The Effect of bentonite on some physical properties of soils with varying gypsum content

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Abstract .

The impact of bentonite addition on certain physical characteristics of soils with varying gypsum contents Using RCBD (Randomised Complete Block Design), a field experiment was carried out in gypsum soil in the fields of the College of Agriculture/Tikrit University, which is situated at an elevation of 129 meters above sea level and at latitudes 344049 north and 433840 east, to examine the impact of adding bentonite on certain physical characteristics of soils with varying gypsum content. The investigation involved two factors: the first was the addition of bentonite at three different levels (0, 3, and 6) to five distinct soils (i.e., fifteen treatments with three replicates) with gypsum contents of 48.60, 141.51, 236.70, 300.00, and 432.86 g/kg. According to the data, the BoG treatment produced the highest apparent density of 1.53 megagrammes per cubic metre, while the G1 level with all the additional bentonite levels produced the highest real density of 2.62 megagrammes per cubic metre. The highest values of porosity (50.96%) and weighted diameter (1.89 mm) were obtained from the B2G3 and B2G5 treatments, respectively.

Keywords: bentonite, clay minerals, physical properties, gypsum, gypseous soil.

.1 The Introduction

Despite a gypsum percentage ranging from 5% to over 90% of the total soil weight, gypsum is the primary and distinguishing element of gypsum soils. Dry and semi-dry writing, these soils are typically created by gypsum deposits or the breakdown of gypsum-rich rocks (5). The physical, chemical, and hydraulic characteristics of gypsum soils are greatly impacted by their high gypsum content, which distinguishes them from other types of soils. The coarse texture and porous structure of gypsum soils cause them to lose some of their water-holding capacity. . (10(

Because of their distinct physical, chemical, and hydraulic characteristics, gypsum soils present a major obstacle to agriculture. Therefore, in order to make these soils arable and produce high economic returns, unique procedures and cutting-edge technology are needed for their management and improvement. A number of changes, including the use of bentonite, are used to solve these issues. Bentonite is useful for addressing issues with sandy soil and enhancing its hydraulic and physical characteristics. It enhances soil aeration and

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lowers the soil's apparent density by increasing porosity and permeability to water and air. Bentonite improves the soil's capacity to hold water and aids in the breakdown of hard soil layers. and increases the soil's water-retaining capacity, which reduces drought problems and helps stabilize salts on the soil surface and reduce salinization problems. Improving the physical and hydraulic properties of gypsum soil using bentonite .Therefore, this study aims to study the effect of bentonite on some physical properties of soils with different gypsum content(4.(

.2Materials and Methods

Study Site

A site was selected in the research station of the Department of Soil Sciences and Water Resources - College of Agriculture - Tikrit University at latitude 58.240534 and longitude 54.938543, which is classified within the arid and semi-arid areas. Holes were dug with dimensions

Table 1: Some physical and chemical properties of the study soils

Characteristic	Unit	G1	G2	G3	G4	G5
Texture	....	Mixed	....	....	....	....
Sand	$g\ kg^{-1}$	473	460	....	....	....
Silt	$g\ kg^{-1}$	381	387	....	....	....
Clay	$g\ kg^{-1}$	146	153	....	....	....
Bulk Density	$Mg\ m^{-3}$	1.55	1.30	1.48	1.57	1.26
Particle Density	$Mg\ m^{-3}$	2.62	2.62	2.61	2.61	2.60
Porosity	%	40.62	49.98	49.99	39.56	51.53
Volumetric field capacity	$cm^3\ cm^{-3}$	70	61	56	42	35
Volumetric wilting point	$cm^3\ cm^{-3}$	22.30	24.50	26.50	27.60	29.50
PH	....	7.29	7.35	7.55	7.31	7.99
Electrical Conductivity Ec	$Ds\ m^{-1}$	4.50	2.56	3.18	3.44	4.23
Cation Exchange Capacity	$Cmole\ kg^{-1}$	12.31	10.96	10.53	7.16	5.61
Organic Matter	$g\ kg^{-1}$	7.11	5.32	4.31	2.86	.....
CaSo4.2H2O	$g\ kg^{-1}$	48.60	141.15	236.70	300.00	432.86
CaCO3	$g\ kg^{-1}$	202	201	186	137	126

.2.1The process of preparing bentonite and adding it to soil:

Bentonite was purchased from the National Drilling Company in Baghdad and prepared by grinding it, putting it through a 0.02 mm sieve, and then combining it with the study soil in the amounts required for each treatment. For two months, it was then incubated with moisture and stirred to ensure homogeneity. Following the conclusion of the incubation period, the soil samples were allowed to air dry before being prepared for the physical measurements for the study by passing them through a 2 mm-diameter sieve. Table (2) lists some of the characteristics of the bentonite used in the study.

Table 2: Some properties of the bentonite used in the study.

Charecteristic	Bentonite	Unit
PH (1:5)	7.50	....
Ec (1:5)	3.40	$dS.m^{-1}$
WHC	115.5	%
Pb	1.62	$Mg\ m^{-3}$
Cation exchange capacity	38.17	$Mol\ Kg^{-1}$

The bulk density of the study site was determined using soil core sampler method (7.(

The actual density was estimated using the equation proposed by (6.(

Porosity based on apparent and true density values (9) and through the following relationship:

f = [1-Pb/ps]. 100

F Total porosity of soil(%)

pb Bulk density (mcg/m-3(

ps True density (mcg/m³(

2.2Mean weight Diameter (MWD.(

The weighted diameter was measured in the laboratories of the College of Agriculture, Tikrit University, using the wet sieving method after passing the soil through a sieve with holes diameters of (4-9) mm. The weighted diameter was estimated by passing (25) g through a set of sieves with holes diameters of 95-4.75-2-1-0.250.42 mm and the percentage of aggregates present on each sieve was calculated after sieving it for 6 minutes. The weighted diameter was calculated according to the equation:

MWD = i=1 M XW................. (2(

Since:

MWD = Mean Weighted Diameter (mm.(

W i= mass of aggregates as a percentage of the total weight of the model (without units(

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Xi=Average diameter of these clusters (mm.(

2.3Statistical Analysis:

The statistical software (SAS v.9.1) was used to do a statistical analysis of the data. At a 5% probability level, the SAS, (16) means (coefficients) were compared using the Duncan multinomial test.

-3Conclusions and Discussion

3.1Bulk Density (megagramme m-3:(

The effects of bentonite addition on the bulk density values of soils with varying gypsum contents are displayed in Table (3). When bentonite was added, the bulk density dropped, reaching 1.44, 1.39, and 1.34 megagramme m-3 for treatments B, B2, and B2, respectively. The mineral composition of bentonite, an active clay mostly made up of the mineral montmorillonite, which possesses a real density, is the cause of this. between 2.6 and 2.8 megagrammes per cubic metre (9.(

The impact of the gypsum content of the soil on bulk density is also displayed in Table 3. At level G, bulk density readings climbed after decreasing as the gypsum concentration increased. The maximum value of bulk density was 1.49 megagrammes m-3. The bulk density then dropped to 1.38 megagrammes m-3 as the gypsum level increased. Since gypsum has a relatively low specific gravity in comparison to the other components of soil, this is the reason why bulk density decreases as gypsum concentration increases. Additionally, the size of the crystals and the gypsum crystallisation inside the pores have an impact on (3) Variations in the findings of the correlation between bulk density and gypsum content

Table 3 also shows the combined impact of the soil's gypsum content and the addition of bentonite. Generally speaking, the bulk density dropped as the amount of bentonite and gypsum grew up to level G4, after which it rose and then fell with level G. Treatment B2G3 produced the lowest value of 1.27 megagrammes m3, whereas treatment BoG4 produced the highest value of 1.53 megagrammes m3, surpassing all other research treatments. Their findings were not the best, and there was no significant difference between the addition of level B with gypsum levels G4 and G5. This can be explained by bentonite's function in strengthening the gypsum soil's structure and increasing its stability and cohesive (17(

Although the bulk density of the soil decreases as a result of this structural improvement, the disturbing results could have been caused by the dissolution and transport of gypsum (, 15) into the soil pores.

Table 3. Effect of bentonite addition on bulk density (mcg(

)M3) For soils with different gypsum content

G	B			Gypsum Averages
	0%	3%	6%	
G1	1.48ab	1.44abc	cd 1.29	AB 1.40
G2	abc 1.45	1.41bdc	1.31cd	B 1.39
G3	1.32cd	c 1.29	1.27c	B 1.29
G4	a 1.53	ab 1.46	ab 1.47	A 1.49
G5	1.44abc	cdc 1.35	cdc 1.35	B 1.38
Gypsum Averages	A 1.44	1.39B	1.34C	

bentonite addition, this is the result. The real density of the soil is not greatly impacted by low percentages. Furthermore, the calculation of the real density value only considers the mass and volume of the soil; it ignores the matter's pores. (1)

The impact of soil gypsum content on true density is also displayed in Table 4, where it is evident that true density values sharply declined as the gypsum percentage rose. Soil G1 had the greatest actual density value at 2.62 megagrams/m³, while soil G6 had the lowest at 2.54 megagrams/m³. As a result of the relative drop in the specific weight of gypsum, which is around 2.3 g/cm³, increasing the soil's gypsum content had an impact on the real density value (2).

Regarding the combined impact of bentonite addition and soil gypsum content, Table 4 also shows that the true density reached its maximum value of 2.62 megagrammes m-3 for level G1 with all levels of bentonite added, and its lowest value of 2.54 megagrammes m-3 for level G5 with all levels of bentonite added. In other words, compared to the influence of bentonite, the gypsum concentration had the biggest impact on the real density values. The low amount of bentonite addition—which did not surpass 6%—is the cause of the lack of discernible differences. The genuine density is not greatly impacted by these low percentages. For soil, (1)

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Table 4 Effect of adding bentonite on the true density (mcg m−1) of soils with different gypsum content

Values with similar letters are not significantly different at the 0.05 probability level according to Duncan's multiple range test.

G	B			Gypsum Averages
	0%	3%	6%	
G1	a 2.62	a 2.62	a 2.62	A 2.62
G2	b 2.60	b 2.60	b 2.60	B 2.60
G3	c 2.59	c 2.59	c 2.59	C 2.59
G4	d 2.56	d 2.56	d 2.56	D 2.56
G5	e 2.54	e 2.54	e 2.54	E 2.54
Gypsum Averages	A 2.58	A 2.58	A 2.58	

3.3 Soil porosity (%):-

Table 5 illustrates how adding bentonite affected the percentage of soil porosity values for soils with varying gypsum contents. The porosity rose as bentonite was added, reaching its maximum value of 48.07% with addition level B. This was a significant 9.10% increase over treatment B, which had a value of 44.06%. This increase can be explained by bentonite's contribution to the improvement of the soil's overall porous structure, which helps to strengthen the pore structure of gypsum soil in particular, which has weaker particle regularity and structure. This makes the soil more stable, which raises the soil's overall porosity. (12).

The impact of the soil's gypsum content on its overall porosity values is also demonstrated in Table 5, where the porosity peaked at 50.06% at the gypsum content (the porosity values increased insignificantly with the increase in the gypsum percentage, as the saturated water conductivity reached its highest value of 48.750% with the gypsum level), while the porosity fell to its lowest value at 41.92% with the gypsum level G. This may be related to the kind of gypsum crystals, their size, and their degree of solubility (13), in addition to the fact that porosity is a product of the apparent and actual density of the soil.

Table 5 also demonstrates the impact of the interaction between bentonite addition and gypsum soil content. It shows that porosity increases as bentonite addition levels rise in tandem with gypsum content levels. The treatment (BG) yielded the highest value of 50.96%, surpassing all other study treatments, while the treatment BaG yielded the lowest value of 40.23%. This is due to the influence of the study factors, as bentonite addition to the gypsum soil significantly improved the pore size distribution by raising the micro and medium porosity. Waddiria soil's overall porosity rises as a result of this improvement in pore distribution. (11).

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Table 5: Effect of bentonite addition on porosity (%) for different soils in their gypsum content

G	B البنتونايت			Gypsum Averages
	0%	3%	6%	
G1	ef 43.51	d 45.03	a 50.76	B 46.43
G2	de 44.23	cd 45.76	b 49.61	B 46.53
G3	b 49.03	a 50.19	a 50.96	A 50.06
G4	g 40.23	f 42.96	f 42.57	D 41.92
G5	ef 43.30	c 46.85	c 46.85	C 45.66
Gypsum Averages	C 44.06	B 46.51	A 48.07	

Values with like letters are not significantly different at the 0.05 probability level according to Duncan's multiple range test.

4.3 Weighted average diameter (mm):

The results of Table 6 show the effect of adding bentonite on the weighted diameter rate for soils with different gypsum content. The weighted diameter rate increased with the addition of bentonite, reaching values of 1.35, 1.53, and 1.62 mm for treatments B, B, and B2, respectively. The increase rate reached 20.00% for treatment B2 compared to treatment B. This increase can be attributed to the role of bentonite in binding particles and increasing the level of cohesion between them .

Table 6 also shows the effect of the gypsum content of the soil on the stability of aggregates, as the weighted diameter rate increased with the increase in the gypsum percentage. It reached its highest value of 1.69 mm with the G5 gypsum level, which was significantly superior, with an increase rate of 23.35% compared to the treatment, which gave the lowest value of 1.37 mm

The combined effect of adding bentonite and the soil gypsum content is also evident from Table 6. The weighted diameter rate increased with increasing gypsum content, and the effect was greater with the levels of added bentonite. Treatment B2G5 gave the highest value of 1.89 mm, outperforming all other study treatments, while treatment BoG gave the lowest value of 1.31 mm. This can be attributed to the fact that the effect of adding bentonite to agricultural gypsum soils played a major role in increasing the weighted diameter rate, as bentonite can interact with gypsum and other soil components to enhance soil aggregation and form larger and more stable soil aggregates (5)and (13).

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Table 6: Effect of adding bentonite on the weighted diameter rate (mm) for soils with different gypsum content

Values with similar letters are not significantly different at the 0.05 probability level according to Duncan's multiple range test.

G	B البنتونايت			Gypsum Averages
	0%	3%	6%	
G1	j 1.31	h 1.39	gh 1.42	E 1.37
G2	j 1.32	g 1.42	f 1.47	D 1.40
G3	j 1.33	1.50d	de 1.59	C 1.47
G4	i 1.37	d 1.56	c 1.77	B 1.56
G5	g 1.42	b 1.80	a 1.85	A 1.69
Gypsum Averages	C 1.35	B 1.53	A 1.62	

Conclusions

This study led us to the conclusion that bentonite addition may be a solution for enhancing the characteristics of gypsum soils that have poor porosity distribution and structural instability. When applied to soils with varying gypsum amounts, it significantly improved the physical characteristics, and the soils responded well to higher addition levels. The study's objective is accomplished, and some of the issues with gypsum soils—which are common in arid and semi-arid areas of Iraq—are resolved.

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