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Assessment of Effect of Cassava Waste Water on Geotechnical Properties of Soil

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***Abstract*:- This project asses the study of soil properties like liquid limit, plastic limit, dry density, optimum moisture content, grading test CBR values which are affected by cassava liquid waste coming out from Sodabe Cassava Processing Center in Eruwa, Ibarapa East Local Government of Oyo state, Nigeria. Cassava waste water chemical composition analysis was done as well. Chemical analysis of the effluent gives 4.5mg/L of cyanide and trace quantity of heavy metals especially zinc, lead, manganese, and copper which has hightest concentration of 0.2mg/100g of the metals. Grain size analysis shows that the percentage passing No. 200BS sieve is 12.83%, 20.04% 14.83% 24.37% for samples 1.2.3 and 4 respectively. The liquid limit range between 23.18% and 28.39%, plastic limit range between 13.57% and 17.63%, plasticity index was between 9.61% and 12.63% and shrinkage limit range between 4.3% and 7.1%. the maximum dry density range between 2.01g/cm3 and 2.18g/cm3 for BS, 2.11g/cm3 and 2.32g/cm3 for WAS and 2.09g/cm3 and 2.26g/cm3 for AASHTO respectively. Also their optimum water contents ranging between 8.50% and 11,20% for BS, 6.20% and 10.22% for WAS, 7.12% and 12.33% for AASHTO, respectively while California bearing ratio (soaked) is between 51.92% and 66.77%. The result indicates that cassava wastewater affects geotechnical properties of soil especially Atterberg limits with the value of plasticity index lesser than 10% specified by Federal Ministry of Works, Nigeria (1997) thereby renders the contaminated soil material suitable for sub-grade, sub-base and base materials.**

INTRODUCTION

Soil is an important engineering material comprising of three phase materials of mineral particles (solid particles), water and air. A large portion of the earth's surface is covered by soil, and they are widely used as construction and foundation materials. Its mechanical behavior ia largely dependent on the size of its solid particles and voids. The solid particles are formed from physical and chemical weathering of rocks. Physical weathering includes climatic efforts such as freeze thaw cycles and erosion by wind, water and ice. Chemical weathering includes chemical reaction with rainwater. The particle size and the distribution of various particle sizes of a soil depend on the weathering agent and the transformation agents.

Soils are categorized as gravel, sand, silt, or clay, depending on the predominant particle size involved. Gravels are small pieces of rocks. Sands are small particles of quartz and feldspar. Silts are microscopic soil fractions consisting of very fine quartz grains. Clays are flake shaped microscopic particles of mica, clay mineral, and other minerals. The average size (diameter) of solid particles range from 4.75 to 76.6 mm for gravels and from 0.075 to 4.75 mm for sand. Soil with an average particles size of less than 0.075 mm are either silt or clay or a combination of two.

Soil can be divided into n two major categories: cohesion less and cohesive. Cohesion less soils such as gravel, sand, and silt, have particles that do not adhere (stick) together even with the presence of water. On the other hand, cohesive soils (clays) are characterized by their very small flakes like particles, which can attract water and form plastic matter by adhering (sticking) to each other. Soils can be described based on the way they were deposited. If a soil is deposited in the vicinity of the original rocks due to a transportation agent (such as wind, ice or water), it is called a transported soil.

Due to important of soil to engineering construction, it is however important to study the effect of water pollution (especially cassava waste water being generated by industrialization of garri processing) on soil. Soil is the upper layer of the earth crust which is form by weathering of rock. Organic matter in the soil maker it suitable for living organisms.

Drinking water has permissible level of value of metallic materials, any level above such is taking as toxic. Engineering soil ought not to contain toxicity.

Table 1: Parameters Concerning Toxic Substances

Sl No. (1)	Characteristic (2)	Requirement (Acceptable Limit) (3)	Permissible Limit in the Absence of Alternate Source (4)	Method of Test, Ref to (5)	Remarks (6)
i)	Cadmium (as Cd), mg/l, *Max*	0.003	No relaxation	IS 3025 (Part 41)	—
ii)	Cyanide (as CN), mg/l, *Max*	0.05	No relaxation	IS 3025 (Part 27)	—
iii)	Lead (as Pb), mg/l, *Max*	0.01	No relaxation	IS 3025 (Part 47)	—
iv)	Mercury (as Hg), mg/l, *Max*	0.001	No relaxation	IS 3025 (Part 48)/ Mercury analyser	—
v)	Molybdenum (as Mo), mg/l, *Max*	0.07	No relaxation	IS 3025 (Part 2)	—
vi)	Nickel (as Ni), mg/l, *Max*	0.02	No relaxation	IS 3025 (Part 54)	—
vii)	Pesticides, µg/l, *Max*	See Table 5	No relaxation	See Table 5	—
viii)	Polychlorinated biphenyls, mg/l, *Max*	0.000 5	No relaxation	ASTM 5175*	— or APHA 6630
ix)	Polynuclear aromatic hydro-carbons (as PAH), mg/l, *Max*	0.000 1	No relaxation	APHA 6440	—
x)	Total arsenic (as As), mg/l, *Max*	0.01	0.05	IS 3025 (Part 37)	—
xi)	Total chromium (as Cr), mg/l, *Max*	0.05	No relaxation	IS 3025 (Part 52)	—
xii)	Trihalomethanes:				
	a) Bromoform, mg/l, *Max*	0.1	No relaxation	ASTM D 3973-85* or APHA 6232	—
	b) Dibromochloromethane, mg/l, *Max*	0.1	No relaxation	ASTM D 3973-85* or APHA 6232	—
	c) Bromodichloromethane, mg/l, *Max*	0.06	No relaxation	ASTM D 3973-85* or APHA 6232	—
	d) Chloroform, mg/l, *Max*	0.2	No relaxation	ASTM D 3973-85* or APHA 6232	—

NOTES

In case of dispute, the method indicated by '*' shall be the referee method.

1 It is recommended that the acceptable limit is to be implemented. Values in excess of those mentioned under ‘acceptable’ render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the limits indicated under 'permissible limit in the absence of alternate source’ in col 4, above which the sources will have to be rejected.

Source: Ammendment No.1 June 2015 to IS10500:2012 Drinking Water-Specification (second Revision), Publication Unit, BIS, New Delhi, India

These pollutant or contaminants in the soil are physically or chemically combined and integrated with soil particles or trapped in the voids between soil particles.

These pollutant are caused by the activities of man on the environment, chemical or other alteration in the natural environment. The waste water pollution has resultants effect andn alter the soil properties. It is therefore necessary to study cassava waste water on the surrounding soil at District along new eruwa road in order to determine the changes in its use for construction.

Land pollution as a result of illegal and ineffective disposal of cassava waste water is a common feature around area where Garri processing take place. It is one of the greatest environment challenges facing effective disposal of waste water in Nigeria. This action (ineffective cassava waste water) poses a great environmental health risk and hazard to man and the ecosystem from direct contact with contaminated soil, contamination of water table underlying the soil.

Cassava is processed into many foods in Nigeria and among all; garri is the most common in Nigeria. The processing is done in various part of the country especially in southern region where there is large abundant of crop. The processing involves the washing and peeling the brown outer cover of the cassava tuber.

The study was carried out at Sodabe cassava processing center, district along new Eruwa road, ransom area in Ibarapa East Local Government Oyo State, where the indigenous people are traders and farmers who cultivates banana cocoyam and cassava including maize. In other to assist farmers in easily process their cassava into garri and other edible product, a cassava process is establish in the community and about 10 to 20 metric tonnes of cassava tuber are weekly processed generating 75000-10000 litres of cassava waste which is discharge into the immediate environment without any form of treatment.

MATERIALS AND METHOD

Study Area

To determine the effect of cassava waste water on soil properties, a cassava processing site was located at Sodabe cassava processing center in Eruwa Town of Oyo State, Nigeria.

Eruwa meaning 'pieces of yam are available here' is a town and the headquarters of Ibarapa East Local Government Area in south-western Nigeria located in Oyo state. Eruwa is 72 km south west of Ibadan and 60 km north east of Abeokuta (wikipeadia).

The indigenous economic activity of the people of Eruwa revolves around **agriculture** which includes farming, fishing, hunting and animal husbandry. Other economic activities include manufacturing and trading. The main crops include yam, **cassava,** guinea corn, maize, pepper, tobacco, cotton and melon seeds. Also grown in the area are cocoa, kolanuts, oranges and palm-trees. The occupational choice of the people was largely influenced by the geographical location of the town. Sodabe cassava processing center is appropriately located for raw material proximity and hence suitability of the area for this study.

Soil Sample Collection

Samples were obtained from three (3) different locations to check the geotechnical properties of the Soil and an undisturbed sample was also collected for the purpose of control experiment. This control sample was obtained from another source. The waste water sample was also collected to determine its chemical compositions.

RESULTS AND DISCUSSION

TABLE 2: Chemical Composition of Cassava Waste Water

Parameter	Values
Total Cyanide (mg/l)	4.50 4.50 4.50
Zn^{++} (mg/l)	0.05 0.05 0.05
Pb^{++} (mg/l)	0.02 0.02 0.02
Cu^{++} (mg/l)	0.20 0.20 0.20
Mn^{++}(mg/l)	0.05 0.05 0.05

TABLE 3: Natural Moisture Contents of the Soil Samples

Soil Sample	Natural Moisture Content (%)
Uncontaminated sample	1.80
Soil sample at First location (750-500mm)	0.40
Soil sample at Second location (500-250mm)	0.46
Soil sample Third location (250mm-container base)	0.50

TABLE 4: Particle size distribution of the Soil Samples

Bs sieve size	% passing Uncontaminated	% passing 1st location	% passing 2nd location	% passing 3rd location
0.0075mm	12.83	20.04	14.83	24.37
0.125mm	15.34	21.69	17.88	25.62
0.250mm	24.64	26.40	25.18	31.90
0.425mm	36.09	32.57	33.01	40.68
1mm	57.72	54.94	55.28	59.56
2mm	70.09	67.89	69.51	74.05
4mm	86.40	79.01	80.72	86.18
8mm	95.02	93.03	94.61	96.72

TABLE 5a: Atterberg Analysis of the Samples

Sample	Liquid limit (LL) %	Plastic limit (PL) %	Plastic Index (PI)	Shrinkage Limit (SL) %
Uncontaminated sample	28.37	17.74	10.63	5.13
1st contaminated sample	28.44	13.87	14.57	5.41
2nd contaminated sample	26.38	15.26	11.12	6.03
3rd contaminated sample	28.39	17.52	10.87	7.50

TABLE 5b: Atterberg Analysis of the Samples showing liquid and plastic limits

Location	Liquid limits	Plastic limits
Uncontaminated	28.37	17.74
Location one	28.44	13.87
Location two	26.38	15.26
Location three	28.39	17.52

TABLE 6: a. WAS Compaction MC(%) and DD (g/cm^3) for the Samples

Sample	Description	1	2	3	4
Uncontaminated	Moisture Content (%)	7.11	10.22	13.67	14.12
	Dry Density (g/cm)	2.00	2.32	2.11	2.21
Location one	Moisture Content (%)	3.59	5.98	9.80	12.10
	Dry Density (g/cm)	1.97	2.17	2.08	1.95
Location two	Moisture Content (%)	4.74	7.49	10.71	13.78
	Dry Density (g/cm)	1.94	2.15	2.08	1.94
Location three	Moisture Content (%)	4.62	6.42	10.63	13.71
	Dry Density (g/cm)	1.92	2.11	1.98	1.93

b.

Location	Moisture content	Dry Density
Uncontaminated	11.28	2.16
Location one	7.87	2.04
Location two	9.18	2.03
Location three	8.85	1.99

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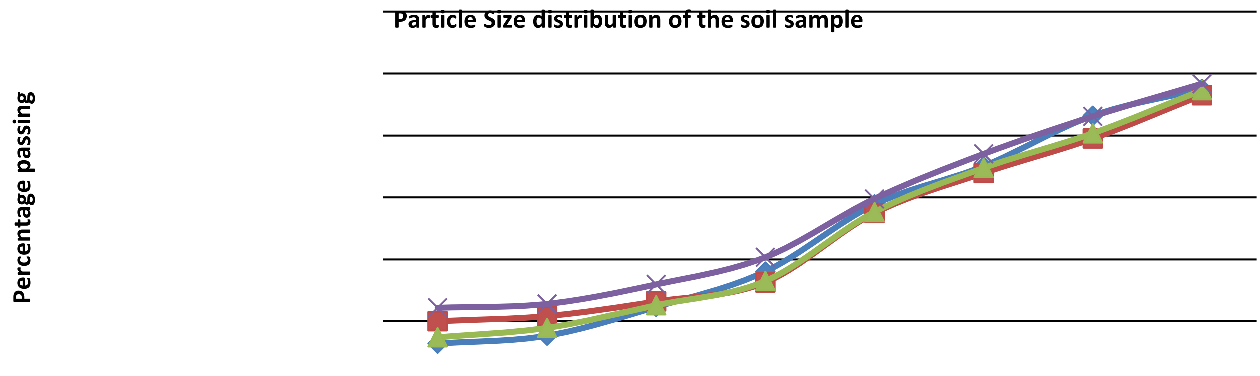

	0.0075mm	0.125mm	0.250mm	0.425mm	1mm	2mm	4mm	8mm
% passing Uncontaminated	12.83	15.34	24.64	36.09	57.72	70.09	86.4	95.02
% passing 1st location	20.04	21.69	26.4	32.57	54.94	67.89	79.01	93.03
2nd location	14.83	17.88	25.18	33.01	55.28	69.51	80.72	94.61
3rd location	24.37	25.62	31.9	40.68	59.56	74.05	86.18	96.72

Figure 1: Particle Size distribution of Soil Samples

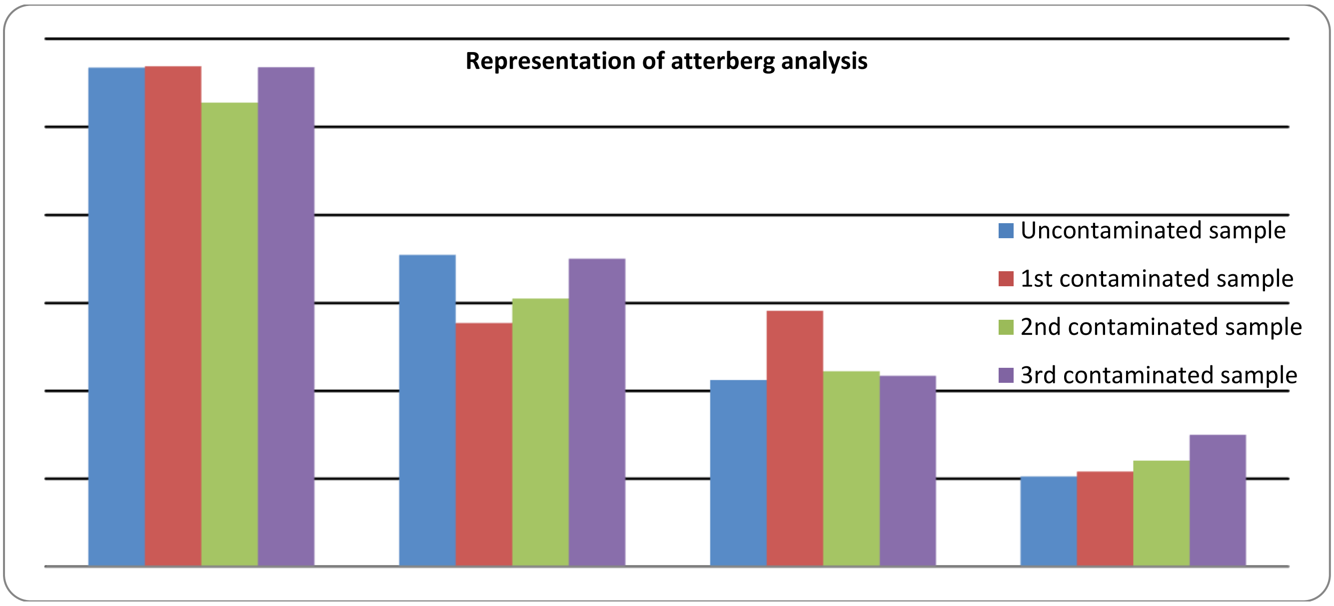

Figure 2a: Representation of Atterberg Analysis

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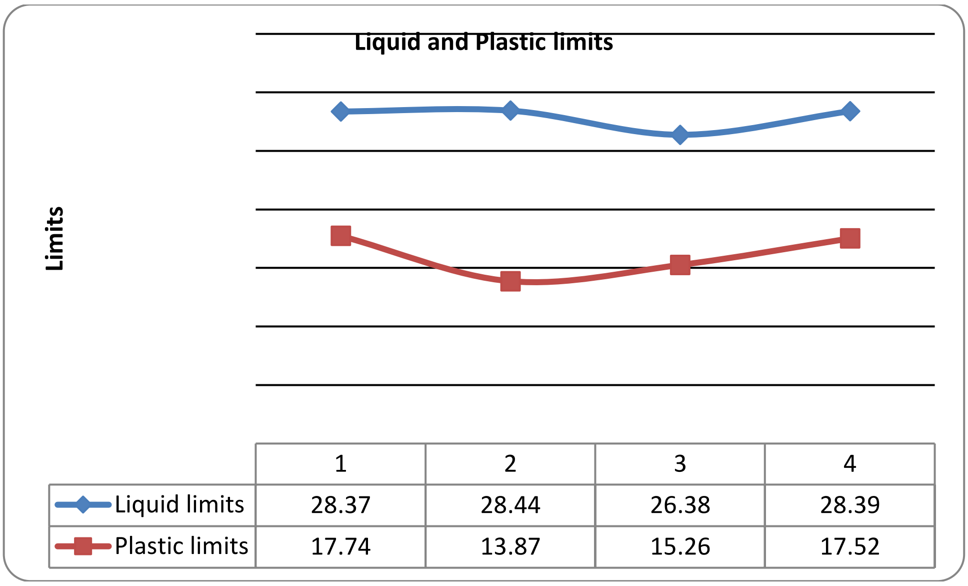

Figure 2b: Atterberg Analysis of the Samples showing liquid and plastic limits

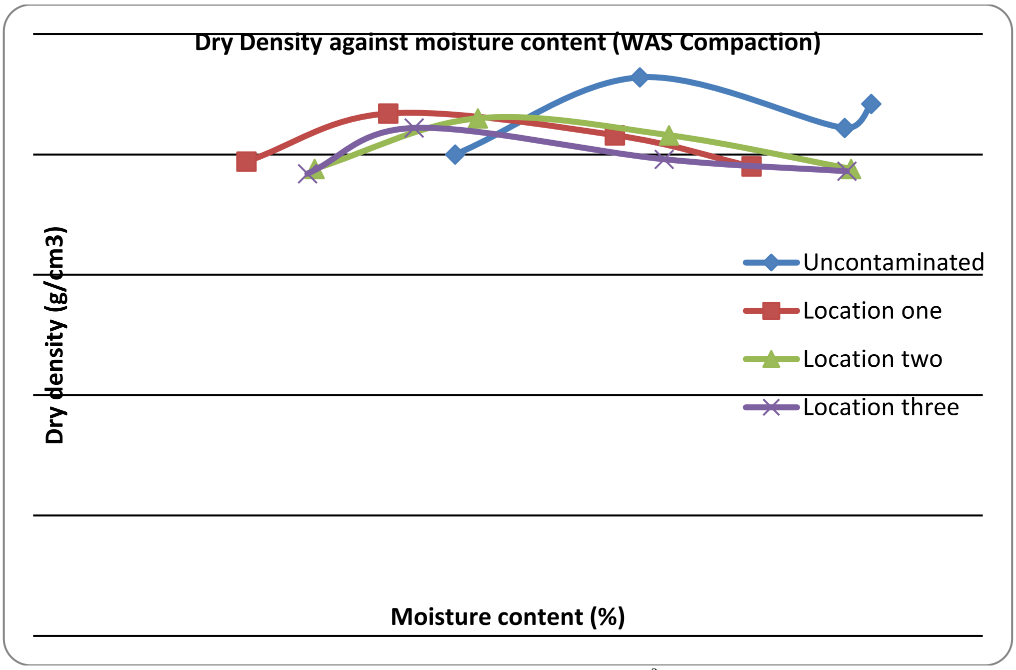

Figure 3: WAS Compaction MC(%) and DD (g/cm^3) for the Samples

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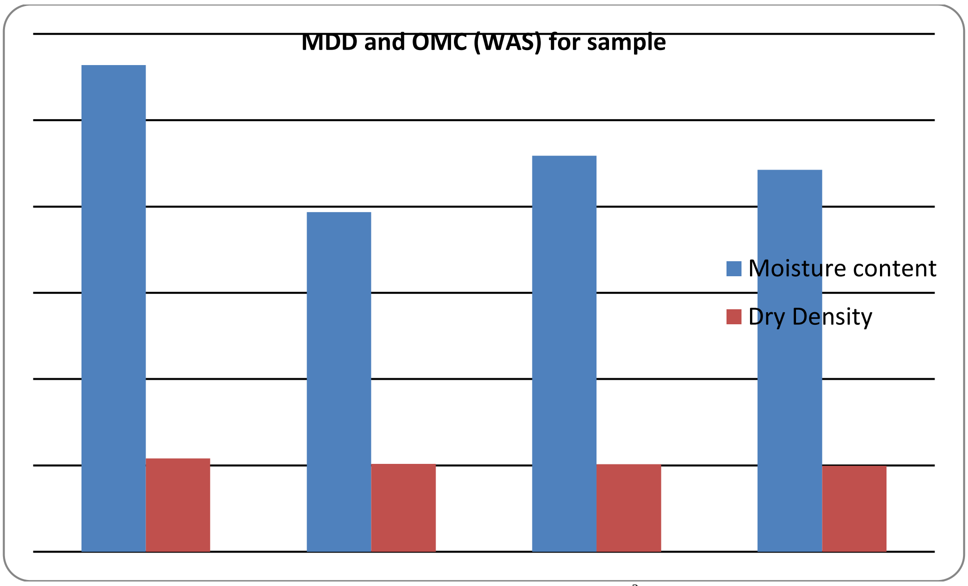

Figure 3b: WAS Compaction MC(%) and DD (g/cm^3) for the Samples

The Chemical composition of Cyanide in the cassava waste water was 4.50 (table 2) is far higher than the permissible value of 0.05 as contained in (table 2). The trend are same for Zinc, Z^{++}, Lead, Pb^{++} Copper Cu^{++} , Manganese Mn^{++} 0.05,0.02,0.20 and 0.05 respectively (table 1) .
The Soil is already contaminated with toxic content of the wastewater coming from the production source of Cassava Plant. (Ghosh,2003) obtained that Toxic Chemicals are sources of contaminants to Engineering Properties of Soil.
Table 3 shows the moisture content of the soil samples taken from three different contaminated locations and one uncontaminated location. The moisture content is higher at the uncontaminated location 1.8 and lower at the first contaminated point 0.4. The soil samples were collected from source where the wastewater is extracted from pressured cassava and draining of the wastewater into the bush area.
Figure 1 showed the results of the sieve analysis represented in table 3. This shows that the percentage passing sieve No.200,that is the 75mm sieve mesh for the uncontaminated material gives 12.83%, the first contaminated sample is 20.04% which means that the percentage passing increased but reduced at the second and increased drastically at the 3rd contaminated sample. According to the specification limits for Materials and workmanship (As per General Specification Reads & Bridges, Revised 1997, Federal Ministry of Works, Nigeria), the percentage passing ought to be less or equal to 35%. This made all the sample materials are suitable for both fill and sub-grade and sub-base use.
Table 5a and b show the Atterberg values obtained from the study and this is illustrated in figure 2a and b. The uncontaminated sample has the highest (17.63%) plastic limit value and its fall upon the addition of effluent; this reduced the plastic limit to 13.57% in the first contaminated sample (the shallowest depth) but the value increases with depth. This means that with age, the soil regain its plastic limit after a drop in the first contaminated sample.
There is also increase of plasticity index as a result of Cassava effluent. The value of uncontaminated sample being (9.37%) and increase at the first sample to (15.13%) but reduced down the depth. This again reinforced the fact that biodegradation causes restoration of certain soil properties. Plasticity index of all the contaminated samples fall below the standard value while the uncontaminated sample remain within the permissible level.
The linear Shrinkage and CBR obtained from the soil samples certify the value given by Specification Limits for Materials and Workmanship (General SpecificationsRoads and Bridges, Revised 1997, Federal Ministry of Works).

CONCLUSION AND RECOMMENDATION

The continuous disposal of cassava processing wastes into the soil environment of the cassava processing mill brought about changes in the chemical and geotechnical compositions of the soil environment around the mill. Most of the cassava millers at this centre are not educated and are not aware of the damage of their actions and inactions are causing to the soil and environmental effects of these wastes. Education about ways of detoxifying the wastes and proper disposal methods is therefore necessary.

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