

(2002 / 1423) 80 -29

2 14

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-1

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[1]

[1]

[1]

[6 5]

[4 3 2]

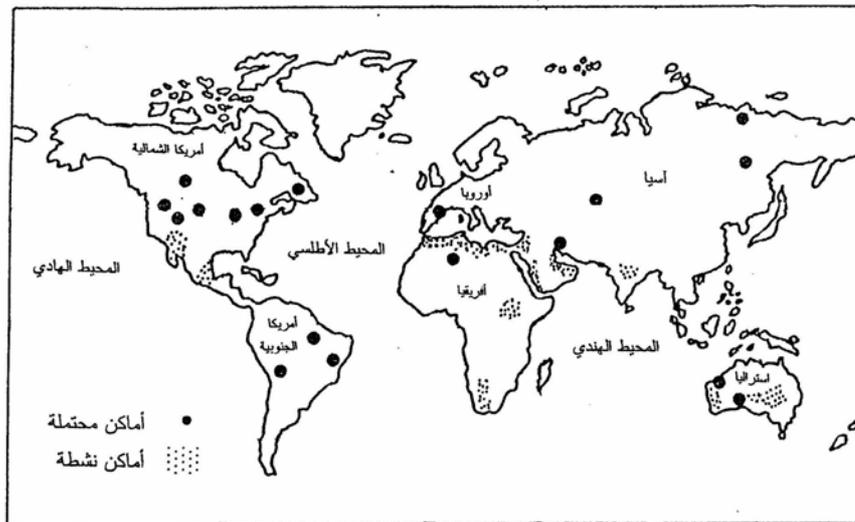
[9 8] [7] [1]
%30
(1) [1]

(1) :

(2)

(3)

(4)



شكل (1): توزيع مناطق تواجد التربة السبخة في العالم [1]

[10]

[2]

[11]

2

[12]

-2 Sabkha

-1 :

[13]

Salina

-4 Salt Playa

-3 Playa

(2)

(2)

:

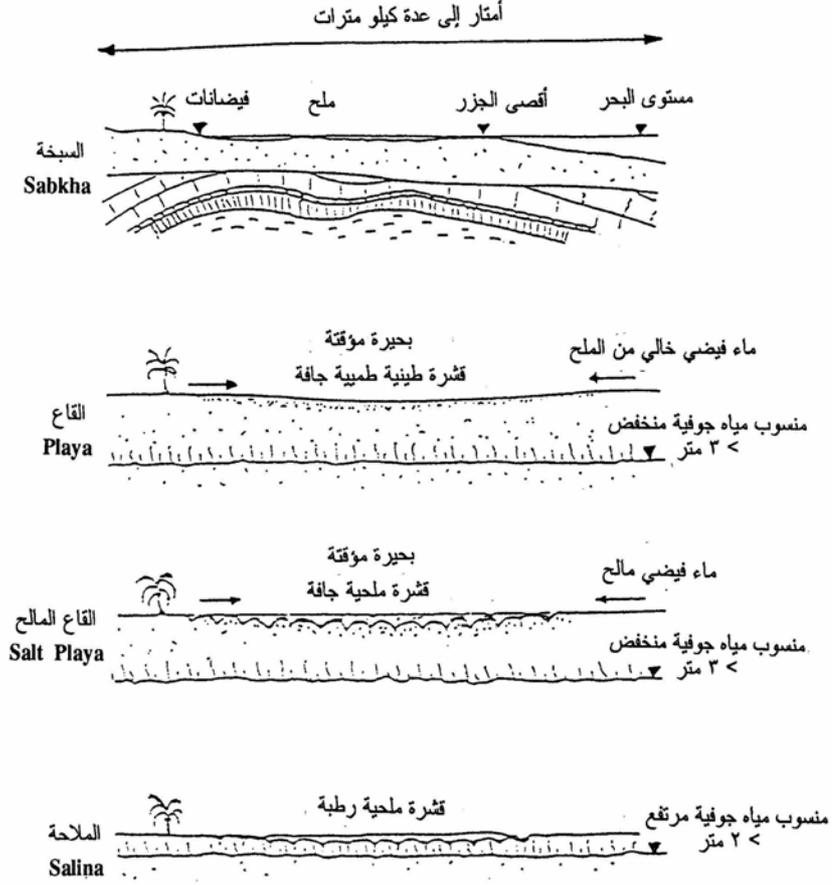
: (Coastal Sabkha)

1 2

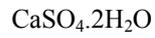
....

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شكل (٢): مقطع عرضي لكل من السبخة، والقاع، والقاع الملح، والملاحه^[١٧]



(3)

(4)

....

[14]

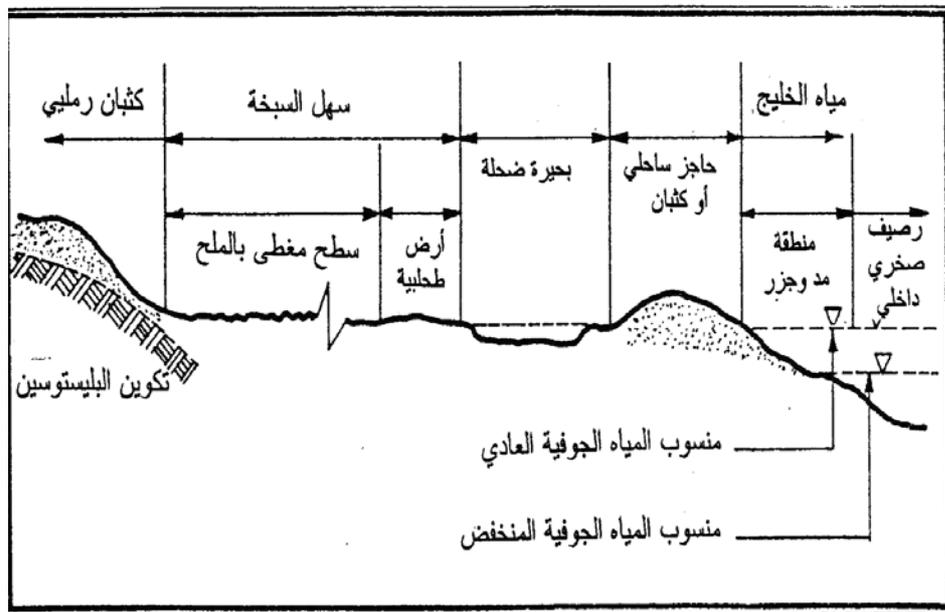
-1 :

-2

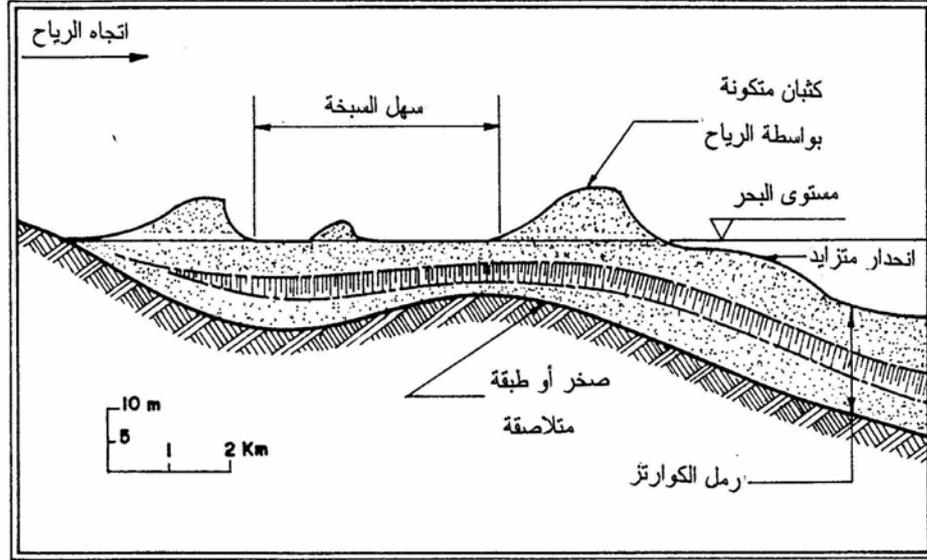
-3

[2]

1.5



شكل (٣): مقطع عرضي نموذجي للسبخة الساحلية^[١٤]



شكل (4): مقطع عرضي لسبخة رمل الكوارتز الساحلية^[14]

: (Continental or Inland Sabkha)

2 2

[15]

(playa)

[1]

[1]

....

(gravel sediments)

NaCl

CaCO₃

[1]

SiO₂

CaSO₄.2H₂O

3

[2]

: (Climatic Factors)

1 3

38

%76

- %67

[8] %67

%95 -

.%76

: (Chemical Composition)

2 3

%4 %3

%37

[2]

%60

[2]

[16]

[1]

:

(CaCO₃)

:

(1)

(CaSO₄·2H₂O)

(CaSO₄)

(NaCl)

....

(SrSO₄)

:

(2)

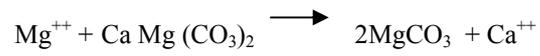
(Ca Mg (CO₃)₂)

[2]

10

(MgCO₃)

:



:(Geomorphological Factors)

3 3

()

[17]

:(Hydrological Factors)

4 3

()

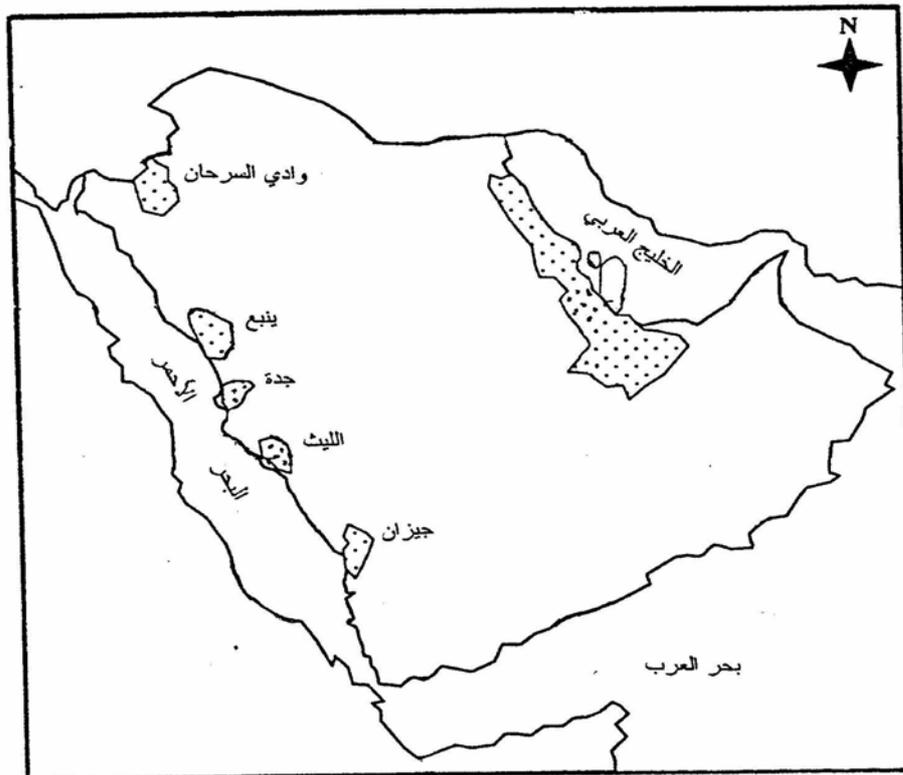
/ 6
[1] / 124

[18] [15] / $6^{-10 \times 1}$ / $5^{-10 \times 6}$

: (**Biological Factors**) 5 3

[2]

(5)



شكل (5): توزيع مناطق التربة السبخة في المملكة العربية السعودية [٧]

[10·11·14·18·26 2 1]

: 1 4

%15

350
(6)

40

[14]

2.9 2.7

4000

[1]

(1)

()

[20]

[20] (55) : (1)

18	97	% 200
10	84.6	%
30	84	%
	39	%
1.34	1.89	³ /
2.51	2.82	
0	6	300/ (SPT)
0	0.54	C (kN/m ²)
0	22	φ (degrees)
1.08	2.16	
0.39	0.95	(Cc)

(2)

[21]

(2)

[(/)]	[(/)]	
20.7	78.8	(Na ⁺)
2.30	10.32	(Mg ⁺⁺)
0.73	3.06	(K ⁺)
0.76	1.45	(Ca ⁺⁺)
		(Fe ⁺⁺)
0.013	0.029	(Sr ⁺⁺)
36.9	157.2	(Cl ⁻)
0.121	0.49	(Br ⁻)
5.12	5.45	(So ₄) ⁻
0.128	0.078	(HCO ₃) ⁻
8.3	6.9	(pH)
46200	208000	(Conductivity)

: 1 1 4

70

30

[19] 12

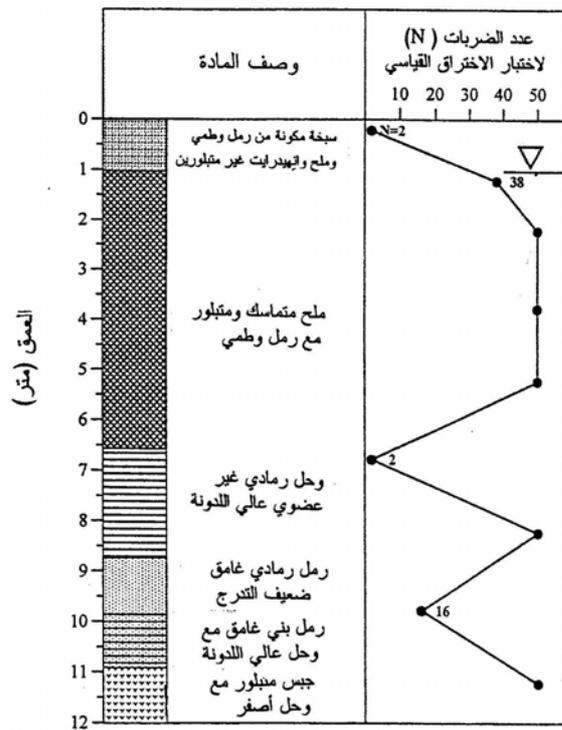
[19]

1.15 30

[2]

(7)

[2]



شكل (٧): مقطع جانبي في سبخة الرياس [١٦]

(3)

. 21.2 17.6

34.5 24.8

[2]

76

108 32

: 2 1 4

[2] 1995

()

[2]

: (3)

AASHTO	Unified	W_{opt} at CBR max (%)	CBR max	W_{opt} (%)	γ_d max (g/cm^3)				# 200	
A-4	ML	6	66	10.8	1.91		-	-	65	1
A-2-4	SM	6.4	84	7.7	2.03		-	-	34	2
A-2-4	SM	9.4	89	11.2	1.94		-	-	21	3
A-3	SP	8.6	32	10.5	1.85		-	-	1.8	4
A-2-4	SM	8.7	90	10.8	2.02		-	-	17.3	5
A-2-4	SM	6.2	73	8.3	2.02		-	-	14.6	6
A-4	SM	7.2	78	11.5	1.89		-	-	43	7
A-2-4	SM	6.5	80	9.1	2.00		-	-	34	8
A-6	CL	14	56	16.5	1.73	13.4	21.1	34.5	76	9
A-4	ML	11.3	65	17.4	1.75		-	-	78	10
A-3	SP- SM	9.8	93	11.9	1.84		-	-	7.5	11
A-3	SP- SM	5.8	88	8	2.03		-	-	9	12
A-2-4	SM	9.8	108	11.8	1.97		-	-	19	13
A-4	ML -CL	9	70	16.2	1.76	7.2	17.6	24.8	81	14

....

3 / 1.57 48 31
 3 / 1.15

 3 / 1.85 3 / 1.31

 (4) .% 16.1 % 13.8

100

52

[2]

: (4)

AASHTO	Unified	W _{opt} at CBR max (%)	CBR max	W _{opt} (%)	γ _{d max} (g/cm ³)				200 #	
A-2-4	SM	9.6	124	12.6	1.91		-	-	28	1
A-4	ML	10.8	52	15	1.85		-	-	55	2
A-4	SM	10.9	108	15.3	1.83		-	-	39	3

: 3 1 4

2

3 / 1.76

.%8.4

[2]

3 / 1.91

72

%4.40

SP

200

[2]

A-3

%6.5

3 /

2.05

[2]

%6.5

46

(8)

14 6

(SPT)

: 4 1 4

15

(9)

[22]

3.5

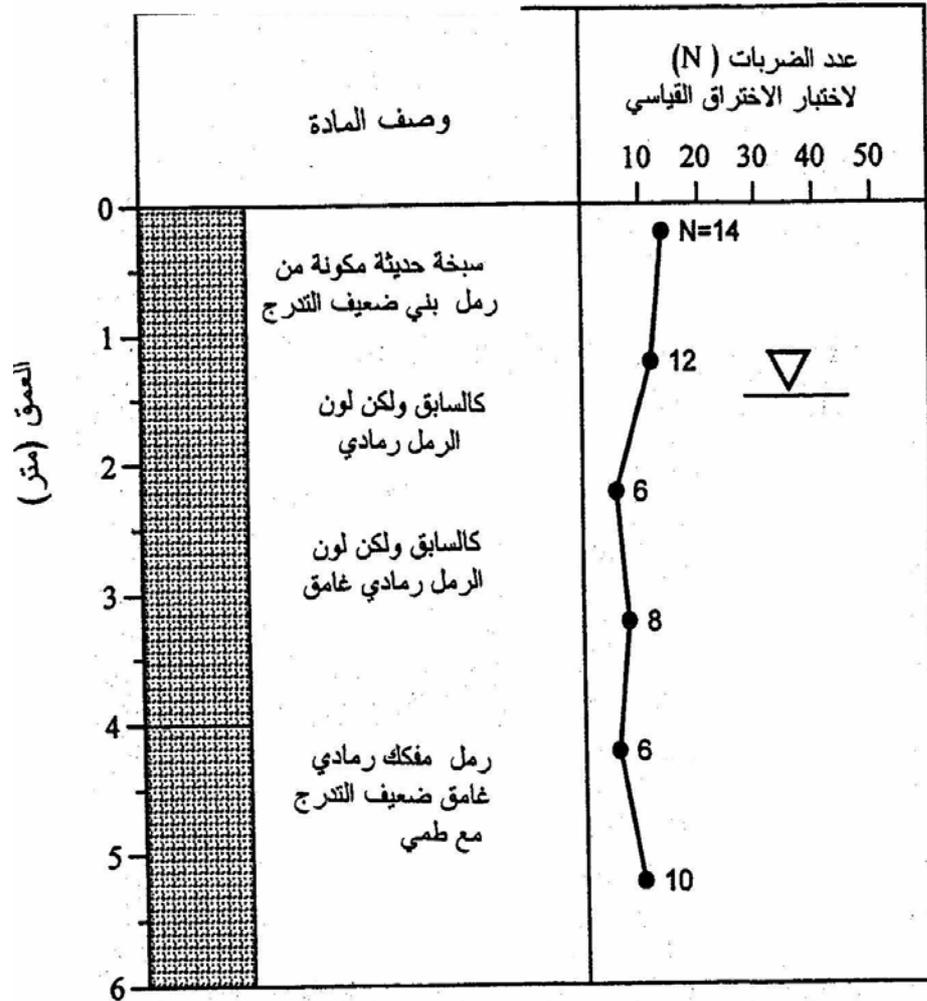
()

1.5

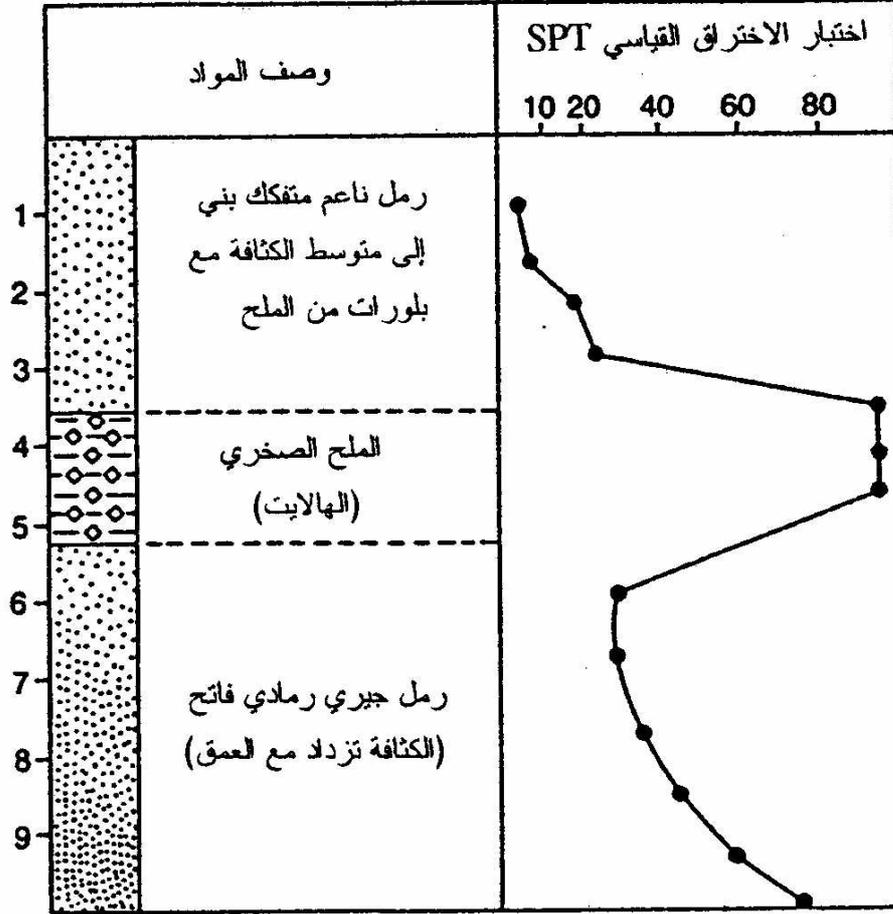
80

10

[22]



شكل (٨): مقطع جانبي في سبحة العزيرية [٢]



شكل (٩) : مقطع جانبي في سبخة رأس الغار [٢٢]

(5)

[22]

[22]

: (5)

13	% 200
1.60	(3 /)
17	(%)
49	(%)
23	(%)
21	(%)
6	(%)
1	(%)
0.2	(Cc)
0.018	(Cs)
4.2	(CBR)
18.3	(3 /) (Subgrade Modulus)
SW-SP	(Unified)

:

2 4

(Salt Dome)

[11]

190

[11]

(10)

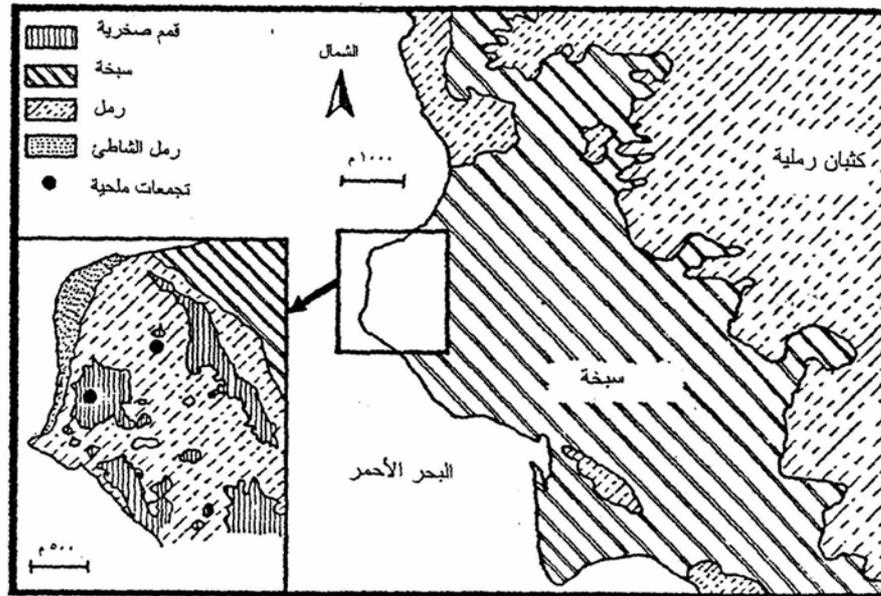
(11)

[11]

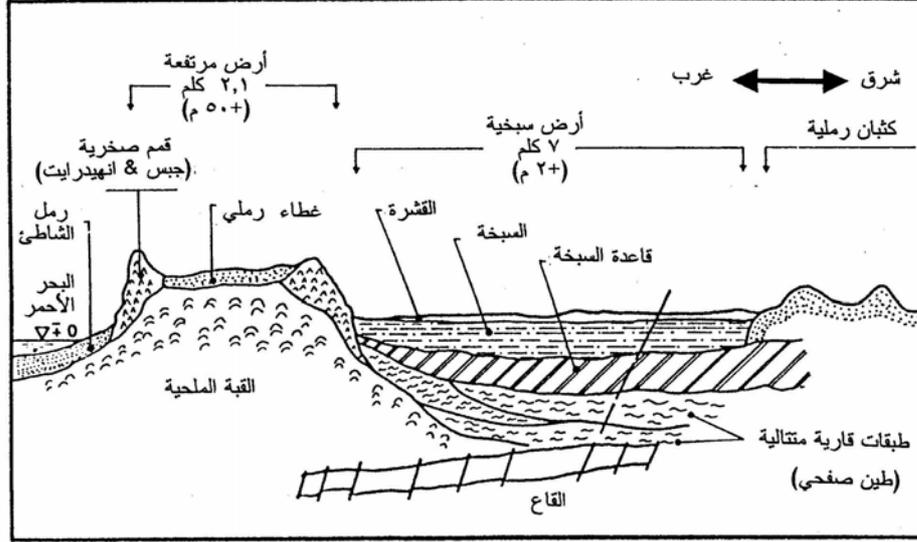
(Secondary Compression)

%8 %2

[11]



شكل (١٠) : الخريطة الجيولوجية لسطح الجزء الساحلي لمنطقة جيزان^{١١}



شكل (١١) : مقطع جانبي للتربة السبخة الساحلية في منطقة جيزان^[١١]

(12)

(6)

15

[11]

العمق (متر)	الطبقة	الرمز	وصف المواد	رمز المجموعة	السك (متر)	SPT, N	الترنم				
							LL %	PI	Wn %		
1	طبقة السبخة للتربة اللينة		طمي غير لين مع رمل ناعم مع وجود كبريتات وكوريد	ML-SM	٢.٢-٠.٧	١٦-٩	غير لين	غير لين	٥.٨ - ٢٤.٤		
2			طين عضوي عالي اللدونة مع طمي	OH, MH	١.٥ - ٢.١	٦-١	١٤ - ٥٧	٨ - ٢٥	١٤.٢ - ٤٩.٣		
3			طمي متوسط إلى منخفض اللدونة مع طين	CL, ML	١.٩ - ٢.٥٥	٦-١	٨ - ٢٢	٤ - ١١	٧.١ - ٢٢.٣		
4			رمل ناعم طيني غير لين	SM, SC	١.٨٥ - ٢.٦٥	٨-٢	غير لين	غير لين	٨.٨ - ٢٥.٥		
5			كاحدة السبخة		رمل ناعم متوسط الكثافة إلى كثيف			متغير (من متوسط كثافة إلى كثيف جداً)	-	-	-
6											
7											
8											
9											
10											
11											
12											
13											

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

شكل (١٢) : خصائص طبقات التربة السبخة في منطقة جيزان [١١]

[11]

: (6)

()	()	
1.94-1.88	1.97	(/ 3)
12	29.8-13.1	(%)
40-27	-	% (LL)

36-21	-	% (PL)
6-4		% (PI)
80-10	95-55	(%)
80-17	26-6	(%)
25-3	7-0	(%)
2.84-2.72	2.81	(G _s)
35-25	20	C (kN/m ²)
33-24.7	35	φ (degrees)

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3 4

[23]

(Lagoons)

[23]

....

59

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1 3 4

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SM SP SW

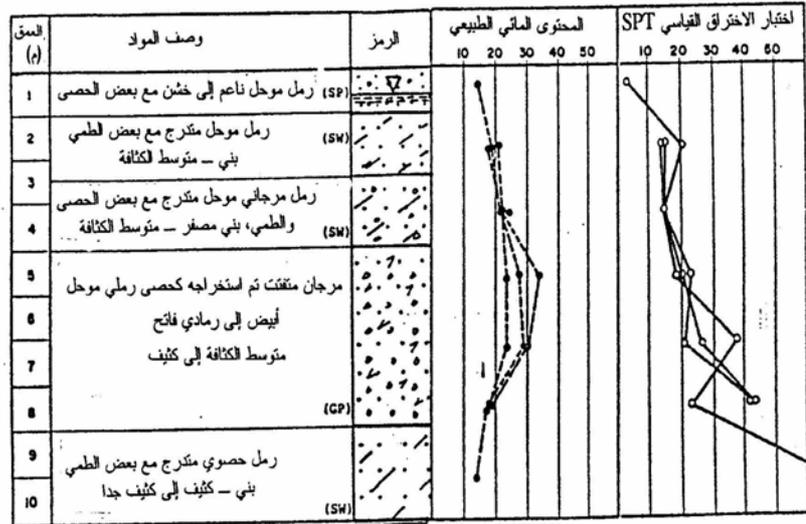
1.5 20

(15) (14) (13)

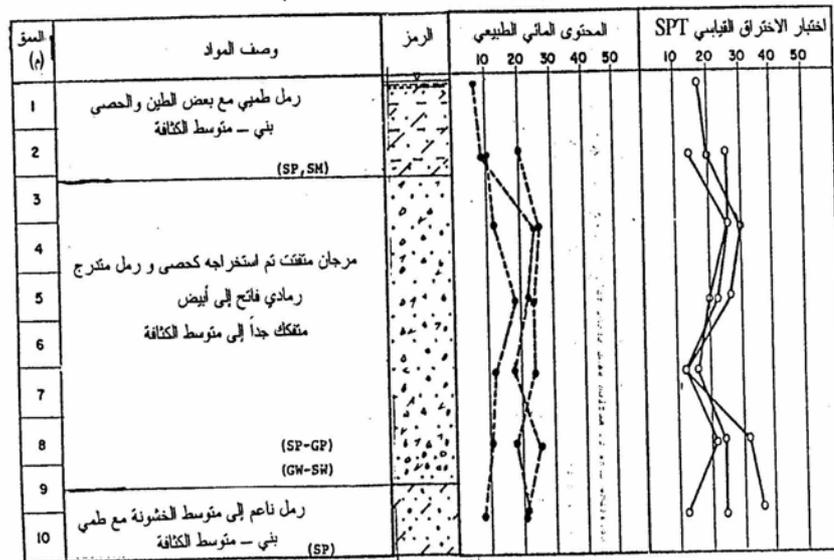
.^[23]

(7)

سبحة الخالدية (البيانات هي متوسط ثلاث جسات)

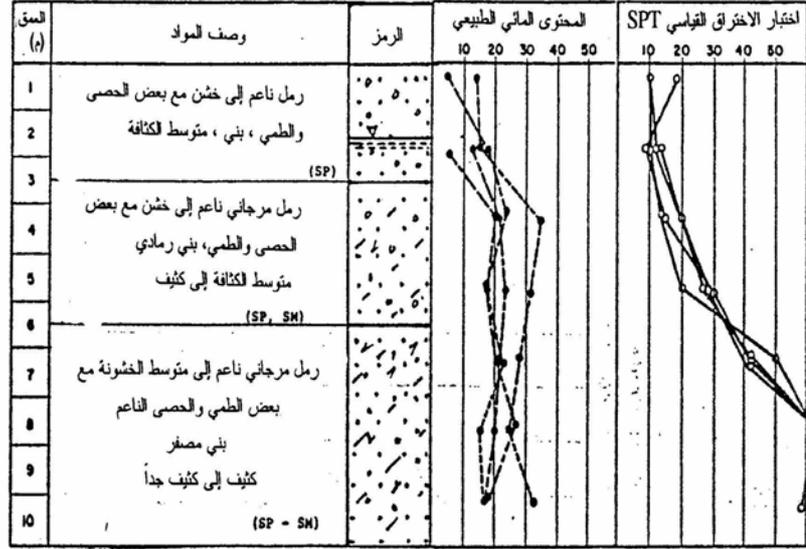


سبحة السلامة (البيانات هي متوسط ثلاث جسات)

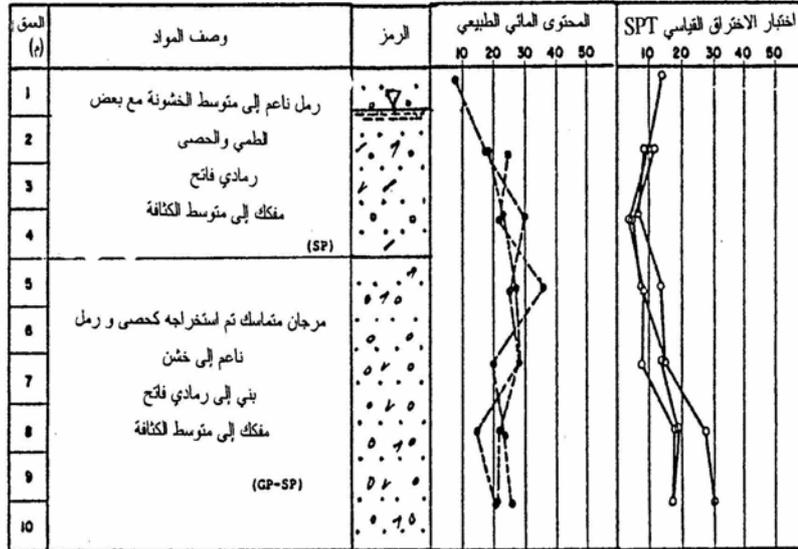


شكل (١٣) : مقطع جانبي لسبحة الخالدية وسبحة السلامة [١٣]

سبخة الحمراء (البيانات هي متوسط أربع جسات)



سبخة الرويس (البيانات هي متوسط ثلاث جسات)



شكل (١٤) : مقطع جانبي لسبخة الحمراء وسبخة الرويس [٢٢]

سبخة الكورنيش (البيانات هي متوسط سبع جسات)

المق (م)	وصف المواد	الرمز	المحتوى المائي الطبيعي					اختيار الاختراق القياسي SPT						
			10	20	30	40	50	10	20	30	40	50		
1	حصى و رمل مرجاني ناعم إلى خشن الحبيبات مع بعض الطمي بني ورمادي متفكك جداً إلى متوسط الكثافة (GP-SP, SP)													
2			3	4	5	6	7	8	9	10				
6			رمل مرجاني ناعم إلى متوسط الخشونة مع حصى ناعم يوجد طبقات من الطمي لرملي لونه رمادي متفكك جداً إلى كثيف (SP)											
7					8	9	10							

سبخة ميناء جدة (البيانات هي متوسط خمس جسات)

المق (م)	وصف المواد	الرمز	المحتوى المائي الطبيعي					اختيار الاختراق القياسي SPT				
			10	20	30	40	50	10	20	30	40	50
1	رمل ناعم إلى متوسط الخشونة مع حصى ناعم رمادي فاتح ، متفكك متوسط الكثافة إلى كثيف (SP)											
2			3	4	5	6	7	8	9	10		
3	رمل عضوي ناعم إلى متوسط الخشونة مع بعض الحصى والطيني رمادي، متفكك جداً (SP)											
4			5	6	7	8	9	10				
6	رمل مرجاني ناعم إلى خشن مع حصى رمادي فاتح، متفكك (SP-GP)											
7			8	9	10							

شكل (١٥) : مقطع جانبي لسبخة الكورنيش وسبخة ميناء جدة [٢٣]

(8)

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.(16)

500

[25]

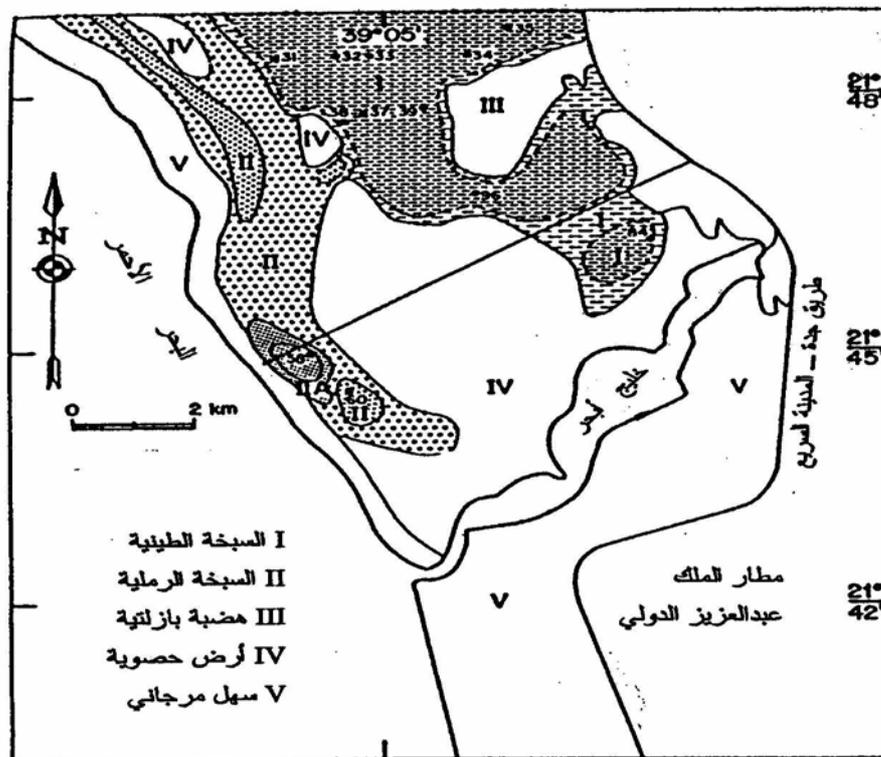
[23]

: (8)

8.7 - 7.4	8.7 - 7.8	8.4	9 - 5.6	8.3	8 - 7.6	
* 2920 ** 3900	* 2880 ** 1400	* 1848	* 3108 ** 400	* 4939	- 2800 * 2925) (
* 30910 ** 9200	* 24400 ** 4800	* 2664	* 5673 ** %0.01	* 8599	- 14750 * 24080) (

**

*



شكل (١٦) : خريطة تبين موقع السبخة الطينية والسبخة الرملية في أبحر [٢٠]

(17)

0.8 0.6

1.2 0.6

[25]

1.2

السيخة الطليونية

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

السيخة الرملية

العمق (م)	وصف المواد	الرمز	قيمة N
1	قشرة رملية متناسكة باهية اللون		3
2	رمل طمهي كربوني متفكك جداً أبيض طباشيري		8
3	رمل طمهي حصوي كربوني متفكك رمادي فاتح		22
4	رمل طمهي حصوي كربوني متوسط الكثافة رمادي فاتح		23
5	23		
6	حصى رملي طمهي كربوني كثيف جداً رمادي غامق		31
7	80		
8	حجر جيري خشن الحبيبات صنموف نسبياً لونه أبيض مصفر		
9			

....

(9)

0.8 - 0.6

1.5

.(16)

.()

[24]

: (9)

31-25	78-40	40-15	(%)
56-50	60-36	50-20	% (LL)
33-25	30-18	40-16	% (PL)
30-24	32-20	20-5	% (PI)
24-9	1	2	(SPT) 300/
50 <	45-12	60-20	() 2 /
60-15	5-3	12-7	(CPT) 2 / (qc)
0.31-0.17	0.88-0.40	0.42-0.37	(Cc)

)

(

(10)

(Type V)

[24]

: (10)

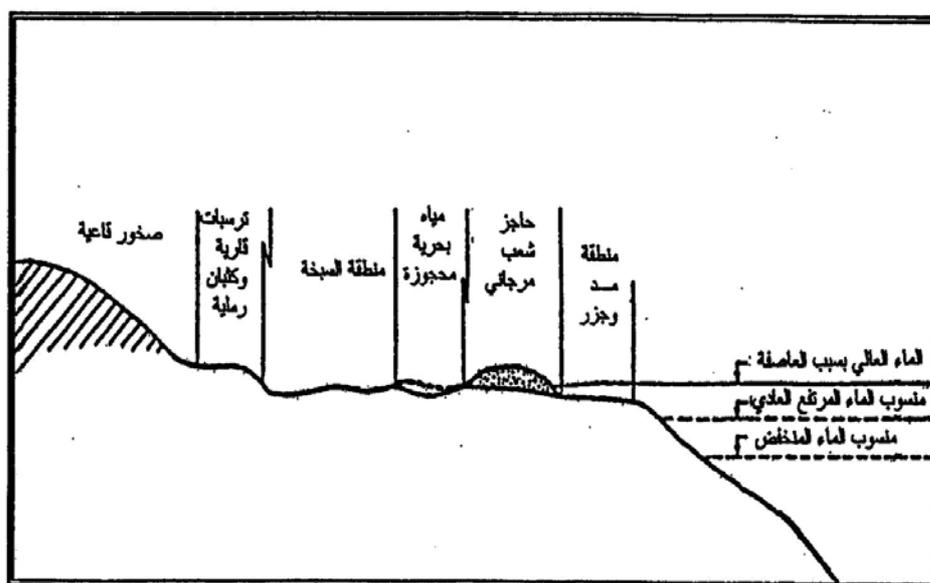
(/)	
95-20	(Na ⁺)
3.33-1.83	(Mg ⁺⁺)
1.9-0.5	(K ⁺)
1.8-0.44	(Ca ⁺⁺)
49.6-27.5	(Cl)
4.35-3.21	(So ₄) ⁻
0.25-0.21	(HCO ₃) ⁻
7.6-7.05	(pH)
155-50	(Salinity)

: 3 3 4

250

(18)

[26]



شكل (١٨) : مقطع جانبي لسبخة الليث [٢٦]

:

[26]

2 0.5

(11)

5

: [1]

[26]

: (11)

48-15	40-22	% (LL)
35-0	16-15	% (PL)
13-0	24-7	% (PI)
0.05	0.41-0.052	² /
40	33-22	ϕ
12.8-2.20	22.8-2.20	(² /)
0.14-0.038	0.186-0.05	(Cc)
0.063-0.016	0.065-0.016	(Cs)

72

-1

[11]

()^[2]

-2

-3

-4

-5

-6

....

73

6

:

-1

.

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-2

.

(Preloading)

-3

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.

-4

(Geotextiles)

-5

: Chemical Stabilization

1 6

%10 %7 %5 %3

(CBR)

[2] (Unconfined Compressive Strength)

(A - 2 - 4)

(A - 6)

[2]

(A - 3)

%3

()

%10

(%10 % 3)

[2]

(12)

CBR
%10 %3

(Exposed

)
(Sealed)

:

[2]

7

%10

(12)

(%89)

CBR

.(%417 %353)

.() %102

[2]

CBR (%) : (12)

()			()			CBR			
31	41	144	53	114	51	47	61	107	3
35	108	279	51	202	67	41	182	184	5
69	454	331	75	303	93	78	228	336	7
98	476	451	128	380	102	89	353	417	10

$$100 \times \left[\frac{\text{CBR}}{\text{CBR}_{\text{ref}}} - 1 \right] = (\%)$$

.%10

:Preloading

2 6

....

77

12

[11]

200

: Geotextiles

3 6

%266

[2]

245

67

.%38

1600

1160

78

[27]

7

[28]

)

....

)

(

. (

.(1.5)

المراجع

- " [1]
- .(1413) 62-56 :(2)6 " [2]
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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.