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RESEARCH ARTICLE

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Physicochemical properties of crude oil contaminated soils as influenced by cow dung

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ABSTRACT

Effects of cow dung on the physicochemical properties of crude oil contaminated soil were investigated for six weeks. Cow dung treatments applied were Control, 30g/kg, 60g/kg, 90g/kg and the soils were amended after two weeks of crude oil contamination. Soil samples were collected from the bags for physicochemical analyses at three different times using standard analytical methods. Crude oil contamination was seen to affect certain soil properties ($p<0.05$). The percentage of Nitrogen, Phosphorus, Potassium and pH significantly decreased two weeks after crude oil contamination, while significant ($P<0.05$) increase in percentage organic carbon and soil moisture contents were recorded. The study suggests that addition of crude oil may have adverse effect on the physicochemical properties of soil, but this can be remedied by addition of Cow dung. In this study, 90g of Cow dung application gave the best results

Key words: Cow dung, Physicochemical properties, Crude oil, Bioremediation

INTRODUCTION

Crude oil contamination of agricultural lands is a major problem in oil producing nations. Even the non oil producing nations that depend on supply through cross country underground and on high sea transportation are not spared due to accidental spillages. Apart from loss of farms, oil spills have led to land use deterioration and led to a loss of soil fertility. The Effect of cow dung was tested in reclamation experiment. It is estimated that more than four thousand incidents of crude oil spills have occurred in the Niger Delta region of Nigeria since 1960, releasing several million barrels of crude oil (some containing heavy metals) into the surrounding areas [1]. The effects are often concentration dependent and also vary in their individual toxicity [2]. The adverse effects of crude oil on soil cannot be overemphasized, upon decreasing the nitrogen and phosphorus contents, crude oil provides to the soil excessive hydrocarbon which affects soil enzymatic activities due to the inability of soil microbes to degrade the excess hydrocarbons [3].

In Nigeria, to improve crude oil polluted soils for enhanced and sustainable ecosystems, several effects which include physicochemical and biological methods have been employed in the remediation of the polluted soils [4]. Several reports have shown that bioremediation method, among other treatment options is the most cost effective and environment friendly way of restoring contaminated soils [5]. Organic manures as well as plants have over the time been used to improve soil fertility [6].

The effectiveness of these organic manure treatments has, however, been conflicting [7]. This might be attributed to the heterogeneity of soils and crude oil samples as well as possible interactions between the soil options, presence of soil microorganisms and the natural soil constituents [8]. The effectiveness of each treatment in any soil therefore needs to be evaluated on a case specific basis. This study therefore is aimed at investigating the effects of Cow dung (as bioenhancement agent) on the physicochemical properties of crude oil contaminated soil. Different weights of Cow dung were added to the several quantities of contaminated soil samples in order to determine the nutrient weight that gives the best performance for remediation purposes.

MATERIALS AND METHODS

Sample Collection

The crude oil used was Bonny light crude oil. It was obtained from Kaduna Refining and Petrochemical Company (KRPC), Kaduna State, in sterile sample bottles and transported at an ambient temperature of the laboratory for the study. The Cow dung manure was collected from a ranch situated at Kwalkwalawa Village along the Usmanu Danfodiyo University Road, Sokoto State. The soil samples were collected with a soil auger from the main campus of Usmanu Danfodiyo University, Sokoto. The top soil (0-15cm) with no previous history of crude oil contamination was collected in polythene bags from three different locations.

Description and treatment of samples

The soil samples were bulk together, homogenized by grinding, and filtered by passing through a 2mm mesh sieve. From the soil samples, 1kg of soil was weighed into perforated labelled bags. This perforation allows for proper drainage (i.e. avoid water logging) and better aeration of the experimental soil. A total of 48 bags filled with experimental soil were used for the experiment. Simulation of the soil samples was done by measuring 17g of Crude oil corresponding to 20ml crude oil from gravimetric measurement into the polythene bags containing 1kg of soil each. The individual mixtures were thoroughly mixed to achieve a 100% artificial contamination [9]. The Cow dung samples were sun dried for one week after which they were ground, thoroughly mixed, sieved through a 2mm sieve to achieve uniform particle size and stored in neat polythene bag for use. The contaminated and uncontaminated soils were allowed to stand under natural environment for two weeks before application of different levels of Cow dung. During this period, the samples were watered at interval of two days. After two weeks of contamination, the Cow dung was carefully weighed into the bags containing the crude oil at various weights (control, 30g/kg, 60g/kg and 90g/kg of soil). Soil samples were replicated 3 times, and arranged in Completely Randomised Design [10].

Sampling

Soil samples were collected from the bag for physicochemical analyses at three different times. First was before crude oil application to ascertain the physicochemical nature of the uncontaminated soil. Second was at two weeks after crude oil contamination and third was at fourth weeks after amendment of crude oil contaminated soil.

Determination of physicochemical parameters of soil

Soil physicochemical properties such as soil moisture contents, pH, organic carbon, nitrogen, phosphorus, potassium, sand, clay and silt were determined before contamination, two weeks after crude oil contamination and fourth weeks after amendment of crude oil contaminated soil with different weights of Cow dung. Soil pH, carbon, moisture content, phosphorus and soil particle size analyses were determined according to standard procedures described by [11]. Nitrogen was determined using the Micro-Kjeldahl method [12]. The determination of potassium was done by mixed acid digestion method [13].

Statistical analysis

The results were expressed as mean $\pm$ standard error of three replicates. Analysis of variance (ANOVA) was used to test whether the different weights of Cow dung amendments given to the crude oil contaminated soil will be statistically significant and mean values were separated using the Ducan's Multiple Range Test (DMRT) at $p \leq 0.05$

RESULTS

Influence of Crude Oil on the Physicochemical Properties of the Soil

The results of the physicochemical properties of the soil before and two weeks after crude oil contamination are shown in Table 1. The results of the moisture content indicated that crude oil contaminated soil showed significant

increases ($p<0.05$) in moisture content when compared to uncontaminated soil. The pH ranges (7.50 ± 0.21 – 6.30 ± 0.24) of the uncontaminated and crude oil contaminated soils indicated that the pH was neutral to slightly acidic. The results also showed significant increases in organic carbon in the crude oil contaminated soil. The results (Table 1) also showed a significant decrease ($p<0.05$) in the nitrogen, phosphorus and potassium content in crude oil contaminated soil when compared to uncontaminated soil. The results (Table 1) showed that the particles size analyses of the soil samples indicated that there was no significant difference ($p>0.05$) in the sand values between uncontaminated and crude oil contaminated soil ($94.25\pm1.53\%$ – $94.50\pm2.68\%$). It was also observed that there was no significant difference ($p>0.05$) in the silt and clay contents of crude oil contaminated soil when compared to uncontaminated soil (Table 1).

Table 1: Physicochemical Properties of the Soil before and Two Weeks after Crude Oil Contamination

Parameters	Control (0ml/kg)	20ml/kg
Moisture (%)	$1.00^{a}\pm0.04$	$3.00^{b}\pm0.12$
pH	$7.50^{b}\pm0.21$	$6.30^{a}\pm0.24$
Carbon (%)	$2.46^{a}\pm0.01$	$3.32^{b}\pm0.11$
Nitrogen (%)	$0.35^{b}\pm0.01$	$0.18^{a}\pm0.05$
Phosphorus (%)	$1.38^{b}\pm0.03$	$1.05^{a}\pm0.02$
Potassium (%)	$200^{b}\pm23.09$	$67^{a}\pm1.73$
Sand (%)	$94.50^{a}\pm2.68$	$94.25^{a}\pm1.53$
Clay (%)	$4.53^{a}\pm0.35$	$4.00^{a}\pm0.36$
Silt (%)	$1.00^{a}\pm0.31$	$1.30^{a}\pm0.21$

a,b mean in a row with different superscripts are significantly different ($p<0.05$) values are means of three replicates $\pm$ standard error.

Influence of Cow Dung on the Physicochemical Properties of the Crude Oil Contaminated Soil

The results of the physicochemical properties of the crude oil contaminated soil four weeks after amendments with different weights of Cow dung are shown in Table 2. The results indicated that Cow dung significantly influenced the physicochemical properties of the contaminated soils. Bags treated with 90g of Cow dung gave the highest values of moisture content followed by those treated with 60g of Cow dung. The increase in moisture contents on application of these different weights of Cow dung differed significantly ($p<0.05$) in all the bags treated. The results (Table 2) showed that bags treated with 60g of Cow dung had the highest pH values followed by those bags treated with 90g of Cow dung and 30g of Cow dung respectively. The increase in pH values differed significantly ($p<0.05$) from one weight to the other except for bags treated with 60g of Cow dung only which were not significant from those treated with 90g of Cow dung. The results also showed that organic carbon of the non-amended and amended crude oil contaminated soil increased significantly ($p<0.05$) with the application of the different weights of Cow dung.

Table 2: Physicochemical properties of crude oil contaminated soil four weeks after amendments with different weights of cow dung

Parameters	**Non-amended**	**30g/kg**	**60g/kg**	**90g/kg**
Moisture (%)	$1.50^{a}\pm0.14$	$3.50^{b}\pm0.27$	$5.00^{c}\pm0.12$	$6.10^{d}\pm0.27$
pH	$6.10^{a}\pm0.07$	$6.30^{a}\pm\pm0.24$	$7.60^{b}\pm0.18$	$7.50^{b}\pm0.21$
Carbon (%)	$3.27^{a}\pm0.03$	$3.30^{b}\pm0.05$	$3.43^{c}\pm0.05$	$3.58^{d}\pm0.12$
Nitrogen (%)	$0.21^{a}\pm0.03$	$0.24^{bc}\pm0.02$	$0.23^{b}\pm0.11$	$0.25^{c}\pm0.02$
Phosphorus (%)	$1.38^{a}\pm0.04$	$1.40^{bc}\pm0.15$	$1.41^{cd}\pm0.11$	$1.42^{d}\pm0.05$
Potassium (%)	$64^{a}\pm1.42$	$100^{ab}\pm2.89$	$200^{b}\pm23.09$	$350^{c}\pm31.24$
Sand (%)	$94.50^{a}\pm1.16$	$92.50^{a}\pm8.51$	$92.50^{a}\pm2.52$	$94.50^{a}\pm1.53$
Clay (%)	$3.40^{a}\pm0.31$	$4.20^{a}\pm0.64$	$4.00^{a}\pm0.36$	$3.50^{a}\pm0.50$
Silt (%)	$1.00^{a}\pm0.31$	$2.10^{ab}\pm0.27$	$2.90^{bc}\pm0.51$	$3.50^{c}\pm064$

a b c d mean in a row with different superscripts are significantly different ($p<0.05$). Values are means of three replicates $\pm$ standard error.

Bags treated with Cow dung significantly increased the percentage of nitrogen and phosphorus in crude oil contaminated soils ($p<0.05$). Bags amended with 90g of Cow dung gave the highest values of nitrogen and phosphorus followed by bags amended with 60g of Cow dung, and 30g of Cow dung had the lowest increased values of nitrogen and phosphorus. Potassium was also influenced by the addition of the various weights of Cow dung to the crude oil contaminated soils. There were significant increases in this metal on addition of these various weights of Cow dung, with 90g of Cow dung producing the highest values in each case. The bags amended with 30g

of Cow dung gave the lowest increment in the value of this metal in all observed cases (Table 2). The increment in values of this metal were, however, significant ($p<0.05$) in most cases. The results of the particle size analysis of all the bags amended with Cow dung showed that there were no significant differences ($p>0.05$) in the sand, clay and silt values of the crude oil contaminated soil.

DISCUSSION

The percentage of the organic carbon and moisture content level of the crude oil contaminated soils significantly increased. This report agrees with [14] who observed increased in moisture content values within the range of 20 to 80 percent of saturation capacity is required for microbial activity. It was observed that available nitrogen, phosphorus, pH and potassium of the soil significantly decreased with crude oil contamination. The decrease in Nitrogen, Phosphorus, pH, and Potassium levels of crude oil contaminated soil was similar to the findings of [15]. This study contradicts the reports of [16] who observed an increased in pH due to crude oil contamination. Although, these observed pH values do not fall completely within the acceptable standards [17]. There were significant increased observed in the physicochemical properties of crude oil contaminated soil amended with Cow dung. This observations also confirm earlier findings [18] that organic manures (e.g. chicken droppings) have buffering effect on crude oil contaminated soil. This rise in the pH of the amended soils may favour oil degradation by microorganisms as observed in similar studies that higher pH range (6 – 9) provides better conditions for mineralization of hydrocarbons since most bacteria capable of metabolizing hydrocarbons develop best at pH conditions close to neutrality [19]. Thus, the increase in the % nitrogen, potassium and phosphorus contents of the amended soil induced by the various weights of Cow dung may enhance the biodegradation of the crude oil contaminated soil and as such enhance its fertility.

CONCLUSION

From the study, it can be concluded that crude oil contaminated soil may result in reduced soil physicochemical properties. But this can be remedied by the addition of organic nutrient supplements especially Cow dung and the quantity of supplement added has significant effect on the remediation process. The result also underscores the need for the use of cheap and available, and environmental friendly organic nutrients as a remedy for the deleterious effect of crude oil contaminants in the soil.

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