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Impact of Rationing on The Properties of Cement-Treated Gypsum Canals

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Abstract— The scarcity of irrigation water requires procedures of specific. One of these procedures is the implementation of the rationing system (a period of the irrigation followed by a period of the dry). This system can have an impact on the properties of irrigation channels. Therefore, the study of rationing system for irrigation channels is important in both water resources and civil engineering, especially if they are constructed with gypseous soil. In order to assess the rationing system on gypseous canals stabilized with a specific ratio of cement, practical experiments were conducted to detect the effect of wetting and drying cycles on the physical and hydraulic behavior of this soil and calculation of some properties of soil such as scouring, grain size and gypsum content of soil at each cycle (10 days wetting and 10 days of drying). Where the gypseous soil with gypsum content 65 % was brought from Lake Sawh-Iraq to the hydraulic laboratory at the University of Baghdad, Physical and chemical tests were carried out according to the standard classification system. The laboratory work includes construction of a laboratory flume with gypseous soil to calculate the scouring of the canal and effect grain size of soil by two methods (the standard sieve analysis and Particle size absorptive test) and also calculate gypsum content at each rationing cycle, where the channel consists of two stages of operation, the one for untreated soil (4 cycles operation) and the other for soil mixed with 10% cement (5 cm of cement mixture above 5cm soil) 4 cycles also. The results show that the rationing cycles reduce the scouring of canal in the case of untreated soil by 56.6% and in the case of treated soil 82%. The rationing system led to course the gradient of soil according to two methods. Also its reduction of the gypsum content in the case of untreated soil by 43% and in the case of treated soil 45.6%. Thus, conclude that the rationing system leads to a positive effect on some properties of gypsum soils and the lining of irrigation channels.

Keywords— Rationing System, Drying and Wetting, Gypsum Soil, Irrigation Canals and Scouring.

1. Introduction

The limited water resources have led to alternative ways of managing water and economizing on water consumption and distribution, one of them is the application of the rationing system, which causes soil exposure to systematic changes in moisture and drought in the surface of the irrigation channels, so the properties of the soil may change according to these changes. And to know the impact of these changes are studied laboratory properties of soil exposed to conditions are similar to those in the field as wetting and drying cycles. Study the effect of these conditions in the physical, hydraulic and engineering properties is important because sometimes they affect the lining of the irrigation channels. Gypseous soil is the soil which contains amounts of gypsum, one of the mineral salts known as calcium sulfate, which that a chemical formula ($CaSO_4.2H_2O$) and the specific gravity is low about is 2.32 that affect significant on the physical and mechanical properties of soil that contains high amounts of gypsum [1]. Gypseous soils are existing across the world, especially in the Middle East, the Gulf and Red Sea region [9, 12]. Its cover about 28.6 % of the total land area in Iraq, equivalent to cover nearly 8.7% of gypseous soil in the world [10]. It represents the most problems that challenge Geotechnics and engineers. So, it's necessary to study and improve most of its properties due to the failure of the structures, for this reason they focused on soil behavior through wetting because of the gypsum dissolution in the soil [4]. Al-Zubaydi et.al. Studied the effect of weather condition different of the structures, indicate that the passing of water through soil causes devastation of soil, leading to increase in permeability, collapse, swelling and settlement [5]. In addition, the study by Razouki and Salem was seemed to be the first study, which dealing with wetting and drying of gypseous soils, their study includes (3 months) of wetting followed by (3 months) of drying [13]. There are of many treatments for gypseous soils, as physical, mechanical, and chemical treatments. These treatments increase the soil durability, where the infiltration decreases under structures and irrigation canals; therefore, it increases the efficiency of the irrigation canals. The most widespread solution to decrease the scouring and infiltration is lining canals [11]. Stabilization of Cement is one of economical techniques for improving the properties of gypseous soils. So the main objective of this study is to analyze performance of the cement by studying of properties of gypseous soils such as scouring, grain size and gypsum content under the influence several times of rationing. In order to compare the results, a single percentage of cement material which is the best treatment percentage used 10% by weight [2].

2. Experimental outlines:

2.1 *The laboratory Flume*

The laboratory flume, used in this study to obtain and extract the results. It is an open channel with English brand, made from steel stiffeners and glass fiber, which has 10 m total length, 0.3 m width and 0.35 m depth. Generally, the laboratory flume is divided into three parts; the first part is a water storage and pumping system. The second part of the laboratory flume represents the most important part of the flame is called the working section. The last part of the laboratory flume is a reservoir which collects water coming from the working section. A point gauge has been used to measure both soil scouring and water depths with an accuracy of (±1) mm. **Figure 1** shown laboratory flume used in this study.

Figure 1: The laboratory flume and some parts it

2.2 *Materials*

2.2.1 Soil

The gypseous soils have been used in this study. It was brought from the region of Lake Sawa, which is located in the western part of Al-Muthanna Governorate (280 km south of Baghdad-Iraq). At the beginning of the work, the region was surveyed and different samples were taken from specific sites by a GPS device, the ratio of gypsum in these samples was examined. After that the soil took the one type of soils collected from a depth of (1.5-2 m) and transported to the hydraulics laboratory of the College of Engineering at University of Baghdad for testing. The total weight of the soil used in these experiments was 1350 kg with high gypsum content is 65.4%.

2.2.2 *Cement*

Cement is the primary material which used to treat the gypseous soil in these experiments; the cement used is of salt-resistant Portland cement.

2.2.3 *Water*

In this work, the tap water was used in all tests.

2.3 *Experimental Work and Testing Program*

The flow chart of all tests performed in this study as shown in Figure 2, the testing program is divided into two parts. The first part is performed on gypseous soil at natural state and cement material which including tests of soil classification (physical tests, chemical tests and mechanical tests) and also test of X-ray diffraction for cement material. Second part of the testing program is the experiments which conducted on the laboratory flume, including the scouring, grain size distribution and gypsum content. These tests can be summarized as follows:

2.3.1 Physical tests

Physical tests are carried out on the gypseous soil, these tests included:

2.3.1.1 *Specific Gravity Test (GS)*

The specific gravity of the natural soil is determined in accordance with the standards of British (BS 1377: 1990, Test 6B, Head 2004) [16], the kerosene is used instead of water to avoid the dissolution of the gypsum in water during the test.

2.3.1.2 *The particle size distribution*

In this study, the particle size distribution of the soil is found by following two methods:

2.3.1.2.1 Grain size distribution

The standard sieve analysis test is carried out to determine the grain size distribution in accordance with standard ASTM test (ASTM D422; 2002) [6], dry sieving. The result is shown in **Figure A-1(Appendix A)**.

2.3.1.2.2 Particle size absorptive test (laser diffraction)

The particle size absorptive of the soil samples was conducted at the laboratories of the Iraqi Geological Survey; it was carried out by technique laser diffraction as shown in figure 3, the data were obtained using software (Mastersizer 2000, Ver. 5.60 from Malvern) Scirocco 2000 dry [14]. The data were expressed as $D_{0.1}$, $D_{0.5}$ and $D_{0.9}$ which are equivalent size diameters at 10%, 50% and 90% cumulative volume, respectively. **Figure 3** shows Mastersizer 2000, Ver. 5.60.

2.3.1.3 *Water content*

The water content is performed in according to (BS 1377: 1990, Test A, Head 2004)[16]; by drying the soil at (45ºC) because the soil has a high ratio of gypsum.

2.3.2 Chemical Tests

Chemical tests are carried out on the soil and cement material, these tests included:

2.3.2.1 *Gypsum content*

In this study, the gypsum content is found by two methods:

2.3.2.1.1 Hydration Method

The gypsum content shall be determined in the Hydration Method, which executed by Al Mufty and Nashat [3]. Its include of drying a soil sample by an oven at a temperature of 45°C until the weight of the sample is fixed and recorded this weight at 45°C. The same sample is drying at a temperature of 110°C for 24 hours and recorded that weight again; **Equation (1)** is used to calculate the gypsum content.

$$\chi\,\% = \frac{w\ 45°C - w\ 110°C}{w\ 45°C} \times 4.778 \times 100 \qquad (1)$$

2.3.2.1.2 Concentration of Sulfate Method

The Concentration of sulfate method used to determine gypsum content according to the British standards (BS 1377:1975)[8] as in the **Equation (2)**.

$$\chi\,\% = SO^3 \times 2.15 \qquad (2)$$

2.3.2.2 *X-ray Fluorescence spectrometer test*

X-ray fluorescence method is the most widely used to determine of minerals and the study of crystal structure of those minerals. The Iraqi-German Laboratory at the College of Geosciences at the University of Baghdad conducted this test. From the result of the X-ray fluorescence test for cement, it is found that the cement is resistant to sulfates according to (the standard Iraqi no. 5 for cement Portland 1984) [15], as it is characterized by low Alumina Modulus as well as a value of the Lime Saturation Factor. See Table 1.

Table 1: Summary of the results of the X-ray tests and limits specified for the compounds of Portland cement by standard Iraqi No. 5 (1984)

Properties	The result of the X-ray fluorescence	The limits specified according to the standard Iraqi no. 5 (1984)
Fe_2O_3	5.504	2 - 4
Al_2O_3	2.576	4 - 8
SiO_2	19.16	18 - 24
CaO	68.62	60 - 69
SO_3	2.967	0.3 - 2.7
MgO	1.943	2 - 5
S.M	0.46	1.9 - 3.2
A.M	2.24	1.5 - 2.5
L.S.F	1.017	1.02 - 0.66

2.3.3 Mechanical Tests

Mechanical tests are executed on the soil, included compaction test only.

- ***Compaction test***

The standard compaction test is performed for the natural soil to determine the density–moisture relationship. It's carried out accordance with (ASTM D698-91, Method A, 2003) [7]. The result of compaction test is shown in **Figure 4**. **Table 2** represents the physical, chemical and mechanical properties of soil, which were in accordance with ASTM specifications.

Table 2: Summary of the physical and chemical tests for natural soil

Properties	**Value**
Gypsum Content (%)	65%
Max. dry unit weight, γ_{max}	16.8 (kn/m^3)
Optimum Water Content (%)	11.8
Specific Gravity, (Gs)	2.37
Void ratio, (e)	0.411
Porosity, (n)	0.29
D_{10}	0.05 *mm*
D_{60}	0.6 *mm*
D_{30}	0.16 *mm*

Coefficient of curvature, Cc	12
Coefficient of uniformity, Cu	0.85
Soil Classification (USCS)	Gypsum soil (SP)

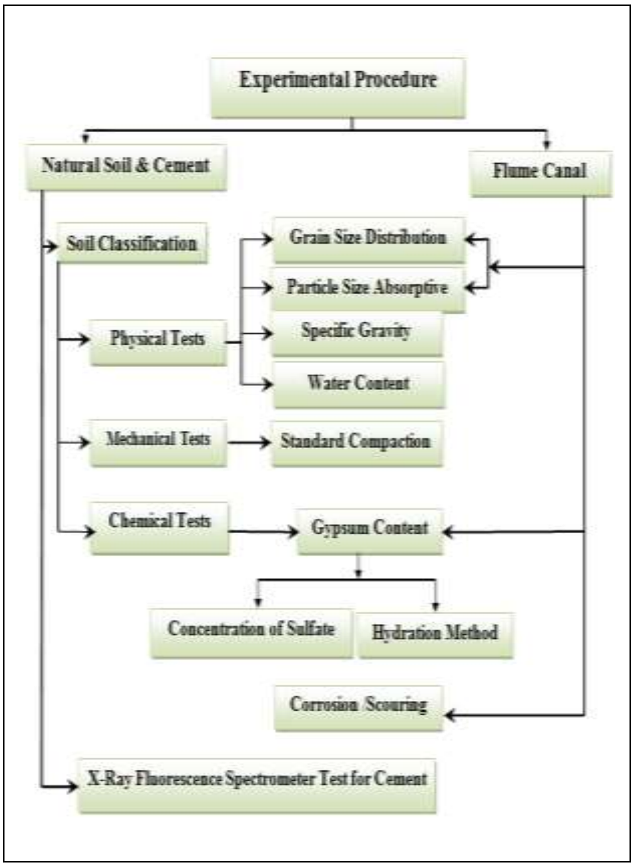

Figure 2: Flowchart of testing program.

Figure 3: Mastersizer 2000, Ver. 5.60 from Malvern, use to determined particle size distribution

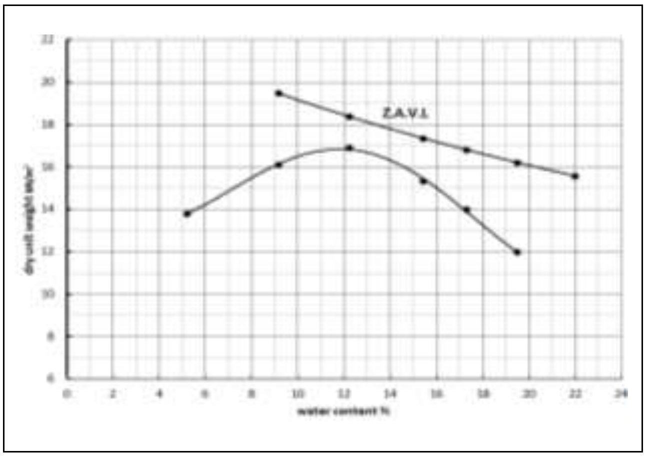

Figure 4: Standard compaction test of the natural soil

3. Preparation of Soil and Test Procedure

Soil models are prepared at a moisture content equal to the optimum water content in accordance with (ASTM D698; 2003)[7], and models of soil are mixed careful with the specified amount of water until the soil reaches to the optimum moisture content. In this study, the test Procedure consists of two stages: the first stage of untreated gypsum soil (one models) and the second stage of the soil treated with cement (one models).

The first stage was with untreated of gypsum soil. One model of the untreated gypsum soil in the laboratory flume is constructed for thickness of 10 cm and compacted by maximum dry unit weight (16.8 kN/m^3) and optimum moisture content (11.8% by weight), using a compactor and point gage to obtain a good compaction and accurate in soil in thickness of 10 cm, the flow characteristics of first stage shown in **Table 3**.

The second stage was with the treatment of gypsum soil. One model of treatment gypsum soil is mixed with a percentage of (10% weight cement) [2], this mixture is prepared in 5 cm thickness and compacted at a maximum dry density (16.8 kN/m^3) and optimum moisture content (11.8%). Where, total soil thickness in the laboratory flume is 10 cm, the duration maturation of the cement mixture is 14 days, see **Figure 5**, the flow characteristics of second stage shown in **Table 4**. The laboratory flume was set on a slope of 0.002 and operated with flow characteristics of water. Where, discharge, velocity and water depth are (0.00637 m^3/sec, 0.212 m/sec and 0.1 m) respectively, are fixed for all cycles. The water flows in the channel for 10 days, it is called the cycle of wetting, after ending of the wetting period, begins drying cycle, where the channel is left in the air atmosphere for 10 days also. After that, a series of measurements are taken after drying period which includes:

1-Elevations measurement of the soil surface by using the point gage device in three dimensions (x, y and z) the distance between the points in (x) direction was (7 cm) and in (y) direction was (10cm). Where the total number of points carried out were 255 points (elevations) on the soil surface for each cycle as shown in **Figure 6**.

2- Grain size distribution and particle size absorptive test. After the drying period, we take the sample from the surface of the soil for the purpose of conducting the tests for soil gradation for each cycle.

3- Calculate the gypsum content at the end each cycle.

Table 3: The flow characteristics of laboratory flume for first stage at 16 C^0 Temp.

S	H (*m*)	W (*m*)	R (*m*)	Q *m^3/sec*	V *m/sec*	Fr	Re	We
0.002	0.1	0.3	0.06	0.006	0.212	0.214	1943	62

Table 4: The flow characteristics of laboratory flume for second stage at 29 C^0 Temp.

S	H (*m*)	W (*m*)	R (*m*)	Q *m^3/sec*	V *m/sec*	Fr	Re	We
0.002	0.1	0.3	0.06	0.006	0.212	0.214	2636	61

Figure 5: Preparation of laboratory flume

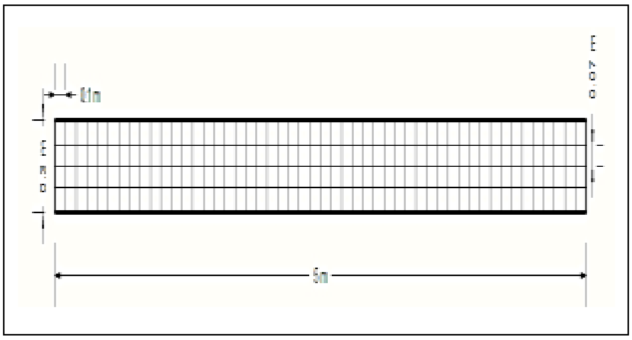

Figure 6: The points on the surface soil of the canal, whose readings were taken

4. Results and Discussions

4.1 *Effect of rationing on the scouring of soil*

Contour maps illustrate the elevation of the soil points. In this study, (SURFER V 13) software used to draw contour maps for showing the scouring for both untreated and treated Soil at each cycle of the rationing system. The results of untreated gypsum soil scouring at each rationing cycle as shown in **Figure 7**. It was observed that, there is a simple scouring in the first half of the canal during the first cycle and begins to increase at the subsequent cycles.

The results of treated soil scouring at each rationing cycle as shown in **Figure 8**. It was observed that, there was a small rate of scouring at first cycle and the change rate of elevation was about constant during the subsequent cycles. Through comparison with the results of previous studies conducted by Al-Hadidi and AL-Maamori [2], on the same laboratory fume and the same percentage of cement, which is 10%, notice that the rationing cycles, reduce the scouring of canal in the case of untreated soil by 56.6% and in the case of treated soil 82%.The summary of results for untreated and treated soil scouring at each rationing cycle as shown in **Table 5**.

From the results of scouring for treated soil, in the case rationing system, it is possible to estimate the scour lined of channels. And also, the period required for periodic maintenance of these lined channels, where maximum corrosion is 0.05 cm every 20 days. Drawing points between corrosion and time, where concludes that relationship with high accuracy presented in **Figure A-2 (Appendix A)**, and described by **Equation (3)**.

$$Y = -0.0071X^2 + 0.9438X + 0.1443 \quad (3)$$

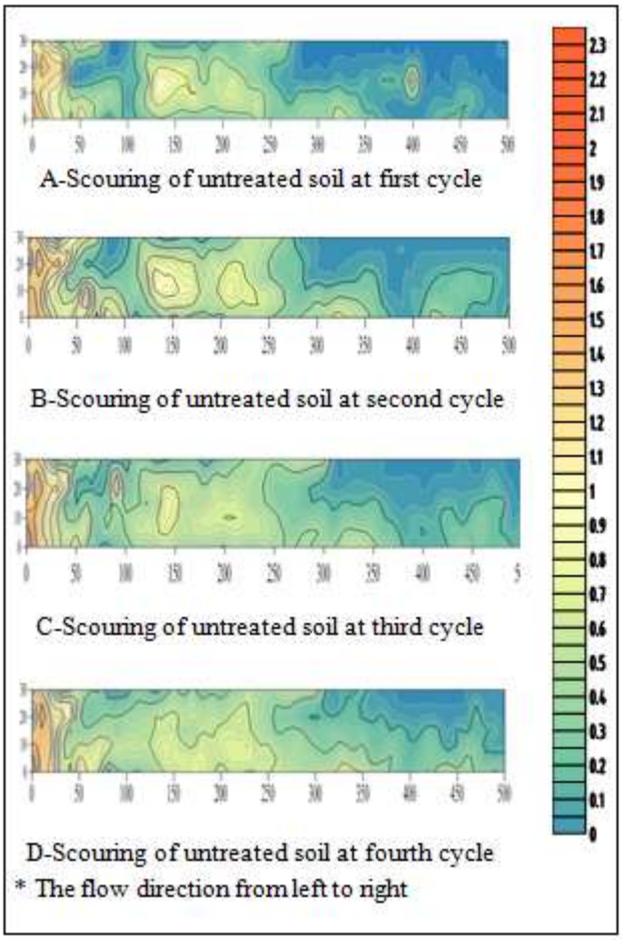

Figure 7: Contour maps of the scouring in the untreated gypsum soil.

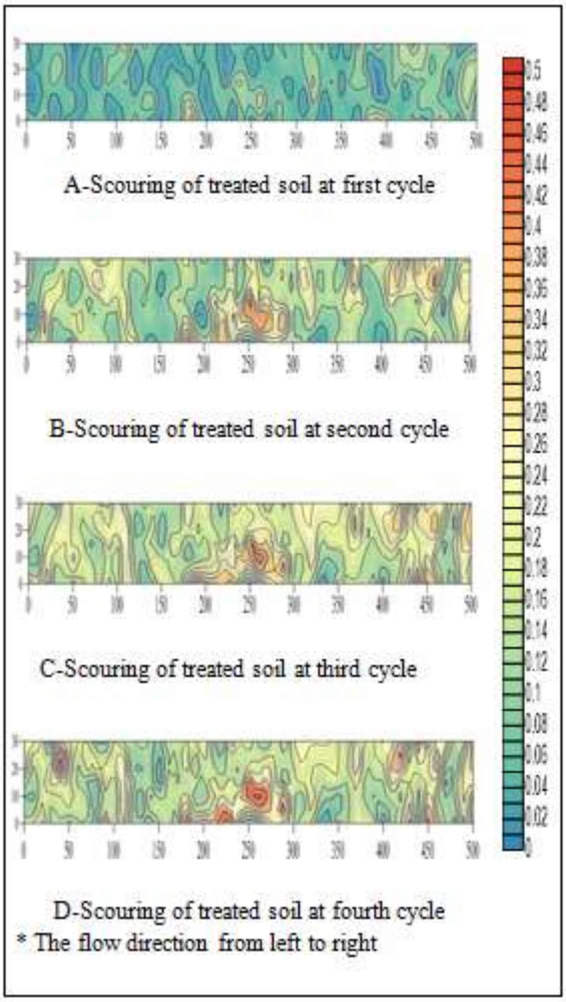

Figure 8: Contour maps of the scouring in the treated gypsum soil.

4.2 *Effect of rationing on the particle size of the untreated soil*

Table 6 and Table 7 are the results of the particle size distribution tests for four cycles were conducted using sieve analysis test and particle size absorptive test (Mastersizer 2000, Ver. 5.60 from Malvern) respectively. **Figure A-7 (Appendix A)** is shown an effect rationing in particle size for four cycles, it is clearly noticed that rationing system yields coarse gradation. This may be interpreted by the dissolution of fine gypsum particles by wetting and drying.

The results of particle size absorptive by Mastersizer 2000were placed in **Figures A-3**, **A-4**, **A-5** and **A-6 (Appendix A)** for the end for the end first, second, third and fourth cycle, respectively

Table 5: Summary of results for untreated and treated soil scouring at each rationing cycle

No. of cycle	Untreated soil		Treated soil	
	Max.scour (*cm*)	Av.scour (*cm*)	Max.scour (*cm*)	Av.scour (*cm*)
1	1.5	1.41	0.25	0.063
2	1.8	1.55	0.4	0.103
3	1.95	1.78	0.45	0.151
4	2.25	2.1	0.5	0.193

Table 6: Summary of D-Values detail (D_{10}, D_{50} & D_{90}) by sieve analysis test

No. of cycle	D_{10} (m)	D_{50} (m)	D_{90} (m)
1	0.000052	0.00040	0.0027
2	0.000065	0.00045	0.0025
3	0.00022	0.0006	0.0030
4	0.00042	0.0011	0.0035

Table 7: Summary of D-Values detail (D0.1, D0.5 & D0.9) by Mastersizer 2000

No. cycle	$D_{0.1}$ (μm)	$D_{0.5}$ (μm)	$D_{0.9}$ (μm)	Specific surface area (m^2/g)	Surface weight Mean (μm)
1	11.100	54.879	385.354	0.272	22.087
2	10.687	62.092	377.344	0.285	21.019
3	11.974	69.945	484.704	0.248	24.167
4	12.879	77.217	503.241	0.23	26.094

4.3 *Effect of rationing on the gypsum content of the gypseous canals*

During four cycles of rationing (80 days), the change in gypsum content is observed during these cycles as shown in **Table 8** and **Figure A-8 (Appendix A)**.

From **Table 8**, in the case of untreated gypsum soils during 80 days, notice that the rationing system reduces gypsum solubility in soil by (43%). In the case of treated gypsum soils during the 80 days, the rationing system reduces gypsum solubility in soil by (45.6%).

Table 8: Summary of gypsum content reduction under the effect several cases.

Number of cycles	Befor e use	1st cycle	2nd cycle	3rd cycle	4th cycle
Time (day)	0	20	40	60	80
Gypsum content for untreated soil with rationing (%)	65.353	64.764	63.836	63.311	62.459
Reduction Gypsum content for untreated soil with rationing (%)	0	0.900	2.002	3.123	4.427
Gypsum content for untreated soil without rationing (%)	65.353	64.254	63.115	61.831	60.285
Reduction Gypsum content for untreated without rationing (%)	0	1.680	3.423	5.388	7.753
Gypsum content for treated with rationing	65.353	65.337	65.278	65.249	65.193
Reduction Gypsum content for treated with rationing (%)	0	0.0233	0.113	0.158	0.243
Gypsum content for treated soil without rationing (%)	65.353	65.310	65.292	65.189	65.059
Reduction Gypsum content for treated without rationing (%)	0	0.0652	0.092	0.249	0.448

5. Conclusions

In this work, two cases with soil gypsum are studied for dealing by scouring canal, grain size and gypsum content. From the analysis of the tests on soil samples and the results of the laboratory flume, the following conclusions can be made:

- The rationing system reduces channel erosion and gypsum solubility in soil compared to channels that operate without this system. Thus, it can be said that the system of rationing gives a longer age to the material lining of irrigation channels.
- In case lining canals, the maximum corrosion of surface canal was increasing 0.05 cm at every cycle. Thus, it can be estimated age for the material lining of irrigation channels.
- The rationing system yields coarse gradation for surface of canals.

- The rationing system leads to a positive effect on some properties of gypseous soils and the lining of irrigation channels.

6. Recommendations

The study of the impact of rationing on other properties such as channel roughness coefficients because it's a very important factor in the study of open channel flow as well as the study of internal cracks in the lining.

Nomenclature

Symbol	Description
AM	Alumina Modulus
$D_{0.1}$	Diameter size at 10% of cumulative volume (μm)
$D_{0.5}$	Diameter size at 50% of cumulative volume (μm)
$D_{0.9}$	Diameter size at 90% of cumulative volume (μm)
D_{10}	Diameter through which 10% of the total soil mass is passing (*mm*)
D_{30}	Diameter through which 30% of the total soil mass is passing (*mm*)
D_{50}	Diameter through which 50% of the total soil mass is passing (*mm*)
D_{60}	Diameter through which 60% of the total soil mass is passing (*mm*)
D_{90}	Diameter through which 90% of the total soil mass is passing (*mm*)
e	The natural soil void ratio
Fr	Froude number
GS	Specific Gravity
H	Depth of water (*m*)
n	The natural soil Porosity
Q	Discharge (m^3/sec)
R	Hydraulic radius (*m*)
Re	Reynolds number
S	Longitudinal slope
SM	Silica Modulus
SP	Poorly graded sand
V	Velocity of water (*m/sec*)
W	Width of canal (*m*)
W_{110^o}	Weight of sample at temperature of 110^o C
W_{45^o}	Weight of sample at temperature of 45^{o}C
We	Weber number
X	Maximum scouring of canal in *cm*
Y	time in year
χ	Gypsum content (%)
Cc	Coefficient of gradation
Cu	Uniformity coefficient
γ_{max}	Maximum unit weight (kn/m^3)
μm	Micrometer

Abbreviations

Symbol	Description
ASTM	American Society for Testing and Materials
LSF	Lime Saturation Factor
USCS	Unified Soil Classification System
Z.A.V.L.	Zero Air Voids Line

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Appendix A

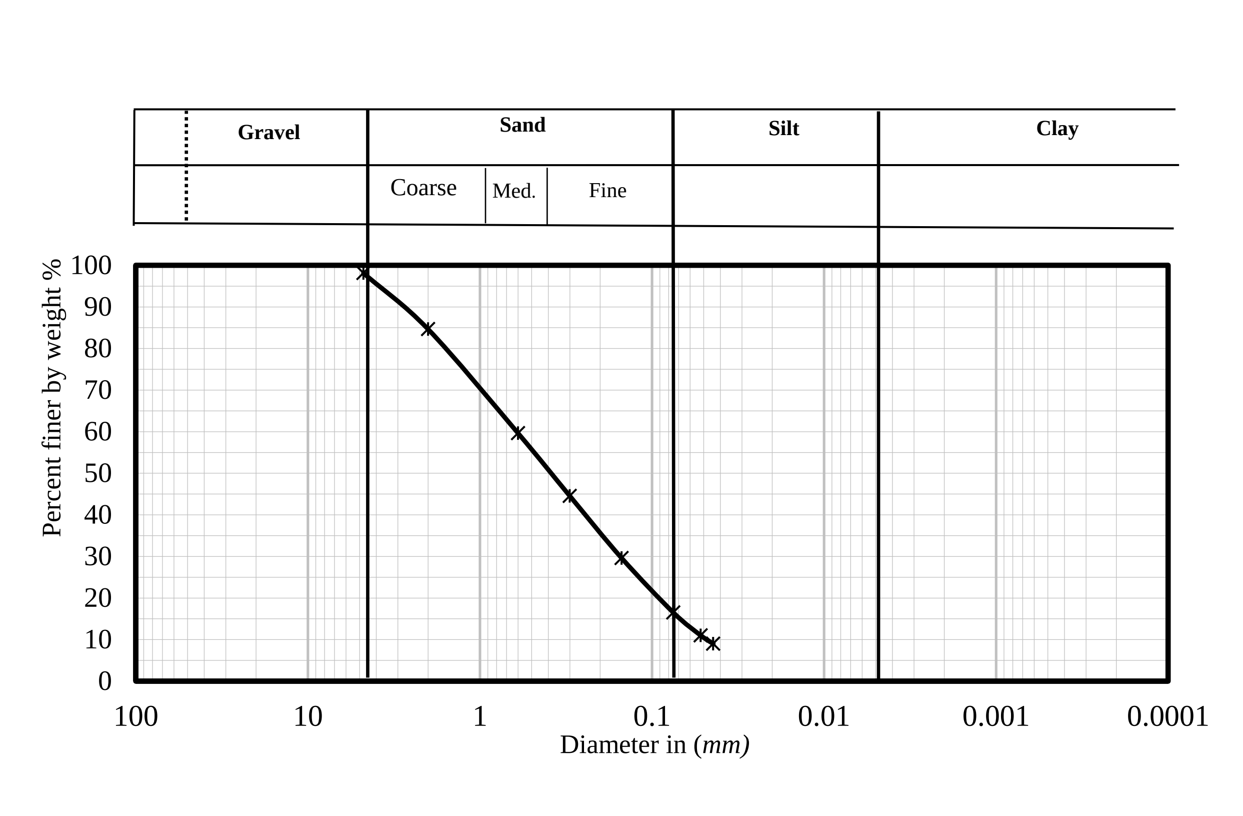


Figure A-1: Standard sieve analysis test of the natural soil

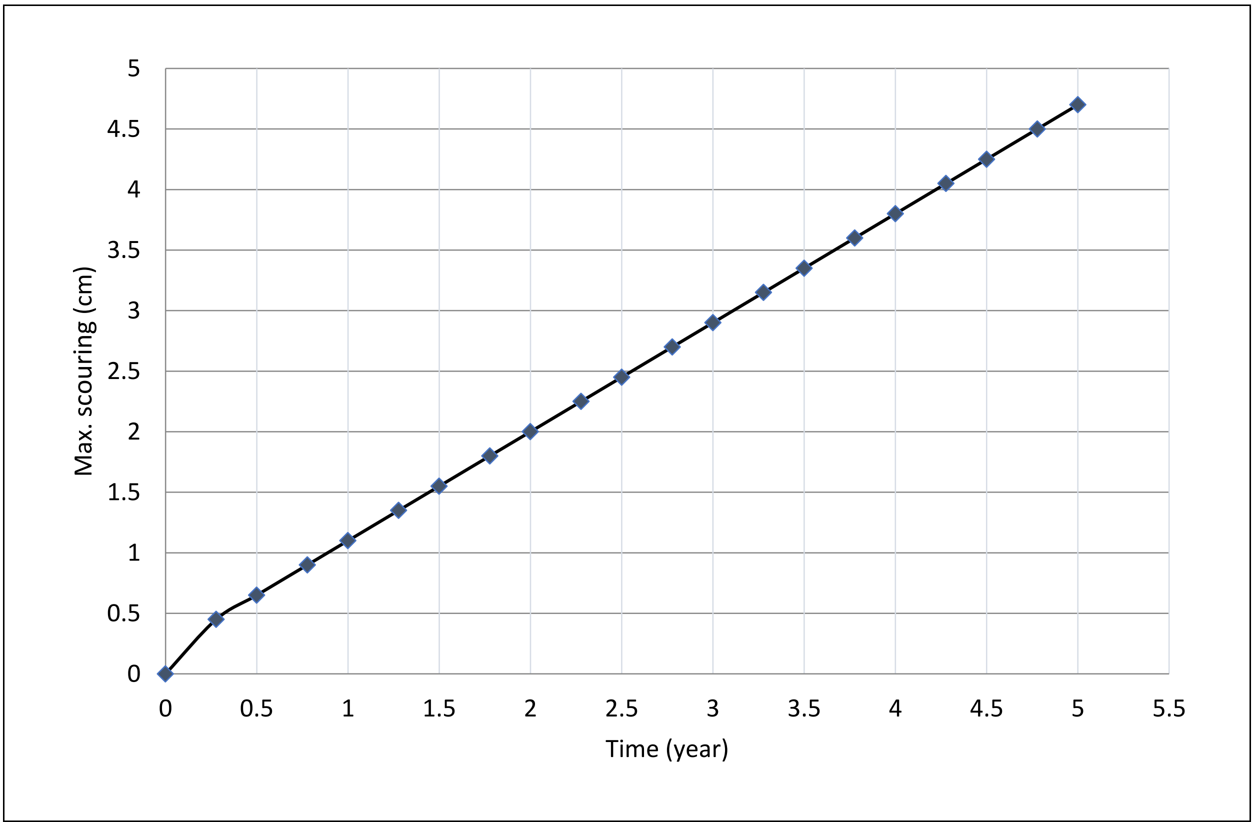


Figure A-2: The relation between maximum scouring of lining material and time in rationing system case

MALVERN INSTRUMENTS

MASTERSIZER 2000

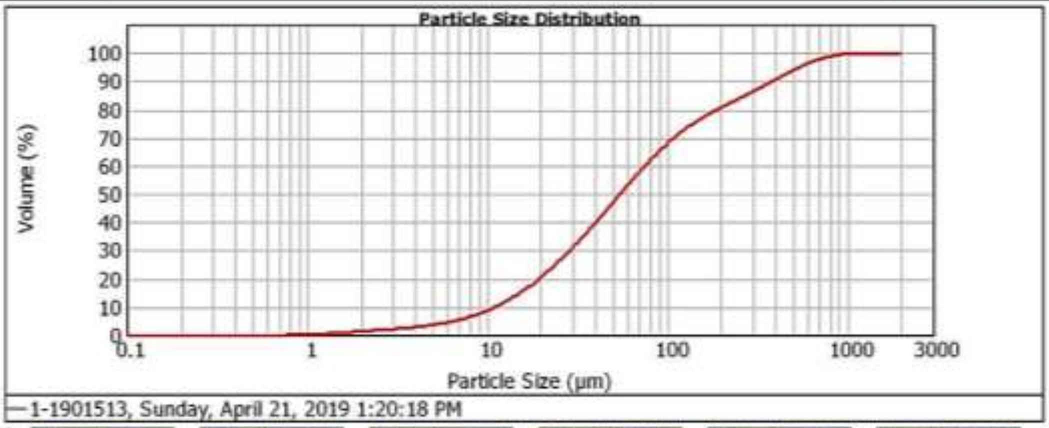
Result Analysis Report

Sample Name: 1-1901513	**SOP Name:** Scirocco 2000 OQ	**Measured:** Sunday, April 21, 2019 1:20:18 PM
Sample Source & type: Works = Baghdad Univ.	**Measured by:** Wurood Yousif	**Analysed:** Sunday, April 21, 2019 1:20:20 PM
Sample bulk lot ref: 19032801	**Result Source:** Measurement	

Particle Name: GYPSUM (HI)	**Accessory Name:** Scirocco 2000	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.531	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 5.05 %
Dispersant Name:	**Dispersant RI:** 1.000	**Weighted Residual:** 0.642 %	**Result Emulation:** Off

Concentration: 0.0034 %Vol	**Span :** 6.820	**Uniformity:** 1.89	**Result units:** Volume
Specific Surface Area: 0.272 m²/g	**Surface Weighted Mean D[3,2]:** 22.087 um	**Vol. Weighted Mean D[4,3]:** 129.152 um	

d(0.1): 11.100 um   d(0.5): 54.879 um   d(0.9): 385.354 um



Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %
0.020	0.00	0.142	0.00	1.002	0.15	7.096	0.90	50.238	3.74	355.656	1.70
0.022	0.00	0.159	0.00	1.125	0.17	7.962	1.07	56.368	3.70	399.052	1.69
0.025	0.00	0.178	0.00	1.262	0.19	8.934	1.25	63.246	3.60	447.744	1.63
0.028	0.00	0.200	0.00	1.416	0.20	10.024	1.44	70.963	3.45	502.377	1.52
0.032	0.00	0.224	0.00	1.589	0.21	11.247	1.65	79.621	3.24	563.677	1.35
0.036	0.00	0.252	0.00	1.783	0.22	12.619	1.86	89.337	2.99	632.456	1.14
0.040	0.00	0.283	0.00	2.000	0.22	14.159	2.08	100.237	2.73	709.627	0.90
0.045	0.00	0.317	0.00	2.244	0.22	15.887	2.30	112.468	2.45	796.214	0.66
0.050	0.00	0.356	0.00	2.518	0.23	17.825	2.52	126.191	2.19	893.367	0.45
0.056	0.00	0.399	0.00	2.825	0.25	20.000	2.73	141.589	1.97	1002.374	0.14
0.063	0.00	0.448	0.00	3.170	0.27	22.440	2.94	158.866	1.80	1124.683	0.00
0.071	0.00	0.502	0.00	3.557	0.31	25.179	3.13	178.250	1.68	1261.915	0.00
0.080	0.00	0.564	0.00	3.991	0.36	28.251	3.30	200.000	1.62	1415.892	0.00
0.089	0.00	0.632	0.00	4.477	0.43	31.698	3.45	224.404	1.59	1588.656	0.00
0.100	0.00	0.710	0.02	5.024	0.52	35.566	3.58	251.785	1.61	1782.502	0.00
0.112	0.00	0.796	0.07	5.637	0.63	39.905	3.67	282.508	1.64	2000.000	
0.126	0.00	0.893	0.11	6.325	0.75	44.774	3.73	316.979	1.68		
0.142		1.002		7.096		50.238		355.656			

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4/21/2019 1:32:44 PM

Figure A-3: The particle size absorptive for first cycle of rationing

MALVERN INSTRUMENTS

MASTERSIZER 2000

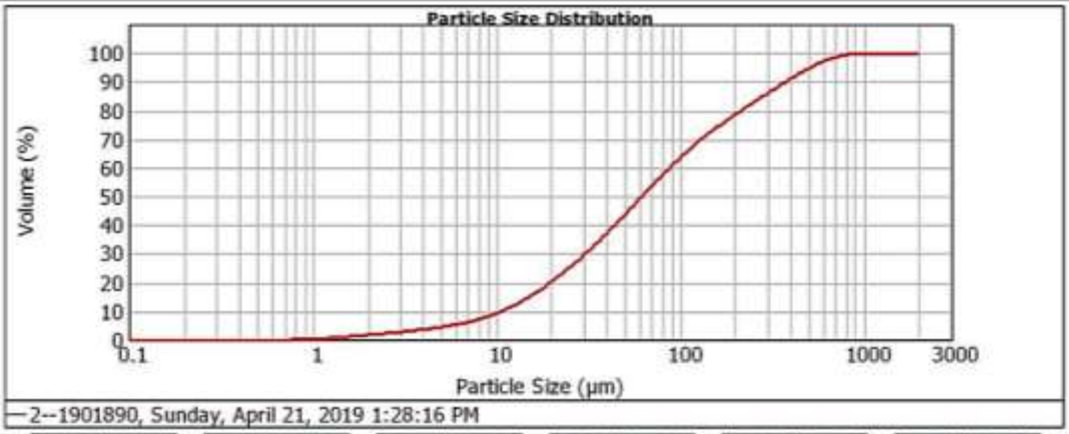
Result Analysis Report

Sample Name: 2–1901890	**SOP Name:** Scirocco 2000 OQ	**Measured:** Sunday, April 21, 2019 1:28:16 PM
Sample Source & type: Works = Baghdad Univ.	**Measured by:** Wurood Yousif	**Analysed:** Sunday, April 21, 2019 1:28:18 PM
Sample bulk lot ref: 19041716	**Result Source:** Measurement	

Particle Name: GYPSUM (HI)	**Accessory Name:** Scirocco 2000	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.531	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 4.15 %
Dispersant Name:	**Dispersant RI:** 1.000	**Weighted Residual:** 0.541 %	**Result Emulation:** Off

Concentration: 0.0026 %Vol	**Span :** 5.905	**Uniformity:** 1.69	**Result units:** Volume
Specific Surface Area: 0.285 m²/g	**Surface Weighted Mean D[3,2]:** 21.019 um	**Vol. Weighted Mean D[4,3]:** 132.116 um	

d(0.1): 10.687 um   d(0.5): 62.092 um   d(0.9): 377.344 um



Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %
0.020	0.00	0.142	0.00	1.002	0.18	7.096	0.88	50.238	3.39	355.656	1.98
0.022	0.00	0.159	0.00	1.125	0.21	7.962	1.01	56.368	3.40	399.052	1.90
0.025	0.00	0.178	0.00	1.262	0.24	8.934	1.17	63.246	3.37	447.744	1.77
0.028	0.00	0.200	0.00	1.416	0.26	10.024	1.34	70.963	3.30	502.377	1.59
0.032	0.00	0.224	0.00	1.589	0.27	11.247	1.53	79.621	3.19	563.677	1.36
0.036	0.00	0.252	0.00	1.783	0.28	12.619	1.72	89.337	3.06	632.456	1.07
0.040	0.00	0.283	0.00	2.000	0.28	14.159	1.91	100.237	2.90	709.627	0.77
0.045	0.00	0.317	0.00	2.244	0.28	15.887	2.09	112.468	2.73	796.214	0.51
0.050	0.00	0.356	0.00	2.518	0.29	17.825	2.28	126.191	2.57	893.367	0.07
0.056	0.00	0.399	0.00	2.825	0.30	20.000	2.45	141.589	2.43	1002.374	0.00
0.063	0.00	0.448	0.00	3.170	0.32	22.440	2.62	158.866	2.31	1124.683	0.00
0.071	0.00	0.502	0.00	3.557	0.35	25.179	2.78	178.250	2.21	1261.915	0.00
0.080	0.00	0.564	0.00	3.991	0.39	28.251	2.92	200.000	2.14	1415.892	0.00
0.089	0.00	0.632	0.00	4.477	0.45	31.698	3.06	224.404	2.10	1588.656	0.00
0.100	0.00	0.710	0.02	5.024	0.53	35.566	3.17	251.785	2.07	1782.502	0.00
0.112	0.00	0.796	0.06	5.637	0.62	39.905	3.27	282.508	2.05	2000.000	
0.126	0.00	0.893	0.14	6.325	0.73	44.774	3.34	316.979	2.02		
0.142		1.002		7.096		50.238		355.656			

Operator notes:

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4/21/2019 1:37:42 PM

Figure A-4: The particle size absorptive for second cycle of rationing

MALVERN INSTRUMENTS

MASTERSIZER 2000

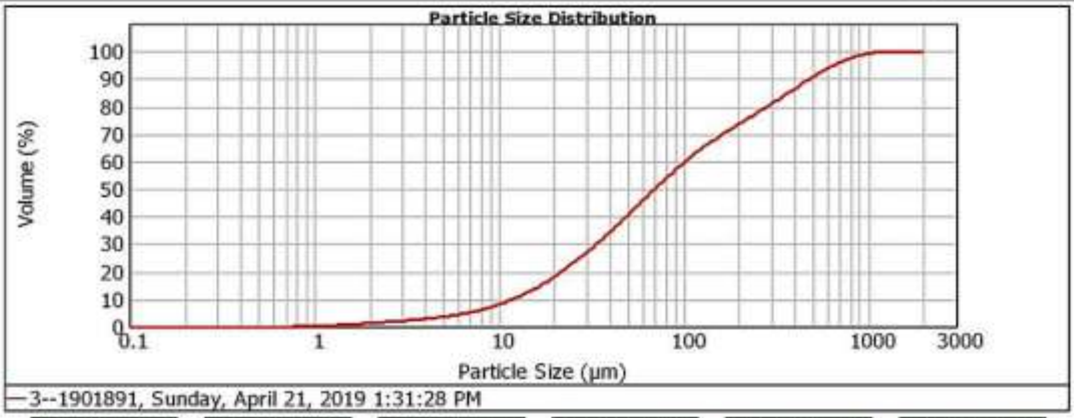
Result Analysis Report

Sample Name: 3--1901891	**SOP Name:** Scirocco 2000 OQ	**Measured:** Sunday, April 21, 2019 1:31:28 PM
Sample Source & type: Works = Baghdad Univ.	**Measured by:** Wurood Yousif	**Analysed:** Sunday, April 21, 2019 1:31:29 PM
Sample bulk lot ref: 19041716	**Result Source:** Measurement	

Particle Name: GYPSUM (HI)	**Accessory Name:** Scirocco 2000	**Analysis model:** General purpose	**Sensitivity:** Normal
Particle RI: 1.531	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 4.57 %
Dispersant Name:	**Dispersant RI:** 1.000	**Weighted Residual:** 0.729 %	**Result Emulation:** Off

Concentration: 0.0033 %Vol	**Span :** 6.759	**Uniformity:** 1.94	**Result units:** Volume
Specific Surface Area: 0.248 m²/g	**Surface Weighted Mean D[3,2]:** 24.167 um	**Vol. Weighted Mean D[4,3]:** 166.205 um	

d(0.1): 11.974 um   d(0.5): 69.945 um   d(0.9): 484.704 um



Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %	Size (μm)	Volume In %
0.020	0.00	0.142	0.00	1.002	0.13	7.096	0.78	50.238	3.26	355.656	2.20
0.022	0.00	0.159	0.00	1.125	0.16	7.962	0.92	56.368	3.27	399.052	2.19
0.025	0.00	0.178	0.00	1.262	0.18	8.934	1.07	63.246	3.23	447.744	2.13
0.028	0.00	0.200	0.00	1.416	0.20	10.024	1.24	70.963	3.16	502.377	2.01
0.032	0.00	0.224	0.00	1.589	0.21	11.247	1.41	79.621	3.04	563.677	1.83
0.036	0.00	0.252	0.00	1.783	0.22	12.619	1.59	89.337	2.89	632.456	1.60
0.040	0.00	0.283	0.00	2.000	0.23	14.159	1.77	100.237	2.72	709.627	1.33
0.045	0.00	0.317	0.00	2.244	0.23	15.887	1.96	112.468	2.58	796.214	1.05
0.050	0.00	0.356	0.00	2.518	0.24	17.825	2.14	126.191	2.39	893.367	0.77
0.056	0.00	0.399	0.00	2.825	0.26	20.000	2.31	141.589	2.25	1002.374	0.52
0.063	0.00	0.448	0.00	3.170	0.28	22.440	2.48	158.866	2.15	1124.683	0.25
0.071	0.00	0.502	0.00	3.557	0.31	25.179	2.63	178.250	2.08	1261.915	0.00
0.080	0.00	0.564	0.00	3.991	0.35	28.251	2.78	200.000	2.05	1415.892	0.00
0.089	0.00	0.632	0.00	4.477	0.40	31.698	2.92	224.404	2.06	1588.656	0.00
0.100	0.00	0.710	0.01	5.024	0.47	35.566	3.04	251.785	2.00	1782.502	0.00
0.112	0.00	0.796	0.06	5.637	0.56	39.905	3.14	282.508	2.13	2000.000	
0.126	0.00	0.893	0.10	6.325	0.66	44.774	3.22	316.979	2.18		
0.142		1.002		7.096		50.238		355.656			

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4/21/2019 1:38:51 PM

Figure A-5: The particle size absorptive for third cycle of rationing

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name: 4-1901891
Sample Source & type: Works = Baghdad Univ.
Sample bulk lot ref: 19041716

SOP Name: Scirocco 2000 OQ
Measured by: Wurood Yousif
Result Source: Measurement

Measured: Tuesday, April 23 2019 1:09:15 PM
Analysed: Tuesday, April 23 2019 1:09:16 PM

Particle Name: GYPSUM (HI)
Particle RI: 1.531
Dispersant Name:

Accessory Name: Scirocco 2000
Absorption: 0.1
Dispersant RI: 1.000

Analysis model: General purpose
Size range: 0.020 to 2000.000 um
Weighted Residual: 0.598 %

Sensitivity: Normal
Obscuration: 4.09 %
Result Emulation: Off

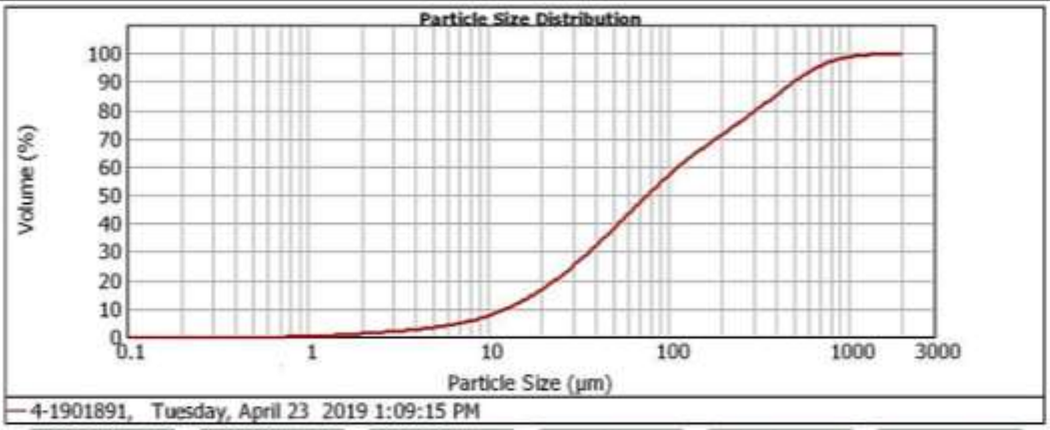
Concentration: 0.0032 %Vol
Specific Surface Area: 0.23 m²/g

Span : 6.350
Surface Weighted Mean D[3,2]: 26.094 um

Uniformity: 1.91
Vol. Weighted Mean D[4,3]: 180.513 um

Result units: Volume

d(0.1): 12.879 um d(0.5): 77.217 um d(0.9): 503.241 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.020	0.00	0.142	0.00	1.002	0.11	7.096	0.71	50.238	3.17	355.656	2.44
0.022	0.00	0.159	0.00	1.125	0.14	7.962	0.84	56.368	3.19	399.052	2.41
0.025	0.00	0.178	0.00	1.262	0.16	8.934	0.98	63.246	3.17	447.744	2.32
0.028	0.00	0.200	0.00	1.416	0.17	10.024	1.13	70.963	3.11	502.377	2.15
0.032	0.00	0.224	0.00	1.589	0.19	11.247	1.30	79.621	3.01	563.677	1.91
0.036	0.00	0.252	0.00	1.783	0.20	12.619	1.47	89.337	2.89	632.456	1.62
0.040	0.00	0.283	0.00	2.000	0.21	14.159	1.65	100.237	2.74	709.627	1.30
0.045	0.00	0.317	0.00	2.244	0.21	15.887	1.82	112.468	2.59	796.214	1.00
0.050	0.00	0.356	0.00	2.518	0.22	17.825	2.00	126.191	2.45	893.367	0.71
0.056	0.00	0.399	0.00	2.825	0.24	20.000	2.17	141.589	2.33	1002.374	0.49
0.063	0.00	0.448	0.00	3.170	0.26	22.440	2.33	158.866	2.25	1124.683	0.33
0.071	0.00	0.502	0.00	3.557	0.29	25.179	2.49	178.250	2.21	1261.915	0.22
0.080	0.00	0.564	0.00	3.991	0.32	28.251	2.64	200.000	2.21	1415.892	0.15
0.089	0.00	0.632	0.00	4.477	0.37	31.698	2.79	224.404	2.24	1588.656	0.09
0.100	0.00	0.710	0.01	5.024	0.43	35.566	2.92	251.785	2.29	1782.502	0.06
0.112	0.00	0.796	0.05	5.637	0.51	39.905	3.03	282.508	2.36	2000.000	
0.126	0.00	0.893	0.09	6.325	0.60	44.774	3.12	316.979	2.42		
0.142		1.002		7.096		50.238		355.656			

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Figure A-6: The particle size absorptive for fourth cycle of rationing

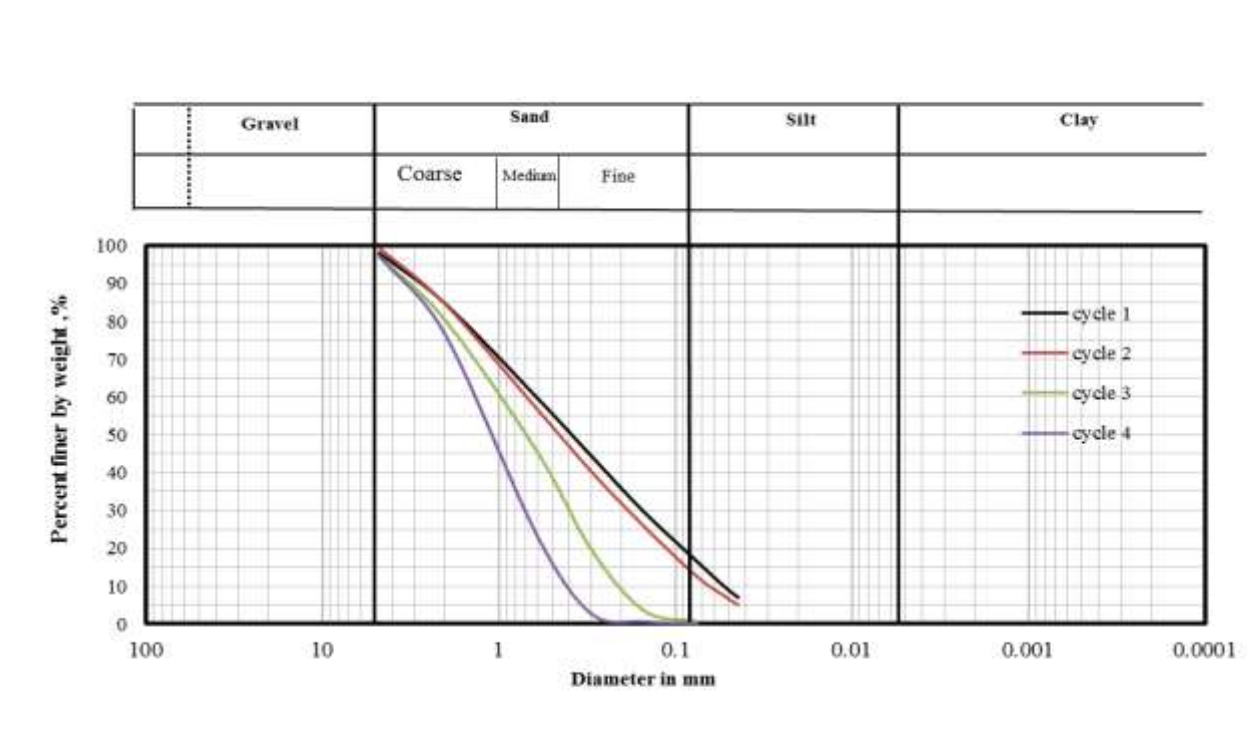
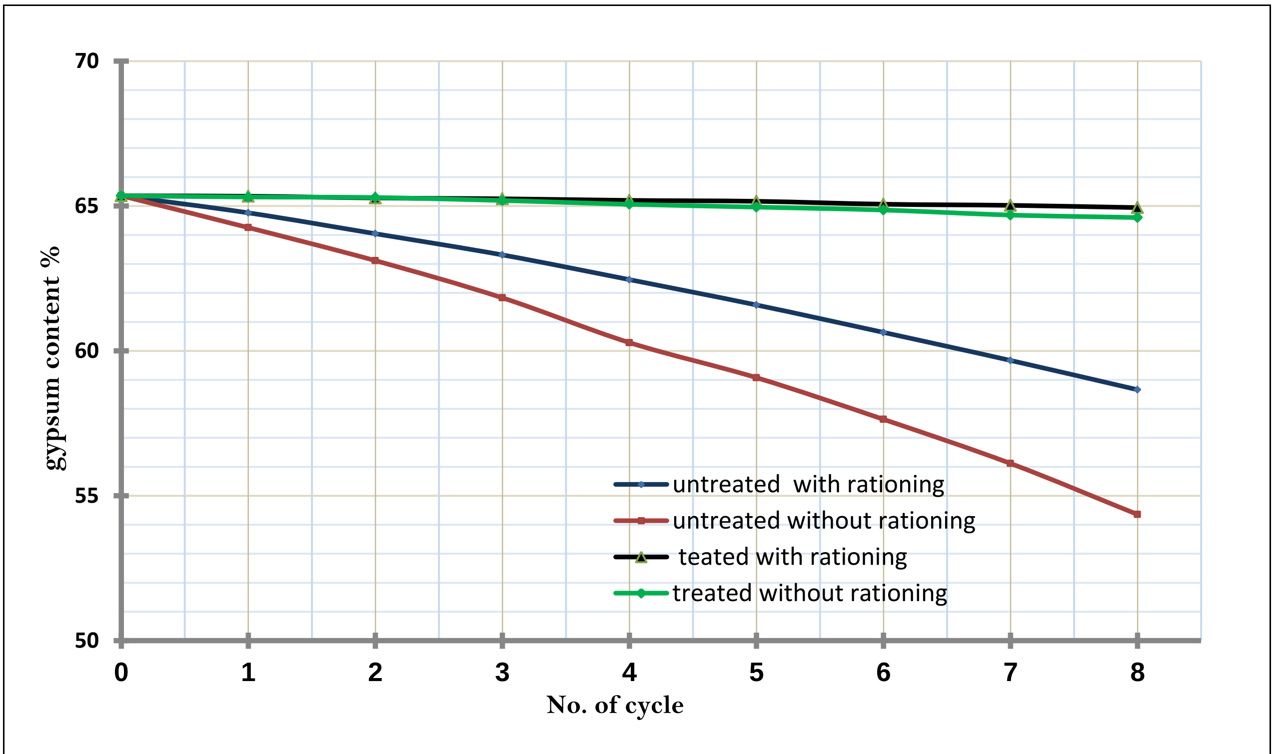


Figure A-7: Effect of the rationing system on particle size distribution of the soil



Time (day)	0	10	30	50	70	90	110	130	150

Figure A-8: Effect of rationing cycles on the gypsum content of gypsoeus canals

References

[1] Ahmad, Fauziah, M. A. Said, and Lamyaa Najah. “Effect of leaching and gypsum content on properties of gypseous soil ” IJSRP, vol. 2, no. 9, p. 1-5, 2012.

[2] Al-Hadidi, Maysam Th, and Zeina Hamed Nasir AL-Maamori. “Improvement of Earth Canals Constructed on Gypseous Soil by Soil Cement Mixture” Journal of Engineering, vol. 25, no. 3, p. 23-37,2019.

[3] Al-Mufty, A. A., and I. H. Nashat. “Gypsum content determination in gypseous soils and rocks” Proceedings of the 3th Jordanian international mining conference, Amman, vol. 2, 2000.

[4] Al-Musawi, Q. S. K. “Effect of leaching on engineering properties of High Gypseous subgrade soil” Master's thesis, Dep. of Highway and Transportation Engineering, University of Al-Mustansiriya, 2005.

[5] Al-Zubaydi, Abdulrahman H., Moafaq A. Al-Atalla, and Ibrahaim M. Al-Kiki. “Long term strength and durability of clayey soil stabilized with lime“ Engineering & Technology Journal, vol. 29, no. 4, p. 725-735, 2011.

[6] ASTM D422 Standers, “Soil and Rock (I)” vol 04.08, 2002.

[7] ASTM, D698 “Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft 3 (600 kN-m/m3))” ,2003.

[8] British Standard Institution BS 1377, Method of Testing Soils for Civil Engineering Purposes, London, 1975.

[9] Fookes, P. G. “Middle East-inherent ground problems” Quarterly Journal of Engineering Geology and Hydrogeology, vol. 11, no. 1, p. 33-49, 1987.

[10] Jafarzadeh, A. A., and J. A. Zinck. “Worldwide distribution and sustainable management of soils with gypsum” Proceedings of the International Symposium on Desertification, p. 362-368, 2002.

[11] Namdar, Abdoullah, and G. S. Gopalakrishna. “Analysis of Mixed Soil Model Characteristics” Modern Applied Science, vol. 3, no. 5, p. 199-203, 2009.

[12] Razouki, Sabah S., Dina K. Kuttah, and Maha H. Abood.“Compaction and design of gypsiferous fill for hot desert road pavements” Proceedings of the Institution of Civil Engineers-Construction Materials, vol. 164, no. 1, p. 3-11, 2010.

[13] Razouki, Sabah Said, and Bushra M. Salem. "Impact of soaking–drying cycles on gypsum sand roadbed soil." Transportation Geotechnics, vol. 2, p. 78-85, 2015.

[14] Shu, Xia, et al. “Mastersizer 2000 laser particle size analyzer and its applications [J] ” Journal of Hefei University of Technology (Natural Science), vol. 2, 2007.

[15] Standard Specification for Cement “specifications Iraqi standards ” Iraqi Ministry of Planning, no. 5, 1984.

[16] Standard, British. “1377 (1990) Methods of test for soils for civil engineering purposes ” British Standards Institution, London, 2004.

تأثير المراشنة على خواص القنوات الجبسية المعالجة بالاسمنت

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نشر في: 30 ايلول 2020

الخلاصة – شحة مياه الري تتطلب إجراءات محددة. أحد هذه الإجراءات هو تنفيذ نظام المراشنة (فترة الري تليها فترة الجفاف). يمكن أن يكون لهذا النظام تأثير على خصائص قنوات الري. لذلك، ان دراسة نظام المراشنة لقنوات الري مهم في كل من هندسة الموارد المائية والهندسة المدنية ، خاصة إذا تم تشييدها بترب جبسية. من أجل تقييم نظام المراشنة على القنوات الجبسية المستقرة مع نسبة محدده من الأسمنت ، أجريت تجارب عملية للكشف عن تأثير دورات الترطيب والتجفيف على السلوك الفيزيائي والهيدروليكي لهذه التربة وحساب بعض خصائص التربة مثل التأكل و حجم حبيبات التربة ومحتوى الجبس في كل دورة (10 أيام ترطيب و 10 أيام تجفيف). حيث تم إحضار التربة الجبسية ذات المحتوى الجبسي 65٪ من بحيرة ساوه- العراق إلى المختبر الهيدروليكي بجامعة بغداد ، وتم إجراء الاختبارات الفيزيائية والكيميائية وفقًا لنظام التصنيف القياسي. يشمل العمل المختبري بناء قناة مختبرية تحتوي على تربة جبسية لغرض حساب تأكل القناة وتأثير حجم حبيبات التربة بطريقتين (تحليل المنخل القياسي واختبار امتصاص الجسيمات) وكذلك حساب محتوى الجبس في كل دورة ، حيث تشغيل القناة يتكون من مرحلتين ، الأولى للتربة غير المعالجة (4 دورات تشغيل) والأخرى للتربة الممزوجة بأسمنت 10٪ (خليط الاسمنت 5 سم فوق التربة 5 سم) 4 دورات أيضًا. أظهرت النتائج أن دورات المراشنة تقلل من تأكل القناة في حالة التربة غير المعالجة بنسبة 56.6٪ وفي حالة التربة المعالجة 82٪. دورات المراشنة أدت إلى تدرج خشن للتربة وفقًا للطريقتين. وكذلك تقلل من محتوى الجبس في حالة التربة غير المعالجة بنسبة 43٪ وفي حالة التربة المعالجة 45.6٪. وبالتالي، نستنتج أن نظام المراشنة يعمل على تاثير إيجابي على بعض خصائص التربة الجبسية وبطانة قنوات الري.

الكلمات الرئيسية – نظام المراشنة ، الترطيب و التجفيف ، التربة الجبسية ، قنوات الري ، التأكل.