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(Research Article)

Effects of Cassava Processing Effluents on the Surrounding Soil of a Local Cassava Mill in Igbodo-Etche, Southern Nigeria

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Abstract

This research work investigated the effects of cassava processing effluents on the soil environment of a local cassava mill in Igbodo-Etche in Rivers State, Southern Nigeria. Experimental soil samples were collected 0-30cm bgl using a hand trowel at 0, 5 and 15m distances away from the cassava mill while soil samples collected at 100m distance away from the mill served as Control. Samples for physicochemical analysis were sun-dried and passed through 2mm sieve. Soil samples collected were analyzed for physicochemical parameters, mineral composition and Total Heterotrophic Bacteria and Fungi (THB and THF) counts. Analytical results revealed changes in pH, conductivity, salinity, temperature, and moisture at various distances from the cassava mill. Soil pH increased significantly ($p<0.05$) with distance, transitioning from acidic pH (4.2) at 0m from the cassava mill to nearly neutral pH (6.55) at 100m distance away from the mill. Conductivity and salinity decreased significantly with distance, indicating reduced ionic content and salinity further from the source. Organic matter content, Carbon, and Nitrogen decreased significantly ($p<0.05$) with distance, with the highest values at 0m sampling point. Phosphorus level was highest at 5m (30.40 mg/kg). Hydrogen cyanide was highest at 0m (9.59 µg/kg), reducing significantly with distance. THB and THF recorded highest counts 100m away from the mill. Findings from this study revealed that disposal of cassava processing effluents in the immediate environment of the mill resulted in significant effects on soil health. This therefore suggests that uncontrolled release of untreated cassava mill effluent is capable of causing changes in physicochemical and microbial properties of soil within the environment.

Keywords: Cassava Mill; Cassava Processing Effluents; Environment; Soil Health

1. Introduction

Cassava (*Mannihot esculanta*) is the third major source of carbohydrate in the world and has wide usage when processed into garri, tapioca, akpu, fufu and starch [1]. It is normally processed before consumption as a means of detoxification, preservation and modification due to the presence of toxic cyanogenic glucosides in unfermented roots and leaves [2-4].

Cassava processing generates solid and liquid residues that are hazardous in the environment [5]. Cassava mill effluent (CME) from traditional grating during processing is a major cause of environmental degradation, contaminating agricultural farmlands, streams and affecting biodiversities [6-8]. Effluent is massively generated during cassava processing into various by-products which include fermentation and sifting into cassava pulp, grinding and dewatering for production of cassava derived products including flakes and starch [2]. When these cassava mill effluents are improperly disposed, they generate offensive odour and unwanted scene [9]. They are thus, a potential hazard to soil, water, flora, fauna, livestock and human population living around the processing locations [10]. Cassava effluent has great influence on the chemical properties of the soil [11]. The toxicity of cassava mill effluent is basically associated

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with its acidic pH and cyanide content [12]. Also, continuous discharge of the effluent into the soil for a long period of time leads to extinction of some bacteria and fungi types that were originally available in the soil [1].

In Southern Nigeria, majority of cassava mills are sited around where the effluent is capable of causing pollution to arable land, water bodies and soil around the mill. The sharp rise in production and increasing trend in supply and demand for cassava in developing countries has accentuated the negative impact that cassava production and processing has on the environment and biodiversity [1].

The main objective of this study is to ascertain the effects of cassava processing effluent on physicochemical parameters, mineral composition and microbial characteristics of soils receiving cassava effluent.

2. Materials and methods

2.1. Study Area

The study area (Igbodo-Etche) is located in Etche L.G.A. of Rivers State, Nigeria. Etche L.G.A. is located at the North-Eastern part of Rivers State. It lies within latitude 4°45'N – 5°17'N and longitude 6°55'E – 7°17'E (Figure 1). The L.G.A. is bounded in the north by Imo State, east-wards by Imo River, then Omuma L.G.A. While Obio-Akpor and Oyigbo is located to the south of the L.G.A, Ikwerre L.G.A. is found west-ward. [13].

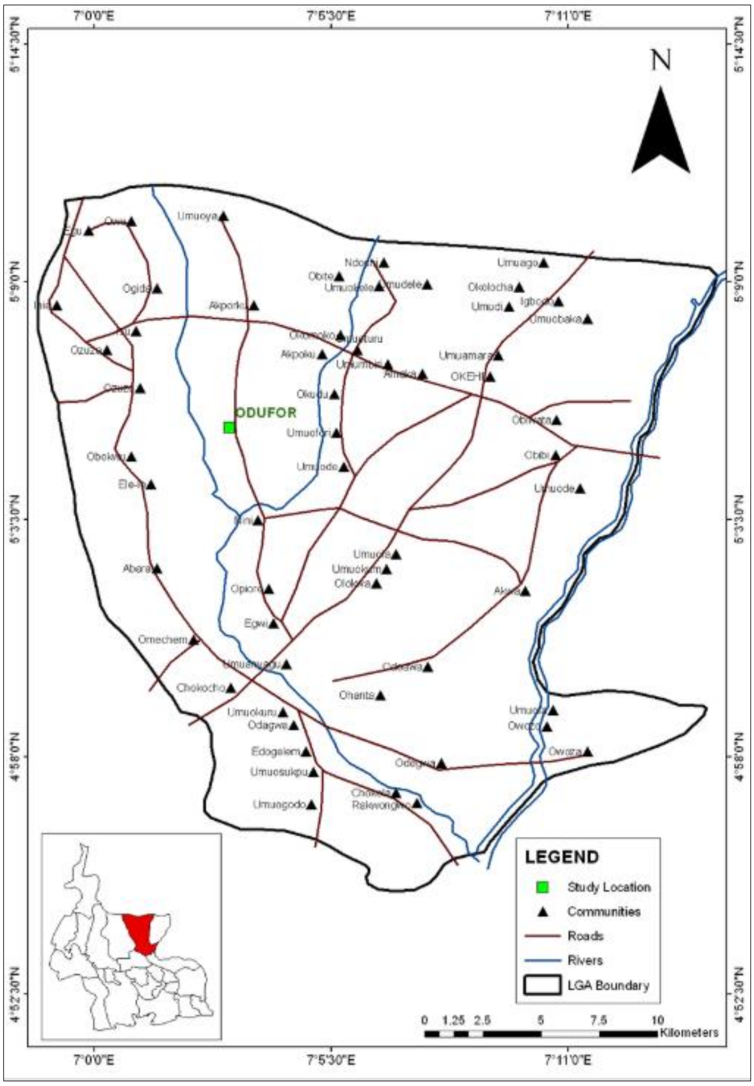

Figure 1 Map of Etche showing the study location (Igbodo-Etche)

2.2. Soil Sample Collection and Grouping

Experimental soil samples were collected 0-30cm bgl using a hand trowel at 0, 5 and 15m distances from the cassava mill while soil samples collected at 100m distance away from the mill served as Control. Samples for physicochemical analysis were sundried, crushed to fine particles and sieved using 2mm sieve. Sterile universal bottles were used to collect the soil sample for microbial analyses and stored in a refrigerator at 4°C for 24 hours. Samples for physicochemical properties were collected in clean transparent ziplock bags and transported to the laboratory for analysis.

Table 1 Soil sample grouping

Distance from Cassava Mill	0 m	5 m	15 m	100 m
Sample ID	SS-1	SS-2	SS-3	SS-4

2.3. Soil Sample Analysis

2.3.1. Physicochemical Analysis

Soil pH was determined by the ASTM D4972 method described by ASTM [14]. Measurement of soil electric conductivity was carried out using the Electrode Method [15]. Moisture content of the soil samples was determined by a method described by the Texas Department of Transport (TxDOT Designation: Tex-103-E) [16]. Mineral (Calcium, Magnesium, Potassium, Sodium) content of soil samples was determined using Atomic Absorption Spectrophotometer method [17]. Temperature was determined in situ by dipping the thermometer of 110°C calibration range into the soil and the reading is taken after 5 minutes' interval. Effective Cation Exchange Capacity (ECEC) was determined using the method described by Chapman [18]. Total Exchangeable Bases and Exchangeable acidity were determined by leaching the soil with 1N KCl solution and the extract titrated with standard NaOH solution [19]. Percentage organic carbon was determined by the wet oxidation method described by Nelson and Sommers [20]. Total nitrogen was determined by macro Kjeldahl digestion method [21]. Available P was determined using Bray P1 as described by IITA [19]. Cyanide content was determined by the alkaline titration method [22] while soil salinity was measured using a digital conductivity meter (Extech 341350A-P Oyster). Organic carbon (OC) was measured using Walkley-Black titration method by TITREX 2000 instrument [23].

2.3.2. Microbial Analysis

Samples for microbial properties were analyzed for bacterial and fungal population count by the methods of Zuberer [24] and Alef [25].

2.4. Statistical Analysis

Statistical analysis results in this study are expressed as Means ± Standard Error Mean (SEM) while one-way ANOVA was used to test for differences between treatment groups using SPSS version 20. The results were considered significant at p-values of less than 0.05, that is, at 95% confidence level ($P< 0.05$).

3. Results and discussion

Soil pH ranged from 4.20 to 5.55 in SS-1 to -3 and recorded 6.55 in SS-4. The pH was generally more acidic in the polluted soils than in control soil samples (Table 2). Hydrogen cyanide content was highest in the soil samples collected at 0m from the cassava mill (SS-1), recording 9.59 ± 0.33µg/kg. While soil samples collected at 15m distance showed hydrogen cyanide value of 6.75 ± 0.12, Control soil samples recorded 3.99 ± 0.16 cyanide levels. It was observed that hydrogen cyanide levels in soil decreased significantly ($p<0.05$) with increasing distance away from the cassava mill. Electrical Conductivity in SS1 and SS-2 was observed to be significantly ($p<0.05$) high (446 ± 63.51 and 102.67 ± 3.18µs/cm respectively) when compared with Control soil values (47.67 ± 1.45 µs/cm). Results for mineral composition of soil samples in this study showed that SS-1 had the highest concentrations for Ca, Na, K and Mg; SS-4 recorded the lowest concentrations for mineral composition (Table 3). Soil mineral composition reduced with increasing distance from the cassava mill. Bacterial and fungal counts were highest in SS-4 (5.70×10^7 ± 0.06 cfu/g and 7.13×10^5 ± 0.18 cfu/ml) and lowest in SS-1 (2.07×10^7 ± 0.09 ± cfu/g and 2.37×10^5 ± 0.03 cfu/g) respectively.

Table 2 Results for physicochemical properties of soil samples

Parameter	SS-1	SS-2	SS-3	SS-4
pH	4.2 ± 0.01^{a}	5.55 ± 0.03^{b}	5.53 ± 0.02^{b}	6.55 ± 0.02^{c}
Temp (°C)	27.85 ± 0.02^{a}	28.5 ± 0.06^{b}	28.5 ± 00^{b}	28.55 ± 0.03^{b}
Moisture (%)	3.24 ± 0.06^{a}	3.15 ± 0.05^{a}	3.29 ± 0.08^{a}	2.25 ± 0.05^{b}
Electrical Conductivity (µs/cm)	446 ± 63.51^{a}	102.67 ± 3.18^{b}	64.67 ± 3.18^{c}	47.67 ± 1.45^{d}
Salinity (ppm)	223 ± 31.75^{a}	50.67 ± 1.45^{b}	32.67 ± 1.45^{c}	28.33 ± 0.88^{d}
Organic matter (%)	2.51 ± 0.07^{a}	2.18 ± 0.09^{a}	2.42 ± 0.01^{a}	1.3 ± 0.01^{b}
Organic carbon (%)	1.46 ± 0.04^{a}	1.26 ± 0.05^{a}	1.4 ± 0.01^{a}	0.75 ± 0.01^{b}
Nitrogen (%)	1.36 ± 0.04^{a}	0.92 ± 0.04^{b}	0.66 ± 00^{c}	0.53 ± 0.02^{c}
Total Exchangeable Bases (cmol/kg)	9.38 ± 0.24^{a}	4.74 ± 0.22^{b}	2.68 ± 0.1^{c}	3.55 ± 0.16^{d}
Exchangeable Acidity (cmol/kg)	1.33 ± 0.17^{a}	2.00 ± 0.00^{b}	2.83 ± 0.17^{b}	2.17 ± 0.17^{b}
ECEC (cmol/kg)	10.72 ± 0.14^{a}	6.74 ± 0.22^{b}	5.51 ± 0.19^{c}	5.72 ± 0.1^{c}
Hydrogen cyanide (µg/kg)	9.59 ± 0.33^{a}	7.48 ± 0.33^{b}	6.75 ± 0.12^{c}	3.99 ± 0.16^{d}

Values are Mean ± Standard Deviation. Data with the same alphabets (a,b,c,d) as superscript shows non-significant differences (p≥0.05), while that with different alphabets as superscript shows significant differences (p≤0.05).

Table 3 Results for Mineral composition of soil samples

Parameter	SS-1	SS-2	SS-3	SS-4
Ca (cmol/kg)	5.77 ± 0.15^{a}	2.77 ± 0.15^{b}	1.7 ± 0.06^{c}	0.59 ± 0.2^{d}
Na (cmol/kg)	0.45 ± 0.03^{a}	0.21 ± 0.01^{b}	0.13 ± 0.01^{c}	0.09 ± 0.01^{d}
K (cmol/kg)	0.27 ± 0.01^{a}	0.16 ± 0.01^{b}	0.13 ± 0.01^{b}	0.1 ± 0.01^{b}
Mg (cmol/kg)	2.9 ± 0.06^{a}	1.6 ± 0.06^{b}	0.75 ± 0.03^{c}	0.28 ± 0.02^{d}
Phosphorus (mg/kg)	30.33 ± 0.37^{a}	30.4 ± 0.4^{a}	29.07 ± 0.37^{b}	25.67 ± 0.42^{c}

Values are Mean ± Standard Deviation. Data with the same alphabets (a,b,c,d) as superscript shows non-significant differences (p≥0.05), while that with different alphabets as superscript shows significant differences (p≤0.05).

Table 4 Results for mineral composition of soil samples

Parameter	SS-1	SS-2	SS-3	SS-4
THB (cfu/g) * 10^7	2.07 ± 0.09^{a}	3.43 ± 1.19^{b}	2.2 ± 0.06^{c}	5.7 ± 0.06^{d}
TF (CFU/g) * 10^5	2.37 ± 0.03^{a}	5.53 ± 0.03^{b}	3.57 ± 0.09^{c}	7.13 ± 0.18^{d}

Values are Mean ± Standard Deviation. Data with the same alphabets (a,b,c,d) as superscript shows non-significant differences (p≥0.05), while that with different alphabets as superscript shows significant differences (p≤0.05)

The acidic pH recorded in soil samples collected at 0, 5 and 15m distance from the cassava mill could be as a result of effluents from the cassava processing plants which had spread over the farmland in close proximity to the mill [26]. Cassava mill effluent has been reported to be acidic with pH of 3.95 [2, 27]. Similarly, Uzochukwu et al. [28] also reported the acidic nature of cassava waste water with pH ranging from 4.00 to 4.20. The pH of the cassava effluent was very acidic due to the high cyanide content [28]. Soil pH determines the availability of nutrients and the potency of toxic substances as well as the physical properties of the soil [29]. Izonfuo *et al* [30] noted that alterations in soil physical, chemical and microbial parameters have both adverse and beneficial effects. Low soil pH values indicate a generally high tendency for high availability of metals; hence, this increases the risk of heavy metal uptake by plants [31].

Results obtained in this study showed that Electrical Conductivity (EC) for SS1 and SS-2 were significantly (p<0.05) high when compared to values for Control soil samples. This finding is indicative of increase in the concentration of soluble salt as EC is used as a means of appraising soil salinity [32]. The discharge of effluents from the cassava mills to the surrounding soils significantly increased the presence of anions in the soil and the resultant high EC values. High EC value is an indication of high levels of contamination due to dissolved ions [33].

Akani et al. [34] reported that hydrogen cyanide has the tendency to reduce the biomass of microorganisms within impacted soil. The cassava mill effluent-polluted soil had a higher cyanide content than control soil samples. Results obtained for hydrogen cyanide in this study corroborates earlier findings by Nwaugo et al. [35] who reported high hydrogen cyanide values for soil samples collected from a waste pit located 5m away from a cassava mill, while control samples recorded hydrogen cyanide values as low as 0.62 mg HCN kg. The high levels of cyanogenic glucoside (linamarin and lotaustralin) have been reported to be responsible for hydrogen cyanide in cassava.

Soil samples collected at close proximity to the cassava mill showed high values for organic carbon (OC), organic matter (OM) when compared to values obtained for control soil samples. Total Organic Carbon is a measure of organic content in soils, sediments and water and contributes significantly to soil acidity through contributions from organic acids and biological activities. The high values of OC and OM in polluted soil is likely due to the discharge of the cassava effluent with some contents of organic matter. Oviasogie and Omoruyi [36] reported in a previous study that the presence of degradable and compostable substances in cassava effluent could lead to increase in OC and OM contents.

The generally elevated levels of minerals in soil samples located at close proximity to the cassava mill decreased gradually away from the impacted point. This is an indication that the cassava mill effluent is the source of the assayed minerals in the soil samples. This finding is at variance with a previous study by Obueh and Odesiri-Eruteyan [1] who reported that mineral contents (Ca, Mg, Na and K) were significantly lower in the cassava effluent-polluted soils than in control samples due to high content of hydrogen cyanide present in the contaminated soil. Cassava tubers contain eight mineral elements namely K, Mg, Ca, P, Zn, Fe, Cu, and Na [37]. The high concentrations for Ca, Na, K and Mg recorded for soil samples collected at 0m away from the cassava mill is suggested to be as a result of the mineral composition and nutritional properties of harvested cassava tubers.

Bacterial and fungal counts were highest in control soil samples. The relatively lower microbial population in soil samples collected at 0, 5and 15m away from the cassava mill could be attributed to the acidic nature of the effluent due to the presence of cyanide. Cyanide in the soil could lead to the inhibition of microbial growth [38]. Cassava processing units generate large volumes of effluent which contain highly lethal substances, mobile in soil and can be detrimental to microbial survival [39]. Only bacteria and fungi that can withstand the high acidic condition of the processing wastes are likely to dominate, thus the lower population of the bacterial and fungal species.

4. Conclusion

This study has shown that uncontrolled release of untreated cassava mill effluent causes changes in the physicochemical and microbial properties of soil within the environment. Also, surface and groundwater could be contaminated due to transient movement, seepage or infiltration of cyanic effluents within and around the cassava mill. Effluents from cassava mill processing plants should therefore, not be disposed nor allowed to spread over the surrounding environment, without proper pre-treatment.

Compliance with ethical standards

Disclosure of conflict of interest

Authors have declared that no competing interests exist.

References

[1] Obueh HO, 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 & Control. 2016; 4:177.

[2] Ezeogo JI, Nwakoby NE, Orji MU, Ejimofor CF. Effects of Cassava Mill Effluent on the physicochemical growth of maize plants. Asian Journal of Plant and Soil Sciences. 2021; 6(1): 111-122.

[3] Oyewole OB. Fermentation of cassava for lafun production. Food Lab News. 199; 17:29-31. 4.

[4] Kobawila SC, Louembe D, Keleke S, Hounhouigan J, Gambe C. Reduction of the cyanide content during fermentation of cassava roots and leaves to produce bikedi and ntoba mbodi, two food products from Congo. African Journal of Biotechnology. 2005; 4:689-696.

[5] Cumbana A, Minone E, Cliff J, Bradbury JH. Reduction of cyanide content of cassava flour in Mozambique by the wetting method. Food Chemistry. 2007; 101: 894-897.

[6] Olorunfemi, DI, Emoefe EO, Okieimen FE. Effect of Cassava Processing Effluent on Seedling Height, Biomass and Chlorophyll Content of Some Cereals. Research Journal of Environmental Sciences. 2008; 2(3):221-227.

[7] Chinyere CG, Iroha AE, Amadike UE. Effects of altering palm oil and cassava mill effluents pH before dumping on dumpsite soils physico-chemical parameters and selected enzyme activities. Journal of Biodiversity and Environmental Sciences. 2013; 3 (4):46-58.

[8] Izonfuo WAL, Bariweni PA, George DMC. Soil contamination from cassava wastewater discharges in a rural community in the Niger Delta, Nigeria. Journal of Applied Science and Environmental Management. 2013; 17(1):105 – 110.

[9] Okafor JO. Impact of effluents from garri processing industries on the environment in Bida, Niger State of Nigeria. Journal of Engineering and Applied Sciences. 2008; 3(6):487-490.

[10] Omonoma, B.T. and Akinpelu, A.O. (2010). Water environment and health implications on cassava production continentals. Journal of Agricultural Science 4: 29-37.

[11] Akpan JF, Solomon MG, Bello OS. Effects of Cassava Mill Effluent on some chemical and micro-biological properties of soils in Cross River State, Nigeria. Global Journal of Agricultural Sciences. 2011; 10(2):89-97.

[12] Nweke RN, Onuoha SC. Effects of Cassava Processing Effluents on the Soil Microbial Population Dynamics in Selected Communities in Abakaliki, Ebonyi State, Nigeria. ChemSearch Journal. 2024; 15(1):27 – 38.

[13] Nwankwoala HO, Nwaogu C. Utilizing the Tool of GIS In Oil Spill Management - A Case Study of Etche LGA, Rivers State, Nigeria. Global Journal of Environmental Sciences. 2009; 8(1):19 – 29.

[14] American Society of Testing and Materials (ASTM), Annual Book of ASTM Standards, Designated D4972 – 95a: Standard Test Method for pH of Soils, 1995.

[15] Hach. SIW-1 Soil and Irrigation Water Manual; 1992. Available at: https://www.hach.com/asset - get.download.jsa?id=7639982669

[16] Texas Department of Transportation, XDOT Designation: TEX-103-E: Determining Moisture Content In Soil Materials. Retrieved from https://ftp.txdot.gov/pub/txdot-info/cst/TMS/100-E_series/pdfs/soi103.pdf

[17] Smith R. A laboratory manual for the determination of metals in water and wastewater by atomic absorption spectrophotometry. National Institute for Water Research Council for Scientific and Industrial Research, South Africa; 1983.

[18] Chapman HD. Total exchangeable base. In C.A. Black (ed.) Methods of Soil Analysis. Part II, 9:902-904, Madison, Wisconsin: American Society of Agronomy; 1965.

[19] IITA. Selected methods for soil and plant analysis. IITA (International Institute of Tropical Agriculture). Manual Series No. 1, Ibadan; 1979.

[20] Nelson DW, Sommer LE. Total organic matter. In A.L. Page, R. H. Miller and C. Keenay (eds). Methods of Soil Analysis, Part 2, Agronomy, 9. Chemical and Microbiological Properties, 2nd ed. Madison: American Society of Agronomy; 1982.

[21] Jackson ML. Soil chemical analysis. New York: Prentice-Hall; 1969.

[22] Association of Official Analytical Chemists (AOAC). Official Methods of Analysis 15th Edition. Washington DC p.38-46; 1990.

[23] Practical Presentation Takesure Tendayi Department of Soil Science and Environment University of Zimbabwe. Soil Organic Carbon Practical Walkley-Black Method (Titration) Available at Dakar.Walkley.Black.777.FINAL.pdf

[24] Zuberer DA. Recovery and enumeration of viable bacteria. In methods of soil analysis, Part 2; Microbiological and biochemical properties. Number 5, Madison, Wisconsin USA: Soil Science Society of American Book Series.

[25] Alef K. Nutrient sterilization, aerobic and anaerobic culture techniques, enrichment and isolation of microorganisms. In Alef, K. and Nannipieri (Eds.): Methods in Applied Soil Microbiology and Biochemistry (pp. 45– 50). London: Academic Press Limited; 1995.

[26] Eze VC, Onyilide DM. Microbiological and physicochemical characteristics of soil receiving cassava effluent in Elele, Rivers State, Nigeria. Journal of Applied & Environmental Microbiology. 2015; 3: 20-24.

[27] Arotupin DJ. Evaluation of Micro-organisms from cassava waste water for production of amylase and cellulase. Research Journal of Microbiology. 2007;2(5):475–480.

[28] Uzochukwu SVA, Oyede R, Atanda O. Utilization of Garri Industry Effluent in the preparation of a Gin. Nigerian Journal of Microbiology. 2001;15:87–92.

[29] Bamgbose O, Opeolu BO, Odukoya OO, Bamgbose JT, Olatunde GO. Physicochemical characterization of leachates generated from simulated leaching of refuse from selected waste dumps in Abeokuta City, Nigeria. Journal of Chemical Society of Nigeria. 2007; 22(1): 117-125.

[30] Izonfuo WAL, Bariweni PA, George DMC. Soil contamination from cassava wastewater discharges in a rural community in the Niger Delta, Nigeria. Journal of Applied Science and Environmental Management. 2013; 17(1):105 – 110.

[31] Osakwe SA. Effect of cassava processing mill effluent on physical and chemical properties of soils in Abraka and Environs, Delta State, Nigeria, Chemistry and Metals Research. 2012; 27:27- 40.

[32] Etienajirhevwe, OM, Agbini OA. Effects of Cassava Processing Mill Effluents on the Surrounding Soil Using Heavy Metals, Conductivity and pH. International Journal of Research Publication and Reviews. 2021; 2(11):627-632.

[33] Essumang DK, Senu J, Fianko JR, Nyarko BK, Adokoh CK, Boamponsem L. Groundwater Quality Assessment: A physicochemical properties of drinking water in a rural setting of developing countries. Canadian Journal on Scientific & Industrial Research. 2011; 2(3).

[34] Akani NP, Nmelo SA, Ihemanandu IN. Effects of cassava processing effluents on the microbial population and physiochemical properties of loamy soil in Nigeria.10thAnnual Conf. Nigeria Society for Microbiology: Keffi, 10-14th October, 2006.

[35] Nwaugo VO, Etok CA, Chima GN, Ogbonna, CE. Impact of cassava mill effluent (CME) on soil physiochemical and microbial community structure and functions. Nigerian Journal of Microbiology. 2008; 22(1):1681-1688.

[36] Oviasogie PO, Omoruyi E. Levels of heavy metals and physicochemical properties of soil in a foam manufacturing Industry. Journal of Chemical Society of Nigeria. 2007; 32 (1):102-106.

[37] Kim DS, Iida F. Nutritional composition of Cassava (Manihot esculenta) and its application to elder-friendly food based on enzyme treatment. International Journal of Food Properties. 2023; 26(1):1311–1323.

[38] Desse G, Taye M. Microbial loads and microflora of cassava (Manihot esculenta Crantz) and effects of cassava juice on some food borne pathogens. Journal of Food Technology in Africa. 2001; 61:21-24.

[39] Eze VC, Onyilide DM. Microbiological and physicochemical characteristics of soil receiving cassava effluent in Elele, Rivers State, Nigeria. Journal of Applied & Environmental Microbiology. 2015; 3:20-24.