Heavy Metal Characteristics of Leaf and Tuber of *Manihot Esculenta Crantz* (Cassava) Grown on Crude Oil Contaminated Soil With Rumen-Based Waste Augmentation

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Abstract -- In this field study conducted at the Teaching and Research Farm of Department of Agricultural Education, Federal College of Education (Technical) Omoku, Rivers State Nigeria to determine the bioremediation potentials of rumen- based wastes (RBW) on crude oil polluted soils, Cassava (Manihot esculenta Crantz.) was used as test crop. The soil was contaminated with Bonny Light crude oil obtained from OB/OB Nigeria Agip Oil Plc. Fresh RBW was obtained from an abattoir in Omoku, Rivers State. Cassava stems were obtained from the NAOC Green River Project, Obrikom. The soil was pulverized, made into raised seed beds, then contaminated with crude oil at the rates of 0litre m-2(Control) , 1.5litre m-2 (Mild), 3litre m-2 (Moderate) and 4.5litre m-2 (Severe). Two weeks after contamination RBW were applied as mulches at the rates of 0, 2, 4 and 6kg/m-2. Results show that RBW increased nickel, lead and copper accumulations in cassava leaf and tuber. It is recommended that RBW should not be used in augmenting crude oil polluted soils as it enhanced accumulation of heavy metals in cassava leaf and tuber.

Indexed Terms: Augmentation, Crude Oil, Heavy metal, Rumen-based waste

I. INTRODUCTION

The environment which can be described as the world around us is constantly under threat due to various human activities. Natural processes such as earthquakes, floods, tsunamis, drought, and volcanic eruptions pollute and degrade the environment, but human activities are the greatest culprits and drivers of environmental degradation. A typical substance arising from human activities and released into the environment is petroleum hydrocarbons (crude oil). Crude oil is a vital non-renewable natural resource that has emerged as a prominent commodity in the local and international market with numerous benefits for producing nations like Nigeria where it is an important part of the Nigerian economy since 1958 (Oyedeji *et al.,* 2015). Demand and utilization of petroleum products have increased its exploration in Nigeria and globally. Oil spills is one serious environmental problem associated with petroleum exploration with consequent environmental contamination, degradation and negative impacts on ecosystems. Typical constituents of petroleum hydrocarbons are heavy metals that are poisonous even at low concentrations. Heavy metal contamination is one major issue faced throughout the world, requiring attention because heavy metals above their normal ranges are extremely threatened to both plant and animal life (Nazir *et al.,* 2015). Over the years, chemical dispersants and physical or manual scooping are methods adopted to decontaminate the environment after oil pollution. According to Frick *et al.,* (1999), these processes are expensive and still have some adverse effects on the environment. However, in recent times, efforts have focused on biological techniques such as bioremediation and phyto-remediation in ameliorating conditions created by crude oil spills (Gupta and Sinha, 2007; Njoku *et al.,* 2009). These techniques are environmentally-friendly and is already being practiced in many countries like United States of America, Britain and Brazil with significant positive results (Oyedeji *et al.,* 2015). These techniques are non-destructive and cost effective in-situ technology that uses plants and associated microbes to clean up contaminated soils.(Nie *et al.,* 2011). Plant based bioremediation technology have received increased attention in the recovery of polluted environment but studies on the use of animal based organic substance such as RBW in bioremediation is scanty. RBW has high pH and is a large store house of microbial organism, enzymes and elements some of which may be necessary for plant growth and development (Isirima *et al.*, 2017. Each time ruminant animals are slaughtered in the abattoir the product of the rumen are heaped and carelessly abandoned with little or no regard for its possible used in augmentation and remediation of crude oil polluted crop lands. It is on this premise that this study aims at determining the effectiveness of rumen-based waste in reducing heavy metal accumulation in leaf and tuber of the test crop (cassava).

II. METHODOLOGY

The experiment was conducted at the Teaching and Research Farm of the Federal College of Education (Technical) Omoku. The land for the experiment was fallowed for four years after cassava grown on it was harvested. The loamy soil was ploughed and plant thrash removed. The soil was levelled and a land area of 30m x15m was measured using a measuring tape and marked out. It was a 4x4×3 split plot factorial experiment fitted into a completely randomized design with 3 replications. Each replicate had 12 sub-plots measuring 2m x 2m each. The sub plot was then made into raised beds of 30cm high. Bonny light crude oil was obtained from OB/OB plant of Nigeria Agip Oil Company (NAOC), measured and applied at the rates of 0ml, 1500ml 3000ml and 4500ml with the aid of a watering can. Watering can was preferred to ensure uniform distribution of the crude oil. Care was taken to avoid splash effect. Rumen-based waste freshly obtained from an abattoir in Omoku was applied at the rates of 0, 2, 4 and 6kg/m^2 two weeks after crude oil treatment. Cassava stems (TMS/80/001935) were then planted on the soil earlier polluted with the crude oil and augmented with rumen-based waste. Stems were planted at 1m x 1m spacing two weeks after crude oil and rumen-based waste treatment. Atomic Absorption Spectrometer (AAS) was used to analyze cassava leaf and tuber samples for heavy metals (nickel, lead and copper). The instrument setting and operational conditions were set according to manufacturer's specifications.

III. RESULTS AND DISCUSSION

Table 1 showed nickel accumulation increasing with increasing rumen based waste augmentation at all crude oil levels except at the severe level where it decreased with increasing rumen based waste augmentation. Lead accumulation also decreased with increasing rumen-based waste augmentation at 3MAP and 6MAP at all spill simulation levels. Mean copper concentration at the double control treatment (0ml crude oil and 0kg rumen based waste) was 5.75. This value is lower than mean copper levels obtained at various crude oil simulation levels with 0kg rumen based waste. Mean values decreased at 6MAP as quantity of rumen-based waste increased from 2kg, 4kg to 6kg, at various simulation levels showing the potency of rumen-based waste in reducing copper accumulation in cassava leaf.

Table 1: Heavy Metals (Nickel, Lead and Copper) concentrations in cassava leaf

Treatments		Metal concentration in cassava leaf (mg/kg)					
		Nickel (Ni)		Lead (Pb)		Copper (Cu)	
Crude oil levels	Rumen Based Waste	3MAP	6MAP	3MAP	6MAP	3MAP	6MAP
Control (0ml/m^2)	0 kg/m^2	8.95	8.49	6.40	9.76	4.63	6.86
	2 kg/m^2	11.28	8.50	7.20	9.50	5.23	5.20
	4 kg/m^2	11.30	10.35	7.20	9.32	8.71	4.17
	6 kg/m^2	11.28	10.60	7.40	9.32	8.50	4.12
Mild (1500ml/m^2)	0 kg/m^2	8.35	8.50	6.0	8.0	7.20	5.60
	2 kg/m^2	8.65	9.0	4.210	7.80	7.10	5.20
	4 kg/m^2	9.15	10.35	3.00	7.62	6.75	5.01
	6 kg/m^2	9.20	10.42	3.00	7.21	6.80	5.00
Moderate (3000ml/m^2)	0 kg/m^2	9.00	9.21	5.00	6.30	7.00	5.80
	2 kg/m^2	9.25	10.12	4.00	6.20	7.40	5.70
	4 kg/m^2	9.35	10.80	3.80	6.19	7.83	5.56
	6 kg/m^2	9.50	14.86	3.70	6.00	8.20	5.50
Severe (4500ml/m^2)	0 kg/m^2	8.12	6.32	5.60	5.14	7.83	7.10
	2 kg/m^2	7.00	4.21	5.20	4.98	8.70	6.20
	4 kg/m^2	6.31	2.39	5.20	4.71	9.00	4.72
	6 kg/m^2	6.30	2.50	5.00	4.00	9.15	4.22

Heavy metals adversely affect soil ecology, quality of agricultural produce and human health (Nazir *et al.*, 2015). In the current study, nickel, lead and copper accumulation levels in cassava leaf and tuber was ascertained. The observed high nickel concentration in cassava leaf with application of highest (6kg/m^2) rumen-based waste treatment level suggest that degradation of rumen-based waste promoted availability and uptake of nickel in the cassava tissue under control experiment. Decrease in lead and copper concentration in the leaf with increasing levels of rumen-based waste augmentation shows the potency of the organic manure to reduce accumulation of the lead and copper in cassava leaf.

Table 2 shows that nickel was not detected in cassava tuber at the double control and across various levels of RBW treatment of the control experiment, but crude oil + RBW augmentation enhanced accumulation of nickel in the cassava tuber. Greater Nickel accumulation was recorded at higher rumen-based waste augmentation. Lead value of the cassava tuber under double control (No crude oil + No rumen-based waste) was 1.00mg/kg, whereas highest rumen-based waste (6kg) augmentation recorded a lead value range of between 1.40 and 1.80 across mild, moderate and severe crude oil treatment. Copper status of the cassava tuber was 1.02mg/kg at the double control experiment but increased with increasing augmentation to 2.81mg/kg at severe crude oil level. Again copper value obtained across mild, moderate and severe crude oil treatment was higher than mean copper value of 1.02mg/kg obtained at the double control treatment. In this case, rumen-based waste enhanced copper accumulation in cassava tuber.

Table 2: Heavy Metals (Nickel, Lead and Copper) concentrations in cassava tuber

Treatments		Concentrations in cassava tuber at 6MAP (mg/kg)		
Crude oil levels	Rumen Based Waste	Nickel (Ni)	Lead (Pb)	Copper (Cu)
Control (0ml/m^2)	0 kg/m^2	Not Detected	Not Detected	1.02
	2 kg/m^2	Not Detected	1.00	1.62
	4 kg/m^2	Not Detected	1.40	2.70
	6 kg/m^2	Not Detected	1.40	2.73
Mild (1500ml/m^2)	0 kg/m^2	2.50	1.00	2.50
	2 kg/m^2	2.58	1.00	2.53
	4 kg/m^2	2.70	1.00	2.54
	6 kg/m^2	2.75	1.40	2.55
Moderate (3000ml/m^2)	0 kg/m^2	2.78	1.10	2.40
	2 kg/m^2	2.80	1.40	2.50
	4 kg/m^2	3.00	1.40	2.65
	6 kg/m^2	3.17	1.41	2.67
Severe (4500ml/m^2)	0 kg/m^2	3.02	1.20	2.60
	2 kg/m^2	3.00	1.50	2.60
	4 kg/m^2	3.14	1.80	2.71
	6 kg/m^2	3.17	1.80	2.81

Nickel has been considered to be an essential trace element for human and animal health (Zigham *et al.*, 2012). Absence of nickel in cassava tuber across levels of rumen-based waste in the control experiment and the observed increase in the level of nickel in the crude oil + rumen-based waste augmentation implies that activities of hydrocarbon and degradation process of RBW enhanced deposition of the heavy metal in cassava tubers. Nickel level was within WHO permissible limits of 10mg/kg (Zigham *et al.*, 2012; Nazir *et al.*, 2015). Lead as a soil contaminant is a widespread issue; It accumulates with age in bones aorta, and kidney, liver and spleen. Lead levels increased from not detected (ND) to 1.80mg/kg at the highest levels of severity and rumen-based augmentation. However, lead levels were within WHO permissible limit of 2mg/kg (Zigham *et al.*, 2012; Nazir *et al.*, 2015). Lead is especially accumulated in surface soil horizon because of its low water solubility and mobility especially within an environmentally relevant pH range. Lead is a non essential element and its presence in very toxic levels could lead to neurological problems, it could endanger health and cause enzymatic changes, anaemia and hyperactivity (Barkirdere and Yaman, 2008). Copper, though an essential trace element, may be toxic to both humans and animals when concentration exceeds safe limits. Copper levels increased from 1.02mg/kg at double control to 2.81mg/kg at highest levels of severity and rumen-based augmentation. Copper levels above permissible limits could lead to blood shortage, abdominal pains, nausea, diarrhoea, headache, dizziness and liver cirrhosis (Iqbal *et al.*, 2011; Chinedu *et al.*, 2011). Copper levels were within WHO permissible limits of 10mg/kg (Zigham *et al.*, 2012; Nazir *et al.*, 2015). Findings of this study agrees with Akonye and Onwudiwe (2007) who observed high accumulation of heavy metal (lead) lead at 2% pollution with saw dust augmentation

IV. CONCLUSION

Cassava tubers showed increased heavy metals (Nickel, Lead and Copper) content as rumen-based waste augmentation increased. While rumen-based waste reduced accumulation of heavy metals in leaf of cassava at specific crude oil levels, it enhanced the accumulation of these metals in cassava tuber that is mainly utilized in cassava crop production. Rumen-Based Waste is therefore not a very good material for remediation of crude oil polluted soils as it enhances the accumulation of heavy metals that are dangerous to human health.

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