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 it 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±0.11 - 11.44±0.12mg/l with pH of 4.32±0.16-5.09±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<1.55mg/l for the unripe plantain peel treatment (UPPT), and 7.96<6.39<3.08<0.86mg/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

Introduction

Water play an 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. 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. 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%. 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. 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. Unfortunately, actualization of clean and safe water in the Niger Delta could be problem at it 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±0.11 - 11.44±0.12mg/l with pH of 4.32±0.16-5.09±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<1.55mg/l for the unripe plantain peel treatment (UPPT), and 7.96<6.39<3.08<0.86mg/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

Materials and methods

Samples collection and analysis

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. The indigenous application of plantain for optimizing aquaculture water has become a common practice, though the science behind this practice yet to be unravelled. Several Authors have reported remedial measures to high iron and acidic water using single and double trickling filter and, using activated carbon from bamboo. Fortunately, a recent study showed that leaves, trunk and bracts of plantain were able to optimized mitigate high iron content, thereby optimizing acidic pH. 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.

Analysis of water samples

All analysis was carried out following standard protocol. The water was analysed for in-situ physicochemical parameters like; Temperature, pH, Total dissolved Solids (TDS), Dissolved Oxygen.
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±0.12mg/l), with low pH value of 4.32±0.16 (p<0.05), other assessed parameters were Temperature (26.29±0.16OC), Dissolved oxygen (3.07±0.02mg/l), Biochemical oxygen Demand (1.44±0.31mg/l), Total dissolved Solid (55.80±0.44mg/l), Nitrate (2.13±0.05mg/l) and Hardness with value of 309.71±5.71mg/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±0.12mg/l to 9.98±0.26mg/l The temperature was 27.86±0.04OC; Dissolved Oxygen 4.10±0.10mg/l and Biochemical Oxygen Demand of 1.36±0.12mg/l. Total dissolved Solid (TDS), was 64.50±0.20mg/l, while the values of Nitrate and Hardness were 3.79±0.17 and 293.64±0.23mg/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±0.55mg/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±0.12mg/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±0.17OC, Dissolved oxygen increased to 3.57±0.17mg/l, Biochemical oxygen Demand was 1.44±0.31mg/l, TDS and Nitrate values indicated no significant change (p>0.05), while Hardness 301.38±0.08mg/l (p>0.05). However, the treatment with unripe plantain peels (UPPT), indicated improved pH (5.83±0.03) and Iron (7.96±0.05mg/l) values compared to the first week. The temperature of the unripe plantain peels treatment was 28.65±0.17OC while DO and BOD were 4.31±0.11 and 1.10±0.06mg/l respectively (p>0.05). Total Dissolved Solid was 54.17±0.11mg/l, while nitrate increased to 4.29±0.17mg/l, Hardness was 213.71±0.17mg/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±0.23mg/l (p<0.05). While other parameters in the RPPT were Temperature (28.43±0.02OC), DO (4.54±0.03mg/l), BOD (1.38±0.11mg/l), TDS (47.09±0.01mg/l), Nitrate and Hardness were 4.52±0.02 and 219.76±0.13mg/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±0.14OC, Dissolved oxygen was 3.57±0.17mg/l, Biochemical oxygen Demand was 1.44±0.31mg/l, TDS and Nitrate values indicated no significant change (p>0.05), while Hardness 203.07±0.14mg/l (p>0.05). However, the treatment with unripe plantain peels (UPPT), indicated improved pH of 6.34±0.03and Iron value of 4.92±0.15mg/l compared to the second week. In addition, the unripe plantain treatment had temperature of 29.25±0.26OC; with DO and BOD of 4.42±0.05 and 2.73±0.16mg/l respectively (p>0.05). Total Dissolved Solid was 50.48±0.31mg/l, while nitrate was 4.62±0.21mg/l, and Hardness was 203.07±0.14mg/l (p>0.05). The RPPT improved the water quality with pH value of 6.55±0.02reduced iron concentration to3.08±0.08mg/l (p>0.05), while other parameters were Temperature (28.43±0.02OC), DO (4.54±0.03mg/l), BOD (1.38±0.11mg/l), TDS (47.09±0.01mg/l), Nitrate and Hardness were 4.43±0.05 and 150.98±0.05mg/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 5.50±0.36 and 5.86±0.04. Temperature was 26.86±0.06 and 27.60±0.10OC. Dissolved oxygen was 4.04±0.06 and 4.36±0.40mg/l. Biochemical oxygen Demand was 2.37±0.16 and 2.42±0.30mg/l. TDS values were 44.25±0.41 and 33.97±0.10mg/l, while Nitrate was 4.57±0.08 and 4.39±0.07 (p>0.05). Hardness of the water was 162.18±0.32mg/l for UPPT, and 110.11±0.10mg/l for RPPT (p<0.05). The results of this research corroborate Ohimain et al. which confirm acidic pH in water with high iron content, especially in some part of the Niger Delta. Ohimain et al. reported pH of 4.39-5.17 with iron content of 5.32-9.96mg/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., 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 8.62-2.12mg/l and 4.15-6.48 for the leaves, 8.62-1.05mg/l and 4.15-6.85 for the bract and 8.62-0.11mg/l and 4.15-7.88 for the trunk. 4.73mg/l water is often preferred for aquaculture due to the fact that it is devoid of contaminants. However, ground water from the study area (Niger Delta), contains high levels of iron have been found to be toxic to fish, especially fingerlings. 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.
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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 in 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.

### Acknowledgements

None.

### Conflict of interest

The author declares no conflict of interest.

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### 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) |
|----|----------|--------|-----------|------------|------------|---------------|----------------|-------------|
| 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 |
|    | Control   |        |           |            |            |               |                |             |
| 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±0.13h | 10.81±0.11h |
| 4  | 28.71±0.08g | 5.09±0.06c | 4.07±0.02c | 1.44±0.31a | 61.64±0.20i | 3.73±0.30d | 300.98±0.13i | 10.81±0.11h |
| 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  |
|    | Unripe Peels|        |           |            |            |               |                |             |
| 2  | 28.65±0.17fg | 5.83±0.03f | 4.31±0.11d | 1.10±0.06a | 64.50±0.20j | 3.79±0.17d | 213.71±0.17f | 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±0.13h | 10.81±0.11h |
| 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  |
| 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  |
|    | Ripe Peels  |        |           |            |            |               |                |             |
| 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.
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