International Journal of Innovative Environmental Studies Research 11(4):59-64, Oct.-Dec., 2023

 www.seahipaj.org ISSN: 2354-2918

Effective Waste Management: A Panacea For Environmental Pollution In Cassava Processing Factories In Nigeria

Isiwu Chinedu; I.S. Ezennia; *Ikenna Michael Onuorah & Ejiofor Samuel Osita

Department of Architecture,
Faculty of Environmental Sciences,
Nnamdi Azikiwe University, Awka, Anambra state, Nigeria
***Email: im.onuorah@unizik.edu.ng**

ABSTRACT
Nigeria is the highest producer of cassava in the World with concomitant generation of millions of tons of solid and liquid wastes. These wastes are indiscriminately disposed into the environment causing degradation with attendant serious health hazards to both flora and fauna. There is need, therefore, to properly manage these wastes for a sustainable environment. This research investigated the critical role of efficient waste management practices in mitigating environmental pollution stemming from cassava processing factories in Nigeria. With the burgeoning cassava industry contributing significantly to the nation's economy, the study explores the environmental impact of waste generated during processing and proposes sustainable waste management strategies. Employing a multidisciplinary approach, the research integrates environmental science, engineering, and policy analysis to assess the current state of waste management in cassava processing and suggests innovative solutions. By identifying and addressing key challenges, the study highlighted actionable insights for policymakers, industry stakeholders, and environmental advocates, emphasizing the pivotal role of effective waste management in fostering a sustainable and eco-friendly cassava processing sector in Nigeria.
Keywords: Solid waste management; Waste Management; Cassava Processing; Cassava waste; biogas generation; sustainable technology

INTRODUCTION

Solid waste management is the most pressing environmental challenge faced by urban and rural areas of Nigeria, with a population exceeding 170 million people. Among several wastes generated by this huge population is agricultural waste. Improper handling of agricultural waste has raised a significant challenge in the past decades. In 2016, agriculture contributed 19.17% to the gross domestic product (GDP) of Nigeria and it also generated large amounts of waste materials. Nigeria is involved in growing and producing many food crops. One such crop is cassava, a starchy staple food crop that has the ability to resist drought and diseases. In 2012, the production of cassava worldwide was estimated at over 260 million tonnes, with Nigeria being the largest producer, contributing over 20% of the global production. In Nigeria, cassava is mostly produced and processed by small-scale farmers at the family or village level. Cassava provides a reliable and inexpensive source of carbohydrates for people in Sub-Saharan Africa, especially in Nigeria, where its production, processing, and consumption are most predominant and significant on a global scale.

It also provides different job opportunities for both men and women from the production stage until it gets to the final stage. There are indications that the domestic demand for cassava, particularly as a staple food, tends to outweigh the demands of the industrial sector. As farmers are unable to meet their demand, some industries are now engaging in the direct production of their cassava requirements.

Globally, 60% of the cassava produced is mostly used for consumption in numerous forms by humans, while the animal food industry uses about 33% of the world production. The remaining 7%is used by industries to produce products such as textiles, paper, organic acids, flavor and aroma compounds, and cassava bagasse. Three main types of residues are generated during the industrial processing of cassava: peels, solids, and wastewater. These wastes are poor in protein content, but their residues are very rich in carbohydrate and are generated in large amounts during the production of ‘garri’ and cassava flour from the tubers. The cost associated with the handling and disposal of these wastes constitutes a huge financial burden to the cassava-processing industries in most rural regions of the country. As a result of this challenge, most rural cassava processors choose to dispose the cassava-processing wastes generated into the environment. These wastes have been identified to be toxic to the environment.

The technology of processing cassava roots predominantly includes peeling, grating, dewatering, fermenting, drying, frying, etc. The type and composition of the waste depend on the processing method and type of technology used. In most cassava-processing communities, several tonnes of cassava peels are generated as a waste product from the processing activity and are generally considered to contribute largely to environmental pollution. With an expected increase in cassava production, it is also expected that waste generation will continue to rise. Even though cassava peels can be used as feed for livestock, the quantities generated and the remoteness of many of the communities where processing takes place leave behind a lot of waste, which is burnt or left to rot, with many environmental consequences. Tonukari et al. presented a report of a cassava starch production center that produces 100 tons of tubers per day, with an output of about 47 tons of by-products. This output may cause environmental problems when abandoned in the surroundings of processing plants or carelessly disposed. The basic form of cassava flour production comprises sorting, weighing, peeling, washing, grating, machine/milling, detoxification, dewatering, granulation, drying milling, sieving, and packaging.

Management of cassava waste varies across several processing centers in the country, andover55% of waste generated from its processing is disposed in dump sites. This implies that a great number of cassava processors do not get benefit from the waste they produce. The majority of the cassava peels in Nigeria are abandoned close to the processing site, while some are used for land fling or burnt. This approach causes a serious threat to the environment and a health hazard to processors and communities. Oparaku et al. from their experiment, expressed that cassava wastes can be used as a biogas substrate, either as a standalone raw material or in combination with livestock manure. Attempts have been made by various researchers to produce products such as organic acid, flavor and aroma compounds, methane and hydrogen gas, enzymes, ethanol, lactic acid, biosurfactant, polyhydroxyalkanoate, essential oils, xanthan gum, and fertilizer from cassava bagasse, peels, and wastewater.

Furthermore, prior studies on cassava waste management focused on different aspects of cassava waste management; however, there is still a dearth in the literature of studies that combine the potential in the reuse of cassava waste, gender composition of cassava processors in Nigeria, and also factors affecting the willingness to pay for cassava waste management in Nigeria. According to Echebiri and Edaba, there is a high positive correlation between the increase of cassava production and the estimated demand for the commodity. It was also found that the waste disposal habits of the people, corruption, work attitude, and inadequate plants and equipment, among others militate against effective waste management in Nigeria. From the foregoing, there is a need for better management and utilization of these waste residues through a better waste management system. It is against this backdrop that this research investigates the potential for an integrated cassava waste management strategy with a focus on Nigeria. Furthermore, this study examined the waste management systems presently in use by cassava processors and their willingness to pay for a value-added solid waste management system.

The aim of this study is to assess the effectiveness of waste management practices as a comprehensive solution to mitigate environmental pollution caused by cassava processing factories in Nigeria. Through a thorough examination of current waste management systems, identification of environmental impacts, and the development of sustainable strategies, the research aims to contribute insights that can guide policy formulation and industry practices toward a more environmentally responsible and sustainable cassava processing sector in Nigeria.

RESEARCH METHODOLOGY

This study utilized content-based analysis of secondary data sources to explore the effects of implementing effective cassava mill waste management strategies in Nigeria. It examined the potential effects of integrating sustainable cassava waste management strategies in these mills, providing a deep understanding of the implications and potential benefits of utilizing the positive potential of innovative waste management strategies in the cassava processing industry.

FINDINGS

Integrating effective waste management strategies in cassava mill within Nigeria can yield significant positive economic results and reduce environmental pollution (Smith et al., 2020). This could be made possible by adopting sound waste management practices, such as proper disposal methods, recycling, and treatment of cassava processing.

Below are cutting-edge production waste management strategies that are very much applicable in cassava processing mills:

Use as Food/Feed Ingredients

Many by-products of agro-industry can be fed to animals directly as such without any modification or can be used after fermentation of the agro-residues. Generally, by-products to be used as feedstuff should be economical, rich in nutrients, and free of toxins or other substances that may be unhealthy to animals. Recovering by-products for use as animal feed can help agro-industry save money by reducing waste discharges and cutting waste management costs and also can prevent environmental pollution. Most of the agro residues offer a less expensive source of nutrients than traditional feeds and also support acceptable animal performance. Feeding by-products of the crop and food processing industries to livestock is a practice as old as the domestication of animals. It has two important advantages, can reduce the dependence of live stock on grains that can be used as animal feed and also can eliminate the need for costly waste management programs (Dhiman et al. 2003; Firkins et al. 2002; Gallo et al. 2001). The use of conventional feed stuffs for small ruminant is generally inefficient and expensive (Al-Jassim et al. 1997). Ruminant feeding by agro residues are often a practical alternative because the rumen microbial ecosystem can utilize this agro residues which often contain high levels of structural fibre required for their maintenance, growth, reproduction and production. Many by-products can be used as animal feed. During the last decades, the scientific research has been focused on many aspects of agro by-products as animal feed, in particular optimizing their nutritive value, characterization and quantification of phenolic compounds and fatty acids and their potential effects on the diet, effects on animal performance and product quality from feeding theses materials. There are many factors such as types and proportions of by-products generated, variability in moisture and nutrient content, storage of the material, potential for the presence of physical and microbial contaminants and toxins, handling characteristics etc should be considered for evaluating the suitability of by-products as animal feed (Crickenberge and Carawan 1996). It also depends on the target animal, processing and handling of the by-products, volume of material, cost versus benefits, effects on feed consumption, safety concerns etc.

Carbon Source for Growing Microorganisms for Production of Valuable Chemicals and Enzymes

By-products from the cassava processing industry as a whole can be used in a number of ways especially for biomass production. Microorganisms are grown on food processing by-products. An animal feed from apple pomace has been produced and evaluated (Joshi and Sandhu 1996). It was reported that Kloceckera apiculata and Candida utilis could transform apple pomace into an improved stock feed by solidstate fermentation (Rahmat et al. 1995). Various by-products can be used to grow microorganisms to produce enzymes, single cell protein, amino acids, lipids, carbohydrates and organic acids, which have applications in the field of animal feed and food processing. Various fruit and vegetable wastes from the tomato, grape, apple, cabbage, carrot, beetroot and watermelon are used as the substrate for the lysine production by Brevibacterium spp. (Trifonova et al. 1993). Protein enrichment has been obtained by growing Aspergillus niger on mango peel, orange peel, green immature banana and carrot wastes in solid state fermentation (Davy et al. 1981; Garg et al. 2000).

Use for the Production of Fertilizer

Agro-by-products can be beneficially used as a soil conditioner or fertilizer. The by-product characteristics of interest include the moisture content, BOD, calcium carbonate, C:N ratio, fat and oils, odors, pathogens, pH, soluble salt and toxicity. Agro-industrial wastes from agriculture; food processing or any cellulose based industries remain largely unutilized and often cause environmental pollution. These wastes could be converted into potential renewable source of energy, if managed sustainably and scientifically. In the last few decades, composting technology has been arising as a sustainable tool for the efficient utilization of the agro-industrial processing wastes and to convert them into value-added products. The usability of the process depends upon several factors, such as raw material, various process conditions like pH, temperature, moisture, aeration etc. Composting is a natural aerobic biochemical process in which thermophilic microorganisms transform organic material into a stable soil like product. It is a managed biological conversion of waste material, under controlled conditions into hygienic humus rich, relatively bio stable product that conditions soils and nourishes plants. Organic wastes from fruit and vegetable processing industry used for composting include peelings, pulping, outer skins, pomace, cores, leaves, fruit twigs and sludge from the processing and packaging of various products. The by-product from sugarcane industry can be used for the production of fertilizer by composting. Composting technology is a suitable tool for efficient conversion of agro industrial processing wastes, which serves as a rich source of plant nutrients. These waste materials are packed with a tremendous source of energy, protein and nutrients, which would otherwise be lost if they are disposed as such in the open dumps and landfills. Moreover, with the use of compost as organic amendments in the agriculture, recycling of the nutrients back to the soil takes place, in turn, maintaining the sustainability of the ecosystem. Therefore, the production of fertilizer has enormous potential in agro-industrial waste management in a sustainable and decentralized manner, as it yields rich organic fertilizer, safely disposes the organic waste and helps tackle environmental problems, such as landfill and reduces the expense of collecting and transporting this waste.

Use for Energy Production

Over the last century, energy consumption has increased beyond control as a result of growing world population and industrialization (Sun and Cheng 2002). Renewable energy sources, such as ethanol, methane and bio-hydrogen can be produced by fermentation of sugars unlike the fossil fuels. Owing to diminishing natural oil and gas resources, interest in the bioconversion of renewable cellulosic biomass into fuel ethanol as an alternate to petroleum is rising around the world (Stevenson and Weimer 2002). Biomass is the earth’s most attractive alternative among fuel sources and sustainable energy resource. Bio-fuels can be broadly classified into two major types, gaseous and liquid biofuels. Purification of the conventional biogas into methane-enriched biofuel led to the development of biomethane. Biohydrogen is a relatively new type of gaseous biofuel, which is produced by anaerobic fermentation of agro-industrial wastes by the synergistic action of a consortium of methanogenic, acidogenic and hydrogenic bacteria (Fountoulakis and Manios 2009.) Liquid biofuels have recently been classified into bioethanol and biodiesel. While bioethanol has recently gained rejuvenated importance in the wake of present energy crisis worldwide, biodiesel occupied the centre stage as a potential substitute for petroleum diesel in the last two decades (Sumathi et al. 2008; Demirba 2009). In developing countries, production of biogas from waste is an appropriate solution. Biogas generation through anaerobic fermentation is considered to be a simple and economical system of waste treatment and a number of processes have been developed and commercially exploited.

Use as Metal Adsorbent for the Environmental Pollutants

Removal of heavy metals ions from the aqueous streams by agricultural waste materials is an innovative and promising technology. Agricultural materials rich in cellulose have metal absorption capacity. The cellulose, hemicelluloses, lignin, sugars, proteins, and starch contain a variety of functional groups that facilitate metal complexion which in turn helps in the sequestration of heavy metals (Hashem et al. 2007). Most of the agricultural wastes seem to be a viable option for heavy metal adsorption due to their unique chemical composition, low cost and availability in abundance etc. Various agricultural wastes materials, such as rice bran, rice husk, wheat bran, wheat husk, husks, coconut shells, apple, banana, peels etc have been reported to possess metal adsorption capacity (Annadurai et al. 2002; Hashem et al. 2007). The metal adsorption using aqueous stream by using agricultural materials is based on metal desorption. The process of metal biosorption involves a solid phase (sorbent) and a liquid phase (solvent) containing dissolved species to be absorbed. The high affinity of the sorbent for the metal ion species, the metal ions are attracted and bound by a complex process involving different mechanisms, such as chemisorption, complexation, adsorption on surfaces and pores, ion exchange, chelation, adsorption by physical forces, entrapment in inter and intrafibrillar capillaries and spaces of the structural polysaccharides network (Basso et al. 2002). The functional groups, such as acetamido groups, carbonyl, phenolic, structural polysaccharides, amido, amino, sulphydryl, carboxyl groups, alcohols and esters present in agro byproducts possess the affinity for metal complexation (Gupta and Ali 2000). Some biosorbents are specific for certain types of metals depending upon their chemical composition and some are non- specific. Agricultural wastes, such as hazelnut shells, orange peels, maize combs, peanut shells have been reported to have nickel removal efficiency (Kurniawan et al. 2006). Current treatment technologies employed for the removal of heavy metals are not economical and generate huge quantity of toxic chemical sludge and other toxic by-product compounds. Recently, biosorption has emerged as a alternative method to the existing conventional methods for the removal and remediation of metal ions from the environment. The major advantages of metal adsorption by agro residues over conventional treatment methods are low cost, minimization of chemical and biological sludge, regeneration of biosorbents, high efficiency, and easy availability of the raw material. Hence, the use of agro residues for metal remediation will not only reduce the heavy metal pollution but also mitigate the biological pollution resulting from agro-residues.

Closed-loop manufacturing (waste recycling)

Closed-loop manufacturing significantly contributes to waste management and environmental pollution reduction through a circular economy approach.

Closed-loop systems promote resource conservation by reintegrating recycled materials into the manufacturing process, reducing the demand for virgin resources (McDonough & Braungart, 2002). By emphasizing the reuse and recycling of materials, closed-loop manufacturing minimizes the generation of waste, contributing to a more sustainable and efficient production system (Geng et al., 2016). The recycling of materials in closed-loop systems results in lower emissions, aligning with environmental goals to reduce the carbon footprint associated with production (Ghisellini et al., 2016).

Furthermore, products designed for recyclability and reusability within closed-loop systems tend to have longer lifespans, reducing the frequency of disposal and minimizing environmental impact (Blomsma & Brennan, 2017).

Closed-loop processes generally require less energy compared to traditional manufacturing, as recycling often consumes less energy than extracting and processing new raw materials (Lund, 2015).

In essence, closed-loop manufacturing fosters a sustainable and regenerative approach to production, addressing both waste management challenges and environmental pollution.

Closed-loop manufacturing plays a key role in waste management and environmental pollution reduction by promoting a circular economy. In a closed-loop system, products and materials are designed, manufactured, used, and then recycled or reused in a continuous cycle.

CONCLUSION

From this study, it is clear that cassava waste if properly managed can contribute to a sustained environment rather than a source of degradation. Its solid waste is economically being used as an animal supplement and in the production of activated carbon on a laboratory scale for the adsorption of lethal heavy metals from stubborn industrial wastewater. Great potential still exists for its application in the production of fine chemicals and other value-added products.

Cassava wastewater can be used to generate electricity to power low voltage laboratory equipment using the MFC technology, and at the same time bio-remediating the wastewater by reducing the COD, BOD, and other dangerous organic matters in the wastewater before its safe disposal into either soil or water bodies.

Research efforts geared towards the potential application of cassava wastewater as substrate for the cultivation of microalgae for the production of biomass that can be used to produce biodiesel through transesterification reaction as well as other value-added products have also been discussed

RECOMMENDATIONS

From the findings, the study therefore recommends the following:

i. Proper waste disposal methods should be adopted by cassava processors in Nigeria to minimize pollution and reduce health risks.

ii. There is a need for awareness of the income generation potential of cassava waste among cassava processors in Nigeria.

iii. It is highly recommended that the wastewater generated from cassava processing undergoes proper treatment before it is discharged.

iv. Based on the biogas generation potential of the cassava-processing factories in Nigeria, it is important that this resource be harnessed.

REFERENCES

Asante-Pok, A. (2013). Analysis of Incentives and Disincentives for Cassava in Nigeria; FAO Technical Notes Series; FAO:Rome, Italy, 2013.

Aro, S.O.; Aletor, V.A.; Tewe, O.O.; Agbede, J.O. (2010). Nutritional potentials of cassava tuber wastes: A case study of a cassava starch processing factory in south-western Nigeria. Livest. Res. Rural Dev. 2010,22, 1–11.

Adebayo, K.; Anyanwu, A.C.; Osiyale, A.O. (2003). Perception of Environmental Issues by Cassava Processors in Ogun State, Nigeria—Implications for Environmental Extension Education. J. Ext. Syst. 2003,19, 103–112.21.

Barros, F.; Ana, P.D.; Júnio, C.; Gláucia, M. (2012). Potential Uses of Cassava Wastewater in Biotechnological Processes. In Agriculture Issues and Policies: Cassava Farming, Uses and Economic Impact; Pace, C.M., Ed.; NOVA Science Publishers Inc.: New York, NY, USA, 2012; Chapter 2; pp. 33–54. ISBN 978-1-61209655-1.

Coker, A.; Achi, C.; Sridhar, M.K. (2010). Utilization of Cassava Processing Waste as a Viable and Sustainable Strategy for Meeting Cassava Processing Energy Needs: Case Study from Ibadan City, Nigeria. In Proceedings of the Thirtieth International Conference on Solid Waste Technology and Management, Philadelphia, PA, USA, 3–6 April 2010.22.

Dada, A.D.; Afolabi, O.O.; Siyanbola, W.O., (2009). Harnessing Science and Technology for Cassava Productivity and Food Security in Nigeria. In Proceedings of the Portland International Conference on Management of Engineering & Technology, Portland, OR, USA, 2–6 August 2009.

Echebiri, R.N.; Edaba, M.E., (2008). Production and Utilization of Cassava in Nigeria: Prospects for Food Security and Infant Nutrition. Prod. Agric. Technol. 2008,4, 38–52.

Eze, J.I. Converting Cassava (Manihot spp) Waste from Gari Processing Industry to Energy and Bio-Fertilizer. Glob. J. Res. Eng. 2010,10, 113–117.

FAO (Food and Agricultural Organization) of United Nations. Annual Statistics; FAO: Rome, Italy, 2004.

Olukanni, D.O.; Adeleke, J.O.; Aremu, D.D.(2016). A Review of Local Factors affecting Solid Waste Collection in Nigeria. Pollution 2016,2, 339–356.24.

Oparaku, N.F.; Ofomatah, A.C.; Okoroigwe, E.C.,(2013). Biodigestion of cassava peels blended with pig dung for methane generation. Afr. J. Biotechnol. 2013,12, 5956–5961. [CrossRef]

Tonukari, N.J.; Ezedom, T.; Enuma, C.C.; Sakpa, S.O.; Avwioroko, O.J.; Eraga, L.; Odiyoma, E., (2015) White Gold: Cassava as an Industrial Base. Am. J. Plant Sci. 2015,6, 972–979. [CrossRef]

Sackey, I.S.; Bani, R.J., (2007). Survey of waste management practices in cassava processing to garri in selected districts of Ghana. J. Food Agric. Environ. 2007,5, 325–328.