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Effects of Cassava Effluents on the Soil Physicochemical Properties and Water Quality in Ibarapa Region, Oyo State, Southwestern, Nigeria

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Abstract

Purpose: This study investigated the effects of cassava effluents on the soil physicochemical properties and water quality in Ibarapa Region Southwestern, Nigeria.

Methodology: Three Cassava Processing Sites (CPSs) and Control Sites (CSs) of 5m by 5m quadrant and three wells of varying distances to the CPSs were randomly selected in each of the three local government areas in Ibarapa Region. In all, nine CPSs, nine CSs and nine wells (SPs) were sampled during the dry season. The soil and water samples collected were subjected to laboratory analysis for physicochemical and bacteriological characteristics. The spatial distribution of the CPSs was determined using GIS techniques and Nearest Neighbour Statistic.

Findings: The results showed that the CPSs distribution was significantly dispersed. However, that distance to the cassava processing sites impacted on the concentration of parameters tested. Analysis of the soil properties showed that the pH values were higher at the CPSs, elevated values of heavy metals were also noticed and cyanide concentration. Analysis of water quality in some of the sampled wells showed that the water samples were mainly within the WHO permissible standard except higher values recorded for heavy metals in SP 2 and elevated cyanide in SPs 1, 2, 3, 4 and 8 which were in close proximity to the processing sites. Bacteriological analysis also revealed that only SP 2 had the presence of Coliform Escherichia coli.

Unique Contribution to Theory, Practice and Policy: The findings alluded to the inherent danger in man's defective interaction with the environment. Hence, the study to a great extent could trigger appropriate measures in soil, water and waste management by stakeholders. Such measure could include treatment of cassava effluents before being dumped in to the environment as well as treating water before being consumed. Governments through her agencies such as the NAFDAC and sanitary inspectors should monitor the activities of these gari, fufu, lafun and tapioca makers especially about the discharge of cassava effluents.

Keywords: *Cassava Effluents, Water Quality, Soil Physicochemical Properties, Bacteriological Analysis, Ibarapa*

INTRODUCTION

Nigeria is one of the leading producers of Cassava in the world. The common types include *Manihot esculeuta, Cantz, Cassava manioc and mandioca or yucca*). This perennial woody shrub of the spurge family is often cultivated by the residents of Ibarapa Region, Oyo State, South West, Nigeria because of its edible starchy tuberous roots. Cassava is often processed into delicious delicacies such as Garri, Fufu, Lafun and Tapioca which are fermented commodities. Starch, sucrose, coating of tablets and ingredients of cough syrup are also derivable industrial products of Cassava.

Garri, Lafun and Fufu are the most common products that are processed from Cassava in the Ibarapa Region. This is done as part of subsistence farming. It is also produced at medium scale when it is sold at the rural periodic markets such as Maya and Towobowo. Now, it is sold to cassava millers at Iseyin, Sango-Otta, Ibadan and Lagos. At the large scale, it is exported out of the country. Cassava is the fourth largest staple food after rice, wheat and maize (Izah, Bassey & Ohimain 2018). As at 2018, Nigeria accounted for 20.3% of Cassava production globally, making her the largest producing nation. During processing of cassava flour (Garri), three main wastes are generated; Cassava Mill Effluents (CME), solid and gaseous emission. Olorunfemi, Einoefe & Okieimen (2008) said much waste from cassava mills are generated which are usually discharged on land or into water bodies indiscriminately and this in turn affects the biota (human, flora and fauna).

Cassava processing into Garri involves several unit operations, including peeling, washing, grating, pressing and drying. Traditional Garri, Lafun and Fufu production are associated with the discharge of effluents. These effluents could be seen as a pale yellowish disorganized liquid with a worldly but mild odour. These Cassava effluents could be damaging to the available water sources and the bio-physical environment especially, in the surrounding environment. This may lead to cyanogenic glycosides which may result in fatal cyanide poisoning. Hence, Cassava must be properly detoxified by soaking it in water and it must be dried. A position supported by Osakwe, (2012) effluents could be hydrocyanic acid, organic matter in the form of peels and sieves from the pulp as waste products. Continuous discharge of these wastes may accentuate the adverse effect of cassava waste on the environment and bio-diversities. In a similar vein, Ogboghodo, Osemewata, Eke & Iribhogbe (2001) reported some of the challenges posed by cassava effluents to include odour pollution, breathing and sleeping difficulty, coughing, stomach discomfort and loss of appetite, eye, nose and throat irritation, disturbance from external environment and annoyance.

Literature Review and Conceptual Framework

The literature is replete with relevant articles about cassava mill effluents, soil physicochemical properties and water quality especially in Nigeria. For instance, Sanni (2011) examined wet season pollution of water bodies proximate to Garri processing sites in Olokomeje and Iyalamu in Oyo and Odo-Aro in Ilora, Oyo State. Osakwe and Vincent (2012) analyzed selected heavy metals and physicochemical characteristics of the soils around some cassava processing mills in Abraka and environs. The results of the physicochemical analysis showed overall decrease in pH values and corresponding increase in the other parameters. Other scholars such as, Igbinosa and Igiehon (2015) studied the effects of cassava effluent on soil microbial and physicochemical properties using culture-dependent and standard analytical methods. Soil samples were collected from sites polluted with cassava effluent and from adjacent sites that were not impacted by the effluent pollution. The isolation and enumeration of microbial population was carried out using standard culture-based methods. Standard analytical methods were used to assay physicochemical properties.

Other scholars, Dantas, Rolim, Duarte, Silva, Pedrosa and Dantas (2014) evaluated the changes in chemical properties of dystrophic red-yellow latosol (oxisol) at different sampling times after re-use of cassava wastewater as an alternative to mineral fertilizer in the cultivation of sunflower, hybrid Helio 250. In another article, Ehilenboadiaye, Osamudiamen and Mujakperuo (2018) carried out Physicochemical analysis in water and soil samples obtained in and around cassava processing mill in the environment where cassava is being processed to determine areas prone to contamination by taking soil and water samples in the various study location at a depth of 1.2 m for soil samples and 10 m for water samples in a hand dug well. The result from the physicochemical analysis of the soil and water samples showed traces of heavy metals when compared with the standard set by World Health Organization. It is evident that in some sites investigated, the water and soil has been polluted by the discharge from the cassava effluent. The research thus pointed out the need for environmental education and proper management/location of cassava processing sites in the study area by relevant agencies. Izah, Bassey and Ohimain (2018) found out that Cassava Mills Effluents physicochemical quality often exceeds the limit for effluents discharge onto land and surface water as recommended by Federal Environmental Protection Agency (FEPA), Nigeria. CME alters the quality of soil and water with regard to physicochemical, heavy metal and microbial characteristics. Izah, Enaregha and Epidi (2019) evaluated the changes in in-situ water quality characteristics of cassava wastewater due to the activities of indigenous microorganism from a smallholder cassava processor in Ndemili, Delta state, Nigeria. The effluents were analyzed for in-situ characteristics.

Odoabuchi, Ejiogu, Nwanya and Azubuike (2020) assessed Effect of Cassava Effluent on Farmland Soil. Two soil samples were collected; one from a farmland polluted with cassava effluent and, another as an unpolluted sample. Results showed that unpolluted soil sample was normal, while the polluted soil sample showed elevated pH value 9.0 and other soil chemical properties. Enlightenment campaign, detoxifying cassava effluent in accordance with environmental safety standard, appropriate method(s) of environmentally friendly disposal of both solid and cassava wastewater are recommended for safe and healthy environment.

From the literature review, the extant studies such as Sanni (2011), Osakwe and Vincent (2012) and Ehilenboadiaye, Osamudiamen and Mujakperuo (2018) merely reviewed effects of Cassava Effluents on soil physicochemical properties and on quality of water in Nigeria. None of the studies considers the spatial distribution of Cassava Processing Sites (CPSs). This represents the knowledge gap the study intends to fill. , This study therefore mapped all CPSs in the study area and subjected these sites locations to appropriate geographical information system procedures and statistical techniques in order to determine the randomness of their distribution. This study also suggested probable solutions towards reducing the adverse effects of cassava mills effluents on both the water quality and soil physicochemical properties in Ibarapa Region.

Florence Nightingale's Environmental Theory and the Theory of Planned Behaviour

This study was anchored by Florence Nightingale's environmental theory. This theory was based on five main points: viz a viz clean water, clean air, basic sanitation, cleanliness and light. These points according to her are fundamental to a healthy living. This study was also primed by the theory of planned behaviour as developed by Icek Ajzen (1991); this theory is used to understand and predict behaviours. Ajzen posited that behaviors are immediately determined by behavioral intentions and under certain circumstances, perceived behavioral control. These two theories were relevant to this study, in the first instance, the quality of "clean water" were measured by the extent to which the available water for men and animals in Ibarapa Region, Oyo state southwestern Nigeria was free from bacteria and harmful organisms, extent to which water meet World Health Organisation (WHO's) standards and extent to which the water was generally free from cassava effluents, as well as the soil free from contamination. This would in essence ensure that water and soil available are clean and safe. Secondly, Ajzen (1991) postulated that conceited efforts should be made while interacting with the environment. Resident's actions and attitudes should be controlled; whatever is given to the environment is given back to us by the environment.

Statement of the Problem

Cassava processing into gari, fufu, lafun, starch and ethanol is one of the major activities embarked upon by residents of Ibarapa Region. The ecological characteristics of this region support cassava cultivation and hence the establishment of cassava processing mills in the three local governments in this region. Hence, part of this study is to investigate the randomness of the distribution of cassava processing mills. Cassava processing generates incomes, revenues, aids food production and generates raw materials. However, cassava processing could lead to environmental degradation, when cassava effluents were dumped indiscriminately into the environment or allowed to seep into water bodies. Cassava effluents contain harmful materials such as cyanides and heavy metals which could lead to proliferation of harmful bacteria and pathogens in our immediate environment. These organisms could affect the physico-chemical parameters of the soil, could alter the quality of underground and surface water, as well as capable of rendering them useless for man and animal consumption. To this end, this study therefore investigated the possible effects of cassava effluents on soil properties and water quality as well as suggesting possible solutions of tackling environmental issues associating with cassava processing effluents.

Objectives of the Study

This study examined the effects of Cassava effluents on the soil physicochemical properties and water quality in Ibarapa Region, Oyo State, South-western, Nigeria. In order to achieve this aim, the following objectives were pursued.

(i) To examine the spatial spread of Cassava Processing Sites (CPSs) in Ibarapa Region.
(ii) To examine the effect of Cassava effluents on soil physicochemical properties in Ibarapa Region.
(iii) To investigate the effect of Cassava effluents on the fresh water quality in the study area.
(iv) To suggest probable solutions towards reducing the effect of cassava effluents on both quality of water and soil physicochemical properties in Ibarapa Region.

METHODOLOGY

Geography of the Study Area

Ibarapa Region (Latitudes 70.15' N and 70.55' N and Longitudes 30E and 30.30' E) is approximately 100 km north of the coast of Lagos and about 65 km west of the Oyo state capital city of Ibadan. Ibarapa Region is approximately 2,496 km² in geographical size, representing 8.77% of Oyo State. The *Ibarapas* are a Yoruba people group located in the Southwestern Oyo State. Ibarapa Region comprises seven major towns and the adjoining settlements. These towns include Igangan, Eruwa, Ayete, Tapa, Idere, Igbo-Ora and Lanlate. Igangan, Tapa and Aiyete are in Ibarapa North Local Government Area; Idere and Igbo-Ora in Ibarapa Central, while Lanlate and Eruwa are located in Ibarapa East Local Government (See Figure 1).

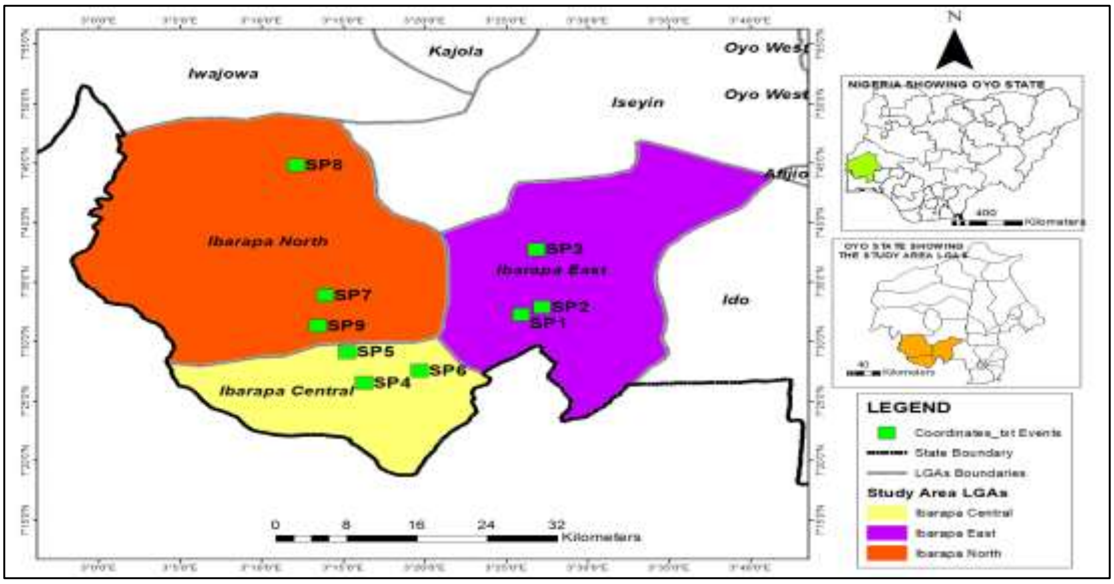

Figure 1: Map of the Area

The vegetation is rolling savannah with forests situated along the southern border and in isolated patches along river courses such as the Ogun. The natural vegetation was originally rainforest but has been transformed into derived type savanna as a result of slash & burn agricultural practices. Most of the land lies at elevations ranging between 120 and 200 meters above sea level, but rocky inselbergs and outcrops can be seen rising to 340 meters. These ecological features are suitable for cassava cultivation on varying scales. The important staple foods of the residents of the Ibarapa Region include Garri, Lafun, Fufu and Tapioca which are associated with cassava and are produced in this region. The location of each cassava processing centre represented the sources of cassava effluent being generated in the region. This as a matter of fact may not only threaten the survival of aquatic living organisms but also likely to alter the quality of surrounding fresh water as well as the physicochemical properties of the soil in the study area.

Sample and Sampling Technique

Spatial Spread of CPSs:

This involved the mapping of cassava effluents sites in order to determine the randomness or otherwise of the spatial distribution of CPSs. This involved the use of Geographical Information Systems procedures and Statistical techniques.

Soil Physiochemical Properties Testing:

in order to effectively evaluate the possible effects of cassava effluent on the soil physicochemical properties, soil samples were collected from where cassava has been processed otherwise called Cassava Processing Sites (CPSs) and from sites which had not been subjected to cassava processing otherwise called Control Sites (CSs). For the purpose of sampling, quadrants of 5m by 5m was delimited in nine cassava processing sites that were selected randomly in the three local government areas in Ibarapa region i.e. 3 sites each were sampled in each local government (Figure 1 & Table 1). 20 metres away from each CPS another plot (control site) of the same size was delimited. The size of the quadrant (5m by 5m) was chosen because of the disparity in the sizes of the cassava processing sites. At each site, soil was sampled at the depth of 0-10 cm at five randomly selected points. All sampled plots were ensured to fall in area with comparable topographical locations on a flat plain upper segment of the catena to ensure that catenary influences on the soil characteristics were minimal. The soil samples were collected with bucket auger and mixed very well in a tray, and dried, pass through a 2mm sieve and analysed for soil particle composition using the Hydrometer method (Bouyoucos, 1962), Total organic matter carbon was determined by using the chronic acid digestion method of Walkley & Black (1934). Soil pH was determined potentiometrically in distilled water using a soil to water ratio 1.1 base saturation (Gbadegesin & Olabode, 1999). Copper, Iron, Manganese and Zinc were extracted from the soil samples by two extraction methods, AAA_C-EDTA and DTPA. The concentration of Cu, Fe, Mn and Zn were determined with an atomic absorption spectrophotometer (Varian Techtron 1200), air acetylene flame and appropriate standards. P, NH^{4+}, NO^{3+} and NO^{3-} were estimated with the use of AAS (Perkin Elmer AA Analyst 800 series Graphite Furnace AA). Results of laboratory analyses were discussed in the appropriate section to determine the level of significant relationships between cassava effluent and soil physicochemical properties at the two sites.

Water Quality Testing:

As a result of the disparities in the distribution of wells (in term of distance) at the sampled CPSs. Wells were sampled according to their distances to the point of effluents discharge., Wells were therefore sampled from distances of between 5 and 20 metres away from the points of discharge of effluent at the cassava processing sites. In all, nine wells of varying distances to the cassava processing sites were sampled i.e three in each local government area (Table 5). Samples for this study were collected during the dry season i.e January/February 2023.

Table 1: Cassava Processing Sites (CPSs), Wells' Location and Identification Codes

S/N	Site Location	Identification Code
1.	Ibarapa East Local Government Area	SP 1, SP 2 & SP 3
2.	Ibarapa Central Local Government Area	SP 4, SP 5 & SP 6
3.	Ibarapa North Local Government Area	SP 7, SP 8 & SP 9

Source: Field Survey

Collections of water samples were done by using metal fetcher. The fetcher was sterilized with 70% (V/V) ethanol. The samples were collected from the wells and poured inside screw capped sterilized plastic bottles. Each sample was labelled accordingly. Water samples were transported to the laboratory in a cooler with ice for physicochemical characteristics and bacteriological analyses within 4 hours of collection. Physicochemical characteristics and analytical techniques adopted were shown in Table 2.

Table 2: Analytical Methods for Physicochemical Characteristics of Water Sampled

Parameters	Analytical Technique to be adopted
Appearance (Colour)	This is determined by using organoleptic (the sensory organ)
Temperature (0°C)	in-situ using mercury-in-glass thermometer
p^H	pH of water samples was determined electrometrically by using the pH meter.
Electrical Conductivity	A model Suntex SC-120 conductivity meter was used
i. Dissolve Oxygen (DO) (mg/L) **ii. Biochemical Oxygen Demand BOD (mg/L)** **iii. Total Dissolved Solid (TDS)**	These were measured in-situ using a multi parameters water quality monitor (Orion Model 1260)
i. Total hardness **ii. Nitrate (mg/L)** **iii. Sulphate (mg/L)** **iv. Phosphate (mg/L)**	Titrimetry method be adopted (APHA, 1985) Brucine method (APHA, 1979) Turbid metric method (APHA, 1985) Stannous chloride method (APHA, 1985)
i. Iron (mg/L) **ii. Calcium (mg/L)** **iii. Potassium (mg/L)**	Atomic adsorption spectrophotometer (Perkin-Elmer AAS3110)
i. Zinc (mg/L) **ii. Chromium (mg/L)** **iii. Copper (mg/L)** **iv. Lead (mg/L)**	Atomic adsorption spectrophotometer (Perkin-Elmer AAS3110)

Bacteriological Analysis: Total coli form count and differential Escherichia coli count were determined using multiple tube fermentation method (most potable number) for enumeration. This involved the use of Laury Tryptose Broth (LTB) along with fermentation tubes (Durham tubes). The results of the analysis were compared with the World Health Organisation (WHO) 1993, 2006 and 2010 guidelines for drinking water standards.

RESULTS AND DISCUSSION

Spatial Distribution of Cassava Processing Sites

Nearest Neighbour Ratio:	1.370465	
z-score:	2.126175	
p-value:	0.033489	

Average Nearest Neighbour Summary

Observed Mean Distance:	6784.8647 Meters
Expected Mean Distance:	4950.7767 Meters
Nearest Neighbor Ratio:	1.370465
z-score:	2.126175
p-value:	0.033489

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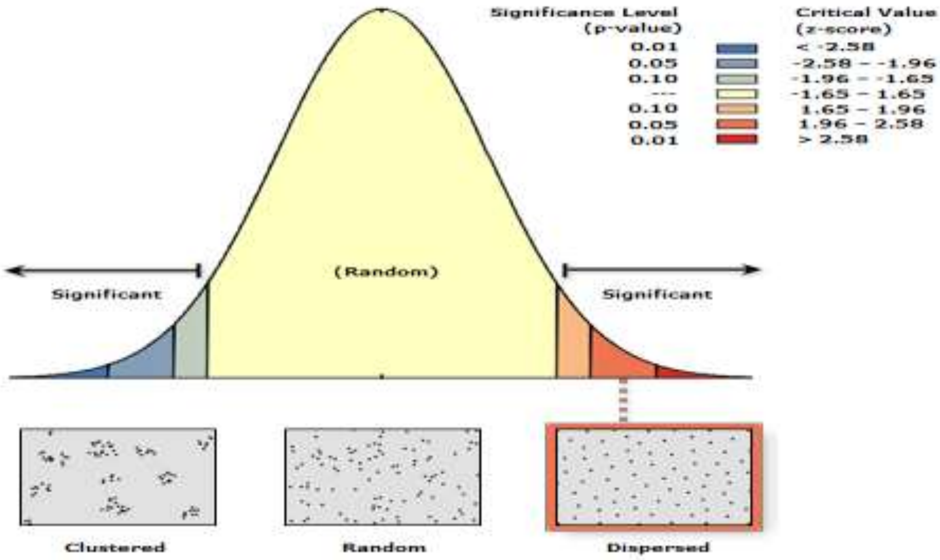

Figure 2: Spatial Distribution of the Cassava Processing Sites: Nearest Neighbor Statistics

Attempt was made to determine the spatial distribution of the CPSs in the study area by testing their randomness. This was done by using the GIS technique and the nearest neighbor statistics. The result (Figure 2) showed that the spatial distribution of the sample locations was significantly dispersed ($z=2.126175$; $p<0.05$). This showed that the distribution pattern was neither clustered at a place nor random. The analysis thus showed that there is less than 5% likelihood that this dispersed pattern could be the result of random chance.

Effects of Cassava Effluents on the Soil Physicochemical Properties

Table 3: Physicochemical Characteristics of Soil Samples in the Cassava Processing Sites (CPSs)

S/N	Parameters	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9
1	p^H	5.8	5.3	5.6	4.8	4.9	5.2	5.6	5.5	5.4
2	Silt (%)	1	2	0	2	1	2	0	0	2
3	Clay (%)	8	9	7	7	8	7	9	8	8
4	Sand (%)	89	71	78	85	81	77	65	76	72
5	Temperature (^{0}C)	29	27	30	28.5	28.6	30	29.5	26.9	30
6	Total Organic Carbon (%)	2.80	2.75	2.95	2.65	3.00	2.65	2.05	2.65	3.26
7	Nitrate (mg/kg)	6.25	6.85	4.75	5.25	5.85	4.00	4.75	4.35	5.75
8	Sulphate (mg/kg)	8.65	5.00	6.05	5.25	7.00	5.05	6.50	5.15	8.25
9	Phosphate (mg/kg)	4.85	6.65	5.25	4.85	6.50	4.95	5.00	4.85	6.35
10	Iron (mg/kg)	10.35	8.55	9.25	6.50	5.25	7.50	5.25	6.20	4.00
11	Copper (mg/kg)	3.15	2.70	2.50	2.45	2.55	2.60	1.85	2.17	2.35
12	Manganese (mg/kg)	2.20	1.75	0.35	1.55	0.28	2.05	0.30	1.45	1.02
13	Zinc (mg/kg)	2.09	1.95	1.50	1.76	1.45	1.55	1.85	1.60	1.47
14	Chromium (mg/kg)	0.02	0.01	0.01	0.02	0.00	0.01	0.00	0.01	0.01
15	Cyanide (mg/kg)	20.20	22.15	18.15	20.10	19.00	21.05	19.00	20.99	17.20

Table 4: Physicochemical Characteristics of Soil Samples in the Control Sites (CSs)

S/N	Parameters	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9
1	pH	6.0	6.3	6.1	5.9	5.8	6.0	6.1	6.0	6.2
2	Silt (%)	2	3	2	2	2	4	2	2	3
3	Clay (%)	7	8	6	6	7	7	7	6	6
4	Sand (%)	80	70	75	76	78	75	64	78	70
5	Temperature (^{0}C)	28	28	29	29	27.9	29.4	28.5	28	29
6	Total Organic Carbon (%)	1.81	2.50	2.00	2.35	2.05	2.45	2.20	1.90	1.50
7	Nitrate (mg/kg)	5.20	5.75	4.00	5.05	4.95	3.75	3.95	4.00	4.75
8	Sulphate (mg/kg)	7.95	6.05	5.25	4.85	6.05	5.00	5.95	4.85	7.95
9	Phosphate (mg/kg)	4.25	6.55	5.05	5.05	6.35	4.85	4.50	4.75	5.85
10	Iron (mg/kg)	9.90	9.15	8.95	6.35	4.95	6.95	5.05	6.00	3.75
11	Copper (mg/kg)	2.75	2.05	1.95	2.25	2.05	2.15	1.75	1.95	2.05
12	Manganese (mg/kg)	2.05	1.25	0.20	1.25	0.18	1.95	0.25	1.25	0.95
13	Zinc (mg/kg)	1.95	1.75	1.35	1.45	1.25	1.35	1.65	1.50	1.32
14	Chromium (mg/kg)	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
15	Cyanide (mg/kg)	9.00	10.50	7.50	9.50	7.50	9.00	9.75	8.05	5.00

Analysis of the results showed that the soils in in both the CPSs and the CSs were predominantly sandy in nature and texturally similar. The distribution of sand fraction was the highest followed by clay and silt. The soil can be described as sandy- loamy. The implication of this finding was that the soils at both sites are products of the same parent materials. Ogundele, Oladapo & Aweto (2012) reported the same particle composition in the study area.

The pH values range from 4.8 to 6.3 at both sites. Hence, the soils are generally acidic. These p^{H} values are similar to those reported by Osakwe, (2012) and Orji & Ayogu (2018) but lower than those reported by Odoabuchi, Ejiogun, Nwanya & Azuibuke (2020). The study also showed that the pH values at the cassava processing sites are lower (more acidic) compared to the control sites. Orji & Ayogu (2018) explained that such condition was mostly due to the presence of cyanogenic glycosides in the cassava effluent contaminated soils. Fuller (2004) posited that low pH high negative soil charges and low clay contents as reported in the sampled soil increase cyanide mobility. This can pose serious problem to agricultural activities because p^{H} determines the availability of nutrients and the potency of toxic substances as well as the physical properties of the soil.

The temperature values range between 26. 9 ^{0}c and 30 ^{0}c at both sites but the highest values of 30 ^{0}c were recorded at the CPSs SP 3, SP 6 and SP 9. Apart from the impact of cassava effluents on these values the samples were collected during the dry season when there is increase in sun intensity and this therefore results in temperature increase.

The organic carbon content ranges between 2.05% and 3.26 % in the CPSs and between 1.50% and 2.50% at the CSs. The organic carbon content was higher in all the processing sites soils except in SP 7. The higher values have been attributed to high organic matter in the cassava effluents (Igbinosa & Igiehon, 2015). Similarly, Osakwe (2012) also suggested that the elevated organic carbon suggestive of increased microbial activity on the residues contained in the effluents.

The value of Nitrate, Sulphate and Phosphate are generally higher at the CPSs compared to the CSs except in SP 2 where the recorded value for Sulphate was lower and at the SP 4 where the value for Phosphate was also lower. The findings are similar to the one reported by Orji & Ayogu (2018) as well as Uzochuckwu, Oyede, & Ajanda (2001). While elevated Nitrate and Sulphate are said to be associated with microbial activities (Chinyere, Akubugwo & Ugbogu,

2013) Phosphate elevation at the CPSs are said to be as a result of breakdown phosphorus stored in the cassava tubers during processing.

There was high occurrence of heavy metals (Iron, Copper, Manganese, Zinc and Chromium) at the CPSs compared to the control sites. However, a lower value (8.55mg/kg) of iron was recorded at the CPS SP2 compared to the corresponding CS with a value of 9.15 mg/kg. Similarly, the same level of chromium was obtained at the SP5 and SP7 of both CPSs and the CS. Heavy concentration of metals at CPSs were also observed by Osakwe (2012), Odoabuchi, Ejiogu, Nwanya & Azuibuike (2010) and Orji & Ayogu (2018).

Apart from the fact that the soils receiving the cassava effluents may have some levels of initial heavy metals enrichments. It has also been established by Adriano (2001) and Osakwe (2010) that a high concentration of heavy metals like zinc, copper and manganese in CPSs could also be attributed to the wearing off or abrasion of the milling machine parts and emission of the metal through the exhaust of the machines. It was observed during this study that all the sampled CPSs were using machines for peeling, crushing, cutting and drying of cassava tubers into various forms of cassava products. Thoughthe samples were collected during the dry season when leaching of materials into the sub-soil is minimal, the sandy nature of the soil in the study area allows percolation of cassava effluent (waste-water) containing metals and other components into the soil.

Elevated values of cyanide are recorded at the CPSs compared to the control sites. The values range between 17.20mg/kg and 22.15 mg/kg at the CPSs while a range of 5.00mg/kg to 10.50mg/kg occurred at the CSs (Table 4). Studies have shown that cassava processing effluents are the major source of high concentration of cyanide in the environment (Knowles, 1988; Osakwe, 2012; Igbinosa & Igiehon, 2015). Cyanide is extremely toxic to human beings and other animals if injected in raw form or semi processed forms therefore there is the need to process cassava very well before consumption.

Effects of Cassava Effluents on the Water Quality

Table 5: Physicochemical and Bacteriological Analysis of Water Samples in the Cassava Processing Sites (CPSs)

S/N	Parameters	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9	WHO Standard (1993, 2006 & 2010)
	Distance of well to CPSs (m)	5	5	10	5	10	15	15	8	20	
1	Appearance (colours)	Clear	Muddy	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
2	Temperature (^{0}C)	26.05	29.02	25.02	26.06	23.05	21.10	22.10	27.00	23.00	>40
3	pH	4.8	4.5	6.0	4.4	6.0	6.5	6.6	5.0	7.00	6.5-8.5
4	Electrical Conductivity	108	480	88	185	85	65	75	100	55	1000
5	Dissolve Oxygen (DO) (mg/L)	2.75	4.76	2.50	2.81	2.56	3.50	3.55	2.76	3.35	5
6	Biochemical Oxygen Demand (BOD) (mg/L)	6.50	8.00	5.41	4.05	4.03	3.05	3.15	5.17	3.00	10
7	Total Dissolved Solid (TDS) (mg/L)	200	485	150	180	165	105	108	165	102	500
8	Total hardness (mg/L)	100	305	95	106	89	75	68	107	72	500
9	Nitrate (mg/L)	7.90	12.00	6.78	7.20	6.50	5.68	5.75	6.20	4.55	10
10	Sulphate (mg/L)	230.45	250.65	200.00	225.05	195.00	182.05	180.05	165.80	150.00	500
11	Phosphate (mg/L)	3.50	4.95	3.25	3.75	3.20	2.90	2.85	3.45	2.55	5
12	Calcium (mg/L)	70.02	75.50	63.02	65.00	63.09	61.90	62.05	64.5.	60.50	200
13	Potassium (mg/L)	28.75	39.25	25.15	26.50	22.75	25.26	23.00	26.25	21.75	42.45
14	Iron (mg/L)	0.33	0.55	0.25	0.40	0.24	0.19	0.20	0.32	0.15	1.0
15	Zinc (mg/L)	0.35	0.55	0.30	0.40	0.35	0.18	0.25	0.33	0.15	1.0
16	Chromium (mg/L)	0.36	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.1
17	Copper (mg/L)	0.40	0.53	0.24	0.35	0.30	0.17	0.25	0.36	0.12	1.0
18	Lead (mg/L)	0.02	0.04	0.01	0.02	0.01	0.01	0.02	0.01	0.00	0.10
19	Cyanide (mg/L	2.75	3.00	0.20	2.50	0.05	0.06	0.05	1.50	0.00	0.1
						BACTERIOLOGICAL ANALYSIS					
1.	Total coliform count	00	02	00	00	00	00	00	00	00	0cfu/100ml
2.	Differential Escherichia coli	00	02	00	00	00	00	00	00	00	0cfu/100ml

Table 5 depicted the physicochemical and bacteriological properties of the water samples collected from wells with varying distances to CPSs.

The appearances of all the samples were cleared except the sample from well SP2 which was muddy. WHO (2010) posited that water that is fit for drinking must be clear (colourless) in nature in addition to other parameters such as odourless and tasteless.

The temperatures of the sampled wells ranged between 21.10 ^{0}C and 29.02 ^{0}c. The temperature values fall within the WHO permissible values of less than 40 ^{0}c. The pH values range between 4.4 and 7.00. All samples were acidic except the sample from SP 9 which was the farthest to the point of effluents discharge. It was observed that all the samples from wells that are closer to the points of cassava processing sites appeared more acidic compared to the samples from the farthest wells to the point of processing. However, three of the samples, SP 6, SP 7 and SP 9 fell within the WHO (2010) permissible limit for drinking water. Similarly, these samples were 15, 15 and 20 metres farthest away respectively from the cassava processing points. This result was similar to that of Akpan, Eyong & Isong (2017). The current study like the previous (Akpan, Eyong & Isong, 2017) showed that the nearer the sampling point to the point of discharge the more acidic the soil sampled. The implication of this is that cassava effluents increase the acidic nature of the water.

Electrical conductivity (EC) measures the activity of all dissolved ionized solids in the water. The EC values showed the water samples range between 55 uScm^{-1} and 480 uScm^{-1} Though, the values fall within the WHO limit (1000uScm^{-1}) an elevated value was recorded at the SP 2 (480 uScm^{-1}). Generally, the samples depicted low conductivity and low mineralization. According to Ogundele (2014) the Dissolved Oxygen (DO) content of water is mainly determined by the sources, raw water temperature, treatment and chemical or biological processes taking place in the distribution system. The DO of the water samples ranges between 2.50mg/L at the SP 3 and 4.76 mg/L at the SP 2. The values fall within the WHO permissible limit of 5mg/L and showed a negligible organic and thermal pollution.

The Biochemical Oxygen Demand (BOD) of the water samples showed values that range from 3.00mg/L at the SP 9 and 8.00mg/L at the SP 2. Notwithstanding the elevated value at the SP 2 the values fall within permissible limit. Similarly, the values for the Total Dissolved Solid (TDS) which range between 102mg/L and 485 mg/L fall within the WHO permissible limit. TDS in water has been attributed to the release of contaminants which are mainly Carbonates, Bicarbonate, Chlorides, Phosphate and Nitrates of Calcium, Magnesium, Sodium, Pottasium, Manganese, Organic matter, Salt and other particles (Mahanandda, Mohanty and Behera, 2010) from natural causes, industrial waste water, urban run-off, sewage as well as chemical utilized in water treatment process (EPA, 2002). Ashraf, Maah & Yusoff (2010) reported that excessive TDS level results in massive discoloration of water pipes, heaters and household utensils

The Total Hardness (TH) values range between 68 mg/L at the SP 7 and 305 mg/L at the SP 2. The values of the water samples showed that they fall within the classes of soft water (0-75 mg/L); moderately hard water (75-150 mg/L) and hard water (>300mg/L) (Sawyer and McCarthy, 1967). However, the values are within the permissible limit for save water.

Nitrate which minimum value of 4.55 mg/L was recorded at the SP 9 and maximum value of 12.00 mg/L was recorded at SP 2 falls within the permissible limit except at the SP 2. The implication of this was that the water at SP 2 had high Nitrate content. According to Kumar, Rammohan, Sahayan & Jeevanandam (2009) Nitrates are common chemicals pollutants of water and its high concentration in water results in blue babies disease in children, gastric carcinoma, abnormal pains, diabetes and birth defection in central nervous system.

Sulphate has the lowest value of 150 mg/L at the SP 9 and the highest value of 250 mg/L at the SP 2. The values are generally low compared to the WHO standard of 500mg/L. However, Onifade, Adeniran & Ojo (2015) averred that an elevated value of Sulphate above 250mg/L may alter water taste. Hence, water from SP 2 may be susceptible to unpleasant taste. Although, the Phosphate values in all the samples are within the permissible level it was noted that they all have values above 50% of the WHO permissible value of 5mg/L. The maximum value of 4.95 mg/L was recorded at the SP 2 and the minimum value of 2.55mg/L was recorded at the SP 9.

The concentrations of Calcium and Potassium were low and moderate respectively in the water samples. The minimum value of 61.90 mg/L for Calcium was recorded at SP 6 and the maximum value recorded at the SP 2 while the minimum value of 21.75 mg/ L for Potassium was recorded at SP 9 and the maximum value of 39.25 mg/L was recorded at the SP 2. However, the concentrations of the two parameters are within the WHO permissible limit of 200mg/L and 42.45 mg/L respectively.

The heavy metals investigated in this study included Iron, Zinc, Chromium, Copper and Lead. The values for each metal range from 0.15-0.55mg/L,0.15-0.55mg/L,0.00-0.50mg/L,0.12-0.53mg/L and 0.00-0.05 respectively. The analysis showed that there was elevated level of all metals in the water sampled from well SP 2 compared to the WHO permissible limit. Probably due to its distance to the point of effluent discharge and other factors which include the nature of the well for instance the depth, whether it was covered, cased with concrete rings and its elevation above the ground. Higher concentration of heavy metals can lead to toxicity within the elements of the environment especially soil and water (Ehilenboadiaye, Osamudiamen & Mujakperuo, 2018).

The concentration of Cyanide in the water samples was higher in five of the sampled well i.e in SP 1 (2.75mg/L), SP 2 (3.00mg/L), SP 3 (0.20mg/L), SP 4 (2.50mg/L) and SP 8 (1.50mg/L).It was noted that all these wells with elevated Cyanide are in close proximity (within the distance of 5 to 10 meters) to the points of discharge of the cassava effluent. Similar observation was recorded by Oyewusi, Osunbitan, & Taiwo, (2021). It was only SP 9 that was without element of Cyanide this may be probably due to it far distance (20 meters) to the point of discharge of effluents and the season when the samples were taken in dry season when there was minimal see-page and leaching. SPs 5, 6 and 7 have their Cyanide levels within the WHO permissible limit.

The bacteriological analysis of the water samples showed that the water from all the sampled wells except SP 2 was free from bacterial contamination. The 02cfu/100ml of total coliform and differential Escherichia coli in the SP 2 was greater than the 0cfu/100ml WHO permissible limit. The implication of this finding is that water in the SP 2 has been contaminated by the bacterial and was injurious to health if consumed.

Conclusion

This study revealed that the cassava processing centres in the study area are dispersed and not clustered to a particular local government in the Ibarapa region. This showed that the main raw material (cassava) needed at the centres is readily available in every part of Ibarapa region which is noted for its agricultural activities. The study also revealed that distance played an important role in the distribution, concentration and utilization of matters in the environment, especially the soil and sources of water as evidenced in the elevation of values recorded for nearly all the soil parameters tested at the Cassava Processing Sites (CPSs). This was also revealed in the results recorded in water samples from wells in close proximity to the cassava processing sites especially at the SP 2 which is one of the wells with least distance to the point of discharge of effluent. However, future study of this nature in the study area should take into consideration the nature of wells to be sampled. Properties of the wells to be considered should include depth of the well, whether covered or otherwise, whether lined with concrete or not among other properties.

Generally, the result revealed that cassava processing and discharging of its effluents into the environment affect soil properties and water quality by raising the levels of some harmful materials such as heavy metals and cyanide.. Based on this finding, there is the need for cassava processing effluents to be treated before being discharged into the environment and that water sources within cassava processing area are treated before consumption. Finally, governments through her agencies such as the Nigeria Agency for Food and Drug Administration and Control (NAFDAC), Ministries of Health and sanitary inspectors should monitor the activities of these gari, fufu, lafun and tapioca makers especially about the discharge of cassava effluents.

Credit Authorship Contribution Statement

All authors declared no vested interest.

OOS: Conceptualization, data collection, re drafted the proposal, review & editing.

OAT: Conceptualization, methodology, data collection, wrote of the final draft.

OMO: Conceptualization and Data collection.

OOA: Data collection and draft the proposal.

ARA: Data collection, conceptualization, drafted the initial proposal.

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