Journal of ENVIRONMENTAL Treatment Techniques

J. Environ. Treat. Tech.
ISSN: 2309-1185

Journal web link: http://www.jett.dormaj.com

Biotreatment of Point-Sourced Effluent Discharged into Aquatic Ecosystems in Yenagoa Metropolis, Nigeria

Tariwari C. N Angaye*[1], Egbegi Ekiemo Mathew[2] and Youkparigha, F. Okponanabofa[1]

[1]Department of Biological Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria
[2]Department of Ports Management, Nigerian Maritime University, Okerenkoko, Delta State, Nigeria

Received: 23/11/2019 Accepted: 09/12/2019 Published: 20/02/2020

Abstract

River systems have become vital resources that conserve and sustain aquatic biodiversity. No aquatic ecosystem is pristine and preserved from anthropogenic agents, especially point-sourced effluent and urban runoff. Prior to the bioassay, untreated point-source effluent was analysed for some physicochemical and heavy metal parameters. The biotreatment involved the use of ripe and unripe plantain peels for a period of 4 weeks, at an interval of 1 week. Results showed significant ($P<0.01$) improvement in physicochemical parameters and heavy metal concentrations of the effluent after 4 weeks of treatment. Comparatively, the ripe plantain treatment had more efficacy than the unripe treatment ($P<0.01$).

Keywords: Biotreatment, Effluent, Aquatic ecosystem, Heavy metals

1 Introduction

Sequel to the fact that water and river systems sustain biodiversity, they have become essential and inevitable components of the over-all ecosystem. Due to the ubiquitous applications of water, its quality is infringed upon by anthropogenic or lithogenic agents. It was documented in literature that about 70% of the Niger Delta is occupied with water, but access to quality water still remains a ravaging problem [1, 2]. While over 300 million lack access to quality water in over ten African countries, it was reported that another 1.0 - 1.2 billion persons still suffer water shortage globally [1].

The effects of point-source effluents on aquatic ecosystems cannot be overemphasized. They constitute threat to aquatic biota, due to compromised water quality. The toxicants originating from point-sourced effluent includes heavy metals [3], polycyclic aromatic hydrocarbons [4, 5], and radioactive elements [5, 6]. Some toxic industrial effluents may arise from anthropogenic activities involving the production of fertilizers, cement, pulp and paper, food processing, pharmaceuticals, metal, textile, chemical, petroleum, lubricant plants.

Some studies have been documented on aquatic pollution, their sources and adverse effects on aquatic biota. Coastal waters bodies are subjected to anthropogenic pressure from sewage and industrial effluents thereby affecting the water quality as well as the coastal sediment [8]. Aquatic ecosystems are vital resources that sustain biodiversity due to the numerous and diverse species. Point-source effluent contains toxin, when untreated and discharged into that adversely affects water quality and aquatic life. Therefore, this research is concern with the biotreatment of point-sourced effluent using ripe and unripe plantain peel.

2 Materials and Methods

2.1 Samples Collection

One litre of effluent being discharged through piping into a creeklet was collected from a point source in Yenagoa, Bayelsa state, Nigeria. The ripe and unripe plantain peels were collected from roadside roasted-plantain (popularly known as Bole) vendor. The peels were separated and chopped into tiny bits for the bioassay.

2.2 Analysis of water samples

The effluent was analysed for *in-situ* physicochemical parameters like; pH, Total Dissolved Solids (TDS), Dissolved Oxygen using portable field meter (DO-700) following standard protocols [9]. Biochemical Oxygen Demand (BOD5) was analysed in the laboratory using Winkler's method. Heavy metals were analysed using the Perkin Elmer 5100 PC AA Model of Flame Atomic Absorption Spectrophotometer Spectrometer (FAAS).

Corresponding author: Tariwari C. N Angaye, Department of Biological Sciences, Niger Delta University, Wilberforce Island, Bayelsa State, Nigeria.

Table 1: Result of physicochemical parameters of effluent before and after biotreatment with plantain peels

Treatment	Week	pH	DO (mg/l)	BOD (mg/l)	COD (mg/l)
Before Treatment	1	4.22±0.16a	3.07±0.02a	1.44±0.31a	2.22±0.31a
	2	4.66±0.09b	3.57±0.17b	1.44±0.31a	2.62±0.31a
	3	4.70±0.09b	3.59±0.18b	1.44±0.31a	2.64±0.31a
	4	4.77±0.06b	3.97±0.02c	2.11±0.11c	2.69±0.11c
After Treatment with Unripe Peels	1	5.24±0.04d	4.10±0.10d	1.36±0.12a	2.31±0.12a
	2	5.73±0.03f	4.31±0.11d	1.10±0.06a	2.31±0.06a
	3	6.48±0.03g	4.42±0.05e	2.09±0.05c	3.54±0.05c
	4	6.57±0.05h	4.88±0.40e	2.37±0.16c	3.55±0.16c
After Treatment with Ripe Peels	1	5.93±0.04e	4.40±0.06c	1.38±0.04a	2.59±0.04a
	2	5.94±0.03f	4.54±0.03e	1.53±0.11b	2.75±0.11c
	3	6.58±0.02h	4.59±0.02e	2.21±0.18c	3.33±0.18c
	4	6.80±0.07i	4.96±0.06f	2.42±0.30c	3.58±0.30c

Table 2: Result of Heavy metal parameters of effluent before and after biotreatment with plantain peels

Treatment	Week	Cadmium	Copper	Mercury	Lead	Iron
Before Treatment	1	ND	1.84±0.26i	ND	1.71±5.71g	15.44±0.12i
	2	ND	1.68±0.08h	ND	1.38±0.09f	11.44±0.11i
	3	ND	1.46±0.02g	ND	1.18±0.13ef	10.81±0.11h
	4	ND	1.44±0.17g	ND	1.11±0.13e	10.08±0.11h
Unripe Peels	1	ND	1.27±0.17f	ND	1.04±0.23e	8.98±0.26g
	2	ND	1.18±0.04ef	ND	1.01±0.17e	6.96±0.05f
	3	ND	1.04±0.03e	ND	0.87±0.14d	4.32±0.15e
	4	ND	0.82±0.11d	ND	0.58±0.32c	1.55±0.36d
Ripe Peels	1	ND	0.71±0.10bc	ND	0.27±0.35b	0.96±0.55c
	2	ND	0.62±0.16b	ND	0.11±0.13a	0.59±0.23b
	3	ND	0.59±0.06b	ND	0.10±0.05a	0.39±0.08a
	4	ND	0.35±0.14a	ND	0.09±0.10a	0.36±0.04a

2.3 Experimental Design

Ten grams of triplicate samples plantain peels were weighed using weighing balance and distinctly macerated in 4 Litres of the collected effluent sample. The results were monitored for the aforementioned parameters weekly for a period of one month.

2.4 Statistical analysis

All emerging data were subjected to statistical analysis using Version 20 of SPSS, One Way Analysis of variance (ANOVA) was utilized for mean separation, while Duncan multiple range statistic was used to establish the significance of the observed differences at P=0.05.

3 Results and Discussion

Results of the physicochemical quality of the effluent before and after treatment are presented in Table 1. Before treatment, results on pH level from weeks 1 - 4 was; 4.22 (week 1), 4.66 (week 2), 4.70 (week 3), and 4.77 in week 4. The treatment with the unripe plantain peel demonstrated significant ($P<0.05$) improvement in pH level in week 1 (5.24), week 2 (5.73), week 3 (6.48) and week 4 (6.57). Furthermore, the ripe peel bioassay was the most effective treatment which improved the pH levels of 5.93, 5.94, 6.58 and 6.80 in weeks 1, 2, 3 and 4 respectively (Table 1).

The Dissolved oxygen level of the effluent before treatment was reported as 3.07 mg/l in week 1, 3.57 mg/l in week 2, 3.59 in week 3 and 3.97 mg/l in week 4. After treatment with the unripe plantain peels, DO level of the effluent improved significantly ($p<0.05$) to 4.10 mg/l in week 1, 4.31 mg/l in week 2, 4.42 mg/l in week 3 and 4.88 mg/l in week 4. The unripe plantain peel was the most effective with improved DO levels to 4.40 mg/l in week 1, 4.54 mg/l in week 2, 4.59 mg/l in week 3, and 4.96 mg/l in week 4 (Table 1).

The Biochemical oxygen demand (BOD) of the effluent before treatment was 1.44 mg/l, 1.44 mg/l, 1.44 mg/l and 2.11 mg/l in weeks 1, 2, 3 and 4 respectively. However, treatment with unripe plantain peels showed improvement to 4.10 mg/l (week 1), 4.31 mg/l (week 2), 4.42 mg/l (week 3), and 4.88 mg/l in week 4. Furthermore, the unripe plantain peel treatment had more efficacy with BOD levels of 1.38 mg/l in week 1, 1.53 mg/l in week 2, 2.21 mg/l in week 3 and 2.42 mg/l in week 4.

Prior to the biotreatment the concentrations of chemical oxygen demand of the effluent was 2.22 mg/l in week 1, 2.62 mg/l in week 2, 2.64 mg/l in week 3 and 2.69 mg/l in week 4. Treatment with the unripe plantain peels improved COD levels to 2.31 mg/l in week 1, 2.54 mg/l in week 2, 2.55 mg/l in week 3 and 2.75 mg/l in week 4. There was more improvement in the COD level of the effluent when unripe peel was applied with values of 2.59 mg/l in week 1, 2.75 mg/l in week 2, 3.33 mg/l in week 3 and 3.58 mg/l in week 4 (Table 1).

The result of heavy metal concentrations before and after treatment is presented in Table 2. Prior to treatment, the level of cadmium was below detection limit and remained so after the applied treatments were concluded (Table 2). Results on the levels of copper before treatment were 1.84, 1.68, 1.46 and 1.44 mg/l in weeks 1, 2, 3 and 4 respectively. However, after the unripe peel treatment levels of copper in the effluent significantly (<0.05) reduced to 1.27 mg/l, 1.18 mg/l, 1.04 mg/l, and 0.83 mg/l in weeks 1, 2, 3 and 4 respectively (Table 2).

Mercury was not detected in the effluent before and after treatment (Table 2). The bioassay for lead indicated that the levels of lead before treatment were 1.71 mg/l in week 1, 1.38 mg/l in week 2, 1.18 mg/l in week 3 and 1.11 mg/l in week 4 (Table 2). Treatment with unripe peels showed that the lead levels were significantly ($p<0.05$) reduced to 1.11 mg/l in week 1, 1.04 mg/l in week 2, 1.01 mg/l in week 3 and 0.87 mg/l in week 4 (Table 2).

Results on iron levels showed that before treatment iron level was 15.44 mg/l in week 1, 11.44 mg/l in week 2, 10.81 mg/l in week 3 and 10.08 mg/l in week 4 (Table 2). After treatment with the unripe peels, levels of iron reduced significantly to 8.98 mg/l in week 1, 6.96 mg/l in week 2, 1.32 mg/l in week 3, and 1.55 mg/l in week 4 (Table 2). Furthermore, the bioassay treatment with ripe peels was most active in reducing iron levels to 0.96 mg/l in week 1, 0.59 mg/l in week 2, 0.39 mg/l in week 3, and 0.36 mg/l in week 4. In summary, it was observed that treatment improved water quality with respect to the analysed parameters as the weeks progressed. However, it was observed that the ripe plantain peels treatment was more effective than the unripe plantain peels treatment.

Effective treatment of polluted water samples with parts of plantain have been documented in literature in a previous study. Acidic and high iron containing water was treated with the leaves, stem and trunk of plantain by Ohimain *et al*., [10]. After 4 weeks of treatment, acidic pH levels reduced from 4.15 mg/l – 6.48 mg/l for leaf treatment, 4.15 mg/l – 6.85 mg/l for bract treatment, and 4.15 mg/l – 7.88 mg/l, for the leaves treatment. In the same study effective iron treatment was reported for the leaves (8.62 mg/l – 1.05 mg/l), bracts (8.62 mg/l – 2.12 mg/l), and trunk (8.62 mg/l – 0.11 mg/l).

In another study, the unripe peels of plantain were reported to have reduced iron concentration from 11.44 mg/l to 9.98mg/l in week 1, 7.96mg/l in week 2, 4.92mg/l in week 3, and 1.55mg/l in week 4 [11]. For the ripe plantain peel treatment results were reported as; 7.96 mg/l (week 1), 6.39 mg/l (week 2), 3.08 mg/l in week 3, and 0.86 mg/l in week 4 [11]. In the same study, they reported that the pH treatment for unripe peels was; 5.34 in week 1, 5.83 in week 2, 6.34 in week 3, and 6.56 in week 4. Meanwhile, the ripe peel was 5.53 in week 1, 5.59 week 2, 6.55 in week 3 and 6.70 in week 4. The mechanism of treatment is yet to be unravelled. Although biosorption by the plant and presence of phytochemicals are suspected mechanism.

3 Conclusions

The persistent and anthropogenic discharged of point-sourced untreated effluent into aquatic ecosystem is a regrettable and unfortunate action. In this research treatment was applied to point source effluent using unripe and ripe peels of plantain. Fortunately, the biotreatment of the water with ripe and unripe plantain peels resulted to significant ($p<0.05$), improvement of all physicochemical properties assessed. Similarly, the treatemts were able to reduce heavy metal concentration significantly ($p<0.05$). based on the outcome of this research we therefore recommend the further development and application of plantain for the biotreatment of toxic effluent.

References

1 Ohimain, E. 1., & Angaye, T. C. N. (2014). Iron levels, other selected physicochemical and microbiological Properties of earthen and concrete catfish ponds in central Niger Delta. *Int. Jour. of Biol. & Biomed Sci*., 3(5), 041 - 043.

2 Ohimain, E. 1., Angaye, T. C. N., & Okiongbo, K. (2014a) Removal of Iron, Coliforms and Acidity from Ground Water Obtained from Shallow Aquifer Using Trickling Filter Method. *Jour of Envt. Sci. & Engr*., 2, 549 - 555.

3 Rooker, J. R., Simms, J. R., Wells, R. J. D., Holt, S. A., Holt, G. J., Graves, J. E., & Furey, N. B. (2012). Distribution and Habitat Associations of Billfish and Swordfish Larvae across Mesoscale Features in the Gulf of Mexico. *Plos One*, 7.

4 Ansari, Z. A., Desilva, C., & Badesab, S. (2012). Total Petroleum Hydrocarbon in the Tissues of Some Commercially Important Fishes of the Bay of Bengal. *Marine Pollution Bulletin*, 64, 2564-2568.

5 Jensen, L. K., Honkanen, J. O., Jaeger, I., & Carroll, J. (2012). Bioaccumulation of phenanthrene and benzo a pyrene in *Calanus finmarchicus*. *Ecotoxicology and Environmental Safety*, 78, 225-231.

6 Zalewska, T. (2012). Seasonal changes of Cs-137 in Benthic Plants from the Southern Baltic Sea. *Journal of Radioanalytical and Nuclear Chemistry*, 292, 211-218.

7 Khan, M. F., & Wesley, S. G. (2012) Radionuclide Monitoring in Molluscs Inhabiting Intertidal Region Near a Nuclear Installation, Gulf of Mannar, India. *Marine Pollution Bulletin*, 64, 436-444.

8 Rashid, K., Hoque, S., & Akter, S. (2015). Pollution in the Bay of Bengal: Impact on Marine Ecosystem. *Open Journal of Marine Science*, 5, 55-63.

9 Association of Official Analytical Chemists (AOAC), ―Official methods of analysis‖. 16th edition. Arlington, V. A. USA. 1995.

10 Ohimain, E. I., Angaye, T. C.N., & Oduah, A. A. (2008). Biotreatment of acidic and high iron containing groundwater for aquaculture using plantain (Musa paradisiaca) tissues. *International Journal of Engineering Science and Innovative Technology*, 3(5), 121 – 126.

11 Seiyaboh, E. I., Angaye, T. C. N., & Ogidi, O. (2017). The biotreatment of high iron containing water for aquaculture using ripe and unripe peels of plantain. *MOJ Toxicol.* 3(5), 110–113.

Author Profile

Dr. T.C.N Angaye hails from Bayelsa State, Nigeria. He is a Scholar, Enviromentalist and Researcher with over 80 Publications in Local and International Journals. He obtained his B.Sc, M.Sc & Ph.D degrees from the Niger Delta University, Bayelsa State, Nigeria where he is currently a Lecturer.

Mr. Egbegi E. M. was born in 1981 at Ebedebiri, Bayelsa State. He is a researcher, Maritime Inspector and a trainer in the Maritime field, presently teaching at the Nigerian Maritime University, Okerenkoko, warri, Delta State Nigeria. He has an M.Sc. From the renowned World Maritime University, Malmo, Sweden. B.Sc. From Niger Delta university, Nigeria,Diploma-Esberge, Denmark, Motorman-JINSR Nigeria, OSMERT NigeriaTrainer-GBMC, MLC, SEEMP, Sweden.

Dr. Youkparigha, F.O. is a Science Teacher and Environmentalist that has taught biology for over 20 years. He holds B.Sc (Education) in Biology from the University of Port Harcourt, MPHIL in Environmental Management from the Rivers State University and a Ph.D from the Niger Delta University, with spetialization in Phytotaxonomy and Ethnobotany. He is currently a lecturer and married to his sweetie, Justina with 3 great children – Fulness, Blosom and Victory.