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Investigation of Physico Chemical Parameters of Potentials of Selected Jatropha Species under Cement Kiln Waste Soil Treatments

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Abstract

Soil Physico chemical properties is a dynamic and complex natural resources that plays a crucial role in supporting life on earth. Soil scientist and farmers use these soil physico chemical parameters to make informed decisions about soil contamination to aid land use, soil improvement practices and crop selection. The study aimed at ameliorating physico chemical parameters of soil treated with cement waste and remediation potentials of three *Jatropha* species namely *J. gossipifolia, J. podagrica and J. curcas.* A 3 x 4 factorial complete randomized design replicated 8 times pot experiment was laid out. The soil treatments composition consist: T_0 (30kg undisturbed soil and 0kg cement waste), T_1 (30kg undisturbed soil and 1kg cement waste), T_2 (30kg undisturbed soil and 2kg cement kiln waste), T_3 (30kg undisturbed soil and 3kg cement waste). After 4 month growth period ninety six (96) soil and plants samples harvested for soil texture, pH, electric conductivity, cation exchange capacity, and soil organic matter. Soil physico chemicals were analysed before and re-analyzed after Phtoremediation. Data obtained in duplicates were subjected to two-way statistical ANOVA and mean values separated using LSD at 95% confidence limit. Results of pre investigation kiln waste soil physico-chemical reveals that most *Jatropha* plants thrive in slightly acidic to neutral soils with a pH range of 6.0 to 7.5. Soil with electric conductivity below 0.4 Ms/cm are normally considered marginally or non-saline whereas soils above 0.8Ms/cm are considered strictly saline. Post soil physico-chemical investigation reveals clay soil generally have a higher CEC compared to sandy soil. The cement waste which is highly alkaline gives rise to high pH values. High EC values indicates excess salts affecting plant growth. Monitoring soil physico-chemical is crucial in agricultural settings to prevent salinity issue, particularly in arid regions that can lead to salty accumulation.

Keywords: *Jatropha*; Soil Physico- Chemical; Cement kiln waste; Phytoremediation

Introduction

Cement factory can significantly impact the physicochemical properties of the soil and water through the release of various contaminants. The emissions from these facilities often include heavy metals such as cadmium lead and chromium etc. as well as pollutants like sulphur dioxide and particulate matter. These contaminants can accumulate in soil, altering its composition and reducing fertility. Dust from cement and other factories leads to considerable changes in pH and accumulation of emitted metals in soil which may affect both the composition and physiological processes of microorganisms leading to a reduction in microbial biomass and enzymatic activities [3]. The cement dust particles can enter the soil as dry, humid or occult deposits and then demoralise its physico chemical; properties [13]. Similar studies that emphasizes on adverse impact of cement dust pollution on soil quality have also been reported in Saudi Arabia [14]. Iran [6] and Jaimaca [12]. Understanding soil physico chemical parameters is necessary for sustaining agriculture, environmental conservation, and ecosystem management regular monitoring and assessment of these parameters contribute to the development of effective soil management strategies, ensuring the long term productivity and health of our vital soil resources. These parameters provide valuable insights into the soil ability to support plant growth, nutrient availability and overall ecosystem health, some of the soil physicochemical parameters include: Soil pH, Cation Exchange Capacity, Electric Conductivity, Organic matter, Soil structure. The removal of soil contaminants using plants with inherent potentials is largely called phytoremediation. It is an in situ environmentally friendly and long-lasting approach that required no particular tools [11]. Several plants species have been reported for their ability to absorb and store pollutants into their tissues metabolism, one of such plants belong to the genus "*Jatropha*". *Jatropha* belongs to the Euphorbiaceae family; it has wide topographical spread and is made up of over 170 species of herbaceous perennials, shrub, and ornamental woody trees. It is broadly dispersed within the tropic and subtropical locals, particularly in Africa and South America [11]. A few known *Jatropha* species have been detailed for their phytoremediation abilities namely, *Jatropha curcas*, *Jatropha podagrica*, *Jatropha gossypifolia*, and *Jatropha multifida*, among others [13]. Some studies have investigated toxic uptake from contaminated growth media in *Jatropha* species. These contaminants can accumulate in soil, altering its physico-chemical composition and reducing fertility [12].

Materials and Methods

Experimental Design

The pot experiment was conducted at the Biological garden (Botany Department of Joseph Sarwuan Tarkaa University Makurdi (JOSTUM). The seeds of *Jatropha curcas, Jatropha gossypifolia* and *Jatropha podagrica* were sourced locally in Benue State, Nigeria. The *Jatropha* seeds and plants were validated at the Botany and Agronomy laboratory respectively. Soil samples within the depth of 0 - 15cm was collected randomly around the location with a soil auger at the dump site sited around the Cement Plant Gboko Benue state, Nigeria (7°18'N and 3°50'E) [1]. Coarse and other unwanted materials were removed from the soil samples before potting. Control (undisturbed soil) was sourced from around the experimental site. Samples from the waste site soil and control (undisturbed soil) were mixed, air dried, sieved with 2 mm mesh, followed by routine soil physico-chemical analysis using standard procedures. Seeds of *Jatropha curcas*, *Jatropha gossypifolia* and *Jatropha podagrica* were planted into a germination tray, seedlings of about 5cm, transplanted into polythene pots containing 30kg contaminated soil. The experiment was set up in a 3 × 4 factorial, arranged in complete randomized design (CRD) replicated 8 times. The soil treatments composition (T_0, T_1, T_2, T_3) consist: T_0 (30kg undisturbed soil and 0kg cement waste), T_1 (30kg undisturbed soil and 1kg cement waste), T_2 (30kg undisturbed soil and 2kg cement waste), T_3 (30kg undisturbed soil and 3kg cement waste). A total of 96 pots experiment used for the Soil Physico- chemical preliminary and post investigation.

Physico Chemical Analysis of Soil

Determination of pH

The pH of the soil was determined by using the soil to water of 1: 1

16.0g of the air dried ground soil sample was weighed into a 50 ml plastic beaker and 10ml of distilled water added, mixture stirred gently with a glass rod and allowed to stand undisturbed for 30minutes. Then the pH meter was calibrated using a buffer solution of pH 4.0, 7.0 and 10.0. Then electrode of the pH meter was inserted into the supernatant solution and the pH reading taken after 30seconds. The temperature was taken same time using a pH meter temperature probe.

Electric Conductivity (EC)

Each air dried soil of 100g was taken in a beaker and 25 ml of water added. The mixture stirred with a glass rod for 10 minute and allowed to stand for 30 minutes without disturbance. The soil allowed to settle down and the EC value measured by inserting an electrical conductivity meter into the supernatant solution. The electrical conductivity of the sample read directly and recorded in μ s/cm.

Determination of Cation Exchange Capacity of the soil

Cation exchange Capacity (CEC) was determined by the method described by [11]. 5 g of air-dried soil sample was taken in a centrifuge tube and 33ml of 1N sodium acetate solution was added into the centrifuge tube, and shaken for 5minutes, after which the stopper was removed immediately from the tube and centrifuge 300rmp until the supernatant liquid was cleared and decant. The 33ml of 95% ethanol was added to the stopper tube and shaken for 5 minutes the tube stopped and centrifuged until the supernatant is cleared and decant repeatedly three times. The absorbed sodium (Na^+) from the sample was replaced by extracting with three 33 ml portion of 1 N ammonium acetate solution. Each time shaken for 5 minutes and centrifuged until the supernatant liquid get cleared. The three supernatant liquids was poured into a 100 ml volumetric flask. The solution in the 100 ml standard measuring flask was made up to 100 ml. The flame photometer was calibrated with a standard sodium solution. The prepared solution was injected into the instrument and the readings recorded [11].

Calculation for cation exchange capacity in soil:

Where: A = total volume of the extract (ml)

Wt = weight of the air dry soil (g)

Determination of sand clay and silt in the soil

40 g air- dry soil (2mm) weighed into 60 ml beaker dispensing solution added. The beaker covered with watch glass and left overnight. This then transferred into a soil stirring cup and the cup filled to about three –quarters with water and stirred. The stirring paddle withdrawn and rinsed into a cup and allowed to stand for 1minutes then transferred into a 1 L calibrated cylinder (hydrometer jar) and brought to a volume with water. The blank will be determined by diluted 60ml dispensing solution into a 1 l hydrometer jar with water at temperature of 20 c, hydrometer inserted and reading recorded.

Determination of silt plus clay. After withdrawing the paddle, the hydrometer immediately inserted into the suspension and the reading taken within 40 seconds.

Percentage of silt + clay in soil:

$$\%[slit + caly](w/w) = \frac{(Rsc - Rb)100}{dry\ soil\ sample\ (g).}$$

Percentage of silt in soil

$$\%silt(w/w) = [\%silt + clay(w/w] - [\%clay(w/w)].$$

Determination of sand: after taken readings required for clay and silt, the suspension poured quantitatively through a 50mm sieve into a 50 beaker of known weight, the sand allowed in the beaker to settle and excess water decanted. The beaker with the sand dried overnight at 105^{Oc}, cooled in a desiccator and reweighed.

Percentage of sand in soil solution. % sand (w/w) = sand weight 100/dry soil sample (g).

Where, weight of sand followed from Sand weight (g) = [beaker + sand (g) – [beaker (g)].

Determination of organic matter: I g of soil weighted into 250 ml flask and 10 ml of $k_2cr_20_7$ was added using a pippete and then stirred. A 10 ml H_2so_4 added and flask stirred gently until the content mixed thoroughly. After which it was swirled more vigorously for one minute and allowed to stand for 30minutes. Then 100 ml of distilled added and allowed to cooling addition 4-5 drop of ferroin indicator added and titrated against iron (ii) ammonium sulfate. Blank determinations were similarly made and the percentage organic matter calculated (wadaje and Alemyehe 2014) using the following formular:

Where f =correctional factor =1.33, m =concentration of ferrous ammonium sulphate.

Statistical Analysis

Data obtained were subjected to two way analysis of variance (ANOVA) while significant treatment means were separated using LSD at 95% confidence limit.

Results

Table 1: Pre and Post Physico-Chemical Parameters Soil Investigation Treated with Cement Kiln Waste

Preliminary Soil Investigation								Post Soil Investigation						
Treatments	EC (µm/hos/cm)	CEC (meq/100g)	PH	Silt (%)	Clay (%)	Sand (%)	Organic Matter (%)	EC	CEC	PH	Silt (%)	Clay (%)	Sand (%)	Organic Matter (%)
T_0	0.260^c	5.700^c	6.533^a	21.667^a	7.633^a	59.033^b	11.667^a	0.386^c	0.433^a	8.100^b	7.893^a	7.100^b	75.366^a	9.667^d
T_1	0.353^b	6.533^b	6.600^a	12.400^b	7.333^a	73.933^a	6.333^b	0.390^b	0.420^b	7.567^d	7.833^b	7.067^c	74.667^b	10.000^c
T_2	0.413^b	7.300^a	6.433^a	10.667^b	7.067^a	76.600^a	5.667^b	0.389^b	0.410^c	7.600^c	7.300^d	7.533^a	73.433^c	11.333^b
T_3	0.527^a	7.633^a	6.400^a	14.000^b	7.567^a	71.767^a	6.667^b	0.403^a	0.406^d	8.013^a	7.709^c	7.533^a	71.599^d	12.999^a
LSD	0.064	0.721	1.244	7.160	1.694	9.740	3.412	0.002	0.002	0.001	0.002	0.002	0.002	0.001
Mean	0.388	6.790	6.490	14.700	7.400	70.300	7.580	0.392	0.417	7.850	7.684	7.308	73.767	11.000
SE	0.026	0.295	0.508	2.930	0.692	3.980	1.394	0.001	0.001	0.001	0.001	0.001	0.001	0.000

Results with the different superscript in the same row are significantly different using LSD at 95% confidence limit.

Preliminary soil investigation presented in Table1, electrical conductivity showed that T_3 recorded highest value of 0.527

(µm/hos/cm) followed by T_2 (0.04 µm/hos/cm) and T_1 (0.35 µm/hos/cm). Similar trend was observed on the effect of treatment on cation exchange capacity of sampled soils. Variations in cation exchange capacity showed that T_3 recorded the highest cation exchange capacity of 7.633 meq/100g, statistically more than cation exchange capacity of 6.600 meq/100g and 5.700 meq/100g recorded in T_1 and T_0 respectively. Differences in silt composition showed that the control treatment with percentage silt of 21.667 % varied significantly from all soils treated with various amounts of cement waste (T_1, T_2 and T_3) with lower percentage silts of 12.400 %. 10.667 % and 14.000 % respectively. Differences in sand composition however showed that the control treatment with lower percentage sand of 59.033 % varied significantly from all soils treated with various amounts of cement waste T_0 (30kg undisturbed soil and 0kg cement waste), T_1 (30kg undisturbed soil and 1kg cement waste), T_2 (30kg undisturbed soil and 2kg cement waste), T_3 (30kg undisturbed soil and 3kg cement waste) with higher percentage sands of 73.933 %. 76.600 % and 71.767 % respectively. Variations in organic matter showed that the control soil treatment T_0 was higher in organic matter content (11.667 %), significantly different from organic matter contents of 6.333 %, 5.667 % and 6.667 % recorded for T_1, T_2 and T_3 respectively. post soil investigation presented in Table 1 shows Significant differences in electrical conductivity showed that soils of T_3 recorded the highest electrical conductivity of (0.403 µm/hos/cm), statistically more than electrical conductivity of (0.386 µm/hos/cm), (0.390 µm/hos/cm) and (0.389 µm/hos/cm) recorded in post soil analysis of treatments T_2, T_1 and T_0 respectively. However, it was observed that the effect of treatment on cation exchange capacity of sampled soils revealed soils of T_3 recording the highest cation exchange capacity of (0.433 meq/100g), statistically more than cation exchange capacity of (0.420 meq/100g), (0.410 meq/100g) and (0.406 meq/100g) recorded in soils of T_1, T_2 and T_3 respectively. The effect of treatment on the pH from post soil investigation showed the higher pH values of 8.13 was recorded in soil of treatment T_3 and differed significantly from post soil pH values of 8.100, 7.567 and 7.600 recorded in soils of treatment T_0, T_1 and T_2 respectively. Differences in silt composition showed that the control treatment (T_0) with higher percentage silt of 7.893 % varied significantly from the lower percentage silt of 7.833 %, 7.300 % and 7.709 % recorded in soils treatments T_1, T_2 and T_3 respectively. Variations in the soil clay composition from post soil investigation showed that a significant higher percentage (7.533 %) was recorded in soils of Treatments T_2 and T_3, statistically more than those recorded in soils of treatments T_0 (7.100 %) and T_1 (7.067 %).

Table 2: *Jatropha* Spp on Physico- Chemical Parameters in Post Soil Investigation

Jatropha	EC	CEC	PH	Silt (%)	Clay (%)	Sand (%)	Organic Matter (%)
J. gossipifolia	0.389^{b}	0.418^{b}	7.775^{b}	7.920^{a}	7.175^{b}	72.575^{b}	11.750^{b}
J. curcas	0.402^{a}	0.428^{a}	7.675^{c}	7.507^{c}	6.600^{c}	77.776^{a}	8.000^{c}
J. podagrica	0.384^{c}	0.407^{c}	8.099^{a}	7.625^{b}	8.149^{a}	70.949^{c}	13.249^{a}
LSD	0.002	0.002	0.001	0.001	0.002	0.002	0.001
Mean	0.392	0.417	7.850	7.684	7.308	73.767	11.000
SE	0.001	0.001	0.000	0.001	0.001	0.001	0.000

Results with the different superscript in the same row are significantly different using LSD at 95% confidence limit.

Jatropha species on the physiochemical parameters examined in post soil investigation is presented in Table 2. Significant differences in electrical conductivity showed that soils planted with *J. curcas* recorded the highest soil electrical conductivity of (0.402 µm/hos/cm), statistically more than electrical conductivity of (0.389 µm/hos/cm) and (0.384 µm/hos/cm) recorded for soils planted with *J. gossipifolia* and *J. podagrica* respectively. Similar trend was observed on the effect of *Jatropha* on cation exchange capacity from post soil analysis. Variations in cation exchange capacity showed that soils planted with *J. curcas* recorded the highest cation exchange capacity of (0.428 meq/100g), statistically more than cation exchange of (0.418 meq/100g) and (0.407 meq/100g) recorded in soils planted with *J. gossipifolia* and *J. podagrica* respectively. The effect of *Jatropha* was also found to influence soil pH. Result post soil investigation showed that pH values were higher for soils planted with *J. podagrica*, significantly different from pH values of 7.775 recorded in soils planted with *J. gossipifolia* and 7.675 in soils planted with *J. curcas*. Differences in silt composition showed that the soils planted with *J. gossipifolia* recorded higher percentage silt of 7.920 %, significantly different from percentage silt composition of 7.507 % and 7.625 % in soils planted with *J. curcas* and *J. podagrica* respectively. The effect of *Jatropha* also influenced the composition of clay from the post soil investigation. Result showed that percentage clay was higher (8.149 %) in soils planted with *J. podagrica*, significantly different from clay composition of soil (7.175 % and 6.600 %) when planted with *J. gossipifolia* and *J. curcas* respectively. Differences in sand composition however showed that soils planted with *J. curcas* recorded higher percentage sand of 77.776 %, varying significantly from soils planted with *J. gossipifolia* and *J. podagrica* which recorded lower percentage sand of 72.575 % and 70.949 % respectively. Variations in organic matter showed that soils recorded higher organic matter content (13.249 %) when planted with *J. podagrica* specie. However, significant lower organic matter contents (11.750 % and 8.000 %) resulted from soils planted with *J. gossipifolia* and *J. curcas* respectively.

Discussion

Soil contaminated with cement waste had both positive and negative effects on soil physicochemical properties though dependent on the phytoremediation mechanism adapted to clean up the soil. Soil pH value determines the availability of nutrients, the potency of harmful substances as well as the physical properties of the soil [12]. This study showed soil pH difference of 1.067 between pre investigation and post soil investigation. By implication there was a significant change from soil acidity (6.533) to alkalinity (8.100) due to remediation processes using *Jatropha* plants. By implication most plants thrive in slightly acidic to neutral soils with a pH range of 6.0 to 7.5. Soil pH influences nutrient availability, microbial activity and the solubility of minerals. Acidic soils may require lime to raise the pH while alkaline soil may need amendments to lower it. The cement dust which is highly alkaline give rise to high pH values. This result is in line with the findings of [3] which showed progressive reduction from acidity to alkalinity when *Jatropha* species are grown around the cement waste contaminated soil. Similar result has been reported by [9] in his study, when *Jatropha curcas* were used around heavy metal polluted soil. Treatment (T_0 0%, T_1 20% T_2 40% and T_3 60%) indicates the amount concentration of cement contaminants in the soil. However solubility the determining the soil physico parameters in pre and post soil. But contaminants solubility in the soil, is factor of plant remediation potential [3]. In the study of [2] who reported an increase in soil Electric Conductivity (EC) and Cation Exchange Conductivity (CEC) valued at harvest of the *Jatropha* species compared with their initial values shows initials was higher but afterwards became slightly lower in values. Though, this is contrary to the findings of [3] who reported decrease in soil Electric Conductivity (EC) and Cation Exchange Conductivity (CEC) valued at harvest of the *Jatropha* species. This can be attributed to Heavy metal emitted from cement waste such as cadmium lead and chromium, which poses substantial threats to the physiochemical properties of both soil and the environment. Cation electrical conductivity is directly related to the soil capacity in absorbing or exchanging cations [2]. A significant increase in electrical conductivity of the contaminated soil was observed in soils treated with 20% of cement waste. This increase can be attributed to relatively high anthropogenic Co_2 emissions, it's emit from the calcination process of limestone, to the combustion of fuels in the kiln as well as from power generation process [14]. A significant increase was recorded in the soil organic matter and trace metals (mercury, copper cadmium, colbalt and manganese). This is in line with the study of [8] which showed an increase in the salt concentration, organic matter and plant nutrients in soil contaminated with cement waste. The increase in the concentration of organic matter recorded in this study may be attributed to the soil mineralization by *Jatropha* roots and stem as reported by [10]. Soil pH, Electric Conductivity (EC) and Cation Exchange Conductivity (CEC) value was observed to vary across the different soil treatment and the control. According to [10] in low pH soils, the solubility of soil contaminants decreases and suitable growth environment becomes less available. The study of [3] revealed that Soil pH, Electric Conductivity (EC) and Cation Exchange Conductivity (ECE) value are efficient indicator of soil nutrients, and thus soil physico chemical parameters is studied to monitor the pre and post *Jatropha* harvest effect on the polluted soil in the study.

Conclusion and Recommendations

Most plants thrive in slightly acidic to neutral soils with a pH range of 6.0 to 7.5. Soil pH influences nutrient availability, microbial activity and the solubility of minerals. Acidic soils may require lime to raise the pH while alkaline soil may need amendments to lower it. The cement dust which is highly alkaline gives rise to high pH values. Soil with high CEC can retain more nutrients, making them available to plants over time. Clay soil generally has a higher CEC compared to sandy soil. Proper management of CEC is essential for sustaining plant growth and productivity. High EC values may indicate excess salts affecting plant growth. Monitoring EC is crucial in agricultural settings to prevent salinity issue, particularly in arid regions where irrigation practices can lead to salty accumulation. Soil with electric conductivty below 0.4 Ms/cm are normally considered marginally or non-saline whereas soils above 0.8Ms/cm are considered strictly saline. Heavy metal emitted from cement factories such as cadmium lead and chromium, poses substantial threats to the physico- chemical properties of both soil and water. Soil Physico chemical properties is a dynamic and complex natural resources that plays a crucial role in supporting life on earth. Soil scientist and farmers use these soil physico chemical parameters to make informed decisions about soil contamination to aid land use, crop selection and soil improvement practices.

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