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Evaluation of the Impact of Untreated Cassava Mill Effluent on the Physicochemical Properties of Soil in Aba, Abia State, Nigeria

Okoye Rosemary *[1], Onuorah Samuel [2], and Abba Oluchi[1]

[1] *Department of Microbiology, Federal University Gusau, Zamfara State, Nigeria.*
[2] *Department of Applied Microbiology and Brewing Nnamdi Azikiwe University, Awka, Nigeria.*

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ABSTRACT

Samples of fresh cassava effluent, cassava effluent polluted soil and unpolluted soil were collected during the rainy season to evaluate the effect on the physicochemical characteristics of the soil in Aba, Abia State. The physical and chemical parameters of the untreated cassava mill effluent, untreated cassava mill effluent-polluted soil and unpolluted soil were determined using standard laboratory methods. It was observed that addition of cassava mill effluent to the soil resulted to changes in the physicochemical parameters. The cyanide content, conductivity, turbidity, moisture content, TDS, TSS, TS, total acidity, total alkalinity, total chloride, and magnesium were higher in the contaminated soil samples than the unpolluted soil. The values of pH, Total hardness, calcium hardness, phosphorus, organic carbon, COD and BOD of the contaminated soil samples were lower than those of the unpolluted soil due to high content of hydrogen cyanide present in the contaminated soil. The high cynogenic potential had been attributed to the high cyanogenic glucoside (linamarin and lotaustralin) contained in cassava. The pH range of the untreated cassava mill effluent and the untreated cassava mill effluent polluted soil were completely acidic while the unpolluted soil was neutral indicating that the effluent impacted acidic properties to the soil. Phosphorus buildup in the unpolluted soil can be caused by excessive use of inorganic fertilizer or use of composts and manures high in phosphorus. The effluent from cassava plant when discharged on soil causes physicochemical changes in the soil, which calls for serious concern if the soil will be used for agricultural and other purposes. Therefore, cassava mills must be owned and managed by individuals who have basic knowledge of environmental protection.

1. INTRODUCTION

Cassava is an important staple crop and in the tropical world, it ranks fourth in importance after rice, wheat and maize [1]. In Sub-Saharan Africa, it is currently the major staple food for 40% of the population and for an estimated 500 million people in the tropics [1, 2, 3]. People also eat cassava leaves as a green vegetable, which provides a cheap and rich source of protein and vitamins A and B. However, cassava is increasing in its importance, particularly in arid and semi-arid areas, because it is a hard, drought-resistant crop that can give acceptable yields even in low-fertility soils.

Nigeria is the largest producer of cassava, while the largest exporter of this crop is Thailand [4]. Cassava is normally processed before consumption as a means of detoxification, preservation and modification [5] due to toxic cyanogenic glucosides that are present in unfermented roots and leaves [6].

Cassava tubers contain two cyanogenic glucosides, linamarin and lotaustralin which are formed from amino acids. This occurs as cyanogenesis is initiated in cassava when the plant tissue is damaged. Rupture of the vacuole releases linamarin, which is hydrolyzed by linamarase, a cell wall-

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*Corresponding author:
E-mail address: Okoye Rosemary <lexa_ebby@yahoo.com>.

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associated β-glycosidase [7]. Hydrolysis of linamarin yields an unstable hydroxynitrile intermediate, acetone cyanohydrin, plus Glc. Acetone cyanohydrin spontaneously decomposes to acetone and HCN at pH >5.0 or temperatures >35°C and can be broken down enzymatically by HNL[8,9,10,11,12,13,14, 15,16]. The HCN formed dissolves in effluent and remains in the solution [17].

Cassava and its wastewater have been reported to be toxic and poisonous [18, 19, 20, 21]. The toxicity of cassava and its wastewater is associated with its pH and cyanide content. Cassava has been observed to be highly acidic, with the pH as low as 2.6 [22]. Nko and Ikediobi (2000), [23] reported the pH of the fermenting cassava can be between 5.5 and 6.3. Cassava wastewater may therefore influence the activity of soil when large amounts are released to the soil. It was reported that when soil pH is acidic, the plants cannot utilize nitrogen (N), phosphorus (P) and potassium (K) N.P.K and other nutrients [24]. In acidic soils, plants are also likely to take up toxic metals, which may lead to their eventual death (24).

Due to the fact that these cassava mills at a small scale are managed by persons who lack knowledge of environmental safety, the wastewater that contains cyanide, along with other organic and inorganic compounds present in the wastewater affect native micro-biota and reduces nutrient availability in the soil when it is improperly discharged into the soil. This work was aimed at evaluating the impact of cassava mill effluent on the physicochemical characteristics of soil in Aba, Abia State, Nigeria. State the significance of this study. These cassava mill wastewater apart from constituting breeding grounds for flies also affects soil physicochemical properties. These alterations in the physicochemical properties of the soil can be detrimental to human health, when edible crops grown on these polluted soil absorbs nutrient below or above the required level and are ingested by humans. This has led to this experiment being carried out. This research will enlighten the general public particularly the cassava mill operators and the farmers on the level of these parameters in our soil.

2. MATERIALS AND METHODS

2.1 Sample collection

Fresh untreated cassava mill effluent, soil polluted with untreated cassava effluent, and soil free of cassava effluent (control) were collected from five (5) cassava processing mills in Iheorji, Iheorji avenue, Umuogele, 16 Dike Street, and Owerri Aba were evaluated physicochemically during the rainy season. The samples were collected in triplicates.

The soil samples were collected using a disinfected soil auger into sterile screw cap containers from a depth of 15cm and the soil free of cassava effluent (control) were also collected 100 m away from the cassava processing site. These samples were transported to the microbiology laboratory of Abia State Polytechnic, Aba, where they were analysed within twenty-four hours of collection

Two-litre plastic containers with screw caps were used to collect the samples. The containers were washed with detergent and then rinsed with distilled water. At the point of collection, the containers were rinsed with effluent..

2.2 Physicochemical Analysis

The temperature, pH, electrical conductivity, turbidity, total dissolved solids, total suspended solids, total solids, moisture content, total acidity, total alkalinity, total hardness, total chloride, calcium hardness, magnesium hardness, cyanide, phosphorous, total chloride, organic carbon, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were evaluated.

- Determination of physical parameters
- Determination of temperature

The temperature was determined using a centigrade thermometer as described by APHA [25]. The thermometer was immersed into a beaker containing the effluent and soil-water suspension samples. The temperature value was recorded when the reading stabilized.

- Determination of pH

The test was performed according to the AOAC [26]. The pH was measured with a pH meter that was standardized with pH buffers. The electrode of the meter was inserted into the effluent and soil-water suspension samples, it was read when the reading stabilized.

- Determination of electrical conductivity

This was performed according to the method described by Chopra and Kanzar [27]. It was determined using a conductivity meter. The electrode of the meter was inserted into a beaker containing the effluent and soil-water samples. The value was read when the reading stabilized.

- Determination of turbidity

This was performed as described by Okunda and Adekalu, 2013 [28]. The turbidity of the effluent and soil-water samples was measured using a turbidimeter. The sample was introduced into the turbidity meter to the desired level indicated on the bottle. The bottle was cleaned with oily soft tissue which was then inserted into the meter. The meter was turned on and calibrated, and the reading was taken. The value was expressed as nephelometric turbidity unit (N

- Determination of total dissolved solids

The test was performed according to the APHA method [25]. One hundred millilitres of each of the effluent and soil water suspension samples were filtered through a pre-weighed whatman filter papers. The filter papers were carefully removed and dried in an oven at 105°C for 30seconds. Caution was taken to avoid the filter papers being chared. The filter papers were allowed to cool and re-weighed.

- Determination of total suspended solids

This was performed according to APHA [25]. Fifteen clean, dried conical flasks were heated at 105°C for 30 seconds in an oven. They were allowed to cool and weighed. One hundred millilitres of each of the effluent and soil-water suspension samples were measured and transferred into each of the pre-weighed conical flasks and were evaporated to dryness in an oven. They were allowed to cool and then re-weighed.

- Determination of total solids

The total solids were easily obtained by simple calculation as follows:

Total dissolved solids + Total suspended solids = Total solids

- Determination of moisture content

Moisture content was determined using the gravimetric method as reported by Obi [29]. Soil sample of 10g each was put in Petri dishes while one 100 mL of the cassava effluent were measured into a conical flask. They were dried in an oven and checked every 30 seconds until a constant weight was attained after cooling in desiccators.

$$\% \text{ moisture content} = \frac{\text{weight of wet sample} - \text{weight of dry sample}}{\text{weight of wet sample}} \times 100 \quad (1)$$

- Determination of chemical parameters
- Determination of total acidity

This was determined using the titration method as reported by Akharayi and Omoya, 2005 [30]. One hundred millilitres of each effluent was measured into a 250 ml conical flask. One drop of mixed indicator which was made up of Bromothymol blue and phenolphthalein was added and titrated with barium hydroxide solution till a colour change from yellow to red was observed. The value was recorded.

- Determination of total alkalinity

This was determined using titration method as described by Akharayi and Omoya[30]. One hundred millilitres of each effluent was measured into a 250 ml conical flask. Two drops of bromocresol green were added as the indicator and titrated with 0.02 N Sulphuric acid till a colour change from blue to yellow was observed. The value was thereafter recorded.

- Determination of total hardness

Titration method was used as reported by Akharayi and Omoya, 2005 [30]. One hundred millilitres of each effluent was measured into a 250 ml conical flask. One millilitres of buffer (pH10.0), 2mls of Sulphuric acid and 0.2 millilitres of Eriochrome Black T were added and titrated with Ethylene-diamine-tetra-acetic acid (EDTA) till a colour change from purple to blue was observed and the titre was recorded..

- Determination of calcium hardness

Titration method described by Patile et al. [31] was employed. One hundred millilitres of each effluent was measured into a 250 ml conical flask, 0.5 millilitres of the mixed indicator made up of murexide and sodium chloride was added with 1 ml of sodium hydroxide to obtain a pH of 12. This EDTA till a color change from pink to purple was observed. The value was thereafter recorded.

- Determination of Magnesium Hardness

Calculation from Total hardness and calcium hardness was used. The values from total hardness and calcium hardness determined by EDTA titration were calculated.

Total hardness – calcium hardness × 0.234 = magnesium hardness [23].

- Determination of cyanide

Alkaline titration method was used as reported by AOAC [24]. One hundred millilitre of each effluent was measured into a 250 ml conical flask. Eight millilitres of 6N NH_4OH solution and 2 ml of 5% KI solutions were added as the indicator and titrated with 0.02 N silver Nitrate ($AgNO_3$) solution to get a light turbid endpoint. The titre values were used to calculate the cyanide concentrations in mg HCN/kg.

- Determination of phosphorous

The calorimetric determination of phosphorous in soil and cassava effluent was done using Bray 2-p method as described by Nwakaudu *et al.*, [25]. The soil samples were first extracted after digestion. Two grams of soil polluted with untreated cassava effluent and 2g of soil free of cassava effluent (control) were measured into 50 ml beaker. Twenty-five millilitres of the untreated cassava effluent was introduced into a breaker. 14 ml of ammonium chloride (NH_4CL) which was the extracting solution were added in each of them. The mixtures were stirred with magnetic stirrer and filtered with Whatman filter paper No.40. 1 ml of the filtrates was pipetted into a 100 ml flask and made up to mark with distilled water. 5ml of these solutions and 5 ml of distilled water was pipetted into two beakers and labelled Sample A for the polluted soil, Sample B for the unpolluted soil and Sample C for the effluent water and blank, respectively. 12g of ammonium molybdate $\{(NH_4)_6\ M_7O_{24}\}$ was dissolved in 250 ml distilled water and labelled as solution 1. Solution 2 was prepared by dissolving 0.28g of potassium antimony tartarate ($KSBC_4H_4O_6$) in 100ml of distilled water. Solution 3 was prepared by diluting 148g of concentrated sulphuric acid (5N H_2SO_4) with 100ml of distilled water. Solutions 1, 2, and 3 were then mixed together in a 2litre flask and made up to mark with distilled water. These mixtures were labelled as reagent A. Reagent B was prepared by dissolving 1.056g of ascorbic acid in 200ml of reagent A and shake for 5 minutes. 4ml of reagent B was added into the beakers labelled Samples A, B, C and Blank respectively. The solutions were left to stand for 15minutes for colour to develop. Absorbance was measured at 882nm using an electro photometer.

- Determination of total chloride

Chloride was quantified using argentometeric titration method as done by Okunda and Adekalu [20]. One hundred millilitres of each of the effluent water and soil-water suspension samples were measured into a 250ml conical flask. 1ml of potassium dichromate (K_2CrO_7 and K_2CrO_4) was used as an indicator and titrated with silver nitrate ($AgNO_3$) till a colour change from yellow to reddish brown was observed. The value was thereafter recorded.

- Determination of organic carbon

Organic carbon was determined using titration method as done by Patile et al. [31]. Two hundred millilitres of the effluent were measured into a 500ml conical flask and oven dried so as to weigh out 0.2g from the sediment likewise the effluent polluted soil and unpolluted soil. These soil samples were dried and grinded into fine powder in a mortar. 0.2g was weighed out from the dried soil-water suspension into a 500ml conical flask. 10ml of 0.5 M potassium dichromate ($K_2Cr_2O_7$) were added into the samples and swirled gently. 20ml of con. sulfuric acid (H_2SO_4) were gently added to avoid splashing and directing the acid into the suspension. Immediately, it was gently swirled for a minute until the regents were properly mixed. The flask was allowed to stand for 30 minutes. 200ml of distilled water was cautiously added into these mixtures with 10ml conc. orthophosphoric acid (H_3PO_4). It was allowed to cool. 4 drops of ferroin indicator were add. This was titrated with 0.25M ferrous ammonium sulphate (FAS) till a colour change from blue to deep green was observed. The value was thereafter recorded.

- Chemical oxygen demand (COD)

Titration method as described by APHA [25] was used. 25cm^2 of each of the effluent water and soil-water suspension samples were measured into a 250ml conical flask. 1.1 sulphuric acid was measured using a test tube and added into each sample. Afterwards, 10cm^2 of potassium dichromate was measured using a 25cm^2 pipette and was added into each samples. It was all mixed together 3 drops of ferroin were used as an indicator and titrated with ferrous ammonium sulphate till a colour change from blue-green to reddish brown was observed. The values were thereafter recorded.

- Biochemical oxygen demand

Titration method was employed as done by APHA [25]. One hundred millilitres of each of the effluent and soil-water suspension samples were measured. It was carefully dispersed into the BOD bottle so as to avoid air bubbles. 2ml of manganese sulphate was carefully added to the BOD bottle by inserting the pipette below the surface of the water so as to avoid air bubbles. 2ml of alkali-iodide-azide reagent were added in the same manner. The bottle was closed and the samples mixed by invertin`g many times. The presence of oxygen was indicated by the appearance of a brownish cloud in the solution. This brown precipitate was allowed to settle to the bottom. 2ml of concentrated sulphuric acid (H_2SO_4) were carefully added to avoid air bubbles. The bottle was closed and the solution properly mixed so as to dissolve the precipitate. The bottle was incubated for five days. After the incubation, 50ml of the samples were titrated with 0.025N sodium thiosulphate till a pale yellow colour was observed. 2ml of starch solution were added, which turned the samples to blue colour. It was still titrated till the sample was clear. The value was thereafter recorded.

3. RESULTS

The physical parameters investigated in triplicate for the untreated cassava mill effluent are shown in Table 1. The temperature ranged between 24±4.08°C and 27.67±4.28°C; pH, 1.8±0.11 and 3.8±0.11; electrical conductivity, 370±11.32 and 500±29.94 µS/cm; turbidity, 24.0±1.13 and 39.27±1.31 NTU, moisture content, 13.87±1.13% and 21.5±3.33 %; total dissolved solids, 134±7.42 and 240±42.40 mg/l; total suspended solids, 103±5.88 and 160±2.26 mg/l and total solids, 270±49.33 and 370±49.33 mg/l.

The physical parameters investigated in triplicate for the untreated cassava mill effluent-polluted soil are presented in Table 2. The temperature ranged between 21±2.26°C and 28.33±4.57°C; pH, 3.8±0.29 and 5.23±1.34; electrical conductivity, 550±22.63 and 750±59.88 µS/cm; turbidity, 10.2±2.55 and 21.3±5.79 NTU, moisture content, 11.2±4.93 and 14.0±1.96 %; total dissolved solids, 103±16.67 and 140±24.0 mg/g; total suspended solids, 88±18.69 and 120±16.04 mg/g and total solids, 187±10.0 and 260±9.87 mg/g.

The physical parameters investigated in triplicate for the unpolluted soil are presented in Table 3. The temperature ranged between 21±2.99°C and 26±4.93°C; pH, 5.6±1.12 and 7.0±0.41; electrical conductivity, 230±10.37 and 400±7.42 µS/cm; turbidity, 5.5±1.19 and 15.3±2.87 NTU, moisture content, 10.5±0.59 and 13.2±0.63 %; total dissolved solids, 70±2.99 and 100±4.93 mg/g; total suspended solids, 61±4.08 and 95±5.99 mg/g and total solids, 131±4.08 and 195±4.93 mg/g.

The chemical parameters investigated in triplicate for the untreated cassava mill effluent are shown in Table 4. The total acidity ranged between 1.70±0.43 and 5.20±0.12 mg/l; total alkalinity, 0.04±0.03 and 3.72±0.67 mg/l; total hardness, 68±8.12and 110±6.30 mg/l; calcium hardness, 49.22±2.11. and 95.23±6.17 mg/l; magnesium hardness, 2.197±1.069 and 8.834±1.08 mg/l; total chloride, 47±6.88 and 61±10.91 mg/l; cyanide, 171.11±4.93 and 287.04±24.19 mg/l; phosphorus, 2.50 and 50.11±5.64 mg/l; organic carbon, 0.32±0.20 and 0.91±0.06mg/l; chemical oxygen demand, 200.92±10.10 and 268±19.29mg/l and biochemical oxygen demand, 58.5±2.89 and 76.0±10.66 mg/l.

The chemical parameters investigated in triplicate for the untreated cassava mill effluent polluted soil are shown in Table 5. The total acidity ranged between 1.70±0.41 and 5.20±0.10; total alkalinity, 0.04±0.02 and 3.72±0.08 mg/g; total hardness, 68±4.08 and 110±8.54 m/g; calcium hardness, 49.22±8.51 and 95.23±5.96 mg/g, magnesium hardness, 2.197±1.13 and 8.834±0.77 mg/g; total chloride 47±4.08 and 61±9.87 mg/g; cyanide, 171.11±19.40 and 287.04±12.90 mg/g; phosphorus, 2.50±0.91 and 50.11±4.69 mg/g; organic carbon 0.32±0.25 and 0.91±0.48 mg/g; chemical oxygen demand, 200.92±17.91 and 268.92±7.50 mg/g; biochemical oxygen demand 58.5±12.80 and 76.0±6.74 mg/g; chemical oxygen demand, 200.92±17.91 and 268.92±7.50 mg/g; biochemical oxygen demand 58.5±12.80 and 76.0±6.74 mg/g.

The chemical parameters investigated in triplicate for the unpolluted soil are presented in Table 6. The total acidity ranged between 3.66±0.28 and 4.90±0.62 mg/g; total alkalinity, 0.05±0.92 and 2.76±0.30 mg/g; total hardness, 95±7.42 and 145±21.56 mg/g; calcium hardness, 77.06±6.84 and 139.05±9.14 mg/g; magnesium hardness, 1.392±0.33 and 7.1000±1.98 mg/g; total chloride, 15±4.93 and 31±2.99 mg/g; cyanide, 12.05±1.99 and 49.11±5.99 mg/g; phosphorus, 55.70±5.05 and 86.53±3.08 mg/g; organic carbon, 0.30±0.03 and 0.66±0.03 mg/g; chemical oxygen demand, 122.92±2.93 and 256.56±11.31 mg/g and biochemical oxygen demand, 59.00±2.99 and 80.5±5. 76mg/g.

Table 1. Physical parameters investigated in the untreated cassava mill effluent

Physicochemical characteristics	Cassava mill location				
	Iheorji	Iheorji Avenue	Umuogele	16 Dike Street	Owerri Aba
Temperature (˚C)	24±4.08	26.33±2.85	27.67±4.28	27.67±4.28	26.33±2.85
pH	2.5±0.23	3.8±0.11	1.8±0.11	2.93±0.07	2.4±0.23
Electrical conductivity (µs/cm)	370±11.32	420±11.32	469.33±2.85	380±10.37	500±29.94
Turbidity (NTU)	24±1.13	36.13±1.99	39.27±1.31	31.57±1.59	29.37±0.62
Moisture content (%)	20±1.13	13.87±1.13	14.27±0.46	18.53±0.62	21.5±3.33
Total dissolved solids (mg/l)	185±4.53	134±7.42	167±2.99	170±6.30	240±42.40
Total suspended solids (mg/l)	160±2.26	154±7.42	103±5.88	155±25.88	130±10.79
Total solids (mg/l)	345±59.61	288±40.04	270±49.33	325±63.01	370±49.33

Table 2. Physical parameters investigated in the untreated cassava mill effluent-polluted soil

Physicochemical Characteristics	Cassava mill location				
	Iheorji	Iheorji Avenue	Umuogele	16 Dike Street	Owerri Aba
Temperature (˚C)	25±2.26	21±2.26	24±4.08	26±2.26	28.33±4.57
pH	3.8±0.29	4.2±0.41	4.9±0.19	4.8±0.91	5.23±1.34
Electrical conductivity (µs/cm)	580±27.46	627±63.88	550±22.63	630±49.33	750±59.88
Turbidity NTU)	10.2±2.55	13.8±1.86	21.3±5.79	20.1±4.93	19.5±3.34
Moisture content (%)	14.0±1.96	13.0±1.07	13.5±1.39	11.2±4.93	12.3±4.63
Total dissolved solids (mg/l)	130±24.66	105±21.20	103±16.67	140±24.0	122±11.15
Total suspended solids (mg/l)	95±24.66	115±14.13	88±18.69	120±16.04	112±4.93
Total solids (mg/l)	225±9.87	220±8.98	187±10.06	260±9.87	234±13.77

Table 3. Physical parameters investigated in the unpolluted soil

Physicochemical Characteristics	Cassava mill location				
	Iheorji	Iheorji Avenue	Umuogele	16 Dike Street	Owerri Aba
Temperature (˚C)	25±3.92	21±2,99	24±2.26	26±4.93	24±4.08
pH	6.5±0.59	5.6±1,12	5.9±1.13	6.6±1.19	7.0±0,41
Electrical conductivity (µs/cm)	230±10.37	360±21.68	265±16.67	300±6.30	400±7.42
Turbidity NTU)	5.5±1.19	11.8±1.08	15.3±2.87	9.8±1.45	10.1±0.41
Moisture content (%)	12.1±0.71	11.5±0.30	13.2±0.63	10.8±0.71	10.5±0.59
Total dissolved solids (mg/l)	95±6.30	83±4.08	99±7.07	70±2.99	100±4.93
Total suspended solids (mg/l)	80±7.07	91±13,77	884.93	61±4.08	95±5.99
Total solids (mg/l)	175±10.80	174±9.26	191±5.19	131±4.08	195±4.93

Table 4. Chemical parameters investigated in the untreated cassava mill effluent

Physicochemical Characteristics	Cassava mill location				
	Iheorji	Iheorji Avenue	Umuogele	16 Dike Street	Owerri Aba
Total Acidity (mg/g)	3.31±1.05	2.66±0.02	5.20±0.12	1.70±0.43	2.00±0.37
Total Alkalinity (mg/g)	0.04±0.03	3.66±1.43	2.81±0.3	3.72±0.67	0.78±0.26
Total Hardness (mg/g)	68±8.12	68±17.79	98±10.91	101±2.99	110±6.30
Calcium Hardness (mg/g)	58.61±3.97	49.22±2.11	60.25±4.99	70.12±7.92	95.23±6.17
Magnesium Hardness (mg/g)	2.197±1.069	4.395±1.04	8.834±1.08	7.226±1.19	3.456±0.52
Total Chloride (mg/g)	47±6.88	61±3.92	57±3.39	61±10.91	56±1.96

Cyanide (mg/g)	171.11±4.93	191.37±4.33	263.20±2.37	186.58±17.50	287.04±24.19
Phosphorus (mg/g)	50.11±5.64	2.50±0.92	2.75±0.69	5.66±0.59	4.32±0.10
Organic Carbon (mg/g)	0.32±0.20	0.50±0.07	0.66±0.23	0.91±0.06	0.88±0.09
COD (mg/g)	200.92±10.10	258.12±17.85	268.92±19.29	211.76±31.44	245.75±16.74
BOD (mg/g)	58.5±2.89	74.5±7.15	64.0±5.28	76.0±10.66	67.5±7.36

Table 5. Chemical parameters investigated in the untreated cassava mill effluent-polluted soil

Physicochemical Characteristics	Cassava mill location				
	Iheorji	Iheorji Avenue	Umuogele	16 Dike Street	Owerri Aba
Total Acidity (mg/g)	3.30±0.19	2.66±0.48	5.20±0.10	1.70±0.41	2.00±0.13
Total Alkalinity (mg/g)	0.04±0.02	3.66±0.9	2.81±0.34	3.72±0.08	0.78±0.12
Total Hardness (mg/g)	68±4.08	68±4.08	98±5.19	101±8.16	110±8.54
Calcium Hardness (mg/g)	58.61±6.63	49.22±8.51	60.25±5.08	70.12±2.03	95.23±5.96
Magnesium Hardness (mg/g)	2.197±1.13	4.395±0-.59	8.834±0.77	7.226±0.96	3.456±1.04
Total Chloride (mg/g)	47±4.08	61±9.87	57±10.91	61±5.98	56±11.15
Cyanide (mg/g)	171.11±19.40	191.37±5.11	263.20±3.87	186.58±18.74	287.04±12.90
Phosphorus (mg/g)	50.11±4.69	2.50±0.91	2.75±0.52	5.66±1.77	4.32±1.05
Organic Carbon (mg/g)	0.32±0.25	0.50±0.11	0.66±0.07	0.91±0.48	0.88±0.22
COD (mg/g)	200.92±17.91	258.12±20.05	268.92±7.50	211.76±3.66	245.75±10.47
BOD (mg/g)	58.5±12.80	74.5±8.24	64.0±2.45	76.0±6.74	67.5±4.27

Table 6. Chemical parameters investigated in the unpolluted soil

Physicochemical Characteristics	Cassava mill location				
	Iheorji	Iheorji Avenue	Umuogele	16 Dike Street	Owerri Aba
Total Acidity (mg/g)	4.90±0.62	3.66±0.28	8.20±0.43	4.55±0.10	4.00±0.67
Total Alkalinity (mg/g)	0.05±0.29	2.76±0.30	2.66±0.19	1.72±0.19	0.07±0.03
Total Hardness (mg/g)	115±3.42	95±7.42	144±23.38	125±5.99	145±21.56
Calcium Hardness (mg/g)	88.05±3.15	77.06±6.84	124.11±5.25	94.66±12.34	139.05±9.14
Magnesium Hardness (mg/g)	6.306±1.46	4.198±1.16	4.654±0.44	7.100±1.98	1.392±0.33
Total Chloride (mg/g)	31±2.99	22±4.93	15±4.93	19±4.93	21±2.99
Cyanide (mg/g)	49.11±5.99	28.66±5.57	47.12±4.83	12.05±1.99	18.11±1.96
Phosphorus (mg/g)	71.11±4.07	76.20±2.24	69.80±2.48	55.70±5.05	86.53±3.08
Organic Carbon (mg/g)	0.049±0.029	0.58±0.029	0.30±0.03	0.46±0.03	0.66±0.03
COD (mg/g)	256.56±11.31	151.48±5.07	194.76±6.31	241.16±8.09	122.92±2.93
BOD (mg/g)	59±2.99	69.5±3.72	80.5±5.76	73.5±5.34	61.5±5.51

4. DISCUSSION

The temperature was higher for the untreated cassava mill effluent-polluted soil than the untreated cassava mill effluent and unpolluted soil (Tables 1-3). The cassava mill effluents dumping led to rises in polluted soil temperatures over those of control soil samples. This agreed with the work of Chinyere et al. [34], who studied seasonal impact of cassava mill effluents (CME) on dumpsites in Isuikwuato Area, Abia State, Nigeria and reported a rise in temperature of the polluted soil over the control soil and that of Izah et al. [35] which indicated temperature of CME discharge point at 24.5°C and for the control at the same range of 24.5°C, in their study of the impacts of cassava mill effluents in Nigeria. Changes in soil temperature strongly affects root growth and nutrient uptake by plants. Shoot development and mineral nutri˙ent accumulation by plants was consequently hindered [36, 37].

It was found that the pH range of the untreated cassava mill effluent and the untreated cassava mill effluent-polluted soil were highly acidic (Tables 1 and 2) while the unpolluted soil was neutral (Table 3). The acidity could be attributed to the presence of hydrogen cyanide in the cassava mill effluent. This suggested that the effluent imparted acidic properties to the soil. This result agreed with the finding of Izah et al. [35], who reported that the cassava mill effluent in Nigeria ranged from 2.50 – 4.20, indicating that the cassava mill effluent was acidic. It also, comformed to with the findings of Olorunfemi et al. [38], who carried out an investigation on the effect of cassava processing effluent on the germination of some cereals and reported that the pH of the effluent was 3.96 which was highly acidic. The soil pH determines the availability of nutrients and the potency of toxic substances as well as the physical properties of the soil [39]. Soil pH is one of the most important soil properties which determine the species, availability, survival and growth organisms in the soil thereby affecting nutrients availability. Generally, soil falling between pH of 6.5 to 8.0 is suitable for most of the common crops. At elevated pH, most microorganisms become dormant [40].

Electrical conductivity is a measure of water capacity to convey electrical current. It signifies the amount of total dissolved salts. The electrical conductivity values were higher in the untreated cassava mill effluent polluted soil (Table 2) than in the untreated cassava mill effluent and the unpolluted soil (Table 3). This conformed to the finding of [39], who reported that the electrical conductivity of the unpolluted soils in Abraka, Delta State ranged from 136 to 958 µS/cm. Electrical conductivity is used as a means of appraising soil salinity. The values recorded in the soils may be due to increase in the concentration of soluble salts. Eze and Onyilide [41], reported that the electrical conductivity of soil receiving cassava effluent in Elele, Rivers State, Nigeria, ranged at 33.4 µS/cm for contaminated soil and 16.6 µS/cm for the control soil sample. The implication of high electrical conductivity in soils is that there are reasonable or significant presences of anions [42]. The elevated values of electrical conductivity in the polluted soil means that the soil polluted with cassava effluent can reduce population and proliferation of soil microorganisms to make nutrients available for plant absorption [40].

The cassava mill effluent was more turbid than the effluent-polluted soil and unpolluted soil (Tables 1-3). This agreed with the findings of Izah et al. [35], who studied cassava mill effluent in Nigeria and stated its turbidity at the range of 24.0 NTU for contaminated soil and 5.5NTU for control soil. Ayansina et al. [43] recorded high turbidity values from cassava wastewater that was collected from a cassava processing local factory in Saw-mill Area of Ibadan, Oyo State, at the range 1.10 to 1.55 NTU. From the high turbidometry values obtained, they deduced that cassava wastewater was highly turbid and polluted [43].

The moisture content of cassava mill effluent (CME) soil samples changed with depth and distance of sample collection from discharge point. This suggested that CME increased the water holding capacity of soils [44]. The untreated cassava mill effluent and effluent polluted soil had higher moisture content than the unpolluted soil (Tables 1-3). This may be due to the decrease in the soil porosity caused by the effluent, which is expected because of the starch content of the cassava effluent [33]. Chinyere et al. [26] studied the seasonal impact of cassava mill effluents (CME) on dumpsites physicochemical parameters and selected enzyme activities in Isuikwuato Area, Abia state, Nigeria and stated that its cassava mill effluent dumpsite soil sample had higher percentage moisture content ($P<0.05$) than control in both seasons. Excess soil water reduces soil oxygen available to plants and microbes thus altering microbial activities [34].

Total dissolved solids measure the minerals, metals, cations, anions or salts that are dissolved into water. Leaching form the cassava effluent into soil contributes to the total dissolved solids. The untreated cassava mill effluent had higher total dissolved solids than the untreated cassava mill effluent polluted soil and unpolluted soil (Tables 1-3). This disagrees with the work of Agbo et al. [45] carried out an assessment of the effects of cassava mill effluent on the soil and its microbiota in Biase Local Government Area of Cross River State, Nigeria and recorded total dissolved solids for cassava effluent at 478.75±0.01mg/l, Impacted soil at 4.51±0.01mg/g, un-impacted soil at 57.12±0.01mg.g. Izah et al. [35] also carried out an investigation on cassava mill effluent in Nigeria and reported the total dissolved solids of cassava mill effluent at the range of 779 mg/l.

Total suspended solids provide the dry weight of the suspended particles that are not dissolved in a sample which are trapped by a filter. The untreated cassava mill effluent and untreated effluent polluted soil had higher total suspended solids than the unpolluted soil. Izah et al. [35] reported a higher range of total suspended solids at the range of 789 mg/l in cassava mill effluent.

Total solids (TS) are the sum of the total dissolved solids and total suspended solids. The untreated cassava mill effluent had the highest total solids than the untreated effluent polluted soil and unpolluted soil. This result conformed to the findings of Omomowo et al. [46], who carried out the bacteriological screening and pathogenic potential of soil receiving cassava mill effluents in Oyo State, Nigeria, and reported TS for cassava effluent at the range of 280.0 mg/l and control at 196.0 mg/l.

The untreated cassava mill effluent was highly acidic than the effluent polluted soil and the unpolluted soil. This is result conformed to the findings of Izah et al. [35], who reported total acidity at discharge point at the range 1.77 mol/kg of and control at the range of 1.96 mol/kg. The untreated cassava mill effluent had higher total alkalinity than the untreated cassava mill polluted soil and unpolluted soil. Okunade and Adekalu [28], however carried out physico-chemical analysis of contaminated water resources due to cassava wastewater effluent disposal in

Osogbo, Osun State, and recorded total alkalinity at the range of 195-376 mg/l.

Total hardness of the unpolluted soil and the untreated effluent polluted soil were higher than that of the untreated cassava mill effluent. Izah et al. [35] however who carried out an investigation on cassava mill effluent in Nigeria and recorded total hardness of CME at discharge point at the range of 280 mg/l and control at 196 mg/g while Okunade and Adekalu [28], carried out physico-chemical analysis of contaminated water resources due to cassava wastewater effluent disposal in Osogbo, Osun State, and recorded total hardness at the range of 166-362 mg/l. The unpolluted soil had higher calcium hardness than the untreated cassava mill effluent and untreated cassava mill effluent polluted soil. Agbo et al. [45] recorded cassava mill effluent value at the range of 64.30±1.41 mg/l, 34.15±0.10 mg/g and 6.71±0.01 mg/g respectively for the impacted and un-impacted soils.

The untreated cassava mill effluent polluted soil had higher magnesium hardness than the untreated cassava mill effluent and unpolluted soil. Orji and Ayogu [47], reported magnesium content to be higher at the range of 2.43±0.47 mg/kg for the contaminated soil than 0.88±0.98 mg/kg for the control soil. The increase in magnesium in polluted soil could have been caused by cassava mill effluent. The untreated cassava mill effluent had higher total chloride than the polluted and unpolluted soil. Okunade and Adekalu [28] however recorded a higher total chloride at the range of 31.4-162.0 mg/l.

Cyanide is a metabolic poison and has the tendency to reduce the biomass of microorganisms within the impacted soil [48]. The untreated cassava mill effluent and untreated cassava mill effluent-polluted soil had a higher cyanide content than the unpolluted soil. The high cyanide content observed in the untreated cassava mill effluent agree with studies of Nwaugo et al. [49] who reported values of 5.21 for the waste pit 4.66 for 5m away from waste pit and control at 0.62 mg HCN kg. The high cynogenic potential had been attributed to the high cyanogenic glucoside (linamarin and lotaustralin) contained in cassava. Continual application of cassava effluents may lead to changes in the physicochemical properties of the soil within the environment and the quality of water both on the surface and underground could be contaminated due to transient movement, seepage or infiltration of cyanic effluents within and around the milling site [50]. Cyanide occurs naturally in a variety of fruits, vegetables and grains, while some plants also absorb cyanide from the soil [51]. Padmaja [52] and Onabolu et al. [53], reported that cyanide can be found in most plants in the form of cyanogenic glycoside. Ingestion of cyanide containing staple foods such as cassava and forage plants have accounted for many instances of cyanide poisoning in humans and animals. The exposure of persons to gaseous cyanide leading to intoxication by inhalation causes acute cyanide poisoning, while dietary exposure may occur as a result of high intake of the products of some nutritive plants of different root tubers; which contain cyanogenic glycosides [54, 56].

The unpolluted soil had more phosphorus content than the untreated cassava mill effluent and the untreated effluent-polluted soil. Phosphorus buildup in the unpolluted soil can be caused by excessive use of inorganic fertilizer or use of composts and manures high in phosphorus. Excessive soil phosphorus reduces the plant's ability to take up required micronutrients, particular iron and zinc, even when soil test showed adequate amounts of these nutrients in soil [57]. The high level of Phosphorus observed in the untreated effluent polluted soil could be due to a higher level of organic matter in the soil as increasing organic matter increases P availability [58]. High values of phosphorus in the soils is not surprising since cassava tuber is a rich source of phosphorus [59]. Okoli et al. [60] studied long-term impact of cassava mill effluent on some chemical and biological properties of soils and observed a high phosphorus level of 32.58 mg kg-1 in cassava effluent-polluted soils while Agbo et al. [45] recorded phosphorus for cassava mill effluent at the range of 432.00±1.41mg/l, impacted soil at the range of 79.51±0.01mg/g and un-impacted soil at the range of 288.85±0.10 mg/g. Iza [35] also obtained a lower range of phosphorus in cassava mill effluent at the range of 0.18 mg/l.

The untreated cassava mill effluent and the untreated cassava mill effluent-polluted soil had a higher organic carbon than the unpolluted soil. The values may be due to the discharge of the waste with some contents of organic matter and also suggested presence of degradable and compostable substances in the effluent [61, 62] as well as 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 [63]. Total organic carbon is a measure of organic content in soils, sediments and water [64] and contributes significantly to acidity through contributions from organic acids and biological activities. Lopez-Sanchez et al [66] observed that both anthropogenic and natural processes have resulted in elevated concentrations of organic carbon in sediments.

The untreated cassava mill effluent and unpolluted soil had a higher COD than the untreated cassava mill effluent-polluted soil. Izah et al. [35] reported cassava mill effluent at the range of 320-365 mg/l while Obueh and Odesiri-Eruteyan [66] studied the effects of cassava processing wastes on the soil environment of a local cassava mill and recorded COD at the range 841.0 ± 3.4 mg/l for effluent from waste pit.

The untreated cassava mill effluent had a higher BOD than the untreated cassava mill effluent-polluted soil and unpolluted soil. Izah et al. [35], reported BOD of cassava mill effluent at the range of 13.0-73.0 mg/l while Agbo et al. [455], reported cassava mill effluent at the range of 5.73±0.01 mg/l, impacted soil at 7.18±0.01 mg/g and un-impacted soil at 4.54±0.01mg/g. High BOD constitutes risks to fauna, flora and surface or underground water [67]. High BOD and COD levels are attributed to the presence of high organic matter in the effluent [68]. The organic matter is broken down by bacteria which require oxygen for decomposition process, thus increasing the levels of BOD and COD [66].

The values for pH, moisture content, total dissolved solids, total suspended solids, total solids, total acidity, calcium hardness, total chloride, cyanide and phosphorus were significant using analysis of variance while the values of temperature, total alkalinity, total hardness, magnesium hardness, organic carbon, chemical oxygen demand and biochemical oxygen demand were insignificant using analysis of variance.

The physicochemical parameters investigated showed variations among samples. The cassava mill effluent caused some physicochemical changes in the soil contaminated with cassava effluent. The cyanide content, conductivity, turbidity, moisture content, TDS, TSS, TS, total acidity, total alkalinity, total chloride and magnesium were higher in the contaminated soil samples than the control soil while the values of pH, total hardness, calcium hardness, phosphorus, organic carbon, COD and BOD of the contaminated samples were lower than those of the control soil. High cyanide content is detrimental to soil health and reduces quality of the soil and can result in the decrease of soil pH (increased acidity), magnesium and calcium among others. These cations present in these effluents are dangerous and poisonous to humans [41].

5. CONCLUSION

The effluent from cassava plant when discharged on soil causes physiochemical changes in the soil, which calls for serious concern if the soil will be used for agricultural and other purposes. The present study has shown that the physicochemical properties of the cassava mill effluent decreases the soil pH. The pH of the untreated cassava mill effluent, untreated cassava mill effluent polluted soil were acidic whereas the pH of the control soil samples was neutral. There was a significant increase in the physiochemical parameters: cyanide content, conductivity, turbidity, moisture content, TDS, TSS, TS, Total acidity, Total alkalinity, Total chloride and magnesium were higher in the contaminated soil samples than the control soil. The reverse was observed for total hardness, calcium hardness, phosphorus, organic carbon, COD and BOD of which the unpolluted soil was higher than the contaminated soil, this is due to high content of hydrogen cyanide present in the contaminated soil. Cassava effluents should be treated first to reduce the pysicochemical load before discharging either to natural drains or farm land. It is advisable for strategic well-built structures (Cassava Processing Plant) to be made available to all the cassava processing workers in Aba, Abia state and Nigeria, to avoid open processing of cassava flakes.

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REFERENCES

[1] Dufour, D.L Effectiveness of cassava detoxification techniques used by indigenous peoples in Northwest Amazonia. Interciencia, vol. 14: pp. 86-91, 2009.

[2] Okafor, P.N. Assessment of cyanide overload in cassava consuming populations of Nigeria and the cyanide content of some cassava based foods. African Journal of Biotechnology, vol. 3: pp. 358-361, 2004.

[3] Burns, A., Gleadow, R., Cliff, J., Zacariaas, A. and Cavagnaro, T. Cassava: The drought, war and famine crop in a changing world. Sustainability, vol. 2, pp. 3572-3607, 2010.

[4] (FOA), Food and Agricultural Organization. Cassava industrial revolution in Nigeria. Codex Alimentarius XII, Supplementary 4, Rome 2004.

[5] Oyewole, O.B. Fermentation of cassava for ‘lafun’ and ‘fufu’ production in Nigeria. Food Laboratory News. vol. 7, issue (2): pp. 29-31. 2001.

[6] Kobawila, S.C., Louembe, D., Keleke, S., Hounhouigan, J. and Gambe, C. Reduction of the cyanide content during fermentation of cassava roots and leaves to produced bikedi and ntobambodi, two food products from Congo. African journal of Biotechnology, vol. 4: pp689-696, 2005.

[7] McMahon, J., White, W. and Sayre, R.T. Cyanogenesis in cassava (Manihot esculenta Crantz) Journal of Experimental Botany, vol. 46:pp731–741, 1995.

[8] Cutler, A. and Conn, E. The biosynthesis of cyanogenic glycosides in Linum usitatissumum (Linen flax) in vitro. Archives of Biochemistry and Biophysics, vol. 212: pp468–474, 1981.

[9] Yemm, R. and Poulton, J. Isolation and characterization of mandelonitrile lyase from mature black cherry (Prunus serotina) seeds. Archives of Biochemistry and Biophysics, vol.247: pp440–445, 1986.

[10] Wajant, H. and Mundry, K-W. Hydroxynitrile lyase from Sorghum bicolor: a glycoprotein heterodimer. Plant Science, vol. 89: pp127–133, 1993.

[11] Wajant, H., Riedel, D., Bent, S. and Mundry, K-W. Immunocytological localization of hydroxynitrile lyases from Sorghum bicolor L. and Linum usitatissimum L. Plant Science. Vol. 103: pp145–154, 1994.

[12] White, W., McMahon, J. and Sayre, R.T. Regulation of cyanogenesis in cassava. Acta Horticulturae, vol. 375: pp 69–78, 1994.

[13] White, W. and Sayre, R.T. The characterization of hydroxynitrile lyase for the production of safe food products from cassava (Manihot esculenta, Crantz) In DL Gustine, HE Flores, eds, Phytochemicals and Health, Current Topics in Plant Physiology, American Society of Plant Physiologists, Rockville, MD, vol. 15. pp 303–304, 1995.

[14] Zheng, L. and Poulton, J.E. Temporal and spatial expression of amygdalin hydrolase and (R)-(+)-mandelonitrile lyase in black cherry seeds. Plant Physiology, vol. pp109:31–39, 1995.

[15] Hasslacher, M., Schall, M., Hayn, M., Griengl, H., , S. and Schwab, H. Molecular cloning of the full- length cDNA of (S)-hydroxynitrile lyase from Heveabrasiliensis. Journal of Biological Chemistry. vol. 271: pp5884–5891, 1996.

[16] Wajant, H. and Pfizenmaier, K. Identification of potential active site residues in the hydroxynitrile lyase from Manihot esculenta by site-directed mutagenesis. Journal of Biological Chemistry, vol. 271: pp 25830–25834, 1996.

[17] Pearson, D. Laboratory technique in food analysis. Butterwort London and Boston, pp50-57, 1973.

[18] Okezie, B.O. and Kosikowski. F.V. Cassava as food. Food Science and Nutrition, vol. 17: pp259-275, 1982.

[19] Akintowa, A. and Tunwashe, O.L. Fata cyanide poisoning from cassava-based meals. Human and Experimental Toxicology, vol.11: pp47-49, 1992.

[20] Hans, R. Measuring effects in humans of dietary cyanide exposure from cassava. Acta Horticulturae. Cassava safety. No 375, pp, 271-283, 1994.

[21] Adeymo, O.K. Haematological and histopathological effects of cassava mill effluents in clarias gariepinus. African Journal of Biomedical Research, vol. 8, pp179-183, 2005.

[22] ESCAP (Economic and Social Commission for Asia and the Pacific). Industrial pollution control Guidelines. V: Tapioca industry. United Nations, Bangkok. Thailand, pp17, 2002.

[23] Nok, A.J. and Ikediobi, C.D. Purification and some properties of linamarase from cassava (Manihot esculenta). Journal of Food Biochemistry, vol.14, issue (6), pp447-489, 2000.

[24] Spectro, C. (2001). About soil pH. http://soil.gsfc.nasa.gor/soilpH/plantpH.htm. Accessed March 12, 2022.

[25] American publish health association (APHA). American water works association and water pollution control federation, standard methods for the examination of water and wastewater, 16th edition, pp.70-81, 2005.

[26] Association of Official Analytical Chemists (AOAC). Official Methods of Analysis 18th edition. Virginia, pp. 309-315, 2005.

[27] Chopra, C. and Kanzar C. Analytical Agricultural Chemistry.4th Edition, Pretice Hall, Charles Mall Publishers Co., Upper Saddle River, pp121-125, 1998.

[28] Okunade, D.A. and Adekalu, K.O. Characterization of cassava waste effluent contaminated soil in Ile-Ife, Nigeria. European International Journal of science and Technology,vol. 3, issue (4), pp246-276, 2014.

[29] Obi, M.E. Soil Physics. A compendium of lectures. Nsukka. Attan to Publishers, Nsukka, Nigeria, pp28-40, 2000.

[30] Akharayi, F.C. and Omoya, F.O. Physiochemical determination and sensory evaluation of wine produced from selected tropical fruits. Bioscience Biotechnology Research, vol. 3, pp21-28, 2005.

[31] Patil. P.N., Sawant. D.V. and Deshmukh, R.N. Physicochemical Parameters for Testing of Water. International Journal of Environmental Sciences, vol. 3, issue (3), pp1194-1270, 2012.

[32] Association of Official Analytical Chemists (AOAC). Official Methods of Analysis 15th edition. Washington DC, pp. 38-46, 2000.

[33] Nwakaudu, M.S., Kamen, F.L., Afube, G., and Nwakaudu, A.A., Ike, I.S. Impact of cassava processing effluent on Agricultural soil: A case study of Maize growth. Journal of emerging trends in Engineering and applied science. Vol. 3, issue (5), pp881-885, 2012.

[34] Chinyere, G.C., Osuocha, K.U., Offor, C.E. and Ugbogu, A.E. Seasonal Impact of Cassava Mill Effluents (C M E) On Dumpsites Physicochemical Parameters and Selected Enzyme Activities in Isuikwuato Area, Abia State, Nigeria. International Journal of Science, Environment and Technology, vol. 5, issue (3), pp1777-1795, 2016.

[35] Izah S. C., Bassey S. E. and Ohimain E. I. Cyanide and Macro-Nutrients Content of Saccharomyces cerevisiae Biomass Cultured in Cassava Mill Effluents. International Journal of Microbiology and Biotechnology, vol. 2, issue (4), pp176-180, 2017.

[36] Tagliavini M., Hogue, E.J. and Neilson, G.H. Influence of phosphorus nutrition and root zone temperature on growth and mineral uptake of peach seedlings. Journal of Plant Nutrition, vol. 14, pp1267-1276, 2008.

[37] Mc Michael, B.L. and Burke, J. J. Soil temperature and root growth. Horticulture Science, vol. 33, pp97-951, 1998.

[38] Olorunfemi, D. I., Emoefe, E. O. and Okieimen, F. E. Effect of cassava processing effluent on seedling height, Biomass and chlorophyll content of some cereals. Resource Journal ofEnvironmental Science, vol. 2, issue (3), pp221-228, 2008.

[39] Osakwe, S.A. Effect of cassava processing mill effluent on physical and chemical properties of soils in Abraka and Environs, Delta State, Nigeria. Chemistry and Materials Research, vol. 2, issue (7), pp27-31, 2012.

[40] Odoabuchi, V.E., Ejiogu, C.C., Nwanya, E. and Azubuike, C. Effects of Cassava Mill Effluent on Physicochemical Properties of Garden Soil – Eziobodo, Imo State, Nigeria. Global Scientific Journal, vol. 8, issue (9), pp1647-1656, 2020.

[41] Eze V. C. and Onyilide, D. M. Microbiological and Physicochemical Characteristics of Soil receiving Cassava Effluent in Elele, Rivers State, Nigeria. Journal of Applied & Environmental Microbiology, vol. 3, issue (1), pp20-24, 2015.

[42] Fuller, M.A., Fearnebough, W., Mitchel, D.I. and Trueman, I.C. Desert reclaimation using yellow river irrigation water in Nigeria. China Soil Use and Management, vol. 11, pp77-83, 1995.

[43] Ayansina, A.D.V., Garuba, E.O. and Baba, J. Some Physico-Chemical Parameters and Major Microorganisms Isolated from Cassava Wastewater and a Receiving nearby Stream. International journal of current microbiology and applied sciences, vol. 4, issue (6), pp211-217, 2015.

[44] Akubugwo, I.E., Ofoegbu, C.J. and Ukuoma, C.U. Physiochemical studies on Uburu salt lake. Ebonyi State Nigeria. Pakistan Journal of Biological Sciences, vol. (7), pp3170- 3174, 2009.

[45] Agbo, B. E., Ogar, A. V., Itah, A. Y., Brooks, A. A. and Akonjor, M. A. Assessment of the effects of cassava mill effluent on the soil and its microbiota in Biase local government area of Cross river state, Nigeria. World Journal of Advanced Research and Reviews, vol. 01, issue (02), pp034–044, 2019.

[46] Omomowo, I.O., Omomowo, O.I., Adeeyo, A.O., Adebayo E.A. and Oladipo, E.K. Bacteriological Screening and Pathogenic Potential of Soil Receiving Cassava Mill Effluents. International Journal of Basic and Applied Science, vol. 3, issue (4), pp26-36, 2015.

[47] Orji, J.O. and Ayogu, T.E. Effects of Cassava Mill Effluent on Physicochemical Characteristics and Bacterial Flora of Soil in Ezzamgbo Community Ebonyi State, Nigeria. World Journal of Medical Sciences, vol. 15, issue (1), pp20-33, 2018.

[48] Akani, N.P., Nmelo, S.A. and Ihemanandu, I.N. Effects of cassava processing effluents on the microbial population and physicochemical properties of loamy soil in Nigeria. Nigeria Society of Microbiology, pp200-210, 2006.

[49] Nwaugo V.O., Etok C.A., Chima G.N. and Ogbonna C.E. Impact of cassava mill effluent (CME) on soil physiochemical and microbial community structure and functions. Nigerian journal of Microbiology, vol. 22, issue (1), pp1681-1688, 2008.

[50] TTAC. TrAC Trends in Analytical Chemistry. The standard addition method revisited, vol. 89, pp21-33, 2017.

[51] Jorgensen, K., Bak, S., Busk, P.K., Sorensen, C., Olsen, C.E. and Puonti-Kaerlas, B.L. Cassava plant with depleted cyanogenic glucoside content in leaves and tubers. Distribution of cyanogenic glucosides, their sites of synthesis and transport, and blockage of the biosynthesis by RNA interference technology. Plant Physiology, vol. 139, issue (1), pp363-374, 2005.

[52] Padmaja, G. Cyanide detoxification in cassava fr food and feed users. Critical Reviews in Food Science and Nutrition, vol. 35, issue (4), pp299-339, 1995.

[53] Onabolu, A.O., Oluwole, S.O., Bokanga, M. and Rosling, H. Ecological variation of intake of cassava food and dietary cyanide load in Nigerian communities. Public Health Nutrition, vol. 4, issue (4), pp871-876, 2001.

[54] Kamalu, B.P. The adverse effect of long term cassava (Manihot esculenta Grantz) Consumption. International Journal of Food Science Nutrition, vol. 46, issue (1), pp65-93, 1982.

[55] Oluwole, O.S., Onabulu, A.O., Cotgreave, I.A., Rosling H, Persson, A. and Link, H. Incidence of endemic ataxia polyneuropathy and its relation to exposure to cyanide in a Nigerian community. Journal of Neurology Neurosurgon. Vol.74, issue (10), pp1417- 1422, 2003.

[56] Provin, T.L. and Pitt, J.L. Phosphorus too much and plant may suffer. Texas A&M Agrilife extension. Publication can be found at Agrilife Book store.org, 2017.

[57] Brady, N.C. and Weil, R.R. Elements of the Nature and Properties of Soils (3rd Ed.., upper Saddle River, NJ: Prentice Hall. pp. 235-243, 2010.

[58] Jung, G.B., Kim, W.I., Moon, K.K. and Ryu, I.S. “Fractionation and availability of heavy metals in paddy soils near abandoned mining areas (Korea)”. Journal Agriculture, vol. 19, issue (4), pp319-323, 2002.

[59] Okoli, N. H., Oti, N. N., Ekpe, I. I. and Mbawuike, S. A. Long-Term Impact of Cassava Mill Effluent on Some Chemical and Biological Properties of Soils. Malaysian Journal of Soil Science, vol. 22, pp101-115, 2018.

[60] Mumoz, M., Pena, L. and Halloroms, J.O. “Use of an industrial by product as a liming source”. Journal of Agriculture of the University of Puerto Rico, vol. 78, issue (3-4), pp195-202, 1994.

[61] Oviasogie, P.O. and E. Omoruyi. “Levels of heavy metals and physicochemical properties of soil in a foam manufacturing Industry”. Journal of Chemical Society of Nigeria, vol. 32, issue (1), pp102-106, 2007.

[62] Haider, K., Martin, J.P. and Fillip, Z. “Humus Biochemistry. In: E.A. Paul. and A.D. McLaren. (Eds)”. Soil Biochemistry, vol. 4, pp195-244, 1975.

[63] Yun, O. “Simulating dynamic load of naturally occurring Total Organic Carbon (TOC) from watershed”. Water Research, vol. 37, pp823-832, 2003.

[64] Lopez-Sanchez, J.F., Sahuqullo, A., Fielder, H.D., Rubio, R.., Rauret, G., Muntau, H., Marin, P., Valladon, B.M., Polve, M. and Monaco, A. Analytical Chemical Acta, vol. 342, pp91, 2006.

[65] Obueh H.O. and Odesiri-Eruteyan, E. A study on the effects of cassava processing wastes on the soil environment of a local cassava mill. Journal of Pollution Effects and Control, vol. 4, issue (4), pp177-182, 2016.

[66] Horsefall, M., Abia, A.A. and Spiff, A.I. Kinetics studies on the absorption of cadmium, copper and zinc ions from aqueous solutions by cassava tuber bark waste. Bioresource Technology, vol. 97, pp283-291, 2006.

[67] Ademoroti, C.M.A. Standard method for water and effluent analysis. 1st ed Foludex Press Ltd Ibadan, pp66-89, 2006