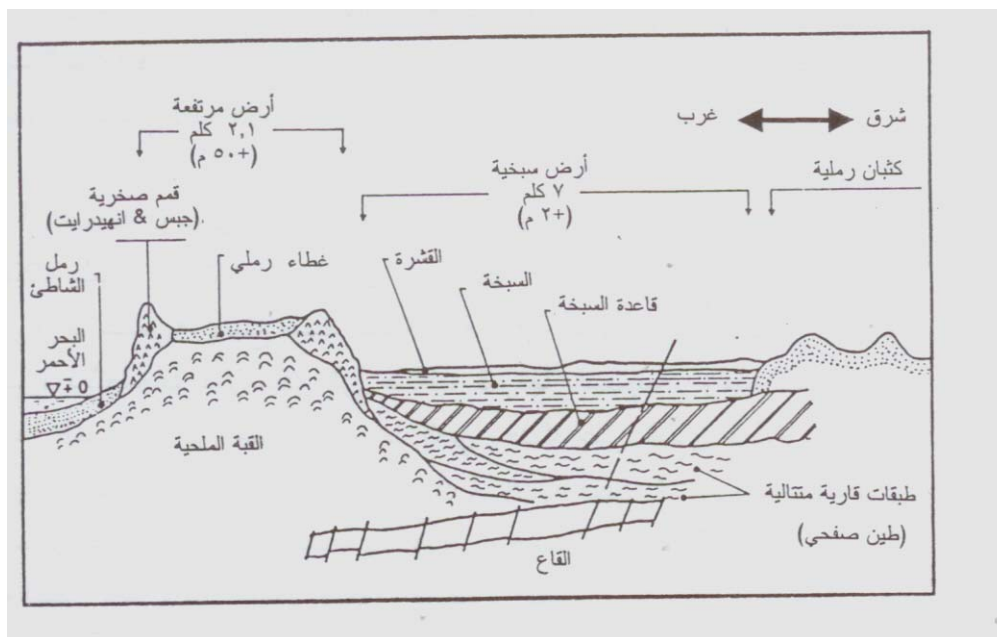
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العمق (متر)	الطبقة	الرمز	وصف المواد	رمز المجموعة	المسك (متر)	SPT, N	القولم		
							LL %	PI	Wn %
1	الطبقة الأسفلية		طمي غير لدن مع رمل ناعم مع وجود كبريتات وكلوريد	ML-SM	٢.٢-٠.٧	١٦-٩	غير لدن	غير لدن	٥.٨ ± ٢٤.٤
2									
3	طبقة السياسة القابلة للاستخدام		طين عضوي عالي اللدونة مع طمي	OH, MH	١.٥ ± ٣.١	٦-١	١٤ ± ٥٧	٨ ± ٢٥	١٤.٢ ± ٤٩.٣
4									
5			طمي متوسط إلى منخفض اللدونة مع طين	CL, ML	١.٩ ± ٣.٥٥	٦-١	٨ ± ٣٣	٤ ± ١١	٧.١ ± ٣٣.٦
6									
7	قاعدة السياسة		رمل ناعم طيني غير لدن	SM, SC	١.٨٥ ± ٣.٦٥	٨-٢	غير لدن	غير لدن	٨.٨ ± ٢٥.٥
8									
9									
10									
11	قاعدة السياسة		رمل ناعم متوسط الكثافة إلى كثيف			متغير (من متوسط الكثافة إلى كثيف جداً)	-	-	-
12									
13									

LL : حد السيولة ، PI : معيار اللدونة، Wn : المحتوى المائي الطبيعي، SPT : اختبار الاختراق القياسي، N : عدد الضربات

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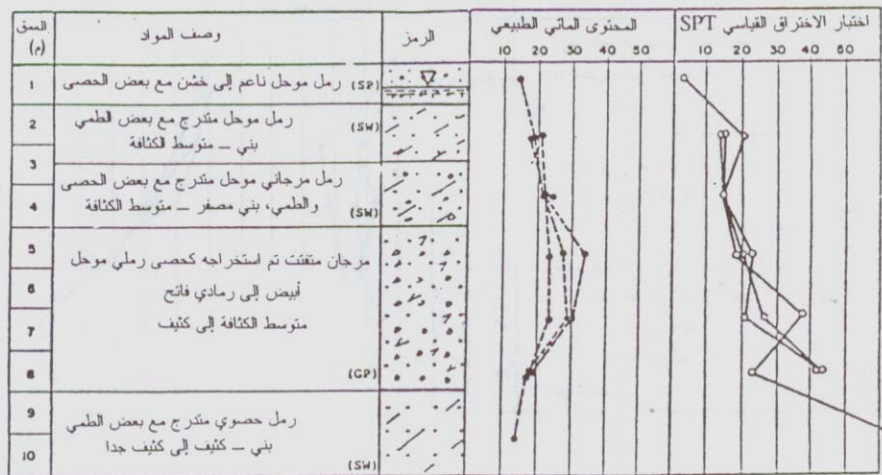
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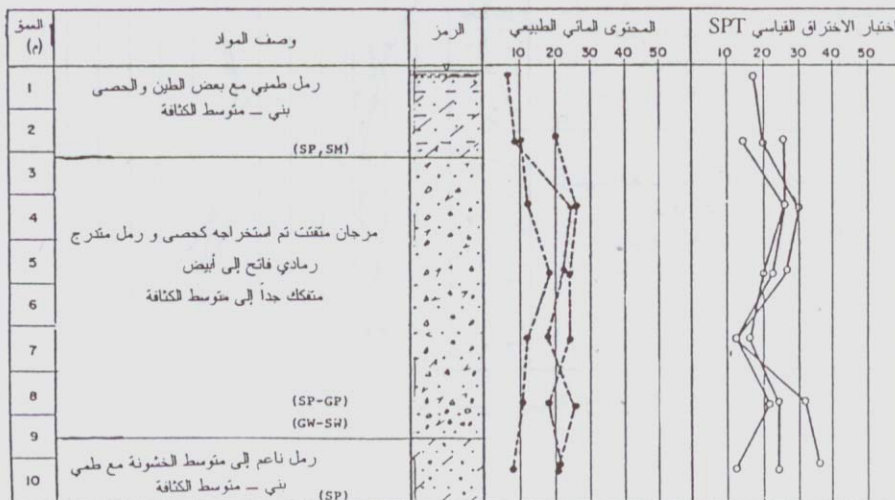
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سبحة الخالدية (البيانات هي متوسط ثلاث جسات)



سبحة السلامة (البيانات هي متوسط ثلاث جسات)





سبحة الكورنيش (البيانات هي متوسط سبع جسات)

العمق (م)	وصف المواد	الرمز	المحتوى المائي الطبيعي					اختبار الاختراق القياسي SPT				
			10	20	30	40	50	10	20	30	40	50
1	حصي و رمل مرجاني ناعم إلى خشن الحبيبات مع بعض الطمي بني ورمادي متفكك جداً إلى متوسط الكثافة (GP-SP, SP)											
2												
3												
4												
5	رمل مرجاني ناعم إلى متوسط الخشونة مع حصي ناعم يوجد طبقات من الطمي الرملي لونه رمادي متفكك جداً إلى كثيف (SP)											
6												
7												
8												
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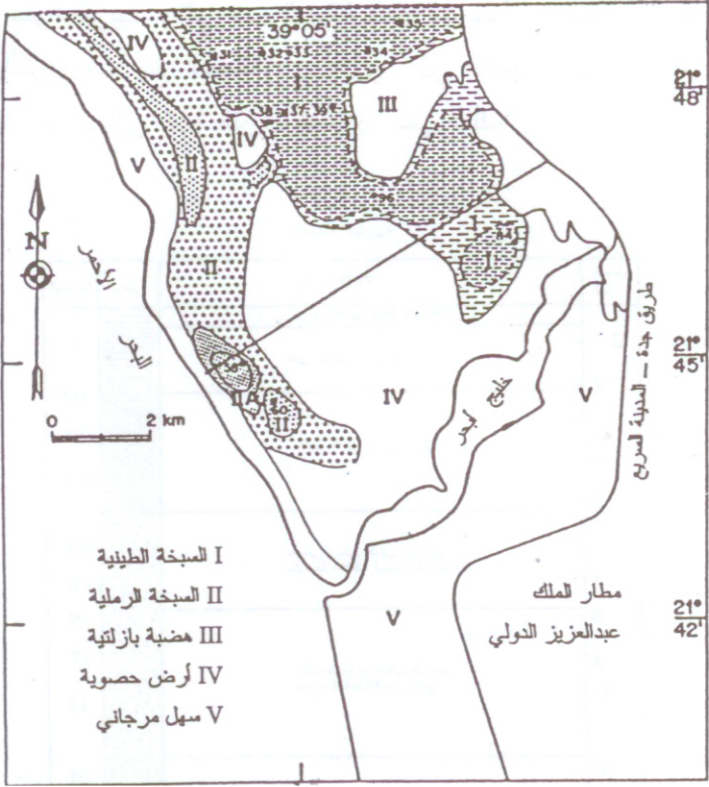
سبحة ميناء جدة (البيانات هي متوسط خمس جسات)

العمق (م)	وصف المواد	الرمز	المحتوى المائي الطبيعي					اختبار الاختراق القياسي SPT				
			10	20	30	40	50	10	20	30	40	50
1	رمل ناعم إلى متوسط الخشونة مع حصي ناعم رمادي فاتح ، مفكك متوسط الكثافة إلى كثيف (SP)											
2												
3	رمل عضوي ناعم إلى متوسط الخشونة مع بعض الحصى والطيني رمادي، مفكك جداً (SP)											
4												
5												
6	رمل مرجاني ناعم إلى خشن مع حصي رمادي فاتح، مفكك (SP-GP)											
7												
8												
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10	رمل مرجاني ناعم إلى خشن مع حصي رمادي بني ، مفكك جداً إلى مفكك											

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-	(Na <sup>+</sup> )
, - ,	(Mg <sup>++</sup> )
, - ,	(K <sup>+</sup> )
, - ,	(Ca <sup>++</sup> )
, - ,	(Cl <sup>-</sup> )
, - ,	(So <sub>4</sub> ) <sup>-</sup>
, - ,	(HCO <sub>3</sub> ) <sup>-</sup>
, - ,	(pH)
-	(Salinity)

## المنطقة الطينية

العمق (م)	وصف المواد	الرمز	قيمة N
1	رمل طيني متكتل بني فاتح		1
2	طين طيني رملي لين رمادي		10
3	طين طيني رملي كثيف بني		14
4	طين طيني رملي كثيف بني		25
5			
6	حصى رملي طيني كربوني متوسط الكثافة لونه طينيسي		28
7	حصى رملي طيني كربوني متوسط الكثافة لونه طينيسي		25
8			19
9	رمل حصوي طيني كربوني متوسط الكثافة بني فاتح		17
10	رمل حصوي طيني كربوني متوسط الكثافة بني فاتح		13
11			
12			78
13	طين طيني رملي حصوي كثيف بني محمر		92
14			
15			

## المنطقة الرملية

العمق (م)	وصف المواد	الرمز	قيمة N
1	قشرة رملية متماسكة بلوة اللون		3
2	رمل طيني كربوني متكتل جداً لونه طينيسي		8
3	رمل طيني حصوي كربوني متكتل رمادي فاتح		22
4	رمل طيني حصوي كربوني متوسط الكثافة رمادي فاتح		23
5			31
6	حصى رملي طيني كربوني كثيف جداً رمادي غلق		80
7			
8	حجر جيري خشبي الحبيبات ضخم لونه ليموني مصفر		
9			

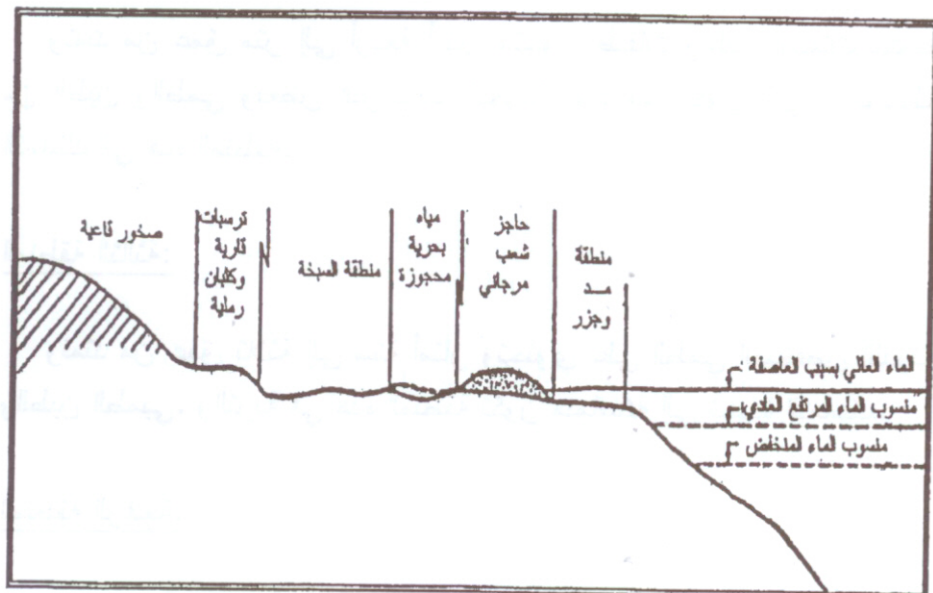
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CBR max	W <sub>opt</sub> (%)	CBR max	W <sub>opt</sub> (%)	CBR max	W <sub>opt</sub> (%)	CBR max	W <sub>opt</sub> (%)	CBR max	W <sub>opt</sub> (%)	CBR max	W <sub>opt</sub> (%)	
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$q_u$ (kPa)	$W_{opt}$ (%)	$q_u$ (kPa)	$W_{opt}$ (%)	$q_u$ (kPa)	$W_{opt}$ (%)	$q_u$ (kPa)	$W_{opt}$ (%)	$q_u$ (kPa)	$W_{opt}$ (%)	$q_u$ (kPa)	$W_{opt}$ (%)	(%)
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[2] Aiban, S.A. , Al-Abdul Wahhab, H. I. And Al-Amoudi, O. S. B. " Identification , Evaluation and Improvement of Eastern Saudi Soils For Constructional Purposes", *Final Report Project No. AR-14-61*, King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia (1999).

[3] Tomilson, M. J. " Middle East - Highway and Airfield Pavements " *The Quarterly Journal of Engineering Geology*, **11** : 65-73 (1978).

[4] Shin, E. A. " Sedimentary Accretion along the Leeward, SE Coast of Qatar Peninsula, Persian Gulf" *The Persian Gulf*, Ed. By B.H. Purser, Springer-Verlag, 109-209 (1970).

[5] Newbery, J. and Subramaniam, A. S. " Middle East - Sewerage Projects for Coastal Towns of the Libyan Arab Republic" *The Quarterly Journal of Engineering Geology*, **11** : 101-112 (1978).

[6] Horta, J. C. " Characterization of Calcrete and Gypcrete as Pavement Materials" *Proceedings of the International Conference on Roads and Road Transport Problems, ICORT-88*, New Delhi, India, 781-788 (1988).

[7] Akpokodje, E. G. " The Stabilization of Some Arid Zones Soils with Cement and Lime" *The Quarterly Journal of Engineering Geology*, **18** : 173-180 (1985).

- [8] Kinsman. D.J.J " Modes of Formation, Sedimentary Associations, And Diagnostic Features of Shallow-Water and Supratidal Evaporites" *The American association of petroleum Geologist Bulletin*, **53(4)** : 830-840 (1969).
- [9] Lund, O. L. and Ramsey, W. J. "Experimental Lime Stabilization in Nebraska " *Highway Research Board, HRB*, **231** : 24-59 (1983).
- [10] Farwana, T. A. and Majidzadeh, K. " An Investigation into the Use of Emulsified Asphalt in the Stabilization of Sandy Sabkha" , *Proceedings of the 3<sup>rd</sup> IRF Middle East Regional Meeting*, **3**: 3.355-3.379 (1988).
- [11] Dhowian , A.W and Erol, A.O " Ground Conditions and Associated Structural Problems In Tabuk and Jazan Regions" *Final Report Project No. AR-8-106*, King Abdul Aziz City for Science and Technology, Riyadh, Saudi Arabia (1993).
- [12] Ellis, C.I. "Arabian Salt-Bearing Soil (Sabkha) as an Engineering Material", *Transport and Road Research Laboratory, TRRL Report LR 523*, UK, (1973).
- [13] Fookes, P. G. and Collis, L." Problems in the Middle East" *Concrete*, **9(7)**: 12-17 (1975).
- [14] Akili, W. " On Sabkha Sands of Eastern Saudi Arabia " *Proceedings, Symposium on Geotechnical Problems in Saudi Arabia*, Riyadh, Saudi Arabia, **2** : 775-796 (1981).

[15] Fookes, P.G., French, W.J. and Price, S.M. " The Influence of Ground and Groundwater Geochemistry on Construction in the Middle East" *The Quarterly Journal of Engineering Geology*, **18** : 101-128 (1985).

[16] Bush, P. " Some Aspects of the Diagenetic History of the Sabkha in Abu Dhabi, Persian Gulf" in: Purser, B.H., *The Persian Gulf*, Springer-Verlag, Austria, 395-407 (1973).

[17] Levy, Y. " The Origin and Evolution of Brine in Coastal Sabkhas, Northern Sinai" *Journal of Sedimentary Petrology*, **47(1)** : 451-462 (1977).

[18] James, A.N. and Little, A. L. " Geotechnical Aspects of Sabkha at Jubail, Saudi Arabia" *The Quarterly Journal of Engineering Geology*, **27**: 83-121 (1994).

[19] Johnson, H.S., Kamil, M.R., Pierson, G.O. and Ramsay, J.B. " Sabkhas of Eastern Saudi Arabia" in Al-Sayyari, S.S. and Zolt, J.G. (Ed.), *Quarterly period in Saudi Arabia*, Springer, Berlin, 84-93 (1978).

[20] Abu-Taleb, M.G. and Egeli, I. " Some Geotechnical Problems in the Eastern Province of Saudi Arabia", *Proceedings, Symposium on Geotechnical Problems in Saudi Arabia*, Riyadh, Saudi Arabia, **2** : 799-811 (1981).

[21] Al-Amoudi, O.S.B., Abduljawwad, S.N., El-Naggar, Z.R. and Rasheeduzzafar " Response of Sabkha to Laboratory Tests: A Case Study" *Engineering Geology*, **33**:111-125 (1992).

- [22] Abduljawwad, S.N. and Al-Amoudi, O.S.B. " Geotechnical Behaviour of Saline Sabkha Soils" *Geotechnique*, **45(3)**: 425-445 (1995).
- [23] Ghazali, F.M, Fatani , M.N. and Khan , A.M. " Geotechnical Properties Of Sabkha Soils of Jeddah , Saudi Arabia" , *Proceedings of the Second Saudi Engineers conference* , Dhahran, Saudi Arabia, **1**:286-307 (1985 ).
- [24] Hossain, D. and Ali, K. M. " Geotechnical and Geochemical Characteristics of Obhor Subsoil", *Faculty of Earth Science Bulletin No.7* , King Abdul Aziz University (1987) .
- [25] Hossain, D. and Ali, K. M." Shear Strength and Consolidation Characteristics of Obhor Sabkha, Saudi Arabia " , *Quarterly Journal of Engineering Geology*, **21**: 347-359 (1988).
- [26] Abou Al Heija, M. K. and Shehata, W.M. " Engineering Properties of Al-Lith sabkha, Saudi Arabia " *5 th. International IAEG Congress* ,Buenos Aires, 935-941(1986).
- [27] Abduljawwad, S. N. , Bayomy, F., Al-Shaikh, A. M. and Al-Amoudi, O.S.B. " Influence of Geotextiles on Performance of Saline Sebkhha Soils" , *Journal of Geotechnical Engineering*, ASCE, **120(11)** : 1939-1960 (1994).
- [28] Al-Amoudi, O.S.B and Abduljawwad, S. N. " Suggested modifications to ASTM Standard Methods When Testing Arid, Saline Soils" , *ASTM Geotechnical Testing Journal*, **17(2)** : 243-253 (1994).

## Sabkha Soil in the Kingdom of Saudi Arabia : Characteristics and Treatment

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**ABSTRACT.** Sabkha soil is found along the Arabian Gulf and Red Sea coasts of Saudi Arabia and in small areas inside the Kingdom. It exists at many locations of the coastal plains of the Eastern Province and along the western shores at Jizan, Jeddah, Obhor and Al-Lith. Sabkha soil is also reported to exist in Wadi As Sirhan in the north and in small areas in Al-Qassim region and the Empty Quarter. The distinguishing features of sabkha soil are the presence of shallow and highly concentrated brines and the variability of its geotechnical characteristics in both the horizontal and vertical directions. These features cause several engineering problems in roads and buildings constructed on the sabkha. There are primarily two types of sabkha soils: coastal and continental. Coastal sabkhas exist in Eastern Province along the Arabian Gulf and in the western shores along the Red Sea. Continental sabkhas are formed inside the land away from the sea and found in Wadi As Sirhan in the north and in small areas in Al-Qassim region and the Empty Quarter. This paper presents a brief description of sabkha soil, its occurrence around the world, its types as well as the main factors affecting it. It also presents the distribution of sabkha soil in Saudi Arabia and the geotechnical and chemical characteristics of sabkha soil in the Eastern Province and in Jizan, Jeddah, Obhor as well as Al-Lith in the western regions. The paper is concluded by mentioning several techniques for treating sabkha soil and presents the results of some of these techniques which were used to treat sabkha soil in some regions.