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Agronomic Usefulness of Anaerobic Slurry on Tomato (Lycopersicum Esculentum) Seedlings

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Abstract

Current anaerobic digestion technologies are geared towards maximizing biogas yield and the subsequent use of the anaerobic slurries as soil amendments. However, only few studies have established the agronomic risk associated with the utilisation of anaerobic slurries. Therefore, this study evaluates the effect of agronomic use of anaerobic slurry on lycopersicum esculentum seedlings. L. esculentum is one of the most important vegetables worldwide. In this study, Palm esculentum Oil Mill Effluent (POME) collected from the Nigeria Institute for Oil Palm Research (NIFOR) was anaerobically digested at 1:1 effluent (E) to inoculum (I) ratio using the mesophilic technique. The physicochemical of the POME such as pH, Chemical Oxygen Demand (COD), lead, chromium, zinc, calcium, magnesium, phosphate, etc., were determined before and after anaerobic digestion. The anaerobic slurry was evaluated for their bio-fertility potential by using them as soil amendments at different doses: 0, 200, 400 and 600 ml/3 kg soil in a completely randomized design in triplicate followed by screenhouse trial. The physicochemical properties of the soil were determined using standard methods before and after the screenhouse experiment. The results showed that anaerobic digestion of the effluent was a successful biological treatment system with high COD removal efficiency (over 60 % reductions), while water properties such as total solids, nitrate, phosphate etc., were not considerably affected by the treatments. Result from the pre-plant soils revealed that the soil organic carbon, nitrogen, phosphorus, magnesium and calcium increased with increasing anaerobic slurry applications while the soil pH remained in the acidic region and the soil exchangeable acidity reduced. The plant height, number of leaves, leaf length, stem girth and total biomass yield by the plant significantly ($p<0.05$) increased with increasing anaerobic slurry treatments. Soil amendments with the anaerobic slurry improved soil fertility, plant nutrient and heavy metals uptake increased. Therefore, this should be applied with caution to avoid bio-accumulation of heavy metals in plants. Among the selected heavy metals evaluated, zinc in the 200 ml treatment had the highest uptake (195.50 mg/kg) while cadmium in the control and 200 ml treatment had the lowest (0.00 mg/kg).

Keywords: Anaerobic slurry, soil properties, tomato growth, heavy metals

1.0 INTRODUCTION

The current waste management status requires policies that are sustainable, profit yielding and environment friendly. In this regard anaerobic digestion has in recent times received considerable attention as the most advanced and sustainable organic waste treatment method (Abduraman *et al.*, 2011). Anaerobic digestion process offers several advantages because while it produces energy from waste, it also simultaneously prevent adverse environmental impact (Sunarso *et al.*, 2012). The technique is environment friendly, profit yielding, sustainable, inexhaustible and in line with the United Nation Frame-work Convention on Climatic Change (NNFCC) and the Kyoto protocol.

The increase of biogas yield has subsequently led to the generation of large amount of anaerobic slurries. Research studies reveal that about 70-75% of the nutrient in the original feed stock is retained in the anaerobic slurries (Islam, 2015) and as such, anaerobic slurries are commonly used as soil amendment (Weiland, 2010). Better yield for vegetable crops was recorded for soils amended with anaerobic slurry as compared with chemical fertilizer (Krishna, 2001). Loria *et al.*, (2007) reported the provision of sufficient nutrients to support biomass and crop yield from anaerobic digested manure as compared to synthetic fertilizers and raw manures.

Clearly, current anaerobic technologies are geared towards maximizing biogas yield and the subsequent use of the digestate as soil amendments. However, only few studies have been conducted to establish the agronomic risk associated with the use of anaerobic slurries. Therefore, in continuation for the search of more environments friendly and cost effective waste management technique, this study evaluates the risks and benefits of the agronomic use of anaerobic slurries on tomato (L .esculentum) seedlings. Tomato (L esculentum) is one of the most important vegetables worldwide (Balcha *et al.*, 2015; Regassa *et al.*, 2016). It is a relatively short duration crop and gives a high yield. Tomatoes are rich in minerals, vitamins; phytochemicals etc., which enhances the human health (Chaudhary *et al.*, 2018). Thus, the specific objectives of the study are; to determine the physiochemical properties of the effluent before and after anaerobic digestion, to determine soil physicochemical properties before and after effluents application and evaluation of the risk and benefits of the agronomic use of anaerobic slurry on tomato (lycopersicum esculentum) seedlings.

2.0 MATERIALS AND METHOD

2.1 Samples Collection/Preparation

Palm oil mill effluent (POME) was obtained from the Nigeria Institute for Oil Palm Research (NIFOR), the cow dung that was used as inoculum to improve the rate of anaerobic digestion of POME, was collected from a slaughter house in Oluku, Benin City. Samples were stored in a refrigerator at 4°C before use. The palm oil mill effluent (POME) was treated with inoculum at 1:1 effluent to inoculum (E:I) using the mesophilic techniques (Vavilin *et al.,* 2008), at 20 day retention time. The tomatoes seeds were obtained from the Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Edo State. Nigeria. The tomato seeds were planted in the nursery and allowed to grow for three weeks before been transplanted for the experiment. Composite soil samples were collected at a depth of 0 – 30 cm using an *auger* from an uncultivated land behind the Faculty of Agriculture University of Benin, Benin City. The samples were bulked, air-dried, sieved through 2 mm stainless steel sieve to remove debris and thoroughly mixed to ensure uniformity and then stored in polythene bags at room temperature before the experiment.

2.2 Analyses of the Effluents

Physicochemical properties the palm oil mill effluent (POME) were analyzed before and after anaerobic digestion using standard methods. Before the treatment, the pH was determined in-situ using the pH meter. Conductivity and suspended solids were determined with a conductivity meter (Model Hanna 911). The pH was again determined by using the HACH colorimeter Model Dr/ 89. The pH value obtained was compare with the pH value obtained in-situ and the values were comparable. The total solid was determined by adding suspended solids and dissolved solids. Dissolved solids were obtained by multiplying conductivity by 0.53. A cnductivity meter (Model Hanna 911), calibrated using 0.01M potassium chloride (KCl) was used to determine the conductivity of the samples. The volatile solid was determined according to standard methods (Ademoroti, 1996), using a nickel container. The Chemical oxygen demand was determined according to standard methods (APHA, 1999). Oil and grease content were determined according to standard methods (Ademoroti, 1996). Phosphate, nitrate, sulphate and metal (calcium, manganese, copper, cadmium, lead, chromium and zinc) analysis of samples was determined using the Atomic Absorption Spectrophotometer (AAS Unicam 969 Series) while K and Na were determined by flame photometer (Model PFP-7). The effluent were acid preserved and digested prior to the analysis. These Physicochemical properties the palm oil mill effluent (POME) were again analyzed after the anaerobic digestion.

2.3 Treatment of the Soil Samples

Three kilograms (3 kg) each of soil samples were separately treated with 0 ml, 200 ml, 400 ml, and 600 ml of the anaerobic digested palm oil mill effluent (ADPOME). This rate was chosen so that changes in the soils and the growth parameters of the tomatoes sown in the amended soil can be noticed easily. The effluents applied were thoroughly mixed with the soil, watered, and left for eight weeks for adequate mineralization and equilibration before the tomato seedlings were transplanted.

2.4 Characterization of Soil Samples

The soil analyses were carried out before and after the experiment. The soil pH was determined in a 1:10 (w/v) ratio of soil to distilled water using a pH meter. The soil textural analysis was determined by Bouyoucus hydrometer method as modified (Day, 1965) using sodium hexametaphosphate as the dispersing agent. Organic carbon was determined by the Walkley-Black chromic acid wet oxidation method (Jackson, 1962). as well as the total nitrogen and available phosphorus (Udo *et al*., 2009). The metal content (Mg, Ca, Mn, Cu, Cd, Pb, Cr and Zn) was determined using the Atomic Absorption Spectrophotometer (AAS Unicam 969 Series) while K and Na were determined by flame photometer (Model PFP-7). The summation of the exchangeable cation (Na^+, K^+, Mg^2+, Ca^{2+}) and exchangeable acidity (H^+ and Al^{3+}) was reported as cation exchange capacity (CEC). The % base saturation was determined by the summation of the cation (K^+, Mg^{2+}, Ca^{2+}) divided by the CEC.

2.5 Pot Experiment

Three weeks old uniform seedlings of tomatoes (*L. esculentum)* were selected and transplanted at two plants per pot, in a completely randomized design in triplicate. Weeding was carried out regularly and plant growth parameters in terms of plant heights, stem girth and numbers of leaves, were determined on a weekly basis. Plant analyses in terms of nutrient uptake and total biomass yield were determined using standard methods. Thereafter, the plant samples were wrapped in aluminium foil and dried in an oven at 105°C to attain a constant weight. The dried weight obtained was noted and recorded as the total biomass yield. The nutrient uptake of the plants was calculated by multiplying the mean dry weight (g) of each plant by the plant nutrient content (%) (Pal, 1991).

2.6 Heavy Metal Analysis of the Tomatoes Plant

The whole plant samples were harvested by uprooting them at four (4) weeks after transplanting (this corresponded to seven (7) weeks after planting). Thereafter, the plant samples were rinsed with distilled water to remove all the sand debris from their roots. After which they were air dried to a constant weight and grounded into powder. Plant samples were first pre-digested in concentrated HNO_3 and this was followed by digestion in a 3:2 diacid mixture of HNO_3 and $HClO_4$. Deionized water was added followed by filtration with Whatmann No 1 filter paper. The samples were then diluted appropriately and analyzed for mineral uptake using the Atomic Absorption Spectrophotometer (AAS Unicam 969 Series) (Bandita *et al.,* 2011).

2.7 Statistical Analysis

One-way analysis of variance (ANOVA) was carried out to assess the significant differences in the data obtained. The mean of the data was compared using SPSS (Statistical package for Social Scientist).

3.0 RESULTS AND DISCUSSIONS

The physicochemical properties of the effluent before and after anaerobic digestion (Table 1), reveals that the Chemical Oxygen Demand (COD) of the effluents were considerably reduced by the treatment from 59,814.81 to 24,335.80 mg/l (over 60 % reductions). Oil and grease was also reduced by the anaerobic treatment. However, other water properties such as total solids, nitrate, phosphate etc., were not considerably affected by the treatments. Apparently, the complex materials that could not be broken down by the anaerobic microorganism along with the remains of the dead microorganisms within the digester contributed to the observation. This also explains why the digestate is rich in nutrient. COD reduction has been associated with anaerobic treatments of various effluents. Membrane Anaerobic System (MAS) was found to be a successful biological treatment system that achieved a very high COD removal efficiency (about 96.5%) (Abdurahman, *et al*., 2011). Also, improved anaerobic treatment of POME in a semi-commercial closed digester tank with sludge recycling led to COD removal efficiency higher than 90% (Busu *et al.*, 2010).

Table 1: Physicochemical Properties of the Palm Oil Mill Effluent (Pome) Before and After Anaerobic Digestion

PROPERTIES	POME	ADPOME
pH	4.50±0.10	7.50±0.20
Organic carbon %	25.00±0.50	4.34±0.02
COD mg/l	59,814.81±10.00	24,335.80±200.00
Total solids mg/l	48,000.00±200.00	48,560.00±200.00
volatile solids mg/l	42,000.00±50.00	43,450.00±200.00
Suspended solid mg/l	1,8178.00±8.00	6,500.00±50.00
Oil and grease mg/l	4,200.00±30.41	1,806.00±3.00
Calcium mg/l	280.00±2.00	112.32±0.02
Magnesium mg/l	675.00±5.00	325.32±0.30
Phosphate mg/l	31.00±1.00	29.10±0.11
Potassium mg/l	1,800.00±10.00	1,134.00±4.00
Sodium mg/l	120.00±5.00	83.46±0.20
Nitrate mg/l	20.00±0.21	18.32±0.20
Sulphate mg/l	180.20±2.00	50.00±0.02
Manganese mg/l	25.36±0.10	14.28±0. 02
Copper mg/l	28.36±0.02	16.48±0. 10
Cadmium mg/l	ND	ND
Lead mg/l	ND	ND
Chromium mg/l	ND.	ND.
Zinc mg/l	ND	ND

ND = Not Detected

The physiochemical analysis of the parent soil (Table 2) reveals that the soil is in the acidic region, with medium organic matter and low percentage base. Available phosphorus (3.20 mg/kg) and nitrogen (0.33 g/kg) indicate that the nutrient level of the soil is low. Soils generally require a minimum of 15,000 mg/kg (1.5%) nitrogen (Bonner and Verner, 1999) and between 10.9 - 21.4 mg/kg (0.00109 – 0.00214%) of phosphorus as the critical levels for optimal crop yield (Bai *et al.,* 2013). Soil textural analysis shows that the soil is sandy.

Effects of the slurries on soil physicochemical properties before and after planting (Table 3), suggest that the treatment altered the soil properties but in no particular trend. This is because the property of any particular soil is determined by several interrelated factors. However, the pre - plant soils had properties better than the control as soil nutrients were increased. Similarly, in a related study, it was observed that diagestate from wine industry mineralized nitrogen at a higher rate compared to compost (Nkoa, 2014). While a 2 % increase in organic carbon was observed for soil amended with digestate compared to the control (Šimon *et al*., 2015).

Table 2: Soil Physicochemical Properties Before Treatment

PARAMETERS	VALUES
pH	5.14
Total organic carbon (g/kg)	6.41
Nitrogen (g/kg)	0.33
Av. phosphorus (mg/kg)	3.20
Potassium (cmol/kg)	0.15
Sodium (cmol/kg)	0.11
Magnesium (cmol/kg)	0.35
Calcium (cmol/kg)	0.42
Manganese (mg/kg)	4.08.
Copper (mg/kg)	4.72.
Cadmium (mg/kg)	0.06
Lead (mg/kg)	0.03
Chromium (mg/kg)	0.30
Zinc (mg/kg)	0.50.
% Base Saturation	31.94
Sand (g/kg)	871.50
Silt (g/kg)	65.30
Clay (g/kg)	63.20

Results from the post plant soils suggest that nutrient were taken up by the plants as nearly all the trace and other nutrients were reduced in value. The level of uptake was Ca (28.36 %) at the 400 ml treatment, Av P (48.28 %) at the control. At the 400 ml treatment, K uptake was 31.43% while Na (40.91%) and N (51.33%) was at 600 ml treatments.

No particular trend in the soil pH was observed in the pre and the post-harvest soils with the different treatments owing to the complex interrelation between the soil and the plant. This observation is contrary to the report of Aziz *et al*., (2010), who reported a slight decrease in the soil pH on treatment with biogas slurry. Also, successive increase in the anaerobic slurry did not significantly change the soil pH. This is constituent with (Khan *et al.,* 2015).

Soil amendment with the anaerobic slurry increased soil total organic carbon and organic matter in all the pre-planting soils which is attributed to the addition of the effluents which is rich in organic matter and contains appreciable soil nutrients in terms of total solids (48,560.00 mg/l), phosphate (29.10 mg/l), nitrate (18.32 mg/l) and sulphate (50.00 mg/l). The study is contrary to Orhue *et al*., (2005) who reported a decrease in organic carbon attributed to the presence of biological activities in soils polluted with brewery effluent. Increase in soil total organic carbon and organic matter in amended soils observed in this study may due to the nature of the effluent, which was also anaerobically treated, unlike Orhue *et al*., (2005) where untreated brewery effluent was used. Similar study associates rich soil nutrient status of anaerobic slurries to the indigestible part of the original feedstock along with the mineralized remains of the dead micro-organisms within the digester (Bonten *et al.,* 2014). Also studies comparing digestates and undigested manures indicated that digestate have higher ammonium (NH_4): total nitrogen (N) ratios, decreased carbon (C) contents, reduced biological oxygen demands (BODs), elevated pH values and lower C:N ratios (Möller and Müller, 2012).

Soil exchangeable acidity was affected by the various treatments. In the pre-planting soil, there was decrease in the soil exchangeable acidity (EA) in all the treatments. This observation is consistent with report of Islam et *al.,* (2016) who reported a decrease in soil EA on application of solid waste slurry from biogas on soil parameters and yield of spinach. Reduction of the EA values could be attributed to the increase in the pH level of the soil as a result of the amendments. Increased pH will reduce the H^+ of the soil, leading to low EA.

In this study, cation exchange capacity (CEC) of the parent soil was higher than all the amended soils. The lower values of CEC of the amended soils suggest increased nutrient bioavailability and nitrogen, phosphorus, sodium, potassium and calcium significantly ($P<0.05$) increased. This is attributed to the application of the soil amendment which is rich in organic soil nutrients that included phosphate (29.10 mg/l), nitrate (18.32 mg/l) and sulphate (50.00 mg/l), potassium (1,134.00 mg/l), calcium (112.32 mg/l), etc.

No considerable changes were recorded in the soil textural class in the after treatment as the soils remained textually sandy. However the original soil had the highest sand and lowest silt content, indicating that higher concentration of the amendment could cause a noticeable change on the soil texture. This observation is consistent with report by Orhue *et al., (*2005) in soil amendment with brewery effluent.

Results from the effects of the treatments on soil heavy metal properties before and after planting (Tables 4) suggest that apart from chromium, all the heavy metals levels increased in the pre plant soils. The amendment increased the bio-availability of soil heavy metals and increased the soil with Cd (133.33%), Pb (333.33%), and Zn (188.00%) at the 200 ml treatment. At the 400 ml treatment, Cu increased by 88.14% while Mn (10.78%) was at 400 ml and 600 ml treatments. Soil amendment with anaerobic slurry has been associated with the potential to provide soils with considerable amount of both macro and micronutrients besides appreciable quantities of organic matter (Kumar *et al*., 2015).

Table 3: Soil Physicochemical Properties Before and After Transplanting

Sample Code	pH	T. Org. C g/Kg	Org. Matt g/Kg	Ca cmol/kg	Ca % Uptake	Mg cmol/kg	Mg % Uptake	Av. P mg/kg	Av. P% Uptake	K cmol/kg	K % Uptake
BEFORE TRANSPLANTING											
Control	5.14 [a]	6.41 [a]	11.08 [a]	0.42 [a]	-	0.35 [c]	-	3.19 [a]	-	0.15 [c]	-
200 ml	5.67 [b]	13.16 [b]	16.75 [b]	0.67 [b]	-	0.25 [a]	-	6.13 [c]	-	0.36 [g]	-
400 ml	5.63 [b]	13.15 [b]	16.76 [b]	0.67 [b]	-	0.25 [a]	-	6.13 [c]	-	0.35 [e]	-
--600 ml	6.11 [c]	20.06 [c]	38.15 [c]	0.71 [c]	-	0.31 [b]	-	5.42 [b]	-	0.41 [b]	-
AFTER TRANSPLANTING											
Control	5.57 [b]	5.66 [a]	9.78 [a]	0.82 [d]	+95	0.35 [a]	0.00	1.65 [a]	48.28	0.17 [a]	+13.33
200 ml	5.10 [a]	9.38 [b]	16.15 [b]	0.67 [b]	0.00	0.25 [a]	0.00	5.42 [c]	11.58	0.35 [c]	2.78
400 ml	5.20 [a]	9.40 [b]	16.16 [b]	0.48 [a]	28.36	0.27 [a]	+8.00	5.42 [c]	11.58	0.24 [b]	31.43
600 ml	6.43 [c]	10.94 [c]	18.88 [c]	0.74 [c]	+4.23	0.33 [a]	+0.45	5.21 [b]	3.78	0.36 [c]	12.20

Results are expressed as mean of triplicate determinations. Superscripts represent statistical significance. Means with different alphabet remarks in the same column are significantly different at 5% probability level ($P<0.05$). Positive values for % nutrient Uptake indicate that the post plant soil increased nutrient by the stated value.

Table 3 Continues: Soil Physicochemical Properties Before and After Transplanting

Sample Code	Na cMol/kg	Na % Uptake	N g/Kg	N % Uptake	CEC cmol/kg	% Base Saturation	Sand g/kg	Clay g/kg	Silt g/kg
BEFORE TRANSPLANTING									
Control	0.11 [a]	-	0.33 [a]	-	2.88 [a]	31.94 [a]	871.50 [b]	63.20 [b]	65.40 [a]
200 ml	0.17 [b]	-	0.72 [b]	-	2.15 [b]	59.07 [c]	862.00 [b]	54.70 [a]	83.30 [b]
400 ml	0.17 [b]	-	0.73 [b]	-	2.15 [b]	50.07 [b]	861.30 [b]	55.30 [a]	83.30 [b]
600 ml	0.22 [c]	-	1.13 [c]	-	1.99 [a]	72.36 [a]	827.00 [a]	73.70 [c]	106.30 [c]
AFTER TRANSPLANTING									
Control	0.12 [a]	+9.09	0.48 [a]	+45.45	3.36 [a]	39.88 [a]	871.50 [c]	63.20 [b]	65.4 [b]
200 ml	0.13 [a]	23.53	0.52 [b]	28.78	2.11 [ab]	60.19 [c]	862.00 [a]	54.70 [a]	83.30 [d]
400 ml	0.14 [a]	17.65	0.50 [ab]	31.51	2.15 [b]	59.07 [b]	86.90 [b]	6.10 [b]	7.00 [c]
600 ml	0.13 [a]	40.91	0.55 [c]	51.33	1.90 [a]	75.79 [d]	88.09 [d]	7.63 [c]	4.27 [a]

Results are expressed as mean of triplicate determinations. Superscripts represent statistical significance. Means with different alphabet remarks in the same column are significantly different at 5% probability level ($P<0.05$). Positive values for % nutrient Uptake indicate that the post plant soil increased nutrient by the stated value.

Table 4: The Effect of Treatment on Heavy Metal Content of the Soil Before and After Transplanting

Treat - ment	Cd	% Cd (I)	Cr	% Cr (I)	Cu	% Cu (I)	Mn	% Mn (I)	Pb	% Pb (I)	Zn	% Zn (I)
BEFORE TRANSPLANTING												
Control	0.06 [a]	-	0.30 [c]	-	4.72 [a]	-	4.08 [a]	-	0.03 [a]	-	0.50 [a]	-
200 ml	0.14 [c]	133.33	0.06 [a]	-80	6.34 [b]	34.32	4.37 [b]	7.12	0.13 [b]	333.33	1.44 [c]	188.00
400 ml	0.12 [b]	100.00	0.06 [a]	-80	8.88 [d]	88.14	4.52 [c]	10.78	0.12 [b]	300.00	1.32 [b]	164.00
600 ml	0.06 [a]	0.00	0.12 [b]	-60	7.20 [c]	52.54	4.52 [c]	10.78	0.12 [b]	300.00	1.32 [b]	164.00
AFTER TRANSPLANTING												
0 ml	0.09 [b]	-	0.02 [a]	-	4.20 [a]	-	2.99 [a]	-	0.03 [a]	-	1.32 [b]	-
200 ml	0.15 [d]	66.65	0.06 [b]	200.00	7.38 [c]	75.71	5.56 [d]	85.95	0.19 [c]	533.55	1.89 [c]	43.18
400 ml	0.12 [c]	33.33	0.06 [b]	200.00	8.88 [d]	111.43	4.52 [c]	51.17	0.12 [b]	300.00	1.32 [b]	0.00
600 ml	0.04 [a]	-55.56	0.05 [b]	-0.83	5.27 [b]	25.48	3.77 [b]	26.09	0.11 [b]	266.67	0.85a	-35.61

***Key**: I – Increase; **Unit:** mg/kg*

Results are expressed as mean of triplicate determinations. Superscripts represent statistical significance. Means with different alphabet remarks in the same column are significantly different at 5% probability level ($P<0.05$). Positive values for % nutrient Uptake indicate that the post plant soil increased nutrient by the stated value.

The post plant soils had reductions in their heavy metals, suggesting uptake by plants. The result agrees with the soil CEC result obtained. That is, soil CEC reduced as a result of the amendment thereby making metal cation more bio-available for plans uptake. It therefore follows that there is the risk of plants easy heavy metal uptake when sown in heavy metal contaminated soils or when the slurry is contaminated with heavy metals. Thus, application should be done with caution and also slurry characterization and after treatment could be necessary. On the hand, application may be used to mop out heavy metals from heavy metal contaminated soils.

The effect of treatment on plant nutrient uptake (Table 5) confirms its bio-fertility potentials. The nutrient levels, trace and heavy metals were higher in plants grown in the treated soils, with only a few exceptions. Therefore, application should be done with caution to avoid bio-accumulation of heavy metals in plants. Among the selected heavy metals evaluated, Zinc in the 200 ml treatment had the highest uptake (195.50 mg/kg) while Cadmium in the control and 200 ml treatment had the lowest (0.00 mg/kg). The highest zinc uptake by the plant could be attributed to the anaerobic slurry treatment of the soils which enhanced the higher bioavailability of zinc to as compared to the other heavy metals. This result agrees with the result obtained from the effect of the treatment on heavy metal content of the soil before and after transplanting (Table 4). Apart from lead, Zinc uptake at 200 ml treatment higher than the other metals showed that the number of leaves varied and increased with increasing treatments (Figure 3). The maximum

Table 5: The Effect of Treatment on Plant Nutrient Uptake

Treatments	Ca (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	K (mg/kg)	Mg (mg/kg)	Mn (mg/kg)	N (mg/kg)	Na (mg/kg)	P (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
Control	300.30 ^{a}	0.000 ^{a}	0.15 ^{a}	1.81 ^{b}	8295 .00 ^{a}	180.10 ^{c}	21.81 ^{a}	1.51 ^{d}	400.30 ^{c}	103.30 ^{a}	0.80 ^{b}	28.60 ^{a}
200 ml	360.20 ^{c}	0.000 ^{a}	1.22 ^{c}	1.22 ^{a}	11370.00 ^{b}	170.30 ^{b}	27.18 ^{b}	0.26 ^{a}	230.20 ^{a}	112.50 ^{b}	0.13 ^{a}	195.50 ^{c}
400 ml	360.3 ^{c}	0.72 ^{c}	1.18 ^{b}	20.71 ^{d}	13880.00 ^{c}	145.20 ^{a}	34.20 ^{c}	0.46 ^{b}	395.10 ^{b}	102.30 ^{a}	1.04 ^{c}	72.84 ^{b}
600 ml	320 .40 ^{d}	0.51 ^{b}	1.18 ^{b}	11.81 ^{c}	11370.00 ^{b}	145.40 ^{a}	57.81 ^{d}	0.73 ^{c}	415.30 ^{d}	117.54 ^{c}	1.17 ^{d}	29.77 ^{a}

Results are expressed as mean of triplicate determinations. Superscripts represent statistical significance. Means with different alphabet remarks in the same column are significantly different at 5% probability level (P<0.05). Positive values for % nutrient Uptake indicate that the post plant soil increased nutrient by the stated value.

Table 6: Effect of Treatment on Total Biomass Yield

	0.00ml	200.00ml	400.00ml	600.00ml
BE FOREDRYING(g /plant)				
Control	15.44±0.01	15.44±0.01	15.44±0.01	15.44±0.01
POME	15.44±0.01	25.35±0.01	33.16±0.01	40.05±0.01
AFTERDRYING(g /plant)				
Control	2.45±0.01	2.45±0.01	2.45±0.01	2.45±0.01
POME	2.45±0.01	2.96±0.006	4.31±0.02	5.76±0.01

The results from Table 6 revealed that plant weight were better than the control. The highest value was obtained in the treatment with 600 ml (5.76 g). The lower yield from the control could be attributed to soil's poor nutrient status, containing lesser than the critical amount of soil nutrient required for healthy plant growth (Bonner and Varner, 1999). In a similar study, Özyazıcı (2013) reported increase yield in all components of wheat, white head cabbage and tomato in soil amended with sewage sludge as to the control.

3.1 Plant Growth Parameters

Plant growth parameters suggest that the plant grown in the amended soil was better than the control. Result from plant height (Figure 1) revealed that plant height increased with increasing treatment. Studies conducted by Orhue *et al.,* (2005) reported no significant difference (p<0.05) of plant growth parameters on soil amended with rubber effluent. This could be attributed to the short period of time that the effluent was left to mineralize in the soil before planting (two weeks). In this study effluent was allowed mineralize in the soil for 8 weeks.

Plant girths (Figure 2) were comparable in nearly all the trials as there was little significant difference observed among the trials. This study is not consistent with Osaigbovo *et al.,* (2010) were stem girth increased in soils amended with fish pond effluent.

Although studies conducted by Orhue *et al.*, (2005) observed no significant changes in the number of leaves on plant sown on rubber effluent-amended soils, results from this study.

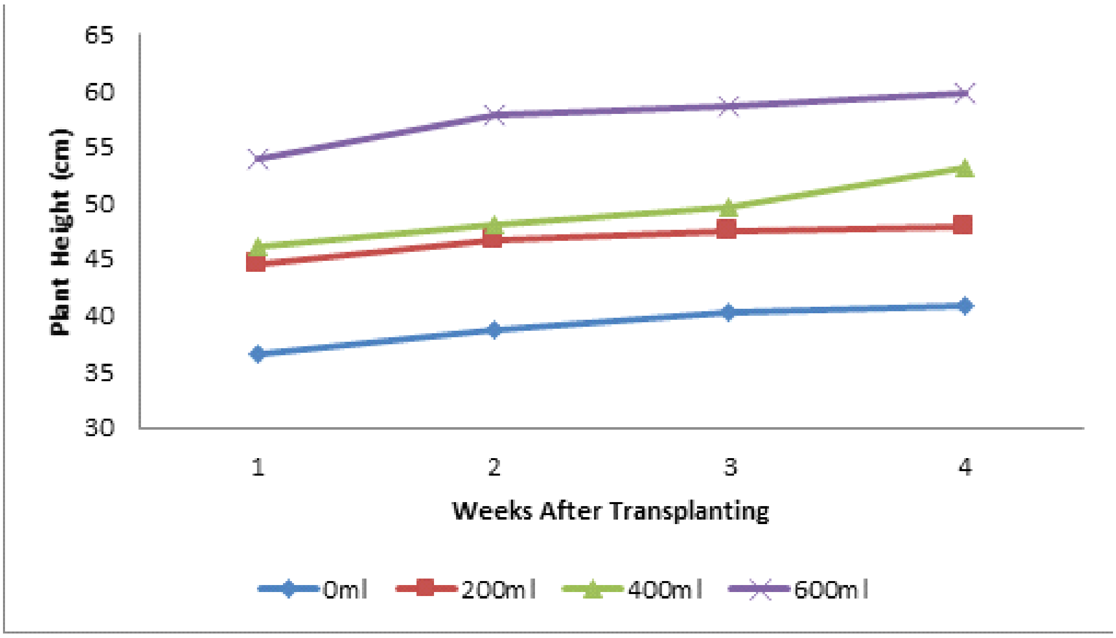

Figure 1: Effect of Anaerobic slurry treatment on plant height

was observed in the treatment with 600 ml (63.87 cm). The result obtained in this study is consistent with Kant and Kumer (1994) who reported increase in the number of rice tiller in soil amended with organic manure. Increased number of leaves on plant sown on amended soils is attributed to the soil nutrient provided the anaerobic slurry applied.

4.0 CONCLUSIONS

Anaerobic digestion treatment of the effluent was a successful biological treatment that achieved high COD removal efficiency (over 60 % reductions). However, water properties such as total solids, nitrate, phosphate etc., were not considerably affected by the treatments, explaining why the digestate is rich in nutrient. Soil amendment with

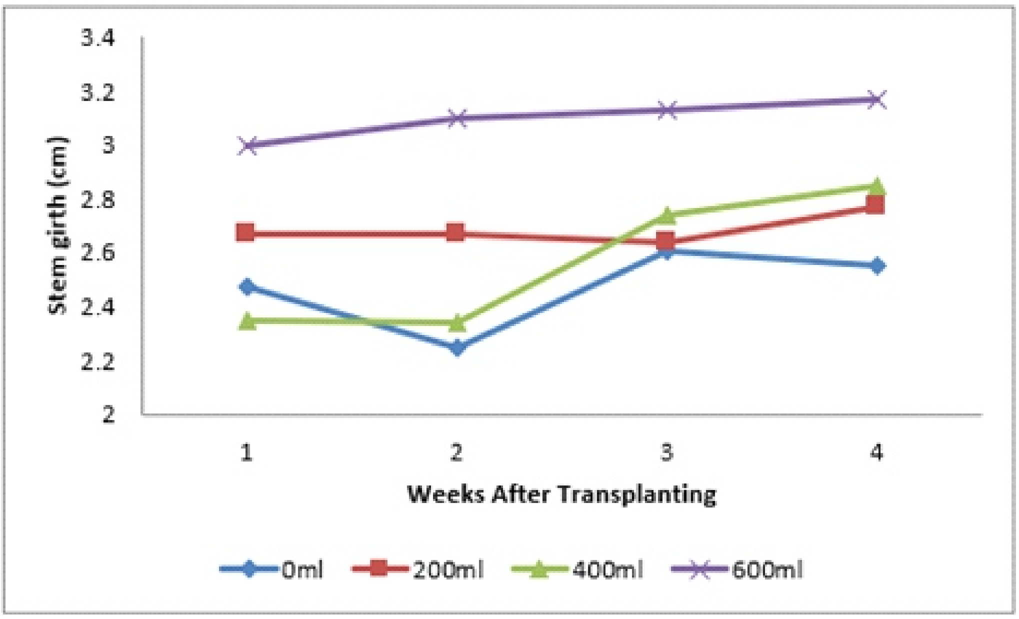

Figure 2: Effect of Anaerobic slurry treatment on stem girth.

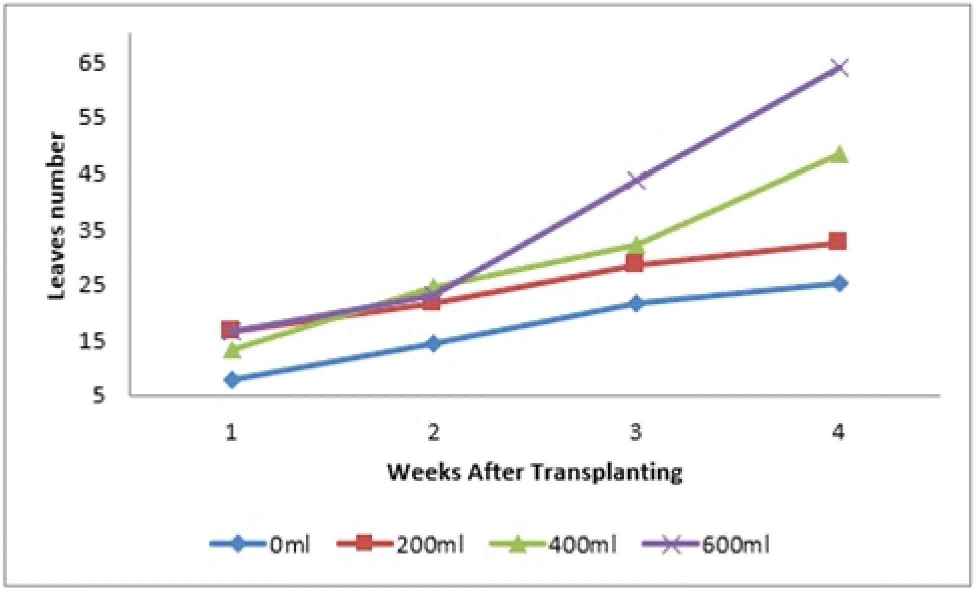

Figure 3: Effect of Anaerobic slurry treatment on number of leaves.

anaerobic slurries altered the soil properties but in no particular trend. The pre-plant soils had nutrient levels higher than the control and there was increase in total solids (48,560.00 mg/l), phosphate (29.10 mg/l), nitrate (18.32 mg/l) and sulphate (50.00 mg/l). The amendment also increased the bio-availability of soil heavy metals and increased soil with Cd (133.33%), Pb (333.33%), and Zn (188.00%) at the 200 ml treatment. At the 400 ml treatment, Cu increased by 88.14% while Mn (10.78%) was at 400 ml and 600 ml treatments.

The effect of treatment on plant nutrient uptake confirms its bio-fertility potentials. The nutrient levels, trace and heavy metals were higher in plants grown in the treated soils, with only a few exceptions. Therefore application of anaerobic slurry should be done with caution to avoid bio-accumulation of heavy metals in plants.

Plant weights were better than the control, which is attributed to soil's poor nutrient status, containing lesser than the critical amount of soil nutrient required for healthy plant growth. Apart from the plant girths whose values had little significant difference among the trials, plant growth parameters suggest that the plant grown in the amended soil was better than the control.

Further investigations to on whether the amendment could be used to mop out heavy metals from heavy metal contaminated soils is recommended. Furthermore, anaerobic digestion technologies that produce high quality digestate in addition to maximized biogas yield should be developed.

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