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Effects of Cassava Processing Effluents on the Soil Microbial Population Dynamics in Selected Communities in Abakaliki, Ebonyi State, Nigeria

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ABSTRACT
Cassava processing effluent constitutes environmental nuisance and pollutes both soil and water which releases foul odour causing air-pollution. This study evaluated the effects of cassava mill effluent on the microbial population dynamics and physicochemical characteristics of soil in selected communities in Abakaliki, Ebonyi State. Soil samples were collected in a depth of 0-20 cm from both cassava mill effluent polluted soil and unpolluted soil samples for three month and conveyed to the laboratory for analysis. The result showed that there was significant difference ($p<0.05$) in the microbial (bacterial and fungal) population between the polluted and unpolluted sites. Bacterial population ranged from $4.0\pm0.2x10^6$ Cfu/g to $8.6\pm0.8x10^6$ Cfu/g, while fungal population ranged from 1.4 ± 0.1 to $3.4 \pm 0.3x10^6$ Cfu/g across the three months study period. Most of the bacteria species identified in the polluted and unpolluted sites includes; *E. coli*, *Bacillus* species *Staphylococcus aureus*, *Klebsiella pneumonia*, *Shigella* species, *Pseudomonas aeroginosa* and *Proteus* species, while fungal species isolated from the polluted site was the *Articulospora inflata* while the mold, *Aspergillus* species and the *Penicillium* species were commonly found in both polluted and unpolluted sites. The physicochemical properties of the soil samples showed that there was no significant difference in the physicochemical characteristics of both polluted and unpolluted sites although the soil physicochemical properties differed very significantly ($P<0.001$) across the locations studied. Most of the physicochemical parameters were higher in the polluted soils compared to their unpolluted counterparts except for the exchangeable cations. This study showed that there is a shift in microbial population structure in soils polluted with cassava mill effluent. However, although this increases most physicochemical properties of the contaminated soil such as pH, OC, OM, N and P, it did not lead to significant shift in these parameters in the three months study period across the locations. This study has elucidated the nature of changes in both microbial population structure and physicochemical properties of soil exposed to cassava effluent pollution.

Keywords: Cassava effluents, Ebonyi State, Microbial Population, Polluted Soil

INTRODUCTION
Nigeria is the World's largest producer of cassava (*Mannihot esculanta*) and in cassava producing countries like Nigeria, wide adoption of high-yielding varieties and better pest management have resulted in a sharp rise in production (Agedah, 2015). Cassava is an annual crop that is propagated by stem and harvested between 7 – 13 months after planting depending on variety (Agedah, 2015). In Nigeria several varieties of cassava are grown, but the two major cultivars cultivated are sweet and bitter variety, the bitter variety has its Cyanogenic glucoside distributed throughout the tuber, while the sweet variety has low Cyanogenic glucoside, mainly in the peel of the tuber.

The cassava mill effluent (CME) from traditional grating during processing is a major cause of environmental degradation, contaminating agricultural farmlands, streams and affecting biodiversities (Olorunfemi *et. al*., 2008; Chinyere *et al.*, 2013; Izonfuo *et al.*, 2013). The discharged CME contains large amount of water, hydrocyanic acid and organic matter in the form of peels and sieves from the pulp as waste products. The toxicity of cassava mill effluent is basically associated with its acidic pH and cyanide content. In acidic soils, plants are likely to take up toxic metals, which may prevent seed germination or eventual death (Olorunfemi *et al*., 2008).

When these cassava mill effluents are improperly disposed, they generate offensive odour and unwanted scene (Okafor, 2008). They are thus, a potential hazard to soil, water, flora, fauna, livestock and human population living around the processing locations (Omonoma and Akipelu, 2010). The increasing level of heavy metals in the environment from various anthropogenic sources like cassava mill effluent should be a source of concern for environmentalists (Iwegbue 2007; Opeolu *et al.*, 2008; Osakwe and Egharevba, 2008). These heavy metals that are released into the environment tend to persist indefinitely, accumulating in living tissues through food chain causing severe diseases to man (Akpoveta *et al*., 2010; Enerijiofi and Ajuzie, 2012).

Knowing that cassava effluent constitute environmental problem, it is therefore pertinent to ascertain the level of pollution on soil receiving cassava effluent and that soil not receiving cassava effluent. The purpose of study therefore is to investigate microbial and physicochemical characteristics of soil receiving cassava effluent and compare same with the one that do not receive cassava effluent in Abakaliki over a three months study period.

MATERIALS AND METHOD

Study Area

The study was carried out in selected cassava mill plants in Abakaliki, Ebonyi State. Ebonyi State is located approximately within latitude 6º20'N and longitude 8º06'E in the derived savannah of South-Eastern part of Nigeria at an elevation of 117m. The rainfall pattern is bimodal (April-July and September-November) with a short spell in August referred to as August break and annual rainfall of about 1,800-2,000mm. The average temperature is between 25ºC in January, 34ºC in June and 30ºC in November and the relative humidity is between 60-80 % (Ofomata, 2005; Ude, 2011). The vegetation of the area is predominantly derived Savannah. Abakaliki has a population of about one hundred and thirteen thousand one hundred and thirty (113,130) people (National Population Census (NPC), 2006). The major occupations of people in Abakaliki are farming and trading, there are also civil servants and students.

Collection of Cassava Mill Effluent Sample:

Cassava mill effluents were collected from ten (10) cassava processing mill site at Abakaliki, Ebonyi State. A sterile four (4) litre plastic container was used to collect the samples in triplicate. The samples collected were carefully labeled and conveyed to the Applied Microbiology Laboratory, Ebonyi State University, Abakaliki for Physicochemical and microbiological analysis using standard procedures.

Enumeration of Total Heterotrophic Bacterial and Fungal Counts:

Ten - fold serial dilution of the cassava mill effluent sample was prepared. Aliquot 1ml of appropriate ten - fold serial dilution (10^{-3} to 10^{-9}) of the cassava mill effluent sample was inoculated into nutrient and potato dextrose agars plates containing fuscin and streptomycin in triplicate using pour plate method for bacterial and fungal enumeration respectively (Cheesbrough, 2006). The inoculated plates were incubated at 37ºC for 24hrs in an incubator and at room temperature of 28ºC for 72hrs for the enumeration of the total heterotrophic bacterial and fungal counts respectively. The results were expressed in colony forming units per milliliter of the sample (CFU/ml).

Characterization and Identification of Bacterial and Fungal Isolates:

Discrete colonies of bacterial and fungal isolates were purified by sub-culturing thrice into freshly prepared nutrient and potato dextrose agars plates respectively. Pure cultures of bacterial isolates were characterized and identified based on their cultural, morphological and biochemical characteristics (Holt *et al*., 1994) while pure cultures of fungal isolates were identified based on cultural characteristics and microscopically using lactophenol blue (Barnett and Hunter, 1972)

Determination of Physicochemical Parameters and Heavy Metals Concentrations:

The method of APHA, (2011) was used to determine the physicochemical parameters which included pH, electrical conductivity, total dissolved solids, turbidity, alkalinity, chloride, sulphate, nitrate, cyanide, phosphate, chemical oxygen demand, dissolved oxygen and biochemical oxygen demand. The cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) were determined with a flame photometer, model Jenway model PFP7 while the heavy metals concentrations were analysed with the aid of atomic absorption spectrophotometer, model PG 550 (Edori and Edori, 2012).

Statistical Analysis

The statistical analyses of data were conducted using Minitab16 software and Microsoft excel. The data was subjected to Anderson-Darling normality test. Comparisons of means were assessed statistically by subjecting data to one-way analysis of variance (ANOVA). Regression analysis and probability values (*p*-values) of less than 0.05 were considered as significant.

RESULTS

Bacterial and Fungi Population across Different Effluent Polluted Sites in Abakaliki, Ebonyi State

The total bacterial colony count of the cassava effluent polluted area showed that rice mill cassava processing site had the highest bacteria load of$8.6±0.8x10^6$ Cfu/g followed by Abofia and Sharon ($5.8±1.3x10^6$ Cfu/g and $5.8±1.2x10^6$ Cfu/g) respectively, while Igwe-Okpo cassava processing sites recorded the least bacterial population ($4.0±0.2x10^6$ Cfu/g) as shown in Figure 1. A decrease in bacteria load was recorded at rice mill cassava processing site in July, with bacteria load ranging from (8.5±0.7to $3.3±0.3x10^6$ Cfu/g). Abofia recorded significantly higher bacteria count ($8.5±0.7x10^6$ Cfu/g) followed by Mgbabor ($6.9±3.0x10^6$ Cfu/g), Obegu ($6.9±0.7$ $x10^6$ Cfu/g) and Onuebonyi ($6.8±0.3x10^6$ Cfu/g) but Echara Unuphu recorded significantly least bacterial load ($3.3±0.3x10^6$ Cfu/g) (Figure 1). Meanwhile, in

August, the bacteria loads across the location were significantly higher in Obegu cassava effluent pollution site (6.5±0.6x10^6 Cfu/g) compared to other locations. This was followed by Abofia (5.4±0.2x10^6 Cfu/g), Echara Unuphu (5.1±1.5x10^6 Cfu/g) and Onuebonyi (5.0±0.7x10^6 Cfu/g), while Mgbabor recorded the least colony forming units (3.3±0.3x10^6 Cfu/g) as shown in Figure 1.There was significant difference ($p<0.05$) in the bacteria colony count across the locations within the three months period.

The fungal colony count in the month of June was significantly higher in Obegu (3.4±0.3x10^6 Cfu/g) followed by Mgbabor (3.2±0.8x10^6 Cfu/g) and Abofia (3.0±0.1x10^6 Cfu/g) but lowest in Rice-mill (1.7±0.1x10^6 Cfu/g). Mean while, in the month of July, the fungal count was highest in Echara Unuphu polluted site (2.6±0.5x10^6 Cfu/g) followed by Agbaja and Ndiebor polluted sites (2.3±0.5x10^6 Cfu/g and 2.3±0.2x10^6 Cfu/g) respectively, but lowest fungal population for the month was observed in Sharon cassava-mill effluent contaminate site (1.7±0.2x10^6 Cfu/g). However, in the month of August, Abofia had highest fungal count (2.9±0.1x10^6 Cfu/g) followed by Echara Unuphu contaminated site (2.2±0.4x10^6 Cfu/g) but lowest Sharon (1.2±0.3x10^6 Cfu/g) as shown in Figure 2. There was significant difference ($p<0.05$) in the fugal population.

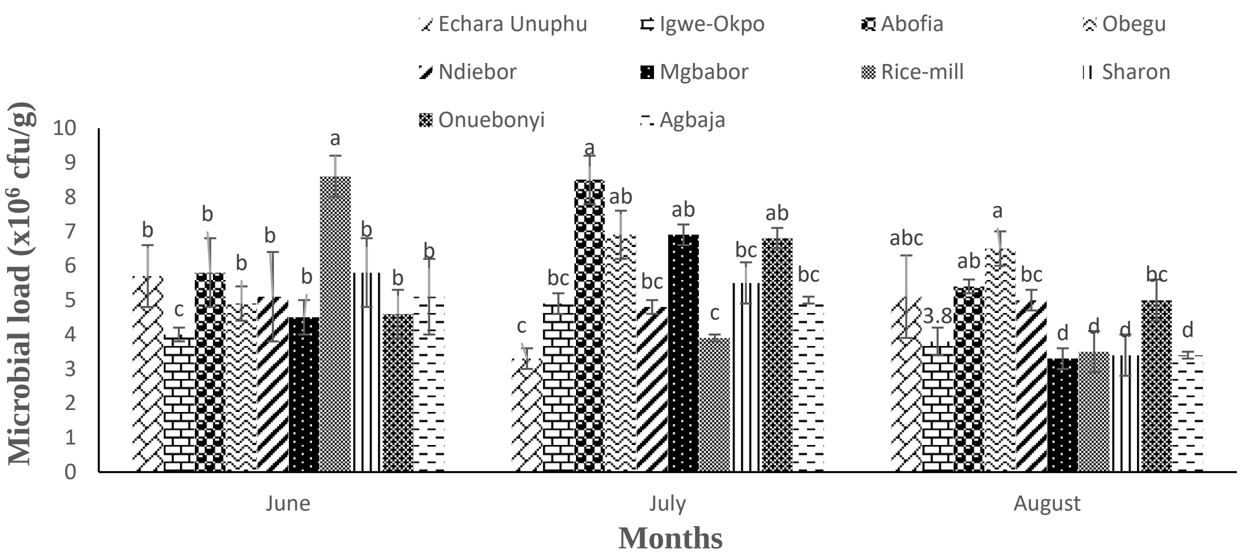

Figure 1: Bacterial population across the different sample locations and study period

Key: Bars with same alphabets do not have significant difference, while those with different alphabets show significant difference

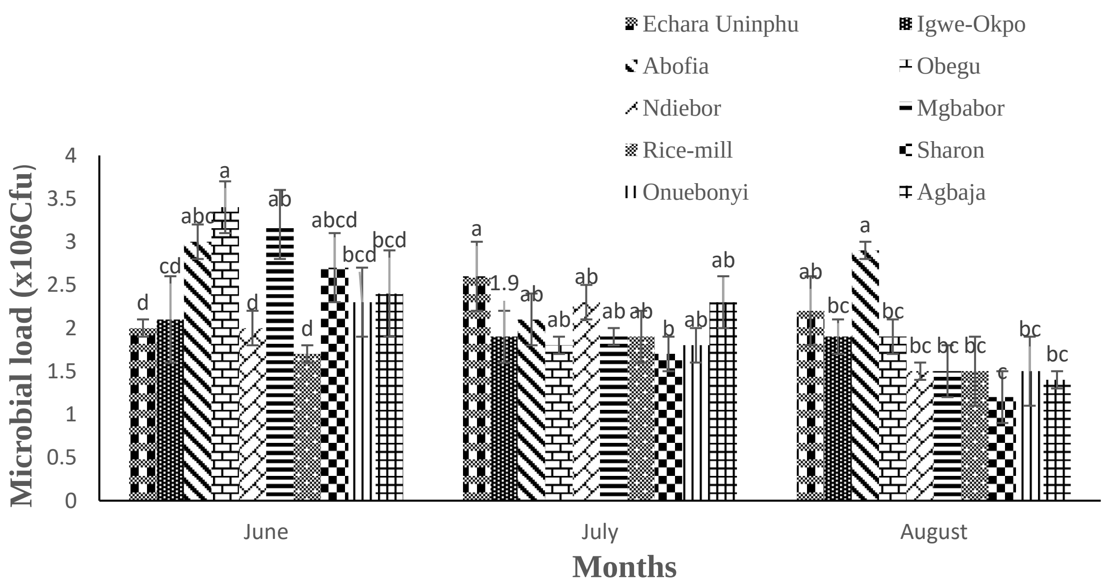

Figure 2: Fungal population across the different sample locations and study period

Dynamics in Bacterial and Fungi Population Structure in the Study Locations over Three Months Period

The bacteria isolated from the studied areas were *Bacillus spp, Pseudomonas aeruginosa, Klebsiella spp, Shigella spp. Proteus spp. and Staphylococcus aureus.* On the other hand, four species of fungi belonging to the genera *Aspergillus*, *Articulospora inflata*, *Penicillium* and *Trichoderma spp.* were isolated. Figure 3 represents the occurrence and the distribution pattern of bacterial species or diversity in the studied areas; while Figure 4 shows the occurrence and the distribution pattern of fungal diversity in the studied areas.

The study as shown in Figure 3 describes the variation (dynamics) in the microbial population structure across the location in the three months period, while Figure 4 shows the same dynamics (changes) in fungal population structure across the period of study.

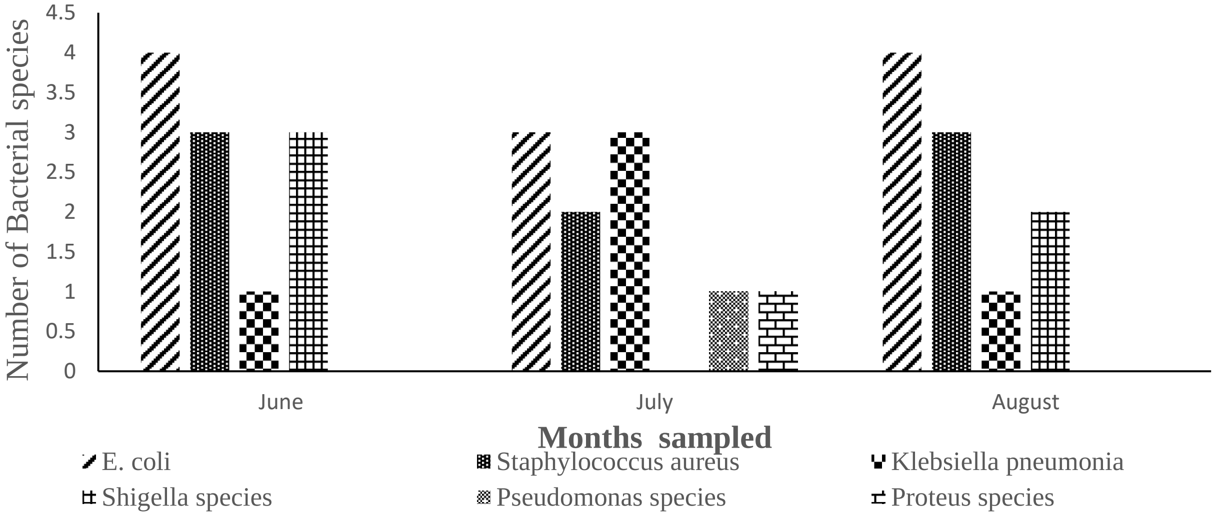

Figure 3: Number of different Species of bacteria isolated from the study locations over three months period

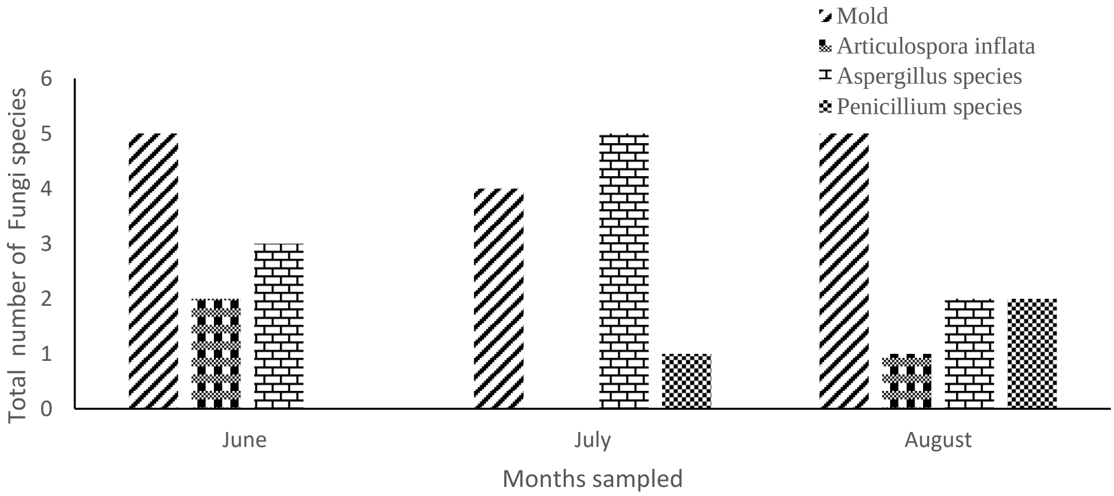

Figure 4: Number of different species of Fungi isolated from the study locations over three months period

Physicochemical Properties of Selected Cassava Mill Effluents Locations in Abakaliki Over Three Months of Study

The result of the physicochemical properties from Abofia sampled effluents showed that there was significant difference ($p<0.001$) in physicochemical compositions of the soil samples with percentage base saturation (BS) having highest value (95 to 97 %) followed by sand and phosphorus (P) contents (62.9 to 64.8 % and 62.4 to 64.8 mg/kg respectively), while there was low nitrogen (N), potassium (K), sodium (Na) and exchangeable acidity (EA). There was however no significant difference ($p>0.05$) in most of the physicochemical properties of the polluted and unpolluted soils except for organic matter (OM), calcium (Ca) and exchangeable cation exchange capacity (ECEC) which showed significant decrease in August of the same year as shown in Figure 5

The values obtained from Agbaja soil exhibited the same trend as seen in Abofia samples which showed significant difference ($p<0.05$) in base saturation (BS) with low concentrations in nitrogen (N), potassium (K), sodium (Na) and Exchangeable acidity (EA).

Samples from Echara Unuphu showed high significant difference ($p<0.001$) in concentration of the physicochemical parameters of the soil. Base saturation was highest in concentration (95 to 98 %) followed by sand portion (48.6 to 55.2 %), silt (30.4 to 32.4 %) and phosphorus contents (28.8 to 30.6 mg/kg) across the months. The result revealed a significant decrease in sand and clay contents in pollutes site in (August) 48.6 % and 12.2 % respectively compared to the other months and the polluted sites (Figure 7).

Igwe-Okpo sampled soil also showed same trend in concentration of the different physicochemical parameters of the soil as shown in other soil tested, however, there was no significant difference ($p>0.05$) observed in the pH of the polluted and unpolluted sites across the months as shown in Figure 8.

Generally samples from all the sites sampled exhibited a significant high percentage base saturation (BS) with different variations in all the other physicochemical properties with respect to the different sampling sites as can be observed in Figures 5- 14.

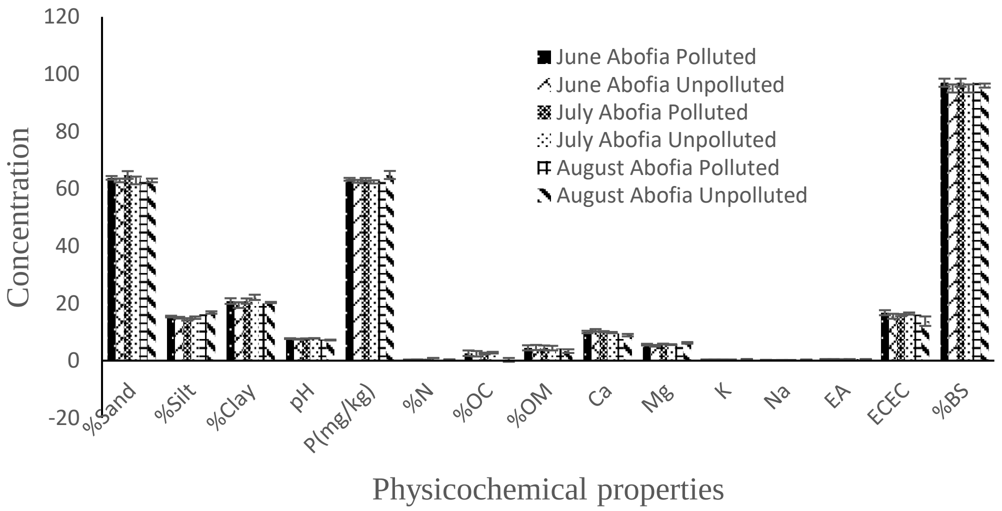

Figure 5: Physicochemical properties of Abofia soil over the three months of study

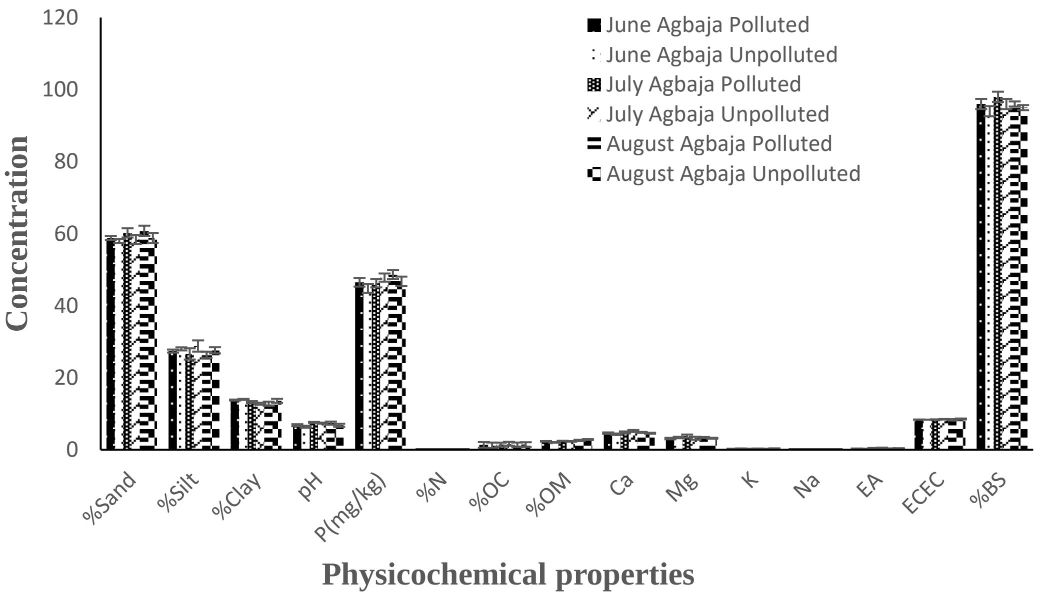

Figure 6: Physicochemical properties of Agbaja soil samples over the three months of study

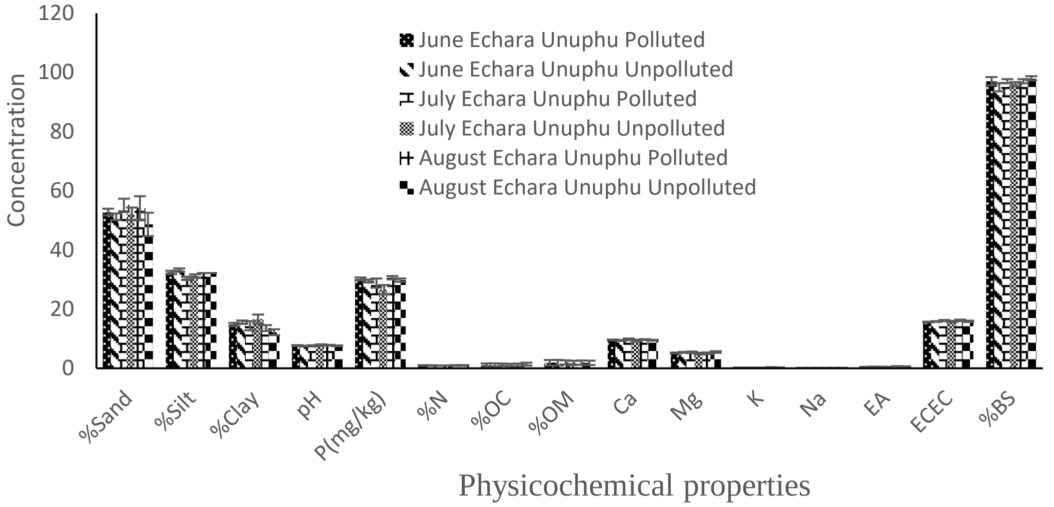

Figure 7: Physicochemical properties of Echara Unuphu soil over the three months of study

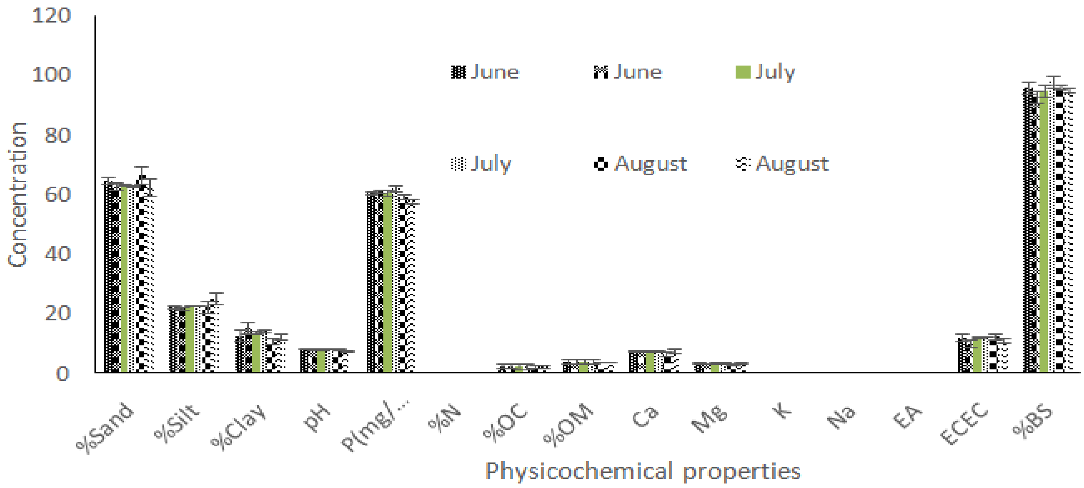

Figure 8: Physicochemical properties of Igwe-Okpo soil over the three months of study

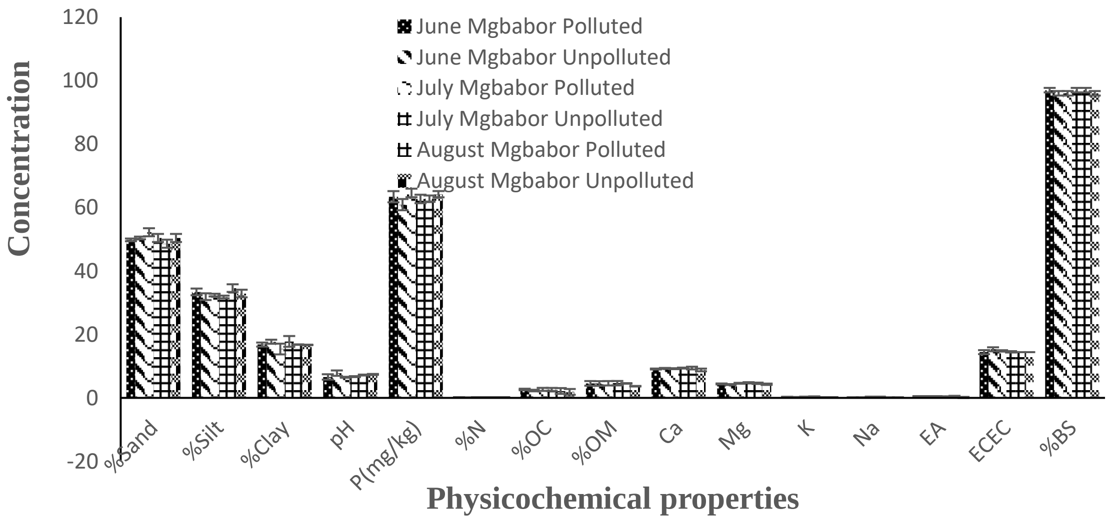

Figure 9: Physicochemical properties of Mgbabor soil over the three months of study period

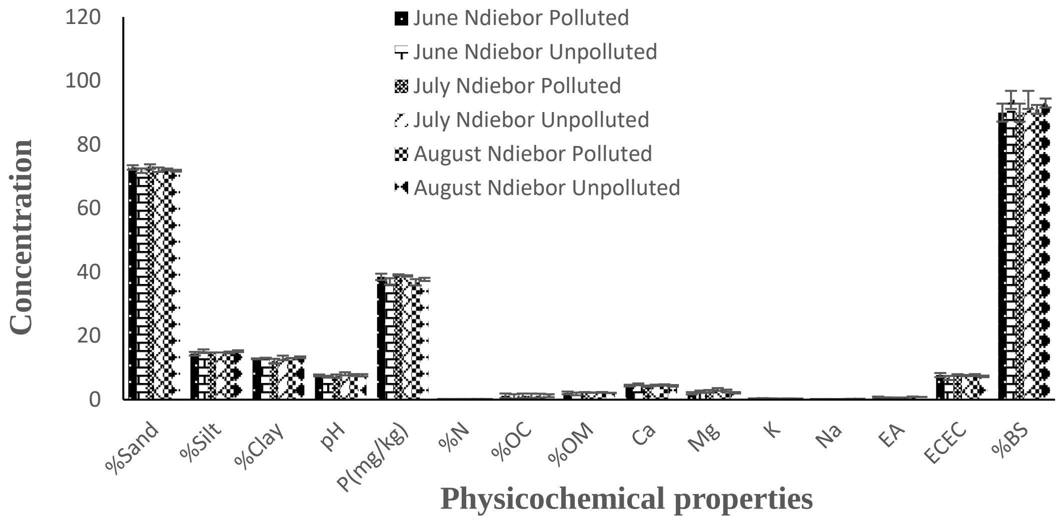

Figure 10: Physicochemical properties of Ndiebor soil over the three months of study period

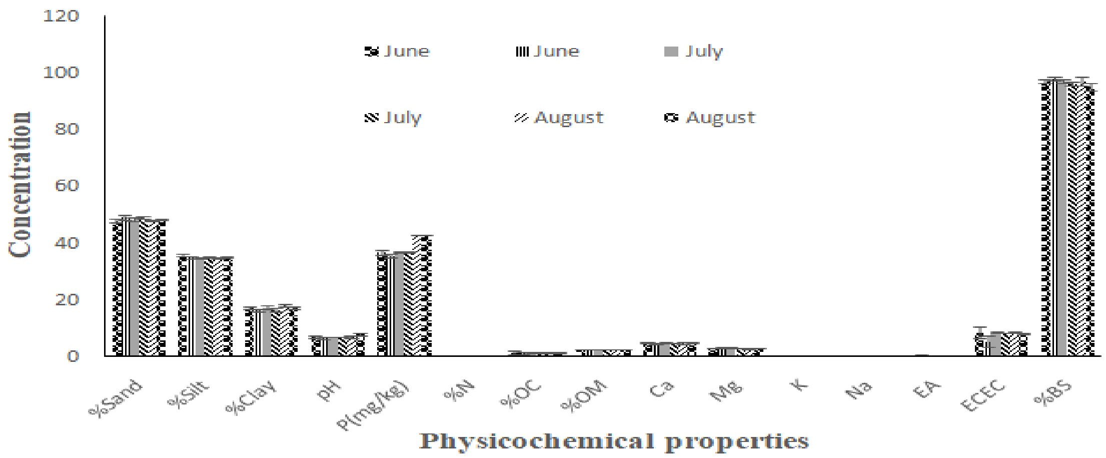

Figure 11: Physicochemical properties of Obegu soil over the three months of study period

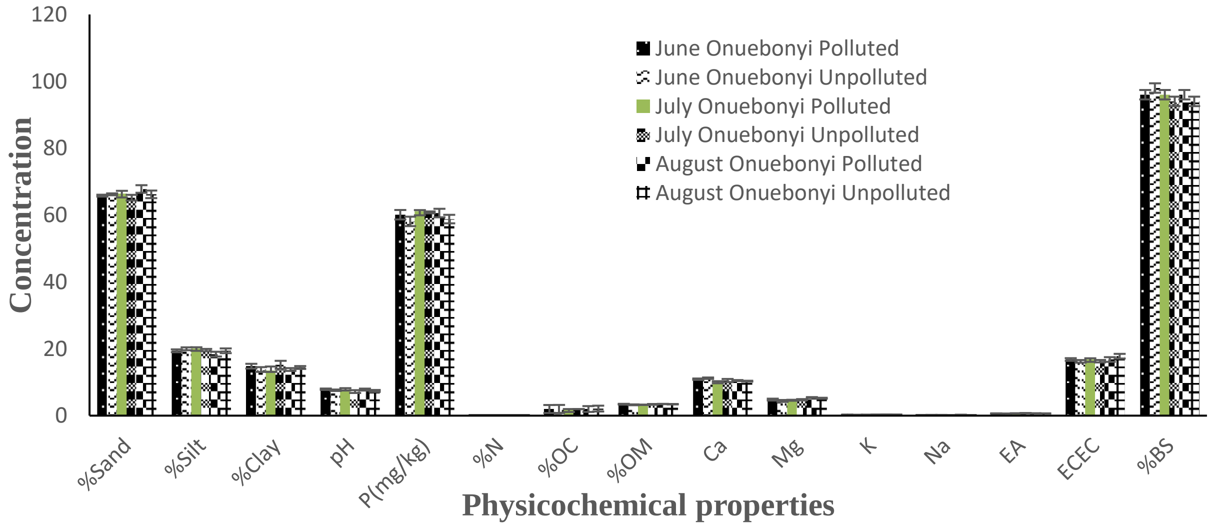

Figure 12: Physicochemical properties of Onuebonyi soil over the three months of study period

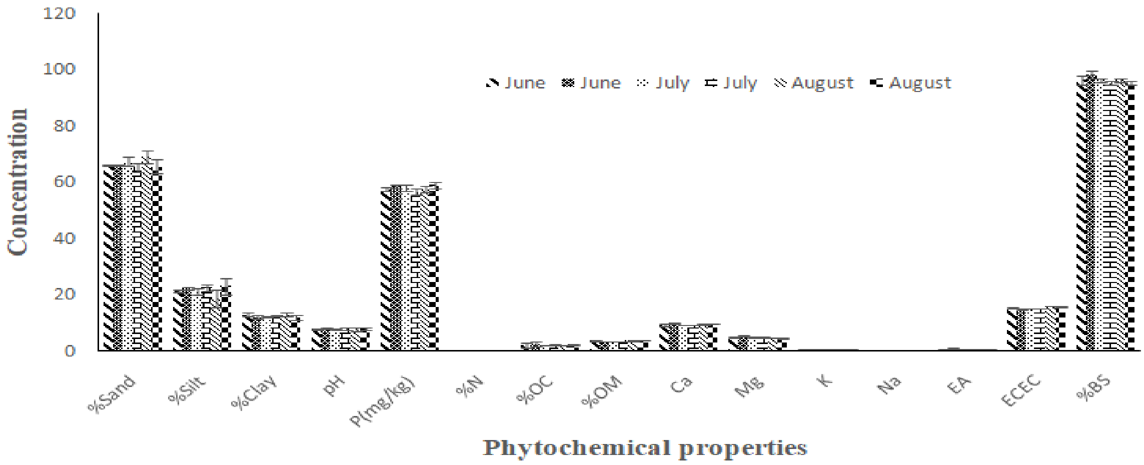

Figure 13: Physicochemical properties of Rice mill soil over the three months of study period

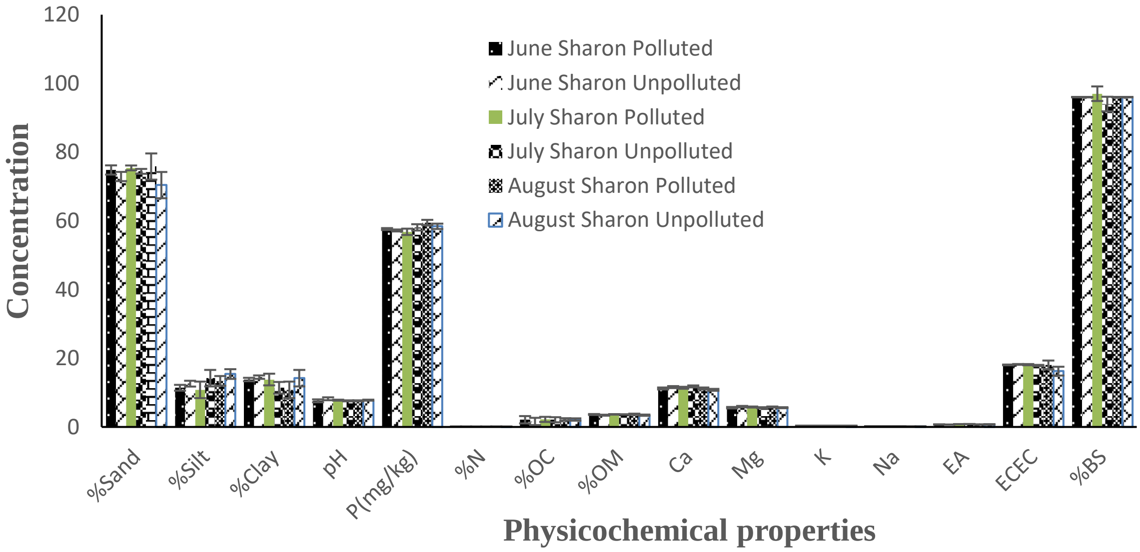

Figure 14: Physicochemical properties of Sharon soil over the three months of study period

DISCUSSION

Cassava processing generates great volume of effluent (wastewater) which causes land pollution that create environmental nuisance in the region when discharged into the environment (Eze, 2015). This study observed the average total bacterial colony count of the cassava effluent polluted area to range from 4.0±0.2x10^6 Cfu/g (Igwe-Okpo) to 8.6±0.8x10^6 Cfu/g (rice mill) across the locations studied. Fungal colony count also ranged from 1.4±0.1 to 3.4±0.3x10^6 Cfu/g across the locations studied within the three months study period. There was a significant difference ($p<0.05$) in the microbial load among the locations and between polluted and unpolluted sites. In a similar study by Akpan *et al.* (2012) who studied the effects of cassava mill effluent on some chemical and micro-biological properties of soils in Cross River State, Nigeria, and reported that bacterial population ranged from 1.6x10^6 to 4.8x10^6Cfu/g in unpolluted site and 3.4x10^6 to 5.2x10^6 Cfu/g in polluted sites while the fungal population ranged from 4.0x10^3 to 9.0x10^3 in unpolluted soil and from 4.0x10^3 to 9.0x10^3 in polluted sites. The findings above is in line with the results obtained in this study which reported bacterial population of 5.8±1.3x10^6 Cfu/g and 5.8±1.2x10^6 Cfu/g in cassava wastewater (effluent) polluted soil at Abofia and Sharon respectively as noted in our study. The observation of higher bacterial population in polluted sites compared to the unpolluted locations across the studies areas suggests that cassava wastewater (effluent) polluted soil has higher microbial activities. This can be attributed to the presence of biodegradable compounds as well as higher decomposable organic matter content impacted on the soil by the polluting cassava effluent.

The microbial species dynamics over the period of three months revealed the presence of *E. coli, S. aureus, K. pneumoniae, Shigella* species, *P. aeroginosa*, *Bacillus* species and *Proteus* species across the cassava wastewater effluent polluted sites although their population where significantly higher (P<0.05) in the polluted samples when compared to unpolluted sites in this study. Similarly, Obueh and Odesiri-Eruteyan (2016) who carried out a study on the effects of cassava processing wastes on the soil environment of a local cassava mill, and identified similar bacteria species such as *K. pneumoniae*, *P. aeroginosa, Lactobacillus plantarum*, *L. delbruekii* and *S. aureus* as well as the following fungal species; *Fusarium solani, Aspergillus niger* and *Saccharomyces cerevisiae* from cassava effluent and soil samples polluted with cassava wastewater. Izah *et al.*(2018) who studied the impacts of cassava mill effluents in Nigeria, further reported microbial diversity comprises of several microbial genera which includes *Neisseria, Streptococcus, Staphylococcus, Bacillus, Entrobacter, Proteus, Lactobacillus, Pseudomonas, Micrococcus, Saccharomyces, Penicillium, Aspergillus* and *Mucor.* Another studies also identified presence of microbes which includes *Lactococcus lactis* and *Bacillus subtilis;* fungi (*Articulospora inflate,* Trichoderma spp, *Aspergillus niger, Fusarium* species, *Rhizopus* species and *Penicillium* species) in cassava wastewater effluent polluted and unpolluted soil (Akpan *et al.,* 2012). Thus, the above report by previous researchers is in line with the findings of this study which reported presence of similar bacteria and fungi (*Penicilium* species and *Aspergillus* species, *Articulospora inflata,* and Trichoderma spp.) from both polluted and unpolluted sites. This suggests that there was no significant difference (p<0.05) in the microbial (bacterial and fungal) population structure across the locations between polluted and unpolluted sites but inherent microbial species inhabiting an area also colonizes the polluted site which leads to significant increase in their population as a result higher nutrient availability. The increase in bacteria and fungi in the polluted soils help in the rapid decomposition of organic matter and also help in releasing of essential nutrients from the soils for plants growth.

The sand fraction was higher followed by the clay then the silt fraction as observed in this study. This observation is in agreement with the study done on soil samples by Osakwe (2012), who evaluated the distribution of heavy metals in soils around automobile dumpsites in Agbor and its environment, Delta State, Nigeria, Ano *et al.* (2007) and Onweremadu *et al.* (2007) who also evaluated lead and cadmium levels in soils and cassava (*Manihot esculenta* grantz) along Enugu-Port Harcourt Express Way in Nigeria reported that the distribution of sand fraction was highest followed by clay and then silt. Also, this finding also agreed with the report of Akpa *et al.* (2011) who examined the effects of cassava mill effluent on some chemical and micro-biological properties of soils in Cross River State, and concluded that the texture of the soils ranged from sandy to loamy sand in the polluted soils.

This study also observed that the soil pH in the studied area ranged from6.3 to 8.4 in polluted and unpolluted sites across the locations during the 3-months study period. There was no significant difference in pH of the soil content among the 3 months study period, although the pH values was generally higher in polluted than unpolluted soils in most of the studied sites. The pH range obtained in this study is similar to those reported by previous researchers who reported pH between 6.5 to 8.2 in cassava effluent contaminated site (Ano *et al.,* 2007; Amusan *et al.,* 2005; Bamgbose *et al.,*2007). Ehiagbonare *et al*. (2009) carried out research on the effect of cassava effluent on Okada denizens and reported that pH of CPE discharged soil as 5.37 and pH of non-CPE discharged soil to be 6.04. However, the pH value obtained from this study was higher than the pH ranged of 5.1 to 6.6 in polluted soils and 4.3 to 5.4 in non-polluted soils as reported by Akpa *et al.*(2011).The pH values of polluted soils within this range and even above in some areas is indicating nutrient availability and microfloral activities to support plant growth. Osakwe (2012) also reported a lower pH of soils polluted with cassava wastewater effluent that ranged from 3.89 to 5.74 indicating that their soils were acidic compared to their unpolluted counterpart (6.7 to 7.8 at varying depth). He stated that the effluent imparted acidic properties to the soil which could be attributed to the presence of hydrogen cyanide in the cassava mill effluent. He however, noted that the acidity decreased with depth in all the sites. Bamgbose *et al.,* (2007) argued that soil pH determines the availability of nutrients and the potency of toxic substances as well as the physical properties of the soil. Alterations in soil physical, chemical and microbial parameters have both adverse and beneficial effects (Izonfuo *et al.,* 2013). Low soil pH values indicate a generally high tendency for high availability of metals; hence, this increases the risk of heavy metals plant uptake (Osakwe, 2012). Previous studies have also correlated decreased heavy metal availability with increasing pH Bamgbose *et al.,* (2007) and that a reduction in pH may allow the release of toxic metals that would otherwise be adsorbed in the soil or sediment. Hence, the difference in the pH of both studies may be attributed to heavy metal presence in the locations studied by Osakwe (2012).

Although there were significant differences (p<0.05) in some physicochemical parameters such as organic carbon (OC), organic matter (OM), nitrogen and phosphorus across locations, the polluted sites generally has higher values of these physicochemical components. The OC and OM contents ranged from 0.22 % to 2.31 % and from 0.54 % to 2.69 % respectively in unpolluted sites, from 0.68 % to 2.88 % and from

2.14 to 4.61 % respectively in cassava wastewater effluent polluted soil sites. The higher values of OC and OM in polluted soil may be due to the discharge of the cassava effluent with some contents of organic matter. Another study indicates the presence of degradable and compostable substances in the effluent which could lead to increase in OC and OM contents (Oviasogie and Omoruyi, 2007).Cassava processing units generate large volumes of effluent which contain highly lethal substances, mobile in soil, affect biodiversity including marine lives, benthic macro-invertebrates, fisheries, microbes, plants, human, domestic animals (goat and sheep), fauna and flora, and affect water and soil physicochemical parameters (Izah *et al.,* 2017). The presence of degradable compost (organic matter) also suggests an increased microbial activity on the residues contained in the effluent. Such decomposition processes would lead to the deposition of humic substances and increased carbon content of the soil (Osakwe, 2012). Total Organic Carbon is a measure of organic content in soils, sediments and water and contributes significantly; to acidity through contributions from organic acids and biological activities. The organic carbon (OC) and organic matter (OM) content recorded in this study was similar to the values reported by Tukura *et al.* (2007) but comparatively greater than the range (0.02 to 3.35 %) reported by Osakwe (2012) and Oviasogie and Omoruyi,(2007). Hence, the soil with higher organic matter content may be healthier for plant growth.

More so, the available phosphorus (P) was higher in polluted soils than unpolluted soils may be attributed to the cyanogenic compounds from the cassava effluent which led to high organic carbon in the polluted soils (Ebhoaye and Dada,2004). The high value of phosphorus in the soils is not surprising since cassava tuber is a rich source of phosphorus (Alemu and Tadele, 2019). The effluent impacted the phosphorus content due to direct phosphorus deposition to the polluted soil. The result also showed that nitrogen content ranged from 0.02 % (Obegu) to 0.21 % in Abofia While in polluted sites, nitrogen content ranged from 0.11 % to 0.34 % in Obegu and Abofia respectively. In a similar study by Ebhoaye and Dada (2004), It was reported that total nitrogen content was higher in polluted soils than non-polluted ranging nitrogen from 0.08% to 0.53%. Nitrogen content was reported to be higher in polluted soil compared to unpolluted soil and is attributed to increase in pH. This can also be attributed to the fact that increase in the soil pH indicates high level of nutrient availability with increase in the ECEC (Sohi *et al*., 2009). The higher level of nitrogen was recorded, probably due to nitrogen mineralization as a result of organic matter. The nitrogen content was consistent with the range reported by Osakwe (2012). Nitrogen is one of the elements needed by plant for healthy growth.

Exchangeable cation exchange capacity is directly related to soil capacity of adsorbing heavy metals. It is important to emphasize that organic matter (Carbon) content and clay composition are solely responsible for exchangeable cation exchange capacity of soils (Kolawole, 2014). In the present study the organic matter composition as indicated by the levels of organic carbon and the clay fractions can be regarded as having additive contribution to the overall ECEC of the soil. The exchangeable cations Ca^{2+}, K^{+} Na^{+}, Mg^{2+} were reported in this study but at a lower level in unpolluted samples than their polluted counterparts. This finding is in disagreement with reported cases where exchangeable cations were generally low in polluted soils than non-polluted soils and further argued that it could probably be due to low Ca^{2+}, K^{+} Na^{+}, Mg^{2+}contents of the cassava effluent (Akpa *et al.,* 2011). Also, the exchangeable acidity showed no significant difference between the polluted and unpolluted soil, although it was mildly higher in unpolluted soil than the polluted soil. Cassava wastewater effluent can alters soil microbial characteristics, physicochemical properties, heavy metals concentration, cation and anions exchange, soil enzymatic activity, soil particle size, bulk density and porosity (Ezeigbo *et al.,* 2014). The EA ranged from 0.21cmol/kg to 0.84 cmol/kg in polluted soil and from 0.25 cmol/kg to 0.85 cmol/kg in this study. Difference in exchangeable acidity in polluted and unpolluted soils was reported, however, the observed exchangeable acidity (EA) ranged from 1.70 to 3.16 cmol/kg in polluted soils and 1.93 to 3.68 cmol/kg in unpolluted (Akpa *et al.*,2011) which was higher than that observed in this study. However, the base saturation observed in this study agreed with the report of Akpa *et al.* (2011) who stated that base saturation was high in polluted soils compared to the unpolluted soil samples.

CONCLUSION

The study has shown the variation in microbial population structure and physicochemical properties of soil polluted with cassava processing effluent across different locations within three months study period. Bacteria population was higher in polluted soil samples, while fungal population showed little increase in polluted site. The bacteria species identified in the polluted soil samples include *E. coli, Bacillus* species *Staphylococcus species, Klebsiella pneumonia, Shigella species, Pseudomonas aeroginosa* and *Proteus* species while fungal species identified *Articulospora inflata, Trichoderma spp*. *Aspergillus* spp. and the *Penicillium* spp. These organisms were also present in the unpolluted soil samples except for *Articulospora inflata* which was observed in polluted soil sample in some locations. Also, the physicochemical properties of the soil differed significantly across locations but only non-significantly from one month to the other. Hence, this study has elucidated the nature of changes in both microbial population structure and physicochemical properties of soil exposed to cassava effluent pollution. There is need to adopt the report of this study as a guide to further investigate the specific roles of each species in toxic hydrocarbon degradation such as hydrogen cyanide.

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