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Effect of Cassava Industrial Effluent on Physicochemical Properties and Microflora of Soil

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ABSTRACT

The effect of cassava mill effluent on the receiving soil was assessed. The effluent and the soil contaminated by the cassava mill effluent as well as farm land soil were collected for assay. The physicochemical parameters of the samples and the microbiological property were analyzed using standard techniques. The results indicate that bacterial and fungal counts were highest in the uncontaminated soil with 10.3×10^5 cfu/g and 9.60×10^5 sfu/g while the cassava effluent had a slightly higher bacterial count of 3.71×10^5 cfu/ml than the cassava effluent contaminated soil which recorded 1.12×10^5 cfu/g. Albeit, the fungal count in the effluent was lower (1.32 sfu/ml) compared to that of the contaminated soil which had a count of 3.04×10^5 sfu/g. The isolated organisms include *Klebsiella pneumoniae*, *Bacillus subtilis, Pseudomonas aeruginosa*, *Lactobacillus* spp and *Staphylococcus aureus* (bacteria) *Fusarium* spp, *Aspergillus niger, Rhizopus stolonifer, Penicillum* spp and *Saccharomyces cerevisiae* (fungi). The moisture content of the contaminated soil was higher (15.03%) than that of the control soil sample (11.10%). The pH values were between 3.1 and 7.3. The cassava effluent sample was the most acidic with pH 3.1, followed by the contaminated soil which had 4.8. The BOD value of the cassava effluent was 7.81 mg/ml. Nitrate, phosphate and sulphate contents were lowest in the uncontaminated soil (1.95, 0.24 and 0.22 mg/ml) and highest in the effluent contaminated soil (2.01, 0.37 and 0.41 mg/l respectively). Other minerals like Zn, Pb, Fe, Cu and Al were higher in the effluents than the contaminated soil and the control soil whereas, Mg, K, Ca and Na were higher in uncontaminated soil than the contaminated soil and the effluent. These results clearly indicate a negative impact of the cassava mill effluent on soil, therefore there is a need to detoxify them before been discharged into the environment.

Keywords: caasava, effluent, physicochemical, microflora, heavy metal

1.0 Introduction

Like rice and maize, cassava (*Manihot esculenta* Crantz) which belongs to the Euphorbiaceae family is a major staple food in Africa especially Nigeria. Cassava is a typical food security crop. Cassava is one of the most vital food crops consumed in developing countries especially in tropical areas. Its cultivation and processing into useful products such as gari and fufu (Kolawole, 2014). Cassava is cultivated in over 80 countries of humid tropical region in the world. Cassava products are rich in carbohydrates, vitamins (mostly vitamins B and C), essential minerals and low in protein.

Cassava is an annual crop that is propagated by stem and harvested between 7 – 13 months after planting depending on variety. However, some farmers harvest cassava after 2 - 3 years of planting depending on their income. Cassava thrives well in warm, moist climate, but can tolerate harsh environmental conditions. In Nigeria, cassava farming and processing into useful food items is a major source of livelihood to several families especially in rural areas. Moreover, smallholder processors have dominated the enterprises before the presidential cassava initiative of 2002-2003. According to Afuye and Mogaji (2015), smallholder cassava processors account over 80% of cassava production and processing into useful products for Nigeria. After petroleum, cassava is a major contributor of Nigeria's gross domestic product (GDP).

Basically, cassava tuber contains about 70% water. During cassava processing into gari, several by-products are derived including cassava peelings (21.8%), Cassava Mill Effluents (CME) (16.2%), sieviates (7.5 %), air emission (19.8%), high quality cassava flour (25.0%). In Nigeria, these by-products (mainly solid and liquid wastes) are discharged into the ecosystem without treatment. Elijah *et al.* (2012) opined that wastewater of cassava processing units could pose more intense problem in near future probably due to lack of effluent treatment facility, as effort of Nigerian Government is ongoing to boost cassava based products (Kigigha *et al.*, 2015). These wastes stream could lead to environmental impacts especially on soil fertility, water and air quality. The solid wastes are consumed by domestic animals such as goat in some part of Nigeria. The liquid wastes are also consumed by domestic animals such as goat, but instances of toxicity leading to death of flora and fauna have been reported in literatures. Furthermore, CME contaminates agricultural farmland, surface water (creek, river, stream, pond etc) and percolates into sub-soil and groundwater resource. The discharge of effluents, sludge, and biosolid from food processing such as cassava on the land has been an age long practice. Sen and Annachhatre (2015) have reported instances of CME flowing into vegetation, abandoned in living communities.

In Nigeria several varieties of cassava abound, but the two major cultivars cultivated are sweet and bitter varieties. Bitter cassava is known to contain glucoside which forms hydrocacyanic acid during processing. Ezeigbo *et al.* (2014) reported that cassava contains cyanogenic glucoside viz: linamarin and lotaustralin which is stored in the vacuole of plant cell and are converted into hydrogen cyanide, and when it comes in contact with cell wall hydrolysis of linamarin and lotaustralin takes place. During processing (cooking, frying, boiling), the linamarin is reduced because it is hydrolyzed in the digestive system of humans and animals by indigenous microbial flora and in the process hydrogen cyanide (HCN) is released. Cyanide enters the human body through inhalation, ingestion and/ or skin contact and distribute round the body through the blood stream (Izah and Aigberua, 2017).

Nigeria being the largest cassava processing nation produces high amount of waste streams. The wastes need to be well utilized to avoid the attendant impacts associated with the various wastes stream. In view of the large quantity of wastes associated with cassava processing, this study assessed the impacts of cassava mill effluents on soil in Owo, Ondo State.

2.0 MATERIALS AND METHODS

2.1 Sample collection

Fresh cassava effluent from the cassava mill at Ehinogbe quarters in Owo was collected directly into sterile plastic bottles. Soil around the cassava mill and the control soil sample from the school farm were collected aseptically into black polythene bags using soil auger. All samples were taken to the laboratory for analyses immediately.

2.2 Sterilization procedures

The glass wares, such as conical flask, beaker, test-tubes etc. were duly soaked in detergent for 12 hours and then washed thoroughly using brush. They were subsequently rinsed in large quantity of clean water and finally with distilled water to remove salt content of the tap water. The glass wares were air dried and then sterilized in hot air oven for 2 hours at 160^0C. Inoculating wire loop used were sterilized by flaming with a Bunsen burner until red hot and then allowed to cool before using. The surfaces of the workbench were sterilized by cleaning with 75% alcohol before and after each working period.

Physicochemical Analysis

Properties like the pH, temperature, moisture, water retention capacity, transparency, colour, total dissolved solid (TDS), hardness, organic matter, C, N, P and moisture were determined using the method described by UNEP (2003) and CEC (2016). The biochemical oxygen demand (BOD) of the sample was determined over five days period using the method described by Dubey and Maheshwari (2004)

Determination of minerals and heavy metals

The minerals and heavy metals present in the samples were assayed using the Atomic Absorbance Spectrophotometer (AAS) method.

Microbial Analysis

Samples of the pond water were serially diluted in ten folds. Total viable heterotrophic aerobic plate counts were determined by plating in duplicate, using pour plate technique. Molten nutrient agar, Salmonella- Shigella agar, Manitol salt agar, MacConkey agar and Eosin Methylene Blue agar at 45 ^{0}C were poured into the Petri dishes containing 1mL of the appropriate dilution for the isolation of the total heterotrophic bacteria, Salmonella and Shigella, Staphylococci group, coliforms and *Escherichia coli* respectively. They were swirled to mix and colony counts were taken after incubating the plates at 35 ºC for 24 hours (Akinnibosun *et al*., 2020).

3.0 RESULTS AND DISCUSSION

The results of the microbial count in the cassava mill effluent and the receiving soil is shown in Table 1. The bacterial and fungal counts were highest in the uncontaminated soil with 10.3×10^5 cfu/g and 9.60×10^5 sfu/g while the effluent had a slightly higher bacterial count of 3.71 x 10^5 cfu/ml than the czassava effluent contaminated soil which recorded 1.12 x 10^5 cfu/g. Albeit, the fungal count in the effluent was lower (1.32 sfu/ml) compared to that of the contaminated soil which had a count of 3.04 x 10^5 sfu/g.

Table 1: Microbial count on the cassava mill effluent and soil samples (x 10^5 cfu)

Sample	Total Bacterial Count	Total Coliform Count	Total Fungal Count
Effluent	$3.71{\pm}0.01^b$	$1.00{\pm}0.00^a$	$1.32{\pm}0.01^a$
Contaminated soil	$1.12{\pm}0.00^a$	$1.50{\pm}0.00^a$	$3.04{\pm}0.01^b$
Uncontaminated soil	$10.30{\pm}0.04^c$	$6.50{\pm}0.05^b$	$9.60{\pm}0.02^c$

Table 2 presents the distribution of the microbial isolates in Table 2, which reveal the presence of *Klebsiella pneumoniae, Bacillus subtilis, Pseudomonas aeruginosa, Lactobacillus* spp *Staphylococcus aureus, Fusarium* spp, *Aspergillus niger, Rhizopus stolonifer, Penicillum* spp and *Saccharomyces cerevisiae*. Out of the ten organisms, only *S. cerevisiae* was absent on uncontaminated soil whereas, the contaminated soil and the effluent each contained only five organisms apiece.

The microbial population of uncontaminated soil was higher than the contaminated soil and cassava effluent samples. The relatively lower microbial population could be attributed to the acidic nature of the effluent due to the presence of cyanide. Cyanide in the soil and fermented cassava could lead to the inhibition of microbial growth (Kigigha *et al.*, 2015). Disposal of cassava wastes from processing activities in mills lead to the release of a wide variety of microorganisms. These organisms may release toxins in the effluent which can be harmful. Only those that can withstand the high acidic condition of the processing wastes will dominate, thus the lower population of the microbial species. The absence of the acidic effluent in uncontaminated soil may have explained the higher number of the isolated organisms.

Table 2: Distribution of isolated organisms on the samples

Isolate	Effluent	Contaminated soil	Uncontaminated soil
Bacillus subtilis	+	+	+
Staphylococcus aureus	-	-	+
Klebsiella pneumoniae	+	+	+
Lactobacillus spp	+	+	+
Pseudomonas aeruginosa	+	+	+
Fusarium spp	-	-	+
Rhizopus stolonifer	-	+	+
Saccharomyces cerevisiae	+	-	-
Aspergillus niger	-	-	+
Penicillum spp	-	-	+

Table 3 showed the physicochemical parameters of the cassava effluent as well as the contaminated soil and the control. The moisture content of the contaminated soil was higher (15.03%) than that of the control soil sample (11.10%). The pH values were between 3.1 and 7.3. The cassava effluent sample was the most acidic with pH 3.1, followed by the contaminated soil which had 4.8. The BOD value of the cassava effluent was 7.81 mg/ml. Nitrate, phosphate and sulphate contents were lowest in the uncontaminated soil (1.95, 0.24 and 0.22 mg/ml) and highest in the effluent contaminated soil (2.01, 0.37 and 0.41 mg/l respectively). Other minerals like Zn, Pb, Fe, Cu and Al were higher in the effluents than the contaminated soil and the control soil whereas, Mg, K, Ca and Na were higher in uncontaminated soil than the contaminated soil and the effluent.

From the results, it is seen that the effluent from cassava processing plants obviously caused some changes in the contaminated soil sample collected. The moisture content was higher in the contaminated soil sample than the uncontaminated ones. This may be due to the decrease in the soil porosity caused by the effluent, which is expected because of the starch content of the cassava effluent (Afuye and Mogaji, 2015). The pH of the effluent and the contaminated soil were lower (more acidic) than that of the uncontaminated soil. This is no doubt due to the presence of hydrogen cyanide present in the effluent. Cassava are known to contain high level hydrogen cyanide (Nwokoro *et al.*, 2013).

Table 3: Physicochemical parameters of the cassava mill effluent contaminated soil

Parameter	Effluent	Contaminated soil	Control
Moisture content %	NA	15.03 ± 0.07^{b}	11.10 ± 0.05^{a}
BOD (mg/l)	7.81	NA	NA
pH	3.1 ± 0.01^{a}	4.8 ± 0.01^{b}	7.3 ± 0.01^{c}
Nitrate (mg/l)	1.91 ± 0.00^{a}	2.01 ± 0.00^{a}	1.95 ± 0.00^{a}
Phosphate (mg/l)	0.52 ± 0.00^{c}	0.37 ± 0.00^{b}	0.24 ± 0.00^{a}
Sulphate (mg/l)	0.34 ± 0.00^{a}	0.41 ± 0.00^{c}	0.22 ± 0.00^{a}
Zinc (mg/l)	28.06 ± 2.00^{c}	12.19 ± 0.05^{b}	1.09 ± 0.00^{a}
Lead (mg/l)	0.82 ± 0.00^{b}	0.60 ± 0.00^{a}	ND
Iron (mg/l)	70.12 ± 5.03^{c}	22.01 ± 1.00^{b}	0.52 ± 0.00^{a}
Sodium (mg/l)	17.56 ± 2.05^{a}	35.11 ± 1.50^{b}	52.01 ± 4.25^{c}
Copper (mg/l)	4.07 ± 0.06^{b}	1.59 ± 0.00^{a}	ND
Calcium (mg/l)	19.12 ± 1.15^{a}	22.02 ± 2.00^{b}	26.89 ± 1.50^{b}
Potassium (mg/l)	15.23 ± 1.00^{a}	14.67 ± 1.00^{a}	31.17 ± 3.00^{b}
Magnesium (mg/l)	19.11 ± 1.00^{a}	21.90 ± 1.00^{a}	43.01 ± 3.06^{b}

Aluminum (mg/l)	1.43±0.00^{b}	0.73±0.00^{a}	ND

The pH of the cassava effluent was very acidic which may be due to the high cyanide content. Effluent from cassava processing plants therefore may be regarded as harmful and should not be allowed to spread over farmlands. The soil pH determines the availability of nutrients and the potency of toxic substances as well as the physical properties of the soil (Ezeigbo *et al.*, 2014).

The BOD value obtained from this study exceeded the levels of 6 mg/l for drinking water <4 mg/l, therefore cassava mill effluents may be a threat to human health. High BOD constituted risks to fauna, flora and surface or underground water. The high BOD level from this study might be attributed to the presence of high organic matter in the effluent. The organic matter is broken down by bacteria which require oxygen for decomposition process, thus increasing the levels of BOD (Nweke, 2004).

The nitrate, sulphate and phosphate levels were higher in the effluent and contaminated soil than in the uncontaminated soil sample. High nitrate levels have been associated with increased aeration and increased concentration of ammonia. But altered pH in effluent soils has significantly higher nitrate and phosphate contents due to the fact that cellulose debris of the effluent enhanced organic matter decomposition (Ezekiel *et al.*, 2012; Ariyomo et al., 2017). This is in agreement with the results of this study.

The mineral contents (Ca, Mg, Na and K) were significantly lower in the contaminated soil than in uncontaminated soil sample due to high content of hydrogen cyanide which may be present in the contaminated soil. The hydrogen cyanide dissolves in the effluent and remains in solution; when it enters the soil, part of the cyanogenic glycosides remain unconverted by microorganisms because of the few enzymes present in the cassava fibre which are not enough for complete conversion (Izah, 2016). This is detrimental to soil health and reduces quality of the soil and can result in the decrease of soil pH (increased acidity), magnesium, potassium, calcium and sodium while phosphate, nitrate and sulphate were on the increase. Long-term and continued use of effluent water may lead to changes in soil chemical and physical properties (Nweke, 2004).

Heavy metals such as Zn, Pb and Fe were higher in the effluent contaminated sample than the control soil sample. This has deleterious effect on the environment. Heavy metals affect the growth, morphology and metabolism of microorganisms in soil through functional disturbance, protein denaturation or the destruction of the integrity of cell membranes. Soils receiving cassava mill effluent have higher level of heavy metals with iron having the highest concentration. This is in agreement with the report of this study that reported an increase in heavy metal content in the order Fe>Zn>Mn>Cu>Al>Pb for the cassava effluent and contaminated soil 1 samples (Izah *et al.*, 2017).

CONCLUSION

Based on the results obtained in this study, the continuous disposal of cassava processing wastes into the soil environment of the cassava mill brought about changes in the microbiological and physicochemical properties of the soil environment around the mill. The changes are deleterious to the environment as helpful microorganisms are destroyed, soil pH is lowered and there are spikes in the heavy metal content of the contaminated soil. Based on the foregoing, it is recommended that cassava processors should be educated and made aware of the health and environmental effects of cassava effluent. Also, more studies should be done to determine the effect of the cassava mill effluents on the growth of some food crops.

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