The effect of the addition of banana stem compost to aerated and non-aerated acid sulfate water media on the growth performance of snakehead fish (*Channa striata* Bloch) juveniles

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Abstract. This study aimed to determine the effectiveness of aeration and banana stem compost addition in the culture of the snakehead fish (*Channa striata*). An experiment was conducted using a factorial design consisting of two factors, namely, aeration (aerated and non-aerated) and banana stem compost doses (0, 9, and 18 g L^{-1}). Snakehead fish juveniles measuring 2.4±0.3 cm and weighing 0.21 ±0.02 g were reared in aquaria sized 30 x 25 x 35 cm^3 with a water volume of 25 L at a stocking density of 2 juveniles L^{-1} for 40 days. The fish were given commercial feed with a protein content of 40%, twice a day (morning and afternoon), ad satiation. The feces and unconsumed feed in the experimental media were siphoned, and the water was changed (10% of total water volume) every 2 days. The results showed that the snakehead fish reared in non-aerated acid sulfate water demonstrated better growth and physiological performance when compared to those reared in aerated acid sulfate water ($p < 0.05$). Compost at a dose of 9 g L^{-1} resulted in better survival (95.33%), specific growth rate (7.66%), feed efficiency (87.17%), albumin level in muscle (5.89 g per 100 mL), and blood glucose level (43.77 mg per 100 mL) than compost at the 0 and 18 g L^{-1} doses ($p < 0.05$). However, protein and fat retention were not affected by compost administration to the acid sulfate water medium. A combination of non-aerated medium and addition of compost at a dose of 9 g L^{-1} obtained the highest growth.
Key Words: acid sulfate water, aeration, banana stem compost, dissolved oxygen, snakehead fish, water quality.

Introduction. Indonesia has a large area of tidal wetlands (20.11 million ha) consisting of 2.07 tidal potential land, 6.71 million ha acid sulfate land, 10.89 million ha peatland, and 0.44 million ha saline land (Purnamawati et al 2018). Tidal wetlands in Indonesia are found in Sumatra, Kalimantan, Sulawesi, and Papua (Ritung et al 2015). Purnamawati et al (2018) reported that West Kalimantan has tidal wetland area of 1.12 million ha. Aquaculture development programs are not only conducted in potential land, but also in suboptimal land such as freshwater tidal swamp land and brackish water swamp land (Nurussalam et al 2023). Tidal areas are quite potential to be utilized for aquaculture. However, the productivity in these areas is relatively low due to many problems, particularly poor water quality. To utilize acid sulfate water from a tidal area as a fish farming media, some research is required to check the physical, chemical, and biological aspects of water quality, particularly regarding the minimum ranges of water quality for the lives of cultured organisms. The main existing problems in the tidal area are sub-optimum water quality ranges, including pH levels of 2.53-3.39, sulfate levels of 6.91-8.7

mg L^{-1}, Fe levels of 0.72-2.83 mg L^{-1}, dissolved oxygen (DO) levels below 5 mg L^{-1}, and high fluctuation in salinity, that will hinder the stenohaline fish growth. Moreover, the entrance of seawater causes a quite high salinity difference in the rainy season and the dry season, which reaches 0-28 ppt (Purnamawati et al 2017a).

Another problem concerning the characteristics of an acidic sulfate area is pyrite (FeS_2). When oxidized, pyrite results in Fe^{2+}, H^+, and SO_4^{2-}. In pH < 7 (acidic), the equilibrium shifts to the formation of ionized H_2S. If oxygen is not available in water, sulfate will be the source of oxygen in the oxidation process performed by anaerobic bacteria. In this condition, the sulfate ion was reduced into a sulfite ion forming an equilibrium with a hydrogen ion to form hydrogen sulfide. With this sub-optimal condition, not many fish species can be reared in the tidal area, particularly in acidic sulfate soil (Wilson et al 1999; Cook et al 2000; White et al 2001; Adhikari 2003).

The snakehead fish (*Channa striata*) is one of freshwater fish species that can be reared in an acidic sulfate water medium. This freshwater fish is a potential aquaculture commodity (Mollah 1985; Marimuthu et al 2009; Mollah et al 2009; Rahman et al 2013) with a high economic value in the price ranges in the market between Rp. 55,000 and Rp. 65,000 per kg. Moreover, snakehead fish flesh is commonly used as a post-surgical therapeutic material (Gam et al 2006; Marimutu et al 2009) and as a source of protein (albumin), fat, and minerals, particularly zinc. The snakehead fish is categorized as a fish that is resistant to poor water quality condition due to its air-breathing organ (diverticula) to enable it to absorb oxygen directly from the air (Akbar 2014). However, this fish is sensitive to an extreme change in the environment. This fish normally lives in calm waters with no flows. The snakehead fish reared in unaerated acid sulfate water showed better growth and physiological response parameters than that reared in aerated sulfate water (Purnamawati et al 2017b). Yet, many things are still unknown regarding the long-term biological effects that occur when the fish lives in a medium that experiences oxygen saturation. Purnamawati et al (2018) has been used ameliorant to improve water quality of sulfate acid water, but it did not give a significant result in the improvement of dissolved oxygen. To create a better environment for the cultured commodity, an appropriate farming technology is needed, especially a technology to enhance several critical water quality parameters such as dissolved oxygen and pH in acid sulfate water media. This future technology is expected to improve the growth of cultivated organisms.

The acidity level (pH) of water may increase through ion exchange (Olayinka et al 2009; Osman et al 2010). One of the materials that can increase pH in water is humus from compost. The humus substance in compost can perform an adsorption process with a high cation exchange capacity. The addition of compost to water enables the release of the positive ions (cation) in compost into water, leading to an increased pH level (Stevenson 1994; Wu et al 2008; Kocasoy & Güvener 2009). Mature compost contains a functional group that contains abundant negative ions, such as $-COO^-$ and $-O^-$. This functional group will bind H^+ ions when entering water with low pH (high H^+ ions). This phenomenon exists due to the electric force between ions (Sparks 2002).

The banana stem is waste that can be used as a compost raw material. The waste of this plant is quite effective to be used as compost because of the low cost required for the production, as well as other factors such as high availability, ease of technology, and harmlessness to aquaculture organisms (Purnamawati et al 2018). Composting using this material is expected to solve the problem in aquaculture activity concerning acid sulfate rearing media with water sourced from a tidal area.

Compost made from banana stems has yet to be used to increase the pH of water and to minimize SO_4^{2-} for aquaculture activity in acid sulfate media. Therefore, the use of banana stems as a compost raw material should be tested for its effectiveness. Moreover, it is also necessary to observe the function of compost in affecting the survival and growth of the snakehead fish.

Material and Method

Experimental design. This study was conducted on July-September 2019 in the laboratory condition applying a factorial design consisting of two factors, namely, aeration and banana stem compost doses. Factor I (aeration) included 2 factor levels, i.e., with aeration and without aeration. Factor II (compost doses) consisted of 3 levels, i.e., 0, 9, and 18 g L^{-1}. Hence, this study applied 6 treatments with 3 replications or 18 units of experiment in total.

Experimental fish. Snakehead fish juveniles (936 fish) with an average initial length of 2.4±0.3 cm and an average initial weight of 0.21±0.02 g were used as experimental fish in this study. The fish were reared in aerated and non-aerated acid media.

Experimental media. As experimental tanks, a total of 18 glass aquaria sized 30 x 25 x 35 cm^3 were used. The fish tanks were filled with acid sulfate water from a tidal area with an optimum salinity of 3.6 ppt prepared in a reservoir beforehand. The top part of the aquaria was covered in a net to prevent fish issuance from the aquaria.

Experimental procedures. The compost was prepared using a bio-activator (effective microorganism 4; EM4) to speed up the aerobic composting process. Once the raw material turned into compost, it was dried in the sun. The chemical content of the banana stem compost is presented in Table 1.

Table 1

Chemical content of banana stem compost

Parameters	*Unit*	*Value*
Ca	%	1.54
Mg	%	0.86
C-Organic	%	43.39
N	%	2.48
C/N	-	17.50
pH	Unit	8.8
Cation exchange capacity$^+$	cmol$^+$ kg^{-1}	41.07
Humic acid	ppm	2.50
Fulvic acid	ppm	0.80
Moisture	%	68.78

Rearing conditions. Acclimatization of experimental fish was conducted beforehand to adjust the fish to new environmental conditions. The fish were left to adapt in 4 aquaria sized 30 x 25 x 35 cm^3 for 7 days. Later, the fish were acclimatized to a medium with an optimum salinity of 3.6 ppt.

The snakehead fish that had successfully adapted to the new environment were reared in aquaria at a stocking density of 2 fish L^{-1} (Vivekanandan 1977) and a salinity level of 3.6 ppt. The experiment was conducted for 40 days. The fish were fed commercial feed with a protein content of ±40%, twice a day, ad satiation. During the experiment, water change (10% of total water volume) was done every 2 days. The water used for the water change was stored in a reservoir tank with a salinity level similar to the water changed.

Experimental parameters. The variables observed in this study included physico-chemical parameters of rearing media consisting of water temperature, pH, dissolved oxygen, salinity, sulfate (SO_4^{2-}), sulfide (H_2S), alkalinity, hardness, ammonia, and carbon dioxide (CO_2), growth performances of snakehead fish juveniles including survival rate (Kang'ombe & Brown 2008), specific growth rate (Weatherley et al 1987), feed efficiency (Kang'ombe & Brown 2008), protein and fat retention (Takeuchi 1988), and blood biochemical parameters consisting of albumin level (Infusino & Panteghini 2013) and blood glucose level (Wedemeyer & Yasutake 1977).

Observation and measurement of water temperature, pH, dissolved oxygen, and salinity were conducted daily, while measurement of SO_4^{2-}, H_2S, alkalinity, hardness, ammonia, and CO_2 were performed at the beginning and the end of the experiment. Water temperature and dissolved oxygen were measured by using multi-parameter water quality checker device (Lutron DO-5510), while pH was measured using a pH meter (pH Meter Trans, Senz pH) and salinity was measured using hand refractometer (ATAGO Salinity Refractometer MASTER-S/MillM). Alkalinity measurement was based on titration of a water sample to a designated pH using the diluted sulfuric acid (0.1 or 0.02 N H_2SO_4) as a titrant and a pH meter to measure pH, while hardness was measured by titration method based on a colorimetric reaction occurred when all hardness ions have been removed from the solution and CO_2 was measured through titrimetric Standard 4500-CO_2 (APHA 1998). Ammonia, SO_4^{2-}, and H_2S were measured using spectrophotometric methods APHA 4500-NH_3-F, APHA 4500-SO_4 2-E, and APHA 4500-S2D, respectively (APHA 2017).

Fish were counted every day to record survival rate. Total initial weight and total final weight of the fish were measured to obtain specific growth rate that was calculated using a formula as follows:

$$\text{Specific growth rate (\% day}^{-1}) = [\log_e \text{final mean weight (g)} - \log_e \text{initial mean weight (g)/days}] \times 100$$

The feed consumed was also monitored every day to find out feed efficiency using this formula:

$$\text{Feed efficiency (\%)} = [\text{final body weight (g)} - \text{initial body weight (g)}]/\text{feed consumption (g)} \times 100$$

The initial and final content of protein and fat contained in the experimental feed and fish were measured by proximate analysis to obtain protein retention and fat retention. At the end of the experiment, fish blood was collected as the sample for albumin level and blood glucose level. The measurement of blood glucose level used a commercial kit (Glucose Liquicolor GOD-PAP) through calorimetric method and the result was detected using spectrophotometric method at a wavelength of 500 nm. The measurement of blood albumin level used Bromocresol Green (BCG) and albumin standard analysis which prepared from Bovine Serum Albumin (BSA) as reagents for albumin analysis. The analysis was carried out by measuring the absorbance in the sample at a wavelength of 578 nm detected by spectrophotometric method.

Statistical analysis. Survival rate, specific growth rate, albumin level, feed efficiency, protein retention, fat retention, and blood glucose level were analyzed using ANOVA at a confidence level of 95%. Any significant results were further analyzed using the least significant difference (LSD) test. The physico-chemical parameters of the water were interpreted descriptively.

Results. The water quality variables in each snakehead fish rearing medium were varied. Some water quality parameters observed were not ideal for the life of the snakehead fish, yet some others were still within the standard levels. The temperature during the experiment was optimal for the fish growth, and pH, hardness, sulfate level, hydrogen sulfide level, and dissolved oxygen were still within the tolerance levels for the fish growth (Table 2).

Aeration was indicated as a factor that significantly affected all the variables observed ($p < 0.05$). The snakehead fish reared in the non-aerated medium was found to have better growth and physiological performance compared to those reared with aeration.

In terms of compost doses, significant results were obtained in the survival rate, specific growth rate, feed efficiency, albumin level in muscle, and blood glucose level ($p < 0.05$), with better results found in the addition of compost at 9 g L^{-1}. The addition of compost to the acid sulfate water medium did not significantly affect protein and fat retention (Table 3).

Table 2

The physico-chemical parameters in the media for all treatments during the study

Parameters	Aeration						Tolerance ranges
	Aerated			Non-aerated			
	Compost doses						
	0 g L^{-1}	*9 g L^{-1}*	*18 g L^{-1}*	*0 g L^{-1}*	*9 g L^{-1}*	*18 g L^{-1}*	
pH	4.5-5.1	5.5-6.3	5.8-6.5	4.5-5.0	5.8-6.3	5.8-6.5	4.25-9.4[3)]
Sulfate (SO_4^{2-}) (mg L^{-1})	41.00	24.12-26.10	24.03-27.05	41.35	24.32-27.05	23.26-28.11	< 50[1)]
Hydrogen sulfide (H_2S) (mg L^{-1})	0.00-0.005	0.000-0.002	0.000-0.002	0.00-0.005	0.000-0.002	0.000-0.002	0.02-0.1[1)]
Hardness (mg L^{-1})	24.00-38.00	31.05-33.00	24.50-41.00	25.21-58.15	27.00-54.11	26.73-59.10	10-400[1)]
Alkalinity (mg L^{-1})	23.05-28.24	23.56-48.25	31.05-52.11	24.53-31.09	36.27-61.15	32.33-56.04	80-120[1)]
Ammonia (mg L^{-1})	0.41-1.27	0.41-1.27	0.41-1.27	0.41-1.27	0.41-1.27	0.41-1.27	0.54-1.57[2)]
Dissolved oxygen (mg L^{-1})	4.25-6.61	5.28-6.21	5.65-6.15	4.18-5.22	5.42-5.80	5.22-5.51	> 5[3)]
Temperature (^oC)	28.32-30.02	29.32-30.12	29.42-30.29	28.13-30.09	29.22-30.19	29.07-30.17	26-32[3)]

Note: [1)]Boyd (1982), [2)]Qin et al (1997), and [3)]Courtenay Jr. & Williams (2004).

Table 3

Survival (SR), specific growth rate (SGR), albumin, feed efficiency (FE), protein retention (PR), fat retention (FR), and blood glucose (BG) of the snakehead fish (*Channa striata*) for all treatments during the study

Parameters	Aeration (A)						A	B	A x B
	Aerated			Non-aerated					
	Compost doses (B)								
	0 g L^{-1}	*9 g L^{-1}*	*18 g L^{-1}*	*0 g L^{-1}*	*9 g L^{-1}*	*18 g L^{-1}*			
SR (%)	74.00±2.00^a	88.67±2.31^a	86.67±11.02^a	89.33±5.03^a	95.33±3.06^a	88.66±3.06^a	p<0.05	p<0.05	p>0.05
SGR (%)	5.87±0.21^a	7.03±0.36^{bc}	6.97±0.32^b	7.40±0.37^{bc}	7.66±0.47^c	6.90±0.46^b	p<0.05	p<0.05	p<0.05
Albumin (g per 100 mL)	5.24±0.08^a	5.73±0.08^{bd}	5.48±0.08^c	5.81±0.16^d	5.89±0.08^d	5.59±0.12^{bc}	p<0.05	p<0.05	p<0.05
FE (%)	50.37±13.13^a	76.50±7.04^a	66.50±9.75^a	68.90±19.85^a	87.17±5.25^a	73.03±6.65^a	p<0.05	p<0.05	p>0.05
PR (%)	37.49±2.93^a	46.42±4.19^a	46.50±7.49^a	48.56±6.33^a	51.99±2.06^a	50.34±6.64^a	p<0.05	p>0.05	p>0.05
FR (%)	20.99±1.37^a	26.12±2.38^a	26.28±4.13^a	28.23±3.52^a	31.71±0.43^a	29.95±4.25^a	p<0.05	p>0.05	p>0.05
BG (mg per 100 mL)	58.74±1.75^a	54.83±1.76^b	58.44 ±1.63^a	47.14 ±1.83^c	43.77 ±1.46^c	52.71±1.51^b	p<0.05	p<0.05	p<0.05

Different superscript letters within the same row show a significant difference ($p < 0.05$).

In terms of the interaction between aeration and compost doses, not all the variables observed provided significant responses. The variables that showed significant interaction effects included specific growth rate, albumin level in muscle, and blood glucose level. Moreover, significant interaction effects were not found in survival rate, feed efficiency, protein retention, and fat retention ($p > 0.05$).

A higher specific growth rate was found in the non-aerated medium that was added with compost at 9 g L^{-1}, which was not significantly different from the non-aerated, non-composted medium and from the aerated medium that was added with compost at 9 g L^{-1}.

The highest concentration of albumin was found in the non-aerated, non-composted medium and in the non-aerated medium that was added with compost at 9 g L^{-1}.

The lowest blood glucose was obtained in the snakehead fish reared in the non-aerated, non-composted medium and in the non-aerated medium that was added with compost at 9 g L^{-1} (Table 3).

The lowest survival rate (74%) was found in the aerated, non-composted medium, yet it was not significantly different from other treatment combinations.

The feed efficiency resulted was not significantly different among the treatment combinations. The protein and fat retention was not significant among the treatment combinations (Table 3).

Discussion. This study proved that water treatment with compost resulted in water quality that was suitable for the snakehead fish. The improvement of water quality in acid sulfate water through the addition of compost at 9 g L^{-1} caused the fish to be able to utilize feed more optimally. In the pH range of 7.5-8.7, the fish gills will have a great ability to bind oxygen, allowing the oxygen requirement for metabolism and other activities to be fulfilled (Wedemeyer 1996). Furthermore, within this range of pH, the fish gills work optimally and can maximally bind ions that are necessary for the body. This allows for the improvement of feed efficiency and albumin level, resulting in optimal fish growth.

The improvement of water quality in acid sulfate water through the addition of compost provided maximal results when the fish were reared in the non-aerated medium. This interaction led to quite a good response in most of the variables in this experiment. Survival rate is one of the indicators for aquaculture success. A high survival rate will determine the fish productivity to be achieved (Keshavanath et al 2001). Survival rate is affected by many factors, including water quality, abiotic factors, competition between species, lack of feed, increasing population within the same environment, predator and parasite, wrong handling, age, and adaptability to the environment (Schmittou 1991).

Concerning environmental conditions, the survival rate of fish will be high in good environmental conditions. Otherwise, poor water quality will lead to fish stress, which results in high mortality. The snakehead fish that is included in the air-breathing fish group may survive in water with low dissolved oxygen levels by breathing directly in the air. This condition resulted in a higher survival rate (95.33%) obtained by the fish reared in the non-aerated medium that was added with compost at a dose of 9 g L^{-1} compared with the survival rate obtained by those in the aerated medium. Aeration causes turbulence, requiring more energy to balance the water current; this also leads to stress due to growth disturbance and high mortality (Barton 2002). The study conducted by Sarma et al (2013) showed that *Clarias batrachus* reared at a salinity level of 4 ppt demonstrated a high survival rate (93.3%). The symptoms of stress in the snakehead fish were reflected by the high blood glucose level found in the group reared in the aerated medium. Meanwhile, the lowest blood glucose level was obtained by the group reared in the non-aerated medium that was added with 9 g L^{-1} of compost (43.77 mg per 100 mL). This blood glucose level is considered low compared to previous study results, such as the blood glucose levels of the snakehead fish reared in a medium with a salinity level of 0 ppt (6.25 mmol L^{-1}) (Nakkrasae et al 2015), stressed channel catfish (*Ictalurus punctatus*) due to handling (2.8 mmol L^{-1}) (Welker et al 2007), stressed emerald rockcod (*Trematomus bernacchii*) due to temperature fluctuation (7.5 mmol L^{-1}) (Lowe & Davison 2005), and stressed Nile tilapia (*Oreochromis niloticus*) due to poor environment (6.7 mmol L^{-1}) (Barreto & Volpato 2006).

When a fish is under stress, it requires more energy to adapt to the stress due to environmental change. The high requirement of energy to survive will stimulate the mobilization of glucose into the bloodstream (Barreto & Volpato 2006; Costas et al 2008).

An increase in blood glucose level is a response to the stress resulted from the release of cortisol in the hypothalamus through the bloodstream to the chromaffin tissue in the kidney, glycogenesis, and glycogenolysis (Iwama et al 1999; Madhusudan et al 2003; Begg & Pankhurst 2004; Lowe & Davison 2005; Martínez-Porchase et al 2009). Moreover, Reid et al (1998) also mentioned that chromaffin cells release catecholamine, adrenaline, and noradrenaline to the blood circulation in sub-optimum or stress conditions.

Growth is a complex biological process. A fish grows when there is excess energy and material produced from feed. The snakehead fish was found to have a better growth when treated with the non-aerated medium (7.66%), indicated by high albumin level (5.89 g per 100 mL), high protein retention (51.99%), and high fat retention (31.71%), as a result of energy and material accumulation (Houlihan et al 1993; Labh et al 2014). This condition cannot be separated from protein synthesis. In this study, a relationship between protein synthesis and energy for physical or voluntary activity existed. The growth rate obtained in this study was better than that of the *C. batrachus* reared for 30 days in a medium with a salinity of 2 ppt (0.74%) (Sahoo et al 2003).

The feed efficiency was also affected by the capacity of aeration and weak motion energy as in non-aerated fish rearing. If the water is not mixed or aerated, the feed can be completely utilized by the fish. Furthermore, the feed consumed in calm water can be fully converted into fish muscle (Nelson & Chabot 2011). The fish reared in the non-aerated medium that was added with compost at 9 g L^{-1} was found to efficiently utilize the feed (87.17%). The lowest feed efficiency was obtained by the fish reared in the aerated medium that was treated with the addition of compost at 0 g L^{-1} and 18 g L^{-1} (50.37 g L^{-1} and 66.50 g L^{-1}).

The high albumin level in the fish reared in the non-aerated medium that was treated with the addition of compost at 9 g L^{-1} was due to the fact that the fish absorbed the dietary nutrients consumed to maintain the osmotic pressure by minimizing motion activity. Maintaining albumin level in the blood plasma means that the fish also maintain the blood volume. Later, when the albumin level decreases, a fluid accumulation may occur in the tissue. According to Infusino & Panteghini (2013), albumin is one of the blood plasma proteins synthesized in the liver. Albumin plays an important role in maintaining the osmotic pressure of the plasma and the transport of small molecules through the plasma or the extracellular fluid (Suprayitno 2014).

The addition of compost to acid sulfate water was found to be able to improve the growth performance of the snakehead fish due to the quality improvement of the water that was used as the rearing medium. Several water quality variables that improved were pH level, sulfate level, hardness, and alkalinity. This improvement in the water quality decreased the toxicity of the water to the fish, improving the blood glucose level as one of stress indicators and in turn the fish survival rate (Boyd 1982). The improvement of the water quality in the acid sulfate water medium that was added with compost is attributable to the increase of Ca^{2+} cation content, as contained in lime ($CaCO_3$), required to bind SO_4^{2-} (the source of the water acidity) to form gypsum (Fitzpatrick et al 1998). The content of humic acid, fulvic acid, and humin in compost increases pH (decreasing H^+ ion). According to Stevenson (1994), in all pH conditions, humic acid, fulvic acid, and humin have a negative charge that will bind the H^+ ion in water, thus increasing pH. In addition to negative ions in compost functional groups, an increase in pH value in water is also caused by the release of positive ions (cations) from compost to water. Therefore, cations will increase pH in acid sulfate water.

The maturity level of compost positively correlates with the increase in pH; as a result, compost tends to be alkaline (about 8.8 in pH level) (Table 1). In basic pH, H^+

ions are deprotonated. According to Sparks (2002), the organic matter of humus will have a negative charge in alkaline pH or pH above 3. The condition of increasing pH in the environment during the last stage of composting results in an increasing level of negative charge of humus due to deprotonated or dissociated H^+ in the functional group. The deprotonation process gives mature compost a functional group that contains abundant negative ions, such as $–COO^-$ and $–O^-$. This negative functional group, when entering water with low pH (high H^+ ion), will bind H^+ ions due to the electrostatic force between ions.

Conclusions. The addition of compost at 9 g L^{-1} was found to be able to increase the pH of acid sulfate water media to ensure maximum levels of survival and growth of snakehead fish juveniles. The non-aerated medium that was added with compost at 9 g L^{-1} provided significantly different results on the growth performance of snakehead fish juveniles. This experiment showed that the application of adequate ameliorant in stagnant sulfate acid water media could be a future approach to achieve a better living environment for the snakehead fish that will result in the improvement of growth performances.

Conflict of interest. Authors declare that there is no conflict of interest.

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