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Bioremediation Of Soil Contaminated With Cassava Effluent Using Organic Soap Solution

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Abstract: *Cyanide is a chemical that is widely distributed in the environment and had harmful effects both on the environment and human life, if not properly managed. Soil remediation is among the most expensive treatments in the world nowadays. The objective of this research is to degrade the effect of cassava effluent through bioremediation means. To achieve this aim, thirty plastic buckets were filled with top soil and ponded with cassava effluent for twenty days consistently, and later divided into two lots. One of the lots was treated with organic soap solutionfor three days; after which the following parameters (cyanide, Zine, Copper, Nickel, Chromium, Potassium, Sodium and Phosphorous) were tested on the two lots. The results show degradation of the cyanide and heavy metals in the soil;and stabilization of the soil is a function of time,faster with treated soil samples. From the results, organic soap had significant ($P \leq 0.05$) effect on the degradation of the cyanide, Ni, Cr, Cu, and Zn in the soil within the treatment period of twenty-one days. and was able to stabilize the soil. In respite to the Na, P and K values in the two lots, it was found that the organic soap significantly increased their availability, making the soil more fertile. This research shows that there is appreciable level of soil detoxification arising from the usage of organic soap solution as bioremediationagent; and at the same time improving the essential elements (P, Na, K) in the soil.*

Keywords*:Bioremediation, environment, Degradation, cassava effluent, organic soap.*

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Nomenclature

K =	Potassium	Ni =	Nickel
Cn =	Cyanide	Cu	Copper
Zn =	Zinc	P	Phosphorus
Cr	Chromium	Na =	Sodium

I. Introduction

Cassava belongs to the *genius manihot* and of the natural order of *Euphorbracaea*. Cassava was first cultivated in some parts of South America, and later, across the Atlantic in the 17th century, which eventually formed part of diets for Africans and Asians (Olsen and Schaal, 1999), and Nigeria cassava production stands at 5,7134,478 tonnes, in 2016 (FAOSTAT, 2018).Cassava contains cyanogenic glucosides (toxic substances), mainly linamarin (92-98%), which releases hydrogen cyanide after hydrolysis by an endogenous linamarase (Okafor and Ejiofor 1986; Nok and Ikediobi, 1990), and waste management is a major problem facing most cassava processors in Nigeria. Almost all the wastes form cassava processing factories are poured directly on the soils and in some places, pits are dug and the liquid are drained directly into them (Oko*et al*., 2004;Eyong., 2006). The processing of cassava tubers has been reported to be associated with large discharge of effluents which contains substances that are lethal, mobile in soil, affect biodiversities, cause extinction of benthic macro invertebrates, makes marine lives difficult to survive, inhibit germination of cereal seed and destroy microbes (Ezeigbo*et al*., 2014; Olorunfemi*et al*., 2008).

Cyanide ion concentration in the soil must be low as its accumulation in the soil tend to destroy beneficial microbes who normally carry out the degradation process. Plants and other living organisms produce minute quantities of cyanide(Alström and Burns 1989; Davis, 1991; Eisler, 1991). Cyanogenic glycosides are widely distributed in more than 1000 species of plants; including cassava, peas, beans, etc. (Eisler, 1991).Cassava effluent has been found to increase the number of organisms in the soil ecosystem, and associated with increase in the soil pH, cyanide, organic carbon and total nitrogen. It had been observed that bacteria (e.g. *Lactobacillus planetarium, Pseudomonas aeruginosa, Bacillus spp* and *Viltro* spp.) and fungi population increased with time as the soil was polluted with cassava effluent (Ogboghodo*et al*., 2001; Ogboghodo, *et al*. 2006; FAO, 2008). Humans and the environment are highly affected by cyanide; it is onethe significant environmental contaminants that affects wildlife mortality (Henny *et al*. 1994).

The mobility of cyanide compounds in soil depends onstability and dissociation characteristics of the compound,soil type, soil permeability, soil chemistry, and thepresence of aerobic and anaerobic microorganisms (Fuller1984; Higgs 1992). Cyanide present at low concentrations in the soil can be decomposed to ammonia, carbon (iv) oxide, and nitrogen or nitrate under aerobic conditions, and to the ammonium ion, nitrogen, thiocyanate, and carbon dioxide under anaerobic conditions (Rouse and Pyrih 1990). Experimental studies on the mobilityof cyanide in saturated anaerobic soils have shown thataqueous simple cyanides and aqueous ferricyanides tendto be very mobile. Cyanides dissolved in leachate werefound to move through soils much more slowly than thosein aqueous solution as they tended to precipitate out as therelatively immobile compound Prussian Blue. The mobility of copper, cobalt,zinc, and nickel-cyanide complexes in the soil are comparably higher than iron and manganese cyanide complexes (Alesii and Fuller 1976; Higgs 1992).

Most methods of degrading the cyanide in the soil and water are expensive and have several disadvantages (Wild *et al*. 1994). For instance, alkaline chlorination process is not effective in the case of cyanide species complexed with metals such as nickel, silver, etc. due to slow reaction rates (Patil and Paknikar 2000). In addition, various chlorinated organics may be produced if the wastewater contains organic substances (Dash *et al*. 2009).Bioaugmentation is the applications of indigenous or allochthonous wide type or geneticallymodified microorganisms to polluted hazardous waste sites in order to accelerate the removal of undesired compounds(Mrozika and Piotrowska-Seget, 2010).Someof the organic products employed are sewage sludge and cow dung. However,studies on bioremediation of cassava mill effluent are still in the preliminary stage, therefore, the main objective of this work is to evaluate the efficiency of organic soap locally formulated from oil palm bunch waste, in degradation of the effect of cassava effluent on the soil chemical properties of the soil, with the ultimate goal of eliminating some toxic substances such as cyanide and other heavy metals in the soil.

II. Materials And Methods

2.1 Samples preparation

Forty dark coloured containers filled with 6 kg of the soil sample were ponded daily with two litres of cassava effluent (100 % concentration) for twenty days,to obtained a stabilization stage.Twenty of the containers were then treated with organic soap (locally formulated soap from oil palm bunch) at a concentration of 200g/25L; while the remaining 20 containers were left untreated (control). The initial chemical properties of the soil sample before the ponding with cassava effluent were analysedand the result presented in Table 1

Table 1: Physico-chemical properties of the soil and the compost manure

Parameters	**Soil sample**
Particle size distribution (%)	
Sand	39.4
Silt	33.2
Clay	27.4
Chemical analysis	
Soil pH (H_20)	7.75
Total nitrogen (mg/kg)	0.119
Available Phosphorus (mg/kg)	0.337
Copper (mg/kg)	4.911
Nitrate (mg/kg)	0.303
Sodium (mg/kg)	450.748
Extractable Potassium (mg/kg)	687.585
Nickel (mg/kg)	2.57
Cyanide (mg/kg)	2.8
Chromium (mg/kg)	1.87
Zinc (mg/kg)	7.23

2.2 Organic soap preparation

Palm fruit bunch waste was collected from the oil mill of Delta State polytechnic, Ozoro, Nigeria. The waste was sundried before they were burnt into ashes; and the ashes were dissolved in distill water to obtain a heterogeneous solution. The filtrate obtained was evaporated and used to prepare the organic soap.

2.3 Chemical analysis of the soil

The soil chemical analysis was performed at theanalytical services laboratory of Thermosteel Nigeria Limited, Warri, Delta state, Nigeria. The soil samples were air dried in a clean, well-ventilated room temperature for a period of two weeks; the dried samples were then grinded, homogenized, and sieved through a

2mm stainless sieve. Chemical parametersanalyzed forin this research include: cyanide, nitrogen,phosphorous, metallic cations of zinc, sodium, copper, potassium, nickel and chromium.Sodium, potassium, nickel, and chromium, presented in the pretreated soil samples were determined using standard methodsas prescribed by AOAC, 2002; while Zn and copperwere determined by the method as described by Nwakaudu*et al* (2012). Cyanide levels in the soil samples was analyzed by measuring 10 g of the sample mixed with 50ml of distilled water and continuously shaken for about 30minutes using the electronic shaker. The solution is then filtered and the filtrate is analysed for cyanide as described by Ademoroti (1996).Five replicates of the soil samples were used for the chemical analysis for each experimental date and the average recorded.

2.4 Data analysis

The response data were analyzed on IBM SPSS Statistics 20. The analysis of variance test (ANOVA) was carried out using the software SPSS 20.0 to examine the effect of compost manure on the growth and development of the five bean varieties (iron, butter, honey, brown and cowpea), and followed by Duncan's test ($p < 0.05$). The summary of the readings was plotted in Microsoft Excel 2015, and the coefficients of determination and correlation were determined by using the MS Excel 2015 (Microsoft Corporation Redmond, WA 98052).

III. Results And Discussion

The effect of organic soap solution amendment on the soil chemical properties is as presented in Analysis of Variance (ANOVA) table (Table 2). From the ANOVA table (Table 2), the soil treatment and treatment period had significant ($p<0.05$) effect on the eight parameters (Na, K, Cu, Ni, Cn, Cr, P and Zn) investigated in this research. The content of Cn, Cu, Zn, Ni and Cr in the soil decreased significantly ($P < 0.05$) with the application of organic soap solution from Day 0 to Day 21. As for K, Na and P content in the soil, their availability in the soil increased significantly ($P < 0.05$) with the application of organic soap solution from Day 0 to Day 21. The correlation coefficient (r) values recorded in Tables3 and 4 exhibited that all the studied parameters were highly significantly and positively associated with soil treatment andtreatment period. The significant degrading of the cyanide and other heavy metals in the soil is an indication that organic soil solution could be used effectively in soil bioremediation.

Table 2: Analysis of variance (ANOVA) of effect of treatment and treatment period on cyanide, heavy metals and other metals in cassava effluent contaminated soil

Source	df	Cu		Zn		Cn		Ni	
		F	Sig	F	Sig	F	Sig	F	Sig
T	1	964.7	2.58E-14*	587.8	7.81E-13*	513.1	1.97E-12*	267.1	1.63E-10*
P	4	54.2	5.94E-08*	230.7	3.75E-12*	162.2	4.15E-11*	107.0	6.86E-10*
T x P	4	5.99	0.013197*	0.18	0.838894^{ns}	8.45	0.003921*	2.81	0.094175^{ns}

T = soil treatment; P = treatment period * = significant at $p \leq 0.05$; ns = not significant

Table 2 continued

Source	df	Cr		P		K		Na	
		F	Sig	F	Sig	F	Sig	F	Sig
T	1	208.3	8.47E-10*	1323.7	2.89E-15*	275.6	1.32E-10*	213.9	7.1E-10*
P	4	68.4	1.32E-08*	27.1	4.30E-06*	19.0	3.32E-05*	5.7	0.00942*
T x P	4	3.83	0.047261*	54.42	2.49E-07*	9.88	0.0021*	14.51	0.0003*

T = soil treatment; P = treatment period * = significant at $p \leq 0.05$; ns = not significant

Table 3: Correlation (r) matrix of cyanide, heavy metals and other metals in cassava effluent contaminated soil

Parameter	Days	Cn	Cu	Zn	Cr	Ni	P	K	Na
Days	1								
Cn	-0.9715	1							
Cu	-0.9695	0.8925	1						
Zn	-0.9830	0.9673	0.9199	1					
Cr	-0.9972	0.9863	0.9527	0.98252	1				
Ni	-0.9961	0.9762	0.9686	0.9669	0.9967	1			
P	-0.9974	0.9729	0.9725	0.9692	0.9965	0.9997	1		
K	-0.9240	0.9791	0.8458	0.8965	0.9483	0.9462	0.9390	1	
Na	-0.9716	0.9985	0.8873	0.9764	0.9854	0.9718	0.9693	0.9679	1

Table 4: Correlation (r) matrix of effect of treatment on cyanide, heavy metals and other metals in cassava effluent contaminated soil.

Parameter	Days	Cn	Cu	Zn	Cr	Ni	P	K	Na

Days	1								
Cn	-0.8974	1							
Cu	-0.9061	0.9978	1						
Zn	-0.9489	0.9849	0.9918	1					
Cr	-0.9504	0.9816	0.9898	0.9997	1				
Ni	-0.9857	0.9565	0.9639	0.9884	0.9889	1			
P	0.9186	-0.9797	-0.9906	-0.9943	-0.9950	-0.9704	1		
K	0.9049	-0.9789	-0.9901	-0.9901	-0.9913	-0.9618	0.9994	1	
Na	0.9337	-0.9027	-0.9272	-0.959	-0.9653	-0.9581	0.9679	0.9642	1

3.1 Effect of organic soap solution on the soil cyanide level

The research result show that the organic soap solution significantly ($P \leq 0.05$) degraded the cyanide level in the soil (Figure 1). In reference to Figure 1,at Day 0, cyanide concentrations in samples without organic soap was 26.36 mg/kg; however, at Day 21, cyanide level in the soil was degraded to 4.19 mg/kg in the treated soil sample, while the untreated soil sample retained the cyanide level of 14.87 mg/kg. This result is in conformity with the chemical treatment of cassava effluent by Ugwu and Agunwamba (2012) and Omotosho and Amori (2015), who used NaOH and caustic hydrogen peroxide respectively. The sodium hydroxide decomposed cyanide to cyanate salt and to carbon (IV) and nitrogen (Ugwu and Agunwamba 2012) for the degradation.

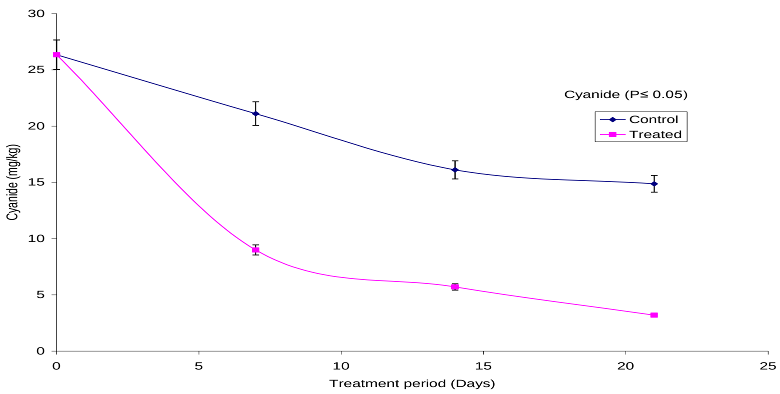

Figure 1: Changes in the cyanide concentration in the soil using organic soap treatment.

3.2 Organic soap solution effect on heavy metals (Zn, Cu, Ni and Cr)

Results from this research show that the organic soap solution was able to degrade some of the heavy metals content of the soil. In reference to Figure 2, the organic soap amendment significantly ($p<0.05$) reduced the copper concentration in the soil from 8.11 mg/kg (Day 0) to 2.78 mg/kg (Day 21). Copper is an essential element for various metabolic processes in soils (Scheiber*et al.*, 2013), but is its required in trace amounts as high concentration becomes toxic to the plant. Akinnifesi*et al*. (2006) reported that increasing copper content of soils reduced the amount of plant available phosphorus that caused nutrient imbalance, which may affect nutrient uptake by plants. In respect to the Chromium content in the soil, it was observed from the results that it's level decreased significantly ($p<0.05$) with the application of the organic soap solution (Figure 3). The treated soil samples had the lower Chromium concentration at the end of treatment period, suggesting the positive impact of organic soap solution on the contaminated soils. Chromium and its compounds are known to cause cancer of the lung, nasal cavity and paranasal sinus and suspected to cause cancer of the stomach and larynx (ATSDR, 2000).

From the results, there was significant difference ($P < 0.05$) in the Zinc content in the soil, among the treated and untreated soil samples. Figure 4 depicts the results of influence of organic soap solution on the Zinc content in the soil; the availability of Zinc decreased significantly ($p<0.05$) with the application of the organic soap solution, within the treatment period of 21 days. In respite to the availability of Nickel in the soil, there was significant variation ($P < 0.05$) in the rate of degradation of Nickel between the treated and untreated soil samples. Based on interaction of treatment and treatment period, there was no significant effect on the distribution (Table 2 and Figure 5); these results are in agreement with the study of Thompson and Gerteis (1990), and Song *et al*., (2016).Heavy metals affect the growth, morphology and metabolism of microorganisms in soil through functional disturbance, protein denaturation or the destruction of the integrity of cell membranes (Leita*et al*., 1995). Variations in these findings with previous works on bioremediation of contaminated soil could be due difference in organic components and concentration of the materials used.

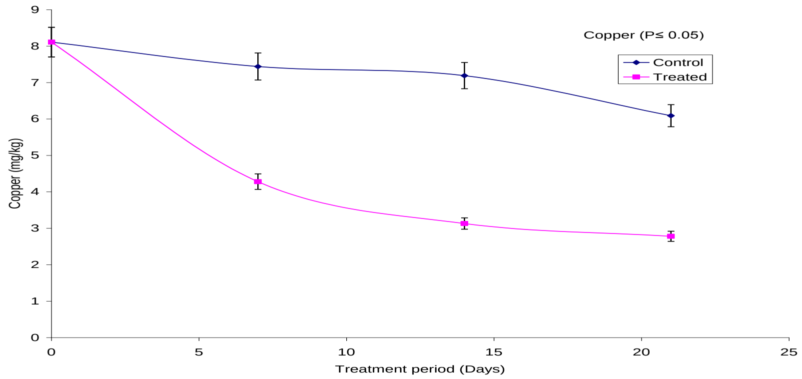

Figure 2: Changes in the copper concentration in the soilusing organic soap treatment.

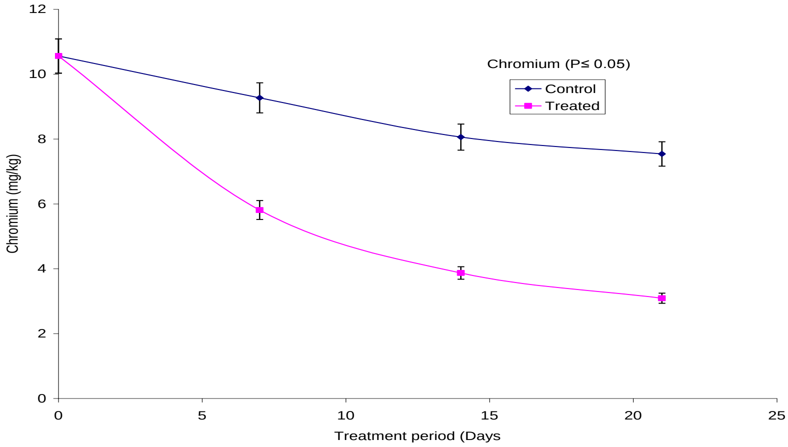

Figure 3: Changes in the Chromium concentration in the soilusing organic soap treatment.

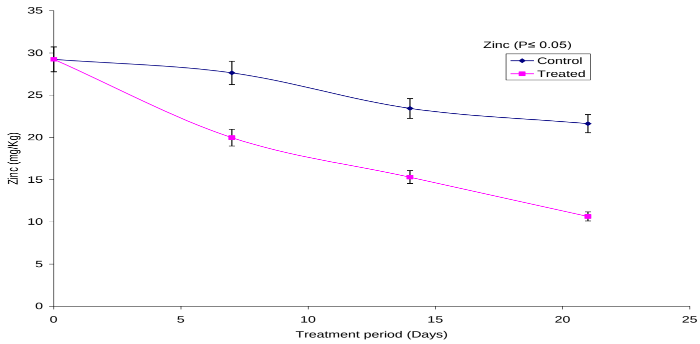

Figure 4: Changes in the Zinc concentration in the soilusing organic soap treatment.

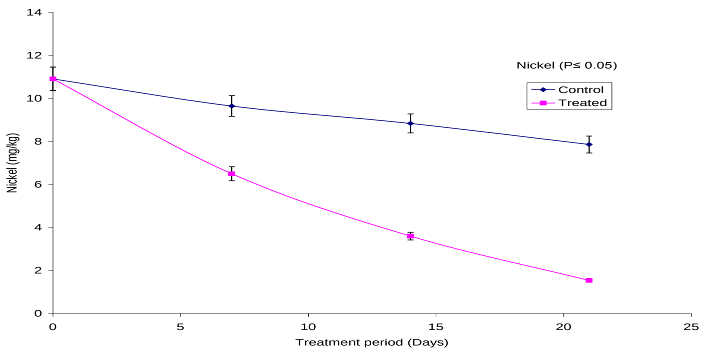

Figure 5: Changes in the Nickel concentration in the soilusing organic soap treatment.

3.3 Effect of organic soap solution bioaugmentation on P, K and Na availability in the soil

The relationship between P, K, and Na and bioaugmentation treatment was statistically significant ($P < 0.05$); as their respective availability in the soil increased with the treatment (Figures 6, 7 and 8). The increased concentration of phosphate, potassium and sodium in the soil samples maybe attributed tothe major components of the organic soap, used in the bioaugmentation of the soil; and components of the cassava effluent.Cassava tuber, from where the effluent is gotten is a rich source of phosphorus (Jung *et al*., 2002); while palm fruit bunch is rich in potassium and phosphorus.Ehiagbonare*et al*. (2009) reported that cassava mill effluent increased soil pH, available P and organic carbon significantly; while Onyia*et al*., (2001), stated that controlled application of effluents increases soil pH, Ca, K, Mgand organic carbon. Potassium is macro nutrient essential for plant growth, as its deficiency resulted in stunted growth and poor resistances to diseases and insects.

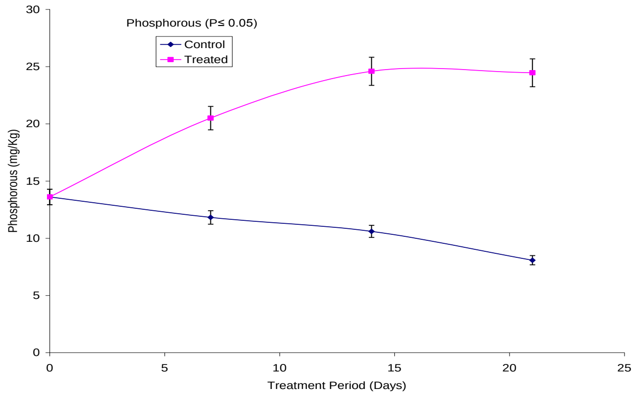

Figure 6: Changes in the Phosphorus concentration in the soil using organic soap treatment.

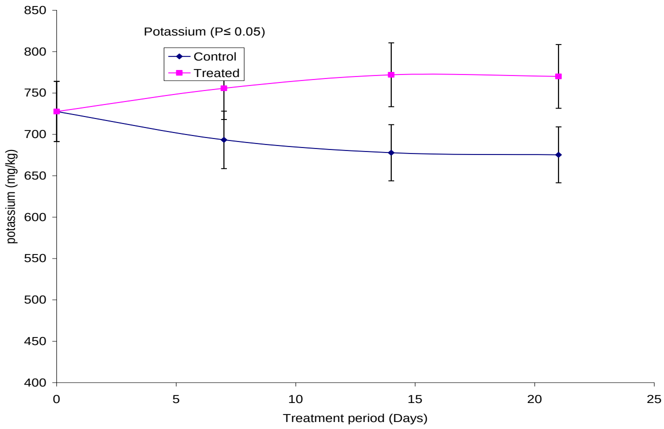

Figure 7: Changes in the Potassium concentration in the soil using organic soap treatment.

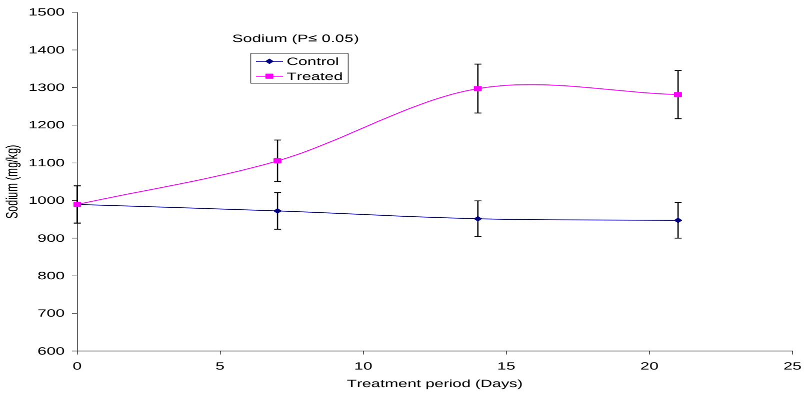

Figure 8: Changes in the Sodium concentration in the soil using organic soap treatment.

IV. Conclusion

The results gotten from this research shows that organic soap can be used to effectively treat cassava effluent effect in the soil. The process requires avery less effort and cost-effective process when compared to other conventionalmethods that are used for cleanup of cyanide and other heavy metals infested soils. This method not only degrade the cyanide plus heavy metals level but improve soil nutrient content. As a result of bioaugmentation treatment, soil available Potassium, Sodium and Phosphorus increased significantly, which are essential elements required by plants for growth. The significant degrading of the cyanide and other heavy metals in the soil is an indication that organic soil solution could be used effectively in soil bioremediation. The correlation relationship of heavy metals level with the soil treatment showed a strong relationship. Thisstudy has unveiled the potentials of organic soap which is cheaply available in Nigeria as a bioaugmentation of cassava effluent contaminated soils.

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