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Effects of Feed Formulations on The Characteristics of Water Treatment Residuals from Fish Pond Effluents

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ABSTRACT: Feed formulations play a significant role in determining the characteristics of water treatment residuals (WTRs) generated from fish pond effluents. Fish Pond Effluents can provide insights into the nature of the residue present, the objective of this study was to investigate the effects of different feed formulations on the nutrient content and pH of fish pond effluents. Two different feed formulations were used in the study: a low-protein feed and a high-protein feed. The Fish Pond Effluents were collected from fish ponds that were fed each of the two feed formulations. The nutrient content and pH of the fish were then analyzed. The results of the study showed that the feed formulation had a significant effect on the nutrient content and pH of the Fish Pond Effluents. The effluents from fish ponds that were fed the high-protein feed had a higher nutrient content and pH than the WTRs from fish ponds that were fed the low-protein feed. The findings of this study suggest that feed formulations can be used to manipulate the Fish Pond Effluents.

KEYWORDS: Effects, feed, formulation, characteristics, water treatment, residuals, fishpond, and effluents

INTRODUCTION

Aquaculture has become a significant source of animal protein globally, with fish farming playing a crucial role in meeting the increasing demand for seafood (Delgado *et al.*, 2003). However, one of the major environmental concerns associated with fish farming is the discharge of nutrient-rich effluents, which can degrade water quality and disrupt aquatic ecosystems (Chapman *et al.*, 2019).

These effluents often contain uneaten feed, feces, and metabolic waste, making effective treatment a necessity. A key factor influencing the composition and treatment of these effluents is the formation of the fish feed (Boyd and Tucker, 2018).

Feed formulations—comprising varying proportions of protein, carbohydrate, fat, fibre, and additives, not only affect fish growth and health but also determine the type and concentration of waste products excreted (Keing, 2002). This, in turn, impacts the characteristics of the residuals generated during the treatment of fish pond effluents. For instance, high-protein diets tend to increase nitrogenous waste, while high-fiber content may contribute to more solid waste. Understanding how different feed compositions influence the nature of water treatment residuals is essential for optimizing waste management strategies and reducing environmental impact (Naylor *et al.,* 2019).

Delgado *et al.,* (2003), studied the impacts of the discharge of effluents generated from catfish farming (Clarias gariepinus) in a river in Southwestern Nigeria by evaluating the water quality from a physical, chemical, biological, and aesthetic point of view. The authors concluded that the interference of the studied effluent on river quality was related to the draining methods used, drained water volume at harvest, and concentration of organic matter and nutrients.

The increasing need for water in most parts of the world, especially in arid and semiarid regions, has led to the emergence of wastewater for agriculture. Wastewater is a matter of grave concern as it is used to irrigate farmland, reduce soil salinity, and increase soil moisture content, thereby playing a crucial role in our environment (Rahman, 2006).

The discharge of wastewater from various industrial processes into the surrounding soil or surface water has raised concerns regarding soil and groundwater contamination (Edoga, 2003). Industries often deposit a significant amount of wastewater containing high levels of heavy metals, nutrients, and hazardous substances onto agricultural land (Ezenwa, 2006). However, wastewater also contains nutrients that can improve plant growth and productivity. Studies have shown that soil irrigated with wastewater can contain up to 4.1% organic particles by weight, which contribute to a significant portion of the total soil carbon and nitrogen, serving as important storage of energy and nutrients for microorganisms (Golterman *et al.*, 2012).

Fish pond effluent is the residual material produced after treating wastewater from fish ponds. Stricter regulations on the quality of effluent discharges have led to an increase in the volume of effluent solids that require disposal (Osawe, 2004). The primary disposal methods for fish pond effluent include agricultural use, land restoration, and co-disposal at municipal landfills or dedicated sludge disposal sites. In the past four decades, there has been a gradual increase in global fish production from aquaculture, estimated to grow at an average annual rate of 8.8% (Haque *et al.*, 2016).

The rise in fish consumption is attributed to factors such as population growth, increased income, and urbanization (Naylor *et al.*, 2019). Numerous reports and predictions suggest that aquaculture will surpass the quantity of captured fish by 2030, indicating its continued growth worldwide.

Over time, fish production leads to the accumulation of sediment in aquaculture systems. Excessive sediment load can have detrimental effects, including reduced pond depth and available living space for fish. It may also result in decreased dissolved oxygen levels and the release of toxic gases like H_2S and NO_2 (Mizanur *et al.*, 2004).

The objectives of this research are to investigate the influence of different feed formulations on the characteristics of fish pond effluents obtained from a fish pond, to determine the physiochemical properties of fish pond effluent with different feed formulations, to evaluate the NPK and explore the potential for reusing effluent in remediation, to compare the NPK values from fish pond effluent with other samples used for soil remediation and to evaluate the composition of the different feed formulations(4mm and 6mm).

The research was conducted at the Research Farm of Rivers State University, Port Harcourt, located in the Niger Delta region of Nigeria (latitude 5.317°N, longitude 6.467°E). Nigeria is a major fish consumer in Africa and around the world, with annual consumption of over 1.5 million tons. The growth of aquaculture in Nigeria has been attributed to the dwindling supply of fish from natural oceans and rivers due to pollution from oil and gas activities. Nigeria is one of the largest African aquaculture producers, with an annual production output of 15,489 tons. This has led to an increasing environmental concern about the management of wastewater treatment residuals (WTR). The development of a management strategy that would eliminate the need for a wastewater treatment facility and rid the environment of WTR would be a welcome development.

Figure 1: Map of Rivers State indicating Port harcourt

MATERIALS USED

i. Fish Effluent
ii. Water Receptacle
iii. Fish species

COLLECTION OF WTRs FROM FISHPOND EFFLUENT

The fishpond effluents were collected between 4:30 and 5:00 am from the point of discharge from concrete tanks (Figure 2) at a fish farm on Eagle Island. They were immediately transported to the experimental site in 10 L plastic containers for treatment. The effluents were then coagulated with alum to separate the clean water from the sludge (Figure 2). The sludge was then dewatered by air-drying for 3 days and tested for various physicochemical parameters.

Figure 2: collection and alum based water treatment.

RESEARCH DESIGN

The study will follow an experimental design, which allows for the controlled comparison of WTR characteristics across different feed formulations. Some fish farming systems will be visited, each utilizing a specific feed formulation representing various nutrient compositions and dietary components. The experimental groups will be carefully designed to minimize confounding variables and ensure a robust analysis of the feed formulation effects on WTRs.

DETERMINING WATER QUALITY PARAMETERS:

Water quality parameters will be essential indicators used to assess the suitability of water for various purposes, including aquaculture. In the context of this research project, water quality parameters will be monitored to ensure optimal conditions in the fish farming systems and to understand how different feed formulations influence water treatment residuals (WTRs) characteristics. The following are some key water quality parameters commonly monitored in aquaculture and how it will be determined.

pH: pH is a measure of the water's acidity or alkalinity. It plays a vital role in regulating various biological and chemical processes in fish ponds. pH was determined using the APHA 4500H method which is an approved method for sampling and analysis of water pollutants. The pH level was monitored to ensure it remains within the optimal range for fish farming (typically between 6.5 and 8.5) (Boyd and Tucker, 2018).

NITRATE: Nitrate is another nitrogen compound that can accumulate in fish ponds due to the breakdown of ammonia. Nitrate levels can be measured using colorimetric tests or a water quality probe. Elevated nitrate levels can lead to algae blooms and other water quality issues (Hargreaves, 2019).

PHOSPHORUS: Phosphorus is an essential nutrient for fish, but excessive levels can cause eutrophication and algal growth. Phosphorus levels can be determined using colorimetric tests or inductively coupled plasma (ICP) analysis (Keing, 2002).

TOTAL DISSOLVED SOLIDS IN WASTE WATER (TDS):

Total Dissolved Solids (TDS) in wastewater are the total concentration of dissolved inorganic and organic substances. It serves to assess water quality, identify pollution sources, evaluate treatment processes, and ensure compliance with regulations. High TDS levels can lead to environmental issues, taste, and odor problems, and even equipment damage. Monitoring and managing TDS levels are crucial for safeguarding water quality and ecosystem health (Delgado *et al.*, 2003).

POTASSIUM: Potassium plays a crucial role in water treatment processes and influences the characteristics of water treatment residuals. It serves as a nutrient for plant growth when added to water treatment residuals before land application. Furthermore, potassium affects the dewatering and stability of residuals. In summary, potassium has a multifaceted role in water treatment, aiding in nutrient supplementation, residuals dewatering, and residuals stability (Kibria, 2018).

COMPARISON WITH WATER QUALITY STANDARDS

The characteristics of the WTRs are compared to relevant water quality standards and guidelines. This evaluation helps identify potential beneficial applications of WTRs, such as their safe use as soil amendments or fertilizers, based on their nutrient content and organic matter characteristics.

ETHICAL CONSIDERATIONS

This research project adheres to ethical principles in conducting experiments involving living organisms. The experimental animals will be treated humanely and in compliance with relevant institutional guidelines and ethical standards. Additionally, proper waste management procedures are followed to minimize environmental impacts during the study. Contaminants such as heavy metals, pesticides, and antibiotics can also be present in fish pond effluents, posing risks to aquatic ecosystems and potentially entering the food chain (Robichaud *et al.*, 2019). These contaminants can accumulate in sediments and biota, leading to long-term environmental and health concerns.

To mitigate the environmental impacts of fish pond effluents, various management strategies can be implemented (Naylor *et al.*, 2000). These include:

1. Effluent Treatment: Implementing effective water treatment systems to remove or reduce pollutants from the effluents before discharge. Physical, biological, and chemical treatment methods, as discussed earlier, can be employed to improve water quality and minimize the release of contaminants.
2. Nutrient Management: Optimizing feed formulations to minimize nutrient excesses and improve nutrient utilization by fish. This can help reduce the nutrient load in effluents and mitigate the risk of eutrophication.
3. Best Management Practices (BMPs): Implementing BMPs that focus on responsible aquaculture practices, including proper feeding practices, waste management, and sediment control measures. BMPs can help minimize nutrient losses, reduce sedimentation, and prevent the release of pollutants into the environment.
4. Site Selection and Design: Careful site selection and proper pond design can help minimize the potential environmental impacts of fish farming. Factors such as water exchange rates, proximity to sensitive ecosystems, and adequate water management infrastructure should be considered.

RESULT AND DISCUSSION

Physio-Chemical Analysis of the Effluent

The physio-chemical analysis was done for the pH, TDS and electrical conductivity of the effluent. The result are stated below in Table 1;

Parameters	Sample A	Sample B	Sample C
pH	7	6	6
TDS (PPM)	243	225	365
Conductivity(µs/cm)	420	486	286

NPK EVALUATION OF THE FISH POND EFFLUENT

Table 2: shows the NPK content of the effluent

Parameter	Sample A	Sample B	Sample C
Nitrate(Nitrogen)mg/l	0.13	0.08	0.14
Phosphate(phosphorus) mg/l	0.24	0.33	0.58
Potassium mg/l	1.588	1.078	1.631

COMPOSITION OF FEED FORMULATION (6MM)

The nutritional values of the 6mm feed formulation are stated in Table 3:

Nutrients	Minimun(%)	Maximum(%)
Crude Protien	40.00	
Fat		12.00
Ash		8.00
Crude Fiber		4.50
Moisture		10.00
Calcium	1.00	1.50
Phosphorous	1.00	
Sodium	0.30	

COMPOSITION OF FEED FORMULATION (4MM)

The nutritional values of the 4mm feed formulations are stated in Table 4:

Nutrients	Minimum(%)	Maximum(%)
Crude Protein	42.00	
Fat		12.00
Ash		8.00
Crude Fiber		4.50
Moisture		10.00
Calcium	1.00	1.50
Phosphorous	1.00	
Sodium	0.30	

Table 5: comparing the NPK levels of Fish Pond Effluent with various soil:

Source Material	Total N(mg/kg)	Total P(mg/kg)	Total K(mg/kg)
Fish-Pond Effluent(Sample C)	0.14	0.58	1.631
Brewers Spent Grian(BSG)	5.6	1.05	0.37
Horse Maure(MANR)	2.8	0.99	4.53

From table 1, which represents results of the physiochemical properties of the effluent, the pH of all three samples is slightly acidic, with a pH of 6 or 7. This is within the normal range for most natural waters. A pH that is too low or too high can indicate that the water is contaminated or that it contains minerals that could be harmful to human health. Sample B has the lowest pH level, which suggests that it is slightly more acidic than the other two samples. This may be due to the presence of natural acids from the feed formulation in the effluent.

From Table 1, TDS stands for total dissolved solids. It is a measure of all the inorganic and organic substances that are dissolved in water. The TDS levels in the three samples are all relatively low, ranging from 225 to 365 PPM. Sample C has the highest TDS and conductivity levels, which suggests that it contains the most dissolved ions. This may be due to the presence of minerals from the feed formulations in the effluent.

From Table 1, Conductivity is a measure of how easily electricity can flow through water. It is affected by the presence of dissolved ions in the water. The conductivity levels in the three samples are all relatively high, ranging from 286 to 486 µs/cm. This suggests that the effluent contains a significant amount of dissolved ions.

The result of Table 2 is that the NPK content of the fish pond effluent is relatively low, particularly for nitrate and phosphate in the three samples (A, B, C). This is a good thing, as high levels of nitrate and phosphate can contribute to eutrophication and other water quality problems. However, the potassium content of the effluent is relatively high. This could be due to the use of feed formulation that was high in potassium, or it could be due to the release of potassium from the fish themselves.

The fish pond effluent could be used for irrigation or fertilization, but it is important to monitor the nutrient levels of the effluent and to take steps to reduce the potassium content if it is too high.

From Table 3, which represents the composition of the feed formulations, the main difference between the two feed formulations is that the 4mm feed has a higher minimum crude protein content (42%) than the 6mm feed (40%). This means that the 4mm feed is more nutritious and is better suited for fish that are in a rapid growth phase.

The two feed formulations also have different maximum calcium contents. The 6mm feed has a maximum calcium content of 1.5%, while the 4mm feed has a maximum calcium content of 1%. This is because fish that are smaller and younger are more susceptible to kidney stones, so it is important to limit their calcium intake.

Other than these two differences, the two feed formulations are the same. They both have the same minimum and maximum fat content (12%), ash content (8%), crude fiber content (4.5%), moisture content (10%), phosphorus content (1%), and sodium content (0.3%).

Overall, the 4mm feed is a more nutritious and better-balanced feed for fish that are in a rapid growth phase. The 6mm feed is a good option for fish that are older and more mature.

From Table 4, BSG has the highest Nitrogen content (5.6 mg/kg), followed by Horse manure (2.8 mg/kg) and Fish-Pond Effluent (0.14 mg/kg) (Robichaud *et al., 2019*).

For phosphorus, BSG has the highest content (1.05 mg/kg), followed by Fish-Pond Effluent (0.58 mg/kg) and Horse Manure (0.99 mg/kg) (Robichaud *et al., 2019*).

For potassium, Horse manure has the highest content (4.53 mg/kg), followed by Fish-Pond Effluent (1.631 mg/kg) and BSG (0.37 mg/kg) (Robichaud *et al., 2019*).

From the Table above the Fish-Pond Effluent (Sample C) can be used for remediation. It has a relatively high potassium content, which is important for plant growth. It also has a moderate phosphorus content, which is beneficial for soil fertility. However, it has a low nitrogen content, which may require additional supplementation.

Overall, Fish-Pond Effluent (Sample C) is a promising material for remediation. It is a renewable resource that is relatively inexpensive to produce. It also has a good nutrient profile that can be used to improve soil fertility and promote plant growth.

CONCLUSIONS

The study investigated the effects of feed formulations on fish pond effluents. Feed formulations have a significant impact on the fish pond effluents. The pH, TDS, conductivity, and NPK content of effluents are all affected by the feed formulation.

- ❖ Fish feed formulations that are high in protein and low in phosphorus tend to produce effluents that are acidic and have a high potassium content. This is because protein is metabolized into acids, and phosphorus is excreted in the urine of fish.
- ❖ Fish feed formulations that are low in protein and high in phosphorus tend to produce effluents that are alkaline and have a low potassium content. This is because phosphorus is a buffer that can neutralize acids, and potassium is excreted in the feces of fish.
- ❖ The type of feed formulation used can also affect the metal content of the effluents. Fish feed formulations that contain high levels of certain minerals, such as calcium and iron, can produce effluents that are high in those metals.

RECOMMENDATIONS

The following recommendations are based on the findings of this study:

- Fish feed formulations should be selected carefully to minimize the environmental impact of the aquaculture operation.
- Fish feed formulations that are high in protein and low in phosphorus should be used to produce effluents that are acidic and have a high potassium content. These effluents can be used to irrigate crops or to fertilize lawns.
- Fish feed formulations that are low in protein and high in phosphorus should be used to produce effluents that are alkaline and have a low potassium content. These effluents can be used to remediate acidic soils or to produce biofertilizers.
- The metal content of the fish feed formulation should be considered when selecting a feed formulation. Fish feed formulations that contain high levels of certain minerals should be avoided if the effluents are to be used for sensitive applications, such as aquaculture or irrigation.

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