



## Effect of Cassava Processing Mill Effluent on Physical and Chemical Properties of soils in Abraka and Environs, Delta State, Nigeria

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### Abstract

*Selected heavy metals and physicochemical characteristics of the soils around some cassava processing mills in Abraka and its environs in Delta State, Nigeria, were analysed in order to assess the impact of the cassava mill effluent on the soils. The results of the physicochemical analysis showed overall decrease in pH values and corresponding increase in the other parameters. The pH values indicated that the soils were acidic which suggests that the effluents imparted acidic property on the soils. The elevated levels of Total Organic Carbon and Total Nitrogen are suggestive of increased organic matter and microbial activities in the effluent residues. Electrical conductivity values indicate presence of dissolved inorganic salts while the phosphorus values confirm the rich source of phosphorus in cassava tuber. The result of heavy metal analysis shows elevated levels of heavy metals in the soil receiving cassava mill effluent. The relative potential index and enrichment coefficient values of the metals in the soils coupled with the observed physicochemical characteristics revealed that there are some levels of heavy metal enrichment, contamination and bioavailability in the soils studied.*

**Key words:** Physicochemical characteristics, heavy metals, soil pollution, cassava mill effluent, Abraka.

### Introduction

Increasing level of heavy metals in the environment from various anthropogenic sources has become a source of concern for environmentalists<sup>1</sup>. As a result there is a need for increasing awareness of the emergency created by environmental pollution caused by human activities. Unlike the toxic organics that in many cases can be degraded, the metals that are released into the environment tend to persist indefinitely, accumulating in living tissues through food chain<sup>2</sup>. Evidence of the potential and observed human hazard due to environmentally acquired heavy metals and their ecological impact has been extensively studied<sup>3,4</sup>.

In Nigeria and in most tropical countries, processed cassava tuber has been the staple food and with the present increase in production, it is gradually transforming from a famine reserve commodity and rural staple food to cash crop for urban consumption and to an export commodity for international market<sup>5</sup>. In this part of the country, cassava tuber is processed and made ready for consumption mainly either as garri, starch, or as dried or wet cassava flour. In each of these, the major processing stage is the milling stage and this leads to the location of cassava milling machines all over the environment. The residues obtained during this process include the solid and the liquid wastes.

Although several studies have been conducted or carried out on the biochemical change associated with the fermentation of cassava marsh and liquid effluent, there are a few and scanty reports on the effect of the disposal or discharge of these mill

effluent or processing waste on land especially in soil physical and chemical properties. This study aims at investigating the effect of cassava mill effluent on soils with respect to heavy metal levels and physicochemical characteristics.

### Material and Methods

**Study Area:** Abraka, a University town, located in Ethiope East Local Government Area of Delta State, Nigeria, lies approximately on latitude 5° 48'N and longitude 6° 06' E. Its main relief feature is lowland type of landscape grouped under the coastal lowland of Western Nigeria within the tropical rainforest region. The parent topography consists, of rolling lowland plain generally above 45m sea level. The soil type is made up of ferrosol precisely the red and brown soil with abundant free iron oxide. The topography and location factors and prevalence of the tropical rainy climate that is warm, humid and moist in most part of the year, encourages their major occupation which is farming.

**Sampling:** Soil samples containing cassava mill effluent were collected from five selected locations in Abraka and environs. Soil samples free of cassava mill effluent were also collected from two different locations to serve as control samples.

In each of the sampling sites, soil samples were taken using soil auger. These auger borings were bulked and representative samples were taken. Composite soil samples collected at each site included 0-15 cm for top soil, 15-30 cm for subsoil and 30-45 cm for bottom soil, and horizontally 10m, 20m, 30m and 40m away also at the same depth.

**Sample Preparation and Analysis:** The soil samples were air-dried for a period of one week in a clean well-ventilated laboratory, homogenized by grinding, passed through a 2mm (10 mesh) stainless sieve, and stored in labelled plastic cans until analysis. The samples for metal analysis were digested using a mixture of 2cm<sup>3</sup> of 60% perchloric acid, 15cm<sup>3</sup> of concentrated nitric acid and 1cm<sup>3</sup> of concentrated sulphuric acid. The digested samples were analysed for the metals using Atomic Absorption Spectrophotometer (PerkinElmer Model a Analyst 2002) fitted with deuterium lamp for background correction. Physicochemical characteristics of the soil samples

such as soil pH, Total Organic Carbon, Cation Exchange Capacity, Particle Size, Available Phosphorus, Total Nitrogen and Electrical Conductivities were determined using approved standard methods respectively, in each case<sup>6-12</sup>. All reagents used in this study were of pure analytical grade, and were checked for possible trace metal contamination. All glassware were previously soaked in 14% nitric acid for 24 hours to remove entrained metals, washed with detergents and rinsed with deionized water. Quality control was assured by the use of duplicates, standard reference materials and procedural blanks.

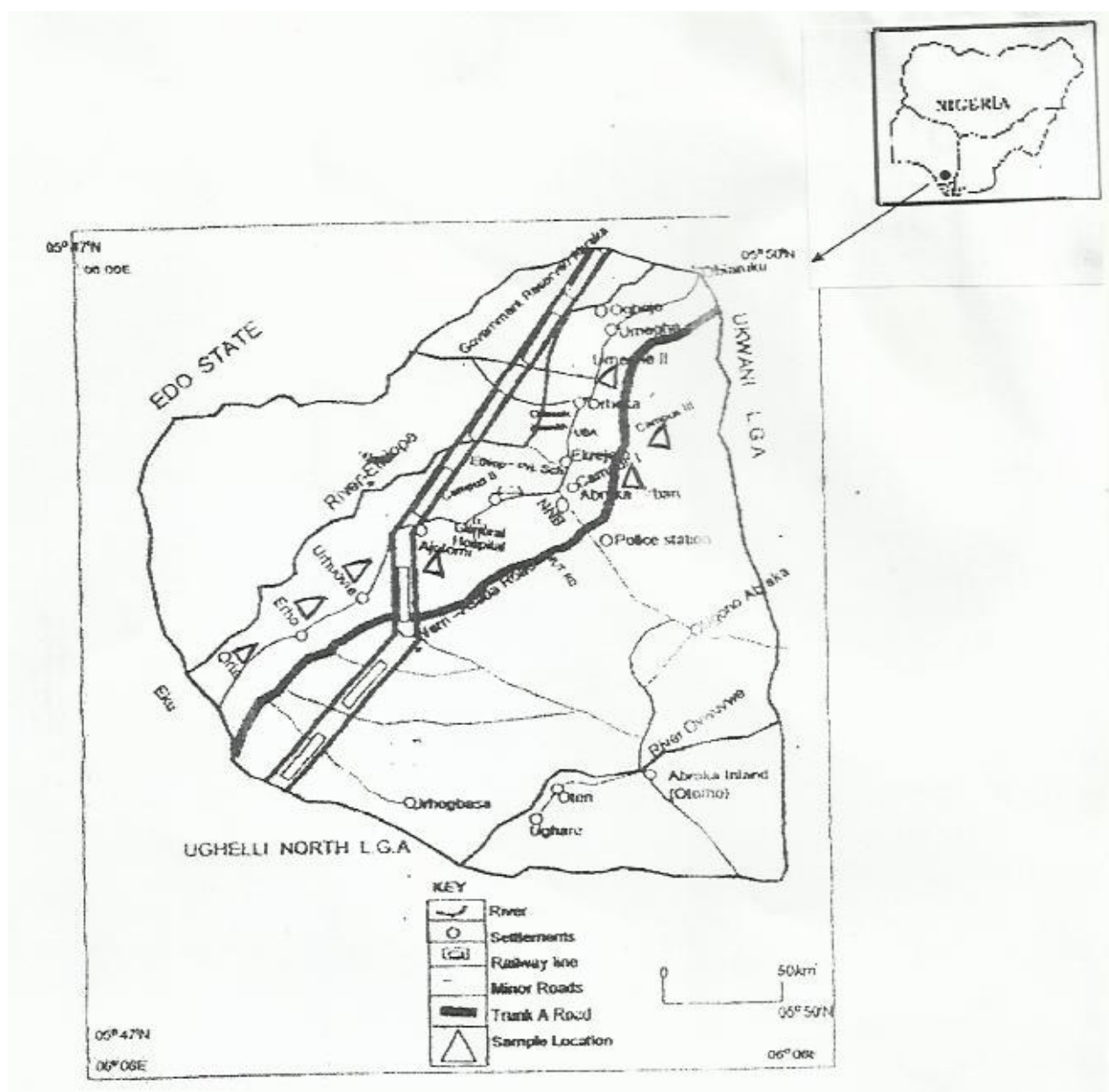


Figure -1  
Map of Abraka showing sampling locations

## Results and Discussion

The results of the physicochemical properties of the soil receiving effluent are shown on table - 1.

The pH of the soils ranged from 3.89 to 5.74 indicating that the soils were acidic. This suggests that the effluent imparted acidic properties to the soil. The acidity could be attributed to the presence of hydrogen cyanide in the cassava mill effluent. The acidity decreased with depth in all the sites. The pH values recorded in this study are in the same range with those reported in some related studies<sup>13,14</sup>. The values are however lower than those reported by some other researchers<sup>15,16</sup>. The soil pH determines the availability of nutrients and the potency of toxic substances as well as the physical properties of the soil. The pH values of these study sites indicate a generally high tendency for high availability of the metals; hence, this increases the risk of heavy metals plant uptake. Previous studies have shown decreased metal availability with increasing pH<sup>17</sup>, the total organic carbon ranged from 0.02 to 3.35%. The values may be due to the discharge of the waste with some contents of organic matter and also suggests presence of degradable and compostable substances in the effluent. It is also suggestive of increased microbial activity on the residues contained in the effluent. The total organic carbon values recorded in this study are similar to the values reported in a similar study<sup>18</sup>, but comparatively lower than the values reported elsewhere in another related study<sup>19</sup>. Total Organic Carbon is a measure of organic content in soils, sediments and water, and contributes significantly; to acidity through contributions from organic acids and biological activities<sup>20</sup>. Anthropogenic and natural processes have been observed to result in elevated concentrations of organic carbon in soil and sediments<sup>21</sup>. The total nitrogen ranged from 0.08 to 0.10%. These values are in the same range with the values reported in another related study<sup>22</sup>. The total nitrogen recorded was probably due to nitrogen mineralization as a result of organic matter. Nitrogen is one of the elements needed by plant for healthy growth. The electrical conductivity values ranged from 136 to 958  $\mu\text{S}/\text{cm}$ . Similar values have been reported<sup>23,24</sup>. 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. The implication of high electrical conductivity in soils is that there is reasonable or significant presence of anions. For soil particle size, the distribution of sand fraction was highest followed by clay and then silt. The high values of phosphorus in the soils are not surprising since cassava tuber is a rich source of phosphorus<sup>25</sup>. The soil cation exchange values ranged from 0.49 to 1.63  $\text{Cmolkg}^{-1}$ . Cation exchange capacity is directly related to soil capacity of adsorbing heavy metals.

The vertical distribution of the heavy metals is presented on table - 2.

The results of vertical distribution of the heavy metals showed that the heavy metal concentrations were generally higher at the

top soil than the sub and bottom soils. This higher level of metals on the top or surface soil is expected since the top soil is the point of contact. The heavy metal levels for all the sites were significantly higher than the levels observed in the control sites. This implies that the soils receiving cassava mill effluent have some levels of heavy metal enrichments. Iron had the highest concentration in all the sites. It has been confirmed that natural soils contain significant concentration of iron<sup>26</sup>. It has been suggested that the pollution of the environment by iron can not be conclusively linked to waste materials alone but to other natural sources as well<sup>27</sup>. However one can infer that since the levels of iron at the impacted point is higher than the levels in control sites and also at points away from the impacted point, the cassava mill effluent might have contributed to the increased levels of iron in the soils studied.

The generally elevated levels of the heavy metals at the point of impact which decreased gradually away from the impacted point indicate that the cassava mill effluent is a source of some of the heavy metals. The heavy metals are in the abundance ratio of  $\text{Fe} > \text{Mn} > \text{Zn} > \text{Cu} > \text{Cd} > \text{Cr}$ . Fe is the most naturally occurring metal in the soil, so its abundance in the soils studied could be mainly of lithological or crustal origin. Although manganese in the form of oxide is a component of subsoil material<sup>28</sup>, the abundance of manganese in the cassava mill effluent could also be attributed to wears and tears of the machinery part. Presence of zinc could be attributed to corrosion of metal parts of the milling machine. Zinc is also a component of crude oil and machine exhaust<sup>29</sup>. Copper is a component of bronze and brass and is used as a corrosive resistant and decorating painting in machine. Cadmium is a "modern metal" having been used increasingly in corrosion prevention<sup>30</sup>. It is often used instead of zinc for galvanizing iron and steel. Chromium is a component in the manufacture of steel stainless alloys, metal plating for prevention of corrosion. Large amount of copper was used in motors and generators. Studies of heavy metals in various Nigerian crude oil have shown them to contain relatively high concentrations of Fe, Cu, Zn, Pb and Hg<sup>31,32</sup>. Therefore the presence of Fe, Cu, and Zn in the soils studied could also be attributed to the wearing of or abrasion of the cassava milling machine parts and emission of these metals through the exhaust of the machine<sup>33,34</sup>. The lateral distribution of the metals in the soil is presented on table - 3.

The relative pollution potential of a pollutant with respect to the level of chemical interaction between the pollutant and the recipient was computed using the following scheme<sup>35</sup>.

$$Y = \frac{[A] - [B]}{[A]}$$

Where Y = Relative pollution potential index: [A] = Metal concentration at impacted point. [B] = Average metal concentrations at points away from impacted point. The relative potential values of the metals are presented on table - 4.

**Table -1**  
**Physicochemical Properties of the Soil Associated with Cassava Processing Mill Effluent**

Sample	Depth (cm)	pH	E/C (µS/cm)	TOC% (TOC)	TN %	P mgkg <sup>-1</sup>	(CEC) Cmolkg <sup>-1</sup>	Particle size			Texture
								Sand	Silt	Clay	
Site A	0-5	4.00	200.4	1.17	0.09	71.10	0.49	85	0	15	Sandy loam
	15-30	4.02	360.2	0.55	0.12	76.20	0.94	79	0	21	Sandy clay loam
	30-45	4.51	151.8	0.94	0.08	69.80	0.72	71	1	28	Sandy clay loam
Site B	0-15	4.71	425.0	0.35	0.10	88.20	0.66	92	1	7	Sandy
	15-30	4.90	265.5	0.12	0.10	86.52	0.82	78	2	20	Sandy loam
	30-45	5.74	202.4	0.70	0.11	71.64	0.81	72	13	15	Sandy loam
Site C	0-15	4.12	168.3	3.35	0.12	90.75	0.84	85	0	15	Sandy loam
	15-30	4.30	172.8	0.55	0.09	86.60	0.80	81	1	18	Sandy loam
	30-45	4.83	404.0	1.56	0.08	87.50	0.93	73	10	17	Sandy loam
Site D	0-15	3.89	136.2	0.66	0.10	55.50	1.63	78	2	20	Sandy loam
	15-30	4.43	496.0	0.90	0.09	55.70	1.00	69	1	30	Sandy clay loam
	30-45	4.47	427.0	0.98	0.11	53.60	0.98	81	1	18	Sandy loam
Site E	0-15	4.60	958.0	0.02	0.08	46.75	1.23	72	2	26	sandy clay loam
	15-30	4.92	517.0	1.09	0.11	43.82	0.95	76	1	23	sandy clay loam
	30-45	5.41	201.2	0.86	0.09	45.72	0.91	72	2	26	sandy clay loam
Control	0-15	6.96	44.2	0.70	0.11	68.30	0.84	78	2	20	Sandy loam
	15-30	7.40	75.70	0.47	0.11	70.20	0.85	65	4	31	Sandy clay loam
	30-45	7.81	37.03	0.78	0.10	69.20	0.83	76	2	22	Sandy clay loam

**Sapling Locations:** Site A = urhuovie, Site D = Oria, Site B = Urhuoka, Site E = Abraka Main town, Site C = Erho, Control = Urhuoka and Urhuovie Bushes

**Table -2**  
**Vertical Distribution of heavy metals (mgkg<sup>-1</sup>) in the soil profile**

Sample	Depth (cm)	Fe	Cd	Cu	Mn	Cr	Zn
Site A	0-15	137.628	0.001	0.663	2.795	0.001	1.725
	15-30	135.678	0.015	0.655	2.126	0.001	1.652
	30-45	138.541	0.003	0.612	2.617	0.003	1.677
Mean ± S.D		139.282 ±1.462	0.006 ±0.007	0.643 ±0.027	2.512 ±0.346	0.002 ±0.001	1.684 ±0.037
	Site B	0-15	139.221	0.006	0.698	1.735	0.023
15-30		127.542	0.011	0.212	1.378	0.011	0.552
30-45		128.939	0.058	0.217	2.074	0.009	0.545
Mean ± S.D		131.900 ±0.377	0.025 ±0.028	0.375 S±0.279	1.729 ±0.348	0.014 ±0.007	0.931 ±0.663
	Site C	0-15	129.112	0.013	0.312	1.503	0.008
15-30		130.223	0.015	0.331	4.557	0.010	0.557
30-45		82.926	0.021	0.111	0.219	0.012	0.722
Mean ± S.D		114.087 ±26.991	0.016 ±0.004	0.251 ±0.121	2.093 ±2.228	0.010 ±0.002	0.618 ±0.090
	Site D	0-15	85.221	0.036	0.132	6.498	0.022
15-30		85.636	0.055	0.156	3.575	0.026	0.625
30-45		83.779	0.031	0.152	0.197	0.012	0.710
Mean ± S.D		84.878 ±1.378	0.040 ±0.040	0.146 ±0.056	3.420 ±3.149	0.020 ±0.007	0.677 ±0.046
	Site E	0-15	132.612	0.093	0.222	0.205	0.024
15-30		132.317	0.001	0.206	0.291	0.028	1.198
30-45		133.487	0.001	0.235	0.323	0.016	1.178
Mean ± S.D		132.805 ±0.608	0.031 ±0.075	0.221 ±0.014	0.273 ±0.061	0.022 ±0.006	1.202 0.026
	Control Mean	0-15	85.20	0.001	0.206	0.250	0.037
15-30		85.62	0.001	0.011	0.367	0.010	0.155
30-45		84.10	0.005	0.010	0.326	0.001	0.166
Mean ± S.D		84.88 ±2.218	0.002 ±0.002	0.235 ±0.220	0.314 ±0.059	0.016 ±0.008	0.506 ±0.599

**Table -3**  
**Lateral Distribution of the Heavy metals in the soils along a gradient from the impacted point**

Metal	Site	Point of Impact	10m away	20m Away	30m away	40m away
Fe	A	139.28	132.8	114.10	104.5	84.88
	B	131.90	125.6	118.5	112.6	96.8
	C	114.09	106.8	90.5	79.6	65.5
	D	84.88	70.5	62.5	56.7	42.8
	E	132.81	126.0	105.6	93.6	70.9
Cd	A	0.006	0.004	0.002	0.002	ND
	B	0.025	0.021	0.020	0.019	0.012
	C	0.016	0.016	0.014	0.012	0.010
	D	0.040	0.038	0.038	0.035	0.030
	E	0.031	0.028	0.026	0.023	0.022
Cu	A	0.643	0.611	0.500	0.380	0.250
	B	0.375	0.310	0.296	0.248	0.201
	C	0.251	0.236	0.215	0.213	0.182
	D	0.146	0.140	0.132	0.118	0.009
	E	0.221	0.208	0.192	0.182	0.135
Mn	A	2.512	2.30	1.85	1.75	1.46
	B	1.729	1.58	1.32	1.25	1.00
	C	2.093	1.90	1.63	1.56	1.10
	D	3.420	0.27	0.25	0.25	0.20
	E	0.273	0.27	0.25	0.23	0.16
Cr	A	0.002	0.002	-	-	-
	B	0.014	0.008	0.007	0.003	0.001
	C	0.010	0.010	0.060	0.002	0.002
	D	0.020	0.016	0.014	0.014	0.002
	E	0.022	0.009	0.009	0.006	0.002
Zn	A	1.684	1.35	1.26	1.00	0.004
	B	0.931	0.78	0.66	0.37	0.202
	C	0.618	0.58	0.50	0.36	0.21
	D	0.677	0.59	0.56	0.41	0.25
	E	1.202	0.98	0.91	0.63	0.57

**Table - 4**  
**Relative Pollution Potential Index of the Metals in the Soil**

Sites	Fe	Cd	Cu	Mn	Cr	Zn
A	0.22	0.67	0.32	0.26	0.75	0.46
B	0.14	0.28	0.30	0.26	0.66	0.43
C	0.25	0.19	0.43	0.26	0.65	0.33
D	0.32	0.13	0.53	0.91	0.43	0.33
E	0.25	0.19	0.19	0.17	0.70	0.36

Negative value of pollution potential indicates that at the level of infusion of waste material in the soil, the soil is not polluted, while positive interaction parameter on the other hand, gives a positive pollution potential suggesting that the soil is polluted at the level of infusion of the waste. The results gave positive values for all the metals in all the sites suggesting that the soils were contaminated at the points of infusion of the wastes.

The Enrichment Coefficient (Ec) of the metals in the soil was calculated based on the equation<sup>36</sup>, as follows.

$$Ec = \frac{C_1M_e/C_{1n}}{C_2M_e/C_{2n}}$$

Where  $C_1M_e$  = The examined metal concentration in the examined environment.  $C_2M_e$  = The examined metal concentration in the reference environment.  $C_{1n}$  = The reference element concentration in the examined environment.  $C_{2n}$  = The reference element concentration in the examined environment.

Fe was applied as the reference element because it is the most naturally abundant element in the soil. Enrichment Coefficient is a convenient measure of anthropogenic environmental status of the area being studied. Five contamination categories are recognized on the basis of Enrichment Coefficient<sup>37</sup>. The Enrichment Coefficients of the metals in the studied soils samples are presented on table - 5:

**Table - 5**  
**Enrichment Coefficients of the Heavy Metals in the Soils**  
**from all Sites**

Sites	Fe	Cd	Cu	Mn	Cr	Zn
A	1.64	3.50	27.63	3.50	0.12	3.33
B	1.55	12.70	1.60	12.27	0.87	1.84
C	1.34	7.85	1.07	6.67	0.62	1.22
D	1.00	19.64	0.62	10.89	1.25	1.34
E	1.56	15.22	0.94	0.87	1.37	2.38

The values observed in this study are within the range reported in another related study<sup>38</sup>. The values recorded for iron, copper, chromium and zinc were within the category of deficiency to minimal enrichment (<2) except in sites A and E for zinc which fell within the moderate enrichment values (2-5). Cadmium and manganese were in the range of significant enrichment (5-20).

## Conclusion

The present study has shown that for physicochemical properties, the cassava mill effluent decreases soil pH, while it leads to higher levels of available phosphorus, total organic carbon, total nitrogen, and electrical conductivity and cation exchange capacity of the soils. The results of heavy metal analysis showed elevated levels of heavy metals in the soils. The pollution potential index and enrichment coefficient values coupled with the observed physicochemical properties revealed that cassava mill effluent had detectable changes on the availability of the metals and selected physicochemical properties in the soils.

## Recommendation

The milling stage is a major stage in processing cassava tuber to be ready for consumption. As a result, use of cassava milling machine can not be avoided. Therefore it is hereby recommended that the government should set aside, an expanse of land away from residential areas where cassava processing milling machines should be located just as we have mechanic villages where mechanic workshops are located in some of our cities today.

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