The biotreatment of high iron containing water for aquaculture using ripe and unripe peels of plantain

Abstract

The ubiquitous nature and abundance of both surface and underground water resource in the Niger Delta cannot be overemphasized. Water play diverse roles in the ecosystem, including the its inevitable sustainability of the aquaculture sector. Unfortunately, actualization of clean and safe water in the Niger Delta could be problem at ic due high iron levels and acidic pH, which makes farmer struggle to improve water quality for aquaculture suitability there by applying both empirical and instinctive measures. Untreated water having iron content of $10.81 \pm 0.11 - 11.44 \pm 0.12 \text{ mg/l}$ with pH of $4.32 \pm 0.16 - 5.09 \pm 0.06$ was treated with ripe and unripe peels of plantain fruit. Results shows that pH had significant inverse relationship ($P < 0.01$) with iron, hardness and BOD but direct relationship with dissolved oxygen. After 4 weeks of treatment, Iron concentration decreased as; $9.98 < 7.96 < 4.92 < 1.55 \text{ mg/l}$ for the unripe plantain peel treatment (UPPT), and $7.96 < 6.39 < 3.08 < 0.86 \text{ mg/l}$ for ripe plantain peel treatment (RPPT). Results show that there was a significant ($p < 0.05$) corresponding increase in pH for both UPPT ($5.34 > 5.83 > 6.34 > 6.56$) and RPPT ($5.53 > 5.59 > 6.55 > 6.70$) respectively. All the treatments resulted in the improvement of the water quality, especially with respect to pH and iron. The RPPT had better efficacy compared to UPPT, but all treatment improved the suitability of the water to the conformance of suitable for aquaculture.

Keywords: aquaculture, biotreatment, iron, plantain peels, ph

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Introduction

Water playan essential role in the ecosystem because it is an obligate resource for the survival of all organisms. While water is a ubiquitous resource, its quality and aesthetic value are often impaired by either anthropogenic agent or natural phenomena. 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- 0.2 billion persons still suffer water shortage globally.¹ Sequel to the fall in oil price which is the mainstay of the Nigerian economy; Agriculture including fish farming has become one of the major mantra aimed at signalling a multi-economy. Agriculture was reported to create employment with an active labour force of over 70%.^{3,4} Unfortunately, the suitability of water for aquaculture has become a major challenge due to organic and inorganic agents like microbial contamination and high iron content (25-8). For instance, high iron concentration has been reported to affect some vital physicochemical parameters that sustain aquatic organisms, especially fish.¹⁻⁶ The application of instinctive knowledge, failure to adhere to aseptic measures and technical advice on the part of the farmer has been linked poor yield in the aquaculture sector.^{7,8} For instance, fish kill when farmers administer wrong and ineffective treatment without the aid of competent personnel.⁷ Fish kill are largely linked to infectious or non-infectious disease, and in rare cases due to mechanical trauma and excessive usage of exogenous hormone.⁵ Studies have shown that untreated groundwater is toxic to fresh water fish,⁶ in both concrete tank and earthen pond as a result of high iron levels and acidity.¹ On the other hand, some farmers have applied various instinctive methods to remedy poor water quality of their homestead pond including the use of plantain bracts and leaves in what is known as pond fertilization.

Fertilization in this context refers to the application of certain synthetic and natural formulation in order to stimulate the growth of aquatic flora and fauna which act as buffer to acidic pH or even nutrient for fish in homestead pond. For instance, nutrients produced during fertilization, enhance the bioavailability of phytoplankton as primary producers in pond.⁹ The indigenous application of plantain for optimizing aquaculture water has become a common practice, though the science behind this practice yet to be unravelled.¹⁰ Several Authors have reported remedial measures to high iron and acidic water using single and double trickling filter and,⁵ using activated carbon from bamboo.¹¹ Fortunately, a recent study showed that leaves, trunk and bracts of plantain were able to optimized mitigate high iron content, thereby optimizing acidic pH.¹⁰ Application of water treatment technologies is constrained on the part of the farmer due to high cost of fabricating and maintaining contemporary treatment plant; in addition, In the Niger Delta, production of waste stream from plantain peels is constituting environmental problem. Hence necessitating the prospective application of plantain peels in this current study.

Materials and methods

Samples collection and analysis

Fifty litre of untreated iron-containing groundwater was collected from a 60±5Ft 60±5ft bore hole in near a fish farm in Yenagoa, Bayelsa state, Nigeria. Ripe and Unripe peels of plantain were collected from a roadside plantain vendor, popularly known as Bole joint, the peels were distinctly chopped to smaller unit for the biotreatment assay.

Analysis of water samples

All analysis was carried out following standard protocol.¹² The water was analysed for in-situ physicochemical parameters like; Temperature, pH, Total dissolved Solids (TDS), Dissolved Oxygen

using portable field meter (DO-700). Biochemical Oxygen Demand (BOD₅) was analysed in the laboratory using Winkler's method, Colorimetric method was used for the analysis of nitrate. Iron was analysed using the Perkin Elmer 5100 PC AA Model of Flame Atomic Absorption Spectrophotometer Spectrometer (FAAS). For microbiological analysis, Heterotrophic bacteria and fungi were enumerated by aerobic standard plate count (Pour Plate Technique), while the total and fecal coliforms were determined using Multiple Tube Fermentation Technique expressed as MPN (Most Probable Number) APHA 9222C.

Experimental design

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

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 $P=0.05$.

Results and discussion

As presented in Table 1, results of the water quality assessment in the control (i.e. without treatment) after one week was high in iron content ($11.44 \pm 0.12 \text{ mg/l}$), with low pH value of 4.32 ± 0.16 ($p < 0.05$), other assessed parameters were Temperature ($26.29 \pm 0.16^\circ\text{C}$), Dissolved oxygen ($3.07 \pm 0.02 \text{ mg/l}$), Biochemical oxygen Demand ($1.44 \pm 0.31 \text{ mg/l}$), Total dissolved Solid ($55.80 \pm 0.14 \text{ mg/l}$), Nitrate ($2.13 \pm 0.05 \text{ mg/l}$) and Hardness with value of $309.71 \pm 5.71 \text{ mg/l}$ ($p < 0.05$). But after treatment with unripe plantain peels, the inverse correlation between pH and Iron was still observed as pH improved from 4.32 ± 0.16 to 5.34 ± 0.04 while iron concentration reduced from $11.44 \pm 0.12 \text{ mg/l}$ to $9.98 \pm 0.26 \text{ mg/l}$. The temperature was $27.86 \pm 0.04^\circ\text{C}$; Dissolved Oxygen $4.10 \pm 0.10 \text{ mg/l}$ and Biochemical Oxygen Demand of $1.36 \pm 0.12 \text{ mg/l}$. Total Dissolved Solid (TDS), was $64.50 \pm 0.20 \text{ mg/l}$, while the values of Nitrate and Hardness were 3.79 ± 0.17 and $293.64 \pm 0.23 \text{ mg/l}$ respectively ($p < 0.05$). Similarly, the treatment with ripe peels of plantain (RPPT), further improved the water quality compared to the unripe peels with pH of 5.53 ± 0.04 and iron concentration of $7.96 \pm 0.55 \text{ mg/l}$ with significant difference ($p < 0.05$). In the second week, the water quality of the control indicated no significant change ($p > 0.05$) in iron concentration compared to the first week ($11.44 \pm 0.12 \text{ mg/l}$). But there was slight change in pH value with significant difference ranging from 4.32 ± 0.16 in the first week to 4.76 ± 0.09 in the second week ($p < 0.05$). Temperature was $27.69 \pm 0.17^\circ\text{C}$, Dissolved oxygen increased to $3.57 \pm 0.17 \text{ mg/l}$, Biochemical oxygen Demand was $1.44 \pm 0.31 \text{ mg/l}$, TDS and Nitrate values indicated no significant change ($p > 0.05$), while Hardness $301.38 \pm 0.08 \text{ mg/l}$ ($p < 0.05$). However, the treatment with unripe plantain peels (UPPT), indicated improved pH (5.83 ± 0.03) and Iron ($7.96 \pm 0.05 \text{ mg/l}$) values compared to the first week. The temperature of the unripe plantain peel treatment was $28.65 \pm 0.17^\circ\text{C}$; while DO and BOD were 4.31 ± 0.11 and $1.10 \pm 0.06 \text{ mg/l}$ respectively ($p < 0.05$). Total Dissolved Solid was $54.17 \pm 0.11 \text{ mg/l}$, while nitrate increased to $4.29 \pm 0.17 \text{ mg/l}$, Hardness was $213.71 \pm 0.17 \text{ mg/l}$ ($p < 0.05$). The

RPPT further improved the water quality with pH value of 5.94 ± 0.03 with significant corresponding reduction in iron concentration of $6.39 \pm 0.23 \text{ mg/l}$ ($p < 0.05$). While other parameters in the RPPT were Temperature ($28.43 \pm 0.02^\circ\text{C}$), DO ($4.54 \pm 0.03 \text{ mg/l}$), BOD ($1.38 \pm 0.11 \text{ mg/l}$), TDS ($47.09 \pm 0.01 \text{ mg/l}$), Nitrate and Hardness were 4.52 ± 0.02 and $219.76 \pm 0.13 \text{ mg/l}$. In the third week, it was no significant difference in pH and total Iron compared to the controls of the second week ($p > 0.05$).

Temperature was $26.95 \pm 0.14^\circ\text{C}$, Dissolved oxygen was $3.57 \pm 0.17 \text{ mg/l}$, Biochemical oxygen Demand was $1.44 \pm 0.31 \text{ mg/l}$, TDS and Nitrate values indicated no significant change ($p > 0.05$), while Hardness $203.07 \pm 0.14 \text{ mg/l}$ ($p < 0.05$). However, the treatment with unripe plantain peels (UPPT), indicated improved pH of 6.34 ± 0.03 and Iron value of $4.92 \pm 0.15 \text{ mg/l}$ compared to the second week. In addition, the unripe plantain treatment had temperature of $29.25 \pm 0.26^\circ\text{C}$; with DO and BOD of 4.42 ± 0.05 and $2.73 \pm 0.16 \text{ mg/l}$ respectively ($p < 0.05$). Total Dissolved Solid was $50.48 \pm 0.31 \text{ mg/l}$, while nitrate was $4.62 \pm 0.21 \text{ mg/l}$, and Hardness was $203.07 \pm 0.14 \text{ mg/l}$ ($p < 0.05$). The RPPT improved the water quality with pH value of 6.55 ± 0.02 reduced iron concentration to $3.08 \pm 0.08 \text{ mg/l}$ ($p < 0.05$). While other parameters were Temperature ($28.43 \pm 0.02^\circ\text{C}$), DO ($4.54 \pm 0.03 \text{ mg/l}$), BOD ($1.38 \pm 0.11 \text{ mg/l}$), TDS ($47.09 \pm 0.01 \text{ mg/l}$), Nitrate and Hardness were 4.43 ± 0.05 and $150.98 \pm 0.05 \text{ mg/l}$.

Compared to the control, results of UPPT and RPPT indicated that in the fourth week, the pH and total Iron of the water sample improved significantly ($p > 0.05$). The pH was 6.56 ± 0.05 and 6.70 ± 0.07 for UPPT and RPPT respectively, while total iron was 1.55 ± 0.36 and 0.86 ± 0.04 . Temperature was 26.86 ± 0.06 and $27.60 \pm 0.10^\circ\text{C}$, Dissolved oxygen was 4.04 ± 0.06 and $4.36 \pm 0.40 \text{ mg/l}$, Biochemical oxygen Demand was 2.37 ± 0.16 and $2.42 \pm 0.30 \text{ mg/l}$, TDS values were 44.25 ± 0.41 and $33.97 \pm 0.10 \text{ mg/l}$, while Nitrate was 4.57 ± 0.08 and 4.39 ± 0.07 ($p > 0.05$). Hardness of the water was $162.18 \pm 0.32 \text{ mg/l}$ for UPPT, and $110.11 \pm 0.10 \text{ mg/l}$ for RPPT ($p < 0.05$). The results of this research corroborate Ohimain et al.² which confirm acidic pH in water with high iron content, especially in some part of the Niger Delta. Ohimain et al.⁵ reported pH of 4.39-5.17 with iron content of 5.32-9.96 mg/l in untreated ground water of Bayelsa State. Apart from iron and pH that showed inverse correlation, other parameters improved significantly ($P < 0.05$) as a result of the treatment. Dissolved oxygen increased while BOD, nitrate and hardness decreased ($P < 0.01$) as the treatment progressed, though the RPPT treatment indicated better results compared UPPT. The results of this study also corroborated the finding of Ohimain et al.,² which showed the plantain leaves, stem and bracts was able to significantly reduce high iron containing water with acidic pH after 4 weeks of treatment from 8.62-2.12 mg/l and 4.15-6.48 for the leaves, 8.62-1.05 mg/l and 4.15-6.85 for the bracts and 8.62-0.11 mg/l and 4.15-7.88 for the trunk. Ground water is often preferred for aquaculture due to the fact that it is devoid of contaminants.⁶ However, ground water from the study area (Niger Delta), contains high levels of iron have been found to be toxic to fish, especially fingerlings.⁶ Fortunately, RPPT and UPPT had resulted in decreased iron levels as well as optimized pH. Although the mechanism of treatment is yet to be unraveled but biosorption by the plant was a suspected mechanism. Since there was improvement of pH as well as dissolved oxygen with a resultant decrease in BOD, hardness and nitrate. Notwithstanding, further research to validate this claim will be necessary, as well as the field trial to determine the actual dose of the treatment.

Table 1 Result of water quality parameters after biotreatment with plantain peels

	WK	Temp (°C)	pH	DO (mg/l)	BOD (mg/l)	TDS (mg/l)	Nitrate (mg/l)	Hardness (mg/l)	Iron (mg/l)
Control	1	26.29±0.16a	4.32±0.16a	3.07±0.02a	1.44±0.31a	55.80±0.14g	2.13±0.05a	309.71±5.71j	11.44±0.12i
	2	27.69±0.17de	4.76±0.09b	3.57±0.17b	1.44±0.31a	55.80±0.09g	2.13±0.05a	301.38±0.09i	11.44±0.11i
	3	26.95±0.14b	4.76±0.09b	3.57±0.18b	1.44±0.31a	59.80±0.10h	3.33±0.05c	300.98±0.13i	10.81±0.11h
	4	28.71±0.08g	5.09±0.06c	4.07±0.02c	2.11±0.11c	61.64±0.20i	3.73±0.30d	300.98±0.13h	10.81±0.11h
Unripe Peels	1	27.86±0.04e	5.34±0.04d	4.10±0.10d	1.36±0.12a	64.50±0.20j	3.79±0.17d	293.64±0.23i	9.98±0.26g
	2	28.65±0.17fg	5.83±0.03f	4.31±0.11d	1.10±0.06a	54.17±0.11f	4.29±0.17de	213.71±0.17e	7.96±0.05f
	3	29.25±0.26h	6.34±0.03g	4.42±0.05e	2.09±0.05c	50.48±0.31e	4.62±0.21f	203.07±0.14d	4.92±0.15d
	4	26.86±0.06b	6.56±0.05h	4.96±0.06f	2.37±0.16c	44.25±0.41c	4.57±0.08f	162.18±0.32c	1.55±0.36b
Ripe Peels	1	27.81±0.11de	5.53±0.04e	4.04±0.06c	1.53±0.04c	67.28±0.19d	4.20±0.10d	250.40±0.35g	7.96±0.55f
	2	28.43±0.02f	5.94±0.03f	4.54±0.03e	1.38±0.11a	47.09±0.01d	4.52±0.02e	219.76±0.13f	6.39±0.23e
	3	27.42±0.03c	6.55±0.02h	4.55±0.02e	2.21±0.18c	40.69±0.01b	4.43±0.05de	150.98±0.05b	3.08±0.08c
	4	27.60±0.10c	6.70±0.07i	4.35±0.40e	2.42±0.30c	33.97±0.10a	4.39±0.07de	110.11±0.10a	0.86±0.04a

Keys: Data were expressed as mean ±Standard Deviation, differences in alphabetical letters indicates significant difference.

Conclusion

The quality of water is a vital and inevitable requirement for an aquaculture system. Regrettably, the quality of groundwater sample in this study which is often used in homestead pond from the Niger Delta, is characterized by high concentration of iron with corresponding acidic pH. This could cause fish kill, which is often a threat to the aquaculture sector. Fortunately, the biotreatment of the water with ripe and unripe plantain peels resulted to significant reduction in iron ($P<0.05$), with an improved pH ($P<0.01$) to meet the threshold standard required by WHO limits/standards for safe water. Based these finding, and previous research on the efficacy of plantain tissues we therefore recommend the field trial of plantain the biotreatment of high iron containing acidic water and to also ascertain the actual treatment mechanism and efficacy.

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None.

Conflict of interest

The author declares no conflict of interest.

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