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POSSIBILITIY OF USING CEMENT KILN DUST FOR IMPROVING SANDY SOIL HEALTH AND ENHANCING MAIZE PERFORMANCE

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ABSTRACT

Many researchers worldwide have suggested the use of cement kiln dust (CKD) as a soil amendment and a source of nutrients to enhance crop performance. Pot experiment was accomplished in the greenhouse of Soil Science Department, Faculty of Agriculture, Minia University, to investigate impacts of white and black CKDs applied at six rates (0, 4, 8, 12, 16, and 20 g kg^{-1}) to sandy loam soil on some soil chemical and biological properties and maize growth and quality parameters. Treated soils with either white CKD or black CKD were very slightly saline; moderately alkaline; and still in a safe lead, nickel, and cadmium levels. Soil amendment by increasing white CKD rate from 0.0 up to 16 g kg^{-1} increased microbial biomass C and N and enzyme activity of arginase and β-glucosidase. The highest values of plant height, fresh and dry weight of maize plants, and water use productivity by maize plants were recorded with 16 g kg^{-1} of white CKD. There was no distinct accumulation of lead, nickel, and cadmium in the maize shoots. It is applicable to use white CKD only at the application rate of 16 g kg^{-1} (16 Mg $feddan^{-1}$) for crops grown in sandy soils under conditions of El-Minia Governorate, Egypt.

Keywords: White, Black CKDs, Health Risk Assessment, Microbial biomass.

Introduction

Cement industry is an important industry all over the world, but it is one of the polluting industries in the environment. As a large manufacturing industry, cement kiln dust (CKD), a by-product dust, is generated in large quantities during the manufacture of the cement. It has been used in many different economical and beneficial applications in different parts of the world. Its pollution has been found to be a problem around cement factories. It may contain hazardous compounds that poses harmful effects to human, animals, plants, and environment. Therefore, cement kiln dust should be properly managed to avoid its harmful effects on humans, animals, and plants. The disposal of CKD is very difficult and causes an environmental hazard. In order to minimize the undesirable environmental impacts of CKD, several researches have been performed to study the beneficial commercial uses of CKD (***Kunal et al. 2012; Elbaz et al. 2019)***.

***Elbaz et al. (2019*)** indicated that the production of one ton of cement generates around 0.06-0.07 ton of CKD. Global cement production is expected to increase from 3.27 billion metric tons in 2010 to 4.83 billion metric tons in 2030; with approximately 220 million tons of cement dust is discarded annually from these cement manufacturing facilities.

***Naik et al. (2003*)** reported that the principal constituents of CKD were compounds of lime, silica, alumina, and iron. In addition, ***Kunal et al. (2012*)** showed that cement kiln dust was a fine powdery material of grey to can in color, relatively uniform in size, and similar in appearance to Portland cement**.** Moreover, ***Mandal and Voutchkov* (2011)** reported that the fine particles of dust can be inhaled along with air and in course of time cause respiratory problems in people living near and working in the factory. Hence, analyzing and characterizing of the constituents of dust are very important from a health point of view**.**

Application of the cement kiln dust improves the sandy soil properties so as to provide suitable conditions for the plant growth. The agriculture use of the cement kiln dust is a useful management practice as it is a soil conditioner and a source of nutrients to increase the crop yield.

In many parts of the world, many researchers have suggested the use of CKD as a soil amendment and a source of nutrients necessary for the growth and development of plants to enhance the crop yield because of the high lime content and potassium concentration in the CKD **(*Adaska and Taubert*, 2008 *and Rahman et al*., 2011).** In addition, ***Daous (2002*)** reported that enriched levels of soluble potassium sulfates in alkali rich cement kiln dust (CKD) makes such dust a promising raw material for the extraction of potash or its soluble salts.

Soil is an important component of the environment and it must be managed properly to conserve its quality for plants, animals, and humans. Soil may become saline as a result of land use. Soil pH is an important indication of the soil chemical status. Heavy metals in soils are one of the main sources of environmental pollution. Heavy metals are environmental pollutants due to their toxic effects on plants, animals, and human health. Soil contamination by heavy metals results from anthropogenic and natural activities. Consequently, it is important to assess and monitor the levels of heavy metals in the environment due to the anthropogenic activities **(*Abd El-Azeim et al., 2016; Abo Shelbaya et al., 2021*).**

Soil is a crucial component of rural and urban environments ***Mehlenbacher* (2002)** found that the three CKD amendments elevated the soil EC to a range of 7.08, and in both places land management is the key to soil quality **(USDA, 2000). Dollhopf and** to 16.63 dS/m for the 12% amendment application rate. ***Scianna* (2002)** pointed out that soil pH is an important soil measure even though it does not directly measure saltiness. A main implication of changing the soil pH is plant nutrient availability, which is often a secondary response to microbial activity levels responding to changing soil pH. As soil pH climbs, elements such as iron, manganese, zinc, copper, cobalt, phosphorus, and boron become limiting **(*Abd El-Azeim* et al., 2016; *Abo Shelbaya* et al., 2021).**

From the view point of this concern, the main objectives of this study were: (1) to characterize and assess the possibility of using the white and black CKDs for the agricultural purposes in a safe manner as a soil amendment and a fertilizer material and (2) to investigate the impact of the white and black CKDs on some soil chemical and biological properties (soil health), maize growth (maize health), and chemical constituents of the maize plants.

. MATERIALS AND METHODS

The current study was carried out in the greenhouse of Soil Science Department, Faculty of Agriculture, Minia University, El-Minia Governorate, Egypt.

Collection and preparation of the studied soil

The soil used in the current study was collected from a private farm at a newly reclaimed land in the Western district of Nile valley, El-Minia Governorate, Egypt. To characterize soil of the study site, a representative soil sample was collected from the soil surface at a depth of 0.0-30 cm. The soil sample was homogenized by the quartering method, then, air-dried, grinded with mortar and pestle, and sieved to pass through a 2.0 mm stainless steel sieve for the chemical analysis. Some analytical data of the studied surface soil at a depth of 0.0-30 cm are presented in Table (1). As it can be seen from the results in Table (1), the soil is sandy loam in texture, non-saline with an electrical conductivity of 1.40 dS m^{-1}, and moderately alkaline pH (7.95).

Table (1) Some analytical data of the studied surface soil at a depth of 0.0-30 cm.

Soil properties	Value
Particle size distribution:	
Coarse sand (%)	50.33
Fine sand (%)	30.40
Silt (%)	4.77
Clay (%)	14.50
Texture grade	Sandy loam
E.C. (Ratio 1:5) (dS m^{-1})	1.40
pH (Ratio 1:2.5)	7.95
$CaCO_3$ (g kg^{-1})	94.40
O.M. (g kg^{-1})	3.40
DTPA-extractable heavy metals (mg kg^{-1}):	
Pb	2.55
Ni	1.47
Cd	0.07

Collection and preparation of the cement kiln dust

Two cement kiln dusts, white and black, were collected from two cement factories in El-Minia Governorate, Egypt. The white CKD was collected from the White El-Minia cement factory at Beni Khaled village, Samalout district, El-Minia Governorate, Egypt, and the black CKD was collected from the ASEC Minia cement factory at El-Sheikh Fadl village, Beni Mazar district, El-Minia Governorate, Egypt. Both of CKDs were used in the pot experiment. A sample of each CKD was taken, oven dried at 105 ^{o}C for 24 hours, grinded with mortar and pestle, and sieved to pass through a 2.0 mm stainless steel sieve for the chemical analysis.

Experimental design and set up of the pot experiment

The pot experiment included 12 treatments, which were six CKD rates (0, 4, 8, 12, 16, and 20 g kg^{-1}) from each studied CKD. Each respected CKD treatment was replicated three times. Before maize cultivation, each CKD treatment was added to five kilograms of air dried and sieved studied sandy loam soil and then mixed thoroughly. Then the soil mixture with CKD was placed in a plastic pot (16 cm in diameter and 18 cm in depth).

Then, five grains of maize (*Zea mays*) were cultivated in each pot in July 2016. Maize plants in each pot were thinned and two plants were left to grow in each pot. The maize plants received the recommended fertilization rates of N, P, and K at the equivalent rates of 99 kg N, 47 kg P_2O_5, and 36 kg K_2O/feddan, respectively. Maize plants were irrigated every three days with an amount of water to compensate loss in moisture content which was maintained at the field capacity. After 65 days from maize cultivation; the plant height of maize was recorded, the water consumptive use by maize plants (l\pot) were measured, and then water use efficiency by maize plants (g/l) was calculated. Also, maize plants were cut at 2.0 cm from the soil surface at 65 days from the maize cultivation in September 2016. After that, fresh weight of maize plants was immediately recorded, then, maize plants were dried in the oven at 65 ^oC and dry weights of maize plants was immediately recorded by weighing. The oven dried maize plants were grinded in a plant mill, passed through a 0.5 mm screen mesh, and a representative sample was taken and analyzed for Pb, Ni, and Cd.

Risk assessment of the soil pollution

Regarding the impact of applying white and black CKDs on soil pollution; soil samples were collected before cultivation and at 65 days from maize cultivation.

Risk assessment of soil pollution is one of the key pathways when investigating the risk of white and black CKDs on the soil, human health, animals, plants, and surrounding ecosystem. The risk assessment of soil pollution was performed using the following three international guidelines:

1- Guidelines for soil salinity classes as proposed by ***Scianna* (2002)** from the United States of America.
2- Guidelines for soil pH classes as proposed by ***Scianna* (2002)** from the United States of America.
3- Guidelines for the permissible limit of DTPA-extractable heavy metals in soils as proposed by ***Maclean et al*. (1987)**.

Health risk assessment for human and animals

In view point of the impact of applying white and black CKDs to soil on human health and animals; the health risk assessment of lead, nickel, and cadmium concentration in maize plants was performed using the following international guidelines:

1- ***WHO/FAO*** guidelines for metals in foods and vegetables as proposed by ***FAO/WHO* (1976)**.
2- Guidelines for the Indian standards for heavy metals in the soil, food, and drinking water as proposed by ***Awashthi* (2000)** from India.

Laboratory analysis

Chemical analysis of the soil and cement kiln dust

The chemical analysis of soil and white and black CKDs was performed according to the standard frequently used methods as described by ***Jackson (1973) and Page et al*. (1982).** Lead, nickel, and cadmium were extracted from the soil and each CKD with diethylene-triamine-penta acitic acid (DTPA). The solution is made up of a mixture of 0.005 M DTPA, 0.1 M triethanolamin (TEA) and 0.01 M $CaCl_2$**,** adjusted to pH 7.3. The concentrations of Pb, Ni, and Cd in the soil extracts and extracts of each CKD were analyzed using an Atomic Absorption Spectrophotometer; Model of VARIAN specter AA. 20 according to ***Mathieu and Pieltain (2003).***

Chemical analysis of the maize plants

Lead, nickel, and cadmium were extracted from the maize plants using the method of micro wave digestion. 0.1 g from each plant sample was homogenized in a Teflon cups with 5.0 ml nitric acid (ultrapure), 2.0 ml H_2O_2 30% and 0.5 ml hydrofluoric acid. The mixture was put in microwave apparatus at 37 wt/12 min. The mixture was frozen at –10 ^oC/30 min and set up at 50 ml with redistilled water. The concentrations of Pb, Ni, and Cd were analyzed by electrothermal Atomic Absorption Spectrometry, Model of VARIAN specter AA. 20 as described by ***Kumpulainen et al.* (1983).**

Biological analysis of the soil

Microbial biomass C and N in the soil

Microbial biomass C (C_{mic}) was determined by the fumigation extraction method as described by **Vance *et al.* (1987)**. Microbial biomass C was calculated as follows:

$C_{mic} = E_C/k_{EC.}$

Where:

E_C = (organic C extracted from fumigated soil) - (organic C extracted from non-fumigated soil).

k_{EC} = 0.45, which is a proportionality factor for converting the E_C value to C_{mic} (**Wu *et al.*, 1990**).

Microbial biomass N (N_{mic}) was determined by the chloroform fumigation-incubation method as described by **Horwath and Paul (1994)**. The NH_4-N thus extracted was determined in a 20-ml aliquot of the extract by steam distillation (**Keeney and Nelson, 1982**). The N_{mic} was calculated as follows:

$N_{mic} = E_N/k_{IN}$,

Where:

E_N = (flush of NH_4-N due to fumigation) - (NH_4-N produced in the non-fumigated soil during 10 days of incubation).

k_{IN} = 0.54, which is a proportionality factor for converting the E_N value to N_{mic} (***Jenkinson,* 1988**).

Enzymes activity of the soil

Enzyme activity of Arginase in soil samples was assayed as described by ***Tabatabai* (1994)** using arginine as the substrate, which involves the determination of NH_4^-N by steam distillation (***Mulvaney*, 1996**). Enzyme activity of β-glucosidase (βG) in soil samples was assayed as described by ***Eivazi and Tabatabai* (1990)** using *p*⁻nitrophenyl⁻β⁻D⁻glucopyranoside as the substrate. The amount of *p*-nitrophenol was estimated spectrophotometrically.

Data handling

All the tabulated data of the current study were recorded at the oven dry basis (105 ^{o}C).

1- The water use productivity by maize plants was calculated using the following equation:

Water use productivity = The biomass yield (g) / The amount of depleted or diverted water (l).

2- The uptake of a heavy metal = Dry matter of maize plants × Concentration of a heavy metal in the maize plants.

Statistical analysis

All the obtained data were subjected to statistical analysis of variance procedures using Excel software (2016). Differences between treatments means were compared using L.S.D. test at 5% probability level.

RESULTS AND DISCUSSION

Chemical characterization and management of white and black cement kiln dusts

The chemical analysis of white and black CKDs is shown in Table (2). As it can be observed from the results in Table (2), the white and black CKDs have high values of the electrical conductivity (7.99 dS m^{-1} and 14.28 dS m^{-1}, respectively). The electrical conductivity value of black CKD was higher than that of white CKD. The results agree with ***Daous (2002), Dollhopf and Mehlenbacher (2002), and Rahman et al. (2011).***

Table 2: Some chemical properties of white and black cement kiln dusts (CKDs).

Chemical properties of CKD	White CKD	Black CKD
E.C. (Ratio 1:5)	7.99	14.28
pH (Ratio 1:2.5)	6.89	11.70
DTPA-extractable heavy metals (mg kg^{-1}):		
Pb	9.73	15.62
Ni	3.62	6.16
Cd	2.10	4.79

Regarding the pH of white and black CKDs, it was obvious from the results in Table (2) that the white CKD was approximately in the neutral pH. However, the black CKD was very strongly alkaline. The pH value of black CKD was higher than that of white CKD. Similar results were reported by **(EPA, *1993; Abd El-Aleem et al., 2005; and Kunal et al., 2012*)** It should be noticed from the results in Table (2) that the white and black CKDs contained low levels of lead and nickel; however, they contained relatively higher level of cadmium as proposed in the researches of many authors all over the world. The white and black CKDs are safe natural materials in terms of the lead and nickel level. The lead, nickel, and cadmium concentration of black CKD was higher than that of white CKD. The results are in consistent with those observed by several researchers **(*Naik, et al., 2003; Rahman et al., 2011;* and *Kunal et al.; 2012*).**

With concern to the chemical constituents of white and black CKDs which is given in Table (3), it is appeared from the results in Table 3 that the white and black CKDs consist primarily of calcium oxide and silicon oxide. The results are in harmony with those reported by (**Waly et al., 2007).**

Table (3) Some chemical constituents of the white and black cement kiln dust (CKDs).

Chemical constituents of CKD (% by weight)	White CKD*	Black CKD**
SiO_2	19.84	14.14
Al_2O_3	2.75	4.46
Fe_2O_3	0.03	2.01
CaO	57.39	56.44
MgO	0.14	0.78
SO_3	5.28	7.60

*White CKD = Analytical chemical composition of white CKD is provided White cement factory.

**Black CKD = Analytical chemical composition of black CKD is provided by ASEC Minia cement factory.

The chemical composition of white CKD varied from the that of black CKD. The amount by weight of Al_2O_3, Fe_2O_3, MgO, and SO_3 of black CKD was higher than that of white CKD. While, the amount by weight of SiO_2 and CaO of white CKD was higher than that of black CKD, its agree with **(*Naik et al.,* 2003).**

Impact of applying white and black CKDs on some soil chemical and biological properties

In order to determine impacts of white and black CKDs on soil properties (soil health), risk assessment of soil pollution included soil salinity build up; changes in soil pH; and spatial distribution and accumulation of lead, nickel, and cadmium in sandy soil. Risk assessment of soil pollution was performed using three international guidelines.

Soil salinity build up

It was prominent from results in Table (4) that addition of white and black CKDs at six rates (0.0, 4, 8, 12, 16, and 20 g kg^{-1}) to sandy soil resulted in an increase in soil electrical conductivity after 65 days from maize cultivation when compared to that before cultivating maize plants (Table 1). Increasing application rate of white and black CKDs from 0.0 up to 20 g kg^{-1} significantly increased soil electrical conductivity ($p \leq 0.05$) after 65 days from maize cultivation when compared to control treatment (0.0 g kg^{-1}). Results are in harmony with the findings of (***Dollhopf and Mehlenbacher, 2002; Uysal et al.*, 2012; *and ElBaz et al., 2019*).**

Table (4) Impact of applying white and black CKDs on some soil chemical properties after 65 days of maize cultivation.

CKD treatment (g kg^{-1})		E.C. (1:5) (dS m^{-1})	pH (1:2.5)	DTPA-extractable heavy metals concentration in the soil (mg kg^{-1})		
				Pb	Ni	Cd
Control		**1.40**	**7.95**	**2.55^{g}**	**1.47^{f}**	**0.061^{f}**
White CKD	**4**	1.48^{a}	8.04	4.49^{f}	2.79^{e}	0.120^{e}
	8	1.68^{a}	8.07	5.40^{d}	3.25^{d}	0.140^{d}
	12	1.74^{a}	8.09	6.19^{c}	3.61^{c}	0.180^{c}
	16	1.96^{a}	8.11	7.12^{b}	4.14^{b}	0.228^{b}
	20	2.00^{a}	8.18	8.00^{a}	5.00^{a}	0.298^{a}
	Mean	**1.71**	-----	**5.63**	**3.38**	**0.171**
Black CKD	**4**	1.59^{a}	8.09	5.02^{e}	3.01^{e}	0.140^{de}
	8	1.79^{a}	8.11	5.67^{d}	3.43^{d}	0.160^{cd}
	12	1.86^{a}	8.14	6.61^{c}	3.82^{c}	0.200^{bc}
	16	2.01^{a}	8.15	7.63^{b}	4.34^{b}	0.253^{ab}
	20	2.15^{a}	8.19	8.11^{a}	5.10^{a}	0.288^{a}
	Mean	**1.80**	-----	**5.93**	**3.36**	**0.184**
LSD at level 5%		**0.29**	-----	**0.44**	**0.31**	**0.014**

Along the six rates of white CKD, the value of soil electrical conductivity ranged from 1.40 to 2.00 dS m^{-1}, while, along the six rates of black CKD, the value of soil electrical conductivity ranged from 1.40 to 2.15 dS m^{-1}. ***Sonon et al.* (2015)** reported that correction a salt - affected soil involves identified the kind and amount of salt, chemical treatment and leaching. The University of Georgia recommends leaching techniques to remove salts from the root zone when EC is greater than 1.25 mmhos/cm at a soil to water ratio of 1:2.

The electrical conductivity values of treated soil with the black CKD was higher than those of treated soil with the white CKD. One explanation for this result is that the electrical conductivity value of black CKD (14.28 dS m^{-1}) was higher than that of the white CKD (7.99 dS m^{-1}) as given in Table (2).

Concerning the risk assessment of soil salinity, all the values presented in Table (4) were compared with the guidelines for the soil salinity classes proposed by ***Scianna (*2002)** as presented in Table (5). According to the guidelines of ***Scianna* (2002),** the electrical conductivity value of most of treated soils with the white CKD and the treated soils with the black CKD is within the range of 2.0-4.0 dS m^{-1} under the salinity class of “very slightly saline”. ***Scianna*** **(2002)** suggested that even soils classified as “slightly saline” are marginally acceptable for many crops.

Table 5: Guidelines for the soil salinity classes (Scianna, 2002).

Salinity class	EC (electrical conductivity) (dS m^{-1} or mmhos cm^{-1})
Non saline	0 – 2
Very slightly saline	2 – 4
Slightly saline	4 – 8
Moderately saline	8 – 16
Strongly saline	> 16

Soil pH

It was evident from the results shown in Table (4) that addition of the white and black CKDs at the studied six rates to the sandy soil resulted in a slight increase in the soil pH with applying the white and black CKDs treatment at 65 days from the maize cultivation when compared to that before cultivating the maize plants (Table, 1). ***Dollhopf and Mehlenbacher*** **(2002)** found that increased soil pH was associated with greater application rates of the three types of CKD. In addition, ***Rahman et a*l. (2011)** pointed out that the application of CKD to agriculture land can increase the pH of soils. Moreover, ***Adaska and Taubert (*2008)** revealed that because of the high lime and potassium concentrations, CKD is used as a soil amendment or fertilization in many parts of the world. The acid neutralizing capacity of the lime in CKD counteracts the acidic soils that result from years of farming.

Across the six rates of white CKD, the value of soil pH ranged from 7.95 to 8.18, whereas, along the six rates of black CKD, the value of soil pH ranged from 7.95 to 8.19. ***Dollhopf and Mehlenbacher*** **(2002)** indicated that three types of CKD produced a desired pH (7.0 - 8.4) in the root zone during the plant growth test of perennial grasses.

With regard to the risk assessment of soil pH, all the values provided in Table (4) were compared with the guidelines for the soil pH classes proposed by ***Scianna (*2002)** as it was given in Table (6). According to the guidelines of ***Scianna*** **(2002),** the pH value of treated soils either with the white CKD or the black CKD is within the range of 7.9-8.4 under the pH class of “moderately alkaline”. ***Adaska and Taubert*** **(2008)** reported that neutral soils are a better growing environment for crops and also enhance herbicide effectiveness. The dust may provide potassium and trace metals that are also depleted from agriculture soils due to plant withdrawal requirements. Furthermore, ***Scianna*** **(2002)** pointed out that a main implication of changing the soil pH is plant nutrient availability, which is often a secondary response to microbial activity levels responding to changing soil pH. As soil pH climbs, elements such as iron, manganese, zinc, copper, cobalt, phosphorus, and boron become limited.

Table (6) Guidelines for the soil pH classes (Scianna, 2002).

pH class	pH
Ultra acid	< 3.5
Extremely acid	3.5 - 4.4
Very strongly acid	4.5 - 5.0
Strongly acid	5.1 - 5.5
Moderately acid	5.6 - 6.0
Slightly acid	6.1 - 6.5
Neutral	6.6 - 7.3
Slightly alkaline	7.4 - 7.8

Moderately alkaline	7.9 - 8.4
Strongly alkaline	8.5 - 9.0
Very strongly alkaline	> 9.0

Accumulation of lead, nickel, and cadmium in the soil

The concentration of lead, nickel, and cadmium in the soil was increased at 65 days from the maize cultivation when compared to that in the soil before cultivation (Table, 1) due to application of the white and black CKDs at the studied six rates as showed in Table (4). Increasing the application rate of white and black CKDs from 0.0 up to 20 g kg^{-1} significantly increased the concentration of lead, nickel, and cadmium in the soil at 65 days from the maize cultivation when compared to that of the control treatment. The results are in harmony with the findings of ***(Mandal and Voutchkov, 2011; Olowoyo et al., 2015; Lafond and Simard, 1999; and USDA, 2000)***

The increase in the concentration of lead, nickel, and cadmium in the soil may be interpreted by: (1) the carry-over of lead, nickel, and cadmium from the dissolution of white and black CKDs to the soil and (2) addition of the chemical fertilizers especially the phosphate fertilizers. The results agree with ***Kloke et al.*** **(1984)**.

Across the six rates of white CKD, the value of lead, nickel, and cadmium concentration in the treated soil with the white CKD ranged from 2.55 to 8.00, 1.47 to 5.00, and 0.061 to 0.298 mg kg^{-1}, respectively. However, along the six rates of black CKD, the value of lead, nickel, and cadmium concentration in the treated soil with the black CKD ranged from 2.55 to 8.11, 1.47 to 5.10, and 0.061 to 0.288 mg kg^{-1}, respectively. The results agree with ***Bhalerao et al.*** **(2015)**.

The heavy metals concentrations in the soils of pot experiment were in the following descending order: Lead > Nickel > Cadmium. This result is obvious in the chemical analysis of the white and black CKDs (Table 2) where the heavy metals concentration in the white and black CKDs was in the following descending order: Lead > Nickel > Cadmium.

It was clear from the results in Table (4) that at 65 days from the maize cultivation, the values of lead, nickel, and cadmium concentration in the treated soil with the black CKD were higher than those in the treated soil with the white CKD. This result may be explained by that the value of lead, nickel, and cadmium concentration of black CKD (15.62, 6.16, and 4.79 mg kg^{-1}; respectively) was higher than that of the white CKD (9.73, 3.62, and 2.10 mg kg^{-1}; respectively) as given in Table (2). The results are in harmony with the findings of ***Dollhopf and Mehlenbacher*** **(2002)**.

The risk assessment of soil pollution helps in screening out the low-risk areas (potential safe areas) and high risk areas (hot spot areas) in terms of lead, nickel, and cadmium concentration in the soil so as to prevent the environment from the pollution. Risk assessment of the soil pollution is a vital step when investigating the risk of white and black CKDs on the soil quality (soil health), plant health, human and animal health, and surrounding ecosystem. Therefore, the risk assessment of soil pollution by lead, nickel, and cadmium was applied to the data set.

Considering the risk assessment of lead, nickel, and cadmium concentration in the soil, all the values of lead, nickel, and cadmium concentration in the soil presented in Table (4) were compared with the guidelines of ***Maclean et al*. (1987)** for the permissible limit of DTPA-extractable heavy metals in soils as illustrated in Table (7). The values of lead, nickel and cadmium concentration in the soil are below the allowable limit of DTPA-extractable of lead, nickel and cadmium concentration in soils.; indicating that there is no evident for pollution of lead, nickel and cadmium. Therefore, the soils of pot experiment were still in a safe lead, nickel and cadmium. The results agree with (***Siti Norbaya et al*., *2014; Shnizai ,2012; and Dong et al*., 2007)**.

Table (7) Guidelines for the permissible limit of DTPA-extractable heavy metals in soils [Adapted from Maclean et al. (1987)].

Heavy metal	Soil (mg/kg)
Lead Pb	13.00
Nickel Ni	8.10
Cadmium Cd	0.31

The results of risk assessment of cadmium concentration in the soil demonstrated that the soils of the pot experiment might have been heavily polluted according to the levels of cadmium that were recorded in soils of current study, suggesting that there is potential that soils of current study have been heavily polluted by cadmium if no soil remediation effort has been implemented.

The risk assessment of lead, nickel, and cadmium pollution in the soil can be used for preventing or reducing the soil pollution in order to conserve the surrounding environment healthy and safe for humans, animals, plants, and all living organisms.

Microbial biomass and enzyme activity in the soil

The studied soil biological properties were microbial biomass C (Cmic), microbial biomass N (Nmic), and enzymes activity of arginase and β-glucosidase are shown in Table 8. As can be seen from the results in Table (8), the microbial biomass C, microbial biomass N, and enzymes activity of arginase and β-glucosidase were increased as a result of increasing the application rate of white CKD from 0.0 up to 16 g kg^{-1} when compared to those of the untreated soil (control treatment). In contrary; when the application rate of white CKD was increased from 16 to 20 g kg^{-1}, the above-mentioned soil biological properties were decreased. In the case of treating the soil with the black CKD, increasing the application rate of black CKD from 0.0 up to 20 g kg^{-1} decreased the above-mentioned soil biological properties when compared to those of the unamended soil. It can be observed from the data in Table (8) that amending the soil with the black CKD has a negative effect on the microbial biomass C, microbial biomass N, and enzymes activity of arginase and β-glucosidase. This negative effect of black CKD on the microbial biomass C, microbial biomass N, and enzymes activity of arginase and β-glucosidase is directly related with the chemical characteristics of the black CKD (Table, 2). Those findings are in agreement with the results obtained by **(Ocak et al., 2004; Arul and Nelson, 2015;** and **Amani et al., 2018)**.

Table (8) Microbial biomass C and N and enzyme activity in the soils amended with white and black CKDs.

CKD treatments (g kg^{-1})		Microbial biomass			Enzyme activity	
		C_{mic} (mg kg^{-1})	N_{mic} (mg kg^{-1})	C_{mic}: N_{mic} ratio	Arginase (mg NH_4-N kg^{-1} soil $2h^{-1}$)	β-glucosidase (mg *p-nitro phenol* kg^{-1} h^{-1})
Control		**85.0**	**49.0**	**1.7**	**45.6**	**37.8**
White CKD	**4**	88.0	54.0	1.6	50.2	41.3
	8	112.0	66.0	1.7	61.5	47.4
	12	145.0	83.0	1.7	69.8	55.4
	16	177.0	103.0	1.7	77.4	66.8
	20	167.0	95.0	1.8	71.8	59.1
Black CKD	**4**	83.0	45.0	1.8	44.3	36.4
	8	80.0	44.0	1.8	41.8	34.8
	12	79.0	40.0	2.0	37.6	30.2
	16	70.0	34.0	2.1	32.2	24.3
	20	62.0	30.0	2.1	28.4	19.7

The decrease in the microbial biomass C, microbial biomass N, and enzyme activity of arginase and β-glucosidase due to increasing the application rate of white CKD from 16 to 20 g kg^{-1} and increasing the application rate of black CKD from 0.0 up to 20 g kg^{-1} may be explained by: (1) the high value of electrical conductivity of white CKD (7.99 dS m^{-1}) and black CKD (14.28 dS m^{-1}) and (2) the concentration of lead, nickel, and cadmium in the white and black CKDs as was provided in Table (2), suggesting that the use of white and black CKDs in the agricultural applications such as a soil amendment and a fertilizer material may cause a soil salinity build up and may affect the surrounding ecosystem. The results are in harmony with the findings of ***Bilen et al. (2019)***.

The value of microbial biomass carbon in the amended soil with the white CKD ranged from 85.0 to 177.0 mg kg^{-1}, however, it ranged from 62.0 to 85.0 mg kg^{-1} in the amended soil with the black CKD. The value of microbial biomass nitrogen in the amended soil either with the white or the black CKD ranged from 49.0 to 103.0 and from 30.0 to 49.0 mg kg^{-1}, respectively.

The highest value of microbial biomass C, microbial biomass N, and enzyme activity of arginase and β-glucosidase (177.0 mg kg^{-1}, 103.0 mg kg^{-1}, 77.4 mg NH_4-N kg^{-1} soil $2h^{-1}$, and 66.8 mg *p-nitro phenol* kg^{-1} h^{-1}, respectively) were obtained when the soil was treated with 16 g kg^{-1} of white CKD. From the view point of the importance of microbial biomass and soil enzyme activity for the soil health, ***Moustafa et al. (2018)*** pointed out that the most commonly used biological indicators for the microbial activity and soil health are microbial biomass and soil enzymes activity.

Impact of applying the white and black CKDs to the soil on the maize crop

Maize growth (maize health)

The maize growth was improved due to application of the white and black CKDs to the sandy loam soil as it resulted in an increase in the plant height and fresh and dry weight of maize plants. Increasing the application rate of white CKD from 0.0 up to 16 g kg^{-1} and increasing the application rate of black CKD from 0.0 up to 12 g kg^{-1} significantly increased the plant height and fresh and dry weight of maize plants ($p \leq 0.05$) when compared to those of the untreated soil (control treatment) as shown in Table (9). In contrary; when the application rate of white CKD was increased from 16 to 20 g kg^{-1} and when the application rate of black CKD was increased from 12 up to 20 g kg^{-1}, the plant height and fresh and dry weight of maize shoots were significantly decreased ($p \leq 0.05$). The improvement in the plant height and fresh and dry weight of maize shoots when the soil was treated with the white CKD was better than that when the soil was treated with the black CKD. This result may be because of the white CKD was approximately in the neutral pH (pH 6.89) (Table, 2). This improvement in the maize growth may be interpreted by the beneficial effects of white and black CKDs which may be useful as: (1) a soil amendment, in which they improve the physical, chemical, and biological properties of the studied sandy loam soil and (2) a fertilizer material, in which they are a source of macro and micro nutrients necessary for the growth and development of the maize plants. The results are in harmony with the findings of many authors. The results are in harmony with the findings of (***Dollhopf and Mehlenbacher, 2002; Adaska and Taubert, 2008; Uysal et al., 2012;*** *and* ***Morsy et al., 2019)***.

Table (9) Impact of applying the white and black CKDs to the sandy soil on some vegetative growth parameters of maize and water use productivity by the maize plants.

CKD treatment ($g\ kg^{-1}$)	Plant height (cm)	Fresh weight (g/pot)	Dry weight (g/pot)	Water consumptive use (l/pot)	Water use productivity (g/l)

Control		**35.31^{f}**	**149.57^{f}**	**25.25^{f}**	**3.48^{a}**	**42.98^{f}**
White CKD	**4**	36.97^{e}	156.24^{e}	27.61^{e}	3.46^{a}	45.16^{e}
	8	38.15^{d}	161.23^{d}	28.26^{d}	3.46^{a}	46.60^{d}
	12	43.13^{c}	182.82^{c}	30.60^{c}	3.38^{a}	54.09^{c}
	16	47.38^{a}	199.86^{a}	34.83^{a}	3.36^{a}	59.48^{a}
	20	45.30^{b}	186.45^{b}	32.50^{b}	3.33^{a}	55.99^{b}
	Mean	**41.04**	**177.70**	**29.84**	**3.41**	**50.72**
Black CKD	**4**	36.01^{f}	152.31^{ef}	26.26^{ef}	3.47^{a}	43.89^{ef}
	8	37.76^{d}	159.73^{d}	27.54^{de}	3.47^{a}	46.03^{d}
	12	41.11^{cd}	173.88^{cd}	29.98^{cd}	3.47^{a}	50.11^{g}
	16	38.01^{d}	160.78^{d}	27.72^{de}	3.45^{a}	46.60^{d}
	20	36.0^{f}	158.50^{de}	27.00^{g}	3.44^{a}	46.08^{d}
	Mean	**37.37**	**159.13**	**27.29**	**3.46**	**45.95**
LSD at level 5%		**0.92**	**2.11**	**0.56**	**0.14**	**1.01**

The decrease in the plant height and fresh and dry weight of maize plants by increasing the application rate of white CKD from 16 to 20 g kg^{-1} and increasing the application rate of black CKD from 12 up to 20 g kg^{-1} may be due to: (1) the high value of electrical conductivity of white CKD (7.99 dSm^{-1}) and black CKD (14.28 dS m^{-1}) and (2) the concentration of lead, nickel, and cadmium in the white and black CKDs as summarized in Table (2), implying that the use of white and black CKDs in the agricultural applications such as a soil amendment and a fertilizer material may cause a soil salinity build up and may affect the surrounding ecosystem. The results are in consistent with those reported by several researchers (**Kloke et al., 1984; Dollhopf and Mehlenbacher, 2002; Pourrut et al., 2011;** and **Bhalerao et al., 2015).**

Water consumptive use and water use productivity by the maize plants

The water use productivity by the maize plants was improved due to application of the white and black CKDs to the sandy loam soil as it resulted in an increase in the water use productivity by the maize plants. Increasing the application rate of either the white CKD or the black CKD from 0.0 up to 20 g kg^{-1} slightly decreased the water consumptive use by the maize plants when compared to that of the untreated soil (control treatment) as listed in Table (9). Increasing the application rate of white CKD from 0.0 up to 16 g kg^{-1} and increasing the application rate of black CKD from 0.0 up to 12 g kg^{-1} significantly increased the water use productivity by the maize plants ($p \leq 0.05$) when compared to that of the untreated soil (control treatment). In contrast; when the application rate of white CKD was increased from 16 to 20 g kg^{-1} and when the application rate of black CKD was increased from 12 to 20 g kg^{-1}, the water use productivity by the maize plants was significantly decreased ($p \leq 0.05$). The improvement in the water use productivity by the maize plants when the soil was treated with the white CKD was better than that when the soil was treated with the black CKD. The results are in agreement with those reported by many authors (***Morsy et al., 2019; Rahman et al., 2011; Schreiber et al., 1998; Naik et al., 2003; and Miller and Azad, 2000***).

The highest value of plant height, fresh and dry weight of maize plants, and water use efficiency by the maize plants (47.38 cm, 199.86 g/pot, 34.83 g/pot, 10.37 g/l, respectively) were recorded when the soil was treated with 16 g kg^{-1} of white CKD. Whereas, the lowest value of plant height, fresh and dry weight of maize plants, and water use productivity by the maize plants (35.31 cm, 149.57 g/pot, 25.25 g/pot, and 59.48 g/l, respectively) were recorded when the soil was untreated either with the white CKD or the black CKD.

Accumulation of lead, nickel, and cadmium in the maize plants

It can be observed from the results in Table (10) that increasing the application rate of either the white CKD or the black CKD from 0.0 up to 20 g kg^{-1} significantly increased the concentration of lead, nickel, and cadmium in the maize plants ($p \leq 0.05$) when compared to that of the untreated soil. The results are in accordance with those reported by many authors **(*Kloke et al., 1984 and Bhalerao et al., 2015*)**

The concentration of lead, nickel, and cadmium in the maize plants as a result of applying the black CKD to the soil was higher than that in the maize plants when the soil was treated with the white CKD. This result may be interpreted by that the lead, nickel, and cadmium concentration of black CKD was higher than that of white CKD (Table, 2).

The highest value of lead, nickel, and cadmium concentration in the maize plants (0.53, 0.31, and 0.21 mg kg^{-1}) was obtained when the soil was treated with 20 g kg^{-1} of the black CKD.

Table (10) Impact of applying the white and black CKDs to the soil on accumulation of lead, nickel, and cadmium in the maize shoots.

CKD treatment (g kg^{-1})		Concentration in the maize plants (mg kg^{-1})			Uptake by the maize shoots (µg/pot)		
		Pb	**Ni**	**Cd**	**Pb**	**Ni**	**Cd**
White CKD	**Control**	**0.28^{d}**	**0.17^{e}**	**0.07^{g}**	**7.10^{b}**	**4.30^{c}**	**1.80^{e}**
	4	0.30^{c}	0.19^{d}	0.08^{f}	8.30^{b}	5.20^{c}	2.20^{e}
	8	0.35^{c}	0.21^{c}	0.11^{d}	9.90^{b}	5.90^{c}	3.10^{d}
	12	0.40^{b}	0.23^{c}	0.14^{c}	12.20^{a}	7.00^{c}	4.30^{c}
	16	0.40^{b}	0.26^{b}	0.16^{bc}	13.90^{a}	9.00^{b}	5.60^{b}
	20	0.40^{b}	0.29^{a}	0.20^{a}	13.00^{a}	10.30^{a}	6.50^{a}
	Mean	**0.36**	**0.23**	**0.13**	**10.70**	**7.00**	**3.90**
Black CKD	**4**	0.34^{c}	0.22^{c}	0.10^{e}	8.90^{b}	5.80^{c}	2.60^{e}
	8	0.38^{c}	0.23^{c}	0.12^{d}	10.40^{b}	6.30^{c}	3.30^{d}
	12	0.43^{b}	0.25^{c}	0.15^{c}	12.90^{a}	7.50^{c}	4.50^{c}
	16	0.47^{b}	0.28^{b}	0.18^{b}	13.00^{a}	7.80^{bc}	5.00^{f}
	20	0.53^{a}	0.31^{a}	0.21^{a}	14.30^{a}	8.40^{b}	5.70^{b}
	Mean	**0.41**	**0.24**	**0.14**	**11.10**	**6.70**	**3.80**
LSD at 5% level		**0.04**	**0.02**	**0.01**	**2.1**	**1.1**	**0.5**

It is clear from the results in Table (10) that increasing the application rate of either the white CKD or the black CKD from 0.0 up to 20 g kg^{-1} significantly increased the uptake of lead, nickel, and cadmium by the maize plants ($p \leq 0.05$) when compared to that of the untreated soil with the exception of that when the application rate of white CKD was increased from 16 to 20 g kg^{-1}, the uptake of lead by the maize plants was decreased. Similar results were reported by several researchers (***Kloke et al., 1984; Lafond and Simard, 1999; Martin and Griswold, 2009;*** *and* ***Bhalerao et al., 2015****)*.

Concerning the health risk assessment of lead, nickel, and cadmium concentration in the maize shoots; all the values of lead, nickel, and cadmium concentration in the maize shoots shown in Table (10) were compared with the guidelines of ***WHO/FAO (1976)*** and the guidelines of ***Awashth*i (2000)** as presented in Tables (11) and (12), respectively. The values of lead, nickel, and cadmium concentration in the maize shoots were below the allowable levels proposed by the guidelines of ***WHO/FAO*** **(1976)** and the guidelines of ***Awashthi* (2000)**. The values of lead, nickel, and cadmium concentration are within the normal range of lead, nickel, and cadmium concentration in foods and vegetables according to the guidelines of ***WHO/FAO* (1976)**. This result implies that there was no distinct accumulation of lead, nickel, and cadmium in the maize shoots; implying that these metals have no risk, does not make a concern, and could not affect the human and animal health through the three primary routes namely inhalation, ingestion, and skin absorption.

Table (11) WHO/FAO guidelines for metals in foods and vegetables [Adapted from FAO/WHO (1976)].

Heavy metal	WHO/FAO	Normal range in plant (mg/kg)
Lead Pb	2.00	0.50 – 30.00
Nickel Ni	-----	0.02– 50.00
Cadmium Cd	1.00	< 2.40

Table (12) Guidelines for the Indian standards for heavy metals in the soil, food, and drinking water [Adapted from Awashthi (2000)].

Heavy metal	Soil (mg/kg)	Food (mg/kg)	Water (mg/l)
Pb	250 – 500	2.5	0.10
Ni	75 – 150	1.5	-----
Cd	3.0 – 6.0	1.5	0.01

4. CONCLUSIONS

From the obtained results, the following conclusion could be made:

1- The white and black CKDs contained low levels of lead and nickel, while, they contained relatively higher level of cadmium. The white and black CKDs are considered to be safe by-product materials in terms of the pH and content of lead and nickel, however; they are potentially hazard in terms of the salinity build up in the soil.

2- Increasing the application rate of either the white or black CKDs from 0.0 up to 20 g kg^{-1} significantly increased the electrical conductivity of the soil, slightly increased the soil pH of soil treated with the white and black CKDs, and significantly increased the concentration of lead, nickel, and cadmium in the soil at 65 days from the maize cultivation.

The microbial biomass C and N and enzyme activity of arginase and β-glucosidase were increased as a result of increasing the application rate of white CKD from 0.0 up to 16 g kg^{-1}. Increasing the application rate of black CKD from 0.0 up to 20 g kg^{-1} decreased the above-mentioned soil biological properties.

3- The plant height, fresh and dry weight of maize plants, and water use productivity by the maize plants were improved due to application of either the white or black CKDs to the sandy loam soil. The improvement in the plant height, fresh and dry weight of maize plants, and water use productivity by the maize plants when the soil was treated with the white CKD was better than that when the soil was treated with the black CKD.

4- The health risk assessment of lead, nickel, and cadmium concentration in the maize plants indicated that their concentration values are below the allowable levels in the food, which are proposed by two international guidelines.

As a final recommendation related to the quality evaluation and management of white and black CKDs for use as a soil amendment and a fertilizer material, it is applicable to use the white CKD only at the application rate of 16 g kg^{-1} (16 Mg $feddan^{-1}$) for crops grown in the sandy soils except the tuber, root, and salt sensitive crops under the conditions of El-Minia Governorate, Egypt. It should be emphasized that to use the white CKD in a safe manner in the agricultural purposes, apply it once only to avoid its hazard and drastic impacts.

. REFERENCES

Abd El-Aleem, S.; Abd El-Aziz, M. A.; Heikal, M.; and El-Diadmony, H. (2005). Effect of cement kiln dust substitution on chemical and physical properties and compressive strength of Portland and slag cements. The Arabian Journal for Science and Engineering, Vol. 30, No. 2B, pp. 263-273.

Abd El-Azeim, M. A.; W. S. Mohamed and A. A. Hammam (2016). Soil physiochemical properties in relation to heavy metals status of agricultural soils in el-minia governorate, Egypt. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 7 (6): 423 - 431, 2016.

Abo Shelbaya, M. M.; M. M. Abd El-Azeim1; A. M. Menesi and M. M. Abd El-Mageed (2021). Heavy Metals and Microbial Activity in Alluvial Soils Affected by Different Land-Uses. J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol. 12 (3):165-177, 2021. DOI: 10.21608/jssae.2021.158670

Adaska, W. S. and Taubert, D. H. (2008). Beneficial uses of cement kiln dust. Presented at 2008 IEEE/PCA 50th Cement Industry Technical Conf., Miami, FL, May 19-22, 2008, pp. 1-19.

Amani, J., Kishore Babu, G.; Lakshmipathi, R.; Ramachandra Rao, G.; and Chandrasekhar, K. (2018). Effect of cement dust deposition on soil microbial properties. Int. J. Curr. Microbiol. App. Sci, 7 (10), pp. 1230-1234.

Arul, A. and Nelson, R. (2015). Effect of cement dust pollution on morphology and photosynthetic pigments of some legume plants grown in Ariyalur district, Tamil Nadu. Int. J. Adv. Multidiscip Res., 2 (12), pp.59-65.

Awashthi, S. K. (2000). Prevention of food adulteration Act No. 37 of 1954. Central and State Rules as Amendment for 1999. IWD Edition. Ashoka Law House, New Delhi [Cited from: Sharma and Agrawal (2005). Journal of Environmental Biology, 26 (2 supp1), pp. 301-313].

Bhalerao, S. A.; Sharma, A. S.; and Poojari, A. C. (2015). Toxicity of nickel in plants. International Journal of Pure and Applied Bioscience, 3 (2), pp. 345-355.

Bilen, S.; Bilen, M.; and Turan, V. (2019). Relationships between cement dust emissions and soil properties. Pol. J. Environ. Stud, 28 (5), pp. 3089-3098.

Daous, M. A. (2002). Recovery of potassium salts from kiln dust of local cement plants. The 6th Saudi Engineering Conference, KFUPM, Dhahran, December 2002, Vol. 2, pp. 473-485.

Dollhopf, D. J. and Mehlenbacher, J. T. (2002). Alkaline industrial by-product effects on plant growth in acidic-contaminated soil system. National Meeting of the American Society for Surface Mining and Reclamation, Lexington, KY June 9-13, 2002, pp. 568-581.

Dong, J.; Mao, W. H., Zhang, G. P; Wu, F. B., and Cai, Y. (2007). Root excretion and plant tolerance to cadmium toxicity: a review. Plant Soil Environ., 53, 2007 (5), pp. 193-200.

Eivazi F. and Tabatabai, M. A. (1990). Factors affecting glucosidases and galactosidases activities in soils. Soil Biol. Biochem., 22, pp. 891-897. DOI:10.1016/0038-0717(90)90126-K.

Elbaz, A. A.; Aboulfotoh, A. M.; Dohdoh, A. M.; and Wahba, A. M. (2019). Review of beneficial uses of cement kiln dust (CKD), fly ash (FA) and their mixture. Journal of Materials and Environmental Sciences, 2019, Volume 10, Issue 11, Page 1062-1073. Online: available at: http://www.jmaterenvironsci.com.

EPA, U. S. Environmental Protection Agency (1993). Report to Congress on cement kiln dust. Volume II:Methods and findings, December 1993, U. S. Environmental Protection Agency, Office of Solid Waste, Washington, D.C. EPA-530-R-84-001 [Cited from: Kunal et al. (2012). Resources, Conservation and Recycling 61, pp. 59-68, Elsevier. Contents lists available at SciVerse Science Direct. Journal homepage:www.elsevier.com/locate/resconrec].

FAO/WHO (1976). List of maximum levels recommended for contaminants by the joint FAO/WHO codex Alimentarias Commission. 2nd series, CAC/FAL, 1976, 3, pp. 1- 8 [Cited from: Opaluwa et al. (2012). Advances in Applied Science Research, Pelagia Research Library, 2012, 3 (2), pp. 780-784. Online: available at the website: www.pelagiaresearchlibrary.com].

Horwath, W. R. and Paul, E. A. (1994). Microbial biomass. In: R. W. Weaver, G. S. Angel, P. S. Bottomley (eds.). Part 2: Methods of soil analysis, Soil Sci. Soc. Am., Madison, WI.

Jackson, M. L. (1973). Methods of chemical analysis. Prentic Hall, Englewood Cliffs, N. T. J.

Jenkinson, D. S. (1988). The determination of microbial biomass carbon and nitrogen in soil. In: J. R. Wilson (ed.). Advances in nitrogen cycling in agricultural ecosystems. CAB International, Wallingford, p. 368-386.

Keeney, D. R. and Nelson, D. W. (1982). Nitrogen inorganic forms. In: Page, A. L.; Miller, R. H.; and Keeney, D. R. (eds.) (1982). Part 2: Chemical and biological properties. Agronomy 9, 2nd edition, Am. Soc. Agron., Madison, Wisconsin, USA, p. 642-698.

Kloke, A.; Sauerbeck, D. R.; and Vetter, H. (1984). The contamination of plants and soils with heavy metals and the transport of metals in terrestrial food chains. Changing metal cycles and human health (editor: I. O. Nriagu), pp. 113-141. Dahlem Konferenzen 1984. Berlin, Heidelberg, New York, Tokyo: Springer Verlag.

Kumpulainen, I.; Raittila, A. M.; Lehto, I.; and Koiristoinen, P. (1983). Electro thermal Atomic Absorbtion Spectrometric determination of heavy metals in foods and diets. J. Associ. Off. Anal. Chem., 66, pp. 1129-1135.

Kunal; Siddique, R.; and Rajor, A. (2012). Use of cement kiln dust in cement concrete and its leachate characteristics: Review. Resources, Conservation and Recycling 61, pp. 59-68, Elsevier. Contents lists available at SciVerse Science Direct. Journal homepage: www.elsevier.com/locate/resconrec.

Lafond, J. and Simard, R. R. (1999). Effect of cement kiln dust on soil and potato crop quality. American Journal of Potato Research, Vol. 75, pp. 83-90.

Maclean, K. S.; Polunson, A, R.; and MacConnell, H. M. (1987). The effect of sewage sludge on the heavy metals content of soils and plant tissue. Commun. Soil Sci. Plant Anal. 18, pp. 1303-1316.

Mandal, A. and Voutchkov, M. (2011). Heavy metals in soils around the cement factory in Rockfort, Kingston, Jamaica. International Journal of Geosciences, 2, pp. 48-54. Scientific Research.

Martin, S. and Griswold, W. (2009). Human health effects of heavy metals. Environmental Science and Technology Briefs for Citizens, Center for Hazardous Substance Research (CHSR), Kansas State University, Issue 15, March 2009, pp. 1-6.

Mathieu, C. and Pieltain, F. (2003). Chemical analysis of soils. Selected methods, France, pp. 3

Miller, G. A. and Azad, S. (2000). Influence of soil type on stabilization with cement kiln dust. Construction and Building Materials, Vol. 14, pp. 89-97 [Cited from: Naik et al. (2003). Center for by-products utilization, report No. CBU-2003-35, REP-529, September 2003, a CBU report for Holcim (US), College of Engineering and Applied Science, the University of Wisconsin, Milwaukee, pp. 1-33].

Morsy, M. A.; El-Dawwy, G. M.; Hassan, H. A.; and Mohammed, K. H. (2019). The residual effect of the modified white CKD on peas plants grown in sandy soil. ACTA SCIENTIFIC AGRICULTURE, Volume 3, Issue 7, July 2019, pp. 134-139.

Moustafa, Y.; Hammam, A.; and Haddad, S. (2018). Potassium humate application and cutting immature flowers affect soil properties: Microbial activity and Jerusalem artichoke yield components. Journal of Soil Sciences and Agricultural Engineering, 9 (1), pp. 33-41.

Mulvaney, R. L. (1996). Nitrogen inorganic iorms. In: Sparks D. L. et al. (Eds.). Methods of Soil Analysis. Part 3: Chemical Methods, ASA and SSSA, Madison, pp. 1123-1184.

Naik, T. R.; Canpolat, F.; and Chun, Y. (2003). Uses of CKD other than for flue gas desulfurization. Center for by-products utilization, a CBU Report for Holcim (US), report No. CBU-2003-35, REP-529, September 2003, College of Engineering and Applied Science, the University of Wisconsin, Milwaukee, pp. 1-33.

Ocak, D.; Sulun, Y.; and Hasenekoglu, I. (2004). The effect of cement dust emitted from Gaziantep cement plant on micro fungus flora of surroundings soils, Turkey. Trakya Univ. J. Sci. 5, pp. 107-115.

Olowoyo, J. O.; van Heerden, E.; Fischer, J. (2013). Trace metals concentrations in soil from different sites in Pretoria, South Africa. Sustainable Environment Research, 23, 93, 2013.

Olowoyo, J. O.; Mugivhsa, L. L.; and Busa, N. G. (2015). Trace metals in soil and plants around a cement factoryin Pretoria, South Africa. Pol. J. Environ. Siud. Vol. 24, No. 5, pp. 2087-2093.

Page, A. L.; Miller, R. H.; and Keeney, D. R. (eds.) (1982). Methods of soil analysis. Part 2: Chemical and biological properties. Agronomy 9, 2nd edition, Am. Soc. Agron., Madison, Wisconsin, USA.

Pourrut, B.; Shahid, M.; Dumat, C.; Winterton, P.; and Pinelli, E. (2011). Lead uptake, toxicity, and detoxification in plants. Reviews of Environmental Contamination and Toxicology, Springer Verlag, Vol. 213, pp. 113-136. ISSN 0179-5953. Online: available at: https://hal.archives-ouvertes.fr/hal-00717188.

Rahman, M. K.; Rehman, S.; and Al-Amoudi, O. S. B. (2011). Literature review on cement kiln dust usage in soil and waste stabilization and experimental investigation. IJRRAS, Vol. 7, Issue 1, April 2011, pp. 77-87. Web Site: www.arpapress.com/Volumes/Vol7Issue1/IJJRAS_7_1_12.pdf.

Schreiber, R. J.; Smeeak., S. D.; and Shreiber, Y. (1998). Acceptable approaches for beneficial use of cement kiln dust. Waste combustion in boilers and industrial furnaces specialty conference, Air and Waste Management Association, Pittsburgh, PA, USA, 15-17 April, pp. 105-118 [Cited from: Rahman et al. (2011). IJRRAS, Vol. 7, Issue 1, April 2011, pp. 77-87].

Scianna, J. (2002). Salt-affected soils: Their causes, measure, and classification. Hort. Note No. 5, Plant Materials Program, pp. 1-3.

Shnizai, Z. (2012). Contaminated land assessment and recommended remediation. Dockland site report, Contaminated Land Remediation Company, Research Gate. Online available at: https://www.reserchgate.net/publication/325713383. Access date: 8 September 2019

Siti Norbaya, M. R.; Hasan, S.; Kamal, M. L.; and Hashim, N. S. M. (2014). Analysis and pollution assessment of heavy metal in soil, Perlis. The Malaysian Journal of Analytical Sciences, Vol. 18, No. 1, pp. 155-161.

Sonon, L. S.; Saha, U.; and Kissel, D. E. (2015). Soil salinity: Testing, data interpretation and recommendations. UGA Cooperative Extension Circular 1019, October 2015, pp. 1-6.

Tabatabai, M. A. (1994). Soil enzymes. In: R. W. Weaver, J. S. Angle, P. S. Bottomley. (eds.). Part 2: Methods of soil analysis: Microbiological and biochemical properties. Soil Sci. Soc. Am., Madison, WI., p. 775-833.

USDA, United States Department of Agriculture (2000). Heavy metal soil contamination. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), Soil Quality-Urban Technical Note No. 3, September 2000, pp. 1-7.

Uysal, I.; Ozdilek, H. G., and Ozturk, M. (2012). Effect of kiln dust from a cement factory on growth of *Vicia faba* L. Journal of Environmental Biology, 32, April 2012, pp. 525-530.

Vance, E. D.; Brookes, P. C.; and Jenkinson, D. S. (1987). An extraction method for measuring soil microbial biomass C. Soil Biol. Biochem., 19, pp. 703-707.

Waly, T. A.; Dakroury, A. M.; Sayed, G. E.; and El-Salam, S. A. (2007). Assessment removal of heavy metals ions from wastewater by cement kiln dust (CKD). Eleventh International Water Technology Conference, IWTC11 2007 Sharm El-Sheikh, Egypt, pp. 879-893.

Wu, J.; Joergensen, R. G.; Pommerening, B.; Chaussod, R.; and Brookes, P. C. (1990). Measurement of soil microbial biomass C by fumigation extraction-an autoclaved procedure. Soil Biol. Biochem., 22, pp. 1167-1169.

امكانية استخدام تراب فرن الاسمنت لتحسين صحة التربة الرملية ولتحسين اداء الذرة

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ملخص البحث

فى عديد من دول العالم، اقترح عديد من الباحثين استخدام تراب فرن الاسمنت كمحسن للتربة و كمصدر للعناصر الغذائية لتحسين اداء "نمو و تطور" المحصول.

أجريت تجربة اصص فى صوبة قسم علوم الاراضى، كلية الزراعة، جامعة المنيا، لبحث تأثير إضافة كل من تراب فرن الأسمنت الأبيض والأسود المضاف بستة معدلات (صفر، 4، 8 ،12 ، 16 ، 20 جرام/ كجم) للتربة الرملية على بعض الخواص الكيميائية و البيولوجية للتربة و النمو و المكونات الكيميائية لنباتات الذرة النامية بها.

وبينت النتائج المتحصل عليها أن كل من تراب فرن الاسمنت الابيض والاسود يتكون اساسا من اكسيد الكالسيوم و اكسيد السيلكون بالرغم من ان خصائصهم الكيميائية مختلفة تماما.

و تعتبر الترب سواء المعاملة بتراب فرن الاسمنت الابيض او الاسود قليلة الملوحة جدا، معتدلة القلوية، و لا تزال فى مستوى امن من الرصاص و النيكل و الكادميوم. و قد ادى تحسين التربة بزيادة معدل تراب فرن الاسمنت الابيض من صفر إلى 16 جرام/كجم إلى زيادة الكتلة الحيوية الميكروبية للكربون و النيتروجين و كذلك النشاط الانزيمى للارجينيز و بيتا-جلوكوسيداز.

وقد سجلت اعلى قيمة لطول النبات والوزن الطازج والجاف لنباتات الذرة وكذلك كفاءة استعمال نباتات الذرة للمياه عند معاملة التربة بتراب فرن الاسمنت الابيض بمعدل 16 جرام/كجم. ولا يوجد تراكم واضح للرصاص والنيكل والكادميوم فى نباتات الذرة.

ومن الناحية التطبيقية، يمكن استعمال تراب فرن الاسمنت الابيض فقط بمعدل 16 جرام/كجم (16 طن/فدان) للمحاصيل النامية فى الاراضى الرملية تحت ظروف محافظة المنيا - مصر.