SAMHONG MUSTARD CULTIVATION BY UTILIZING TILAPIA WASTE IN NUTRIENT FILM TECHNIQUE (NFT) AQUAPONICS SYSTEM BASED ON BIOFLOCS, AND ITS IMPACT ON WATER QUALITY

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ABSTRACT
Biofloc technology (BFT) is an alternative to the tilapia waste management system in the nutrient film technique (NFT)-aquaponics (AP) system. This gadget works by utilizing microorganisms that can transform natural waste into flocks of microorganisms that may then be consumed as natural feed by fish, hence enhancing feed performance. The water from the FT (Fish Tank) is first pumped to the MFT (Mechanical Filter Tank), then to the BT (Biofilter Tank), ST (storage Tank), HS (Hydroponics Subsystem), and lastly back to the FT. The study's findings show that water quality is good, with DO (5.9800-6.7000 mg/L), BOD (2.4422-3.5798 mg/L), COD (17.7916-20.8982 mg/L), pH (7.20-8.63), and temperature (26.9-29.4°C) all being within acceptable ranges. After the study, 96 percent of the fish survived. This suggests that BFT can reduce the mortality rate of cultured fish, and plants no longer exhibit nutrient deficiency symptoms such as stunted growth and necrotic areas on leaves.

Keywords: BFT, NFT-AP System, Water Quality

INTRODUCTION
Intensive fish farming will produce significant organic matter levels from artificial feed leftovers (pellets) and fish feces, reducing water quality. When organic material accumulates and settles at the bottom of the maintenance medium without being digested, the maintenance medium decomposes anaerobically, resulting in a hazardous consequence. A cultivation management system is required to reduce organic waste and waste disposal from the cultivation environment; one of these management systems is biofloc technology.1

BFT's utility has emerged as an environmentally friendly technology capable of resolving a number of environmental and economic difficulties faced by fish farmers. Because nutrients may be continuously recycled and reused, BFT is considered an efficient alternative technology. The device's long-term strategy is focused on the proliferation of microbes in subculture mediums that benefit from little or no water exchange.2 These bacteria (biofloc) have two critical roles: (1) maintaining water quality by nitrogen compound absorption, which produces microbial proteins "in situ"; and (2) vitamins, which increase culture viability by lowering feed conversion ratios and cutting feed costs.

The BFT system, in particular, has been dubbed a fresh new “blue revolution” in the field of aquaculture because it is primarily based on the nutrient cycle and reuse in the same device, which was developed as a zero/minimal water alternate system.2 This technique is well-known for its outstanding performance in maintaining high-quality water, improving fish reproduction, offering alternative food sources, and

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promoting fish welfare and growth. Given the advantages of this biofloc technology, it is widely assumed that its ability to remove, recycle, or manage dangerous nitrogen compounds is the key to this era's success.\(^5\) The ideal solution in aquaponics is BFT, which combines high production with waste recycling and water saving.\(^6\) However, there is still little study linking aquaponic and biofloc systems in Indonesia, and underlines that using bioflocs in aquaponic systems can provide ideal conditions for microorganisms to regulate water quality and increase nutrient recycling in the water.

Tilapia was chosen for this research because it is one of the most productive fish, with quick growth rates, first-rate physiological resistance\(^8\)-\(^{14}\), and good meat quality, resulting in a growing market. Furthermore, while all tilapia are freshwater fish, they lack the euryhaline aptitude that allows a few species and hybrids to adapt and live in brackish and marine conditions.\(^15\)-\(^{17}\) Fish are necessary to produce ammonia, the main waste product produced during the breakdown of proteins and is later transformed into nitrates by bacteria.\(^18\) Deswati et al. 2020 have started a research project to see how BFT affects various water quality metrics in Flood and Drain (FandD)-AP systems.\(^12\)-\(^{14}\) In addition, when the results were compared to earlier research\(^{18-11}\), a few water quality parameters utilizing biofloc were shown to be superior to those not using biofloc.

The influence of samhong mustard cultivation using tilapia waste in an NFT-AP system based entirely on biofloc on water quality (DO, BOD, COD, pH, and temperature), which previously employed the FandD (Flood and Drain)-AP system, is discussed in this work.

**EXPERIMENTAL**

**Instruments and Materials**

In this study, the following instruments were used: Atomic Absorption Spectrophotometer (AAS) AA 240, Analytical Balance (Shimadzu), Hot Plate, Fish Tank (FT, 1 unit), Mechanical Filter Tank (MFT, 1 unit), Biofilter Tank (BT, 1 unit), Storage Tank (ST, 1 unit), Hydroponic Subsystem (HS, 1 set), PVC pipe, water pump, water gallon, aerator, desiccator, and glass.

Fish feed, Samhong mustard, planting media (Rockwall), and 1000 fish/0.8 m\(^3\) of water were utilized in this experiment (2-3 cm). Bioflacto sp, banana, eggs, pineapple, vitamin C, vitamin B complex, yeast,

**Procedure of Analysis**

**Biofloc Culture of Bacteria**

In culture biofloc, Deswati et al., 2000 procedure were used.\(^12\)-\(^{14}\)

**Nutrition Application Biofloc System**

Each week, Biofloc nutrients such as 50 g dolomite lime, 250 g salt, 75 mL molasses, and 80 mL Biolacto sp. are added to FT.

**AP Systems**

The NFT - Aquaponics System is divided into four tanks: FT (119 cm long, 100 cm wide, 74 cm high, 0.88 m\(^3\) water, Tilapia 1,000 pieces), MFT (110 dm\(^3\)), BT (110 dm\(^3\)), ST (110 dm\(^3\)), and HS (110 dm\(^3\)) (Rockwool as planting medium).

The water from the FT is first pumped to the MFT, then to the BT, ST, HS, and finally back to the FT. This recirculation is done continuously and is supported by a pump.

The MFT is equipped with a plastic filter for solid matter or water sediment filtration. The MFT is filled with 110 dm\(^3\) of water.

Aerators, plastic filters, bio-balls, and bio-rings have all been installed at BT. Aerators keep the oxygen required by microbes at a constant level. The plastic filter aids in the removal of any remaining solids or unfiltered sediments. It is given bio-balls and bio-rings at the bottom by attaching to the surface, which is the living places (substrates) for nitrifying bacteria. The BT is filled with 110 dm\(^3\) of water containing a 1:1 mixture of \textit{Nitrosomonas} spp. and \textit{Nitrobacter} spp.

Samhong mustard was employed as the hydroponic plant, and it was seeded for two weeks before being transported to HS. The growth medium was Rockwool, which had been chopped into 1x1 cm pieces and put into a hollow pipe.
Sampling and Analyzing the Data
Several parameters of water quality (DO, BOD, COD, pH, and temperature) were taken from BT, HS, and FPT weekly, and the aerator was turned off while sampling. The results of the study of water quality data are then compared with references.

RESULTS AND DISCUSSION

Concentration of DO
According to Fig.-2, DO levels tend to oscillate at the following intervals (5.9-6.7 mg/L), which are optimal for fish, plants, and microorganisms. Sommerville et al., 2014 (DO > 5 mg/L) and Indonesian Government Regulation No. 82 of 2001 class 2 and 3 (DO 4 mg/L) both corroborate this conclusion. Indeed, fish, plants, and microorganisms thrive in this range, allowing them to maintain high productivity. As a result, selecting appropriate fish and vegetation is critical. Because of their fast development rates and high physiological resilience, tilapia and Samhong mustard were chosen for this investigation.

Concentration of BOD
The Biochemical Oxygen Demand (BOD) is a crucial water metric that depicts the health of freshwater systems. The BOD value tended to rise from days 7 to 35, owing to an increase in the number of fish feces and uneaten fish feed (Fig.-3). The findings of this study support Solomon-Wisdom, and Olatunde 2014, who claim that falling leaves, debris, and fish waste products, as well as various bug populations in the pond and eutrophication due to poor feed, cause eutrophication. The use of this product in water may increase BOD. Munni et al. (2013) found BOD levels ranging from 1.4 to 4.2 mg/L in Bangladesh, and Solomon-Wisdom et al. (2013) found lower levels (0.47 to 2.96 mg/L) in Abuja, Nigeria.
The water utilized is appropriate for developing Tilapia and Samhong mustard in aquaponics systems if the BOD content fulfills quality requirements and is suitable for usage on day-0 (for FT), day-7 (for FT, BT, HS), and day-14. BOD ranges from (2.4422-3.5798) mg/L, with BOD 3 mg/L being the most common (Indonesian Government Regulation No. 82 of 2001 class 2 and 3).\textsuperscript{23} According to Bhatnagar et al. (2004), a BOD level of 3.0-6.0 mg/L is ideal for fishes' normal activity; 6.0-12.0 mg/L is sublethal to fishes; and > 12.0 mg/L can usually result in fish death owing to asphyxia.\textsuperscript{23} According to Santhosh and Singh (2007), the ideal BOD level for aquaculture is less than 10 mg/L, but water with BOD levels of less than 10-15 mg/L can be used for fish production.\textsuperscript{25}

Furthermore, due to the addition of oxygen to FT, BT, and HS, the BOD content reduced after day 35. Water initially flows through BT (there are a bio-ball and bio-coral), which is a bacterial growth medium, causing a biodegradation mechanism in the waste that causes the concentration of BOD to decrease.\textsuperscript{26} After passing through HS, which indicates a high level of bacterial activity in the water, the BOD content in the water rises again, and this is thought to be related to the rotting of plant roots induced by microbe activity. Root rot disease is one of the drawbacks of hydroponic plants.\textsuperscript{27} Root rot is caused by the presence of fungi such as pythium, phytophthora, and fusarium.\textsuperscript{9} BOD values less than 5 mg/L and smaller than DO values mean BOD values in the permitted intervals, according to study data from days 0-42.

**Concentration of COD**

The amount of oxygen required to oxidize particulate matter and dissolved organic matter in water is measured by chemical oxygen demand (COD). COD, unlike BOD, measures all compounds that can be chemically oxidized, not simply biodegradable organic waste.

According to Fig.-4, the COD value changes in the range (17.7916-20.8982 mg/L) but remains within the acceptable range because it is less than 25 mg/L. (Indonesian Government Regulation No. 82 of 2001 class 2 and 3).\textsuperscript{23} On day 0, COD levels of less than 25 mg/L were found in both FPT and BF, indicating that the water utilized satisfied the water quality requirements and was suitable for use in this investigation. The COD concentration in FPT was higher than in BT, owing to the addition of biofloc nutrients such as lime, salt, molasses, and biofloc bacteria. Every week in FPT, where the extra nutrients contained organic and inorganic compounds that required additional oxygen to oxidize.\textsuperscript{28}
COD values appeared to rise from day 1 to 35 in all three samples (FPT, BT, HS), probably because fish feed increased as fish weight rose, resulting in more un consumed fish feed and fish feces in the water. Only 25% of the fish nutrition provided is converted for development and survival, according to 29, while the rest is squandered as waste. Furthermore, biofloc nutrition is provided once a week, allowing organic and inorganic compounds to begin to accumulate in the water, requiring more oxygen to oxidize organic and inorganic compounds in the water, resulting in greater COD concentrations.

**pH**
The oxidation of organic materials, phytoremediation, and plant growth are all affected by the pH of water. 23 The pH value towards the end of the study tends to fall, as seen in Fig.-5. Reduced pH occurs as a result of water quality degradation caused by feed residue, excrement, algae respiration, and increased CO2 in the water, according to Molleda et al. (2007). 30 Furthermore, according to Zidni et al. (2013), the growth of Tilapia and Samhong Mustard is another element in lowering pH. 31 The absorption of components in water, as well as the absorption of these nutrients through plant roots, is affected by pH. According to Tang and Chen (2015), acidic pH conditions can stifle the multiplication of nitrifying bacteria, as well as the outflow of bacteria to feces and feed residue on fish culture media. 32 The study's lowest pH value was discovered at the conclusion. However, because the decrease in water pH during the study was within Tilapia's tolerance limits, it did not affect Tilapia survival. Furthermore, plants grew better in aquaponic systems with a pH of 6–7 water, according to Zou et al. (2016). 33 The hydroponic layer, bio balls, bio corals, and plastic filter contain the majority of the bacteria. Because of the enormous number of bacteria in BT and HS, it is the most important location for nitrogen transformation. 12-14

![Fig.-5: pH at Various Times(Days)](image)

Furthermore, according to 34, the pH range of 6–7.0 is the best for bacteria to work optimally and for plant roots to absorb all-important micro and macronutrients. 34 Tilapia, on the other hand, can tolerate a wide pH range, and each species has a varied optimum pH. Fish are frequently impacted by ammonia poisoning as a result of the increased pH. Furthermore, greater pH values cause tilapia toxicity. However, the greatest results can be obtained in the 6.5–8.5 pH range. As a result, it's critical to maintain a pH value that's steady between (6.0–7.0). 35

**Temperature**
In an aquaponics system, the water temperature has a significant impact on fish, plants, and microbes. Water temperature has an impact on not just the organisms in it but also on fish growth, feeding speed, and size. 23 Furthermore, the behavior and physiological processes of fish in aquaponics systems, as well as the effectiveness of biofilters, are affected by water temperature. 36

According to several studies, each fish species has an ideal water temperature range that is directly influenced by maximal growth. 27,37 Warm temperatures (25-27°C) or 18-30°C are required for optimal growth
growth of tilapia in an aquaponic system.\textsuperscript{35,39} When the optimum temperature in the fish tank is not maintained, the fish's growth is significantly lowered, and infections develop, resulting in other critical issues such as limited reproduction and lethargy due to the fish's digestive ability being slowed.\textsuperscript{40} The best temperature for growing vegetables is 20-25°C, and the ideal temperature for the biofilter (nitrifying bacteria) is 25-30°C. However, tilapia dies at temperatures below 10°C. Based on Fig.-6, a temperature range of 26.9-29.4°C was established, demonstrating that fish, plants, and microorganisms are within permissible limits.

**Fig.-6: Temperature Concentration (°C) with Time (Days)**

### Tilapia and Samhong Mustard Growth

The length of the tilapia on day 0 was found to be 2.1-3.4 cm, with a weight of 0.7522 g. Meanwhile, Tilapia's growth accelerated on the 42nd day, reaching a length of 7.1-7.4 cm and a weight of 4.9971 g. After the study, 96 percent of the fish survived. This demonstrates that biofloc technology can reduce cultured fish mortality.

The 14\textsuperscript{th}, 35\textsuperscript{th}, and 42\textsuperscript{nd} days were used to measure the growth of Samhong mustard. Plant growth is directly proportionate to time, i.e. it has increased each week. Plants also don't show indicators of nutrient inadequacy, such as stunted growth, yellow, white, or brown discoloration, or necrotic patches on the leaves.

### CONCLUSION

BFT is currently being used in an NFT-aquaponics system with great success. Plant nutrition is aided by the presence of a diverse biota (biofloc bacteria) and varied nutrients such as micro and macronutrients derived from artificial feed wastes (pellets) and excrement from fish farming. Biofloc technology can be used in an aquaponics system to improve water quality, decrease mortality, and maximize the growth of Tilapia and samhong mustard plants. After the study, 96 percent of the fish survived. This demonstrates that biofloc technology can reduce cultivated fish mortality, and plants do not display indicators of nutrient inadequacy such as stunted growth, yellow, white, or brown discoloration, or necrotic areas on leaves.

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### REFERENCES

2. M.G.C. Emerenciano, L.R. Martinez-Cordova, M. Martinez-Porches, A. Miranda-Baeza, Water Quality, (pp. 91 (2017), \url{https://doi.org/10.5772/66416}


23. Indonesian Government Regulation No. 82 of 2001 Class 2 and 3 (Water Quality Standards).


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