



Impact of Palm Kernel Oil Mill Effluent on the Soil's Physicochemical Characteristics and Growth of Tomato Plant

Samuel Onuorah^{*1}, Adaeze Nwanyanwu¹, and Patrice Okoye²

¹ Department of Applied Microbiology and Brewing, Faculty of Biosciences, Nnamdi Azikiwe University, Awka, Nigeria

² Department of Pure and Industrial Chemistry, Faculty of Physical Sciences, Nnamdi Azikiwe University, Awka, Nigeria

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ABSTRACT

Effluent is wastewater flowing out of a sewer which constitutes environmental problems ranging from long-term ecological damage to increased water-borne diseases. In Nigeria, palm kernel oil is extracted from oil palm fruits in oil mills and the effluent is discharged without treatment to the soil in the vicinity of such mills. The effluent-receiving soil has been observed not to support the growth of vegetation. Hence in this work, the impact of palm kernel oil mill effluent on the soil physicochemical characteristics and growth of tomato plant was determined and compared with the effluent discharge limit established by the Federal Environmental Protection Agency. Samples of untreated and treated effluent, untreated and treated effluent-polluted soil and unpolluted soil were used for the study. The physicochemical analysis was carried out using standard physicochemical methods. The physicochemical values of the untreated effluent, except the pH, which was acidic, were higher than those of the treated effluent. Most of the physicochemical values of the untreated effluent-polluted soil were higher than those of the treated effluent-polluted soil and the unpolluted soil. The tomato plant grown in the unpolluted soil had better growth characteristics and yielded more fruits than those grown in the treated effluent-polluted soil. In addition, the tomato plant grown in the untreated effluent-polluted soil showed the lowest growth characteristics and yielded no fruits due to its elevated level of heavy metals and total petroleum hydrocarbons. The study showed that the untreated palm kernel oil mill effluent had a negative impact on the soil's physicochemical and growth characteristics of the tomato plant. Therefore, the effluent must be adequately treated to remove hazardous substances before its discharge into the terrestrial environment.

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1. INTRODUCTION

Palm oil industry is a major agro-based enterprise in Nigeria especially in the southern part where palm oil trees are abundant. The global production of palm oil is growing at a very high rate and the pollution caused by waste materials from palm oil mills has become a serious problem [1]. Vegetable oils are mainly the triglycerides extracted from plants as contrasted with waxes with glycerine in the structure. Although many plant parts may yield oil in commercial practice, oil is extracted primarily from seeds.

Vegetable oil facilities require significant amounts of water for oil production, cooling, chemical neutralization processes and subsequent washing and deodorization [2]. The increased consumption of vegetable oils has improved industrial and economic activities. However, these activities produce wastes that invariably are disposed of on land and negatively shift the ecological balance, thus threatening man's life and health [3].

On a global scale, environmental pollution created by food or related industries through effluent discharge has become a threat to plants and animals and may ultimately

*Corresponding author:

E-mail address: Samuel Onuorah <s_onuorah484@yahoo.com>

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threaten the quality of human life [4]. The discharge of untreated or incompletely treated effluents containing algal nutrients, non-biodegradable organics, heavy metals, and other toxicants into the environment deteriorates the quality of the receiving soils.

Physicochemical characteristics of the effluent and soil are critical for the growth and productivity of crops and at higher levels, may adversely affect soil fertility and crop life; Therefore this study was carried out to determine the effect of palm kernel oil mill effluent on the soil's pH, temperature, total suspended solids, total dissolved solids, chemical oxygen demand, biochemical oxygen demand, dissolved oxygen, oil and grease, phosphate, nitrogen, lead, copper, cadmium, chromium and total petroleum hydrocarbons and growth characteristics of tomato plant. The results of this study will educate the general public on the consequences of discharging untreated or incompletely treated palm kernel oil mill effluent into the soil.

2. MATERIALS AND METHODS

2.1 Study Area

The untreated and treated palm kernel oil mill effluent were collected from a vegetable oil processing industry in Umudim Nnewi, Nigeria, while the unpolluted soil sample was collected from a site a hundred meters away from the industry. Anaerobic digestion using anaerobic fluidized bed reactors was adopted by the industry to treat the effluent. The soil in the area is sandy loam, while the geographical coordinates are 6° 0'37.8684"N and 6° 54'37.2420" E. Nnewi falls within the tropical rain- forest region of Nigeria. The annual average temperature is 19-31°C while the average rainfall during the wet season is 485mm.

2.2 Sample collection

2.2.1 Collection of palm kernel oil mill effluent

Five litres of the palm kernel oil mill effluent (untreated and treated) were collected from the effluent discharge point and effluent treatment tank. Polyethylene bottles were used for the sample collection. The containers were carefully washed with 1% hydrochloric acid (Lord's Chloro, India) and rinsed with tap water and distilled water. The bottles were rinsed again with the sample twice before collection. The pH and temperature were determined at the site of sample collection.

2.2.2 Collection of unpolluted soil sample

Unpolluted sandy loam soil sample (10kg) was collected using a sterile hand trowel into a sterilized polyethylene bag at a depth of 10cm from a farmland located a hundred meters away from the effluent- receiving soil.

2.3 Treatment of the unpolluted soil sample with the oil mill effluent

Each unpolluted soil sample (3kg) was weighed into two sterilized plastic containers. The soil samples were then polluted with 300ml of the untreated and treated palm kernel oil mill effluent respectively, and left to stand for three months. Physicochemical analysis was thereafter carried out. The soil samples were diluted with water in a 1:10 proportion before the analysis as described by Onuorah et al [5].

2.4. Physicochemical analysis of the samples

2.4.1. pH and temperature

The pH was measured using by electrometric method using a pH meter (Hanna Model H1991003, India) and temperature using a mercury thermometer as described by APHA [6].

2.4.2 Total suspended solids (TSS)

The method described by APHA [6] was used. Glass microfibre filter paper (Ahlstrom, USA) of diameter 5.5cm was dried to a constant weight at 105°C in an oven (Bosch, India), cooled to room temperature in a desiccator and recorded the weight. Gooch funnel (Simsil, India) and rubber adapter were fixed to a filtering flask, and the glass filter paper was placed into the Gooch funnel carefully with the aid of a pair of tongs. The sample was thoroughly mixed using a magnetic stirrer (Labman, India) after which 100ml was quickly introduced into the filtering apparatus. After filtration, a pair of tongs were used to remove the glass filter paper from the Gooch funnel carefully. The filter paper was then dried to a constant weight at 105°C, and the weight was recorded.

2.4.3 Total dissolved solids (TDS)

The TDS was determined following the method described by APHA [6]. The sample was stirred with a magnetic stirrer and a measured volume (100ml) was introduced onto a glass filter with vacuum applied. It was washed with 10ml of distilled water three times, allowing complete drainage between washings. Suction was continued for 3 min after filtration was completed. Total filtrate with the washings was transferred to a weighed evaporating dish and evaporated to dryness on a steam bath. The evaporated sample was dried in the oven for 1h at 180°C, cooled in a desiccator and weighed.

2.4.4 Chemical oxygen demand (COD)

The COD was determined as described by APHA [6]. Fifteen millilitres of the sample were measured into a 250ml beaker and 2.5ml standard 5% K₂CrO₄ digestion reagent was added slowly and mixed. Then 3.5ml of concentrated sulphuric acid was added through the side of the tube and allowed to get to the bottom. The content was mixed, capped, and transferred into a water bath and heated at 500°C. A blank test was also carried out. The addition of distilled water was done to make up the volume to 50ml. Two drops of phenanthroline indicator were added and the mixture was titrated with 0.05 M ferrous ammonium sulphate solution.

$$COD \text{ (mg/l)} = \frac{A - B \times 8000}{\text{Volume of sample}} \quad (1)$$

Where:

A= Titre of blank

B= Titre of sample

2.4.5 Biochemical oxygen demand (BOD)

The method described by APHA [6] was used. The BOD readings were measured using the Lovibond BOD IR Sensomat. A 10 ml sample volume was collected into the 50ml BOD flask. The IR-pressure sensor (a measurement device) was connected to the BOD flask and the start button

on the sensomat was depressed. The IR sensor was then logged into the BOD-sensomat and the reading was converted directly to mg/l of BOD and recorded.

2.4.6 Dissolved oxygen (DO)

This was determined using the method defined by APHA;2012 [6]. The sample was introduced into a 250ml bottle, followed by the addition of 1ml manganese sulphate solution (Aashi Chem, India) and 1ml of alkali-iodide-azide reagent (Labchem, USA). The bottle was stoppered with care to exclude air bubbles and the solution was mixed by inverting the bottle several times. It was allowed to settle for 2 min, after which 1ml of concentrated sulphuric acid (Alpha Chemika, India) was added by allowing the acid to run down the neck of the bottle, restoppered and mixed by gentle inversion until dissolution was completed. Twenty millilitres of the solution were titrated with 0.0125M sodium thiosulphate solution (Sodochiol, USA) to a pale straw colour. Two millilitres of starch solution were added, which turned the colour to blue. The titration was preceded by adding of the thiosulphate solution drop wise until the blue colour disappeared.

$$DO (mg/l) = \frac{16000 \times M \times V}{V_2 V_1 (V_1 - 2)} \quad (2)$$

Where:

M= Molarity of the thiosulphate solution

V= Volume of thiosulphate used for titration

V₁= Volume of the bottle with stopper in place

V₂= Volume of aliquot taken for titration

2.4.7 Oil and grease

The method described by APHA;2012 [6] was adopted. Two hundred millilitres of the sample were transferred to a separating funnel, followed by adding 30ml of n-hexane. The funnel was shaken vigorously for 30 min for the layers to separate. The n-hexane layer was drained through a funnel containing 10g sodium sulphate on a filter paper already rinsed with n-hexane. The extraction was repeated twice using 30ml of n-hexane for each extraction. The funnel was rinsed with 10ml of n-hexane after filtration in each case. All the hexane layers were mixed in a crucible that was dried and weighed to a constant mass. The crucible was placed in a water bath until the content evaporated completely after which the crucible was dried in an oven for 5 min. Later, it was removed and placed in the desiccator to cool and thereafter weighed. This was repeated until a constant mass was obtained. A blank test was carried out using 100ml of n-hexane.

2.4.8 Phosphate

Phosphate was determined by the Vanado-molybdo-phosphoric acid colourimetric method as described by Ademorati [7]. One hundred millilitres of the homogenized and filtered sample were pipetted into a conical flask. The same volume of distilled water (control) was also pipetted into another conical flask. One millilitre of 18M sulphuric acid and 0.89g of ammonium persulphate (Minglin, China) were added

to both conical flasks and gently boiled for 1.5h and cooled. One drop of phenolphthalein indicator (Merck, India) was added to each flask and after that neutralized to a faint pink colour with 2M sodium hydroxide solution (Plus Chem, India). The pink colour was discharged by drop-wise addition of 2M HCl and the solution was made up to 100ml with H₂O. Twenty millilitres of the sample were pipetted into test tubes and 10ml of the combined reagent composed of sulfuric acid, ammonium molybdate (Alpha Chemika, India), antimony potassium tartrate (Merck, USA) and ascorbic acid (Cecon, USA) was added. The tubes were shaken and left to stand for 10 min before reading the absorbance at 690nm in a Spectrophotometer (Mettler Toledo, Switzerland) using 20ml of H₂O and 1ml of the reagent as reference.

2.4.9 Nitrogen

The test for nitrogen was performed according to the method defined by Ademoroti [7]. The sample was gently introduced into a 30ml Kjehdahl flask and then stoppered and shaken. 1g of the Kjehdahl catalyst mixture (Labchem, Spain) was added. The mixture was heated cautiously in a digestion rack until a clear solution appeared. The clear solution was then allowed to cool after which 100ml of H₂O was added to avoid caking and then transferred to the Kjehdahl digestion apparatus. A 500ml receiver flask containing 5ml of boric acid indicator was then placed under a condenser of the distillation apparatus so that the tap was 20cm inside the solution. Ten millilitres of 40% sodium hydroxide were added to the digestion sample in the apparatus and distillation commenced immediately until it reached the 35ml mark of the receiver flask, after which the mixture was titrated to a pink colour using 0.01N HCl.

$$\%Nitrogen = \frac{Titre\ value \times 0.01}{\times\ atomic\ mass\ nitrogen} \times 4 \quad (3)$$

Where 0.01 = normality of the acid.

2.4.10. Heavy metals (lead, copper, cadmium and chromium) analysis

Heavy metals analysis was carried out using Varian AA240 Atomic Absorption Spectrophotometer (Buck Scientific Model 210VGP, USA) as described by Onuorah et al [5]. Two hundred millilitres of the sample were transferred into a 500 ml beaker and 5ml of concentrated nitric acid (Alpha Chemika, India) was carefully added. The solution was heated in a water bath for 2h in order to concentrate it to 15ml. The resulting concentrate was allowed to cool and then filtered into a 25ml volumetric flask. The beaker was rinsed into the filter paper with distilled water and the solution was made up to mark. The filtrate was after that transferred into a plastic vial for instrumental analysis.

2.4.11 Total petroleum hydrocarbons analysis

The method described by APHA [6] was used in this experiment. These were extracted in a separating funnel with 10 ml of pentane (extraction solvent). The solvent extract was carefully concentrated to 1ml for analysis. One microlitre of the concentrated sample was rapidly injected into the column. The sample was automatically detected as it emerged from the column after separating the gas and liquid phases. The gas chromatograph used was a HP 6890 series (Hewlett Packard,

USA) equipped (at a constant flow rate) with FID detector at 38 minutes run times.

2.5. Growth characteristics of tomato plant

One kilogram of each sample (unpolluted, untreated effluent- polluted and treated effluent- polluted soil) was introduced separately into three plastic containers. Tomato (brandy wine type) seeds were planted in each sample and the growth was observed for three months. The size of the leaf and length of the stalks were measured with a measuring tape at three weeks intervals as described by Onuorah et al [5].

3. RESULTS AND DISCUSSIONS

3.1. Physicochemical characteristics of the untreated and treated palm kernel oil mill effluent

In Nigeria, palm kernel oil is processed and the effluent is usually discharged into the nearby soil. The untreated effluent was acidic while the treated effluent was alkaline. Other physicochemical characteristics of the untreated effluent were found at elevated level when compared with the treated effluent (Table 1). The physicochemical values of the untreated effluent were similar to those reported by Ohimain et al [8] who studied the physicochemical and heavy metals properties of palm oil mill effluents; Eze et al [9] who carried out a study on the microbiological and physicochemical characteristics of soil receiving palm oil mill effluent in Umuahia, Abia State, Nigeria; Nwachukwu et al [10] who studied the impact of palm oil mill effluent contamination on soil enzyme activities and physicochemical properties; Chinyere et al [11] who studied the effect of palm oil mill effluent dumping on soil physicochemical parameters and selected plant nutrients in Uturu, Abia State, Nigeria and Nkwocha et al [12] that carried out an assessment of effluent discharges from vegetable oil plants.

The values obtained in both the untreated and treated effluent for most of the parameters were within the standard for effluent discharge established by FEPA [13]. However, the total suspended solids, chemical oxygen demand, dissolved oxygen (untreated effluent), phosphate (untreated effluent), lead, copper and total petroleum hydrocarbons were above the effluent discharge limit, indicating pollution. Thus the effluent needed complete treatment before discharge into the soil environment.

Table 1: Physicochemical characteristics of the untreated and treated palm kernel oil mill effluent.

Physicochemical characteristics	Untreated effluent	Treated effluent.	FEPA (1991)
pH	6.11	7.40	6.00 -9.00
Temperature (OC)	31.00	31.00	<40.00
Total dissolved solids (mg/L)	0.35	0.10	2000.00
Total suspended solids (mg/L)	3.47	0.86	0.00
Chemical oxygen demand (mg/L)	421.30	37.30	0.00
Biochemical oxygen demand (mg/L)	25.00	0.00	50.00
Dissolved oxygen (mg/L)	1.80	0.00	0.00
Oil and grease (mg/L)	0.08	0.03	20.00

Phosphate (mg/L)	14.91	9.09	10.00
Nitrogen (mg/L)	0.62	0.50	150.00
Lead (mg/L)	0.23	0.18	0.00
Copper (mg/L)	0.07	0.06	0.00
Cadmium (mg/L)	0.00	0.00	0.00
Chromium (mg/L)	0.00	0.00	0.00
Total petroleum hydrocabons (µg/mL)	517.771	184.229	0.000

3.2. Physicochemical characteristics of the unpolluted, untreated and treated effluent- polluted soil

The untreated effluent-polluted soil was more acidic than the treated effluent-polluted and unpolluted soils (Table 2). Other physicochemical values of the untreated effluent-polluted soil were higher than those of the treated effluent-polluted and unpolluted soils. The values for the pH agreed with Ohimain et al [8] who reported that when raw palm oil mill effluent is discharged, the pH is acidic but tends towards alkalinity as biodegradation takes place. It also conformed to the report of Okwute and Isu [14], Chikwendu and Ogbonna [15], Eze et al [9], Nwachukwu et al [10] on the impact of palm oil mill effluent contamination on soil enzyme activities and physicochemical properties and Okwute and Isu [14] on the environmental impact of palm oil mill effluent on soil physicochemical parameters and total aerobic bioload of soil at a dump site in Anyingba, Kogi State, Nigeria.

The physicochemical values of the treated and untreated effluent- polluted soil may be due to the treatment with the effluent and the physicochemical composition of the soil. The availability of plant nutrients in soils is affected by the soil's pH. Most plants grow better within the pH range of 6.5 and 7.5, therefore the discharge of palm oil mill of effluent affects nutrients availability of the nearby plants. The untreated and treated effluent- polluted soil had higher values than the unpolluted soil because the unpolluted soil was not treated with the effluent.

The values for temperature, total dissolved solids and total suspended solids of the untreated effluent- polluted soil were higher than those of the other samples (Table 2). This may be due to the fact that the untreated effluent- polluted soil was highly coloured, turbid and may contain high pollution load due to its closeness to the production outlets. The chemical oxygen demand and biochemical oxygen demand values of the untreated effluent-polluted soil were higher than those of the other samples. Since COD and BOD measure directly the organic compounds in effluents, the result indicated that the untreated effluent-polluted soil was heavily polluted, thus its discharge into the environment could result to severe effect to the environment. The higher DO value of the untreated effluent-polluted soil may be due to the presence of suspended matter as reported by Briton et al;2006 [16]. The values for oil and grease were also higher for the untreated effluent- polluted soil than those of the other samples. This may be attributed to the oil and grease usually applied to the equipment or machines during routine maintenance.

The pollution with the untreated and treated effluent increased the phosphate and nitrogen content of the soil. The

higher phosphate and nitrogen levels in the untreated and treated effluent- polluted soil agreed with the reports of Amelia et al [17] on the effect of palm oil mill effluent application on the soil microbial community structure and oil plantation productivity and Wood [18] on the review of current methods of dealing with palm oil mill effluents. Phosphate within many habitats is combined with calcium and this renders it insoluble and unavailable to plants. Many microorganisms are however capable of solubilizing phosphate from such habitats and assimilate and release it for use by other organisms. Nitrogen is an important constituent of protein and nucleic acid and most microorganisms and plants take up inorganic nitrogen as nitrate or ammonium ions.

The heavy metals (lead, copper, cadmium and chromium) levels (Table 2) were higher in the untreated effluent- polluted soil than in the other samples. The heavy metals may come from parts of the fittings, equipment or machinery and water used at different stages of the production of the palm kernel oil. High concentration of these heavy metals could have adverse effects on plants, aquatic life and humans. The increase in TDS, TSS, oil and grease content, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and heavy metals levels (lead, copper, cadmium and chromium) of the untreated and treated effluent –polluted soil indicated that the effluents contain pollutants and can contribute to soil pollution. Ohimain et al [8] reported that high level of oil and grease, DO, BOD, COD, and heavy metals could contribute to environmental pollution and as such the effluent must be recycled.

Table 2. Physicochemical characteristics of the unpolluted, untreated, and treated effluent-polluted soil.

Physicochemical characteristics	Unpolluted soil	Untreated effluent-polluted soil	Treated effluent-polluted soil
pH	6.60	5.50	6.30
Temperature (0C)	31.00	32.00	31.00
Total dissolved solids (mg/L)	1.50	8.20	2.40
Total suspended solids (mg/L)	3.80	10.50	4.60
Chemical oxygen demand (mg/L)	10.09	17.20	15.00
Biochemical oxygen demand (mg/L)	5.43	11.30	9.00
Dissolved oxygen (mg/L)	0.50	2.00	0.00
Oil and grease (mg/L)	0.09	1.00	0.12
Phosphate (mg/L)	0.62	8.00	6.53
Nitrogen (mg/L)	0.33	1.62	1.12
Lead (mg/L)	0.05	0.39	0.26
Copper (mg/L)	0.69	0.87	0.75
Cadmium (mg/L)	0.08	0.13	0.09
Chromium (mg/L)	0.04	0.10	0.07

Total petroleum hydrocarbons (ug/mL)	195.1	1242.67	448.263
	84	8	

3.3. Total petroleum hydrocarbons concentrations of the untreated and treated palm kernel oil mill effluent.

The total petroleum hydrocarbons content of the untreated effluent was higher than those of the treated effluent (Table 3). The total petroleum hydrocarbons levels of the untreated effluent- polluted soil were also higher than those of the treated effluent-polluted and unpolluted soils (Table 4). The total petroleum hydrocarbon values of both the untreated and treated effluents were higher than the limit recommended by FEPA;1991 [13]. Beg et al;2003 [19] reported that the high level of total petroleum hydrocarbons in the effluents may be due to the wash water from spillage during clean-up operations which was channelled into the effluent.

Table 3. Total petroleum hydrocarbons concentration of the untreated and treated palm kernel oil mill effluent.

Component	Untreated effluent (µg/mL)	Treated effluent (µg/mL)
C12	50.773	23.982
C13	76.851	4.410
C15	62.684	23.288
C18	61.031	21.675
C24	22.190	21.981
C28	32.258	32.018
C34	36.263	25.008
C35	175.721	31.867
Total	517.771	184.229

Table 4. Total petroleum hydrocarbons concentration of the unpolluted, untreated, and treated effluent-polluted soil.

Component	Unpolluted soil (µg/mL)	Untreated effluent-polluted soil (µg/mL)	Treated effluent-polluted soil (µg/mL)
C10	14.396	35.870	33.315
C12	17.296	29.870	13.248
C13	22.044	56.105	27.758
C15	27.372	125.707	28.996
C16	29.552	161.744	30.558
C18	33.584	176.887	61.037
C21	50.940	75.853	72.047
C24	0.000	104.311	39.916
C27	0.000	109.923	0.000
C29	0.000	173.413	33.109
C32	0.000	97.535	64.318
C35	0.000	95.460	43.961
Total	195.184	1242.678	448.263

3.5. Growth characteristics of the tomato plant grown in the unpolluted soil, untreated and treated effluent –polluted soil.

The growth characteristics showed that the tomato plant grew best in the unpolluted soil (Fig.1 and Fig. 2) than the untreated (Fig. 3 and Fig. 4) and treated effluent –polluted soil (Fig. 5 and Fig. 6). The growth characteristics were constant from the 6th week to the end of the experiment for the plant grown on the untreated effluent- polluted soil. The plant in the untreated effluent- polluted soil also did not yield any fruit.

This result indicated that the untreated effluent- polluted soil had negative effect on the growth of the tomato plant due to the level of heavy metals and total petroleum hydrocarbons in such soil. In addition, the plant grown on the unpolluted soil had broad leaves and the fruits were round and large while the stems were woody and angular. The unpolluted soil was better than the untreated and treated effluent-polluted soil in terms of supporting the growth of the tomato plant.

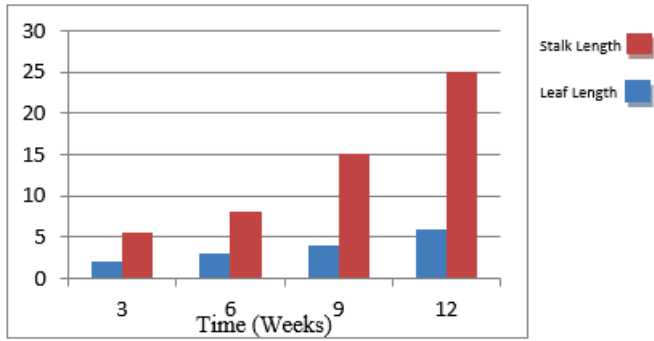


Fig. 1. Leaf and stalk length of the tomato plant grown in the unpolluted soil.



Fig. 2. Tomato plant grown in the unpolluted soil.

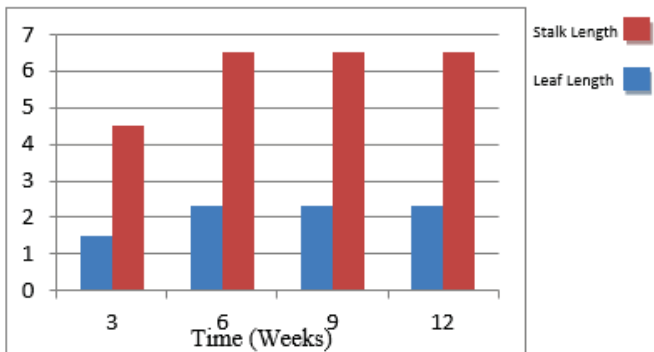


Fig. 3. Leaf length and Stalk length of the tomato plant grown in the untreated effluent-polluted soil.



Fig. 4. Tomato plant grown in the untreated effluent –polluted soil.

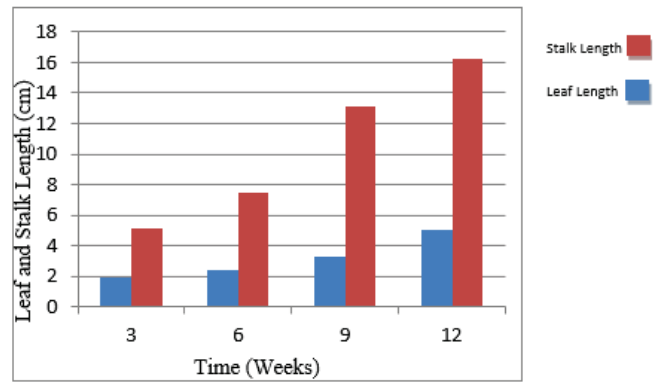


Fig. 5. Leaf and stalk length of the tomato plant grown in the treated effluent- polluted soil.



Fig. 6. Tomato plant grown in the treated effluent- polluted soil.

4. CONCLUSION

This study showed that the untreated palm kernel oil mill effluent discharged into the soil had adverse effect on the soil physicochemical characteristics studied and the untreated effluent- polluted soil adversely affected the growth characteristics of the tomato plant which had the smallest leaf and stalk lengths which were constant from the sixth to the 12th day of the growth and also yielded no fruits. Proper treatment of the effluent as well as the physicochemical analysis of the treated effluent before discharge into the soil

environment is therefore imperative. In addition, untreated palm kernel oil mill effluent must not be discharged into the environment. The Ministry of Environment at the Federal and State levels should also closely monitor the effluent produced and discharged by industries into the soil.

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REFERENCES

- [1] M.U. Orji, S.O. Nwokolo, and I. Okoli, "Effects of palm oil mill effluent on soil microflora". *Nig. J. Microbiol.*, vol.20, issue (2), pp. 1026 – 1031, 2006.
- [2] J. M. Okuo, and A.C. Ozioko, "Adsorption of lead and mercury ions on chemically – treated periwinkle shells". *J. Chem. Soc. Niger*, vol. 26, issue (1), pp. 60 – 65, 2001.
- [3] D. Olorunfemi, E.O. Emoeke, and F.E. Okieimen, "Effects of cassava processing effluent on seedling height, biomass and chlorophyll content of some cereals". *Res. J. Environ. Sci.*, vol. 2, issue (3), pp. 221 – 227, 2008.
- [4] B. A. Uzoukwu, C. Ngoka, and N. Nnaji, "Monthly variation of the physicochemical properties of effluent from Rimco Industries Nnewi, Nigeria". *Glob. J. Pure Appl. Sci.*, vol. 10, issue (1), pp. 203 – 210, 2004.
- [5] S.Onuorah, I.Ibe-Gabriel, and P.Okoye, "Impact of fish pond effluent on the physicochemical characteristics of soil, growth and yield of maize crop". *Int. J. Adv. Technol. Sci. Res.*, vol.2, issue (1), pp. 221-238, 2021.
- [6] American Public Health Association, "Standard methods for the examination of water and waste water". 22nd edition. Clesceri, L.S., Baird, R.B; Rice, E.W. and Eaton, A.D. (Editors). Washington D.C.USA, 2012, Pp. 874 – 2874.
- [7] C.M.O. Ademorati, "Standard methods for water and effluent analysis". Foludex Press Ltd, Ibadan, 1996, Pp. 44 – 54.
- [8] E. I. Ohimain, E. I. Seiyaboh, S. C. Izah, V. E. Oghenegueke, and T.G. Perewarebo, "Some selected physicochemical and heavy metal properties of palm oil mill effluents". *Greener J. Phys. Sci.*, vol. 2, pp. 131 -137, 2012.
- [9] V. C. Eze, N.D. Owunna, and D. A. Avoaja, "Microbiological and Physicochemical characteristics of soil receiving palm oil mill effluent in Umuahia, Abia State, Nigeria". *J. Nat. Sci. Res.*, vol. 3, issue (7), pp. 163 – 169, 2013.
- [10] J. N. Nwachukwu, U. O. Njoku, C.V. Agu, C. C. Okonkwo, and C.J. Obidiegwu, "Impact of palm oil mill effluent contamination on soil enzyme activities and physicochemical properties". *Res. J. Environ. Toxicol.*, vol.12, issue (1), pp. 34 – 41, 2018.
- [11] G. C. Chinyere, C. J. Nwaogwugwu, and O.C. Atasi, "Effect of palm oil mill effluent dumping on soil physicochemical parameters and selected plant nutrients in Uturu, Abia State, Nigeria". *Glob. Sci. J.*, vol. 6, issue (1), pp. 244 – 259, 2018.
- [12] A.C.Nkwocha, I.C. Ekeke, F.C. Kamen, and P.I. Oghone, "Quality assessment of effluent discharge from vegetable oil plant". *Ethiop. J. Environ. Stud. Manag.*, vol. 6, pp. 717 – 723, 2013.
- [13] Federal Environmental Protection Agency, "National guidelines and standards for industrial effluents, gaseous emission and hazardous waste in Nigeria", 1991, Pp. 52.
- [14] L.O.Okwute, and N.R. Isu, "The environmental impact of palm oil mill effluent on some physicochemical parameters and total aerobic bioload of soil at a dump site in Anyingba, Kogi State, Nigeria". *Afri. J. Agric. Res.*, vol. 2, issue (12), pp. 656 – 662, 2007.
- [15] M. U. Chikwendu, and A.N. Ogbonna, "Impact of palm oil mill effluent on the soil in Upkom – Bende Forest Reserve, Abia State, Nigeria". *J. Res. For. Wildl. Environ.*, vol. 10, issue (3), pp. 55 – 61, 2018.
- [16] B. G. H. Briton, K. Yao, and G. Ado, "Evaluation of the Abidjan Lagoon Pollution". *J. Appl. Sci. Environ. Manag.*, vol.10, issue (3), pp. 175-181, 2006.
- [17] J. R. Amelia, S. Suprihatin, N. S. Indrasti, U. Hasanudin, R. Murakami, and K. Fujie, "Effects of palm oil mill effluent application on the soil microbial community structure and oil plantation productivity". *J. Water Environ. Technol.*, vol.15, pp. 77 – 85, 2017.
- [18] B. Wood, "A review of current methods of dealing with palm oil mill effluents". *Planter*, vol.53, issue(619) pp. 477 – 495, 1978.
- [19] M.U. Beg, T. Saeed, S. Al-Muzaini, K. R. Beg, and M. Al-Bahloul, "Distribution of petroleum hydrocarbon in sediment from coastal area receiving industrial effluents in Kuwait". *Ecotoxicol. Environ. Saf.*, vol.54, issue (1), pp. 47 – 55, 2003.