Research Article

Response of Physical Properties of Sandy Soil Treated with Different Levels of Natural Soil Conditioners Zeolite and Perlite

Mustafa Qais Hamid

Department of Soil Science and Water Resources, College of Agriculture, University of Al-Qadisiyah, Al-Diwaniyah, Iraq.

Abstract | Sandy soils are prone to degradation due to their weak structure, which affects water movement and retention. This study was conducted to know the response of physical properties of sandy soil when treated with different levels of zeolite and perlite Conditioners, alone and mixed. The study was implemented Using a randomized complete block design (RCBD) with two factors and three replicates for each treatment. The soil was planted with (Zea mays L.) seeds, different levels of zeolite and perlite were added to the soil (0, 2.5, 5, 7.5, 10 %) of the dry soil weight immediately after planting, individually and mixed, and after 30 and 60 days of addition, Some physical properties of sandy soil were estimated. The combined application of zeolite and perlite significantly reduced bulk density and saturated hydraulic conductivity after 60 days at the 10% application rate, with bulk density decreasing by 25.87% to an average of 1.212 Mg m^{-3} and saturated hydraulic conductivity decreasing by 75.97% to an average of 0.197 cm min^{-1}, compared to control values of 1.635 Mg m^{-3} (bulk density) and 0.82 cm min^{-1} (saturated hydraulic conductivity). Additionally, the combined application at the 10% level resulted in the highest significant ($P < 0.05$) increases in moisture content and total porosity, improving by 51.27% and 55.26%, respectively, compared to control values of 13.22% (moisture content) and 38.27% (total porosity).

Received | January 30, 2025; **Accepted** | February 16, 2025; **Published** | April 24, 2025
***Correspondence** | Mustafa Qais Hamid, Department of Soil Science and Water Resources, College of Agriculture, University of Al-Qadisiyah, Al-Diwaniyah, Iraq. **Email:** mustafa.qais@qu.edu.iq
Citation | Hamid, M.Q. 2025. Response of physical properties of sandy soil treated with different levels of natural soil conditioners zeolite and perlite. *Sarhad Journal of Agriculture,* 41(2): 591-599.
DOI | https://dx.doi.org/10.17582/journal.sja/2025/41.2.591.599
Keywords | Zeolite, Perlite, Bulk density, Total porosity, Moisture content, Saturated hydraulic conductivity

Introduction

Sandy soils are considered to be coarse-textured soils that contain a high percentage of sand estimated at more than 90% of the sand, which is characterized by weak physical properties related to their productivity, they are unstructured, it's their grains do not hold together when dry, not flexible, have good ventilation and drainage, which makes their ability to retain water very weak. In addition, the total porosity of these soils is low, ranging between 32-40%, and Their pore distribution is poor, with a low percentage of small pores (Alhammadi and Al-Shrouf, 2013), and most sandy soils are exposed to wind and water erosion and instability, which leads to damage to these soils because they are also characterized by a low content of organic matter, which is considered one of the cohesive materials that bind soil grains together (Ozores-Hampton *et al*., 2011).

Whiting *et al*. (2005) confirmed that the percentage of available water in this type of soil is very little, ranging between 4-6%, while the surface area of its particles is less than 1 m2g-1 and its cation exchange capacity is less than 10 meq for every 100 g of soil, therefore, these soils have weak properties and are ineffective for producing large quantities of agricultural crops. Alhammadi and Al-Shrouf (2013) also showed that the problems of sandy soils are physical problems related to their weak composition, high water infiltration rate, permeability rate, weak ability to retain water, and high Hydraulic conductivity.

Ibrahim and Fadni (2013) explained that controlling the amount of moisture in the soil is done by improving the physical properties of the soil and will increase the efficiency of fertilizers due to the problems that sandy soils suffer from, including the process of nitrogen oxidation (Nitrification) and the speed of water movement in it due to the large pores, which leads to the process of losing fertilizers by washing.

Sandy soils in Iraq are exploited on a limited scale to produce some crops despite the availability of groundwater for irrigating crops. High management and maintenance costs limit the utilization of these soils for crop production, despite their productive potential, many studies have been conducted to improve the productivity of these soils by improving their physical and chemical properties using natural Conditioners whose effect continues in the long term without leaving any harm to the soil (Al-Obaidi *et al*., 2022).

Soil Conditioners are known as natural materials that work to improve two or more properties of the soil to help it move water and air and grow and develop plants, this happens as a result of the development of the structural properties of the soil, which is reflected in other properties, especially those related to increasing its capacity to retain water. Natural soil Conditioners are added to improve its physical properties, which contributes to increasing its ability to retain the largest amount of water and nutrients within its pores and reducing their loss (Kranz *et al*., 2020).

Zeolite Conditioner is a natural mineral that is formed as a result of changes that occur in volcanic rocks rich in silicon oxide by their interaction with water when the appropriate temperature and basic conditions are available (Badillo-Almaraz *et al*., 2003). It has many unique properties that make it one of the desirable advantages in improving soil properties, including high porosity that leads to water retention and increases the soil storage capacity, regular distribution of its particle sizes, high cation exchange capacity, and selectivity for cations such as alumina and potassium, it can also be used as carriers of nutrients as a means of releasing them (Sangeetha and Baskar, 2016). Zeolite is added to the soil to improve its physical properties by increasing its ability to retain water, improving its aeration, and increasing the readiness of elements for absorption by the plant (Ramesh *et al*., 2015).

Perlite Conditioner is a small particle produced by heating silicate rocks at a temp of 90 -1000 °C. As a result of heating, the size of its particles increases 20 times its size, resulting in air gaps that absorb quantities of water to make them ready for direct absorption by the plant when needed, perlite Conditioner is one of the best agricultural Conditioners as it is characterized by its ability to absorb water and retain it for long periods that ensure spacing of irrigation periods and reduce water and fertilizer consumption (Evans, 2004). In addition, it is characterized by a high surface area and low density and thermal conductivity. It is considered a non-toxic, non-degradable material that does not produce unpleasant odors and is light in weight (Markoska *et al*., 2018).

Alkhateeb *et al*. (2020) explained that perlite Conditioner's effect increases with the increase in the addition level. The analyses of the components of perlite confirmed that it contributes significantly to increasing the growth and production of the crop, in addition to its great ability to retain water and reduce evaporation from the soil.

Materials and Methods

The experiment was conducted in the agricultural fields of the College of Agriculture, Al-Qadisiyah University, on loamy sand soil. The study aimed to evaluate the effects of different levels of zeolite and perlite on the physical properties of sandy soil cultivated with (*Zea mays* L.) seeds. The soil was prepared in the field and planted with (*Zea mays* L.) seeds.

Different levels of zeolite and perlite were added to the soil, individually and mixed, immediately after planting the crop, according to the amount allocated for each treatment. After 30 and 60 days of addition, some physical properties of the soil were estimated, including bulk density, porosity, moisture content, and saturated hydraulic conductivity.

A soil sample was taken, air dried, and sieved with a sieve with a hole diameter of 2 mm to conduct some physical and chemical analyses of the soil, shown in Table 1. Zeolite and perlite Conditioners were obtained from the Green Country Company in Baghdad, and their physical and chemical properties were estimated as shown in Table 2.

Table 1: *Some chemical and physical properties of the studied soil.*

Parameters	Unit	Value	Parameters	Unit	Value
Particle size distribution			Soluble cations		
Sand	$gm.kg^{-1}$	850.00	Ca^{++}	$meq.L^{-1}$	1.08
silt	$gm.kg^{-1}$	105.00	Mg^{++}	$meq. L^{-1}$	1.12
Clay	$gm.kg^{-1}$	45.00	K^{++}	$meq.L^{-1}$	0.74
Textural class	Loamy sand		Na^{++}	$meq.L^{-1}$	2.23
Bulk density	$Mg.m^{-3}$	1.63	Soluble anions		
particle density	$Mg.m^{-3}$	2.65	$HCO3^{-}$	$meq.L^{-1}$	3.24
Total porosity	%	38.30	CL^{-}	$meq.L^{-1}$	4.02
Moisture content	%	13.22	$SO4^{-}$	$meq.L^{-1}$	2.46
Saturated Hydraulic conductivity	$cm.min^{-1}$	0.82	Available nutrients		
Cation exchange capacity	$cmolc/kg^{-1}$	1.71	N	$Mg.kg^{-1}$	23.32
pH $(1:1)_{sups}$	---------	8.27	P	$Mg.kg^{-1}$	9.37
EC $(1:1)_{Ext}$	$dS.m^{-1}$	1.32	K	$Mg.kg^{-1}$	21.87
CaCO3	%	1.21			
OM	%	0.52			

Experimental design and statistical analysis

The experiment was conducted in the field using the Randomized Complete Block Design (RCBD) with two factors and three replicates for each factor. The first factor included two types of soil Conditioner, zeolite, and perlite, while the second factor included five different levels of Conditioner as shown below:

Soil Conditioner 0%

- Adding soil Conditioner at a rate of 2.5% alone and mixed
- Adding soil Conditioner at a rate of 5% alone and mixed
- Adding soil Conditioner at a rate of 7.5% alone and mixed
- Adding soil Conditioner at a rate of 10% alone and mixed

Table 2: *Some chemical and physical properties of natural soil conditioners.*

Parameters	Unit	Conditioner Type	
		Perlite	Zeolite
particle density	$Mg.m^{-3}$	-	2.61
Bulk density	$Mg.m^{-3}$	0.9	1.36
Total porosity	%	-	47.89
Saturated Hydraulic conductivity	$cm.h^{-1}$	8.6	10.1
Cation exchange capacity	$Cmolc. kg^{-1}$	22.1	24.3
Moisture content	%	26.4	30.1
Electrical conductivity	$ds.m^{-1}$	0.15	0.45
pH	-	7.5-6.5	8.2
color	-	white	white
Particle size	mm	1-5	0.25-4

The volume of the soil was estimated based on its three dimensions (15 m length, 0.5 m width and 0.2 depth) in order to know the amount needed to be added to each level of soil conditioner.

$$Volume = 15m \times 0.5m \times 0.2m$$
$$Volume = 1.5\ m^3\ soil$$

$$Mass\ of\ soil = Density \times Volume$$
$$Mass\ of\ soil = 1.635\ mg\ m^{-3} \times 1.5m^3$$
$$Mass\ of\ soil = 2.452\ meq = 2452\ kg\ soil$$

The results were analyzed statistically using the (statistical analysis system) -SAS to determine the significant effects of the factors and their interactions when testing the least significant difference (LSD) at $P \leq 0.05$ (Sas, 2001).

Estimation of physical properties of soil

Soil particles size distribution: The pipette method was used to estimate the sizes of primary soil particles, sand, clay and silt, as described in Black (1965).

Bulk density of soil: The Bulk density of soil was estimated by the metal cylinder method (core sample) according to what was mentioned in Black (1965).

Particle density of soil: The density bottle method (Pycnometer Method) that mentioned in Black (1965) was used to estimate the particle density of soil.

Total porosity: The total porosity was calculated mathematically by knowing the values of Bulk density and particle density of soil samples according to what was stated in Black (1965) by applying the following equation.

$$P\% = (1-(pb/ps)) \times 100 \text{ .... } (1)$$

Where;
P= Porosity (%).
Pb= Bulk density (Mg m^{-3}).
Ps= particle density (Mg m^{-3}).

Saturated hydraulic conductivity

The saturated water conductivity was measured using the fixed water column method proposed by Klute and described in Black (1965). This was done by fixing a column of water 2 cm high above the soil column and calculating the amount of water passing through the soil column for specific periods. When the volume of water coming out from the bottom of the soil column is constant over time, the saturated water conductivity of the soil was calculated by applying Darcy's law.

$$Ks = \frac{Q \times L}{A \times h \times t} \text{ .... } (2)$$

Ks = Saturated Hydraulic Conductivity (cm h^{-1}).
Q = Volume of water passing through the soil column (cm^3).
L = Length of the soil column (cm).
A = Surface area of the soil column (cm^2).
T= time (min).
h = Length of the soil column + Height of water above the column (cm).

Moisture content

The moisture content was estimated by taking the soil mass from the treatments and weighing it while it was wet and then placing it in an electric oven at a temperature of 105 degrees Celsius for 24 hours for the purpose of drying it completely and weighing it while it was dry and the moisture content was estimated as stated in Black (1965) and according to the following equation:

$$\theta m = ((Mw))/Ms \times 100 \text{ .... } (3)$$
$$Mw = (Mm-Ms) \text{ .... } (4)$$

Where;
θm = Organic matter (%).
Mw = Weight of water in the soil.
Mm = Weight of wet soil.
Ms = weight of Dry soil.

Estimating the chemical properties of the soil

PH meter: The degree of reaction was estimated in the soil extract 1:1 using a PH meter according to the method explained by Page (1982).

Electrical conductivity (EC): It was estimated in the soil extract 1:1 using a Conductivity device according to the method of Page (1982).

Organic matter content: It was estimated by the wet oxidation method according to the Black Walkely method explained in Page (1982).

Cation exchange capacity (CEC): It was determined using 1 M ammonium acetate solution at pH 7.0 (Keeney *et al*., 1982).

Carbonate minerals: Estimated using 1 molar of hydrochloric acid (HCL) and titration with sodium hydroxide using phenolphthalein reagent according to the method of Richards (1954).

Soluble ions: Sodium and potassium ions were estimated in the soil extract using a flame photometer, calcium and magnesium were estimated by titration with ferrous (Na EDTA), chloride was estimated by titration with silver nitrate (AgNO3) and using potassium chromate reagent, carbonates were estimated by titration with sulfuric acid (0.01 molar) by using phenolphthalein and bicarbonates reagent, by using methyl orange reagent according to Richards (1954), and sulfates by turbidity using barium chloride and comparison in the Spectrophotometer device according to the methods mentioned in Sparks *et al*. (2020).

Results and Discussion

Table 3, indicates a significant effect after 30 days of adding a mixture of zeolite and perlite Conditioners to sandy soil at additional levels (2.5, 5, 7.5, 10 %), which led to a gradual decrease in the average values of the Bulk density of the soil with increasing the percentage of additives, which reached (1.472, 1.394, 1.353, 1.242) Mg m^{-3} respectively, compared with the comparison coefficient 0%, which reached 1.635 Mg m^{-3} and with the levels of Conditioners added individually, which reached (1.587, 1.513, 1.485, 1.393%) Mg m^{-3} for perlite and (1.563, 1.483, 1.435, 1.376) Mg m^{-3} for zeolite for the same period.

Table 3: *Effect of adding soil Conditioners at different levels on Bulk density (Mg m^{-3}) after 30 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	1.563	1.483	1.435	1.376	1.464
Perlite	1.587	1.513	1.485	1.393	1.495
Mixed Zeolite and Perlite	1.472	1.394	1.353	1.242	1.365
L.S.D $_{0.05}$	0.024				0.012
Average	1.541	1.463	1.424	1.337	
L.S.D $_{0.05}$	0.014				
Control Average	1.630				
L.S.D $_{0.05}$	0.026				

Table 4: *Effect of adding soil Conditioner at different levels on bulk density (Mg m^{-3}) after 60 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	1.545	1.467	1.381	1.332	1.431
Perlite	1.565	1.525	1.461	1.377	1.482
Mixed Zeolite and Perlite	1.454	1.380	1.335	1.212	1.345
L.S.D $_{0.05}$	0.032				0.016
Average	1.521	1.457	1.392	1.307	
L.S.D $_{0.05}$	0.018				
Control Average	1.630				
L.S.D $_{0.05}$	0.033				

Table 4, shows that there are better differences in the decrease in Bulk density values after 60 days of adding a mixture of zeolite and perlite Conditioners to the mentioned levels, where their values reached (1.454, 1.380, 1.335, 1.212) Mg m^{-3}, compared with the comparison factor and other Conditioners added individually, where they reached (1.545, 1.467, 1.381, 1.332) Mg m^{-3} for zeolite and (1.565, 1.525, 1.461, 1.377) Mg m^{-3} for perlite and the reason for the gradual decrease in Bulk density with increasing percentage of addition of Conditioners is due to the composition of the Conditioners, which includes many gaps and channels that lead to a decrease in those values, and this is consistent with Hassan and Mahmoud (2013).

The results show that the interaction between zeolite and perlite Conditioners in a mixed form after 60 days of addition at a 10% addition level gave the highest rate of decrease in the Bulk density values of the soil by 25.87% and an average value of 1.212 Mg m^{-3}, compared with the comparison factor and with all other factors and for different levels of addition, the reason for this decrease is also due to the role of the improvers that work to organize the degraded soils and improve their structure, the porous structure of the improvers helps in improving and aerating the soil in addition to the positive effects on the physical properties of the soil , that which found by El-Kammah *et al*. (2014) and also indicated that when using a mixture of improvers and mixing them with sandy soil, it leads to a significant decrease in the Bulk density of the soil.

Table 5: *Effect of adding soil Conditioners at different levels on the total porosity of the soil (%) after 30 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	41.02	44.04	45.85	48.08	44.75
Perlite	40.11	42.91	43.96	47.43	43.60
Mixed Zeolite and Perlite	44.45	47.40	48.94	54.13	48.73
L.S.D $_{0.05}$	1.35				0.68
Average	41.86	44.78	46.25	49.88	
L.S.D $_{0.05}$	0.78				
Control Average	38.27				
L.S.D $_{0.05}$	1.37				

Table 5, shows the presence of significant differences at a significant level of 0.05 in the effect of the interaction ratios between zeolite and perlite in mixed and for all addition levels (2.5, 5, 7.5, 10 %) on the total porosity values of the soil after 30 days, as the porosity values increased with the increase in addition levels, the total porosity values of the soil reached (44.45, 47.40, 48.94, 54.13%) respectively, compared with the comparison coefficient of 38.30% and the other treatments, which reached to (41.02, 44.04, 45.85, 48.08 %) for zeolite and (40.11, 42.91, 43.96, 47.43 %) for perlite respectively, this may be due to the high porosity of zeolite and perlite on soil pore engineering and improving the soil pore system, and reducing the

Bulk density and improving soil aggregates. Ghazavi and Studies (2015) and Markoska *et al*. (2018) found that the presence of perlite in the soil increases the soil's water retention, this due to the fact that perlite has a very high porosity, so the plant can also easily access water to complete the growth process. The reason for the high porosity of minerals is attributed to the three-dimensional structure of a series of interconnected channels that give the mineral the function of partial sieving and thus work to improve the properties of the soil, Georgiev *et al*. (2009) also confirmed that zeolite is considered one of the minerals with a high capacity for ion exchange and reducing water loss from sandy soil.

Table 6: *Effect of adding soil Conditioner at different levels on the total porosity of the soil (%) after 60 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	41.70	44.64	47.89	49.74	45.99
Perlite	40.94	42.45	44.87	48.04	44.07
Mixed Zeolite and Perlite	45.13	47.92	49.62	55.26	49.48
L.S.D $_{0.05}$	1.67				0.84
Average	42.59	45.00	47.46	51.01	
L.S.D $_{0.05}$	0.97				
Control Average	38.27				
L.S.D $_{0.05}$	1.69				

Table 6, indicates a highly significant increase in the total porosity values of the soil after 60 days of adding the mixture of zeolites and perlite at different levels to the soil, as its values increased to (45.13, 47.92, 49.62, 55.26 %) respectively for the same levels compared with the comparison factor 38.30% and other treatments, where the values of the zeolite increase reached (41.7, 44.64, 47.89, 49.74%) and the values of perlite (40.94, 42.45, 44.87, 48.04 %), the results indicate that the interaction between the zeolite and perlite minerals in a mixed form after 60 days of cultivation at an addition level of 10% gave the highest percentage of increase in the total porosity values compared to all other treatments and for all other periods and levels , this was confirmed by Kheir *et al*. (2017) who founded that mixing Soil Conditioners lead to the response of the physical properties of sandy soil and the formation of high pores capable of providing the necessary ventilation and holding moisture and nutrients.

Table 7, shows the effect of adding different levels (2.5, 5, 7.5, 10 %) of zeolite and perlite alone and mixed on the moisture content of the soil, the results indicate a significant effect at a significant ($P < 0.05$) in the moisture content values after 30 days of adding the zeolite and perlite mixture, as the values increased with increasing the mixture ratio, reaching (19.28, 27.81, 36.24, 48.73 %) , where it was 13.22% in the comparison treatment and other treatments for the levels, where the values of zeolite alone reached (18.32, 25.98, 36.78, 39.58 %) respectively, which is slightly higher than the values of adding perlite to the soil, which reached (15.21, 20.58, 29.85, 36.39 %), as the highest percentage of increase was reached at the level of adding 10% of the zeolite and perlite mixture, which reached 48.73%.

Table 7: *Effect of adding soil Conditioners at different levels on soil moisture content (%) after 30 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	18.32	25.98	36.78	39.58	30.17
Perlite	15.21	20.58	29.85	36.39	25.51
Mixed Zeolite and Perlite	19.28	27.81	36.24	48.73	33.02
L.S.D $_{0.05}$	3.01				1.50
Average	17.60	24.79	34.29	41.57	
L.S.D $_{0.05}$	1.74				
Control Average	13.22				
L.S.D $_{0.05}$	2.87				

Table 8: *Effect of adding soil Conditioner at different levels on soil moisture content (%) after 60 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	19.27	27.31	40.24	44.70	32.88
Perlite	16.36	22.91	32.21	38.38	27.46
Mixed Zeolite and Perlite	21.60	29.74	38.17	51.27	35.19
L.S.D $_{0.05}$	3.53				1.77
Average	19.08	26.65	36.87	44.78	
L.S.D $_{0.05}$	2.04				
Control Average	13.22				
L.S.D $_{0.05}$	3.37				

The results in Table 8 also show that there were highly significant differences in the moisture content values of the mentioned levels after 60 days of adding the mixture. They reached an reached an average of

(21.6, 29.74, 38.17, 51.27 %) respectively compared to the comparison factor, the 10% addition level outperformed all other treatments and periods, reaching 51.27%.

The reason is that the increase in the addition levels of the added Conditioners is followed by an increase in the ready water, due to the ability of these Conditioners to absorb water in the cavities and channels entering their crystalline structure, which contributes to increasing the amount of ready water, this was confirmed by Ramesh *et al*. (2015) and Alkhateeb *et al*. (2020) found that the presence of perlite in the soil causes an increase in water retention near the root zone and increases with the increase in the addition level, as perlite works to reduce water evaporation, thus achieving the greatest increase in water storage and its availability within the soil, which increases the amount of plant production.

Alkhateeb *et al*. (2020) also mentioned that the increase in soil moisture content is also due to the decrease in Bulk density values and the increase in total porosity, which increases its ability to retain water, which is consistent with that reached by Karim *et al*. (2020).

Table 9, shows a significant effect in decreasing the saturated water conductivity values when adding the zeolite and perlite mixture at different levels (2.5, 5, 7.5, 10 %) after 30 days, as the decrease values reached (0.671, 0.478, 0.334, 0.244) cm min^{-1} respectively, compared with the comparison factor 0.82 cm.min^{-1} and other treatments, the values of the zeolite mineral added individually significantly outperformed the values of perlite, as the decrease values of zeolite reached (0.747, 0.653, 0.526, 0.352) cm min^{-1} ,and perlite (0.769, 0.668, 0.589, 0.425) respectively.

Table 10, shows that adding the mixture of zeolites and perlites had a significant effect in reducing the saturated water conductivity of the soil after 60 days, as it gave the highest percentage of decrease at the level of adding 10%, reaching 0.244 cm min^{-1} compared with the comparison factor and all other factors, the mixture of zeolites and perlite outperformed after 60 days in reducing the values of water conductivity by a small difference from 30 days after addition. The role of the decrease comes to the soil Conditioners, whose particles work on mechanical obstruction and closing the reduction of large pores, this is consistent with Abichou *et al*. (2002) and Gholizadeh-Sarabi *et al*. (2013).

Table 9: *Effect of adding soil Conditioner at different levels on the Saturated Hydraulic Conductivity of the soil (cm min^{-1}) after 30 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	0.747	0.653	0.526	0.352	0.570
Perlite	0.769	0.668	0.589	0.425	0.613
Mixed Zeolite and Perlite	0.671	0.478	0.334	0.244	0.432
L.S.D $_{0.05}$	0.062				0.031
Average	0.729	0.600	0.483	0.340	
L.S.D $_{0.05}$	0.036				
Control Average	0.820				
L.S.D $_{0.05}$	0.060				

Table 10: *Effect of adding soil Conditioner at different levels on Saturated Hydraulic Conductivity (cm min^{-1}) after 60 days.*

Treatments	Conc.%				Average
	2.5	5.0	7.5	10	
Zeolite	0.704	0.622	0.491	0.332	0.537
Perlite	0.784	0.677	0.568	0.412	0.610
Mixed Zeolite and Perlite	0.688	0.469	0.313	0.197	0.417
L.S.D $_{0.05}$	0.072				0.036
Average	0.725	0.589	0.457	0.314	
L.S.D $_{0.05}$	0.041				
Control Average	0.820				
L.S.D $_{0.05}$	0.068				

Ilahi and Ahmad (2017) indicated that adding perlite to the soil leads to improving the hydraulic properties of the soil and the reason for the decrease may be attributed to the increase in the levels of soil Conditioners, which leads to improving the soil structure and reducing the soil erosion and degradation or the occurrence of closing of pores, as Gülser and Candemir (2014) showed, the saturated water conductivity values depend on the geometry of the pore distribution and its formation.

Conclusions and Recommendations

The present study was conducted to study the positive effect of natural soil conditioners zeolite and perlite on the physical soil properties related to water movement and retention within. It was observed that adding Conditioners at a rate of 10% of the dry soil weight led to a significant increase ($P<0.05$) in the bulk density, total porosity, moisture content, and saturated hydraulic conductivity. Therefore, the study recommends adding mixed natural Conditioners of two or more types at a rate of 10% to improve the physical properties of sandy soil compared to other ratios.

Novelty Statement

The article is characterized by the fact that it fixes a real soil problem by using natural sustainable materials and environmentally friendly (Zeolite and Perlite), which are considered one of the latest methods in improving the physical properties of sandy soil.

Conflict of interest

The authors have declared no conflict of interest.

References

Abichou, T., C.H. Benson and T.B. Edil. 2002. Micro-structure and hydraulic conductivity of simulated sand-bentonite mixtures. Clays Clay Miner., 50(5), pp.537-545. https://doi.org/10.1346/000986002320679422

Alkhateeb, B.A.A.H., W.F.A. Alshamary and A.M.H. Aljumily. 2020. The role of perlite and irrigation management in water consumptive, growth and yield of potato solanium Tuberosum L. in sandy loam soil. Biochem. Cell. Arch, 19(2), pp.4063-4072.

Al-Obaidi, J.R., M. Yahya Allawi, B. Salim Al-Taie, K.H. Alobaidi, J.M. Al-Khayri, S. Abdullah and E.I. Ahmad-Kamil. 2022. The environmental, economic, and social development impact of desertification in Iraq: a review on desertification control measures and mitigation strategies. Environ. Monit. Assess., 194(6), p.440. https://doi.org/10.1007/s10661-022-10102-y

Alhammadi, M.S. and A.M. Al-Shrouf. 2013. Irrigation Of Sandy Soils, Basics and Scheduling. In Crop Production. Intechopen.

Alkhateeb, B.A.A.H., W.F.A. Alshamary and A.M.H. Aljumily. 2020. The role of perlite and irrigation management in water consumptive, growth and yield of potato solanium Tuberosum L. in sandy loam soil. Biochem. Cell. Arch., 19(2), pp.4063-4072.

Badillo-Almaraz, V., P. Trocellier and I. Dávila-Rangel. 2003. Adsorption of aqueous Zn (II) species on synthetic zeolites. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 210, pp.424-428. https://doi.org/10.1016/S0168-583X(03)01063-2

Black, C.A., 1965. Operator variation. Methods of Soil Analysis: Part 1 Physical and Mineralogical Properties, Including Statistics of Measurement and Sampling, 9, pp.50-53. https://doi.org/10.2134/agronmonogr9.1.c4

El-Kammah, M.A.M., M.G. Ali., M.A. Aboelsoud and S.A. Mashalli. 2014. Effectiveness Of Applying Natural Soil Conditioners Under Moisture Regimes on Sandy Soil Properties And Cereal Crops Production. J. Soi. Sci. Agr. Eng., 5(3), Pp.339-371. https://doi.org/10.21608/jssae.2014.49291

Evans, M.R. 2004. Ground Bovine Bone As A Perlite Alternative In Horticultural Substrates. https://doi.org/10.21273/HORTTECH.14.2.0171

Georgiev, D., B. Bogdanov., K. Angelova., I. Markovska and Y.J. Hristov. 2009. Synthetic zeolites–Structure, classification, current trends in zeolite synthesis. In Economics and society development on the base of knowledge: int. sci. conf., (Vol. 7).

Ghazavi, R., 2015. The application effects of natural ze olite on soil runoff, soil drainage and some chemical soil properties in arid land area. Int. J. Innov. Appl. Stud., 13(1), p.172.

Gholizadeh-Sarabi, S and A.R. Sepaskhah. 2013. Effect of zeolite and saline water application on saturated hydraulic conductivity and infiltration in different soil textures. Arch. Agron. Soil Sci., 59(5), pp.753-764. https://doi.org/10.1080/03650340.2012.675626

Gülser, C and F. Candemir. 2014. Using soil moisture constants and physical properties to predict saturated hydraulic conductivity. Eurasian J. Soil Sci., 3(1), pp.77-81. https://doi.org/10.18393/ejss.69966

Hassan, A.Z.A and A.W.M. Mahmoud. 2013. The combined effect of bentonite and natural zeolite on sandy soil properties and productivity of some crops. Topclass J. Agric. Res., 1(3), pp.22-28.

Ibrahim, K.H and O.A.S. Fadni. 2013. Effect of organic fertilizers application on growth, yield and quality of tomatoes in North Kordofan (sandy soil) western Sudan. Greener J. Agric. Sci., 3(4), pp.299-304. https://doi.org/10.15580/GJAS.2013.3.021813471

Ilahi, W.F.F and D. Ahmad. 2017. A study on the physical and hydraulic characteristics of cocopeat perlite mixture as a growing media in containerized plant production. Sains Malaysiana, 46(6), pp.975-980. https://doi.org/10.17576/jsm-2017-4606-17

Karim, M.R., M.A. Halim., N.V. Gale and S.C. Thomas. 2020. Biochar effects on soil physiochemical properties in degraded managed ecosystems in northeastern Bangladesh. Soil Syst., 4(4), p.69. https://doi.org/10.3390/soilsystems4040069

Keeney, D.R and D.W. Nelson. 1982. Nitrogen—inorganic forms. Methods of soil analysis: Part 2 chemical and microbiological properties, 9, pp.643-698. https://doi.org/10.2134/agronmonogr9.2.2ed.c33

Kheir, A.M.S., M.A. Bayoumi and H.M.A. Abouelsoud. 2017. Effectiveness of natural soil conditioners and irrigation regime on: 1-loamy sand soil properties, crops production and water productivity. Menoufia J. Soil Sci., 2(5), pp.227-246. https://doi.org/10.21608/mjss.2017.126760

Kranz, C.N., R.A. McLaughlin., A. Johnson., G. Miller and J.L. Heitman. 2020. The effects of compost incorporation on soil physical properties in urban soils–A concise review. J. Environ. Manage., 261, p.110209. https://doi.org/10.1016/j.jenvman.2020.110209

Markoska, V., K. Lisichkov., B. Boev and R. Gulaboski. 2018. The influence of the perlite as a substrate for improving on some water properties on the fluvial soil with an aplication of retentional curves. J. Agric. Plant Sci., 16(1), pp.73-82.

Ozores-Hampton, M., P.A. Stansly and T.P. Salame. 2011. Soil chemical, physical, and biological properties of a sandy soil subjected to long-term organic amendments. J. Sustainable Agric., 35(3), pp.243-259. https://doi.org/10.1080/10440046.2011.554289

Page, A.L. 1982. Methods of Soil Analysis. Part 2: chemical and microbial properties Am. Soc. Agron. SoilSci. Soc. Am. Inc. Madison. Wisconsin., *USA*.

Ramesh, K., A.K. Biswas and A.K. Patra. 2015. Zeolitic farming. Indian J. Agron., 60(2), pp.185-191. https://doi.org/10.59797/ija.v60i2.4453

Richards, L.A.E.d. 1954. Diagnosis and improvement of saline and alkali soils (No. 60). US Government Printing Office. https://doi.org/10.1097/00010694-195408000-00012

Sangeetha, C and P. Baskar. 2016. Zeolite and its potential uses in agriculture: A critical review. Agric. Rev., 37(2), pp.101-108. https://doi.org/10.18805/ar.v0iof.9627

Sas, S.A.S. 2001. STAT user's guide for personal computers, release 6.12. SAS Institute Inc. Cary, NC, USA.

Sparks, D.L., A.L. Page., P.A. Helmke and R.H. Loeppert. 2020. *Methods of soil analysis, part 3: Chemical methods* (Vol. 14). John Wiley & Sons.

Whiting, D.E., C.R. Wilson and A.B. Card. 2005. *Managing soil tilth: Texture, structure and pore space*. Colorado State University Cooperative Extension.