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The impact of cassava mill effluent on the total aerobic bioload and physicochemical properties of the soil

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Abstract

The impact of cassava mill effluent on total aerobic bioload and physicochemical properties of soil was determined. Soil samples were collected with sterile soil auger and subjected to standard microbiological analysis. The results revealed significant differences ($P<0.01$) in total aerobic bacterial counts between the impacted samples ($2.0x10^6$ ±0.87cfu/g and $4.7x10^6$ ±1.56cfu/g) collected 5 and 50m away from the mill and the control sample ($4.7x10^6$±1.56cfu/g) collected 50m before the mill. Samples collected 50m before and after the mill recorded no significant difference in bacterial counts. There was no significant difference in total fungal counts recorded at various distances before and after the mill. The pH values of the impacted samples were acidic, recording 4.81 and 6.31 at 5 and 50m away from the mill, while the control recorded 7.6. Impacted samples also recorded higher hydrogen cyanide contents (12.4 and 9.17) than the control (6.8). The C/N ratios of the impacted samples (9.10 and 6.73) were smaller than the control (14.60). The Effective Cation Exchange Capacity of the samples equally followed the same trend. Cassava mill effluent has therefore impacted negatively on the microbial counts and physicochemical properties of the soil.

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Introduction

Cassava is believed to have originated from South America. In Africa, cassava was introduced in the 16th century in around the Congo River basins (Cock, 1985). In sub-Saharan Africa, cassava is a major stable food that is consumed in processed forms in many areas. In West Africa and Nigeria in particular, the crop is most commonly consumed as gari, a dry granular meal made from fermented cassava (IITA, 1985).In South Eastern Nigeria, many cassava processing industries have been established, even around residential homes. Many people are involved in gari processing, particularly among the rural farmers. Raw materials are mainly fresh cassava which is very abundant and cheap.

Traditional garri production is associated with the discharge of large amounts of water, hydrocyanic acid and organic matter in the form of peels and sieves from the pulp as waste products. Around the cassava mills, this liquid waste is indiscriminately dumped and allowed to accumulate, even near residential homes, producing offensive odours and unsightly scenarios (FAO, 2004 and Okafor, 2008).The high cyanide content of the effluent would equally pose a significant threat to humans and the environment (Adewoye *et al.*, 2005 and Akani *et al.*, 2006).

This work therefore intends to ascertain the extent of cassava effluent impact on soil microbial counts and physicochemical properties at various distances from the mill.

Materials and methods

Sample collection

Soil samples were collected from a cassava mill at Mgbakwu, Awka-North L.G.A, Anambra State. These samples were collected at 0-12cm depth and at 50m before the mill (no effluent dumped on it and therefore referred to as the control), 5 and 50m away from the mill (dump sites). The samples were air dried, crushed to fine particles and sieved using 2mm sieve and then stored in fresh clean polyethylene bags in the refrigerator at 2°C between 7-14 days to maintain the stability of the samples without significant alteration in their biological properties (Clark, 1965).

Particle size and texture class

Hydrometer method as described by Bouyoucous (1951) and Agbenin (1995) was used in this test. After, the values for silt and clay were determined, the value of sand was obtained by subtracting the values of silt and clay from 100.

Soil pH

Soil pH was determined using potentiometric method as described by Brady and Weil (1990). A glass electrode Testronic digital pH meter (Model 511) was used.

Organic matter and Organic carbon

These were determined according to the wet oxidation method of Walkey and Black (1945).

Total nitrogen

Total nitrogen assay was determined using Kjeldahl method as described by Bremner and Mulvaney (1982).

Available phosphorus

Available phosphorus was determined by the methods described by International Institute of Tropical Agriculture (IITA) (1979) and Olsen and Sommers (1982).

Exchangeable cations

These were determined according to the methods described by IITA (1979) and Agbenin (1995).

Cation exchange capacity

This was determined by the summation of the cubic centimeter (cm^3) values of the exchangeable cations of each sample determined above.

Hydrocyanic acid content

This was determined using alkaline titration method as described by AOAC, (1984).

Total aerobic bacterial and fungal counts

The total aerobic bacterial and fungal counts were carried out using pour plate technique as described by Fawole and Oso (1995), after ten-fold serial dilution. The media of choice were Oxoid Nutrient agar and Saboroud Dextrose agar, prepared according to the manufacturer's instruction.

Statistical analysis

The results of the plate counts were subjected to statistical analysis using Window's SPSS at $P>0.05$ and $P<0.01$ confidence limit.

Results

Table 1 shows the total aerobic bacterial counts at various distances from the mill. The result at $P<0.01$ showed that total aerobic bacterial count of the sample collected 50m before the mill was significantly higher than that of 5m away from the mill. Also, there was significant difference between count result of sample collected 5m and 50m away from the mill. Samples collected 50m before and away from the mill however recorded no significant difference in their total aerobic bacterial counts.

Table 1. Total aerobic bacterial counts at various distances from the mill.

Distance	Total Aerobic Bacterial Count (cfu/g)
50m before the mill	$4.7 \times 10^6 \pm 1.56$
5m away from the mill	$2.0 \times 10^6 \pm 0.87$
50m away from the mill	$4.7 \times 10^6 \pm 1.56$

Table 2 represents the total fungal counts at various distances from the mill. The statistical results revealed no significant difference in counts between samples collected at various distances from the mill at $P>0.05$. Table 3 shows the results of the physicochemical properties of the samples. According to the results, samples collected 50m before the mill recorded a pH of 7.6 (slightly alkaline); while those of the samples collected 5 and 50m away from the mill were acidic (4.81 and 6.31). Sample collected 5m away from the mill recorded the highest concentration of HCN, while that collected 50m before the mill had the least. Sample collected 50m before the mill recorded the highest C/N ratio and the least ECEC, while sample collected 50m away from the mill had the least C/N ratio.

Table 2. total fungal counts at various distances from the mill.

Distance	Total Fungal Count (cfu/g)
50m before the mill	$1.1 \times 10^6 \pm 1.62$
5m away from the mill	$3.1 \times 10^6 \pm 2.98$
50m away from the mill	$2.3 \times 10^6 \pm 1.73$

Discussion

From the results, sample collected 5m away from the mill recorded the least average bacterial count value of $2.0 \times 10^6 \pm 0.87$cfu/g and the highest average fungal count value of $3.1 \times 10^6 \pm 2.98$cfu/g compared to samples collected 50m before and away from the mill. This higher fungal count could be attributed to the more robust nature of fungi which enables them to withstand the more acidic environment of the site than bacteria. This ability of fungi to thrive better than bacteria in acid soils had been reported (Rangaswami and Bargyaraj, 1993). However, fungal count results at various distances before and after the mill recorded no significant difference. Sample collected 50m before the mill recorded significantly higher total aerobic bacterial count ($P<0.01$) than of 5m away from the mill. This could be attributed to the deleterious effects of the cassava mill effluent on the impacted sample. This result lends credence to the report that the bioload of all bacterial groups increased with distance away from the waste pit suggesting adverse growth conditions towards the pit (Nwaugo *et al.*, 2008b). Initial increase in bacterial and fungal populations in cassava effluent polluted soil, some of which went into extinction overtime had also been reported (Okwu and Nwosu, 1991; Ogboghodo *et al.*, 2006).

Table 3. Physicochemical properties of the soil at various distances from the mill.

Distance	%Sand	%Silt	%Clay	Texture	pH	HCN	Pppm	%N	%OC	C/N	%OM	Ca	Mg	K	Na	EA	ECEC
Y1	87	5.0	6.0	S	7.6	6.8	9.90	0.04	0.54	14.60	0.30	0.17	0.40	0.07	0.20	0.32	4.51
Y2	72	9.4	12.7	SL	4.8	12.4	16.07	0.15	1.40	9.10	1.36	3.17	1.84	0.78	0.84	0.80	9.17
Y3	77.7	5.2	8.1	LS	6.3	9.17	17.40	0.11	0.74	6.73	1.68	3.5	1.80	0.64	0.71	0.47	8.23

Key: OM = Organic Matter, OC = Organic Carbon, HCN = Hydrocyanic Acid, EA = Exchangeable Acidity, ECEC = effective cation exchange capacity; All cations were measured in mg/g; Y1 = sample collected 50m before the mill; Y2 = sample collected 5m away from the mill; Y3 = sample collected 50m away from the mill.

There was however no significant difference in bacterial count results (P>0.05) obtain from samples collected 50m before and away from the mill, thus lending credence to the report that microbial bioload values obtained at 100m were not statistical higher than those from the control. This observation suggests that the high content of cassava mill effluent suppressed bacterial growth but at very low concentrations could support bacterial growth. The high content of cyanogenic glycosides in the effluent was not metabolized by many microorganisms but when in low concentration, could be easily metabolized by the few organisms capable of doing so, while other bacterial species depend on the non-toxic intermediates produced (Nwaugo *et al.*, 2008b). Nwaugo *et al.*, (2008a) and Karin (2002) reported that organic matter when added to the soil in small concentrations, encouraged bacterial growth. This observation agreed well with this study. Conditions and nutrients at 50m sampling point could have been optimum for bacterial growth, thus the results obtained.

The study revealed high percentage content of sand and low clay and silt contents, at the various distances from the mill. This agreed with the report that sand particles take large proportion of the first three-layers in cassava effluent polluted soils (Uzoije *et al.*, 2011). Aggressive weather conditions might equally be responsible for the soil texture observed as reported by (Jungerius and Levellt, 1964). Samples collected 50m away from the mill recorded a more acidic pH of 4.81 compared to those obtained 50m before and away from the mill that recorded 7.6 and 6.31 respectively. This could be attributed to the cassava mill effluent as there was a corresponding increase in the concentration of cyanogenic glycosides in the impacted samples. Similar results have been reported by other authors (Utu-Baku *et al.,* 1995; Okafor, 2008; and Uzoije *et al.*, 2011). The hydrogen cyanide content of the impacted soil collected 5m away from the mill was higher that collected 50m away and 50m before the mill. Such higher concentrations have been observed near cassava mills (Nwabueze and Odunsi, 2007; Nwaugo *et al.*, 2008b and Uzoije *et al.*, 2011).

The C/N ratios were low in the samples collected 5m and 50m away from the mill, compared to that of 50m before the mill. This could be attributed to high percentage of organic carbon and low percentage content of nitrogen in the impacted soils, thus reducing the C/N ratios of the impacted samples. These results agreed with the report that soil impaction with organic matter results in decrease C/N ratio, especially if the impacting material has low nitrogen content (Shanhinrokhsar *et al.*, 2008 and Nattipong and Alissara, 2006). The values obtained for cations calcium, magnesium, sodium and potassium and exchangeable acidity revealed increase in values in the impacted samples collected 5m and 50m away from the mill, compared with those of the unimpacted. These increase in the cations especially calcium and magnesium in the impacted samples could have been caused by the cassava mill effluent. Such increase in the level of calcium in the impacted soil have been reported by (Aderiye and Laleye, 2003; Adewoye *et al*., 2005 and Nwaugo *et al*., 2008b).

Conclusion

The results of the study have revealed that cassava mill effluent has impacted negatively on the total aerobic microbial counts and physicochemical properties of the impacted soil.

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