

Impact of adding zeolite and used engine oil on some physicochemical properties of sandy Loam soil

Wisam Hasan^{1*}, Israa AbdAllah¹, Hussein Nayyef²

¹University of Basrah, Basra, Iraq

²Southern Technical University, Basra, Iraq

*Corresponding author, e-mail: wisam.hasan@uobasrah.edu.iq

Abstract

This study hypothesized that adding soil amendments represented by different levels of zeolite and used engine oil would improve the physical and chemical properties of mixed sandy textured soil. The experiment was conducted to study the effect of adding different levels of zeolite and used engine oil on some physical and chemical properties of mixed sandy soil, using three levels of zeolite amendment (0 without addition (Z_0), 1% (Z_1), and 1.5% (Z_2)), and three levels of used engine oil (0 without addition (F_0), 0.2% (F_1), and 0.4% (F_2)). There was a significant increase in the pw values for zeolite levels Z_1 and Z_2 with a percentage increase of 18.86 and 10.86% compared to the no-add treatment (Z_0), respectively. The bulk density values also decreased significantly by 1.77 and 2.81% for zeolite levels Z_1 and Z_2 compared with the control treatment Z_0 , and this characteristic also decreased by 13.79 and 19.49% for treatments F_1 and F_2 compared with the control treatment F_0 . These results indicate that the use of amendments such as zeolite and used engine oil can improve the structure of sandy textured soils, form soil aggregates, and enhance water conservation and prevent water loss in the shortest period of time, making it an effective solution in terms of wasting irrigation water in these soils, reducing the number of irrigations, and thus lowering the cost.

Keywords: bulk density, electrical conductivity, sandy soil, used engine oil, zeolite

Introduction

Sandy soils suffer from deterioration in their physical and chemical properties such as low moisture storage capacity, high salinity, and dependence on saline groundwater for plant irrigation, which causes a deterioration in their fertility and productivity, which prevents the plant from growing normally (Mohsen, 2000; Nayyef et al., 2025). Therefore, many attempts have been made to find appropriate solutions and different techniques to improve these properties. The use of soil Enhancers is one of the technologies used in the management of sandy soils. Shinde et al., (2019) classified soil Enhancers on two bases: based on the origin of these materials into synthetic or natural improvers and based on their composition into organic or inorganic improvers.

The addition of these materials of various types works to increase moisture retention in the soil, improve its structure, reduce the soil's resistance to compression,

and increase its aeration, which positively reflects on increasing biological activity, thus encouraging plant growth and productivity. Zeolite is one of the natural inorganic soil improvers used to improve the physical and chemical properties of soil, especially in sandy soils. This is due to the nature of its open structural composition, which consists of ring chains of tetrahedra connected to each other by oxygen atoms, in which water enters the composition (Litaor et al., 2017; Ravali et al., 2020). The structural composition of zeolite mineral gives it distinctive properties represented by the abundance of channels and gaps, which results in a decrease in its apparent density and an increase in its porosity by up to 50% of its volume, which allows positive ions and water molecules to easily enter the structural structure of the mineral (Sangeetha & Baskar, 2016), and thus increases the water storage capacity by up to 60% of its weight, which ensures a permanent storage of water that can be

ready in periods of drought and increases the speed of rehydration as well as improving the lateral movement of water towards plant roots (Polat *et al.*, 2004; Nozari *et al.*, 2008). Ravali *et al.*, (2020) and Al-Asadi *et al.*, (2023) found that adding zeolite significantly reduced the Bulk density values of the soil, as the treatment of adding zeolite at a rate of 7.5 tons per hectare recorded the lowest Bulk density of 0.97 g cm^{-3} , and this treatment also significantly improved the soil's water retention capacity by 48.54%.

One of the important agricultural applications of zeolite is its high efficiency in removing ions that cause salinization from different media such as soil and water, as its addition to sandy soil effectively reduces salinity stress and improves the balance of nutrients in the soil. Many studies have found that adding zeolite leads to reducing the electrical conductivity values of the soil and increases the efficiency of water use by increasing the soil's water retention and improving its fertility, which is positively reflected in the growth and production of agricultural crops (Ok *et al.*, 2003; Noori *et al.*, 2006; Al-Busaidi *et al.*, 2008). Hasin *et al.*, (2021) found that adding zeolite at levels of 5 and 10 tons ha^{-1} reduced the salinity of sandy soil irrigated with saline water to 2.12 and 4.65 dS m^{-1} compared to the non-addition treatment. On the other hand, the use of petroleum derivatives of various types and at low concentrations is one of the methods used to improve the physical properties of soil, as it increases in Soil capability for saving and available water and, which contributed to increase the interval time between irrigation periods and reduce the quantity of irrigation water (Hasan *et al.*, 2020; Nayyef & Al-Laghawi 2024).

Petroleum derivatives also work on reducing the effect of surface runoff and erosion processes suffered by

sandy soil. Also, organic clay complexes may form that completely or partially cover soil aggregates with water-repellent surfaces, which increases the angle of contact with water to more than 90 degrees and reduces the movement of water by capillary action (Al-Dabbagh *et al.*, 2010; Hussein *et al.*, 2020). Al-Bayati and Al-Zubaidi (2008) found that adding used car oil to sandy soil at a rate of 0.5, 1, and 2% led to a reduction in the apparent density values of the soil by 4.8, 7.6, and 11.0% compared to the treatment without addition. The researcher also found a decrease in the values of soil resistance to penetration, an improvement in soil structure, and an increase in moisture content.

This experiment was carried out to address some problems of sandy soil through:

- 1 - Studying the effect of both zeolite improver and used engine oil on some physical and chemical soil properties represented by moisture and salt content, bulk density and soil penetration resistance.
- 2 - Studying the Interfering effect of these treatments and determining the most efficient in increasing moisture retention and improving the properties of the soil under study.

Materials and Methods

Sandy-textured soil samples were brought from Al-Zubair area in Basra Governorate. After air drying the samples, they were passed through a sieve with 4 mm holes and packed in 3 kg plastic pots, where the experimental treatments were distributed and prepared for the purpose of implementing the agricultural experiment. A part of the samples was also passed through a 2 mm

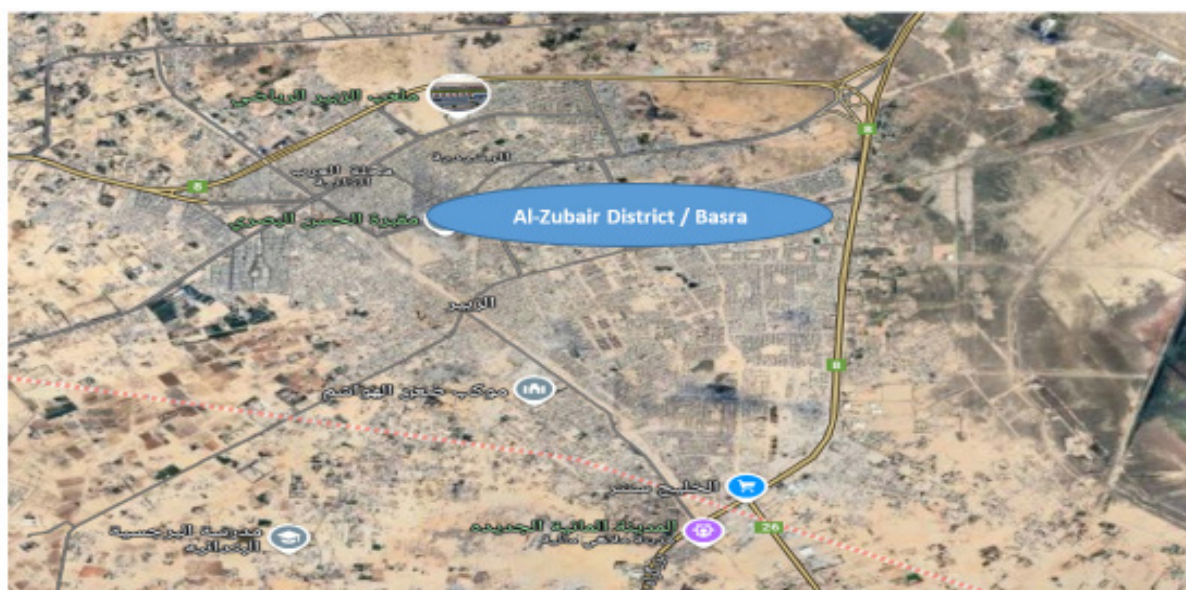


Figure 1. Geographic location of the study area.

sieve to conduct some of the required initial physical and chemical analyses, as shown in **Tables 1** and **2**.

The methods mentioned in Black et al., (1965) were used to estimate the physical properties of the initial soil and other properties in the experiment such as moisture, apparent and true soil density, soil porosity and texture. The soil resistance to penetration was measured using a pocket cone penetrometer by applying continuous pressure to the device perpendicular to the soil surface in the anvils, while recording the device reading from the indicator in kilo newton per square meter. The dissolved cations and anions and the electrical conductivity values of the soil were measured in a 1:1 extract, while the degree of soil reaction (pH) was measured in a 1:1 soil: water suspension using a pH-meter, and each of them was measured according to the methods mentioned in Page et al., (1982).

percentage increase of 18.86 and 10.86 for both levels Z_1 and Z_2 compared to the treatment without addition Z_0 , respectively. This is due to the structural composition of the added zeolite, its high porosity, and its high ability to retain moisture at a rate of up to half its weight, which ensures a permanent water storage that can be ready in dry periods and encourages rapid rehydration. This has been confirmed by many studies (Polat et al., 2004, Nozari et al., 2008, Ghazavi, 2015, Ravali et al., 2020).

As for the effect of the used engine oil addition factor, the results in Table (3) showed that the two used engine oil addition treatments were significantly superior in increasing the pw values, with a percentage increase of 10.04 and 8.35% for both levels F1 and F2 compared to the comparison treatment F0, respectively. This is due to the role of petroleum additives added to the soil in coating the surfaces of soil particles and aggregates, increasing

Table 1. Some initial physical properties of the experimental soil

Soil properties	pw sat.	pw f.c	sand	loam	clay	texture	real density	bulk density	porosity
value	31.55	19.45	837	105	58	Sandy loam	2.63	1.61	38.78
Unity	%		g kg ⁻¹ soil				Mg m ⁻³		%

Table 2. Some initial chemical properties of the experimental soil

Soil properties	pH 1:1	EC	ca ⁺²	Mg ⁺²	Na ⁺¹	HCO ₃ ⁻¹	CO ₃ ⁻²	CL ⁻¹	SO ₄ ⁻²
value	8.12	7.32	16.8	8.15	27.24	3.49	0	51	24.6
Unity	--	dS m ⁻¹	mmol L ⁻¹						

Experimental Treatments

The experiment included the following experimental treatments (zeolite improver at three levels: (Z_0) without addition, (Z_1) at 1% level, and (Z_2) at 1.5% level)]. The second improver was used engine oil at three levels [(F_0) without addition, (F_2) at 0.2% level, (F_4) at 0.4% level)]. The addition levels were calculated on the basis of the dry weight of the soil with three replicates (R) for each treatment. The completely randomized design R.C.B.D. was used to analyze the results of the experiment. The treatments were randomly distributed on the anvils and were coded as follows **Table 3**.

soil granularity, and changing the distribution of pores between and within soil aggregates, thus increasing its ability to hold water (Hesham and Abdul-Jabbar, 2013; Yu et al., 2015; Hasan et al., 2019). As for the two-way interaction between the experimental treatments, there were no significant differences between the treatments.

The effect of the experimental parameters and their interactions on the bulk density of the soil (ρ_b).

The results in **Table 5** showed that the two zeolite treatments significantly outperformed in reducing the values of ρ_b , with a percentage decrease of 1.77 and

Table 3. Treatment combinations and application levels of zeolite and used engine oil in soil.

$Z_0F_0R_1$	$Z_0F_0R_2$	$Z_0F_0R_3$	$Z_0F_2R_1$	$Z_0F_2R_2$	$Z_0F_2R_3$	$Z_0F_4R_1$	$Z_0F_4R_2$	$Z_0F_4R_3$
$Z_1F_0R_1$	$Z_1F_0R_2$	$Z_1F_0R_3$	$Z_1F_2R_1$	$Z_1F_2R_2$	$Z_1F_2R_3$	$Z_1F_4R_1$	$Z_1F_4R_2$	$Z_1F_4R_3$
$Z_2F_0R_1$	$Z_2F_0R_2$	$Z_2F_0R_3$	$Z_2F_2R_1$	$Z_2F_2R_2$	$Z_2F_2R_3$	$Z_2F_4R_1$	$Z_2F_4R_2$	$Z_2F_4R_3$

Results and discussion

Effect of experimental parameters and their interactions on soil moisture content (pw).

The results in **Table 4** showed that the two zeolite treatments significantly increased the pw values, with a

2.81% for both levels Z_1 and Z_2 compared to the comparison treatment Z_0 , respectively. This is due to the high porosity and many cavities of the zeolite mineral resulting from its structural composition, thus reducing the apparent density (Georgiev, 2009). Ravali et al., (2020) found that

Table 4. Effect of experimental treatment and their interactions on water content values (%)

Fuel Zeolite	F ₀	F ₁	F ₂	Ave. zeolite
Z ₀	11.357	12.308	12.859	12.175
Z ₁	13.586	14.871	14.958	14.472
Z ₂	12.882	14.445	13.168	13.498
Ave. Fuel	12.608	13.875	13.662	
RLSD _{0.05}	Zeolite	Fuel	Z*F	
	0.39	0.42	N.S	

Table 5. Effect of experimental treatment and their interactions on soil bulk density values (Mg m⁻³).

Fuel Zeolite	F ₀	F ₁	F ₂	Ave. zeolite
Z ₀	1.625	1.620	1.578	1.608
Z ₁	1.604	1.573	1.562	1.580
Z ₂	1.599	1.552	1.542	1.564
Ave. Fuel	1.609	1.582	1.561	
RLSD _{0.05}	Zeolite	Fuel	Z*F	
	0.001	0.001	N.S	

adding zeolite led to a reduction in the apparent density of the soil from 1.15 in the non-addition treatment to 0.98 Mg m⁻³ in the addition treatment at a rate of 7.5 t ha⁻¹.

As for the effect of used engine oil on the bulk density values of the soil, the results in Table (4) showed that the two treatments of adding used car oil were significantly superior in reducing the values of *pb*, with a percentage of decrease of 13.79 and 19.49% for both levels F₁ and F₂ compared to the comparison treatment F₀, respectively. This is due to the role of the added oil in enveloping the soil particles with non-hydrophilic materials that contributed to preserving the soil structure and increased the formation of aggregates and increased the porosity of the soil, thus reducing the apparent density values of the soil (Al-Zubaidi and Al-Bayati, 2008). This was confirmed by Hassan (2007), who found that mixing used engine oil with the soil after two months of addition led to a decrease in the apparent density values from 1.38 Mg m⁻³ in the comparison treatment to 1.23 Mg m⁻³ for the addition treatment. As for the two-way interaction between the experimental treatments, there were no significant differences between the treatments.

Effect of experimental parameters and their interactions on soil penetration resistance (PR)

The results in Table 6 show that the two zeolite treatments significantly outperformed in increasing the PR values, with a percentage increase of 39.5% and 50 % for both addition treatments Z₁ and Z₂ compared Z₀ to treatment, respectively. This is due to the role of the added improvers in binding soil particles together and increasing their stability, and that increasing the added

concentration works to increase the closure of the pores between the particles and increase their resistance to penetration (Raja, 2020).

On the other hand, the results in Table 5 showed a decrease in the PR values for the two treatments of adding used engine oil, with a percentage decrease of 24.01% and 36.75% for both levels F₁ and F₂ compared to the treatment of no addition F₀. This is due to the effect of the added oil and its role in lubricating soil particles and facilitating the penetration of the auger device into the soil (Hassan, 2019; Nayyef, 2021). There were no significant differences in the interactions of the treatments.

Effect of experimental parameters and their interactions on soil electrical conductivity (EC)

The results in Table 7 show that the two zeolite treatments significantly outperformed in reducing the EC values, with a percentage decrease of 9.12% and 14.07% for both levels Z₁ and Z₂ compared to Z₀ treatment, respectively. This is due to the role of the added zeolite in increasing the moisture content values (Table 3), which causes a dilution of the salt concentration and a decrease in its percentage compared to the comparison of the no-added treatments (Hasin et al., 2021). Hasan et al., (2019) observed a highly significant correlation between the increase in moisture content and the decrease in electrical conductivity.

There were also significant effects of the used engine oil factor on the electrical conductivity (EC) values of the soil after 24 hours of irrigation at the end of the experiment. The values decreased significantly by a percentage of decrease of 13.79% and 24.21 % for both

Table 6. Effect of experimental treatment and their interactions on soil penetration resistance values (Mg m⁻³)

Fuel Zeolite	F ₀	F ₁	F ₂	Ave. zeolite
Z ₀	127.486	78.453	63.743	135.11
Z ₁	138.928	120.131	116.045	122.86
Z ₂	147.100	134.841	122.583	123.95
Ave. Fuel	137.02	125.03	119.86	
RLSD _{0.05}	Zeolite	Fuel	Z*F	
	3.84	3.67	N.S	

Table 7. Effect of experimental treatment and their interactions on soil EC values (dS m⁻¹)

Fuel Zeolite	F ₀	F ₁	F ₂	Ave. zeolite
Z ₀	5.400	4.377	4.233	4.670
Z ₁	4.600	4.200	3.933	4.244
Z ₂	4.450	4.123	3.467	4.013
Ave. Fuel	4.817	4.233	3.878	
RLSD _{0.05}	Zeolite	Fuel	Z*F	
	0.178	0.173	N.S	

addition levels F_1 and F_2 compared to the non-addition treatment F_0 , respectively, as shown in Table 6. This was confirmed by Al-Bayati and Al-Zubaidi (2008), that adding used engine oil to a sandy mixture soil led to a reduction in soil salinity by 8.4% compared to the non-addition treatment. As for the two-way interaction between the experimental treatments, there were no significant differences between the treatments.

Effect of experimental treatments and their interactions on soil pH

There were no significant effects of adding zeolite on the soil pH values **Table 8**. These results are consistent with Ghazavi (2015), who found no significant differences in the soil pH values between zeolite addition treatments at rates of 10 and 20% compared to no addition treatments. While there were significant differences between the treatments of the used engine oil, we note from Table (7) a slight decrease in the values of the soil reaction degree for both F_1 and F_2 compared to the treatment of no addition F_0 , and this may be due to the high organizational capacity of Iraqi soils due to their high content of calcium carbonate. This is consistent with (Kisic et al., 2009), where it was found that adding petroleum derivatives led to a decrease in the acidity of the soil. There were no significant differences in the two-way interaction of the experimental treatments in pH values.

Table 8. Effect of experimental treatment and their interactions on soil pH values.

Fuel Zeolite	F_0	F_1	F_2	Ave. zeolite
Z_0	8.377	8.200	8.203	8.260
Z_1	8.360	8.327	8.305	8.331
Z_2	8.357	8.340	8.180	8.292
Ave. Fuel	8.364	8.289	8.229	
RLSD _{0.05}	Zeolite	Fuel	Z*F	
	N.S	0.003	N.S	

Conclusions

- There are positive effects of adding both the zeolite improver and the used engine oil on the moisture content and electrical conductivity values of the soil. When comparing the effect of the levels of each on the values of these two characteristics, it was noted that the percentage of increase in the moisture content values was close between the zeolite improver by 1% (Z_1) and the second level of the used engine oil (F_2). However, the F_2 level is better in reducing the electrical conductivity values, so it is preferable to use this level under the experimental conditions.

- Although there were no significant differences

in the electrical conductivity values of the zeolite and engine oil treatments, the lowest values were 3.467 dSm⁻¹ in the Z_2F_2 treatment, which were the lowest values even when using both types of improvers (zeolite and engine oil) individually, which encourages the use of mixing treatments between these two levels of improvers in order to obtain positive results.

- A positive role was found for soil improvers used in improving the physical and chemical properties of the soil, represented by increasing the moisture content, reducing the values of the apparent soil density, its resistance to penetration, its resistance to penetration, and reducing the values of electrical conductivity.

References

- Al-Asadi, R.A., Nayyef, H.R., Hameed, H.S. 2023. Study of the effect of drainage and the distance between drippers on soil construction. IOP Conference Series: Earth and Environmental Science 1225: 012003.
- Al-Bayati, A.H., Al-Zubaidi, N.A. 2008. The effect of adding used car oil on some soil properties and the growth of wheat (*Triticum sativum* L.). Diyala Journal for Scientific and Educational Research 29: 10-2.
- Al-Busaidi, A., Yamamoto, T., Inoue, M., Eneji, A., Mori, Y., Irshad, M. 2008. Effects of Zeolite on Soil Nutrients and Growth of Barley Following Irrigation with Saline Water. Journal of Plant Nutrition - Journal of Plant Nutrition. 31. 1159-1173.
- Al-Dabbagh, A.A., Abdul-Wahab, A.A., Saad, A.H. 2010. The effect of adding fuel oil on some physical properties of soil and the growth and yield of yellow corn (*Zea mays* L.). Anbar Journal of Agricultural Sciences 9:33.
- Black, C.A., Evans, D.D., White, J.L., Ensminger, L.E., Clark, F.E. 1965. Methods of soil analysis. Part 1. Agronomy No. 9. American Society of Agronomy, Madison, Wisconsin, USA.
- Deshner, M.A. 2000. Response of tomato plant to super phosphate fertilizer applied through drip irrigation system in desert soils. (MSc Thesis) – College of Agriculture, University of Basrah, Basrah, Iraq. [In Arabic].
- Eedan ,H.A. 2007. The effect of using some petroleum products on the moisture content and salinity of gypsum soil. Journal of the University of Babylon - Sciences – v. 14:
- El-Khatib, H.B., Sobhi, A.M. 2013. The effect of fuel oil and the Champlain plant on some water functions of gypsum soil. Anbar Journal of Agricultural Sciences 11:287.
- Georgiev, D., Bogdanov, B., Angelova, K., Markovska, I., Hristov, Y. 2009. Synthetic Zeolites-Structure, Classification, Current Trends in Zeolite Synthesis. International Science Conference 1-5
- Ghazavi, R. 2015. The application effects of natural zeolite on soil runoff, soil drainage and some chemical soil properties in arid land area. International Journal of Innovation and Applied Studies 13: 172-177.

- Hasan, W.B., Dheyab A.H., Sultan, N.Sh. 2019. Effect of Emulsifying Petroleum Derivatives, Water Deficit Treatment and Emitters Discharge on Dry Weight, Grain yield and Water use Efficiency of Sunflower (*Helianthus annuus* L.). *Basrah Journal of Agricultural Sciences* 32: 1-14.
- Hasan, W.B. 2019. Effect of emulsified oil derivative and dripper discharge under water deficit treatment in some soil physical properties and growth of sunflower crop (*Helianthus annuus* L.). 100f. (PhD Thesis) – College of Agriculture, University of Basrah, Basrah, Iraq.
- Hasan, W.B., Dheyab, A.H., Sultan, N.Sh. 2019. Effect of emulsifying petroleum derivatives, water deficit treatment and emitters discharge on dry weight, grain yield and water use efficiency of sunflower (*Helianthus annuus* L.). *Basrah Journal of Agricultural Sciences* 32: 1-14.
- Hasin, B.A., Hussein, H.J., Mohammed, N.J. 2021. Effect of zeolite and rice husks ash on soil salinity of sandy loam soil irrigated with saline water and yield of tomato (*Lycopersicon esculentum* Mill.). *Iraqi Journal of Soil Sciences* 21:305-3012.
- Hussein, A.S., Nayyef, H.R., Shabeeb, Y.J. 2020. Effect of irrigation periods, tillage systems and their interactions on the growth traits for three cultivars of rice (*Oryza sativa* L.). *International Journal of Agricultural and Statistical Sciences* 16: 1337-1344.
- Kisic, I., Mesic, S., Basic, F., et al. 2009. The effect of drilling fluids and crude oil on some chemical characteristics of soil and crops. *Geoderma* 149: 209-216.
- Litaor, M.I., Katz, L., Shenker, M. 2017. The influence of compost and zeolite co-addition on the nutrients status and plant growth in intensively cultivated Mediterranean soils. *Soil Use and Management* 33: 72-80.
- Mohsen A. Desher. 2000. Response of Tomato plant to super phosphate fertilizer applied through drip irrigation system in desert soils. 85f. (Master's thesis). College of Agriculture da University of Basrah, Basrah, Basra Governorate, Iraq.
- Nayyef, H.R. 2021. Study of some hydraulic parameters of a solar-powered drip irrigation system. *IOP Conference Series: Earth and Environmental Science* 910: 012015.
- Nayyef, H.R., Al-Laghawi, H.S. 2024. The effect of the distance between drippers and drainage on the productivity and growth of tomatoes inside greenhouses. *IOP Conference Series: Earth and Environmental Science* 1371: 082032.
- Nayyef, H.R., Naser, M.A., Al-Laghawi, H.S., Alhasany, A.R., Noaema, A.H., Sawicka, B. 2025. Impact of dripper type and irrigation water salinity on soil bulk density, growth, and yield of maize crop. *Plants* 14: 693.
- Noori, M., Zendehtdel, M., Ahmadi, A. 2006. Using natural zeolite for the improvement of soil salinity and crop yield. *Toxicological & Environmental Chemistry* 88: 77.
- Ok, C.H., Anderson, S.H., Ervin, E.H. 2003. Amendments construction systems for improving the performance of sand-based putting greens. *Agronomy Journal* 95: 1583-1590.
- Page, A.L., Miller, R.H., Keeney, D.R. 1982. Methods of soil analysis. Part 2. 2nd ed. Agronomy 9. Petroleum Industry, American Chemical Society, Washington, D.C., USA.
- Polat, E., Karaca, M., Demir, H., Onus, A.N. 2004. Use of natural zeolite (clinoptilolite) in agriculture. *Journal of Fruit and Ornamental Plant Research* 12: 183-189.
- Raja, A.M. 2020. Effect of the conditioners (zeolites) on some physical properties of desert soils (sandy soil). *Indian Journal of Ecology* 47: 95-97.
- Ravali, Ch., Jeevan Rao, K., Anjaiah, T., Suresh, K. 2020. Effect of zeolite on soil physical and physico-chemical properties. *Metalogic in Science* 10: 776-781.
- Sangeetha, C., Baskar, P. 2016. Zeolite and its potential uses in agriculture: a critical review. *Agricultural Reviews* 37: 101-108.
- Shinde, R., Sarkar, P.K., Thombare, N., Naik, S.K. 2019. Soil conservation: today's need for sustainable development. *Agriculture & Food: e-Newsletter* 1: 175-183.
- Yu, H.L., Gu, W., Tao, J., Huang, J.Y., Lin, H.S. 2015. Impact of addition of FGDB as a soil amendment on physical and chemical properties of an alkali soil and crop yield of maize in Northern China Coastal Plain. *Journal of Chemistry* 2015: 540604.

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

All the contents of this journal, except where otherwise noted, is licensed under a Creative Commons Attribution License attribution-type BY.