A study of the Effect of Al-Kufa Cement Factory dust on some Physical Traits of the soils of the Neighboring regions

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Abstract

A field study was conducted to find out the effect of cement dust on some physical traits of the soil in Al-Najaf Al-Ashraf province - Kufa District for the soils surrounding Al-Kufa Cement Factory, which are of coarse texture with the aim of knowing and determining dust levels and its effects on some physical and chemical traits of the soil surrounding the plant and trying to mitigate its harmful effect on soil and plants, through some comparisons of some physical traits that have a direct effect. The study was conducted on six locations, including five locations affected by factory dust, located northwest-southeast of the factory, while the sixth location is towards the northwest of the factory, which is not affected by precipitated factory dust. Soil samples were taken at a depth of (20 cm), where the layer that interests us in the study, to analyze the physical and chemical traits. Some physical traits of the soil were measured, such as texture, bulk density, total porosity, void ratio, and soil resistance to penetration, with 7 replications for each of the studied comparative traits. Some chemical traits were also measured, which are the degree of soil interaction, electrical conductivity, cation exchange capacity, and CaCO3%.The results showed that dust had an effect on the studied traits; The bulk density, which decreased with the increase of the dust factor, ranged between (1.52-1.77) mg. m^{-3}, and this was reflected in turn on both the total porosity and the void percentage, as each of them increased with the increase of the dust factor, as the values of the total porosity ranged between (40.70-31.10)%,As for the void percentage, it ranged between (68.10-44.60)% for the same locations, and the soil resistance to penetration decreased with the increase of the dust factor, as its values ranged between (20.74-26.82) kg/cm^2.

Keywords: cement dust, bulk density, porosity, soil penetration resistance.

Introduction

The cement industry is considered one of the important national and strategic industries because it contributes to filling the need for cement, which is directly related to construction, reconstruction, development, and the continuous urban movement (16). Cement is a fine powder consisting of mixing lime and clay after crushing and grinding them in ovens with high temperatures up to 450 degrees Celsius and forming Al-Klinker to which crushed gypsum is added and heated at high temperature. Cement is the main component of concrete, and it is the second material consumed worldwide, as it is used in construction and civil engineering works . On the other hand, and similar to all industrial activities, the cement industry faces great environmental challenges because it is characterized by the production of dust in large quantities, which is small solid particles whose diameter ranges approximately between (1-5 microns) the size of clay resulting from crushing, grinding and the rapid reverse flow of combustion gases in the kiln system. towards the stirred raw materials, and this leads to the formation of large quantities of fine particles (dust), some of which are controlled by electrostatic precipitators and fabric filters, and cement kiln dust consists of fine particles of burnt or unburned raw material and Al-Klinker in addition to the resulting materials From the corrosion processes that occur in the furnace system itself, Cement kiln dust includes particles emitted from the kiln system, whether emitted from chimneys or escaping from any part of the kiln system or particles collected in control systems (precipitators) Cement dust can be in two forms, the first: cement kiln dust collected by control systems (precipitator dust) It is called CKD fresh, which is characterized by high softness and dryness, As for the second picture: it is called CKD land full, which represents particles of sedimentary dust that are transported and thrown in large quantities on the ground and in pits close to the cement factories(17).

In spite of the significant impact of dust produced by cement plants, limited attention, and few studies have been carried out on its impact on the surrounding environment. The chemical and physical properties of dust particles are strongly related to the quality of the chemical composition of the raw materials and fuel used and depend in part on the type of kiln operations and the method used in the manufacture of cement (19). This dust leads to a change in the gaseous components of the air and affects the quality of the soil by changing its physical, chemical and biological characteristics. Among these traits are bulk density, porosity, void ratio, and soil resistance to penetration. Note the change in these characteristics when comparing the soils of the dust-affected areas with the soils of the unaffected areas, which leads To its impact on the productivity, growth, and yield of plants in the soils of those areas, where the soil is one of the natural environmental elements that are directly and indirectly linked to human and animal health through its impact on the growth of plants that humans and animals feed on (5). The environment surrounding the plant was characterized as having little population and agricultural use, and its soil was semi-desert in some directions, with the exception of the soils located towards the east near the Euphrates River, which were characterized by clear agricultural use.

Materials and Methods:

A field study was conducted to know the effect of cement dust on some physical properties of soil in the autumn season of 2022, and I am not in close proximity to Al-Kufa Cement Factory, which is located in the Najaf Governorate - Kufa District - Al-Barakiyah. The study included soils affected by dust (X1, X2, X3, X4, X5), as follows:

The first location is located immediately after the outer wall of the factory in the direction (northwest-southeast) of the factory.

The second location is located 2.00 km away from the factory in the direction (northwest-southeast) of the factory.

The third location is located at a distance of (4.00) km in the direction (northwest-southeast) of the factory.

The fourth location is located at a distance of (6.00) km from the factory in the direction (northwest-southeast) of the factory.

The fifth location is located at a distance of (8.00) km from the factory after Najaf-Qadisiyah Street in the direction (northwest–southeast) of the factory and other unaffected ones (control) similar to them in the general characteristics of the soil. One location was chosen that was not affected by the dust of the factory and it is about (2) km away from it towards the northwest of the factory. Seven replications were taken from soil samples to study the effect of dust geolocation within the location for comparison with each other. The sand cone was used to detect the bulk density, through which the total porosity and void ratio were found, according to the method proposed by Blake *et al* (10) Soil resistance to penetration and compaction were also detected by the Penetrometer, according to the method proposed by Al-Jubouri (4) and some chemical properties of the soil were measured according to the methods presented in Blake *et al.* (10), and as shown in Table (1).

Table 1. some of the chemical properties of the soils of the studied locations

Location	PH	EC $ds.m^{-1}$	ECE $Cmol.kg^{-1}$	CaCO3 %
Control	7.9	5.8	2.4	21.6
X1	8.4	3.6	1.8	17.4
X2	8.2	3.9	1.8	17.9
X3	8.1	4.2	1.9	18.4
X4	8	4.7	1.9	19.1
X5	8.1	5.0	2.0	20.7

Results and Discussion

Dust effect on bulk density**:**

The results shown in Table (2) show that there are high significant differences between the mean values of the bulk density of the study locations under the influence of the dust factor (X1, X2, X3, X4, X5), which amounted to (1.52, 1.56, 1.59, 1.67, 1.71) Mg. m^{-3}, respectively, and between the average of the mentioned characteristic for the location unaffected by the dust factor (control location), which amounted to (1.77) Mg. m^{-3}, Where it was observed that the highest average value of the bulk density with a significant effect was in the location outside the influence of the dust factor (control location), which amounted to (1.77) Mg. m^{-3}As mentioned above, the lowest average value of the mentioned trait was in the first location (X1) under the influence of the dust factor, which amounted to (1.52) Mg. m^{-3}.It appears from the above results that the dust factor affected the bulk density of the soil, where it was noted that the bulk density values increased as we moved away from the effect of factory exhausts, and the reason for this is due to the increase in the proportion of sand separation on the proportion of clay and silt in the location unaffected by factory dust (control location),While the percentage of clay and silt separations increased over the percentage of sand separation for the locations under the influence of dust, which led to an increase in the bulk density in control location, as it increases with the increase in the percentage of sand, and this is consistent with Al-Jabri (2), The reason for the decrease in the bulk density in the locations under the influence of the dust factor is also due to the increase in the proportion of soft composts and the decrease in the size of the interfacial pores due to the deposition of fine particles such as clay and silica particles, iron and aluminum oxides, and carbonates among the soil materials in the soils of the studied areas due to the effect of the dust factor, and this was shown by Cassel (13). The bulk density values also increase in sandy soils with a high content of coarse particles, and this is what was observed in the control location with a mixed sand texture. As for soils containing a high percentage of clay and silt, their bulk density is less than soils containing a small percentage of clay and silt, and this is consistent with Lamar and Sigh (18). Also, the reason for the low bulk density is due to the properties of clay soils, which have a better structure compared to coarse-textured soils. This agrees with Borghei (11). In addition, the bulk density values decrease with the increase in the percentage of clay as a result of the increase in the percentage of voids in the clay soil, which leads to a decrease in the bulk density.

Table 2. Some physical properties of the soils of the studied locations

studied location	Bulk density Mgm-3	Porosity %
Control	1.77	31.10
X1	1.52	40.70
X2	1.56	39.10
X3	1.59	38.60
X4	1.56	35.30
X5	1.70	34.00

The total porosity of soil:

Table (2) indicates that there are high significant differences between the average values of the total soil porosity of the study locations under the influence of the dust factor (X1, X2, X3, X4, X5), which amounted to (40.70, 39.60, 38.60, 35.40, 34.00) %, respectively and the mean of the mentioned characteristic for the location located outside the influence of the dust factor (control location) is (31.10) %. It was observed that the highest average value of the total soil porosity was in the first location (X1) located under the influence of the dust factor, which amounted to (40.70) %, and the lowest average value of the mentioned trait was in the location that is outside the influence of the dust factor (control location), which amounted to (31.10) %, as mentioned above. It appears from the above results that there is an effect of the dust factor on the values of the total porosity of the soil, as it increased with the increase of the dust factor, meaning that the values of the total porosity increased as we approached the effect of the factory sediments (dust), and the reason for this is due to the effect of small sediments in reducing the percentage of large pores This is consistent with Agrawal *et al*. (1). Also one of the reasons that lead to a decrease in the total porosity of the soil is the increase in the bulk density, as Al-Mahnawy (6) confirmed that soil pressure leads to the loss of large pores because it affects the distribution and size of the pores, and then the property of retaining water inside the soil. It was observed that the shapes of the distribution of total porosity in the studied soil were the application of the shapes of the distribution of bulk density in the same location, As the porosity depends entirely on the bulk density, and the relationship is inverse between them, that is, with an increase in the bulk density, the porosity decreases, and vice versa. Therefore, the total porosity is considered one of the physical characteristics that change with the change of the tissue and its structure, and this is confirmed by Bavor *et al*., (9) and that the bulk density when it decreases leads to an improvement in the physical properties of the soil by increasing the porosity and the ability of the soil to retain moisture and the large size of the pores through which water moves inside the soil and this is consistent with Dexter (14). Also, the decrease in bulk density is evidence and indication of the presence of a stable stability of soil building blocks and a porous space that allows for a high flow of water and air movement in the soil, and this is confirmed by Anderson and Croft (7). Also one of the reasons that lead to the lack of porosity of the soil is the increase in the bulk density, as the pressure of the soil causes the loss of large pores because it affects the distribution and size of the pores.

The effect of dust on the void percentage:

It appears from Table (3) that there are highly significant differences between the averages of the percentage of voids for the study locations under the influence of the dust factor (X1, X2, X3, X4, X5), respectively, which amounted to (68.10, 64.80, 62.40, 54.00, 49.00). %, respectively, and between the average of the aforementioned characteristic of the location located outside the influence of the dust factor (control location), which amounted to (44.60)%, Where it was observed that the highest average of the characteristic of the percentage of voids was in the first location under the influence of the dust factor, which amounted to (68.10)%, and the lowest average for the same characteristic was in the location outside the influence of the dust factor (control location), which amounted to (44.60%).It appears from the results shown in Table (3) that there is an effect of the dust factor on the characteristic of the percentage of voids, as this characteristic increased with the increase in the amount of dust, meaning that the percentage of voids increased as we approached the effect of the factory sediments, and the reason for this is due to the effect of those deposits on the physical traits of the soil This is consistent with what was found by Agrawal *et al*. (1). Also the reason for increasing the percentage of voids in the studied soils under the influence of the dust factor is due to the increase in the percentage of total porosity in those soils, as it has a direct relationship with the percentage of voids and vice versa.

The effect of dust on the penetration resistance of soil:

The results shown in Table (3) showed that there were highly significant differences between the averages of soil penetration resistance for the studied locations under the influence of the dust factor (X5, X4, X3, X2, X1), respectively, which amounted to (20.74, 22.46, 24.00, 24.84). , 25.76) kg. cm^{-2} and between the mean of the aforementioned characteristic of the location outside the influence of factory dust (control location), which was distinguished by the highest average of the aforementioned characteristic (26.82) kg / cm^2, and the lowest average of the property of soil penetration resistance was in the first location (X1) located under the influence of the dust factor, which amounted to (20.74).) kg. cm^{-2} .

Table 3. Shows some of the physical traits of the soils of the studied locations

studied locations	% void percentage	Soil penetration resistance kg/cm2
Control	44.60	26.82
X1	68.10	20.74
X2	64.80	22.46
X3	62.40	24.00
X4	54.00	24.84
X5	49.00	25.76

he results above show that there is a significant effect of the dust factor on the property of soil penetration resistance, where it was observed that the average of the mentioned characteristic increased with the decrease in the amount of dust (the further away from the dust source)This is what was observed in control location, and the decrease in the average of the above characteristic, the greater the amount of dust (the closer we are to the source of dust), and this is what we noticed in the first location (X1) located immediately after the outer wall of the factory. The reason for this is due to the effect of factory dust on the decrease in the bulk density and, consequently, the decrease in the degree of compaction of the soil in the locations under the influence of the dust factor, which led to a decrease in the penetration resistance of the soil. Soil penetration resistance is an indicator of soil compaction and this is consistent with Eroglu (15) who confirmed that soil resistance to penetration depends on soil texture, bulk density, moisture content, and low porosity and consistent with Busscher (12) who confirmed that the soil penetration resistance increases with the increase in the bulk density and the decrease in porosity, and also the reason for the increase in the penetration resistance of the soil is due to the decrease in soil moisture for all locations, as the lower the soil moisture. The greater the soil resistance to penetration greatly increases due to the increase in soil resistance arising from the closeness of soil particles to each other, and this is consistent with Bauder (8) and Al-Jilani and Ghaibeh (3) who showed that there is an inverse relationship For soil resistance to penetration and soil moisture. Also, the hard dry soil shows resistance to the pressure applied to it.

Conflict of interest

The authors declare no conflict of interest.

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