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Rainfall Intensity Influence On Diesel Retention in Niger Delta Soil

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ABSTRACT
This research is aimed at monitoring the influence of rainfall intensities on the retention of diesel spill in Niger Delta soil. The objectives are to monitor the retention of diesel spill in soil at varying rainfall intensities at constant soil depths and develop a 3D model that will describe the retention of diesel spill in unsaturated soil zone at different spill scenarios. Diesel spill causes problems when retained in soil which includes, destruction of human, plants and animals live. The method used in generating the experimental design was response surface method, which uses two (2) independent variables that includes contaminant volume, rainfall intensity and a constant variable known as the soil depth. . XLSAT software was used to develop diesel retention model of TPH following release on ground surface. Varying rainfall intensity of 5mm/hr, 7.5mm/hr and 10mm/hr were artificially simulated on the soil at different contaminant volumes and constant soil depth. Results showed that Lesser quantities of spilled diesel would be retained in a typical Niger Delta soil during rainfalls with high intensity and more diesel spill will contaminate the groundwater table . Increase in rainfall intensity will initially cause an increase in retained diesel concentration, however at the passage of time further increase in rainfall intensity will result to a simultaneous decrease in the retained diesel concentration. Conclusively, It is preferable to prevent diesel oil spill because more contamination will be impacted on ground water table during high intensity rainfalls. Ministry of environment in alliance with the Niger Delta Development Commission, NOSDRA and other sister agencies should adopt the developed diesel spill reclamation model in the Niger delta soil and implement zero tolerance to oil spill as it agrees with ISO 14001:2015 requirements.
KEYWORD: Diesel fuel, Gas Chromatography, Retained Concentration, Rainfall Intensity. Transportation Model

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I. INTRODUCTION

Oil spills in Bori are mainly caused by accidents, ruptured of pipelines and loss of containment (UNEP report, 2011). Diesel is commonly use in Bori metropolis due to power challenges (Otu and Oloidi,2018; Oluwaniyi ,2018). Hence, it is used as petroleum product for this research.

Whenever a spill occurs, some spilled products infiltrate to the ground water and contaminate it as in the case of Ogali in Eleme in Ogoni, while some proportions of it remain in the soil and cause damages to plants and animals (UNEP report, 2011).

This study is aimed at monitoring the influence of rainfall intensities on retention of diesel spill in Niger Delta soil with specific objectives of monitoring the retention of diesel at given soil depths following release of varying rainfall intensities (Ugwoha et al.,2016).

Diesel fuel retained in soil causes enormous problems which includes soil and ground water contamination (Ericson, 2017), destruction of animals and plants (Richard , John, Sarah, Lawrence, Jackson, Matthew, Julianne, Sandro and Dale, 2017), acute and chronic infection of humans living in the contaminated zones (Ruben , Oksana , Chen., Einav ,Tirza and Yosef ,2018), destruction of aquatic lives(Zock, 2017), destruction of the ecosystem. (Bautista, and Rahman, 2016), extinction of plants and animals (Laffon, Pásaro and Valdiglesias,2016). Oil spillages affects soil properties and retard plant growth (Fowzia and ANM2018).

The work of Obire and Nwaubeta (2018) described the effects of refined petroleum hydrocarbon on the physiochemical and bacteriological characteristics of soil. Brakorenko and Korotchenko, (2016), Richard , John, Sarah, Lawrence, Jackson, Matthew, Julianne, Sandro and Dale, (2017), Aniefiok, Thomas, Clement, Ekpedeme and Iniemem (2018), Mohammadi, Dehestani, Aff, Shooshpasha and Asadollahi, (2015) discussed on the impact of petroleum products on soil. Sharma. Muskan , Ojha . and Shukla , (2018) worked on the effect of contaminant transport in soils. Research in monitoring the influence of rainfall intensity on Niger Delta soil may be just a few. Hence, the research is geared towards closing this gap.

II. MATERIALS AND METHODS

The materials used for this research include, rain fall simulator, lysometer with a mesocosm., diesel, auger rig undisturbed soil collector, soil samples and RSM Excel Stat. Program.

2.1 EXPERIMENTAL SETUP

A simple laboratory experiment was done to monitor the influence of rainfall intensity on retention of petroleum products in Niger Delta soil. The experiment used was designed and reported by Ugwoha et al. (2016) with little modifications. An auger rig undisturbed soil collector was used to collect the soil samples as shown in plate 1. Next the soil collector that served same purpose of a mesocosm was properly installed under a calibrated rain fall simulator as shown in Plate 1. The base of the mesocosm was properly guided to prevent erosion and filter washouts. The calibrated rainfall simulator was used to mimic rainfall at varying intensity of 5mm/h, 7.5mm/hr and 10mm/hr as shown in Plate 1. The washouts were properly collected and recorded after 1hr 45 minutes for a each experiment. The soils were emptied to a flat tray, mixed properly before measuring 500g and stored in a cold environment.

The diesel was carefully extracted from the well labeled soil samples using hexane as shown in Plate 1. The washouts and the soils were properly mixed with hexane in the ratio of 1:10 and 1: 50 respectively. The mixture was properly agitated in a sealed container and purred in a well clamped separating funnel as shown in Plate 1. Hexane was properly discarded from the mixture in the separation funnel due to its less density. The extracted diesel was futher injected into a gas chromatography to determine it total petroleum hydrocarbon.

2.2 ANALYSIS OF SAMPLE

Total petroleum hydrocarbons (TPH) was analyzed with GC-FID methods using a gas chromatography.

2.3 EXTRACTION OF HYDROCARBON IN SOIL

The soil samples were firstly dried to remove moisture content, 5g of contaminated soil was weighed and mixed with 50ml of extraction solvent (Hexane) in a dried bottle, agitated for 30mins and separated using filter papers. The process of filtration was done quickly to avoid escape of the solution, the soil particles were thrown away while the remaining samples (solvent) were well arranged and labeled in a tube for identification as shown in Plate 1.

2.4 GAS CHROMATOGRAPHY

The collected sample extract was injected into the Gas Chromatography Flame Ionization Detector (GC-FID). 1ul of concentrated petroleum hydrocarbon sample extract was injected through a rubber septum into the column by means of hypodermic syringe. The various fractions of the aliphatic compounds (C_8-C_{40}) were automatically detected as it emerges from the column. The results were expressed in mg/l.

2.5 RESPONSE SURFACE METHOD (EXPERIMENTAL DESIGN)

XLSAT software using RSM method of a full factorial design with 3 levels was used to generate the experimental runs required to monitor the influence of varying rainfall intensity in Niger Delta soil. It was used to optimize the output variables which in this case are the leached concentrations. The input variables were soil height (1000mm), diesel contaminant (50ml, 225ml and 400ml) and rainfall intensity ranging from 5mm/hr to 10mm/hr; since the soil depth is constant it was thus neglected. Nine observations/experimental runs were generated as presented in Table 3.1.

2.6 MODEL ASSUMPTIONS

The following assumptions were considered in development of the model.

i. It was a typical Niger Delta soil.
ii. The rain fall intensity was simulated to vary between 5mm/hr, 7.5mm/hr and 10mm/hr.
iii. The soil depth is 1000mm.
iv. The contaminant volumes of diesel vary from 50ml, 225ml and 400ml.

III. RESULTS AND DISCUSSIONS

The results are presented and discussed below.

3.1 SOIL SAMPLE CONCENTRATION RETAINED CONCENTRATIONS OF TOTAL PETROLEUM HYDROCARBONS (TPHS)

Generally, the concentrations of TPH retained in Niger Delta diesel spilled soil decreases with increased rainfall intensity as shown in table 1

Table 3.1. Retained concentrations of TPH for various rainfall intensities and contamination volumes

Observation	Sort order	Run order	Repetition	Contam. Vol.	Rainfall intensity	Retained
Obs1	1	1	1	50	5	21.13
Obs2	2	2	1	225	5	27.63
Obs3	3	3	1	400	5	30.56
Obs4	4	4	1	50	7.5	15.1
Obs5	5	5	1	225	7.5	21.98
Obs6	6	6	1	400	7.5	556.17
Obs7	7	7	1	50	10	24.9
Obs8	8	8	1	225	10	21.24
Obs9	9	9	1	400	10	27.89

Discussion of the result in table 3.1

i. Generally, the concentrations of TPH retained decreases with an increased rainfall intensity as shown in Table 3.1

ii. This implies that lesser diesel will be retained in the soil as rainfall intensity increases due to the soil k/d factor (Yang, Yang, Du and Lei, 2018) and more spilled diesel will contaminate the groundwater table.

3.2 RETAINED CONCENTRATIONS OF DIESEL

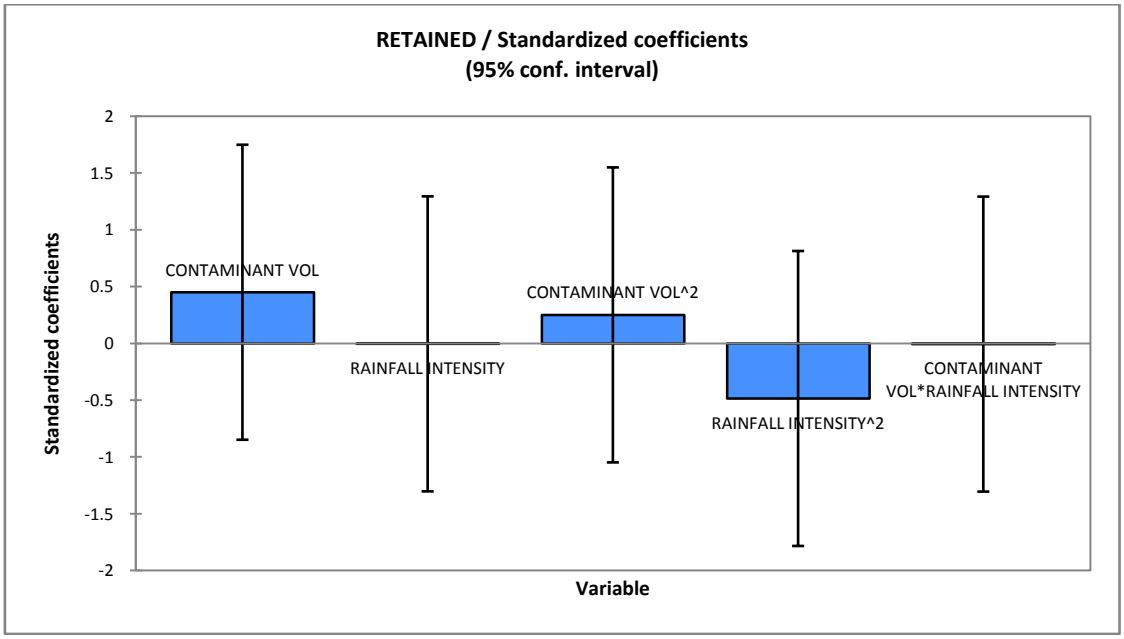
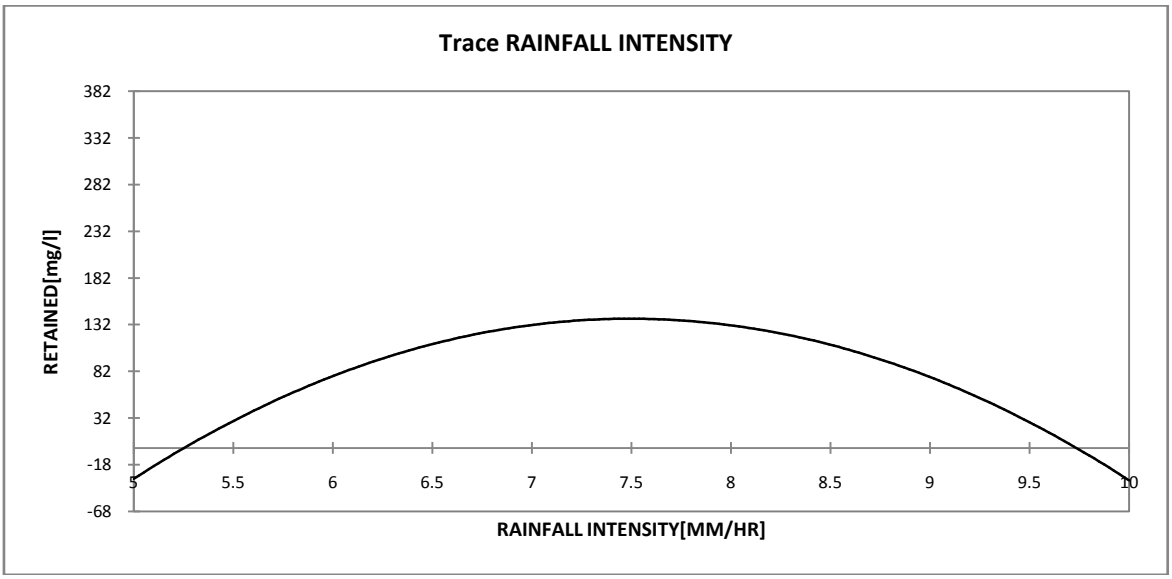


Figure 3.1.Wash out / Standardized coefficients

Discussion of the result in figure 3.1

i. The standardization coefficient of the retention model showed that rainfall intensity is approximately zero, this implies that increased rainfall intensity will result in decreased amount of retained concentration. Hence rainfall intensity can be used to reclaim contaminated soil.

3.3 RELATIONSHIP BETWEEN RETAINED CONCENTRATIONS AND INDEPENDENT VARIABLES



Discussion of the result in figure 3.2

i. Figure 3.2 showed that increase in rainfall intensity will initially cause an increase in retained diesel concentration, however at the passage of time further increase in rainfall intensity will result to a simultaneous decrease in the retained diesel concentration.

ii. This implies that the concentrations of TPH retained decreases with increased rainfall intensity (Jian, Omar, Saeed, and Sokrates, 2018).

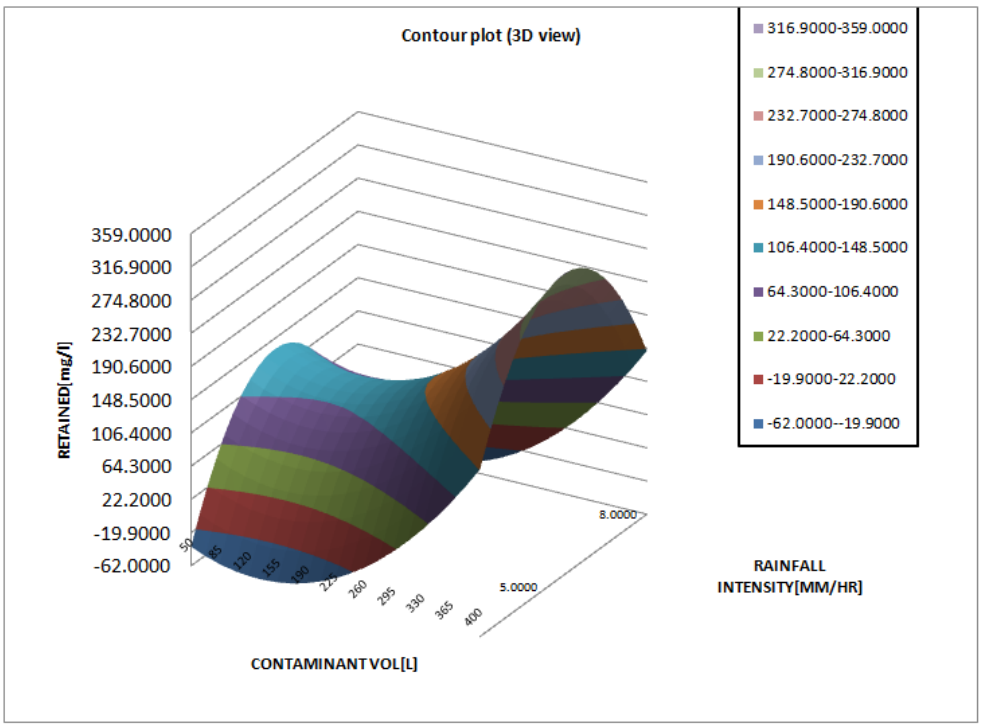


Figure 3.3.Contour plot (3D view)

Discussion of the result in figure 3.3

i. Figure 3.3 showed the 3D view of the developed model.
ii. The model showed that increased rainfall intensity results in decreased leached hydrocarbon contaminant in groundwater.

IV. CONCLUSION

Conclusively, reduced quantities of spilled diesel would be retained in a typical Niger Delta soil during rainfalls with high intensity and more spilled diesel is expected to contaminate the groundwater table (Yang, Yang, Duand Lei, 2018).

Also, increase in rainfall intensity will initially cause an increase in retained diesel concentration, however at the passage of time further increase in rainfall intensity will result to a simultaneous decrease in the retained diesel concentration which agrees with the work of Jian, Omar, Saeed, and Sokrates (2018).

Finally, it is preferable to prevent diesel oil spill because more contamination will be impacted on ground water table during high intensity rainfall.

V. RECOMMENDATION

It is recommended that Khana Local government in alliance with national oil spill detection regulation agency(NOSDRA) should implement the developed diesel retention concentration model as it will help to optimally reclaim oil spilled land.

VI CONTRIBUTION TO KNOWLEDGE

This research suggests best containment technique for cleanup of diesel contaminated soil in Niger Delta. The results and developed models showed that contaminated soil can be technically washed to reclaim it.

This research work will aid oil and gas industries to comply with all environmental management system requirement as per clause 5, 6,7, 8,9 and 10 of ISO14001:2015.

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PLATES

Plate 1. Installation of the fabricated auger rig undisturbed soil collector before soil collection.