

## Original Research Article

# The Effect of Silica Addition in the Red Tilapia Juvenil (*Oreochromis niloticus*) Biofloc System on The Floc Volume Density

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### ABSTRACT

Biofloc technology is a solution to the problem of waste management in aquaculture. Biofloc systems are beneficial because they not only reduce inorganic nitrogen waste from feed residues and fish excrement but also produce flocs. The aim of this study is to determine the effect of silica addition in a biofloc system on floc volume density. The research was conducted from January to March 2024 at the Center of Excellence in Science and Technology (PUI-PT) of Functional Nano Powder at Padjadjaran University. This study used a completely randomized design (CRD) with four treatments and three replications. The treatments included (A) control, (B) 15 ppm silica, (C) 20 ppm silica, and (D) 25 ppm silica. The parameters observed were floc volume density and water quality. Floc volume density data and water quality data were analyzed descriptively. The results showed that the administration of 25 ppm silica in the biofloc system was the best treatment for increasing floc volume density. This was evidenced by the results of treatment D (25 ppm), which achieved a floc volume density of 26.5 ml/L, classified as dense. Therefore, the addition of silica in the biofloc system can increase floc volume density.

*Keywords: Biofloc; floc; diatom; silica.*

### 1. INTRODUCTION

Biofloc technology is a method that utilizes beneficial bacteria, both heterotrophic and autotrophic, to intensively convert organic waste into clusters of microorganisms in the form of flocs, which can then be utilized by fish as a food source [1]. Aquaculture systems using biofloc technology heavily rely on the structure of the microbial community within them. The microbial community consists of a heterogeneous composition of microorganisms such as plankton (both phytoplankton and zooplankton), bacteria (floc formers and filamentous bacteria), living aggregates, bacterial feeders, colloidal particles, organic polymers, and dead cells [2]. The density of floc volume is a key factor determining the success of biofloc systems, as denser flocs can more effectively capture particles and nutrients, and provide an additional food source.

One of the challenges in managing biofloc systems is ensuring that flocs form with optimal volume and density. Biofloc systems must be maintained to achieve a balance in the processes of decomposition, nitrification, denitrification, and floc utilization by cultured organisms, so that water quality parameters remain stable [3]. A major component in floc

formation is phytoplankton, with diatoms being a commonly found phytoplankton in these systems.

Diatoms are phytoplankton with cell walls composed of silica, thus requiring silica for their growth, particularly for cell wall formation. Silica is essential for the formation of cell walls in diatoms and depends on the availability of dissolved silica in the water. Diatoms absorb silica in its dissolved form,  $\text{Si}(\text{OH})_4$  [4]. The growth of diatoms is influenced by the provision of silica by 97.02% [5]. That during the adaptation phase, the highest density of *Thalassiosira sp.* occurred at a silica concentration of 20 ppm, reaching 262,500 cells/ml [6]. Different types of diatoms require varying amounts of silica [7]. Changes in silica content are one of the factors causing diatom succession [8]. Therefore, the appropriate provision of silica content affects diatom succession.

This study aims to specifically evaluate the effect of silica provision on floc volume density in biofloc systems. A better understanding of how silica affects floc volume density can provide important insights for optimizing biofloc management, enhancing aquaculture productivity, and supporting more sustainable cultivation practices.

## **2. MATERIAL AND METHODS**

### **2.1 BIOFLOC**

Biofloc technology is a new alternative to address water quality issues in aquaculture, adapted from conventional domestic waste treatment techniques [9]. The main principle applied in this technology is water quality management based on the ability of heterotrophic bacteria to utilize organic and inorganic nitrogen present in the water. Under balanced conditions of carbon (C) and nitrogen (N) in the water, heterotrophic bacteria utilize both organic and inorganic N for biomass formation, thereby reducing the N concentration in the water [1].

The formation of bioflocs by bacteria, especially heterotrophic bacteria, generally aims to enhance nutrient utilization, avoid environmental stress, and predation [1]. Biofloc consists of a mixture of various microorganisms (floc-forming bacteria, filamentous bacteria, fungi), suspended particles, various colloids and organic polymers, various cations, and dead cells with sizes ranging from 100 - 1000  $\mu\text{m}$  [10]. In addition to bacterial flocs, various other organisms are also found in bioflocs such as protozoa, rotifers, and oligochaetes [11]. The composition of organisms within the flocs influences the structure and nutrient content of bioflocs [12].

### **2.2 DIATOM**

Diatoms are classified as eukaryotic organisms belonging to the kingdom Chromista, division Chromatophyta, class Bacillariophyta, characterized by single-celled organisms that live solitarily or in colonies with a unique structure composed of silica as their cell wall [13]. Diatoms are unicellular microalgae ranging in size from 2  $\mu\text{m}$  to 4 mm. While most diatoms are solitary, some live in colonies [14].

Diatoms, or Bacillariophyta, constitute a major group (phylum) of eukaryotic microalgae. The cell wall of diatoms, known as the frustule, is capable of differentiation, contains silica, and consists of two valves connected by a girdle band. The valves and girdle band are closely fused to prevent the entry of materials into the cell wall, which can only occur through openings such as pores and frustule slits [15]. Within the frustule, there is cytoplasm containing the nucleus and large vacuoles [16].

### **2.3 THE ROLE OF SILICA IN DIATOM**

One of the crucial aquatic organisms is the diatom, serving as an abundant primary producer essential as natural feed, found widely in both freshwater and marine environments. Diatoms are cosmopolitan species distributed extensively across aquatic environments and periodically submerged terrestrial environments like rock surfaces, certain plants, and animals [17].

Diatoms are characterized by specific markings on their cell walls composed of silica, which confers high resistance to environmental pressure. Silica is essential for diatoms, particularly in forming their cell walls, taken up in the form of dissolved  $\text{Si(OH)}_4$  from the water. Different diatom species require varying amounts of silica, leading to succession in diatom communities in response to variations in dissolved silica content [8].

Silica in water poses no toxicity issues for living organisms. Diatoms incorporate silica into their cell walls, crucial for their growth, as noted by [4], who emphasized the dependency on dissolved silica availability in water. Silica and organic materials combine to form the cell wall, with the deposition process regulated by the cytoplasm. The formation of new cell walls occurs within 10-20 minutes after protoplasm division [18].

Silica deficiency in culture media can affect diatom cell formation. Insufficient silica directly impacts the formation of new cell walls; low silica concentrations prevent diatoms from growing, as new cell wall formation does not follow protoplasm division [18].

## **2.4 TIME AND PLACE RESEARCH**

This research will be conducted from January to March 2024 at the Center of Excellence for Higher Education Science and Technology (PUI-PT) Functional Nano Powder, Universitas Padjadjaran, for activities related to the biofloc system, observation of floc volume density and water quality.

## **2.5 TOOLS AND MATERIALS**

The equipment used includes 19 L cylindrical tubes, aeration equipment, a heater, a digital scale (accuracy 0.1 g), a millimeter block (accuracy 0.1 cm), a net, label paper, a microscope, a dropper, and a 1 L measuring cup. The materials used are 3-4 cm red tilapia seeds, PF1000 feed with 39% protein content, molasses, EM4, coarse salt, dolomite lime, and nanosilica.

## **2.6 BIOFLOC MEDIA PREPARATION**

To form the biofloc system in a 19 L water volume medium, the materials used per cylindrical tube are 1.5 grams of salt ( $100 \text{ g/m}^3$ ), 0.75 grams of dolomite lime ( $50 \text{ g/m}^3$ ), 0.6 ml of molasses, and 1 ml/L of EM4. These materials are dissolved in a measuring cup and then added to the biofloc medium, which is the cylindrical tube.

## **2.7 IMPLEMENTATION OF RESEARCH**

The biofloc maintenance activities are conducted for 45 days. Silica is added to each treatment every 7 days. Observations of floc volume density are carried out every 7 days, water quality observations, including temperature and pH, are conducted daily, while observations of nitrite, nitrate, and ammonia levels are performed every 7 days.

## **2.8 RESEARCH METHODS**

The research method used is the experimental method with a Completely Randomized Design (CRD), consisting of 4 treatments and 3 replications, as follows:

Treatment A: Addition of 0 ppm silica concentration (control)

Treatment B: Addition of 15 ppm silica concentration

Treatment C: Addition of 20 ppm silica concentration

Treatment D: Addition of 25 ppm silica concentration

## 2.9 RESEARCH PARAMETERS

### 2.9.1 FLOC VOLUME DENSITY

The floc volume density is measured using a 1 L measuring cup. Every 7 days, a 1 L water sample is taken from each treatment and replication, and then placed in the measuring cup. The water sample is left to settle for 20 minutes, after which the volume of the sedimented solids (floc) at the bottom of the measuring cup is measured. The floc density is recorded in ml/L [25].

### 2.9.2 WATER QUALITY

Here are several parameters of water quality observed in this study (Table 1).

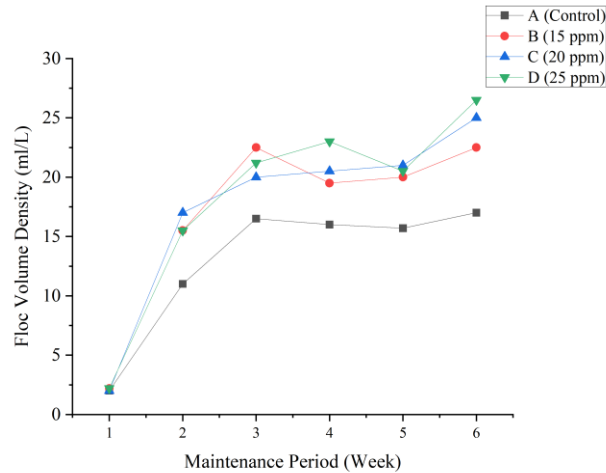
**Table 1. Water quality parameters**

Parameters	Unit	Measurement Time	Standard
Temperature	°c	Per day	25-30°C [19]
pH	-	Per day	6,5-8,5 [21]
DO	mg/L	Per week	> 5 mg/L [21]
Nitrite	mg/L	Per week	<0,06 mg/L [20]
Nitrate	mg/L	Per week	3,9-15,5 mg/L [20]
Ammonia	mg/L	Per week	0,02 mg/L [21]

## 3. RESULTS AND DISCUSSION

### 3.1 FLOC VOLUME DENSITY

Based on the observations of floc volume during the maintenance period, it was found that the addition of silica had an effect on floc volume. The differences in floc volume observed throughout the study were quite fluctuating. Looking at the final observation in the 6th week, the lowest floc volume was found in treatment A (0 ppm) with a value of 17 ml/L, while the highest floc volume was observed in treatment D (25 ppm) with a value of 26.5 ml/L, followed by treatment C (20 ppm) with a value of 25 ml/L, and treatment B (15 ppm) with a value of 22.5 ml/L (Figure 1).



**Fig 1. Biofloc system floc volume density**

Based on Figure 1, it is evident that the treatments with added silica had higher floc content compared to the control treatment. This is due to the increased number of diatoms in the floc, as silica plays a crucial role in the growth and cell wall formation of these diatoms. Silica is an essential macronutrient necessary for the growth of diatom cell walls, providing high resistance to environmental pressures such as extreme conditions [22].

Based on their volume, bioflocs are classified as dense if the floc volume in water exceeds 20 ml/L, moderate if the floc volume reaches 10–20 ml/L, low if the floc volume reaches 1–10 ml/L, and very low if the floc volume is less than 1 ml/L [23]. The treatments with silica addition, namely treatments B, C, and D, fall into the category of dense floc volume as they exceeded 20 ml/L, while treatment A falls into the moderate category.

Comparatively, study on biofloc systems in polyculture of catfish and tilapia, the highest floc volume reached 4.37 ml/L, indicating that the silica addition in this study resulted in higher floc volumes [24]. However, it is lower than the results from study on biofloc systems in tilapia farming, which achieved a floc volume of 33 ml/L [25].

Furthermore, the fluctuation patterns in floc volume are significantly influenced by parameters such as temperature, DO, pH, ammonia, nitrite, and nitrate, which are related to the breakdown processes of leftover feed and metabolic feces in the maintenance medium [26].

### 3.2 WATER QUALITY

Water quality is crucial to aquaculture activities as it significantly impacts the development and growth of fish. Good water quality is characterized by meeting standard criteria for water quality parameters. In this study, water quality parameters measured include temperature, pH, Dissolved Oxygen (DO), nitrate, nitrite, and ammonia. The measurement of water quality was observed from the beginning to the end of the fish maintenance period (Table 2).

**Table 2. Biofloc system maintenance water quality**

Treatments	Temperature (°C)	pH	DO (mg/L)	Nitrate (ppm)	Nitrite (ppm)	TAN (ppm)	NH3 (mg/L)
A	25-27	6,51-7,49	6,18-7,20	0,0-5,0	0,0-0,5	0,3-4,0	0,0006-0,821
B	25-27	6,50-7,49	6,32-7,49	0,0-5,0	0,0-0,3	0,3-4,0	0,0005-0,0821
C	25-27	6,74-7,52	6,15-7,00	0,0-5,0	0,0-0,3	0,3-2,3	0,001-0,0505
D	25-27	6,72-6,67	6,13-6,44	0,0-5,0	0,0-0,3	0,3-1,7	0,0009-0,0484

Temperature significantly affects the rate of decomposition and conversion of organic materials into inorganic substances. In this study, the temperature ranged from 25-27°C, suggestion that suitable temperatures for phytoplankton life generally range from 20°C to 30°C [27]. Observations of pH ranged from 6.5 to 7.52. pH is a key chemical parameter indicating water quality, influencing the growth of aquatic plants and animals [28]. The pH value is greatly influenced by photosynthesis activity and temperature. That the ideal pH range for organisms (including phytoplankton) is between 6.5 and 8.5 [29]. The optimal pH for tilapia breeding is between 6.5 and 8.5 [21]. Dissolved Oxygen (DO) levels during the study ranged from 6.13 to 7.20 mg/L, indicating optimal DO levels which specifies normal conditions as >3 mg/L [21].

Nitrite and nitrate levels during the maintenance period were relatively low. Nitrite levels remained within the optimal range for tilapia maintenance, which is less than 0.05 ppm, who suggest a threshold of 0.05 ppm for nitrite [30]. Recommended that nitrite concentrations in biofloc systems should ideally be below 2 mg/L [31]. Nitrate levels during the study remained within normal limits for cultivation, advise that nitrate concentrations in biofloc should not exceed 10.0 mg/L [30]. Total Ammonia Nitrogen (TAN) levels ranged from 0.3 to 4.0, and ammonia levels ranged from 0.0006 to 0.0821. In a biofloc system, ammonia concentrations should ideally be below 1.5 mg/L [31]. Therefore, the ammonia concentration in the biofloc culture medium, ranging from 0.0006 to 0.0821, indicates a safe level for biofloc systems.

#### 4. CONCLUSION

The addition of silica in biofloc systems can influence the abundance of diatoms. Diatoms, which are part of phytoplankton, can affect floc volume density. Adding a concentration of 25 ppm silica to the biofloc media during maintenance is the most effective treatment for increasing floc volume density. This is evidenced by observations in the last week, where treatment D (25 ppm) showed a floc volume density of 26.5 ml/L, classified as dense.

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