J Environ Anal Toxicol
Volume 11:S6, 2021

Environmental & Analytical Toxicology

Research Article

Open Access

Nutritive Benefits of Plantain (*Musa paradisaica*) Grown with Sludge Obtained from Wastewater Treatment Plant within Port-Harcourt Environment

Emmanuel I Amadi[1*], Ben A Amadi[1], Felix U Igwe[2] and Joy O Akaninwor[1]

[1]*Department of Biochemistry, University of Port Harcourt, Port Harcourt, Nigeria*

[2]*Department of Biochemistry, Rivers State University, Port Harcourt, Nigeria*

Abstract

A study on the nutritive benefits of sludge obtained from the wastewater treatment plant to crops within the Port-Harcourt environment was investigated. The proximate composition and mineral contents were assessed in the different plantain food samples using standard methods, to know the biochemical impact of the applied sludge on their nutrient values over the control. The proximate composition calculated on a dry weight basis revealed an increase in moisture content (5.03%), crude protein (7.41%), crude fibre (3.58%), as well as a decrease in crude fat (2.31%), ash content (3.08%), carbohydrate (78.58%), and energy value (364.78 kcal/kg) for the test sample over the control (3.86%, 3.58%, 2.51%, 2.53%, 3.15%, 84.36%, and 374.57 kcal/kg) respectively. The moisture, crude fibre, protein, carbohydrate and mineral content were significantly different ($p<0.05$), while lipid and ash content showed no significant difference ($p>0.05$) when compared to their controls. The mineral analysis revealed an increase in iron (Fe) (88.87 mg/kg), potassium (K) (5930.46 mg/kg), calcium (Ca) (1783.47 mg/kg), as well as a decrease in sodium (Na) (127.69 mg/kg), phosphorus (P) (0.78 mg/kg), magnesium (Mg) (1000.33 mg/kg), and zinc (Zn) (5.93 mg/kg) for the test sample over the control (55.29 mg/kg, 5086.40 mg/kg, 1736.66 mg/kg, 148.92 mg/kg, 1.13 mg/kg, 1072.25 mg/kg, and 11.12 mg/kg) respectively. These results revealed that the plantain food samples grown on the sludge amended soils contains appreciably high protein and mineral content and thus can be recommended as a diet for diabetic patients and in combating protein deficiency.

Keywords: Sludge • Plantain sample • Proximate composition • Minerals

Introduction

Plantain is said to be among the important staple food crops commonly grown in Central and West Africa, and it belongs to the family *Musaceae* [1]. Plantain contributes to food security and employment in rural and urban areas [2]. Its inclusion as one of the major and reliable food in equatorial Africa is due to the fact that it produces fruits all year round [3,4]. Plantain production in Nigeria is on the decline due to the depletion of soil nutrients, thus inhibiting the uptake of nutrients by the plants [5,6]. Statistics shows that Nigeria is the fifth-highest producer of plantain [7]. Plantain mainly comprises of water 60%, carbohydrate 27-31%, protein 2-3%, 1% fat and other essential metals [8-10]. Plantain is seen as one of the major sources of energy and it is recommended for a low sodium diet [1,8].

The rapid growth rate of Nigeria population and the reckless disposal of untreated solid wastes in our rivers present a serious threat to the sustainability of our environment and food crops [11]. These threats have been reported by various researchers in the developing world as detrimental if not solved [12-15], and Nigeria is not left out due to the increasing discharge of effluents into our rivers, thus leading to surface and groundwater contamination. In underdeveloped countries, wastes from city residents are collected and transported to rural areas, where they are subsequently deposited over agricultural land without undergoing treatments [16]. This practice is reported to have led to hazardous effects to man and the environment. Also industrial effluents from industries which contain great toxic materials are said to be deposited into the water body, thus leading to pollution of the water quality which in turn alter the physical, chemical and biological nature of the receiving water body [16]. These rivers serve as sources of water for domestic use in the rural and semi-urban areas [17]. This declining state of the soil which has led to poor agricultural production has been seen as critical problems that need to be tackled [4,18]. Most soils in West Africa are deficient in nutrients such as phosphorus and nitrogen which results in low productivity [19-21]. Leaching and weathering has thus led to the acidic nature of soils and nutrient deficiency within the southern part of Nigeria where plantains are grown [22-24].

However, maintaining the declined soil fertility using the very expensive inorganic fertilizers is difficult for the rural farmers, hence these solid wastes generated daily from our various homes, universities, hotels, markets, etc which were disposed off into the sea or land as solid amendment material with its negative implication to man and the environment can however be converted into valuable products such as sludge (organic fertilizer) for replenishing the declined soil fertility and is readily available and affordable, renewable source of energy (biogas), and fuels [25]. This study was therefore carried out to investigate the potential nutritive benefits of plantain grown with natural organic fertilizer (sludge) that can be used to replace very expensive artificial inorganic fertilizer with little cost and side effects.

Materials and Methods

Sample collection

Plantain samples (*Musa. paradisiacae*) were harvested in random replicates of three and were bulked to form a composite sample of crops per site from the control site (vegetable farm with zero sludge application) and the test site (wastewater treatment plant with sludge used as the soil amendment), both in Port Harcourt, Rivers State, Nigeria.

Preparation of sample

They were properly washed under running tap water to remove adhered soil particles, and then with deionized water to remove any possible foliar contaminants such as pesticides, fertilizers, dust or mud, they were peeled and then cut into small pieces using a stainless knife, and oven-dried at 50°C for 48 hrs until constant weight was obtained. A measured quantity of the dried samples (100 g) was ground into flour using a ceramic mortar and

***Address for Correspondence:** Emmanuel. I Amadi, Department of Biochemistry, University of Port Harcourt, Port Harcourt, Nigeria; E-mail: emmanueldonb@yahoo.com*

Received: August 05, 2021; **Accepted:** August 19, 2021 ; **Published:** August 26, 2021

pestle to reduce the dried material to a suitable size. The dried samples were stored in a moisture-free environment prior to further digestion and analysis [26].

Digestion of sample

A 5.0 g of each dried and crushed plant sample was accurately weighed (for wet digestion) into porcelain crucibles. This was burnt slightly for 6 hrs, opening the cover for the escape of gases at 500°C. It was also checked periodically until a grey-white ash was obtained. The ashed samples were allowed to cool and 5 ml of 10% HCl was added to each sample to facilitate dissolution, and 5 ml of 10% HNO3 was added thereafter, and set on a water bath to dissolve completely. The digest was allowed to cool to room temperature and filtered through Whatmann no. 42 filter paper, into a clean dried 50 ml standard volumetric flask. Both the dish and the filter paper was washed into the flasks, and marked up with deionized water. The resultant solutions from the respective digestions were kept in the refrigerator prior to metal analysis. The sludge samples were also collected from the wastewater treatment plant at Eagle Island off Agip road, all in Port Harcourt City Local Government Area, Rivers State.

Analysis procedure

The moisture content was determined using the procedure described by AOAC [27]. 2.0 g of sample was weighed into a pre-weighed crucible. The sample was then dried to constant weight in the drying oven at 105°C for 5 hrs, thereafter; they were removed and placed in desiccators to cool. The cooled crucibles were re-weighed. This was done in triplicate. The loss in weight after drying was then calculated as the percentage moisture.

The protein content was determined using the procedure described by AOAC [27]. 2.0 g of sample was weighed and digested. The digested sample was transferred into a 100 ml volumetric flask and made up to the mark. 10 ml of the digested sample was distilled with 15 ml of 40% NaOH. The distillate was titrated with 0.1 M HCl solution. The titre values of the triplicate samples were recorded and the percentage crude protein calculated.

1.0 g of dry sample from moisture determination was transferred to a 22 × 80 mm paper thimble. 150 ml of petroleum ether was added to the previously dried and weighed 250 ml round bottom flask and the apparatus was assembled. A quick fit condenser was connected to the Soxhlet extractor and refluxed for 6 hrs on low heat. The flask was removed and evaporated on a steam bath. The flask with the fat was heated for 30 mins in an oven at 103°C. The flask and its content were cooled to room temperature in desiccators after which it was weighed and percentage lipid calculated.

The ash content was determined by weighing 20 g of sample into a previously weighed crucible and placed in the muffle furnace at 550°C for 4 hrs. The crucible was then cooled in a desiccator and reweighed. The loss in weight was then recorded and the ash content calculated.

The crude fibre was determined by weighing 2.0 g of defatted sample and transfer into a 750 ml Erlenmeyer flask. 200 ml of boiling 1.255% H2SO4 was added and the flask was immediately placed on a hot plate and a condenser was connected. The flask was removed at the end of 40 mins and the contents immediately filtered through cheesecloth and washed with a large volume of boiling water. The washing was continued until the filtrates were no longer acidic. The charge and asbestos were scrapped with a spatula back into the flask with 1.25% NaOH solution using a wash bottle calibrated to deliver 200 ml. The flask again was connected to the condenser and boiling was undertaken for exactly 30 mins. The content of the flask was filtered through fine linen with large volumes of boiling water as before. The residue was transferred to a crucible and washed with 15 ml alcohol. The crucible and contents were dried for 1 hr at 100°C, cooled and then weighed. The crucible was ignited in the muffle furnace for 30 mins, cooled and reweighed. The loss in weight was then determined.

The carbohydrate was calculated by difference according to the procedure of AOAC [27].

The caloric value of Musa paradisiacae was calculated using 4, 9, 4 "Atwater factor" by Onyeike et al. [28].

The minerals were determined in accordance with standard methods, as described by Pearson [29]. It involves ashing dried samples at 550°C in a muffle furnace to constant weight and dissolving the ash in a volumetric flask with distilled water (deionized water) and with a few drops of concentrated HCl. Phosphorus was determined colorimetrically using LKB Biochrom Ultraspec II, (Model 4050, England) with Analytical grade KH2PO4 as standard.

The sodium and potassium were determined on Jenway Digital flame photometer (PF P7) model. All other minerals were determined by atomic absorption spectrophotometry (Perkin- Elmarmodel 403, Norwalk, CT, USA).

The results were expressed as mean ± standard deviation of the mean (SD) in triplicates. All the data obtained were subjected to the statistical ANOVA analysis of the mean, using computer-aided statistical package for the social sciences (SPSS) version 20.

Results and Discussion

The results of proximate composition of two plantain food samples harvested at the control and test sites are shown in Table 1 and Table 2 shows the results of selected minerals analyzed in the two plantain food samples, while Table 3 shows the Parameters investigated on the sludge used in the amendment of the test site.

Table 1. Proximate composition of the plantain samples from the test and control sites (%).

	Control sample	Test sample
Moisture content	3.86 ± 0.20	5.03 ± 0.19*
Protein	3.58 ± 0.23	7.41 ± 0.20*
Lipid	2.53 ± 0.12	2.31 ± 0.18
Ash content	3.15 ± 0.09	3.08 ± 0.05
Crude fibre	2.51 ± 0.00	3.58 ± 0.02*
Carbohydrate	84.36 ± 0.01	78.58 ± 0.47*
Energy value (kcal/kg)	374.57 ± 0.51	364.78 ± 0.77*

Values are expressed as mean ± standard deviation of triplicate determinations (n=3). Key: asterisks (*) denotes significant difference at ($p<0.05$).

Table 2. Selected minerals composition of the plantain samples from the test and control sites (mg/kg).

Parameters	Control sample	Test sample
Fe	55.29 ± 0.07	88.87 ± 0.53*
K	5086.40 ± 0.39	5930.46 ± 0.16*
Ca	1736.66 ± 0.41	1783.47 ± 0.15*
Na	148.92 ± 0.12	127.69 ± 0.37*
P	1.13 ± 0.03	0.78 ± 0.05*
Mg	1072.25 ± 0.04	1000.33 ± 0.58*
Zn	11.12 ± 0.01	5.93 ± 0.06*

Values are expressed as mean ± standard deviation of triplicate determinations (n=3). Key: asterisks (*) denotes significant difference at ($p<0.05$).

The proximate composition of freshly harvested plantain samples in Table 1 shows a significant increase ($p<0.05$) in the moisture content for the test sample (5.03%) over the control (3.86%), which is in agreement with works by Eleazu et al. [30]. The moisture content of any food enables us to ascertain the shelf-life of the food and drugs, which is an index of its water activity and is used as a measure of stability and the susceptibility of microbial contamination [31]. This implies that freshly harvested plantain samples may have a long shelf-life due to their low moisture content and can stand a longer preservation period.

There was a significant increase (p<0.05) in the crude protein content of the test sample (7.41%) over the control (3.58%) as shown in Table 1. The increase in the protein content for the test sample is in agreement with several works [8,30-34]. This is also suggestive that the test plantain sample can be used in combating protein deficiency [30]. This increase is probably due to the uptake of nitrogen inherent in the sludge used in the amendment of the soil as shown in Table 3. Plants deficient in nitrogen tends to have pale yellowish-green colour (chlorosis), have a stunted appearance, and develop thin, spindly stems [35]. The crude protein will serve as an enzymatic catalyst, control growth and cell differentiation and mediate cell responses [36].

Table 3. Parameters investigated on the sludge used in the amendment of the test site.

Experiment	Parameters	Sludge
Physico-chemical	pH	5.86 ± 0.13
	Temperature	27.20 ± 0.10ºC
	Total Dissolved Solids (TDS)	1190.67 ± 19.76 mg/l
	Electrical Conductivity (EC)	2350.00 ± 19.96 uS/cm
Nutrients	Nitrogen (N)	2.63 ± 0.65 mg/kg
	Phosphorus (P)	20.32 ± 3.65 mg/kg
	Potassium (K)	208.69 ± 0.02 mg/kg
	Total organic matter (TOM)	0.48 ± 0.04 mg/kg
Heavy metals	Zinc (Zn)	31.70 ± 0.04 mg/kg
	Lead (Pb)	11.14 ± 0.02 mg/kg
	Nickel (Ni)	2.66 ± 0.03 mg/kg
	Total organic carbon (TOC)	0.28 ± 0.02 mg/kg

Values are expressed as mean ± standard deviation of triplicate determinations (n=3).

The crude fat content shows a reduction in the test sample (2.31%) though not significantly different (p>0.05) when compared to the control (2.53%). The results obtained in this study is in accordance with the previous works [32,34,37]. Fats are major structural elements of biological membranes of phospholipids and sterols [38]. They have high energy value and serve as thermal insulators in the subcutaneous tissues and around certain organs [39].

A slight reduction though not significantly different (p>0.05) was observed for the ash content in the test sample (3.08%) over the control (3.15%). This is in agreement with works by Eleazu et al. [30], which are an indication of its level of mineral contents because high ash content suggests high mineral composition [40]. Minerals are essential for proper functioning of tissues and act as a second messenger in some biochemical cascade mechanisms [41].

The crude fibre contents of the test sample (3.58%) showed a significant increase (p<0.05) when compared to the control (2.51%). The result obtained is higher than the previous works [10,42,43]. Dietary fibre decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes. Dietary fibre contains a portion of cellulose and lignin which can be employed in the treatment of diabetes and gastrointestinal tract diseases [41].

Dietary fibre also functions in the protection against cardiovascular disease, colorectal cancer and obesity [44]. It is increasingly being recognized as a useful tool for the control of oxidative processes in food products and as a functional food ingredient [1]. And also it infers that unripe plantain could be effectively utilized in the management of diabetes mellitus, colorectal cancers and weight reduction in obese individuals. This finding could be one explanation behind the hypoglycaemic action of the flour [45].

The carbohydrate contents showed a significant decrease (p<0.05) in the test sample (78.58%) over the control (84.36%). The result obtained is higher than the previous reports [30,46]. This indicates that the flour could have a low glycemic index when consumed [46] and contains a large amount of starch and low sugar in its green stage [30, 8-10,47]. Carbohydrates provide readily accessible fuel for physical performance and regulate nerve tissues [36]. It also explains the potency of the food to serve as a source of fuel and energy for daily activities [48]. There was a significant decrease (p>0.05) in the energy value of the test sample (364.78 kcal/kg) when compared to the control (374.57 kcal/kg). The result obtained is lower than previous reports of (170.65 kcal/100 g) [45]. This result indicates that unripe plantain cannot be classified as a high energy food as the energy value was observed to be low [45]. They don't contribute much to the energy content Table 2.

Minerals are important in maintaining physiological processes and are constituents of the teeth, bones, tissues, blood, muscle and nerve cells in animals [49]. The results of mineral analysis of plantain samples in Table 2 shows a significant difference (p<0.05) in all the minerals when compared to their control.

There was a significant increase (p<0.05) in the iron content of the test sample (88.87 mg/kg) over the control (55.29 mg/kg), which is higher than the previous works [1,8,32].

The potassium obtained in the plantain flour in Table 2 shows a significant increase (p<0.05) in the test sample (5930 mg/kg) over the control (5086 mg/kg). This is higher than the previous works [1,32].

The calcium obtained in the plantain flour (Table 2) shows a significant increase (p<0.05) in the test sample (1783 mg/kg) compared to the control (1736 mg/kg), which is higher than the previous works [1,8,32].

There was a significant decrease (p>0.05) in the sodium content of the test sample (127 mg/kg) over the control (148 mg/kg) as shown in Table 2. This is higher than the previous works [1,8,42,50]. Due to its low sodium content, it is thus recommended for low sodium diets [42,50]. There was a significant decrease (p>0.05) as shown in Table 2 in phosphorus of the test sample (0.78 mg/kg) over the control (1.13 mg/kg) which is lower than 35.61-59.43 mg/100 g [1,8]. This decrease is probably due to the utilization of phosphorus inherent in the sludge as shown in Table 3 by the soil for its amendment. There was a significant decrease (p>0.05) as shown in Table 2 in the magnesium of the test sample (1000 mg/kg) over the control (1072 mg/kg) which is higher than 3.56-10.20 mg/100 g [1,8]. Magnesium is a cofactor of the glycolytic enzyme hexokinase and pyruvate kinase. It also modulates glucose transport across the cell membranes [51,52]. There was a significant decrease (p>0.05) as shown in Table 2 in zinc of the test sample (5.93 mg/kg) over the control (11.12 mg/kg) which is higher than 3.75-6.23 mg/100 g [1,8]. Zinc plays a key role in the regulation of insulin production by pancreatic tissues and glucose utilization by muscles and fat cells [53]. Zinc also influences glyceraldehydes-3-phosphate dehydrogenase in the glycolytic pathway [54]. Zinc when taken by mouth in excess (above 25 mg/ day) over a short period of time can cause stomach cramps, nausea and vomiting, while for a longer time, it can cause anaemia and decrease the level of good cholesterol [55,56]. Infertility was recorded in rats fed with excess doses of Zn. Inhaling large amounts of Zn (as dusts or fumes) can cause a specific short-term disease called metal fume fever [57,58]. The result of this study revealed an increased amount of Fe, K, and Ca in the test sample when compared to the control and a reduction in Na, P Mg and Zn. Soil amendments using the sludge improved the growth performance of the test sample which resulted in its vigorous growth as well as the quality and structure of the arid and non-farming soils to cultivable land. This increased the activities of micro and macro organisms in the soil types, thus improving soil formation through increasing organic matter content in the soil, structure and aeration. This is in accordance with reports by [4,58].

The results of the physicochemical, nutrient and heavy metal parameters of the sludge obtained from the wastewater treatment plant are presented in Table 3.

The pH of the sludge obtained from the wastewater treatment plant was slightly acidic (<7.0). Temperatures were appreciably uniform, at 27oC, in all the samples investigated. The nitrogen, phosphorus and potassium concentrations were 2.63 ± 0.65 mg/kg, 20.32 ± 3.65 mg/kg, 208.69 ± 0.02 mg/kg, respectively which justifies its use as sludge in soil amendment.

Conclusion

The results of this study revealed that crops grown with sludge obtained from the wastewater treatment plant in Port-Harcourt used as a soil amendment, possesses better nutritive benefits such as an increase in protein and iron content over their controls and thus can be recommended as a diet in combating protein deficiency. This study was therefore carried out to investigate the potential nutritive benefits of plantain grown with natural organic fertilizer (sludge) that can be used to replace the very expensive artificial inorganic fertilizer with little cost and side effects.

References

1. Makanjuola, OM, AB Ajayi, K Mattew and JO Makanjuola. "The Proximate Composition and Mineral Contents of Three Plantain Cultivars Harvested at Matured Green Level." *Int J Innovat Bio Sci* 3 (2013): 23-26.

2. Nkendah, Robert and Emmanuel Akyeampong. "Socio-Economic Data on the Plantain Commodity in West and Central Africa." *Info Musa* 12 (2003): 22-28.

3. United States Department of Agriculture (USDA) Database. "Health Benefits of Plantain." *J Educ Res* (2009): 31-34.

4. Osundare, Opeyemi Tunde, Ayodele Anthony Fajinmi and Christopher John Okonji. "Effects of Organic and Inorganic Soil Amendments on Growth Performance of Plantain (Musa Paradisiaca L.)". *Afr J Agric Res* 10 (2015): 154-160.

5. Ramsey, MD, JW Daniels and VJ Anderson. "Effects of Sigatoke Leaf Spot (Mycophaerellamusicola leach) on Fruit Yields, Field Ripening and Green Life of Banana in North Queenland". *Scientia hortic* 41 (1990): 305-313.

6. Rosati, Adolfo, KR Day and Theodore M Dejong. "Distributions of Leaf Mass Per Unit Area and Leaf Nitrogen Concentration Determine Partitioning of Leaf Nitrogen within Tree Canopies." *Tree phys* 20 (2000): 271-276.

7. Food and Agriculture Organization (FAO). "*Food and agricultural indications*." (2015): 177-181.

8. Oyenuga, Victor Adenuga. "Nigeria's Food and Feeding stuffs, their chemistry and nutritive value." *Ibadan University Press* (1968).

9. Norman Willison, Simmonds. "Banana Longman's 2nd edition" *Heliyon* (1970).

10. Ketiku, Adegboyega O. "Chemical Composition of Unripe (green) and Ripe Plantain (Musa paradisiaca)."*J Sci Food Agric* 24 (1973): 703-707.

11. Dioha, IJ, MK Umar, AM Eboatu and PAC Okoye. "Comparative Studies of the Qualitative and Quantitative Yields of Biogas from Cow Dung and Poultry Droppings." *Niger J Solar energy* 15 (2005): 60-66.

12. NEST. "Nigeria Threatened Environment". *A National Profile, Nest Publication, Ibadan* (1991): 76-88.

13. Abimbola Y. Sangodoyin."Ground and Surface Water Pollution by Open Refuse Dump in Ibadan, Nigeria." *Discovery and Innovation* 3 (1991): 37-43.

14. Ongley, Edwin D. "Modernization of Water Quality Programs in Developing Countries, issues of Relevancy and Cost of Efficiency" *Water Qual Int* 3 (1998): 37-42.

15. Ogedengbe, Kola, and Christopher Oluwakunmi Akinbile. "Impact of industrial pollutants on quality of ground and surface waters at Oluyole Industrial Estate, Ibadan, Nigeria." *Niger J Technol Devlop* 4 (2004): 139-144.

16. Adekunle Adebayo and IT Kehinde "Impact of industrial effluents on quality of segment of Asa river within an industrial estate in Ilorin, Nigeria." *New York Science Journal* 1 (2008): 17-21.

17. Cherfi, Abdelhamid, Samira Abdoun, and Ouardia Gaci. " Food Survey Levels and Potential Health Risk of Chromium, Lead Zinc and Copper Contents in Fruits and Vegetables Consumed in Algeria." *Food Chem Toxicol* 70 (2014) : 48–53.

18. Divrikli, Umit, Nesrin Horzum, Mustafa Soylak and Latif Elci. " Trace Heavy Metal Contents of Some Spices and Herbal Plants from Western Anatolia, Turkey." *Int J Food Sci* 41 (2006): 712-716.

19. Kihampa, Charles, William J.S. Mwegoha and Riziki S. Shemdoe. " Heavy Metals Concentration in Fruits and Vegetables Grown in the Vicinity of the Close Dumpsite." *Int J Enviorn Sci* 2 (2011): 889-895.

20. Carlisle, James C, Kathryn C. Dowling, David M. Siegel and George V. Alexeeff. " A Blood Lead Benchmark for Assessing Risks from Childhood Lead Exposure." J Environ Sci Health 44 (2009): 1200-1208.

21. Rahimzadeh, Mahsa and Somayeh Rastegar. "Heavy Metals Residue in Cultivated Mango Samples from Iran." *J Food Qual Haz Cont* 4 (2017): 29-31.

22. Sardar, Kamran, Shafaqat Ali, Samra Hameed and Sana Afzal, et al. " Heavy Metals Contamination and what are the Impacts on Living Organisms." Greener *J Environmental Management and Public Safety* 20 (2013): 172-179.

23. Steenland, Kyle and Paolo Boffetta. "Lead and Cancer in Humans: Where Are We Now?" *Am J Ind Med* 38 (2000): 295-299.

24. Irizarry, Héber, Edmundo Rivera, and José Rodríguez. "Nutrient Uptake and Dry Matter Composition in the Plant Crop and First Ratoon of the Grand Nain Banana Grown On an Ultisol." *J Agric Univ PR* 72 (1989): 337-351

25. Singh, Anita, Rajesh Kumar Sharma, Madhoolika Agrawal and Fiona M. Marshall. "Health Risk Assessment of Heavy Metals via Dietary Intake of Foodstuffs from the Wastewater Irrigated Site of a Dry Tropical Area of India." *Food Chem Toxicol* 48 (2010): 611-619.

26. Association of Official Analytical Chemists (AOAC). "Official methods of analysis". *15th edition. Washington D.C. USA* (1990).

27. Onyeike, Eugene N, Tamunosiki Olungwe and Augustine A. Uwakwe. "Effect of Heat-Treatment and Defatting on the Proximate Composition of Some Nigerian Local Soup Thickeners." *Food Chem* 53 (1995): 173-175.

28. Pearson, David. The chemical analysis of foods. Longman (1976).

29. Eleazu, CO, PN Okafor and Ikpeama Ahamefuna. "Total Antioxidant Capacity, Nutritional Composition and Inhibitory Activity of Unripe Plantain (Musa Paradisiacae) on Oxidative Stress in Alloxan Induced Diabetic Rabbits." *Pak J Nutr* 9 (2010): 1052-1057.

30. Frazier, WC and DC Westhoff. "Food Microbiology". *New York: Mcgraw hill* (1978).

31. Fagbemi, Tayo N. "Effect of Blanching and Ripening on Functional Properties of Plantain (Musa aab) Flour." *Plant Foods Hum Nutr* 54 (1999): 261-269.

32. Ceriello, Antonio, Nadia Bortolotti, Enrico Motz and Adriana Crescentini, et al. "Meal-Generated Oxidative Stress in Type 2 Diabetic Patients." *Diabetes care* 21 (1998): 1529-1533.

33. Brakohiapa, LA, IK Quaya, AG Amoah and EK Harrison, et al. "Noguchi Memorial Institute for Medical Research." University of Ghana (2001): 220-221.

34. Brady, Nyle C, Ray R Weil and Ray R Weil. "The nature and properties of soils". *NJ: Prentice* 13 (2008)

35. Xu, Shuxia, Xinfeng Zhang, Tao Wan, and Chengxiao Zhang. "A Third-Generation Hydrogen Peroxide Biosensor Based on Horseradish Peroxidase Cross-Linked to Multi-Wall Carbon Nanotubes." *Microchim Acta* 172 (2011): 199-205.

36. Marín Rangel, Vania Marilyn, Raúl Cortés Martínez and Ruth Alfaro Cuevas Villanueva, et al. "As (V) Biosorption in an Aqueous Solution Using Chemically Treated Lemon (Citrus Aurantifolia Swingle) Residues." *J Food Sci* 77 (2012): T10-T14.

37. Singh, Renu, Vijay Kumar and Vishal Kapoor. "Partial Purification and Characterization of a Heat Stable Α-Amylase from a Thermophilic Actinobacteria, Streptomyces sp. MSC702." *Enzyme research* (2014).

38. Prakash, D, G Upadhyay, C Gupta and KK Singh. "Antioxidant and Free Radical Scavenging Activities of Some Promising Wild Edible Fruits." *J Complement Integr Med* 19 (2012): 1109.

39. Järup, Lars. "Hazards of Heavy Metal Contamination." *Br Med Bull* 68 (2003): 167-182.

40. Schwarzenbach, René P, Beate I. Escher, Kathrin Fenner and Thomas B. Hofstetter, et al. "The Challenge of Micropollutants in Aquatic Systems." *Science* 313 (2006): 1072-1077.

41. Krabbenhoft, David P, and Elsie M. Sunderland. "Global Change and Mercury." *Science* 341 (2013): 1457-1458.

42. Adeola Alex Adesuyi, Emmanuel O Awosanya, Adaramola Feyisara Banji, and Omeonu AI "Nutritional and Phytochemical Screening of Aloe Barbadensis." *Curr Res J Biol Sci*. 4 (2012): 4-9.

43. Sawyer, Ronald and S Kirk. “Pearson's Composition and Analysis of Foods”. *Longman* (1991).

44. Eleazu, Chinedum Ogbonnaya, M. Iroaganachi, and K. C. Eleazu. "Ameliorative Potentials of Cocoyam (Colocasia Esculenta L.) And Unripe Plantain (Musa Paradisiaca L.) On The Relative Tissue Weights of Streptozotocin-Induced Diabetic Rats." *J Diabetes Res* (2013).

45. Eleazu, Chinedum Ogbonnaya and Okafor PN. “Antioxidant Effect of Unripe Plantain (Musa Paradisiacae) On Oxidative Stress In Alloxan-Induced Diabetic Rabbits”. *Int J Med Biomed Res* (2012): 232-241.

46. Ahenkora, KM, A Kyei, EK Marfo and B Banful. "Nutritional Composition of False Horn Apantu Pa Plantain During Ripening And Processing." *J Food Chem* 4 (1996): 243-248.

47. Zakpaa, HD, E Mak-Mensah and J Adubofour. "Production and Characterization of Flour Produced from Ripe Apem Plantain (Musa Sapientum L. Var. Paradisiacal; French Horn) Grown in Ghana." *Agric Biotech Sustain Dev* 2 (2010): 92-99.

48. Yisa, Jonathan, J N Egila and AO Darlington. "Chemical Composition of Annona Senegalensis from Nupe Land, Nigeria." *Afr J Biotech* 9 (2010): 4106-4109.

49. Sonni, A. “Importance of Minerals and Trace Minerals in Human Nutrition: In the Magnesium Website Online library”. *Paul Mason Ed* (2002).

50. Stoverand, Robert H and Norman Willison, Simmonds. " Bananas Tropical agricultural series " *John Wiley and Sons* (1987): 468.

51. Song, Munag, Manuel Rosenthal, Bruce Naliboff, and Kisuk Kang. “Effects of Boirne Prostate Powder on Zinc: Glucose and Insulin Metabolism in Old Patients with Non-Insulin Dependent Diabetes Mellitus”. *Metabolism* 47(1998): 39-43.

52. O’Connell, Belinda S. "Select Vitamins and Minerals in the Management of Diabetes." *Diabetes Spectrum* 14 (2001): 133-148.

53. Fernández-Real , José Manuel, Abel López-Bermejo and Wifredo Ricart. “Perspectives in diabetes: crosstalk between iron metabolism and diabetes”. *Diabetes* 51 (2002): 2348-2354.

54. Monago, C and Augustine Amadikwa Uwakwe. "Proximate composition and in vitro anti-sickling property of Nigeria Cyperus esculentus (tiger nut sedge)." *Trees Life J* 2 (2009): 1-6.

55. Food and Agriculture Organization (FAO). " *Guidelines: Land Evaluation For Rain Fed Agriculture*." (1983): 237.

56. World Health Organization (WHO). “Health Guidelines for the use of Wastewater in Agriculture and Aquaculture”. (1989): 778.

57. Agency for Toxic Substances and Disease Registry (ATSDR). “Toxicological profile for zinc. Atlanta GA: United States Department of Health and Human Services, Public Health Service”. (2005).

58. Obiefuna, JC. "Effect of Delayed Fertilizer Application on the Growth and Yield of Plantains in South Western Nigeria." *Fertilizer Res* 5 (1984): 309-313.

How to cite this article: Amadi, Emmanuel I, Ben A Amadi, Felix U Igwe and Joy O Akaninwor. “Nutritive Benefits of Plantain (Musa paradisaica) Grown with Sludge Obtained from Wastewater Treatment Plant within Port-Harcourt Environment”. *J Environ Anal Toxicol* 11 (2021): 003.