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

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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 research is to determine the effect of silica addition on floc volume density in the biofloc system for juvenile red tilapia. The research was conducted from January to March 2024 at the Center of Excellence in Science and Technology (PUI-PT) for Functional Nano Powder at Padjadjaran University. This study uses a Completely Randomized Design (CRD) experimental method with four treatments and three replications. The treatments used were (A) control, (B) 15 ppm silica, (C) 20 ppm silica, and (D) 25 ppm silica. The study used cylindrical containers with a capacity of 19 liters filled with 15 liters of water, a stocking density of 10 juvenile red tilapia per cylinder, with the juvenile measuring 3-4 cm and weighing 3-4 g. The parameters observed were floc volume density and water quality. The data on floc volume density and water quality were analyzed descriptively. The results showed that the addition of 25 ppm silica in the biofloc system was the best treatment for floc volume density. This was evidenced by the results in treatment D (25 ppm) achieving a floc volume density of 26.5 ml/L, which falls into the dense category. Therefore, the addition of silica concentration in the biofloc system can increase floc volume density.

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

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## 1. INTRODUCTION

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Biofloc technology is a new alternative to address water quality issues in aquaculture, adapted from conventional domestic waste treatment techniques [1]. 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 carbon (C) and nitrogen (N) conditions in the water, heterotrophic bacteria will use nitrogen, both in organic and inorganic forms, present in the water for biomass formation, thereby reducing the nitrogen concentration in the water [2].

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The formation of biofloc by bacteria, particularly heterotrophic bacteria, is generally aimed at enhancing nutrient utilization, avoiding environmental stress, and predation [2]. Bacterial flocs consist of a mixture of various types of microorganisms (floc-forming bacteria, filamentous bacteria, fungi), suspended particles, various colloids and organic polymers, different cations, and dead cells, with sizes ranging from 100 to 1000  $\mu\text{m}$  [3].

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Aquaculture systems using biofloc technology heavily depend on the structure of the microbial community within them. The microbial community consists of a heterogeneous array of microorganisms such as plankton (both phytoplankton and zooplankton), bacteria

32 (floc formers and filamentous bacteria), living aggregates, bacterivores, colloidal particles,  
33 organic polymers, and dead cells [4]. Floc volume density is a key factor that determines the  
34 success of the biofloc system, as denser flocs are more effective in capturing particles and  
35 nutrients, and providing an additional food source.

36 One of the challenges in managing a biofloc system is ensuring that the flocs form with  
37 optimal volume and density. The biofloc system must be maintained to achieve a balance in  
38 decomposition, nitrification, denitrification, and the utilization of flocs by cultured organisms,  
39 so that water quality parameters remain stable [5]. One of the main components in floc  
40 formation is phytoplankton, with diatoms being a common type of phytoplankton found within  
41 the flocs.

42 Diatoms are phytoplankton with cell walls composed of silica, thus requiring silica for their  
43 growth, particularly for cell wall formation. Silica is essential for diatom cell wall formation  
44 and depends on the availability of dissolved silica in the water [6]. Diatoms uptake silica in its  
45 dissolved form, as  $\text{Si}(\text{OH})_4$ . The growth of diatoms is influenced by the addition of silica, with  
46 a reported impact of 97.02% [7]. During the adaptation phase, the highest density of  
47 *Thalassiosira* sp. occurred with the addition of 20 ppm silica, reaching 262,500 cells/ml [8].  
48 Different types of diatoms require varying amounts of silica [9]. Changes in silica content are  
49 one of the factors causing diatom succession [10]. Therefore, the proper addition of silica  
50 content influences diatom succession.

51 This research is a novel study aimed at specifically understanding the impact of silica  
52 addition on floc volume density in the biofloc system for red tilapia fry. A better  
53 understanding of how silica affects floc volume density can provide important insights for  
54 optimizing biofloc management, enhancing aquaculture productivity, and supporting more  
55 sustainable aquaculture practices.

## 56 **2. MATERIAL AND METHODS**

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### 58 **2.1 RESEARCH AREA**

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

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### 65 **2.2 EXPERIMENTAL SETUP**

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

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### 73 **2.3 BIOFLOC MEDIA PREPARATION**

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75 To form the biofloc system in a 19 L water volume medium, the materials used per cylindrical  
76 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  
77 molasses, and 1 ml/L of EM4. These materials are dissolved in a measuring cup and then  
78 added to the biofloc medium, which is the cylindrical tube.

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80 **2.4 IMPLEMENTATION OF RESEARCH**

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

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87 **2.5 RESEARCH METHODS**

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

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

92 Treatment B: Addition of 15 ppm silica concentration

93 Treatment C: Addition of 20 ppm silica concentration

94 Treatment D: Addition of 25 ppm silica concentration

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96 **2.6 RESEARCH PARAMETERS**

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98 **2.6.1 FLOC VOLUME DENSITY**

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

105 
$$\text{Floc volume } \left(\frac{\text{ml}}{\text{L}}\right) = \frac{V_{\text{sediment}}}{V_{\text{water sample}}} \times 1000$$

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108 **2.6.2 WATER QUALITY**

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

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**Table 1. Water quality parameters**

Parameters	Unit	Measurement Time	Standard
Temperature	°c	Per day	25-30°C [11]
pH	-	Per day	6,5-8,5 [12]
DO	mg/L	Per week	> 5 mg/L [12]
Nitrite	mg/L	Per week	<0,06 mg/L [13]
Nitrate	mg/L	Per week	3,9-15,5 mg/L [13]
Ammonia	mg/L	Per week	0,02 mg/L [12]

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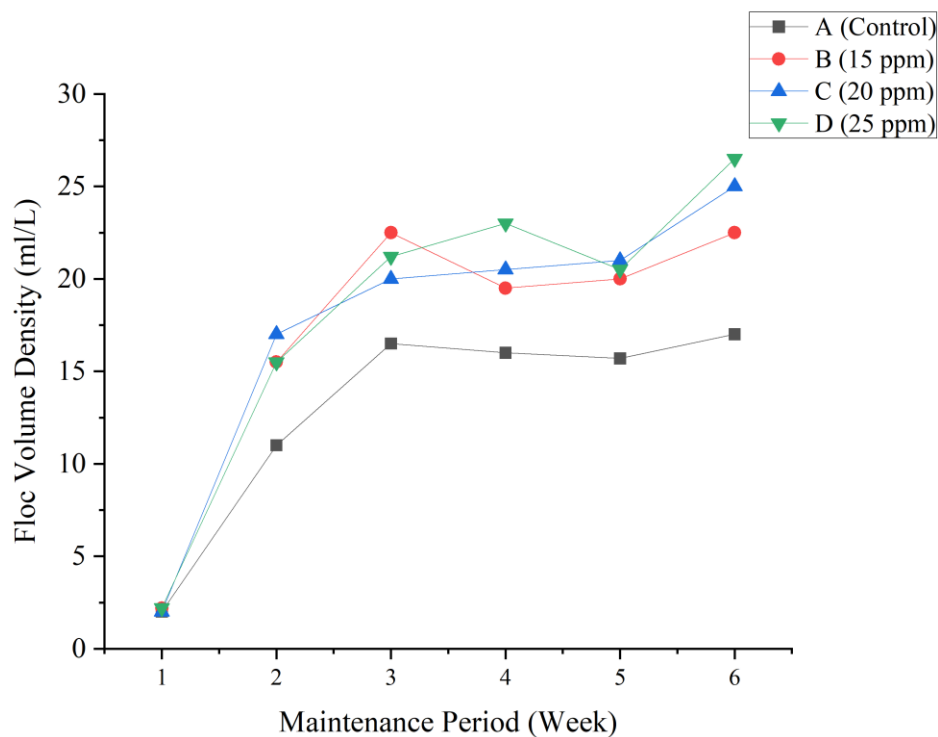
114 **3. RESULTS AND DISCUSSION**

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116 **3.1 FLOC VOLUME DENSITY**

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118 Floc volume is one way to observe the abundance of biofloc-forming organisms. Floc-  
 119 forming bacteria decompose organic matter (protein, carbohydrates, fats, etc.) derived from  
 120 leftover feed, fish waste, and dead organisms in the pond [14]. Floc volume is the amount of  
 121 suspended solids over a certain period in an inverted cone container [15]. A high floc volume  
 122 value in biofloc treatments indicates that the bacteria in the maintenance pond can form  
 123 flocs, which can then be utilized by the fish as additional feed for growth and reduce the  
 124 amount of feed provided. The density of bioflocs in the maintenance media can be measured  
 125 using a floc volume measuring device, which is conical with a volume scale at the bottom  
 126 and made of glass or transparent plastic [14].  
 127 Based on the observations of floc volume during the maintenance period, it was found that  
 128 the addition of silica had an effect on floc volume. The differences in floc volume observed  
 129 throughout the study were quite fluctuating. Looking at the final observation in the 6th week,  
 130 the lowest floc volume was found in treatment A (0 ppm) with a value of 17 ml/L, while the  
 131 highest floc volume was observed in treatment D (25 ppm) with a value of 26.5 ml/L,  
 132 followed by treatment C (20 ppm) with a value of 25 ml/L, and treatment B (15 ppm) with  
 133 a value of 22.5 ml/L (Figure 1).



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

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Based on Figure 1, treatments with added silica showed higher floc density compared to the control treatment. This is attributed to an increased presence of diatoms within the flocs, influenced by silica's role in enhancing their growth and cell wall formation. Silica is an essential macro-nutrient crucial for diatoms to develop robust cell walls that can withstand environmental stresses, including extreme conditions [16]. As more flocs form, the overall floc volume tends to increase [17].

Based on its volume, biofloc is classified as dense when the floc volume in water reaches >20 ml/L, moderate if it reaches 10–20 ml/L, low if it reaches 1–10 ml/L, and very low if it is <1 ml/L [18]. In the treatments with added silica (Treatments B, C, and D), they fall into the

146 dense category as their floc volumes exceed 20 ml/L, while Treatment A falls into the  
147 moderate category.

148 Compared with research in 2023 on polyculture biofloc systems of catfish and tilapia, where  
149 the highest floc volume reached 4.37 ml/L, the silica addition study achieved higher results  
150 [19]. However, it is lower compared to research in 2023 on tilapia biofloc cultivation, where  
151 the floc volume reached 33 ml/L [20].

152 The increase in floc volume indicates optimal activity of floc-forming bacteria, likely due to  
153 the accumulation of ammonia and phosphorus in the culture media beforehand. In  
154 aquaculture, biofloc systems emphasize the growth of bacteria in the media to replace  
155 autotrophic communities dominated by phytoplankton [5].

156 Additionally, according to [21], the fluctuation patterns observed in floc volume are strongly  
157 influenced by parameters such as temperature, dissolved oxygen (DO), pH, ammonia,  
158 nitrite, and nitrate. These factors are related to the breakdown processes of leftover feed and  
159 metabolic waste, which occur within the culture media.

160

### 161 3.2 WATER QUALITY

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

168

**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

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170 Temperature observations during the research, as shown in Table 2, indicate a stable  
171 temperature range within the optimal growth conditions for Biofloc, around 24°C.  
172 Temperature influences cellular metabolism, primarily affecting enzyme activity [22]. Low  
173 temperatures slow down enzyme activity, while excessively high temperatures can damage  
174 enzymes, halting cellular metabolism. The optimal temperature range for Biofloc growth is  
175 typically between 20°C to 30°C [23]. Temperature also affects the rate of decomposition and  
176 conversion of organic matter into inorganic substances. In this study, temperatures ranged  
177 from 25°C to 27°C, which are favorable for phytoplankton life in general, where temperatures  
178 for optimal phytoplankton life generally range from 20°C to 30°C [15].

179 In the pH observations, a range of 6.5-7.52 was recorded. pH (acidity level) is a crucial  
180 chemical parameter in water quality assessment. Optimal Biofloc growth is achieved by  
181 adjusting pH appropriately. This adjustment is important because pH levels in the medium  
182 can influence enzyme activity during cellular metabolism. pH levels also affect the  
183 photosynthetic rates of microalgae and the overall performance of enzymes in metabolic  
184 processes [24]. Acidity levels significantly impact aquatic plants and animals, often serving  
185 as an indicator of water quality for aquatic organisms. pH values are heavily influenced by  
186 photosynthesis activity and temperature. The ideal pH range for organisms, including  
187 phytoplankton, generally falls between 6.5 to 8.5 [25]. Specifically for tilapia hatcheries, the  
188 optimal pH range is recommended to be between 6.5 to 8.5 [12].

189 The dissolved oxygen (DO) levels observed during the study ranged from 6.13 to 7.20 mg/L,  
190 indicating optimal DO values within the normal condition of >3 mg/L [12]. Biofloc cultivation

191 is closely associated with strong aeration to maintain adequate oxygen levels in the culture  
192 medium. It's further noted that bacteria utilized in biofloc systems also require oxygen for  
193 metabolizing leftover feeds and metabolic wastes. In general tilapia culture, DO levels around  
194 3 mg/L are sufficient for tilapia survival; however, in biofloc systems, a minimum DO level  
195 above 5 mg/L is recommended to ensure efficient nitrogen breakdown by heterotrophic  
196 bacteria [26]. Low dissolved oxygen levels can inhibit bacterial activity and lead to increased  
197 ammonia levels in the water.

198 The levels of nitrite and nitrate during the cultivation period remained relatively low. Nitrite  
199 levels throughout the study remained within optimal limits for tilapia farming, specifically  
200 below 0.05 ppm. Who defines the threshold for nitrite at 0.05 ppm [27]. Recommend that  
201 nitrite concentrations in biofloc technology should ideally be kept below 2 mg/L [28]. Nitrate  
202 levels during the study also remained within normal limits for cultivation. Nitrate  
203 concentrations in biofloc systems should not exceed 10.0 mg/L [28].

204 Based on the observation, Total Ammonia Nitrogen (TAN) ranged from 0.3 to 4.0, and  
205 ammonia levels ranged from 0.0006 to 0.821. In a biofloc system, it is recommended that  
206 ammonia concentrations remain below 1.5 mg/L. Therefore, the ammonia concentration in  
207 the biofloc culture medium, ranging from 0.0006 to 0.0821, falls within a safe range for  
208 biofloc systems [28].

209

#### 210 **4. CONCLUSION**

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

217

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219

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222

#### 223 **COMPETING INTERESTS**

224

225 Authors have declared that no competing interests exist.

226

#### 227 **AUTHORS' CONTRIBUTIONS**

228

229 This work was carried out in collaboration among all authors. All authors read and approved  
230 the final manuscript.

231

#### 232 **DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

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234 Author(s) hereby declare that NO generative AI technologies such as Large Language  
235 Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during  
236 writing or editing of manuscripts.

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238 Author(s) hereby declare that generative AI technologies such as Large Language Models,  
239 etc have been used during writing or editing of manuscripts. This explanation will include the  
240 name, version, model, and source of the generative AI technology and as well as all input  
241 prompts provided to the generative AI technology

242 Details of the AI usage are given below:

243 1.  
244 2.  
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