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Investigation into Some Physicochemical Properties of Cassava Processing Effluent

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***Abstract* — *The ecosystem requires proper control in order to keep it healthy for the survival of animal, plant and human being. It is therefore necessary to investigate the level of some physiochemical properties of a typical cassava effluent in order to ascertain if the effluent could affect the ecosystem when discharged to soil and water environment without proper control. In this study, analyses were carried out on prepared cassava (TMS 30572) effluent, cassava effluent free water and then compared the values obtained with safe limit of water quality standard. Statistical analyses were carried out. Result showed that the mean values of physicochemical parameters of cassava effluent and control (water) had statistical significant difference. The physicochemical properties of the cassava effluent when compared with safe limit by FMEnv had higher values except pH, COD, TH and SO_4^{2-}. Technical analysis revealed that discharged cassava processing effluent if not control may cause serious harm to the ecosystem.*

***Keywords* — *Cassava effluent; Physicochemical properties; Water; Soil; Ecosystem.*

I. INTRODUCTION

In some African countries, cassava is staple food; though, it could also find application in livestock as feed. In Nigeria, one of the major varieties grown is TMS 30572. It has a wide ecological adaptation. The bye products of cassava may contain high amount of polyphenols (tannins), hydrogen cyanide (HCN) and phytate. However, its protein content is low. The quality of effluent generated is reasonably large from cassava processing because cassava is used for many purposes. Some of the usages are as food for man and industrial applications like production of adhesives, monosodium glutamate, plywood, alcohol, sweetness, paper, amino acids, etc. (Bengtsson and Trust, 1994; Akpan and Ikenebomeh, 1995). The major problem associated with cassava processing is the manner of disposing the wastewater as it contains high amount of cyanide. Generally, the content of cyanide in cassava may vary depending on factors such as varieties, climate, edaphic, etc. Worthy to note is that cyanide in cassava is in the form glycoside (98% linamarin and 7% lotaustralin). Also, the waste water from cassava fermentation is offensive. In metallurgical activities, the organic cyanide salts could be used industrially in metal surface treatment and in mining of gold, etc. (Metcaf and Eddy, 2004; Holland, 1983; Benia, 2007; David *et al.*, 2013). In mitochondria, it could impair the oxidation phosyhorylation by inhibiting cytochrome oxidase in the respiration electron transport chain. In the environment, the discharge of untreated waste water following cassava processing may affect the soil and by extension the economic plant grown on such effluent affected soil. However, the ecosystem requires water to keep itself healthy. Some standard acceptable for water quality in Nigeria by Federal Ministry of Environment (FMEnv) are as follows:

TABLE 1: FMEnv's (Federal Ministry of Environment) Water Quality Standard

Parameters	FMEnv Limit
Colour	7
Odour	-
pH	6.5 – 8.5
Temperature, (°C)	< 40
Electrical Conductivity (EC), ucm/s	2000
Turbidity (NTU)	15
TDS (mg/l)	500
TSS	30
TH	200
COD	120
BOD_5	10
DO	3.0 (minimum)
NO_3^-	10
SO_4^{2-}	500
PO_4^{3-}	5
Chlorine (Cl^-), mg/l	250
Zinc (Zn), mg/l	1.00
Lead (Pb), mg/l	0.05
Copper (Cu), mg/l	1.00
Iron (Fe), mg/l	0.025
Chromium (Cr), mg/l	0.05
Nickel (Ni), mg/l	0.05

Source: FMEnv's (2005).

Therefore, in this study, attention would be focused on investigating some physicochemical properties of cassava processing effluent in order to provide a data base that would help to draw attention for solution to minimize its effect on the soil and water environment.

II. MATERIALS AND METHOD

A. Materials

The following were used for this study: cassava (TMS 30572), water, cassava effluent, burettes, pipettes, mercury – in-glass Celsius thermometer, pH meter, (HACH model), water-checker, conical flasks, beakers, white polyethylene bottles, steam bath , oven, desiccator, emission-photometer (FEP), atomic absorption spectrophotometer (AAS), UNICAM 8625 UVVIS spectrophotometer, Suntex SC-120 conductivity meter and Kjeldahl distillation apparatus.

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B. Methods

Some of the physicochemical properties of cassava effluent sample were analyzed as follows:

(i) The Determination of Total Cyanide

Standard curve for cyanide concentration was prepared using different concentration of KCN solution that contained between 5 to 50 mg of cyanide. 5 g of cassava sample was grounded into a paste and was dissolved in conical flask containing a 50 ml distilled water. The flask was corked and the extract kept overnight and thereafter filtered. A corked test tube was filled with 1 ml of the filtered sample and 4 ml of alkaline was added. This was incubated for 5 minutes in a bath until reddish brown colour was developed. Spectrophotometer at 490 nm was used to read the absorbance with reference to a blank solution of 1 ml distilled water and 4 ml alkaline. The cyanide curve prepared was used to extrapolate the total cyanide content of the cassava sample.

(ii) Determination of Conductivity

A model Suntex SC-120 conductivity meter was used in measuring the conductivity of the cassava effluent by dipping the meter electrode into the effluent; and reading taken.

(iii) Determination of biochemical oxygen demand (BOD_5); chemical oxygen demand (COD) and total hardness (TH)

The BOD_5, COD and TH of the cassava effluent were carried out based on AOAC (2004) method of analysis.

(iv) Determination of total dissolved solids (TDS); total suspended solids (TSS); dissolved oxygen (DO):

The TDS, TSS and DO were done using Winkler method (Ademoroti, 1996)

(v) Determination of Chloride, Nitrate, Sulphate and Phosphate:

The chloride (Cl^-) concentration; nitrate (NO_3^-) concentration; sulphate concentration (SO_4^{2-}) and phosphate (PO_3^-) concentration were done as described by Ademoroti (1996).

(vi) Determination of Nitrogen

5g (approximately 5 ml) of cassava effluent was added into a Kjeldahl digestion flask; then 1.5 g each of Cu_2SO_4 and Na_2SO_4, 10 ml of concentrated H_2SO_4 were added to the content of the flask. Heated mantle positioned in a fume cupboard was used to heat the mixture to obtain a clear solution. The digest was then pour to 100 ml volumetric flask and diluted with distilled water to mark. 10 ml of the aliquot of the digest was mixed with equal volume of 45% NaOH solution and thereafter distilled in a semi micro Kjeldahl distillation apparatus. Two (2) drops of mixed indicator (methyl red and blue) into 10 ml of 2% boric solution in a flask was used to collect the distillate; and then titrated using 0.1M HCl solution until there was a change in the colour of the digest. Also, a blank experiment was set up. The percentage nitrogen content was calculated using Addy and Eteshola (1994) approach as:

$$\%\ \text{Nitrogen content} = \frac{0.14 \times titre\ value}{Weight\ of\ sample} \quad (1)$$

(vii) Determination of pH

A pH meter was initially standardized using buffer solution and thereafter, the electrodes were of the pH meter were rinsed with distilled water before inserted in the cassava effluent sample to read its pH (APHA, 1995).

(viii) Determination of Zinc and Copper Concentrations in Cassava Effluent

10 ml of the cassava effluent sample was introduced into a digestion flask. 10 ml aqua regia acid was added to the sample and heated in a hot plate for 1 hour. The digested sample was then cooled and thereafter quantitatively removed into 100 ml volumetric flask. The volume was adjusted to 100 ml with distilled water; and the digested sample was taken for the determination of heavy metal contents (Zinc and Copper) using atomic absorption spectrophotometer (AAS) based on the standard of APHA (1998).

(ix) The water used in preparing the cassava effluent were analyzed and taken as control using experimental procedures in (i) to (viii).

The data obtained from the experimental runs were analyzed using Statistical Package for Social Scientists [SPSS] (2011) and Microsoft Excel ™

III. Results and Discussion

The physicochemical properties of the cassava effluent and water used in preparing the effluent were obtained. Their values were statistically compared using t-test along with safe limit by Federal Ministry of Environment (2005) in Nigeria and are presented in Table 2.

TABLE 2: Safe Limits of Water Quality Standard and Comparison of Mean Values of Physicochemical Properties of Cassava Effluent with Water (Control)

	Cassava Effluent		Water (Control)			5% Level of Probability		
Parameters	**Mean**	**Std Dev.**	**Mean**	**Std Dev.**	**FMEnv's Limit**	**t_{cal}**	**t_{tab}**	**Significant?**
Cyanide (CN), mg/l	234.50	0.01	0.00	0.00	-	40616.591	2.776	Yes
pH	3.81	0.01	5.24	0.03	6.5-8.5	-81.262	2.776	Yes
Conductivity, µs/cm	6949.62	0.53	19.47	0.01	2000	22827.36	2.776	Yes
Total Dissolved Solid (TDS), mg/l	3469.68	0.23	9.96	0.01	500	21351.59	2.776	Yes
Total Suspended Solid (TSS), mg/l	1674.97	0.04	3.99	0.02	30	755572.91	2.776	Yes
Dissolved Oxygen (DO), mg/l	3.51	0.02	8.44	0.01	3.0 (min.)	-445.94	2.776	Yes
Biochemical Oxygen Demand (BOD_5), mg/l	8.49	0.00	6.31	0.02	10	218	2.776	Yes
Chemical Oxygen Demand (COD), mg/l	57.54	0.02	28.61	0.02	120	1893.91	2.776	Yes
Total Hardness (TH), mg/l	146.31	0.02	49.13	0.02	200	6688.62	2.776	Yes
Chloride (Cl^-),mg/l	3195.72	0.26	34.13	0.05	250	20575.3	2.776	Yes
Nitrate (NO_3^-),mg/l	37.55	0.03	40.14	0.03	10.0	-110.17	2.776	Yes
Sulphate (SO_4^{2-}), mg/l	55.58	0.03	31.61	0.01	500	1358.78	2.776	Yes
Phosphate (PO_4^{3-}), mg/l	81.40	0.03	5.85	0.02	5.0	4070.9	2.776	Yes
Zinc (Zn), mg/l	3.19	0.03	0.16	0.02	1.00	153.99	2.776	Yes
Copper (CU), mg/l	1.73	0.03	0.14	0.00	1.00	84.64	2.776	Yes
Nitrogen (N) %	8.39	0.06	0.92	0.03	-	189.23	2.776	Yes

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The cyanide content of the effluent was 234.50 mg/l while that of control was zero mg/l. This implies the tendency of high toxicity to crops; animal and even human, if crops grown where the effluent is discharged are consumed.

The pH of the sample (3.81) was lower than that of control (5.24). But the control was a bit lower than that of FMEnv's Limit. The sample pH of 3.81 is an indication of highly acidic environment which might affect microorganisms' functionality.

Besides, the effluent conductivity was found to be 6949.62 μs/cm and was the highest compared to the value of the control (19.47 μs/cm) and FMEnv's Limit (2000 μs/cm). The ability of a medium to conduct electric current is indicated by its conductivity. The conductivity of the effluent and water is contributed by the ionized substances only. Therefore, ionized substances may distort osmoregulation of aquatic lives (Adesemoye *et al.*, 2006).

TDS value (3469.68 mg/l) of the effluent was the highest compared to that of the control (9.96 mg/l) and FMEnv's Limit (500 mg/l). This may be as a result of the presence of organic (bacteria, algae and zooplankton) or inorganic (chloride, calcium, clay, bicarbonates, silt, etc.) materials (Carvallo *et al.*, 1999). The presence of TDS could reduce penetration of light, hence, algae ability to photosynthesize would be reduced. It is therefore necessary to discourage the discharge of such effluent into fresh water environment except if the effluent is further diluted.

Besides, effluent TSS (1674.97 mg/l) recorded the highest value when compared to that of control (3.99 mg/l) and FMEnv's Limit (30 mg/l). It should be noted that TSS could be filtrated and could cause the temperature of the surface water to increase since heat is absorbed from sunlight by the suspended particle. Thus, if such level of TSS is discharged into water bodies without adequate treatment. It would create a negative effect. DO value (3.51 mg/l) observed in the effluent was the highest compared to the values of the control (8.44 mg/l) and FMEnv's Limit (3.0 mg/l). Thus, the effluent could sustain marine life when discharged into the water bodies.

The value of BOD_5 (8.49 mg/l) in the effluent was higher than that of the control (6.3 mg/l), but lower than that of FMEnv's Limit (10.0 mg/l). The value obtained for the BOD_5 suggests that less oxygen may be used for the biodegradation of the waste existing within the environment; and leaving behind large amount for biochemical activities (APHA, 1995).

The effluent COD value (57.54 mg/l) was higher than that of the control (28.61 mg/l) but lower than the value of FMEnv's Limit (120.0 mg/l). The observed value showed that moderate amount of chemical organic matter is present in the effluent.

The effluent TH value (146.31 mg/l) was higher than that of the control (49.13 mg/l) but lower that of FMEnv's Limit (200.0mg/l). This might be as a result of the presence of certain ions such as Ca^{2+}, etc. which if such is discharged into water bodies might constitute a problem or extra cost in softening the water for use.

The effluent chloride content (3195.72mg/l) was found to be the highest when compared to that of control (34.13 mg/l) and the FMEnv's Limit (250.0 mg/l). Chloride would increase the electrical conductivity of water and by extension increase its corrosion; since chloride could react with metal ions to form soluble salts. Thus, the increasing levels of metals would increase in drinking-water. In fresh water, the presence of high concentrations of chloride could cause harm to aquatic organisms as it would interfere with osmoregulation. The osmoregulation process facilitates the maintenance of proper concentration of salt and other solutes in aquatic organism bodily fluids. Hence, it could influence the survival, growth and reproduction of the aquatic organism (Molly *et al.*, 2014). The observed value therefore indicate that the effluent would be harmful to aquatic organisms if the effluent is discharged without treatment.

The effluent nitrate content (37.55 mg/l) was found to be lesser than of control (40.14 mg/l) but greater than of FMEnv's Limit (10.0 mg/l). Nitrate concentration when in excess would stimulate excessive growth in algae and plants. On the other hand, the excess concentration of nitrate in water could create situation where the aquatic insects and fish would find it difficult to survive (WRIG, 2019). The observed value showed that the effluent might be harmful to aquatic fishes and humans.

The effluent sulphate content (55.58 mg/l) was found to be higher than of control (31.61 mg/l) but lesser than of FMEnv's Limit (500.0 mg/l). In water pipes, the building up of scale formation may be encouraged by the presence of sulphate mineral. It may also cause water to have bitter taste and could in humans and young livestock have laxative effect (Orewole *et al.*, 2007). The observed value is moderate. This implies that the effluent can still create healthy environment to human and livestock.

The effluent phosphate content (81.40 mg/l) was found to be the highest compared to that of control (5.58 mg/l) and FMEnv's Limit (5.0 mg/l). The presence of phosphates in water ecosystem could encourage algae to grow out of control. This might cause imbalance that could negatively affect other forms of life and also cause harmful toxin to be produced. More so, plant requires phosphates for its growth but phosphates in excess in water could cause cloudiness and low oxygen. This in turn would reduce the availability of sunlight to the water plant and might likely kill them (Jenny, 2018). So, the observed value indicates that the effluent would pose serious threat to aquatic lives.

The effluent zinc content (3.19 mg/l) was found to be the highest compared to that of control (0.16 mg/l) and FMEnv's Limit (1.0 mg/l). Zinc is one of the essential trace elements required by aquatic organisms and humans. However, high levels of zinc in drinking water could lead to vomiting, cramps and nausea. Higher concentrations of zinc in streams would affect fish's growth and survival. It would also impose structural damage to fish (Sehar *et al.*, 2014; Wang *et al.*, 2000). The observed value implies that the effluent would impose health hazard to both fish and humans.

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The effluent copper content (1.73 mg/l) was found to be the highest compared to that of control (0.14 mg/l) and FMEnv's Limit (1.0 mg/l). When copper concentration is high in drinking water, it might cause chronic anemia (Asma *et al.*, 2011). The Wilson's disease is fundamentally cause by copper toxicity (Gebrekidan and Samuel, 2011). The observed value indicates that the effluent would pose health threat to both human and livestock.

The effluent nitrogen content (8.39 mg/l) was higher than that of control (0.92 mg/l). Usually, plant and animal require nitrogen for their growth but excess of it could over stimulate the aquatic algae and plants growth. This could result in clogging of intake of water and by extension the organism may decompose and use up the dissolved oxygen coupled with blocking of light into the deeper water. This could occasionally kill fish. In drinking water, high concentration of nitrogen, as nitrate, could cause harm infants and young livestock (USGS, 2019). The observed value implies that the effluent if discharged into water bodies would create environmental health threat to humans.

IV. Conclusion

Based on the obtained values of physicochemical parameters of cassava effluent, the effluent if discharged without proper control could cause serious harm to aquatic life, livestock, plant and human.

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