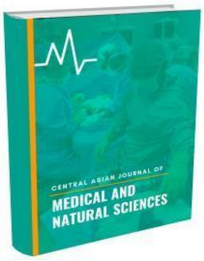

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Article

Utilizing Sodium Montmorillonite (Sodium Bentonite) for Desertification Control

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Abstract: In line with the Sustainable Development Goals, which call for the use of environmentally friendly materials to reduce pollution and achieve a balance between environmental, economic, and social dimensions, bentonite has been adopted as an effective solution to address the problem of desertification. Bentonite is a natural material known for its high water retention capacity and its ability to improve soil properties, contributing to enhanced agricultural productivity and the sustainability of natural resources, while also mitigating land degradation. This approach is part of ongoing efforts to protect the environment, ensure food security, and improve the quality of life in areas affected by desertification. This research studies the effect of adding bentonite (natural clay) rich in montmorillonite in improving the physical and water properties of the soil as an effective means to combat desertification and contribute to achieving sustainable development goals. Soil samples from Hamdaniya University were used, mixed with different percentages of bentonite (0-50%), and the following properties were evaluated: moisture, organic matter, water retention capacity, pH, electrical conductivity, and bulk density and calculate water absorbency Q_{H2O} . The results showed that the addition of bentonite led to: a significant increase in soil moisture and its ability to retain water, an improvement in the organic content and biological activity of the soil, a decrease in pH and electrical conductivity indicating a more favorable environment for plant growth, a decrease in the bulk density of the soil which enhances its aeration and reduces hardening . The water absorbency Q_{H2O} increase .The results indicated that the best effect was recorded at 50% bentonite, making this material a sustainable environmental option to improve soil in arid and semi-arid areas, supporting Agricultural production.

Keywords: Bentonite ,Sustainable Development Goals, natural clay, pollution, water absorbency.

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1. Introduction

The use of bentonite to addres desertification is one of the effective methods that contribute to achieving the sustainable development goals, because of its ability to improve soil fertilitu and water and nutrient retention, which suppory [1], [2]. Bentoniteis a natural clay called in iraq (clay khawa) and its is rich in the mineral montmorillonite, characterized by its high ability to absorb and retain water, and is used to improve soil properties, especially in dry areas threatened by desertifications (1). Improving water retentional in the soil, which reduces its loss and increases the effectiveness of irrigations [3], [4], [5]. Improve the physical properties of the soil and enchance its ability to retain nutrients. Reduce soil erosion caused by wind or water. Support agriculture in marginal and poor lands [6].

The relationship between bentonite use and sustainable development through soil improvement means better agricultural production (SDG: 2 Zero hunger), reduce water loss and increase efficiency (SDG 6 Clean water and sanitation), make soils healthy, store carbon and resist the effects of climate change (SDG 13: Climate Action). Bentonite also works to combat desertification and conserve land (SDG 15: Life on Land)(2).

The use of bentonite to combat desertification is a practical and sustainable solution that contributes to enhancing food security, protecting the environment, adapting to climate change, and is an example of the use of natural resources to achieve the sustainable development goals [7], [8].As for the sustainable development goal 15, which is the preservation of life on land, the protection and restoration of terrestrial ecosystems, sustainable forest management, and combating desertification using environmentally friendly materials, one of which is the use of bentonite, to restore the vitality and sustainability of the earth [9], [10]. Environmentally friendly materials are one of the essential elements in strategies to combat desertification, because of their ability to restore the physical, chemical and biological properties of degraded soils without negatively affecting the surrounding ecosystems. Organic matter such as compost, biocompost and clays such as bentonite, which contribute to raising the organic content of the soil, improving its structure, and increasing its cationic exchange capacity, which enhances its ability to retain water and nutrients.Natural mineral substances such as bentonite and zeolite improve the hydraulic properties of the soil, contribute to the sustainability of soil productivity and reduce the exacerbation of desertification in arid and semi-arid environments. Studies have indicated that bentonite improves the soil's ability to retain water, making it an effective substance in improving soil properties in dry areas [11].The United Nations Conference (UNCOD) defined desertification as the decrease or destruction of the earth's biological potential that ultimately leads to the formation of desert-like conditions, and then redefined it in 1991 as land degradation in arid, semi-arid and dry sub-humid areas resulting from adverse human influences [12], [13].The phenomenon of desertification, according to the belief of many people, is also caused by wind erosion of sandy grazing lands or agricultural lands(6), while others believe that desertification results only from overgrazing in pastoral lands, and some define desertification as climate change towards drought due to human and natural factors, while others define desertification as the transformation of land into unproductive desert lands, and the Rio Summit Convention or the 1992 Earth Summit defined desertification as: Land degradation in arid, semi-arid and sub-humid zones resulting from various factors, including climate change and human activities(7).Desertification affects agricultural land and pastures necessary to provide food, water and air; food production decreases, water sources dry up, and people in affected areas are forced to move to better places, that deforestation and climate change affect the ecosystem, the land, and the human being himself, and the potential effects of desertification on human health include human infection with diseases transmitted through water and food as a result of lack of clean water and low level of hygiene, in addition to cases of malnutrition resulting from lack of food and water, and diseases of the psychological system, Resulting from air pollution with dust from wind erosion and other pollutants(8).. Many arid and semi-arid areas suffer from the problem of desertification due to the continuous deterioration in soil properties [14], [15], [16]. Bentonite is characterized by its high ability to retain water and is basically a type of swollen clay with an amazing ability to absorb water, and is able to absorb up to three times its weight of water according to studies(9). This water absorption capacity makes bentonite an ideal choice for water absorption applications. However, the benefits are not limited to its ability to absorb water [17], [18]. It also has other beneficial properties, such as ion exchange and environmental compatibility, which are important and beneficial for different industries(10). Bentonite powder is a very fine clay composed primarily of mont morelonite, an aqueous aluminum silicate and a member of the smectite group. Most bentonite is formed by changing volcanic ash and rock after intense contact with water. Bentonite has strong colloidal properties, causing it to increase in volume several times upon contact with water creating a gel and viscous(11). .Its unique properties (swelling, water absorption and viscosity) make it applicable in a wide range of industries, ranging from water purification to steel, electricity and food industries.Interestingly, the use of bentonite dates back to 5000 BC, when it was used in Cyprus to wash and thicken woolen fabrics(12). A hundred years ago, specialists discovered that this product is also useful for decolorizing or whitening plant, animal and petroleum oils. After examining its properties closely, they realized its amazing capabilities and applications(13).Bentonite is divided into two types: sodium and calcium. Sodium bentonite is known for its ability to absorb and retain large amounts of water and its ability to swell(14). In comparison, calcium bentonite has limited swelling, which is why industries prefer to use sodium bentonite [19], [20].The production process of bentonite powder involves several stages to convert raw bentonite rock into refined and packaged bentonite powder. The following is a brief overview of these steps(15).

1. Bentonite ore extraction: Bentonite is extracted from mines in ore form. Countries with the largest bentonite deposits include the United States, China, India, Turkey, Iran and Iraq
2. crushing and purification: bentonite ore is crushed into smaller pieces and then ground into powder. During this phase, larger impurities such as rocks and other minerals are removed from bentonite.
3. Activation: Bentonite can be activated by using chemicals such as acid or caustic soda to enhance its properties. Activation increases the surface area and ion exchange capacity of bentonite, which is essential for many of its applications .
4. Drying: The moisture content of bentonite is carefully controlled during this stage to ensure that the quality of the final product is not affected
5. Grinding and grading: Bentonite powder is ground to the desired size. The size of bentonite molecules varies depending on its application. For example, bentonite used in drilling oil wells needs to be much finer than bentonite used in casting. After grinding, bentonite powder is classified based on particle size and intended use
6. Packaging: After the production and classification process is completed, bentonite powder is packed in paper bags or large bags.

The objective of this study is to evaluate the effect of bentonite supplementation on the physical and water properties of the soil and determine the optimal percentage of bentonite to improve field capacity and reduce permeability and thus address the phenomenon of desertification.

2. Materials and Methods

2.1 Water absorbency method (Q_{H2O})

We take (gm6) of dry soil, which contains different amounts of bentonite and put it in (ml500) of distilled water at room temperature and for a period of (24hour) to reach the state of swelling.

Table 1: Shows the values of m_2, m_1, m_0 in grams

We work to separate the model swollen with water from the other that did not absorb water by filtration [21]. The following equation is applied to calculate water absorbency QH2O(16):

The values of m_0, m_1, and m_2 used in the calculation of water absorbency (QH_2O) are presented in Table 1.

$$Q_{H_2O} = \frac{m_1 - m_2}{m_1 - m_0} = \frac{m_2 - m_1}{m_1 - m_0}$$

Where:-

m_0 = weights of clay in the sample (gm).

m_1 = dry soil sample (6gm).

m_2 = swollen sample.

Table 1. shows the values of m2m_2m2, m1m_1m1, m0m_0m0 in grams for the water absorbency tests.

No.	Weight of clay in the sample, m_0 (gm) bentonite	Dry soil sample, m_1 (gm)	Swollen sample, m_2 (gm)
1	0	6	6020
2	0.05	6	6127
3	0.10	6	6144
4	0.15	6	6215
5	0.20	6	6260
6	0.25	6	5957
7	0.30	6	5642

The calculated water absorbency (QH_2O) values based on bentonite concentration are summarized in Table 2.

Table 2. Shows the values of aqueous absorption Q_{H2O} according to the weight quantities used for bentonite

Weight of) bentonite in the sample (gm)	Q_{H2O} g.g $^{-1}$
0	0
0.05	1028.7
0.10	1040.3
0.15	1061.4
0.20	1078.3
0.25	1034.9
0.30	988.7

Figure 1. Shows the relationship between Q_{H2O} and the amount of bentonite added (wt%)

As shown in Figure 1, there is a clear relationship between QH_2O and the amount of bentonite added.

1. Soil: taken from one of the areas within the University of Hamdaniya and the amount used is 3 kg divided into 6 samples each soil sample is estimated at 500 g (half a kilo)
2. Bentonite: a control sample containing 0% bentonite and samples in the following proportions 5%, 10%, 15%, 20%, 25%, 50%(

2.2 Other tests: The soil is taken from one of the areas within the University of Hamdaniya and the amount used is 3 kg divided into 6 samples each soil sample is estimated at 500 g (half a kilo). Bentonite: A control sample containing 0% bentonite and samples in the following proportions 5,10%, 15%, 20,25%, 50%

2.2.1 Soil moisture (%) Weight of a wet soil sample

Dry the sample in an oven with a temperature of 105 ° C for 24 hours. Dry sample weight. Calculation of humidity in the ratio of the difference in weight to dry weight(17).

2.2.2 Organic matter (%) Loss on ignition:

1. The weight of a dry sample of soil.
2. Burn the sample in an oven at 550 ° C for 4 hours.

Calculate the difference in weight as the ratio of organic matter(18).

2.2.3 Water retention capacity (%) Measurement of water trapped in soil after saturation and partial drying under a specified pressure using a water retention capacity measuring device(19).

2.2.4 pH mix an equal amount of soil and distilled water (1:1 by weight). Measure pH by using a pH meter(20)

2.2.5 Electrical conductivity (EC)

Preparation of a solution of soil and water mixture 1:5 Measuring electrical conductivity using an EC meter(21)

2.2.6 Bulk density: Taking a known volume of soil using a cylinder. The weight of dry soil inside the drum. Calculate density by dividing weight by volume(22).

3. Results

Table 3 illustrates the soil property changes before and after the addition of 50% bentonite.

Table 3. The relationship between soil properties before and after adding bentonite (50%)

Values after adding bentonite	Values before adding bentonite	properties	Bentonite concentration %
17.5	8.5	Soil moisture%	50
1.3	0.4	(%)organic materials	50
32	12	(%)water holding capacity	50
7.1	7.8	(pH)	50
0.42	0.6	Electrical conductivity(dS/m)	50
1.35	1.65	Bulk density (g/cm^3)	

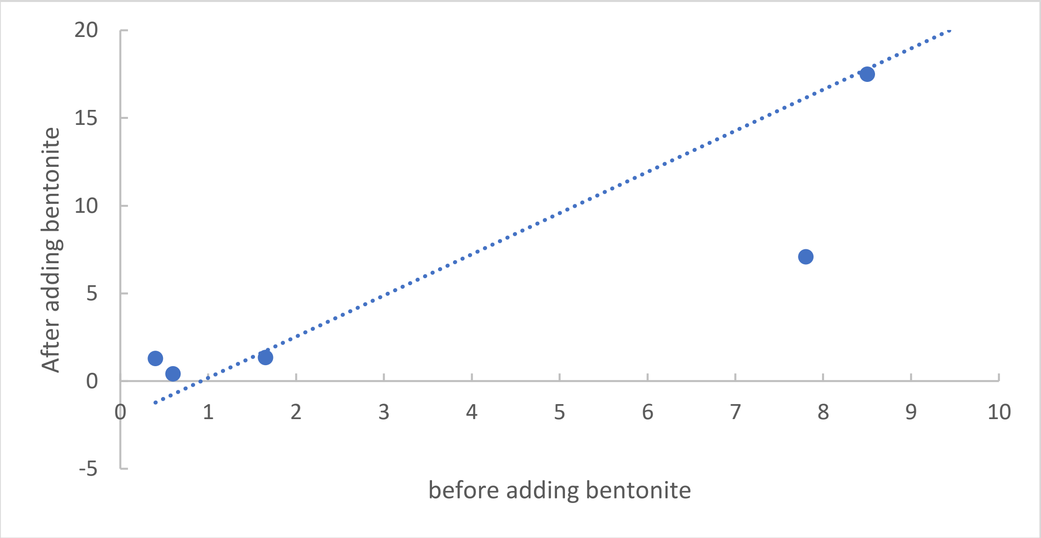

Figure 1.The relationship between soil properties before and after adding bentonite (50%)

As shown in Figure 1, there is a clear relationship between QH_2O and the amount of bentonite added.

The effect of 25% bentonite addition on various soil properties is detailed in Table 4."

Table 4. The relationship between soil properties before and after adding bentonite (25%)

Values after adding bentonite	Values before adding bentonite	properties	Bentonite concentration %
16.0	8.5	Soil moisture%	25
1.1	0.4	(%)organic materials	25
28	12	(%)water holding capacity	25
7.2	7.8	(pH)	25
0.45	0.6	Electrical conductivity(dS/m)	25

1.40	1.65	Bulk density (g/cm³)	25

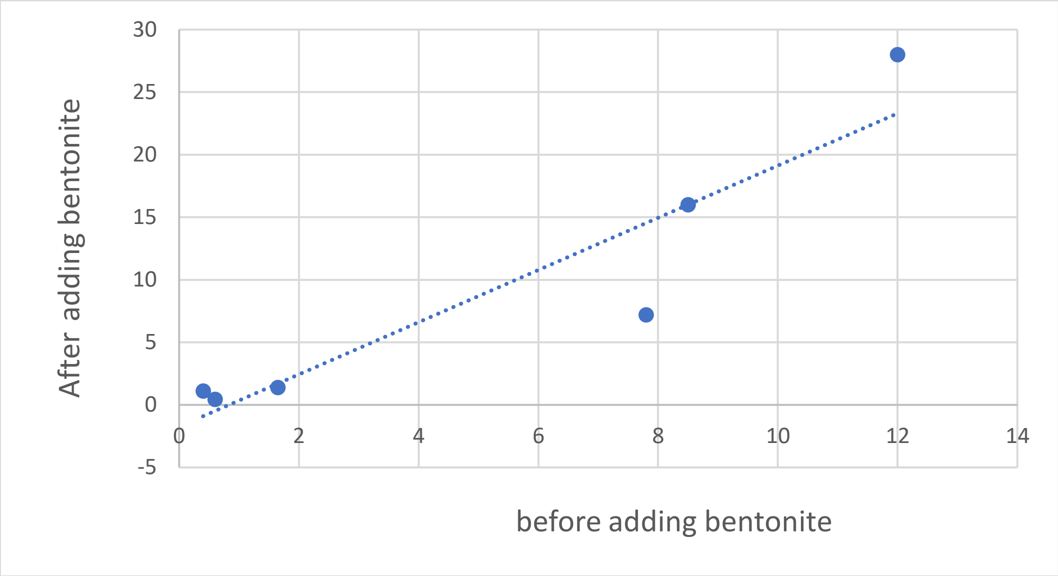

Figure 2.The relationship between soil properties before and after adding bentonite (25%)

The changes in soil properties after adding 50% bentonite are visually demonstrated in Figure 2.

Table 5 shows the comparative values of soil properties with and without 20% bentonite treatment"

Table 5. The relationship between soil properties before and after adding bentonite (20%)

Values after adding bentonite	Values before adding bentonite	properties	Bentonite concentration %
15.5	8.5	Soil moisture%	20
1.05	0.4	(%)organic materials	20
26	12	(%)water holding capacity	20
7.25	7.8	(pH)	20
0.46	0.6	Electrical conductivity(dS/m)	20
1.42	1.65	Bulk density (g/cm³)	20

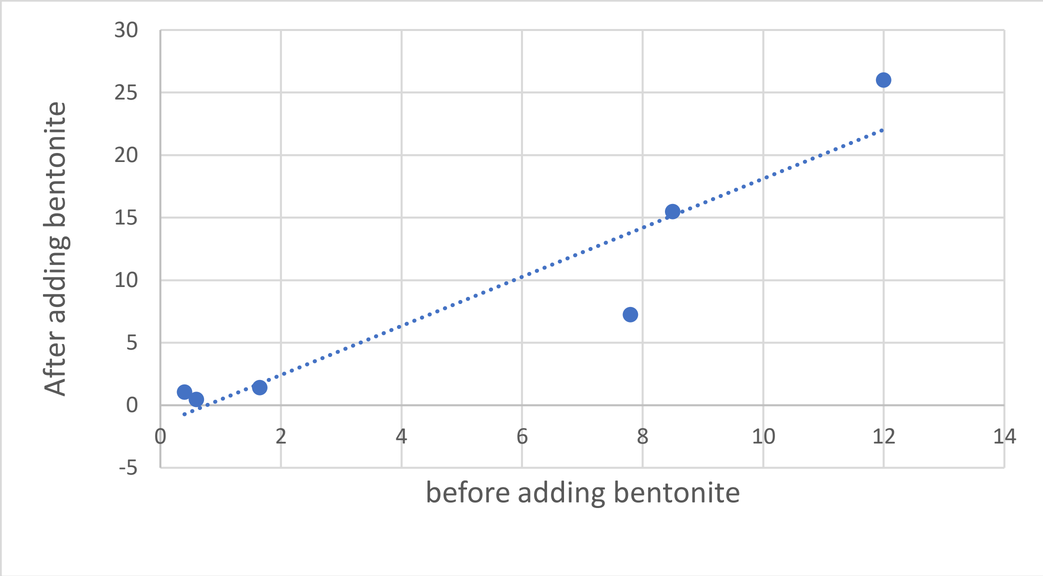

Figure 3.The relationship between soil properties before and after adding bentonite (20%)

Figure 3 represents the changes in soil characteristics following 25% bentonite incorporation.

Table 6. The relationship between soil properties before and after adding bentonite (15%)

Values after adding bentonite	Values before adding bentonite	properties	Bentonite concentration %
14.7	8.5	Soil moisture%	15
0.95	0.4	(%)organic materials	15
24	12	(%)water holding capacity	15
7.3	7.8	(pH)	15
0.47	0.6	Electrical conductivity(dS/m)	15
1.44			
	1.65	Bulk density (g/cm³)	15

Changes in physical soil characteristics after 15% bentonite amendment are presented in Table 6.

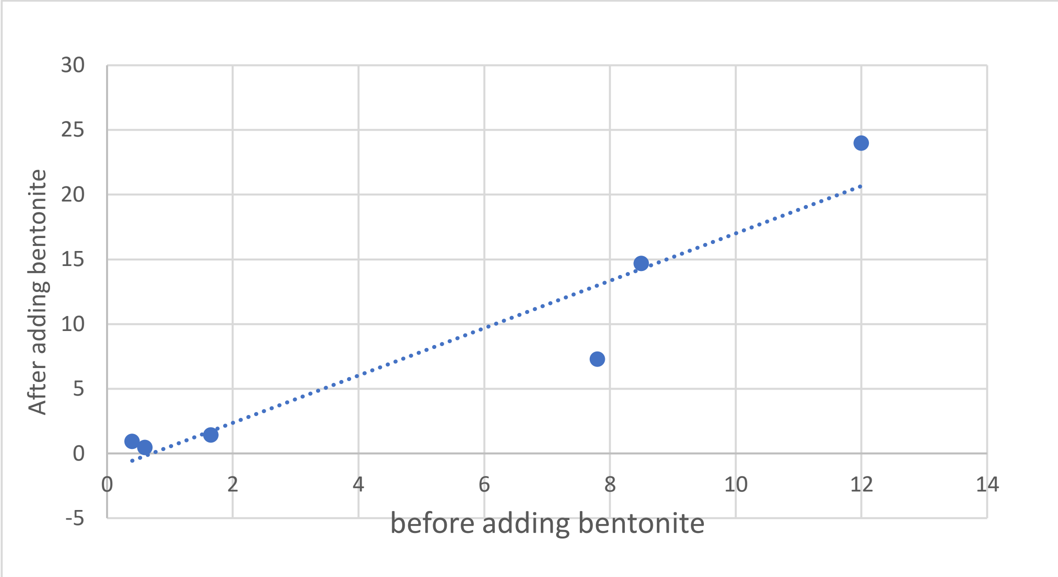

Figure 6. The relationship between soil properties before and after adding bentonite (15%)
Figure 6 highlights the relationship between soil improvement and 20% bentonite addition.

Table 7. The relationship between soil properties before and after adding bentonite (10%)

Values after adding bentonite	Values before adding bentonite	properties	Bentonite concentration %
13.8	8.5	Soil moisture%	10
0.85	0.4	(%)organic materials	10
21	12	(%)water holding capacity	10
7.4	7.8	(pH)	10
0.49	0.6	Electrical conductivity(dS/m)	10
1.48	1.65	Bulk density (g/cm³)	10

Table 7. reflects the effect of applying 10% bentonite on soil moisture, pH, and other parameters.

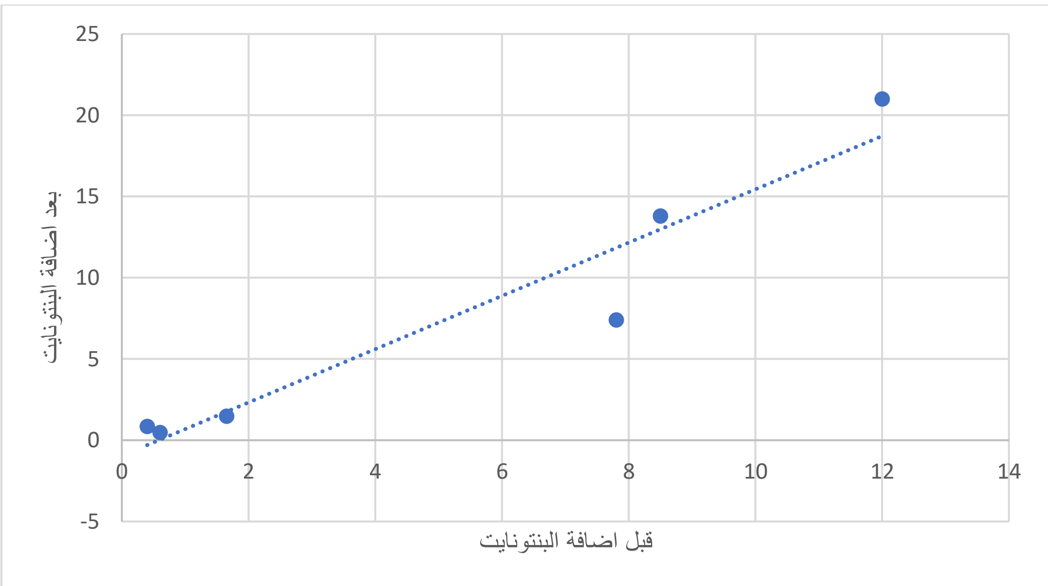

Figure 7. The relationship between soil properties before and after adding bentonite (10%)
Figure 7 provides a visual representation of the impact of 15% bentonite on soil properties.

Table 8. The relationship between soil properties before and after adding bentonite (5%)

Values after adding bentonite	Values before adding bentonite	properties	Bentonite concentration %
12.3	8.5	Soil moisture%	5
0.7	0.4	(%)organic materials	5
18	12	(%)water holding capacity	5
7.5	7.8	(pH)	5
0.52	0.6	Electrical conductivity(dS/m)	5
1.55	1.65	Bulk density (g/cm³)	5

The influence of 5% bentonite on basic soil indicators is presented in Table 8.

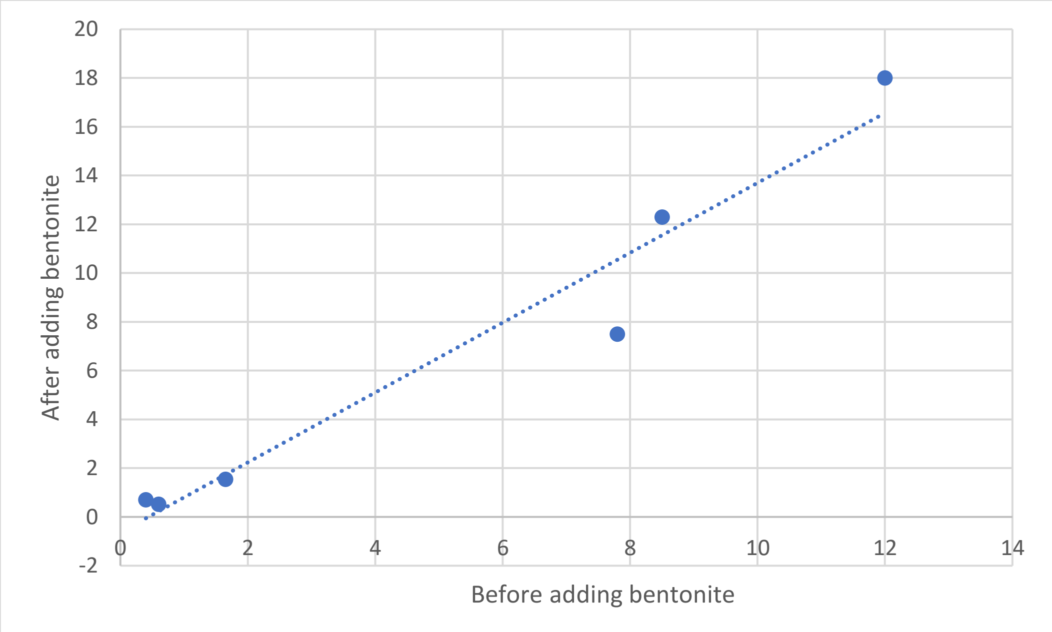

Figure 6. The relationship between soil properties before and after adding bentonite (5%)

4. Conclusion

4-Analysis of results

Soil moisture increases soil moisture with increasing bentonite concentration, which indicates an impressive improvement in the soil's ability to retain water Organic matter Organic matter increases with increased bentonite, indicating improved biological activity in the soil. Water retention capacity The ability significantly improves as the concentration of bentonite increases, making the soil more capable of storing water. pH tends slightly towards neutrality, improving the growing environment of plants. Electrical conductivity Electrical conductivity decreases with increased bentonite, indicating improved soil quality and reduced salinity. Bulk density The bulk density decreases which improves soil aeration and reduces soil compaction.

5. Recommendations

It is recommended to use bentonite bay% as it is useful, but the best percentages are 50% to improve the soil. - The need to mix bentonite with soil in a homogeneous way to achieve better results. - Monitor EC values periodically to avoid long-term accumulation of salts. - Apply this experiment in green spaces and follow up the performance of the plant. - Expanding the use of bentonite in other areas affected by desertification inside and outside the university.

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