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Prediction of Soil Nitrogen Depeltion in Crude Oil Contaminated Soil in Southern Nigeria

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Abstract

Oil spillage is a major environmental threat in south south of Nigeria where most of oil exploration and exploitation activities takes place. If this goes on unchecked or poorly managed, it would lead to total annihilation of the ecosystem. The objective of this study is to develop a model for the prediction of soil nitrogen depletion in crude oil contaminated soil with time using regression analysis. Each sample containing 10kg of soil was artificially polluted with 0.5, 1.0, 1.5, 2.0, and 2.5 liters of crude oil (Bonny Light). The Soil Nitrogen concentrations were determined using standard methods. Results shows that the concentration of residual soil nitrogen in the soil for all the volumes of crude oil introduced into the soil depleted significantly with time when compared to values obtained for the control sample. The residual concentration in the control soil sample was about three times higher than the concentration obtained for other samples. The results obtained from the derived model were very close to the experimental value. The model is suitable for determining Soil Nitrogen content in crude oil polluted site.

Index terms— crude oil, pollution, soil nitrogen, model, niger delta.

1 Introduction

n Nigeria, oil spillage in the Niger Delta region, especially on Agricultural Lands, has been a significant issue of concern both to the government and the people in the area. The outcome of this research work can serve as a vital tool in resolving problems associated with oil pollution and bioremediation of affected lands. Oil has hostile effects on the physicochemical properties of soils, plant and, animal community. Beyond 3% concentration, crude oil has been reported to be increasingly deleterious to soil biota and crop growth . Unfortunately, available data to manage the ecological spoils of the Niger Delta Region has been found inadequate. Though existing data has found various uses in the Post spill management program of the affected ecosystem and communities, recent advances have shown that such data has been specific to particular sites and incidences, predominantly because of the nature of the crude oil contaminant and possible environmental modifications .

2 I

Soil fertility is the result of the interaction between the biological, chemical, and physical properties of soil due to soil type, land use, and effects of climate. Soil chemical properties are related to the supply of plant nutrients that is essential for plant growth. Generally, oil affects the physicochemical properties in plant communities in soil. Oil spill reduces crop yield, land productivity, and grandly decreases farm income. Observation shows that a 10% increase in oil spill reduces crop yield by 1.3% while farm income plummeted to 5% **??**Odjuwuederhie et al., 2006). According to Shell 1996, half of the volume of the crude oil spill is due to the corrosion of aging facilities mostly flow line. Another 21% happens in the course of operations to produce oil, while about 28% is due to sabotage. The remaining 1% is mainly due to engineering and drilling activities. There have been numerous reports on the impact of crude oil spill on farmland in the Niger Delta region **??**Osuji and Mathematical Models can be used to predict the impacts of crude oil spill on the physicochemical properties of soil to reduce the

complaints about polluted farmlands. In predictive modeling, data are collected for relevant predictors (variables that are likely to influence future behavior or results) followed by a model formulation, then predictions are made, and the model is validated. The different approaches to deciding model validity include conceptual model validation and operational validation **??**Nwaogasi, 2006). A case in which n-control variables X 1 , X 2 , X 3 to X n are involved a corresponding linear multiple regression equation is of the form?? = ?? 0 + ?? 1 ?? 1 + ?? 2 ?? 2 + ?? 3 ?? 3 . . . +?? ?? ?? ?? 1.0

The regression coefficient for ?? 0 , A 1 to A n can be obtained using Panel Data Computer Software.

3 II.

4 Methods

They carried out the study over a period of sixteen (16) weeks using different containers measuring 17cm (height) by 18.5cm (diameter). The study area is the research farm of the Federal University of Technology Owerri, located in Owerri, Imo State Nigeria. The soils are derived from coastal plain sands called acid sands -Benin formation (Orajaka, 1975 The soil used in the study was collected from the Federal University of Technology Owerri (FUTO) Research Farm from 15cm to 20cm depth with a shovel. It was measured into containers and taken to the laboratory for treatment (greenhouse treatment).

The soil was air-dried for two weeks and sieved through 2.0cm sieve. The soil samples labeled B, C, D, E, F, each weighing 10kg were polluted with 0.5, 1.0, 2.0, 2.5 liters of crude oil (Bony light), respectively, and thoroughly mixed on a polythene sheet and put in a labeled container.

Sample A was not polluted and was used as the control. To maintain the moisture content of the soil, 50cl of water was sprinkled on each polluted soil sample at two weeks intervals.

The polluted samples were allowed to stay 14 days before the commencement of analysis. The representative samples from (A, B, C, D, E, F) containers were taken at two weeks intervals to the soil science laboratory of Department of Crop, Soil and Pest Management, School of Agriculture and Agricultural Technology, FUTO for analysis to determine the fate of soil nitrogen nutrient with time at various levels of pollution with crude oil. The concentration remaining after 14, 28, 42, 56, 70, 84, 98 and 112 days intervals were obtained.

Ten grams (10g) of air-dried soil sample was introduced into a dry 500ml macro-kjeldahl flask, and 20ml of distilled water was added and allowed to stand for 30 minutes after a little swirling. 30ml of concentrated. H 2 SO 4 was annexed into the mixture and heated at low heat at the digestion stand. The mixture was allowed to boil for five hours. The digest was transferred carefully to a clean 750ml flask, and 50ml of H 3 BO 3 indicator solution was added and placed under the condenser of the distillation apparatus. As distillation commenced, the condenser was kept cool below 30 o C, allowing sufficient cold water to flow through and to regulate heat to minimize fronting and prevent suckback. 150ml distillate was collected, and the distillation process was stopped. The Nitrogen (NH 4 -N) in the distillate was determined by titrating 0.01N standard HCl at 0.1ml intervals, and as the color changes from green to pink. The percentage of Nitrogen (%N) content of the soil was read and recorded. This process was repeated for various levels of crude oil pollution for the soil samples.

The Panel Data Computer Software called Stata 13 version was used to obtain the regression coefficients B 0 , B 1 , B 2 , B 3, and B 4 and the model equation for soil nitrogen using the data obtained from the laboratory. The model equation for the soil nitrogen is expressed as: ?? ???? = ?? 0 + ?? 1 ?? ?????? + ?? 2 ?? ???? +

5 Results and Discussions

Table **??**: The Variation of soil nitrogen values with time after pollution

Table **??** shows the soil nitrogen remaining in the soil after any given time (t = 14 to 112 days), for values of soil samples with crude oil pollution volume ranging from 0 to 2.5L per 10Kg of soil. The R 2 for the determination of the proposed model is 0.9824, with a root mean square error of 0.06255, as shown in table **??**. The root mean square error is small; hence the adopted model fits (Chang, 2015). The P-value of 0.00 shows that there is a strong relationship between soil nitrogen and concentration of crude oil spilled at any given time. The equation for prediction of soil nitrogen fate in crude oil contaminated soil is therefore Nitrogen content of the soil at various levels of crude oil pollution varied with time of pollution as shown in Fig. 2. In control (no crude oil added), soil nitrogen increased with time of pollution up till sixty (60) days and remained almost constant till 112 days after. Best soil nitrogen concentration at 60 days of pollution was 0.315%, with the fluctuation in value before and after this time (60 days). This could be ascribed to Nitrogen transformation processes, especially mineralization and immobilization (Catherine et al., 2004). At 0.5 liters (equivalent to 629 barrels per hectare), of crude oil pollution, N concentration increased with time up till 70 days and then decreased, before a second increase at 112 days. The trend for the 1.0-liter rate of pollution was an increase to 84 days and a second decrease up to 112 days. Values of Nitrogen (N) for the 14, 28, 42, 84 and 112 days of pollution were 0.12, 0.13, 0.13, 0.14, 0.135% respectively. The nitrogen content at 1.5 liters of crude oil pollution increased with time up till 84 days after pollution until a decrease from the 84 to the 112 days of pollution. Values of Nitrogen (N) varied as 0.12, 0.13, 0, 0.135, 0.129, 0, 0.132, 0.137, 0.140, and 0.136 at 14, 28, 42, 56, 70, 84, 98 and 112 days after pollution respectively. Values of N at 2.0 and 2.5 liters of crude oil pollution increased with time of crude application.?? = 0.1927 + 0.1124?? ?????? + 0.0009?? ???? -2.

Fluctuations in Nitrogen (N) content with time for various crude oil pollution rates could be attributed to differences in Nitrogen mineralization and immobilization processes. Generally, soil nitrogen content, averaged over time of crude oil pollution, was three times higher at the control than other rates of crude oil pollution. The low concentrations of N at various crude oil application could be due to reduced microbial activity and depressed nitrogen mineralization, occasioned by toxic and damaging effects of crude oil on soil organism. This bad influence decreased with time of application resulting to improved nitrogen concentration with time.

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The percentage of soil nitrogen content at all levels of crude oil pollution with time was below 0.15%, which is the critical nitrogen limit for soils of southeastern Nigeria (Enwezor et al., 1990). This shows that despite crude oil pollution at various levels, the nitrogen content of the soil was low and could hardly sustain crop production.

IV.

7 Conclusion

The impact of crude oil pollution on the physicochemical properties of soil about soil fertility in the Niger Delta Region of Nigeria has been reviewed. Modeling of soil nitrogen in crude oil contaminated soil over a period was carried out. The soil nitrogen value for various crude oil levels of pollution increased with time being lowest at 14days. [1]

Time (days)	0	0.5	1	1.5	2	2.5
14	0.287	0.143	0.123	0.115	0.121	0.126
28	0.285	0.148	0.128	0.120	0.127	0.128
42	0.291	0.150	0.133	0.125	0.130	0.134
56	0.300	0.152	0.136	0.128	0.127	0.140
70	0.298	0.154	0.138	0.130	0.134	0.142
84	0.300	0.158	0.14	0.133	0.140	0.143
98	0.300	0.159	0.14	0.134	0.140	0.144
112	0.300	0.159	0.14	0.134	0.137	0.144

Figure 1:

[1] © 2020 Global Journals Prediction of Soil Nitrogen Depeltion in Crude Oil Contaminated Soil in Southern Nigeria

MODEL RESULTS

source	ss	df	Ms
Model	0.172198	4	0.43049
Residual	0.004704	43	0.00011
Total	0.176902	47	0.00376

Number of Obs = 48

F(4, 43) = 599.75

Prob > F = 0.0000

R-Squared = 0.9824

Adj R-Squared = 0.9808

Root MSE = 0.06255

N	Coef	Std Err	t	P > |t|	95% Conf.	Interval
Conc	0.112373	0.005989	18.76	0	0.100294	0.1244519
time	0.000414	0.000217	1.91	0.063	-2.3E-05	0.0008518
$time^2$	-2.01E-06	1.68E-06	-1.2	0.237	-5.40E-06	1.38E-06
$conc^{1/2}$	-0.27537	0.009769	-28.29	0	-0.29507	-0.25567
_cons	0.1927	0.006827	40.39	0	0.261974	0.2895091

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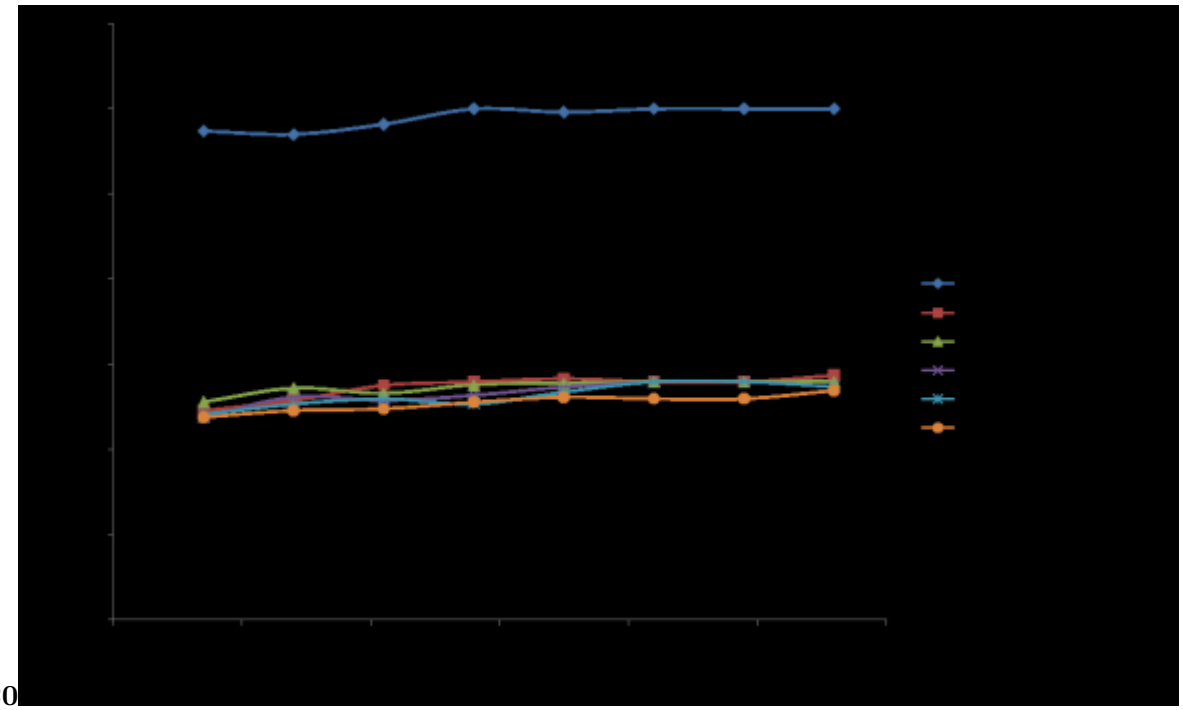
Figure 2: Table 3 :Fig. 1 :



20

Figure 3: 102e?? ???? 2 + 0 ,

Figure 4:

1

).Samples

Figure 5: Table 1 :

4

Time/Day	Experimental Data (ED)	Predicted Value (PV)	Percentage Difference
7	0.119	0.122	2.50
14	0.1192	0.1248	5.10
21	0.1191	0.1270	4.40
28	0.1210	0.1260	4.10
35	0.1270	0.1310	1.50

Figure 6: Table 4 :

5

	TIME	COV	ED for N	PV for N	% Difference
	14	0	0.287	0.281146199	2.039652249
Year	28 42	0 0 0	0.285 0.291	0.285761297	-0.267122925
2020	56 70	0	0.300 0.298	0.289586693	0.485675427 2.459208073
				0.292622387	1.050861862
				0.294868439	
10	84 98	0 0	0.300 0.300	0.29632479 0.296991438	1.225074084 1.002858043
( )	112	0 0.5	0.300	0.296868414	1.043866037 0.268103978
Vol-	14	0.5	0.143 0.148	0.142616615	0.653370589 -
ume	28 42	0.5	0.150 0.152	0.147231698	0.704961653 -
Xx	56 70	0.5	0.154 0.158	0.151057094	1.376844432 -
X	84 98	0.5	0.159 0.159	0.154092804	1.518724677 0.129626446
Is-	112	0.5	0.123000002	0.156338841	0.338457064 0.540932135
sue	14 28	0.5	0.128000001	0.157795191	3.943833426 4.090492609
I V		0.5 1		0.158461854 0.15833883	
er-		1		0.118149087 0.12276417	
sion					
I					
Global	42	1 1 1	0.133000001	0.126589566	4.819875774 4.687294834
Jour-	56 70	1 1	0.135999997	0.129625276	4.441067734 4.765955445
nal	84 98	1 1.5	0.137999986	0.131871313	4.289767554 4.377631186
of	112	1.5	0.140000001	0.133327663	2.219496083 2.447762651
Re-	14	1.5	0.140000001	0.133994326	3.289551246 3.020902324
searches	28 42	1.5	0.140000001	0.133871317	4.040488128 4.259094149
in	56 70	1.5	0.115 0.120	0.112447582	4.422214726 3.192116903
En-	84 98	1.5	0.125 0.128	0.117062658	
gi-	112	1.5	0.130 0.133	0.120888054	
neer-		1.5	0.134 0.134	0.123923771	
ing				0.126169801	
				0.127626151	
				0.128292814	
				0.128169805	
	14	2	0.121	0.116460115	3.751970786
	28	2	0.127	0.121075191	4.665207292
	42	2	0.130	0.124900587	3.922621935
	56	2	0.127	0.127936304	-0.737243726
	70	2	0.134	0.130182341	2.849001867
	84	2	0.140	0.131638691	5.972364094
	98	2	0.140	0.132305354	5.496176202
	112	2	0.137	0.13218233	3.516543661

Figure 7: Table 5 :

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