Direct Research Journal of Public Health and Environmental Technology
Vol.4 (4), pp.21-25, October 2019
ISSN 4372-2603
DOI: https://doi.org/10.5281/zenodo.3475616
Article Number: DRJPHET12508684

https://directresearchpublisher.org/drjphet/

Full Length Research Paper

Remediation of effluent from cassava processing mills

*[1]Uguru, H., and [2]Obah, G. E.

[1]Department of Agricultural and Bio-Environmental Engineering Technology, Delta State Polytechnic, Ozoro, Delta State, Nigeria.
[2]Department of Civil Engineering Technology, Delta State Polytechnic, Ozoro, Delta State, Nigeria.
*Corresponding author E-mail: erobo2011@gmail.com

Received 5 September 2019; Accepted 29 September, 2019

Cassava is a major staple food in most African and Asia countries, but its processing usually releases effluent which is high in cyanide and other heavy metals to the environment. The main objective of this study is to develop a bioremediation method aimed at degrading cassava effluent. Results obtained from this study show that organic soap solution (pH of 9.8 and electrical conductivity and 1330 µS/cm), had a significant effect on the cyanide, Zinc, Nickel, Chromium, Phosphorus and potassium content of the cassava effluent within the treatment period of 6 days. Furthermore, the organic soap solution significantly reduced the total coliforms colonies in the cassava effluent within the treatment period. A comparison of the treatment effluent results with NIS standards shows that most of the pollutant parameters were almost at the acceptable limits after the treatment with the exception of Potassium and phosphate. The results from this study apparently indicated that organic soap solution was very efficient in degrading the cassava effluent to appreciable level, but it should be further researched to explore its greater remediation potential.

Keywords: Cyanide, organic soap, cassava, effluent, environment

INTRODUCTION

Cassava (*Manihot esculenta*) belongs to the family *Euphorbiaceae*, and the tubers are quite rich in carbohydrates with a poor in vitamins and protein. The high carbohydrate content of cassava makes it a staple food item especially for the lower income earners in most countries, especially Africa and Asia (Desse and Taye, 2001). Cassava roots contain toxic substances such as; cyanogenic glucosides, primarily linamarin, and a small amount of methyl linamarin, (Ogunyemi *et al*., 2018). Boadi *et al*. (2008) observed that raw cassava root and its peels contains between 360.05 to 509.51 mg/kg of cyanide. Ingestion of cyanide above 300 ppm (part per million) can lead to respiratory problems and eventually death, if not treated. This is why cassava roots are thoroughly prepared through roasting, boiling or fermentation before consumption. The increased in the utilization of cassava products has increased the problem environmental pollution through indiscriminate disposal of the cassava effluent and other waste products.

In most Africa countries, cassava processing mills are small scale business enterprise, managed by people who have no basic knowledge of environmental protection. Though these processing mills are of small scale, they create enormous negative impact on the environment through air, water and soil pollution (Eze and Onyilide, 2015; Eboibi *et al*., 2018). Akpokodje *et al*. (2018) observed that cassava effluent significantly retarded the growth performance of two bean (*Phaseolus* spp.) cultivars. Researches were conducted on the negative effects of cassava processing effluent on the soil physical characteristics and terrestrial plants by Olorunfemi *et al*. (2008) and Olorunfemi *et al*. (2011). Olorunfemi *et al*. (2008) observed that the pH of soil contaminated with cassava effluent decreased from 6.96 to 3.89; indicating that the effluent imparted acidic properties to the soil properties. Besides the high concentration of poisonous cyanide, Olorunfemi *et al.,* (2019) reported that cassava effluent contains varying concentrations of heavy metals. According to Olorunfemi *et al.,* (2019) the nickel, chromium, cadmium, lead, copper, iron, zinc and manganese content of cassava effluent ware 1.02, 0.20, 0.40, 1.94, 3.08, 72.40, 25.10 and 2.80 mg/L respectively, which are above the National Environmental Standards and Regulations Enforcement Agency (NESREA), and United States Environmental Protection Agency (USEPA) maximum permissible limits for wastewater. In addition, Eze and Onyilide, (2015) reported appreciable high level of contamination arising from the discharge of effluents on agricultural soil, and recommended proper treatment before the discharge in the environment. Water is a vital human resource, human beings depended upon it in the areas such as agriculture, industry, transportation, domestic uses etc. (Awomeso *et al.* 2010); however, it is the most abused, poorly managed and polluted resource by human activities (Fakayode, 2005). Cassava effluent causes anomalies in cell division process and chromosome aberration induction in *Allium cepa* root meristem which could be as a result of heavy metals-cyanide interaction in cassava waste waters (Olorunfemi *et al*., 2011). Indiscriminate discharge of untreated or partially treated wastewaters directly or indirectly into aquatic bodies may render water resources unwholesome and a hazardous to man and other living system (Kumar, 2008; Fawole *et al*., 2008). Total coliforms include species that may inhabit the intestines of warm-blooded animals or occur naturally in soil, vegetation, and water. They are usually found in fecally-polluted water and are often associated with disease outbreaks. Although they are not usually pathogenic themselves, their presence in drinking water indicates the possible presence of pathogens (APHA, 1992). Treatment of effluent and wastewater from agricultural processing activities is essential before they are discharged into the environment in order to reduce potential environmental hazards (Ewemoje *et al*. (2011). Remediation of cyanide contaminated water can be done through chemical or biological processes. Chemical method is very expensive and usually had negative impacts in the environment at times. Biological remediation method makes use of microorganisms, such as fungi (*Fusarium solani*) and bacteria (*Pseudomonas fluorescens*) (Jaszczak *et al.,* 2017). Omotosho and Sangodoyin, (2013) reported that wastewater from cassava processing mills can be effectively treated using a combination of hydrogen peroxide oxidation and sorption with $ZnCl_2$ at activation levels of 2:3 and 1:1. Nigeria, like others developing countries, bioremediation of cassava effluent is still uncommon due to dearth of information. Therefore, the main objective of this study was to investigate the possibility of employing organic soap solution of pH 9.8 and electrical conductivity 1330 µS/cm, in degrading cassava effluent from cassava processing mills, to appreciable level before it is discharged into the environment.

MATERIALS AND METHODS

Sample collection

The cassava effluent was collected from cassava processing mill in black container and stored at about 6°C to ensure the integrity of the cassava effluent before the chemical and biological analyses were carried out on it.

Organic soap preparation

Palm fruit bunch waste was collected from the palm oil mill of Delta State polytechnic, Ozoro, Nigeria. The waste was sundried and burnt into ashes. After that, the ashes were dissolved in distilled water to obtain a heterogeneous solution. The solution was filtered with whatman No1 filter paper, and the filtrate obtained evaporated to dryness. Crystals recovered from the dried solution was used to prepare the organic soap according to standard method.

Physicochemical analyses

The APHA (1992) approved methods for the determination of total cyanide (Cn) in effluent was used in determining the cyanide level in the cassava effluent. Distillation was first carried out followed by the addition of pyridine-barbituric acid to give a red-blue coloured complex and the absorbance was measured in a UV spectrophotometer at 578 nm (Osobamiro, 2012). This method has very low detection limits, making it ideal for the analysis of cyanide in waste water. Heavy metals such as Chromium (Cr), Zinc (Zn) and Nickel (Ni), were determined with the aid of Atomic Absorption Spectroscopy (AAS) at specific wavelengths and pH as recommended (AOAC, 1995). The mineral elements such as Potassium (K) and Phosphorus (P) contents of the cassava effluent were also determined using the AAS (Atomic Absorption Spectrometer) by the procedure recommended (APHA, 2005; AOAC, 1995). While the electrical conductivity and pH of the cassava effluent and the organic soap solution were determined with a digital conductivity meter (EMCEE Model 1152, India).

Biological properties

Coliform MPN (most probable number) test

Series of test tubes were filled with the cassava effluent, and a smaller inverted test tube inside which captures carbon dioxide gas released from the growth of coliform bacteria. The inoculated fermentation tubes were incubated at 35 ±0.5°C for 48h. Formation of gas within 48 hours in the Durham tubes indicated the presence of coliforms, and statistical analysis was used to determine the MPN of bacteria cells present (Ugwu and Agunwamba, 2012).

Experimental setup and data analysis

The experiment was set up in two levels (control and treated). Under the treated level, four dark coloured plastic containers, containing the cassava effluent was treated with organic soap (locally formulated soap from oil palm bunch) solution at a concentration of 200g/25L (weight: Volume). The containers containing the effluent (both control and treated) were stored in dark room. All the parameters (pH, Cn, Cr, Zn, Ni, P, K, coliform counts) of the cassava effluent was be investigated with six days treatment period at 48 h interval, in four replications per each sample.

The analysis of variance (ANOVA) of the data collected in this research was analyzed using the SPSS 20.0 software; and the significant means separated by Duncan's Multiple Range tests ($p \leq 0.05$). The summary of the readings was plotted in Microsoft Excel 2015, and the correlation was determined by using the MS Excel 2015 (Microsoft Corporation Redmond, WA 98052).

RESULTS AND DISCUSSION

The Analysis of Variance (ANOVA) of the effect of organic soap solution amendment on the physiochemical properties of the cassava effluent is presented in (Table 1). From the ANOVA table, organic soap solution had significant ($p \leq 0.05$) effect on the eight parameters (pH, Coliform, K, P, Cn, Zn, Cr and Ni) investigated in this study. Treatment period only had significant ($p \leq 0.05$) effect on the pH, Coliform, Cn, Zn, Cr and Ni. The interaction of treatment and treatment period only significantly influenced the coliform, P, Cn and Zn contents.

The mean results of physiochemical properties of the cassava effluent, before and after remediation are presented in (Table 2). As shown in the results (Table 2) the organic soap solution was able to degrade the toxic heavy metals in the cassava effluent to applicable level, even though they are still slightly higher than the maximum standard permitted by NIS (2007). From the results shown in (Table 2), the application of the organic soap solution degrades the cassava effluent chromium concentration (from 2.33 mg/l to 0.06 mg/l) at the end of the experimental period. Chromium and its compounds are known to cause cancer of the lung, nasal cavity and paranasal sinus and suspected to cause cancer of the stomach and larynx (ATSDR, 2000; Eboibi *et al*., 2018). These results are in conformity with previous studies of Oviasogie and Ndiokwere, (2008) and Omotosho and Amori, (2015). With reference to the mean separation table (Table 2), the treated cassava effluent shows a drastic reduction in levels of contaminants in the effluent within the treatment period of six days, in comparison to the control samples. The high heavy metals (zinc, copper, manganese, iron, etc.) concentration of cassava effluent could also be attributed to the wearing off of the cassava milling machine parts and emission from the cassava grating machine (Osakwe, 2010; Igbinosa and Igiehon, 2015). Unlike toxigenic organic materials which are prone to degradation, these heavy metals are transferred from the abiotic environment to living organisms, accumulated in biota at different trophic levels, and thus contaminate the food chains/webs (Ali and Khan, 2019)

As shown in (Table 2), the cassava effluent cyanide concentration declined significantly ($p \leq 0.05$) within the six day experimental period. The cyanide concentration of the cassava effluent decreased from 3.33 mg/l to 0.08 mg/l, within the experimental period. This result is in similar trend with previous results of Ugwu and Agunwamba, (2012), Omotosho and Amori, (2015) and Eboibi *et al*. (2018) when NaOH, caustic hydrogen peroxide, and organic soap were used as remediation agents. According to Eboibi *et al*. (2018), the cyanide concentration of cassava effluent contaminated soil decline from 26.36 mg/kg to 4.19 mg/kg, after remediation with organic soap solution for experimental period of 21 days. With reference to (Table 2), the level of bacterial coliforms in the control unit increased significantly ($p \leq 0.05$) within the experimental period; whereas, addition of organic soap solution resulted degraded the coliforms content of the cassava effluent within the same experimental period. This could be attributed to increase in the pH of the effluent caused by the organic soap, which might favor the growth of alkali bacteria in the hydrolyzates. The decrease in the coliforms content over time signified a reduction in the pollution of the cassava effluent (Ugwu and Agunwamba, 2012).

The correlation coefficient (r) values (Table 2) exhibited that all the studied parameters were highly significantly and positively associated with organic soap treatment. The high (both positive and negative) correlations are indications of the organic soap solution effectively degraded the pollutants in the cassavas effluent upon the application of the solution. The significant degrading of the cyanide and other heavy metals in the soil is an indication that organic soap solution could be used effectively in soil bioremediation.

In addition, the organic soap solution significantly increased the pH value of the samples during the treatment period (Table 2). The low pH of the raw cassava effluent could be attributed to the hydrocyanic acid contained in the cassava root. High acidity determines the availability of nutrients, the potency of toxic substances as well as some physical properties of the soil (Osakwe, 2012). The increment in the phosphate and potassium values could be attributed to the major constituent of the organic soap used as the bioremediation material. The bacterial count load of the treated effluent was lower than the control sample. The results from this study apparently indicated that organic

Table 1. ANOVA of effect of organic soap on microbial and physiochemical properties of cassava effluent.

Source	pH	Coliform	K	P	Cn	Zn	Cr	Ni
P	3.1E-06*	3.5E-05*	0.9495^ns	0.0912^ns	1.2E-10*	0.000214*	0.04078*	0.00067*
T	3.3E-10*	3.8E-10*	2.9E-05*	5.5E-11*	6.2E-16*	8.3E-11*	5.8E-06*	1.5E-11*
P x T	0.0609^ns	0.00047*	0.7534^ns	0.0478*	0.00073*	0.01627*	0.4325^ns	0.1506^ns

T = treatment; P = treatment period; * = significant at p ≤ 0.05; ns = not significant.

Table 2. The Physicochemical composition of cassava effluent as affected by organic soap treatment.

Parameter	Cassava effluent	Control sample	Treated sample	NIS standard (Maximum Permitted)	Correlation
pH	4.93±0.15	5.77^a±0.06	7.20^b±0.36	6.5 – 8.5	0.96478
Cyanide (mg/L)	3.33±0. .02	2.18^a±0.05	0.08^b±0.09	0.01	-0.8873
Chromium (mg/L)	2.33±0.54	1.79^a±0.52	0.06^b±0.01	0.05	-0.9711
Nickel (mg/L)	2.12±0.14	1.69^a±0.10	0.11^b±0.07	0.02	-0.9096
Zinc (mg/L)	10.95±0.57	9.54^a±0.54	3.16^b±0.61	3	-0.9700
Total Coliform count (cfu/mL)	133±11.27	337^a±46.51	28^b±4.04	10	-0.9678
P (mg/L)	15.39±0.45	13.28^a±1.26	22.43^b±0.35	-	0.9001
K (mg/L)	28.2±23.11	22.77^a±2.57	54.66^b±12.81	12	0.8685

Values are means ± standard deviation; Means on the same row between samples with same superscripts are not significantly different (p>0.05).

soap solution was very efficient in degrading the cassava effluent to appreciable level; but it should be further researched upon to explore its greater remediation potential.

Conclusion

This study was conducted to investigate the possibility of employing organic soap solution in degrading cassava effluent from cassava processing mills, to appreciable level before it is discharged into the environment. Results obtained from this study showed that the treatment of cassava effluent with organic soap solution can significantly degrade the cyanide, pH, bacterial coliform count, and heavy metals content of cassava effluent. Within the six day experimental period, the cyanide concentration of the cassava effluent decreased from 3.33 mg/l to 0.08 mg/l; while the chromium concentration decreased from 2.33 mg/l to 0.06 mg/l. In addition, the results showed that the organic soap solution significantly ($p \leq 0.05$) increased some non-metals (P and K) to appreciable level. The phosphorus content of the cassava effluent increased from 15.39 mg/l to 22.43 mg/l at the end of the experimental period; while the potassium content increase from 28.2 mg/l to 54.66 mg/l within the same experimental period. Since the processing of cassava results in the generation of effluent and other wastewater that contain materials such as cyanide, heavy metals and mineral elements, this research provides useful information for the design and development of efficient treatment plants that can detoxify cassava effluent and wastewater. More researches are needed in this aspect of bioremediation, to find out ways of detoxifying the cassava effluent before its disposal to the environment.

Authors' declaration

We declared that this study is an original research by our research team and we agree to publish it in the journal.

REFERENCES

Ali H, Khan E (2019). Trophic transfer, bioaccumulation, and biomagnification of non-essential hazardous heavy metals and metalloids in food chains/webs—Concepts and implications for wildlife and human health. *Human and Ecological Risk Assessment: An International Journal*, 25 (6): 1353-1376, DOI: 10.1080/10807039.2018.1469398

Akpokodje O I, Uguru H, Esegbuyota D. (2018). Remediation of cassava effluent contaminated soil using organic soap solution: Case study of soil physical properties and plant growth performance. *Journal of Scientific Research & Reports*. 21(3): 1-11.

APHA - American Public Health Association (1992). Standard Methods for the Examination of Water and Wastewater, 18th edition. American Public Health Association, Washington, D.C.

APHA (2005) In: Eaton AD, Clescer LS, Rice EW, Greenberg AE, Franson MAH (eds.) Standards Methods for examination of waters and wastewaters APHA 21st edition Washington DC.1368.

AOAC - Association of Official Analytical Chemists (1995). *Official Methods of Analysis* 16th edition. Virginia.

ATSDR, Agency for Toxic Substances and Disease Registry. (2000).Toxicological Profile for Chromium. Atlanta, GA: U.S. Department ofHealth and Human Service, Public Health Service. 1600 Clifton RoadN.E, E-29 Atlanta, Georgia 30333 (6-9): 95-134.

Awomeso JA, Taiwo AM, Gbadebo AM, Adenowo JA (2010). Studies on the pollution of water body by textile industry effluents in Lagos, *Nigeria. Journal of Applied Sciences in Environmental Sanitation*. 5 (4): 353-359.

Boadi NO, Twumasi SK, Ephraim JH. (2008). Impact of cyanide utilization in mining on the environment. *Int. J. Environ. Res.*, 3(1):

101-108.
Desse G, Taye M (2011). Microbial loads and Microflora of cassava (*Manihot esculenta Grantz*) and effects of cassava juice on some food borne pathogens. *J. Food Technol. Afri.*, 6(1): 21-24
Eboibi O, Akpokodje OI, Uguru H (2018). Bioremediation of soil contaminated with cassava effluent using organic soap solution. *Journal of Environmental Science, Toxicology and Food Technology*.12:50-57
Ewemoje TA, Omotosho OA, Abimbola OP (2011). Life Cycle Assessment of hatchery production process to point-of-lay of a poultry system in a developing country. *In Proceeding Nigeria Institution of Agricultural Engineers Conference* (Ilorin 2010),122–125
Eze V, Onyilide DM (2015). Microbiological and physicochemical characteristics of soil receiving cassava effluent in Elele, Rivers State, Nigeria. *Journal of Applied & Environmental Microbiology*. 3(1): 20-24
Fakayode S O (2005). Impact of industrial effluents on water quality of the receiving Alaro River in Ibadan, Nigeria. *Ajeam-Ragee*, 10: 1-13.
Fawole OO, Yekeen TA, Ayandele AA, Akinboro A, Azeez MA, Adewoye SO (2008). Polluted alamuyo river: Impacts on surrounding wells, microbial attributes and toxic effects on *Allium cepa* root cells. *Asian J. Biotechnol*., 7: 450-458.
Igbinosa EO, Igiehon ON (2015). The impact of cassava effluent on the microbial and physicochemical characteristics on soil dynamics and structure. *Jordan Journal of Biological Sciences*, 8 (2): 107 – 112.
Jaszczak E, Polkowska Z, Narkowicz S, Namieśnik J (2017). Cyanides in the environment—analysis—problems and challenges. *Environ Sci Pollut Res*. 24:15929–15948
Kumar ARG (2008). Anaphase-telophase aberration assay of fertilizer factory effluent in *Allium cepa* L. J. *Cytol. Genet*., 9:131-135.
NIS - Nigerian Industrial Standard (2007). Nigerian Standard for Drinking Water. Approved by SON Governing Council. Abuja/Lagos HQ. 5.
Ogunyemi A K, Samuel T A, Amund O O, Ilori M O (2018). Toxicity evaluation of waste effluent from cassava-processing factory in Lagos State, Nigeria using the *Allium Cepa* assay. *Ife Journal of Science*, (20)2: 3015 – 315
Olorunfemi DI, Emoefe EO, Okieimem FE (2008). Effect of cassava processing effluent on seedling height, biomass and chlorophyll content of some cereals. *Research Journal of Environmental Sciences*, 3(2):221–228.
Olorunfemi DI, Okoloko GE, Bakare AA, Akinboro A (2011). Cytotoxic and genotoxic effects of cassava effluents using allium cepa Assay. *Research Journal of Mutagenisis*, 1 (1): 1-9.
Olorunfemi D I, Ehigiator FA, Ofomata CR (2019). Evaluation of acute toxicity of cassava effluent on the African catfish [*Clarias gariepinus* (Burchell 1822)] and freshwater Clam [*Egera radiata* Lam (Bivalvia, Donacidae)]. *African Scientist*, 20 (2): 81 - 87
Omotosho OA, Sangodoyin AY (2013). Production and utilization of cassava peel activated carbon in treatment of effluent from cassava processing industry. *Water Practice & Technology*, 8(2): 215 - 224. doi: 10.2166/wpt.2013.023
Omotosho O, Amori A (2015). Caustic hydrogen peroxide treatment of effluent from cassava processing industry: prospects and limitations. *International Journal of Engineering and Technology Innovation,* 5(2): 75-85.
Osobamiro MT (2012). Determination of the concentration of total cyanide in waste water of a tobacco company in southwestern Nigeria. *J. Appl. Sci. Environ. Manage*. 16 (1): 61 – 63
Oviasogie OP, Ndiokwere CL (2008). Fractionation of lead and cadmium in refuse dump soil treated with cassava mill effluent. *J. Agric. Environ*. 9: 10-15
Osakwe SA (2010). Distribution of heavy metals in soils around automobile dumpsites in Agbor and its environment, Delta State, Nigeria. *J Chem Soc Nig*., 35: 53-60.
Osakwe SA (2012) Effect of cassava processing mill effluent on physical and chemical properties of soils in Abraka and Environs, Delta State, Nigeria. *Res J ChemSci*. 2: 7-13.
Ugwu EI, Agunwamba JC (2012). Detoxification of cassava wastewater by alkali degradation. *Journal of Research in Environmental Science and Toxicology*.1(7): 161-167.