INTERDEPENDENCE AND INTERRELATIONSHIP AMONG WATER QUALITY PARAMETERS IN BIOLFOC SYSTEMS

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ABSTRACT

Biofloc technology is essentially a water quality management system. It is essential to monitor closely the water quality parameters in the system. However, some of the parameters may not be as easy to examine, either being more rigorous or fairly expensive. Therefore, the needs for development of theoretical models that can be readily available especially when there is an urgent need. The water quality parameters examined in biofloc system over the period of 10 weeks were subjected to correlation and regression to assess the interdependence and interrelationship among the water quality parameters and subsequently developing equations for future estimation some of the relatively difficult to measure water quality parameters. All the water quality parameters were within the recommended level for freshwater fish culture except the total suspended solids (TSS). The TSS had fairly strong and significant interdependence with temperature, total dissolved solids (TDS) and ammonia. Nitrate showed strong and significant interdependence with dissolved oxygen and pH. Ammonia also showed strong and positive interdependence with dissolved oxygen. TSS and nitrate had fairly high co-efficient of determination 0.462 and 0.412, with Fvalue of 14.393 and 11.6731 respectively. The predicted equation for TSS was 230.38T – 271.31DO – 204.17pH + 10.30TDS – 3419, and nitrate was 15.13T - 32.62DO – 28.39pH – 0.04TDS + 91.71. The results showed some good relationships among some of the water quality parameters and considering the high and significant coefficient of determination, the equations could be reliably used for estimation of the dependent variables, especially total dissolved solids and nitrate in biofloc systems.

Keyword: Biofloc system, water quality, aquaculture, correlation, regression.

INTRODUCTION

The success of aquaculture production has been hinged on three major things, quality fish seed, good feed and optimum water quality. The management of the water quality is highly essential to ensure fast growth, survival and high yield (Dauda and Akinwole, 2014). Several fish culture systems have been used and water management is among the basic factors considered in determining the most appropriate fish culture system. It is both important to ensure optimal water quality for fish culture as well as ensuring the minimal impact of wastewater on the culture environment. Water reuse and closed fish culture systems are becoming more popular due to their ability to support optimal performance of fish and being environmental friendly (Martins *et al*., 2010). Biofloc technology is a zero to limited water exchange system, it is essentially a water quality management system that employs manipulation of carbon to nitrogen content in the water to stimulate the growth of microbial organisms that ended up utilising supposedly toxic nitrogenous wastes for their growth (Romano *et* *al*., 2018). The biofloc formed is a complex particle, containing bacteria (floc-forming and filamentous), zooplanktons, microalgae, uneaten feed, colloids, cations, dead cells and organic polymers (Dauda *et al*., 2018; Avnimelech, 2012; De Schryver *et al*., 2008). The complex is available as additional feed to fish species that can effectively collect and consume smaller particles (Bossier and Ekasari, 2017), and beyond the quality protein, it has also been reported to improve immunological responses and disease resistance in fishes both fin and shell (Dauda, 2020; Dauda *et al*., 2018), and hence, the fast acceptance of the system in the aquaculture industry. Being a water quality management system, it requires regular measurement of the water quality parameters, to ensure the fish stocked are not harmed, and to be able to determine the appropriate amount of carbon to be added to balance the ratio of carbon to nitrogen in the system. Like other limited to zero water exchange systems, degradation of water quality within a very short period could result in loss of the total stock (Dauda and Akinwole, 2014). Therefore the needs for devising convenient, fast and relatively cheaper means of measuring the important water quality parameters. Dauda and Akinwole (2014) noted that different methods and techniques are used in measuring important water quality parameters, these include titrimetric procedure requiring chemical reagents, digital meters for pH, temperature, dissolved oxygen, total dissolved solids and electrical conductivity. Spectrophotometer for nitrogenous metabolites, cations and anions, as well as portable test kits for various water quality parameters. While some of the titrimetric methods could be time-consuming and sometimes require expensive reagents, spectrophotometer and its reagents could also be expensive and not readily available to all farmers. Akinwole and Adeola (2012) suggested that the development of theoretical models using easily measured parameters like pH and temperature could be of help to estimate other parameters, especially in interim, when resources for more detailed analytical methods are not immediately available. This research aimed at investigating the interdependence and interrelationship among the selected water quality parameters and possibilities of developing models for estimating some of the, not too easy to measure water quality parameters. The output of the research may be of high relevance to fish culturists using biofloc systems.

MATERIALS AND METHODS

Study area

The research was carried out at Puchong experimental station of the Universiti Putra Malaysia, Serdang, Selangor, Malaysia. The details of the ten weeks experimental procedure and fish culture is as fully described in the part already published, Dauda *et al*. (2018).

Water quality parameters

All the selected water quality parameters were measured twice a week. Temperature, pH, dissolved oxygen, conductivity and total dissolved solids were measured with digital probe meter, YSI 556. HACH DREL/2400 portable spectrophotometer was used for measuring ammonia, nitrite and nitrate. Total suspended solids was measured following the methods of AOAC (2012).

Statistical analysis

Descriptive statistics, mean and standard error were used to present the summary of the water quality parameters. Pearson correlation was used for interdependence analysis while linear regression was used for interrelationship analysis and hence, predict equations using the easily measured parameters as dependent variables. All analysis was done with IBM SPSS version 23.

RESULTS AND DISCUSSION

The overall water quality parameters throughout the experiment are shown in table 2, All the water quality parameters are within the normal range for freshwater fish culture as highlighted by Akinwole (2005) and Akinwole and Adeola (2012), except the total suspended solids. The high TSS may be due to the nature of the system, where complex floc is kept in suspension and consumed by the fish reared in the system. However, the range is still within the limit reported by Akinwole *et al*. (2016) and Green *et al*. (2014) without negative impact on the growth of either African catfish or Channel catfish.

Table 1. Water quality parameters over 10 weeks in the biofloc system

Parameters	Mean	Standard error	*Optimum level for freshwater fish culture
Temperature (^{0}C)	25.87	0.06	26 - 32
Dissolved oxygen (mg/L)	7.38	0.09	>5.0
pH	6.98	0.06	6.5 – 8.5
Total dissolved solids (mg/L)	169.51	3.53	-
Conductivity (µs/cm^3)	0.26	0.01	-
Total ammonia-nitrogen (mg/L)	1.80	0.23	<8.0
Nitrite-nitrogen (mg/L)	1.07	0.21	< 1
Nitrate-nitrogen (mg/L)	37.18	5.85	<250
Total suspended solids (mg/L)	861.50	69.38	<500

* Adapted from Akinwole (2005) and Akinwole and Adeola (2012)

As shown in table 2, the temperature only showed significant correlation with nitrate and TSS, both of which have positive correlation, indicating an increase in temperature may lead to increase in both nitrate and TSS, although the correlation was stronger with TSS. Temperature affects metabolic activities of microbiota in biofloc system, increase biofloc production may occur as the temperature increases, and hence, increase in TSS (Dauda, 2020; De Schryver *et al*., 2008). Dissolved oxygen had a significant positive correlation with TDS and ammonia but negative correlation with nitrate and TSS. Increased dissolved oxygen may lead to increase activity of the microorganisms, therefore leading to fast-breaking down of the solid waste. pH had a negative correlation with nitrite and nitrate, indicating that increasing pH may lead to a decrease in nitrite and nitrate. Microbes in biofloc systems consume alkalinity, hence, reduction in pH. An increase in pH may increase the performance of the microbes and effectively utilise nitrogenous waste and reduce nitrite and nitrate in the system (Martins *et al*., 2017). TDS had a positive significant correlation with TSS, therefore, increase in TSS may lead to an increase in TDS. Ammonia also had a significant but negative correlation with TSS. TSS is increased due to the production of more biofloc as a result of the consumption of ammonia by microbial organisms in the system (Romano *et al*., 2018; Avnimelech, 2012).

Table 2:Interrdependence among water quality parameters in biofloc technology

	Temp	DO	pH	TDS	NH3	NO2	NO3	TSS
Temp	1							
DO	-0.168	1						
pH	-0.132	-0.009	1					
TDS	0.221	0.236*	0.043	1				
NH3	-0.30	0.414**	0.151	0.222	1			
NO2	0.200	0.211	-0.234*	0.169	-0.071	1		
NO3	0.281*	-0.531**	-0.320**	-0.121	-0.180	-0.074	1	
TSS	0.408**	-0.260*	-0.185	0.480**	-0.331**	0.043	0.414	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

The results of the interrelationships and predicted equations are presented in table 3, TSS and nitrate had a fairly high coefficient of determination, 0.462 and 0.412 with significant F values, hence, higher reliability of the equations predicted for the two parameters. Akinwole and Adeola (2012) and Dauda and Akinwole, (2014) had earlier noted that the higher the coefficient of determination, the more reliable is the predicted equation.

Table 3: Interrelationship among water quality parameters in biofloc technology

Y	X	Prediction equation	Co-efficient of determination	F value
TSS	TDS, pH, DO and temp	TSS = 230.38T – 271.31DO – 204.17pH + 10.30TDS - 3419	0.462	14.393
NH_3	TDS, pH, DO and temp	NH3 = 0.11T + 1.01DO + 0.57pH +0.01TDS – 13.80	0.211	4.468
NO_2	TDS, pH, DO and temp	NO2 = 0.63T + 0.51DO – 0.70pH + 0.01TDS – 14.93	0.149	2.923
NO_3	TDS, pH, DO and temp	NO3 = 15.13T - 32.62DO – 28.39pH – 0.04TDS + 91.71	0.412	11.731

Y is dependent variable, X is independent varaiables

CONCLUSION

Some of the water quality parameters are interdependent and interrelated in biofloc system, therefore, knowledge of some can give information about the others. Where there is limited facilities or urgent needs, total suspended solids and nitrate nitrogen values can be estimated mathematically with the information on the values of total dissolved solids, pH, dissolved oxygen and temperature.

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