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ARTICLE

Growth Inhibition of Algae in Aquaculture Fishponds Using Banana Peel Powder: A Mesocosm Experiment

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ABSTRACT

Cyanobacterial blooms or algae problems in aquaculture fish-ponds are becoming a big concern to fish farmers due to reduced production of fish. Although several studies have been conducted around the globe focusing on cyanobacterial blooms in oceans and lakes, little has been done on inhibition of algal biomass impacting fish-ponds in aquaculture industry. The present study assessed the potential of banana peel ashes and potassium sulphate on algal growth inhibition within

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fish-ponds based on a six-weeks mesocosm experiment conducted with varying ash concentrations (i.e., 2, 4, 6, 8, 10 $g \cdot L^{-1}$). This study analysed differences among treatments for the various nutrient variables (nitrates, ammonium and phosphates) at the end of the experiment. The significant experimental differences in physicochemical variables among the study weeks (i.e., 1–6 weeks), treatments (three levels, including controls) and ash concentrations using factorial repeated measures ANOVA were further tested. Moreover, algal growth was determined in order to test the efficiency of treatment n inhibiting algal growth by measuring chlorophyll-*a* concentration across 6 weeks. Banana peel ashes performed significantly well on inhibition of algal growth than potassium sulphate, except for controls. However, no clear patterns between pH and conductivity were observed throughout the experiment. The present study found that banana peel ashes do not have notable effects on water quality variable, particularly physicochemical parameters, which did not significantly change from first week of experiment. With banana peel ashes being the best inhibitor according to the findings of the present study, further studies are required to investigate the effects of banana peel ashes on fish within the ponds.

Keywords: Physicochemical Variables; Nutrients; Banana Peel Ash; Potassium Sulphate; Chlorophyll-*a*

1. Introduction

Globally, the aquaculture sector is growing faster than any other food production industry[1]. This is due to global consumption of farmed fish that has increased drastically. Fish farming has made a significant contribution to food security, poverty reduction, and socioeconomic development, and in turn, promoted sustainable development goals as prescribed by the United Nations[2–4]. However, certain fish farming techniques, including using fish feed in fishponds, deteriorate the quality of water resources and lessen the advantages that these resources would have provided[5, 6]. Most of the artificial fish feeds that are supplied by fish farmers have been proven to contain high concentration of nutrients such as phosphorus and nitrogen, consequently leading to eutrophic ponds[7]. Over the past years, the potential intake of fish feeds by fishponds has led to proliferation of algal blooms, thus leading to reduced production of fish from inland aquaculture[8, 9].

Research evidence indicates that eutrophic conditions cause harmful algal blooms (HABs) to become more prevalent. HABs are a major concern to aquaculture farm ponds as they produce cyanotoxins that pose significant threat to fish health and food security of aquatic product[10–13]. The ingestion of cyanotoxins during feeding on floating diets can passively be assimilated through fish gills during breathing and that can result in fish kills[14, 15]. Furthermore, the presence of HABs in aquaculture fishponds results in reduced dissolved oxygen, which leads to fish suffocation and consequently fish kills. While most algae species are thought to be beneficial in ponds, they can provide food for fish and further eliminate harmful substances like nitrates and ammonia from the water column in addition to releasing oxygen as a byproduct of photosynthesis[16, 17]. Evidence further suggests that HABs are progressively endangering aquatic water quality, notably in inland aquaculture fish dams by producing harmful toxins and limiting sunlight penetration in the water[13, 18, 19].

Since quantifying algal biomass is challenging, limnologists prefer measuring chlorophyll-*a* concentrations in water as a proxy for algal biomass[20]. Water quality models represent algae as biomass; therefore, algae are transformed into chlorophyll-*a* by multiplying with a chlorophyll-*a*/algal biomass ratio[21]. The chlorophyll-*a*/algal biomass ratios for various species are maintained constant throughout simulations, but, in reality, they alter dynamically across time and space based on light and the availability of nutrients[21]. HABs threaten water quality and aquatic life in numerous ways, including toxins release, restricting sunlight penetration into the water, and lowering oxygen during the decomposition process[22] In addition, HABs are hazardous as their presence affects the turbidity of water, suppressing aquatic macrophytes, which in turn severely impacts invertebrates and fish habitat[23]. Moreover, breakdown of algal bloom causes a decrease in oxygen level, thus leading to fish kills[24]. Finally, HABs release toxins that can damage the endocrine and digestive systems of animals, including humans, and induce acute poisoning that can be fatal[25].

Water treatment is quite expensive in most rural areas. Therefore, there is a need for cost-effective and ecologically

friendly techniques that may be conducted to eliminate algal growth in aquaculture fish ponds [26]. Due to the rising incidence of HABs in fish ponds and water supplies, as well as the effects of climate change and an increasing global population, it is important that research studies concentrate on alternative treatment technologies to manage HABs, especially in water bodies used for aquaculture, livestock, and drinking [27, 28]. Although previous batch experiments to treat cyanobacteria have been carried out, little has been done on using environmental friendly and cost-effective materials for treatment of algae in fishponds [29–31].

Several studies have proved that banana is one of the fruits that contain optimum amount of potassium [32–34]. This fruit accounts for bulk of its production in the Vhembe region, leading to over plantation and utilization due to its availability. The Lwamondo fishponds were selected based on the recent proliferation of algal biomass that has led to concerns among fish farmers. Studies further revealed potassium sulphate as an effective inhibitor of algal biomass in water column [35, 36]. In this study, the advantage of banana (being a K- rich fruit) and its accessibility on local market to conceptualize and test its potential on algal inhibition experiment was realized. The objectives of this study were (1) to evaluate the potential of banana peels ashes and potassium sulphate on algal inhibition efficiency using experimental approach and (2) to assess the relationship between chlorophyll–*a*, nutrients, and physicochemical parameters. This study hypothesized that (1) banana peel ashes will have high inhibition potential as compared to potassium sulphate and (2) physicochemical and nutrient variables will have a greater influence on the treatment and chlorophyll-*a* due to changes throughout the mesocosm experiment.

2. Materials and Methods

2.1. Experimental Design

An experiment was conducted for six weeks at the University of Venda, Department of Geography and Environmental Sciences Atrium (22°58'39.6"S, 30°26'37.6"E), from 4 March–13 April 2020. This experiment evaluated the potential of banana peel ashes and potassium sulphate on inhibiting algal growth in a controlled environment. The experiment utilized 33 × 12 L buckets (diameter = 25 cm and depth = 30 cm). The buckets were placed and filled with 10 L filtered (63 µm mesh to remove any zooplankton or phytoplankton available) borehole water collected from one of the University of Venda boreholes in the School of Agriculture.

2.2. Banana Peel Processing

Banana peels were collected from Thohoyandou town in Limpopo Province, South Africa by picking freshly thrown banana peel from the banana market place. The peels were stored in a 50 kg woven polypropylene bags and transported to the University of Venda. Upon arrival, banana peels were dried until their colour became black under room temperature for 3 months. After drying, the banana peels were grinded to powder and sieved through a 0.2 µm sieve and were stored in Ziplock bags for further measurements of potassium on XRF (X-ray fluorescence) (Thermo Fisher ARL9400 XP + Sequential XRF with WinXRF software).

2.3. Introducing Algae into the Buckets

Prior to commencement of experiments, a modified BG11 medium was prepared in the laboratory using the technique for algal culture established by Kruger and Eloff (1977). The medium was prepared using mineral and trace elements composition shown in **Table A1**. Minerals and trace elements were added to a 1000 ml Erlenmeyer flask along with 850 ml of deionized water. The solution in the flask was shaken until the minerals were fully dissolved and combined. The Erlenmeyer flask was then filled with deionized water. The medium was then autoclaved for fifteen minutes at 121 °C in a controlled environmental room. Under sterile condition, 10 ml of cyanobacteria inoculum collected from Lwamondo fish pond was added to Erlenmeyer flask containing 1000 ml of modified BG11 medium. The cultures (n = 36, for each treatment) were incubated for 30 days at room temperature (25 °C) to facilitate 'baseline' phytoplankton growth before the start of the experiment. The remaining 6 buckets were used as controls (without treatments). The quantity of potassium sulphate and banana peels ashes to be added on the buckets containing BG11 medium were measured according to Gammal (2008). The concentration of banana peels ashes were determined using XRF in the Laboratory.

The present study employed a randomized experimental design, with three treatments [i.e., 2 ashes treatments

(potassium sulphate and banana peel ashes), 1 control (no ashes) × 3 replicates × 5 ashes concentrations (i.e., 2, 4, 6, 8 and 10 g L^{-1}—thereafter referred to as B1–B5 and P1–P5)]. After 30 days of algae growth, physicochemical variables were measured and 50 mL of water was collected thereafter for chlorophyll-*a* determination, and this was performed before adding treatments. During the experiment, a portable handheld multi-parameter Cyberscan Series meter (Eutech Instruments, Singapore) was used to measure physicochemical parameters such as water conductivity (µS cm^{-1}), total dissolved solids (mg L^{-1}), pH, temperature (°C), ORP (Oxygen radox potential), sodium chloride (ppm), oxidation-reduction potential (mV) and resistivity (Ω), weekly. After collecting the first water samples (i.e., week 1 was treatment free), the concentration of the treatments were randomly introduced into the individual buckets, except for controls.

2.4. Nutrient Analysis

At the end of the experiment, nutrient concentrations [phosphate (umol L^{-1}), nitrate (umol L^{-1}) and ammonium (umol L^{-1})] within all the buckets were analyzed. Nutrient analyses were conducted in the laboratory using the HI 83203 multiparameter photometer (manufactured by Hanna Instruments Inc. Rhode Island). For analysis of ammonium, nitrates and phosphates concentrations, a 250 ml of water samples were collected in each bucket and analyzed using the Hanna kits, with medium range of 0–10 mg L^{-1} and an accuracy of ±0.5 mg L^{-1}, 0–30 mg L^{-1} and an accuracy of ±1 mg L^{-1} and 0–30 mg L^{-1} and an accuracy of ±1 mg L^{-1}, respectively.

2.5. Determining Chlorophyll-*a* in Water Samples

In the laboratory, water sample from each bucket was filtered (vacuum < 5 cm Hg) through GIC Scientific glass fibre filters of 0.7 µm pore size with 47 mm diameter. After filtration, the filters were inserted in 15 mL centrifuge tubes containing 10 mL of 90% acetone solution and were then stored in a freezer for at least 24 hours to allow for chlorophyll–*a* extraction. Chlorophyll–*a* concentration was then calculated based on Lorenzen (1967) using the following formula:

$$Chl-a\ (\mu g\ L) = \left(\frac{a}{v}\right)\ \times\ (F_O\ -\ F_a)\ \times C \quad (1)$$

where "*a*" in fraction is the quantity of acetone used for extraction in µg L^{-1}, v is the quantity of filtered water in µg L^{-1}, F_o is the chl–*a* reading before acidification with 1 N HCl (hydrochloric acid), F_a is the chl–*a* reading after acidification with 1 N HCl (hydrochloric acid), and C is the constant value (0.325).

2.6. Data Analysis

Water and nutrients data were assessed for normality and homogeneity of variance and the results were found to conform to parametric assumptions using the Shapiro–Wilks W and Levene's tests. A one–way ANOVA analysis was used to determine differences among treatments for the various nutrient variables at the end of the experiment. Furthermore, significant experimental differences in physicochemical variables among the study weeks (i.e., 1–6 weeks), treatments (three levels, including controls) and ashes concentrations (i.e., 2, 4, 6, 8, 10 g L^{-1}; B1–B5 and P1–P5) were tested using factorial repeated measures ANOVA. Significant variables were further tested using Tukey's post-hoc analysis to assess differences among treatments and weeks. A non-parametric test (Kruskal-Wallis) was used to test for differences in chlorophyll-*a* among treatment and weeks. For water and nutrient variables, significance was inferred at $p < 0.05$. All statistical analyses were performed in STATISTICA version 10[37]. To assess relationship between physicochemical variables and chlorophyll–*a* concentrations among study treatments and concentrations, a Pearson correlation was carried out in SPSS v16[38].

3. Results

3.1. Water Physiochemical Parameters

During experimental period, mean average pH (6.5–7.0), total dissolved solids (2.3–2.9 mg L^{-1}), conductivity (4.7–5.8 µS cm^{-1}), oxidation reduction potential (–1.4–15.9 mV), resistivity (181.6–218.7 Ω), temperature (24.6–24.9 °C) and NaCl (2.5–3.2 ppm) differed substantially (**Figures 1** and **2**). pH was slightly acidic throughout the monitoring period and treatments. Banana peels ashes reduced NaCl levels (range 2.5–2.8 ppm) as compared to potassium sulphate (2.9–3.2 ppm), whilst resistivity levels were significantly high for banana peels compared to potassium sulphate

i.e., 192–218.7 Ω and 181.6–188.5 Ω, respectively. Water temperature varied greatly throughout the monitoring period and treatment due to daily temperature fluctuations. This demonstrates that all water quality differences observed were unaffected by potentially confounding effects of temperature. Based on ANOVA, concentrations of banana peel ashes and the time period had a significant effect on all physiochemical parameters ($p < 0.05$; **Table 1**). Furthermore, ash treatments (including controls) indicated significant differences for most physiochemical parameters, with exception for temperature (F = 1.213; $p = 3.000$). Pairwise comparison indicated significant differences for ash concentrations, for example, pH i.e., C *vs* P1 ($p = 0.010$), TDS i.e., B1 *vs* B3 ($p = 0.043$) and B3 *vs* P1 ($p = 0.026$), conductivity B3 *vs* C ($p = 0.001$) B4 *vs* P1 ($p = 0.008$), ORP i.e., C *vs* P1 ($p = 0.013$) C *vs* P4 ($p = 0.027$), resistivity i.e., B1 *vs* B4 (p = 0.019) and B3 *vs* P4 ($p < 0.001$), temperature B1 *vs* B 4 ($p = 0.04$) and C *vs* P1 ($p = 0.023$), NaCl i.e., B1 *vs* B4 ($p = 0.008$) and B3 *vs* P5 ($p = 0.025$).

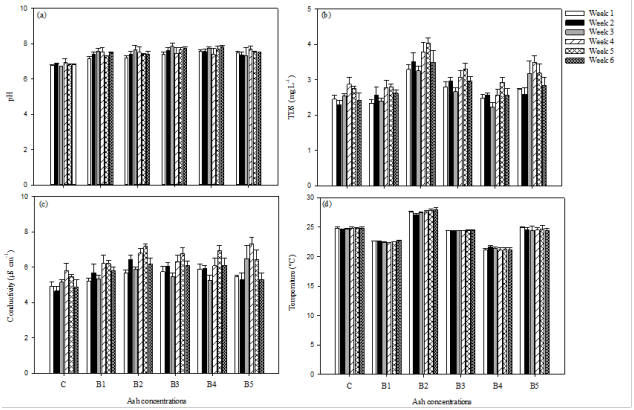

Figure 1. Mean (± standard deviation) (**a**) pH, (**b**) TDS, (**c**) conductivity and (**d**) temperature for banana peels treatment between different ash concentrations and controls over the experimental period (6 weeks).

Note: Abbreviation: C—controls; B—banana peels; TDS—total dissolved solids.

3.2. Nutrient Concentrations

Across treatments, high mean phosphate (6824.1±168.9 µmol L^{-1}); P1), nitrate (1396.9±375.0 µmol L^{-1}; P2) and ammonium (9648.1±762.2 µmol L^{-1}; P4) were observed in potassium sulphate treatments when compared to controls and banana peels (**Figure 3**). Low mean phosphate (3741.1±1079.9 µmol L^{-1}), nitrate (757.3±166.1 µmol L^{-1}) and ammonium (5940.4±1139.3 µmol L^{-1}) were observed in banana peels treatments. Based on ANOVA, significant differences were observed for phosphate (F = 6.061; $p < 0.001$) and ammonium (F = 2.633; $p < 0.001$) across ash concentrations. Pairwise comparison indicated significant differences phosphate, i.e., B1 *vs* B2 ($p = 0.003$), B1 *vs* B3 ($p = 0.001$), B1 *vs* B4 ($p = 0.002$), B1 *vs* B5 ($p = 0.001$), B1 *vs* C ($p = 0.052$), B1 *vs* P1 ($p < 0.001$), B1 *vs* P4 ($p = 0.001$), B1 *vs* P5 ($p = 0.011$), P1 *vs* P2 ($p = 0.042$) and ammonium i.e., B1 *vs* P4 ($p = 0.036$). Across treatments, no significant difference was observed for all nutrient variables ($p < 0.05$).

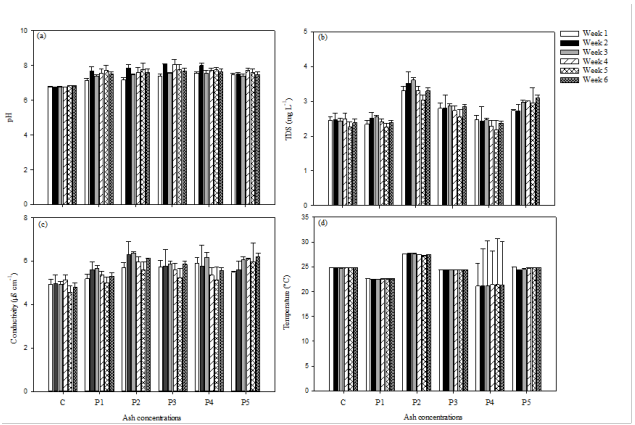

Figure 2. Mean (± standard deviation) (**a**) pH, (**b**) TDS, (**c**) conductivity) and (**d**) temperature for potassium sulphate between different ash concentrations and controls over the experimental period (6 weeks).

Note: Abbreviation: C—controls; P—potassium sulphate; TDS—total dissolved solids.

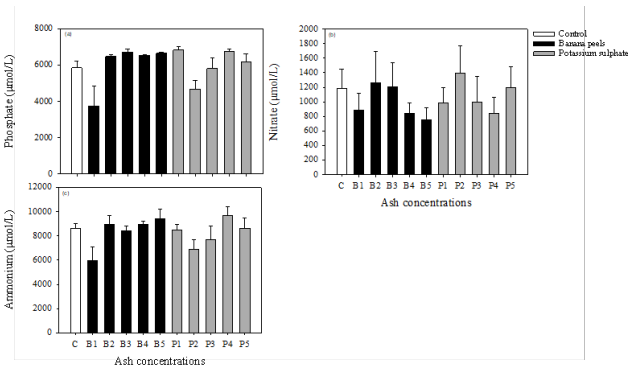

Figure 3. Mean nutrient (± standard deviation) for (**a**) Phosphate, (**b**) Nitrate and (**c**) Ammonium between treatments and ash concentrations over experimental period (6 weeks).

Note: Abbreviation: C—controls, B—banana peels, P—potassium sulphate.

3.3. Chlorophyll-*a* Concentrations

Chlorophyll-*a* concentrations generally decreased with increasing treatment concentrations i.e., B1–B5, P1–P5 (**Figure 4** and **Table 1**). Increasing patterns were observed

for control treatments, whilst decreasing patterns were observed for banana peels and potassium sulphate across different treatment concentrations and weeks. Overall, **Figure 4** shows that chlorophyll–*a* concentrations for controls, banana peels and potassium sulphate treatments ranged from 3.14 µg L^{-1} (week 1)–5.38 3.14 µg L^{-1} (week 6), 0.27 3.14 µg L^{-1} (week 6; B5)–3.55 3.14 µg L^{-1} (week 1; B1) and 0.32 3.14 µg L^{-1} (week 6; B1)–2.90 3.14 µg L^{-1} (week1; P3), respectively. Following Kruskal-Walli's analysis, significant differences were observed between ash concentrations ($H = 65.268$; $p < 0.001$) and weeks ($H = 106.181$; $p < 0.001$). Additionally, significant difference was also observed across treatments ($H = 62.172$; $p < 0.001$). Pairwise comparison indicated significant differences for ash concentrations, for example, B1 *vs* P1 ($p < 0.001$), B2 *vs* P2 ($p < 0.001$), B3 *vs* P3 ($p < 0.001$) and control ($p < 0.001$; all).

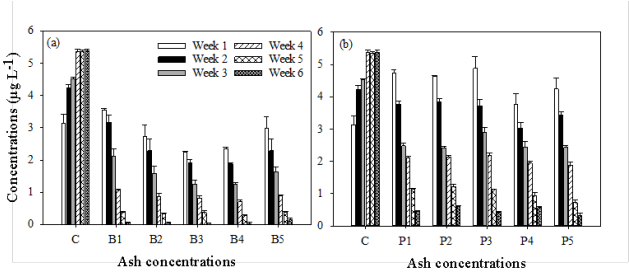

Figure 4. Mean chlorophyll-a concentrations (± standard deviation) for banana peels (**a**) and potassium sulphate (**b**) treatments between ash concentrations and controls over experimental period (6 weeks).

Note: Abbreviation: C—controls, B—banana peels, P—potassium sulphate.

3.4. Relationship between Chlorophyll-*a* and Physiochemical Parameters

Table 1 summarizes Pearson correlations between chlorophyll-*a* and physiochemical parameters. According to Pearson correlations, for banana peels, positive and significant relationships ($p < 0.05$) were observed for ORP and resistivity with chlorophyll-*a* concentrations, whilst negative significant relationships ($p < 0.05$) were observed for pH, TDS, conductivity and NaCl. A positive and non-significant relationship was observed for temperature ($p > 0.05$). For potassium sulphate, positive and significant relationships ($p < 0.05$) were observed for ORP, whilst other physiochemical parameters highlighted negative and significant relationships, with exception of resistivity and temperature which highlighted non-significant and positive relationships ($p > 0.05$) with chlorophyll-*a* concentrations. Control treatments highlighted positive and significant relationships ($p < 0.05$) for pH, conductivity and NaCl, whilst negative and significant relationships were observed for ORP. Resistivity and temperature highlighted negative and non-significant relationships ($p > 0.05$), whilst TDS highlighted positive relationships with chlorophyll-a concentrations (**Table 1**).

4. Discussion

The present study assessed the inhibition efficiency of replicated concentrations of banana peel ashes and potassium sulphate on algae by measuring chlorophyll-*a* concentration over six weeks through a mesocosm experiment. Algal blooms are an increasing problem, especially in the tropical and subtropical environment where the impact of climate change, land use activities and nutrient load cause eutrophication and algal growth, leading to fish mortalities in fish production ponds[9, 18, 39]. In assessing the effectiveness of banana peel ashes (a potassium rich powder) and potassium sulphate on inhibition of algal growth, this study found a clear significant reduction of chlorophyll-*a* concentration across various treatments tested. It was found that banana peel ashes have greater potential than analytical potassium sulphate on inhibiting algal growth in water column. Algae remain a major problem to fish farmers. Similar to Parker et al.[40] and Shukla and Rai[41], the results of this study suggest that banana peels are valuable materials that can be used in aquaculture fish production ponds for inhibiting algal growth.

Physicochemical variables of water were measured throughout the experiment and significant differences among all variables (i.e., pH, TDS, Conductivity, ORP, Resistivity, Temperature and NaCl) were observed across various treatments and week, similar to observation by Netshituni et al.[42]. High concentrations of phosphate, nitrate and ammonium were observed in potassium sulphate treatments as compared to those of banana peel and control. The higher concentration of these elements could have been facilitated by the availability of nitrogen and phosphorus on the BG11 media which allowed algae to grow at the beginning of experiment. Based on ANOVA results, significant differences were observed for phosphate and ammonium across treatments. This suggests that the concentration of potassium in

Table 1. The Pearson correlation analysis for chlorophyll-*a* concentrations and physiochemical parameters across treatment groups.

Variables	Banana Peels		Potassium Sulphate		Control	
	r	p	r	p	r	p
pH	−0.52	< 0.001	−0.49	< 0.001	0.85	< 0.001
TDS	−0.23	0.028	−0.21	0.046	0.12	0.444
Conductivity	−0.39	< 0.001	−0.38	< 0.001	0.56	0.015
ORP	0.53	< 0.001	0.47	< 0.001	−0.85	< 0.001
Resistivity	0.27	0.011	0.14	0.201	−0.23	0.359
Temperature	0.17	0.100	0.17	0.109	−0.23	0.370
NaCl	−0.39	< 0.001	−0.37	< 0.001	0.48	0.046

banana peel powder is relatively directly proportional and is dependent to phosphates since the latter plays an important role as a nutrient which encourage phytoplankton to grow [43]. In addition, the significant differences on phosphates and treatment may be attributed to the relationship between phytoplankton cell size and the rate of phosphate uptake which may have been quicker in banana peel than in potassium sulphate treatment and control [44].

Generally, pH increased from the 2nd week for both treatments, with banana peels treatments recording slightly high pH compared to the potassium sulphates and controls. High pH concentration was facilitated by the release of base cations, i.e., potassium from banana ashes [45, 46], while lower concentration of pH in control samples could be due to non-added treatments on control samples. The TDS generally peaked in the second treatment of both banana peel and potassium sulphate (4 g L^{-1}). The rise in TDS at treatment concentration of 4 g L^{-1} could be due to increases in water temperature in the experiment, which led to allowing more solids to dissolve into the water with rising temperature [47, 48]. Similar patterns between pH and conductivity for all treatments was observed, except for treatment B5 (10 g L^{-1}), where conductivity was low during week 1, 2 and 6. This study suggests that TDS influenced the concentration of conductivity by adding more ions during week 3, 4 and 5 when treatment was much active to the experiment while promoting the electrical conductivity of the water.

Pearson correlation analysis indicated that the final chlorophyll-*a* concentrations in the treatments with banana peels, potassium sulphate and control samples differed significantly ($p < 0.05$) with physicochemical variables. Hence, a direct proportional relationship exists between physicochemical variables in water and chlorophyll-*a* concentration [49–51]. All variables (pH, TDS, Conductivity, ORP, Resistivity, and NaCl) had a positive relationship with banana peel extracts. This suggests that the rise in pH, TDS, conductivity, ORP, resistivity and NaCl resulted on the decrease of chlorophyll-*a* concentration when banana peels extracts were added to water media. However, the rise in temperature can lead to quick growth of phytoplankton in fish ponds [52, 53]. In this experiment, the highest algae growth inhibition was observed in the treatment with banana peels extract, inhibiting up to an estimate of 90% algae growth. However, the implication of using banana peels extract in fish ponds for algal inhibition has not been explored. Furthermore, banana peels being organic natural material is believed to contain non-chemical and non-hazardous constituents that may have negative impact on fish within the ponds. These results also suggest the potential algae inhibition activity by the banana extracts as shown in **Figure 4** could be the best in dealing with algal proliferation in ponds.

To quantitatively investigate the inhibitory effect of banana peels and potassium sulphate treatment, different concentrations of treatments (i.e., 2, 4, 6, 8, 10 g L^{-1}) were dosed while measuring chlorophyll-*a* concentrations across weeks. After inoculation of BG11 into the experimental buckets, chlorophyll-*a* started to peak on day 7. This observation was potentially due to active cell proliferation at the beginning of the mesocosm. The mesocosm showed a significant decrease of chlorophyll-*a* with time for both treatments, however, banana peels performed better as a gradual decrease of chlorophyll-*a* concentration was observed from week 1 to week 6 of the experiment. The effectiveness of banana peels to inhibit algal growth is possibly due to the presence of flavonoids and alkaloids [53]. These results can be attributed to literature, which indicates that high potassium in solid form has high binding efficiency to algal proxy (chl-*a*), and as a result, the cessation of photosynthesis process stops

in the outer wall systems (systems enzymatic) withdrawing nutrients that enter into the composition of the algae, while also stopping the light receptors in the algae cells [54]. The concentration of chlorophyll-*a* on control samples kept rising from week 1 to week 6 due to lack of treatments. This suggests that in a pond where phytoplankton is receiving growth inducing resources such as fish food containing nutrients, enough oxygen and sunlight without any inhibition agent, then problems associated with growth of algae in aquaculture ponds are yet to be solved.

5. Conclusions

The present study demonstrated the most effective and efficient methods for utilizing potassium sulphate and banana peels ashes in a batch experiment to inhibit the proliferation of algae in aquaculture ponds. This study found that potassium in banana peel powder can regulate and inhibit the growth of algal biomass while preventing the uptake of the macronutrients by algae within a water column. Banana peels and potassium sulphate powders have showed positive inhibitory effects on algae growth in pond water. As compared to the control samples, the presence of banana extracts reduced algae biomass with accuracy between 50% and 90%. As an implication, this study had suggested the potential use of banana peels extracts as algae inhibitor. The potential use of banana peels extract is further justified as they are native, easy to grow and low cost. Therefore, further studies are required to investigate further the effects of banana extract concentrations on fish and other aquatic lives.

Author Contributions

Conceptualization, investigation, data curation, conducting experiment, formal analysis, writing—original draft, methodology, writing—review & editing, resources, editing & original draft, L.F.M.; conceptualization, investigation, supervision, writing—review & editing, F.D.; formal analysis, writing—review & editing, T.M.; conceptualization, investigation, supervision, writing—review & editing, J.R.G.; conceptualization, writing—original draft, methodology, writing—review & editing, S.Z.; conceptualization, investigation, data curation, conducting experiment, data curation, writing—review & editing, M.I.M.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflict of interest.

Appendix A

Table A1. Modified BG11 mineral composition concentrations.

Components	**Final Concentrations**
$NaNO_3$	1.500 g
K_2HPO_4	0.040 g
$MgSO_4.7H_2O$	0.075 g
$CaCl_2.2H_2O$	0.036 g
Citric acid	0.006 g
Ferric ammonium citrate	0.006 g
EDTA (disodium salt)	0.001 g
Na_2CO_3	0.020 g
Component (Trace Metal Mix A5)	**Final Concentration (1.0 ml)**
H_3BO_3	2.860 g
$MnCl_2.4H_2O$	1.810 g
$ZnSO_4.7H_2O$	0.222 g
$NaMoO_4.2H_2O$	0.390 g
$CuSO_4.5H_2O$	0.079 g
$Co(NO_3)_2.6H_2O$	49.40 mg

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