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Penulis : Dade Jubaedah, Marsi, Marini Wijayanti, Sofiatul Rahmani

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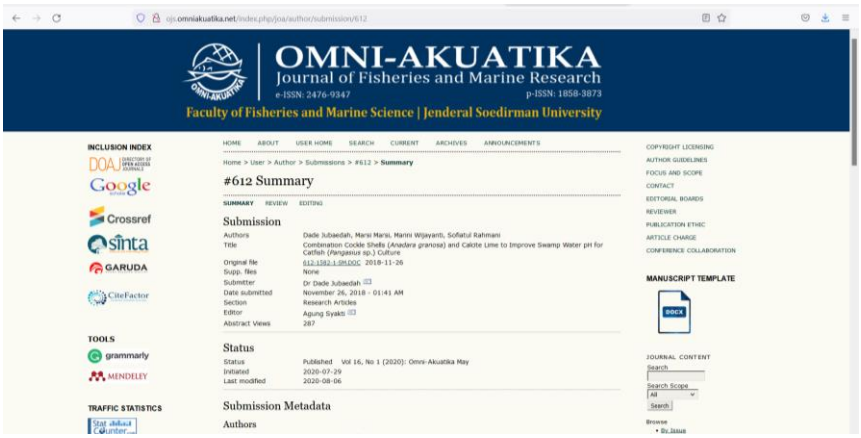

Combination Cockle Shells (Anadara granosa) and Calcite Lime to Improve Swamp Water pH for Catfish (*Pangasius* sp.) culture

Dade Jubaedah[1], Marsi[2], Marini Wijayanti[1], Sofiatul Rahmani[1]

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ABSTRACT

Cockle shells was proven potential used as an alternative liming materials. Combination of lime derived from cockle shells with calcite as common lime materials used to overcome limited quantity of cockle shells as the problem of seasonal avaibility of cockle shells. Beside, these materials have difference characteristics that to be expected can give better effect to pH of soil and water. This study aims to determine the best combination dose between cockle shell limes and calcite to increase the pH of water and soil, survival rate and growth of catfish *(Pangasius* sp.*).* The study used completely randomized design (CRD) with 5 treatments and 3 replications. The treatment of different combination of lime doses 100% calcite (P_1), 100% cockle shell limes (P_2), 75% calcite and 25% cockle shell limes (P_3), 50% calcite and 50% cockle shell limes (P_4), and 25% calcite and 75% cockle shell limes (P_5), dose of lime used as much as 7,000 kg/ha CaO equivalent. The result showed that P_4 was the best treatment according to data of swamp water pH was 8.13 and soil pH was 8.07 at final day (day 60), alkalinity 153.33 mgL^{-1} $CaCO_3$ equivalent, Ca 104.15 mgL^{-1},100% survival rate, 11.23 cm absolute growth of length, 38.60 g absolute growth of weight and 128.38% feed efficiency.

Key words: Calcite, Catfish, Cockle shells, Liming, Swamp

1. Introduction

Liming of soil is an effort to increase soil and waters pH of swamp fish ponds. Ponds can be limed with liquid lime, basic slag, or agricultural limestone (Wynne 1996; Boyd 1982, 1990; Wilkinson 2002). Common liming materials include agricultural limestone and liquid lime, calcium hydroxide, calcium oxide and basic slag. Peters (1996) described liming materials that was commonly used are calcitic aglime, dolomictic aglime, hydrated or slaked lime, quicklime or burnt lime, marl, and industrial by product.

An alternative liming material from domestic waste or by-product have an advantages, not only increase pH level, but also evironmentally acceptable. The reseach showed that cockle shells (*Anadara granosa*) can be used to increase soil and water's pH of swamp fish ponds (Jubaedah *et al.* 2017). Initial soil's pH value from 3.9 increase to 7.2 as affected by 5 ton/ha lime derived from cockle shells application during 7 days incubation time and maximal water's pH value 7.9 at day 87. Next lime application should be considered after day 205.

According Wilkinson (2002), acid sulfate soils within a pond or its watershed must therefore be treated if the pond is to be used for production. However, large amounts of lime are typically required and the technique may ot be economically feasible. Seasonal avaibility of cockle shells need to combine with common agriculture limestone.

Calcite (Calcium carbonates, $CaCO_3$) is one kinds of agricultural lime stone that slowly react but simoultanosly safe to fish (Boyd, 1982; 1990) Calcium carbonates on cockle shells converted to calcium oxide through calcination process. CaO short-therm acting but can be unsafe for fish (Nobre *et al.* 2014). The present work aimed to compare the pH of soil and water as well as survival rate and growth performance of catfish juvenile reared in ponds with aplication of combination of combination of calcite ($CaCO_3$) and lime derived from cockle shells.

2. Materials and Methods

2.1. Preparing Lime Materials and Liming Aplication

Calcination process of *A. granosa* shells according to Jubaedah *et al.* (2017), including burning process using furnace at temperature of 800ºC for an hour. The calcin then mashed and sieved with

60, 40 and 20 mesh-size sieves in order to get lime with 50 % passed 60 mesh-size sieve, 25 % passed 40 mesh-sized sieve, and 25 % passed 20 mesh-size sieve.

Five combination of lime were investigated, namely: P1) 100% calcite, P2) 100% cockle shells lime, P3) 75% calcite and 25% cockle shell limes, P4) 50% calcite and 50% cockle shell limes, and P5) 25% calcite and 75% cockle shell limes, dose of lime each used as much 7,000 kg/ha CaO equivalent. Lime were applied homogeneously on soil ponds and incubated for 7 days at field capacity soil moisture. Water was filled to the ponds and and let equilibrated for 3 days. Fish stocked on ponds and cultured for 60 days.

2.2. Fish Culture

Fiveteen unit of fish ponds filled swamp water with 500 L/ponds at 7 days after liming. Fish were aclimatized for one week before used in this research. The fiveteens of 5 $\pm$ 0.5 cm length *Pangasius sp* stocked for each ponds.

Starting from 10 days after liming, fish was cultured for 60 days. The fish were fed to satiation three times per day with an artificial diet containing 30% protein. Water samples were collected and analyzed, as well as growth of fish was measured every 20 days.

2.3. Experimental variables and analytical procedurs

Water quality, survival and growth performance variables were observed in the present work. The water's pH, total alkalinity, and total ammonia were monitored every 20 day, Ca concentration analyzed every 30 days in all pond. Besides, water temperature and pH were recorded daily. The water pH was measured by using a portable pH meter. The water temperature was observed by using a digital handy thermometer. The analytical determinations of total alkalinity and total ammonia and Ca were carried out according to the guidelines presented by APHA (2012). The fish initial and final body weight and length, survival and feed efficiency were observed in all experimental units.

Water quality, survival and growth performance results were statistically analyzed according to the two-way Anova to detect if there was any significant influence due to experimental treatments. When the influence was at least significant, the means were compared using Least Signifcant Difference (LSD) test.

2.4. Data Analysis

The fish survival rate was calculated from the initial number of fish and mortality after the experiment was completed. The absolute growth of fish were determined from the mean of initial and final weight and length of fish, respectively for absolute weight growth and length growth. Meanwhile, feed efficiency was calculated by the formula of NRC (1977).

3. Results and Discussion

The initial Soil pH used in this current study was 3.60 and then soil pH increased due to liming to pH 7.40–7.53 after incubated for 7 days (Fig. 1). The soil's pH tend to increase rapidly until neutral pH value at the begining of incubation, then increase slowly.

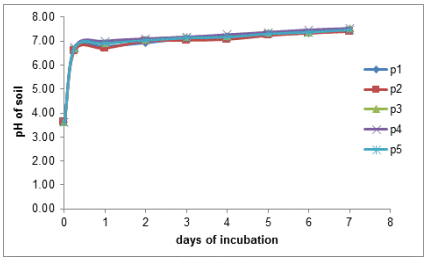

Fig.1. Soil's pH at 7 days of incubation

Regression between combination of limes and pH of soil and water showed polynomial quadratic patterns for day 0, 10, 20 and 30 (Fig. 2 and 3). The results showed combination of calcite (50%) and cockle shells lime (50%) has highest soil's and water's pH. The calcination process of cockle shells convert calcium carbonate ($CaCO_3$) to Calcium Hydroxide (CaO). According to Boyd (1982; 1990), reaction with acidity is faster than $CaCO_3$, but highly caustic and cause the water pH raise to levels toxic for fish. Calcite ($CaCO_3$) is agricultural limestone that is slow-acting product but generally the safest (Boyd 1982; Nobre *et al.* 2014). The combination of cockle shells lime and calcite raise pH value higher than single lime, both cockle shells and calcite.

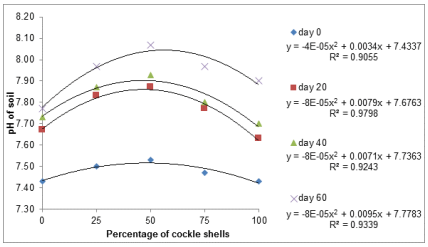

Fig. 2. Relationship between combination of cockle shells and calcite and pH of soil

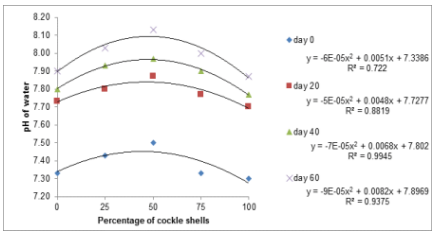

Fig. 3. Relationship between combination of cockle shells and calcite and pH of water

The initial water pH used in this research was 3.5, then water pH increased following polynomial quadratic patterns for 60 days of fish culture due to lime application (Fig. 4). According to equations shown in Fig. 3, the maximum pH and days after lime application to reach maximum water pH can be calculated. The maximum water pH and when it is were 7.85 at 50 days after liming, 7.82 at 50 days after liming, 7.93 at 50 days after liming, 8.31 at 89 days after liming and 8.03 at 59 days after liming, respectively for P_1, P_2, P_3, P_4 and P_5.

The highest maximum water pH among treatments was observed on P_4 (50% calcite and 50% cockle shell lime). Furthermore, based on the equations (Fig. 4) and minimum water pH (6.5) for optimal growth of *Pangasius sp*, the next lime application should be considered after day, 132th, 132th, 134th, 224th and 146th for P_1, P_2, P_3, P_4 and P_5, respectively.

Liming not only increase pH value, but also alkalinity of water. Based on Fig. 5 showed that liming application of combination cockle shell limes and calcite affected to increase alkalinity of water. Greater alkalinity after liming also buffer water from drastic daily changes in pH (Boyd, 1990).

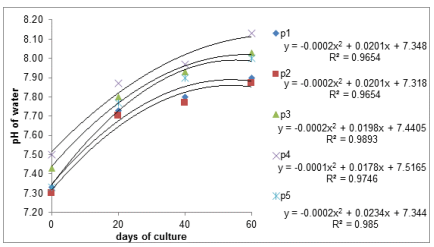

Fig 4. Relationship between days of culture and pH of water for each treatments

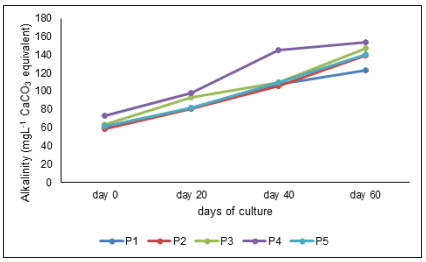

Fig. 5. Alkalinity for each treatment

Liming also related to calcium (Ca) concentration. Fish will lose Ca to the water on extremely low Ca concentration in the water, eventhough the minimum acceptable Ca concentration in the water necessary to permit optimum fish growth has not been established (Boyd, 1990). The liming was gave significantly different to Ca concentration at final day of research (day 60th) (Table 1). Combination of cockle shell lime 50% and calcite 50% (P_4) has highest Ca, significance different with calcite 100% (P1) and cockle shell 100%(P2), but no significant different with combination cockle shell lime 75% calcite and 25% cockle shell limes(P_3), and 25% calcite and 75% cockle shell limes(P_5). According to Boyd *et al.* (2002), Ca concentration from calcite is 40.08%, meanwhile based on the analysis of Ca content from cockle shells is 61.16%.

Table 1. Concentration of Ca in water

	Concentration of Ca (mgL^{-1})		
Treatment	Day 0	Day 30	Day 60
P1	45.77	68.70	69.69_a
P2	45.27	71.23	69.70_a
P3	53.70	74.07	101.32_b
P4	56.53	76.33	104.15_b
P5	48.93	72.33	79.61_{ab}
$LSD_{0.05}$			24.97

number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters means not significant ($p > 0.05$).

The water temperature and dissolved oxygen (DO) of ponds (Table 2 and 3) ranged from 25.3 to 32.2 ^{0}C and from 5.4 to 6.6 mg L^{-1}, respectively. Based on National standardization Agency or Badan Standar Nasional Indonesia (BSNI, 2000), the temperature of water was exceed optimum ranged that is 27-30^{o}C according to optimal value of temperature for *Pangasius sp* but still in tolerance ranged for fish. Meanwhile, the DO was approriate for *Pangasius sp*. No significant effect of lime application on dissolved oxygen at the day 0, 20,40 and 60 of rearing period.

Table 2. The water temperature

Treatment	Range of water temperature (^{o}C)
P1	25.3 - 31.8
P2	25.5 - 32.0
P3	25.6 - 32.1
P4	25.4 - 32.2
P5	25.4 - 32.2

Table 3. Dissolved Oxygen

	Dissolved Oxygen (mgL^{-1})			
Treatment	day 0	day 20	day 40	day 60
P1	5.7	6.3	6.6	6.6
P2	5.5	6.0	6.6	6.6
P3	5.6	5.9	6.5	6.4

P4	5.6	5.9	6.5	6.6
P5	5.4	6.0	6.3	6.5

All treatment showed that the ammonia concentration increased in the final day of research (day 60th of culture) (Fig. 6). The ammonia concentration at culture periods under maximal value for amonia for fish according to Indonesian environmental regulation or Peraturan Pemerintah Republik Indonesia (2001) that is >1 mgL^{-1}.

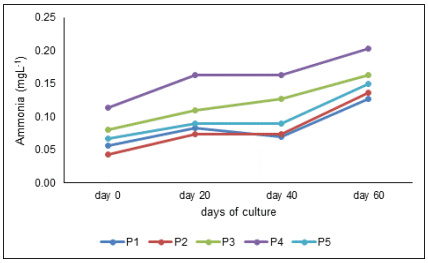

Fig. 6. Ammonia concentration

The survival rate of *Pangsius sp* were100% for all treatments. The liming application using single lime materials both calcite 100% and cockle shells 100%, or combination of them can increase pH until optimum for fish. In general, the water quality supported for living of fish.

The growth performance and fed efficiency showed at Table 4. Based on analysis of variance showed that treatment gave an effect to growth performance of fish. The highest absolute growth (lenght and weight) of fishes was on combination 50% cockle shells and 50% calcite (P_4) and signficant difference with others.

Table 4. Growth performance and feed efficiency

Treatments	Absolute growth of		Feed efficiency (%)
	Lenght (cm)	Weight (g)	
P1	10.00_{ab}	28.67_{a}	91.88
P2	9.74_{a}	29.31_{ab}	99.98
P3	10.48_{b}	32.08_{c}	96.96
P4	11.23_{c}	38.60_{d}	128.38
P5	9.94_{ab}	31.36_{bc}	94.57
$LSD_{0.05}$	0.61	2.18	

Number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters means not significant ($p > 0.05$).

The highest feed efficiency was on fish cultured at ponds with liming combination calcite (50%) and cockle shells (50%). It is probably related to availability of plankton as natural feed of fish. The highest alkalinity shown at P_4 (Fig.5) and it will increase the carbondioxide for photosyntesis of phytoplankton. According to Boyd (1982, 1990) and Wilkinson (2002), the positive effect of liming was increases the alkalinity of water, thereby increasing the availability of carbon dioxide for phytoplankton growth. Wilkinson (2002), from some references conclude that applying lime has been shown to increase soluble phosphorus concentrations as nutrient of phytoplankton. Lime provides calcium and neutralizes acidic soils so that phosphate is released as calcium exchanges with aluminum and iron. Calcium phosphates are more soluble in water than aluminum phosphates or iron phosphates (Burtle, 2015).

4. Conclusions

The combination of 50% cockle shells lime and 50% calcite was the best treatments with pH of soil and water at day 60 were 8.07 and 8.31, respectively; highest maximal water pH value (3.31) and next liming was at day 224; highest alkalinity (153.33 mgL^{-1} $CaCO_3$ equivalent), and Ca (104.15 mgL^{-1});

highest feed efficiency (128.38%); and the best growth performance. The water quality including water temperature, dissolved oxygen and ammonia were in appropriate for *Pangasius sp*.with 100% survival rate.

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#612 Review

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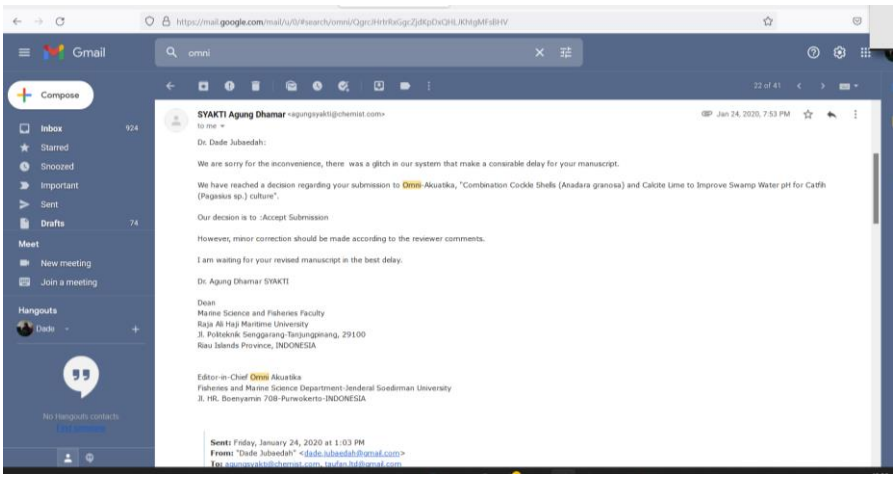

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Water quality, survival and growth performance results were statistically analyzed according to the two-way Anova to detect if there was any significant influence due to experimental treatments. When the influence was at least significant, the means were compared using Least Signifcant Difference (LSD) test.

6.4. Data Analysis

The fish survival rate was calculated from the initial number of fish and mortality after the experiment was completed. The absolute growth of fish were determined from the mean of initial and final weight and length of fish, respectively for absolute weight growth and length growth. Meanwhile, feed efficiency was calculated by the formula of NRC (1977).

7. Results and Discussion

The initial Soil pH used in this current study was 3.60 and then soil pH increased due to liming to pH 7.40–7.53 after incubated for 7 days (Fig. 1). The soil's pH tend to increase rapidly until neutral pH value at the begining of incubation, then increase slowly.

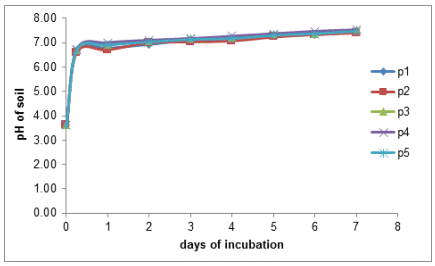

Fig.1. Soil's pH at 7 days of incubation

Regression between combination of limes and pH of soil and water showed polynomial quadratic patterns for day 0, 10, 20 and 30 (Fig. 2 and 3). The results showed combination of calcite (50%) and cockle shells lime (50%) has highest soil's and water's pH. The calcination process of cockle shells convert calcium carbonate ($CaCO_3$) to Calcium Hydroxide (CaO). According to Boyd (1982; 1990), reaction with acidity is faster than $CaCO_3$, but highly caustic and cause the water pH raise to levels toxic for fish. Calcite ($CaCO_3$) is agricultural limestone that is slow-acting product but generally the safest (Boyd 1982; Nobre *et al.* 2014). The combination of cockle shells lime and calcite raise pH value higher than single lime, both cockle shells and calcite.

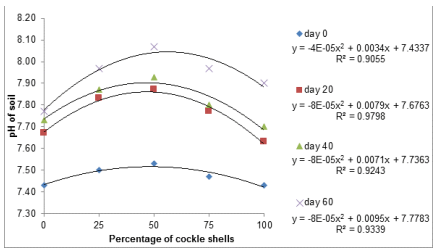

Fig. 2. Relationship between combination of cockle shells and calcite and pH of soil

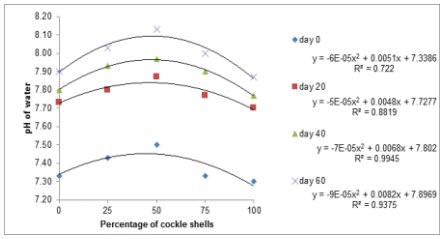

Fig. 3. Relationship between combination of cockle shells and calcite and pH of water

The initial water pH used in this research was 3.5, then water pH increased following polynomial quadratic patterns for 60 days of fish culture due to lime application (Fig. 4). According to equations shown in Fig. 3, the maximum pH and days after lime application to reach maximum water pH can be calculated. The maximum water pH and when it is were 7.85 at 50 days after liming, 7.82 at 50 days after liming, 7.93 at 50 days after liming, 8.31 at 89 days after liming and 8.03 at 59 days after liming, respectively for P_1, P_2, P_3, P_4 and P_5.

The highest maximum water pH among treatments was observed on P_4 (50% calcite and 50% cockle shell lime). Furthermore, based on the equations (Fig. 4) and minimum water pH (6.5) for optimal growth of *Pangasius sp*, the next lime application should be considered after day, 132th, 132th, 134th, 224th and 146th for P_1, P_2, P_3, P_4 and P_5, respectively.

Liming not only increase pH value, but also alkalinity of water. Based on Fig. 5 showed that liming application of combination cockle shell limes and calcite affected to increase alkalinity of water. Greater alkalinity after liming also buffer water from drastic daily changes in pH (Boyd, 1990).

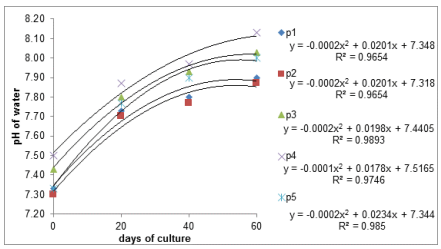

Fig 4. Relationship between days of culture and pH of water for each treatments

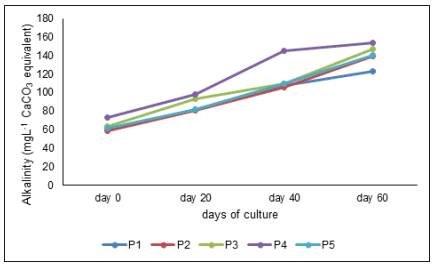

Fig. 5. Alkalinity for each treatment

Liming also related to calcium (Ca) concentration. Fish will lose Ca to the water on extremely low Ca concentration in the water, eventhough the minimum acceptable Ca

concentration in the water necessary to permit optimum fish growth has not been established (Boyd, 1990). The liming was gave significantly different to Ca concentration at final day of research (day 60th) (Table 1). Combination of cockle shell lime 50% and calcite 50% (P_4) has highest Ca, significance different with calcite 100% (P1) and cockle shell 100%(P2), but no significant different with combination cockle shell lime 75% calcite and 25% cockle shell limes(P_3), and 25% calcite and 75% cockle shell limes(P_5). According to Boyd *et al.* (2002), Ca concentration from calcite is 40.08%, meanwhile based on the analysis of Ca content from cockle shells is 61.16%.

Table 1. Concentration of Ca in water

	Concentration of Ca (mgL^{-1})		
Treatment	Day 0	Day 30	Day 60
P1	45.77	68.70	69.69_a
P2	45.27	71.23	69.70_a
P3	53.70	74.07	101.32_b
P4	56.53	76.33	104.15_b
P5	48.93	72.33	79.61_{ab}
$LSD_{0.05}$			24.97

number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters means not significant ($p > 0.05$).

The water temperature and dissolved oxygen (DO) of ponds (Table 2 and 3) ranged from 25.3 to 32.2 ^{0}C and from 5.4 to 6.6 mg L^{-1}, respectively. Based on National standardization Agency or Badan Standar Nasional Indonesia (BSNI, 2000), the temperature of water was exceed optimum ranged that is 27-30^{o}C according to optimal value of temperature for *Pangasius sp* but still in tolerance ranged for fish. Meanwhile, the DO was approriate for *Pangasius sp*. No significant effect of lime application on dissolved oxygen at the day 0, 20,40 and 60 of rearing period.

Table 2. The water temperature

Treatment	Range of water temperature (^{o}C)
P1	25.3 - 31.8
P2	25.5 - 32.0
P3	25.6 - 32.1
P4	25.4 - 32.2
P5	25.4 - 32.2

Table 3. Dissolved Oxygen

	Dissolved Oxygen (mgL^{-1})			
Treatment	day 0	day 20	day 40	day 60
P1	5.7	6.3	6.6	6.6
P2	5.5	6.0	6.6	6.6
P3	5.6	5.9	6.5	6.4
P4	5.6	5.9	6.5	6.6
P5	5.4	6.0	6.3	6.5

All treatment showed that the ammonia concentration increased in the final day of research (day 60th of culture) (Fig. 6). The ammonia concentration at culture periods under maximal value for amonia for fish according to Indonesian environmental regulation or Peraturan Pemerintah Republik Indonesia (2001) that is >1 mgL^{-1}.

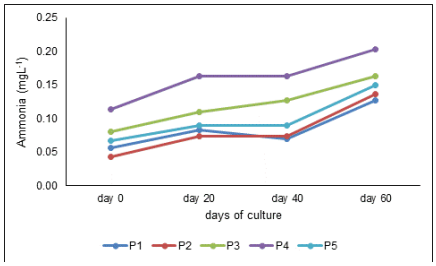

Fig. 6. Ammonia concentration

The survival rate of *Pangsius sp* were100% for all treatments. The liming application using single lime materials both calcite 100% and cockle shells 100%, or combination of them can increase pH until optimum for fish. In general, the water quality supported for living of fish.

The growth performance and fed efficiency showed at Table 4. Based on analysis of variance showed that treatment gave an effect to growth performance of fish. The highest absolute growth (lenght and weight) of fishes was on combination 50% cockle shells and 50% calcite (P_4) and signficant difference with others.

Table 4. Growth performance and feed efficiency

Treatments	Absolute growth of		Feed efficiency (%)
	Lenght (cm)	Weight (g)	
P1	10.00_{ab}	28.67_{a}	91.88
P2	9.74_{a}	29.31_{ab}	99.98
P3	10.48_{b}	32.08_{c}	96.96
P4	11.23_{c}	38.60_{d}	128.38
P5	9.94_{ab}	31.36_{bc}	94.57
$LSD_{0.05}$	0.61	2.18	

Number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters means not significant ($p > 0.05$).

The highest feed efficiency was on fish cultured at ponds with liming combination calcite (50%) and cockle shells (50%). It is probably related to availability of plankton as natural feed of fish. The highest alkalinity shown at P_4 (Fig.5) and it will increase the carbondioxide for photosyntesis of phytoplankton. According to Boyd (1982, 1990) and Wilkinson (2002), the positive effect of liming was increases the alkalinity of water, thereby increasing the availability of carbon dioxide for phytoplankton growth. Wilkinson (2002), from some references conclude that applying lime has been shown to increase soluble phosphorus concentrations as nutrient of phytoplankton. Lime provides calcium and neutralizes acidic soils so that phosphate is released as calcium exchanges with aluminum and iron. Calcium phosphates are more soluble in water than aluminum phosphates or iron phosphates (Burtle, 2015).

8. Conclusions

The combination of 50% cockle shells lime and 50% calcite was the best treatments with pH of soil and water at day 60 were 8.07 and 8.31, respectively; highest maximal water pH value (3.31) and next liming was at day 224; highest alkalinity (153.33 mgL^{-1} $CaCO_3$ equivalent), and Ca (104.15 mgL^{-1}); highest feed efficiency (128.38%); and the best growth performance. The water quality including water temperature, dissolved oxygen and ammonia were in appropriate for *Pangasius sp*.with 100% survival rate.

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APHA (American Public Health Association). 2012. Standard Methods for the Examination of

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Water and Wastewater, 22nd Edition. American Water Works, Washington D.C. 541 pp.
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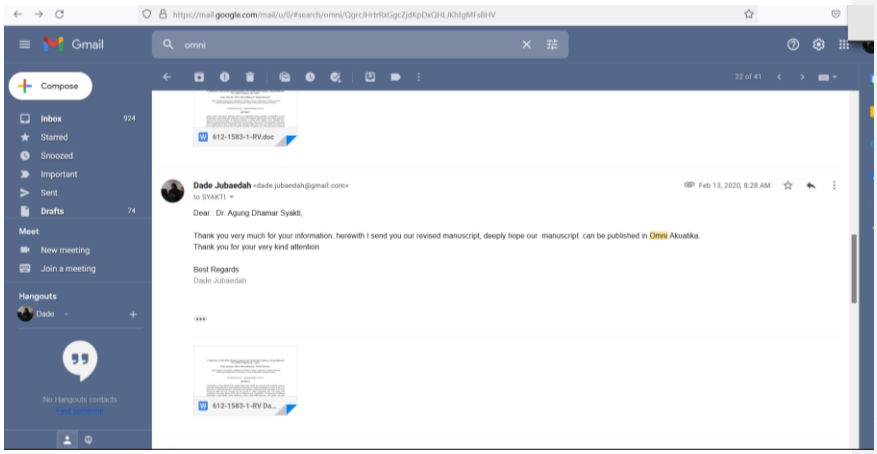
3. BUKTI REVISI ARTIKEL (12 Februari 2020)



Combination Cockle Shells (Anadara granosa) and Calcite Lime to Improve Swamp Water pH for Catfish (*Pangasius* sp.) culture

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ABSTRACT

Combination of lime derived from cockle shells with calcite as common lime materials used to overcome limited quantity of cockle shells as the problem of seasonal avaibility of cockle shells. This study aims to determine the best combination dose between cockle shell limes and calcite to increase the pH of water and soil, survival rate and growth of catfish *(Pangasius* sp.*).* The study used completely randomized design (CRD) with 5 treatments and 3 replications. The treatment of different combination of lime doses 100% calcite (P_1), 100% cockle shell limes (P_2), 75% calcite and 25% cockle shell limes (P_3), 50% calcite and 50% cockle shell limes (P_4), and 25% calcite and 75% cockle shell limes (P_5), dose of lime used as much as 7,000 kg/ha CaO equivalent. The result showed that P_4 was the best treatment according to data of swamp water pH was 8.13 and soil pH was 8.07 at final day (day 60), alkalinity 153.33 mgL^{-1} $CaCO_3$ equivalent, Ca 104.15 mgL^{-1},100% survival rate, 11.23 cm absolute growth of length, 38.60 g absolute growth of weight and 128.38% feed efficiency.

Key words: Calcite, Catfish, Cockle shells, Liming, Swamp

9. Introduction

Liming of soil is an effort to increase soil and waters pH of swamp fish ponds. According to Adhikari (2017), liming is the only way to improve water quality in ponds with acid soils. Liming compounds such as calcium carbonate (agricultural lime), calcium hydroxide (hydrated lime) and calcium oxide (quicklime) are applied during pond preparation to the water or sediment to neutralize acidity (Rico *et al.* 2012). An alternative liming material from domestic waste or by-product have an advantages, not only increase pH level, but also evironmentally acceptable. The reseach showed that cockle shells (*Anadara granosa*) can be used to increase soil and water's pH of swamp fish ponds (Jubaedah *et al.* 2017).

According Wilkinson (2002), acid sulfate soils within a pond or its watershed must therefore be treated if the pond is to be used for production. However, large amounts of lime are typically required and the technique may ot be economically feasible. Seasonal avaibility of cockle shells need to combine with common agriculture limestone.

Calcite (Calcium carbonates, $CaCO_3$) is one kinds of agricultural lime stone that slowly react but simoultanosly safe to fish Nobre *et al.,* 2014; Hussan, 2017). Meanwhile lime as CaO short-therm acting but can be unsafe for fish (Nobre *et al.* 2014).

Calcium carbonates on cockle shells converted to calcium oxide through calcination process (Laonapakul, 2019). Based on Jubaedah *et al. (*2017), the results of calcination process of cockle shells using furnace temperature 800ºC for an hour was lime that containing CaO 61.16% and MgO 21.65%. According to Hussan (2017), the CaO lime is excessive alkaline. The application of this lime instantly increases the pH rapidly, and high toxicity of fish. The present work aimed to compare the pH of soil and water as well as survival rate and growth performance of catfish juvenile reared in ponds with aplication of combination of combination of calcite ($CaCO_3$) and lime as CaO derived from cockle shells.

10.Materials and Methods

2.1. Preparing Lime Materials and Liming Aplication

Calcination process of *A. granosa* shells according to Jubaedah *et al.* (2017), including burning process using furnace at temperature of 800^{o}C for an hour. The calcin then mashed and sieved with 60, 40 and 20 mesh-size sieves in order to get lime with 50 % passed 60 mesh-size sieve, 25 % passed 40 mesh-sized sieve, and 25 % passed 20 mesh-size sieve.

Five combination of lime were investigated, namely: P1) 100% calcite, P2) 100% cockle shells lime, P3) 75% calcite and 25% cockle shell limes, P4) 50% calcite and 50% cockle shell limes, and P5) 25% calcite and 75% cockle shell limes, dose of lime each used as much 7,000 kg/ha CaO equivalent. Lime were applied homogeneously on soil ponds and incubated for 7 days at field capacity soil moisture. Water was filled to the ponds and and let equilibrated for 3 days. Fish stocked on ponds and cultured for 60 days.

10.2. Fish Culture

Fiveteen unit of fish ponds filled swamp water with 500 L/ponds at 7 days after liming. Fish were aclimatized for one week before used in this research. The fiveteens of 5 $\pm$ 0.5 cm length *Pangasius sp* stocked for each ponds.

Starting from 10 days after liming, fish was cultured for 60 days. The fish were fed to satiation three times per day with an artificial diet containing 30% protein. Water samples were collected and analyzed, as well as growth of fish was measured every 20 days.

10.3. Experimental variables and analytical procedurs

Water quality, survival and growth performance variables were observed in the present work. The temperature, pH of soil and water were measured daily. The total alkalinity, and total ammonia were monitored every 20 day, Ca concentration analyzed every 30 days in all pond. The water pH, temperature and dissolved oxygen (DO) were measured by using a portable pH meter, a digital handy thermometer and DO meter, respectively. The analytical determinations of total alkalinity and total ammonia and Ca were carried out according to the guidelines presented by APHA (2012). The fish initial and final body weight and length, survival and feed efficiency were observed in all experimental units

10.4. Data Analysis

Water quality, survival and growth performance results were statistically analyzed according to the two-way Anova to detect if there was any significant influence due to experimental treatments. When the influence was at least significant, the means were compared using Least Signifcant Difference (LSD) test.

11.Results and Discussion

The initial Soil pH used in this current study was 3.60 and then soil pH increased due to liming to pH 7.40–7.53 after incubated for 7 days (Fig. 1). The soil's pH tend to increase rapidly until neutral pH value at the begining of incubation, then increase slowly.

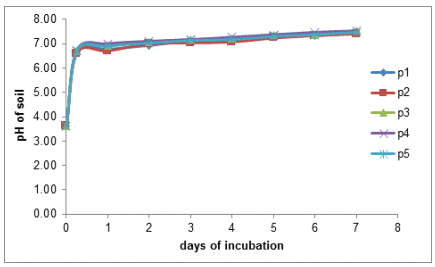

Fig.1. Soil's pH at 7 days of incubation

Regression between combination of limes and pH of soil and water showed polynomial quadratic patterns for day 0, 10, 20 and 30 (Fig. 2 and 3). The results showed combination of calcite (50%) and cockle shells lime (50%) has highest soil's and water's pH. The combination of cockle shells lime and calcite raise pH value higher than single lime, both cockle shells and calcite. The calcination process of cockle shells convert calcium carbonate ($CaCO_3$) to Calcium Hydroxide (CaO). Calcite ($CaCO_3$) is lime that increase pH slowly, but has low toxicity for fish. Otherwise, CaO increase pH rapidly, but high toxicity for fish (Nobre *et al.* 2014; Hussan (2017)..

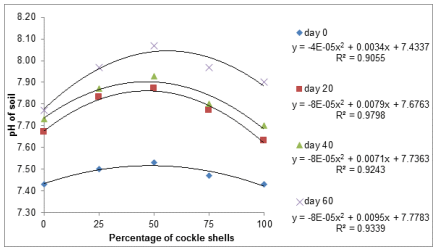

Fig. 2. Relationship between combination of cockle shells and calcite and pH of soil

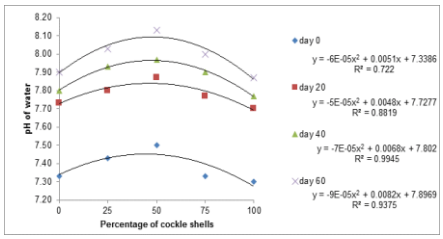

Fig. 3. Relationship between combination of cockle shells and calcite and pH of water

The initial water pH used in this research was 3.5, then water pH increased following polynomial quadratic patterns for 60 days of fish culture due to lime application (Fig. 4). According to equations shown in Fig. 3, the maximum pH and days after lime application to reach maximum water pH can be calculated. The maximum water pH and when it is were 7.85 at 50 days after liming, 7.82 at 50 days after liming, 7.93 at 50 days after liming, 8.31 at 89 days after liming and 8.03 at 59 days after liming, respectively for P_1, P_2, P_3, P_4 and P_5. According to Chakrabarti (2017), pH 7.5-8.5 is desirable for optimum production of fish

The highest maximum water pH among treatments was observed on P_4 (50% calcite and 50% cockle shell lime). Furthermore, based on the equations (Fig. 4) and minimum water pH (6.5) for optimal growth of *Pangasius sp*, the next lime application should be considered after day, 132th, 132th, 134th, 224th and 146th for P_1, P_2, P_3, P_4 and P_5, respectively.

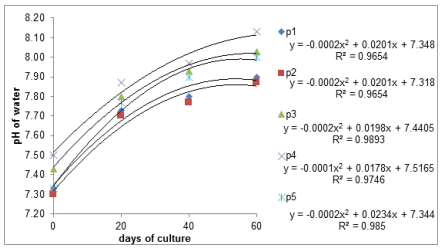

Fig 4. Relationship between days of culture and pH of water for each treatments

Liming not only increase pH value, but also alkalinity of water. Based on Fig. 5 showed that liming application of combination cockle shell limes and calcite affected to increase alkalinity of water. According to Hussan (2017), one of the benefit of liming fish pond is total alkalinity will increase and thus results more CO_2 for photosynthesis. Greater alkalinity after liming also prevents wide fluctuation of pH by establishing a buffer of CO_2 -CHO- $CaCO_3$. Most suitable range alkalinity for fish farming is 80-200 mg/l (Chakrabarti, 2017).

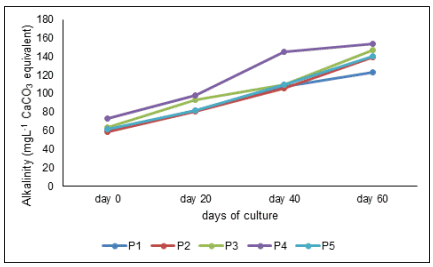

Fig. 5. Alkalinity for each treatment

Liming also related to calcium (Ca) concentration. According to Boyd (2015), calcium is important for fish, mainly for bone development. Calcium ions also affect the toxicity of trace metals to fish and other aquaculture species. The presence of calcium blocks the uptake of metal ions across the gills. The liming was gave significantly different to Ca concentration at final day of research (day 60th) (Table 1). Combination of cockle shell lime 50% and calcite 50% (P_4) has highest Ca, significance different with calcite 100% (P1) and cockle shell 100%(P2), but no significant different with combination cockle shell lime 75% calcite and 25% cockle shell limes(P_3), and 25% calcite and 75% cockle shell limes(P_5). Calcium Carbonate provides with 40% elemental calcium (Trailokya *et al.,* 2017), meanwhile lime derived fromcockle shells provides 61.16% of calcium. The minimum calcium concentration for channel catfish hatcheries should be 10 mg/L (Boyd, 2015).

Table 1. Concentration of Ca in water

	Concentration of Ca (mgL^{-1})		
Treatment	Day 0	Day 30	Day 60
P1	45.77	68.70	69.69_a
P2	45.27	71.23	69.70_a
P3	53.70	74.07	101.32_b
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$LSD_{0.05}$			24.97

number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters means not significant ($p > 0.05$).

The water temperature (Table 2) ranged from 25.3 to 32.2 ^{0}C. The temperature of water was is still in optimal value of temperature for Pangasius. The research of Abedin *et al*. (2017), the water temperature of Pangasius ponds was 29 to 34^{o}C and the The optimum range of temperature for fish culture is generally considered between 25 to 32°C.

Table 2. The water temperature

Treatment	Range of water temperature (^{o}C)
P1	25.3 - 31.8
P2	25.5 - 32.0
P3	25.6 - 32.1

P4	25.4 - 32.2
P5	25.4 - 32.2

The Dissolved oxygen (DO) of ponds (Table 3) ranged from 5.4 to 6.6 mg L^{-1}, respectively No significant effect of lime application on dissolved oxygen at the day 0, 20,40 and 60 of culture period. The dissolved Oxygen was approriate for *Pangasius sp*. According to Chakrabarti (2017), the DO for fish culture pond water the lower value should not fall below 3.5 mg/l. The research of Abedin *et al.* (2017) showed the level of DO was varied from 2.00 to 6.00 mg/l in different culture period of Pangasius. Meanwhile, the DO of water pond for Pangsius sp culture using *Anadara granosa* as lime materials was 3.12 to 7.13 mgL^{-1} (Jubaedah *et al.,* 2017).

Table 3. Dissolved Oxygen

	Dissolved Oxygen (mgL^{-1})			
Treatment	day 0	day 20	day 40	day 60
P1	5.7	6.3	6.6	6.6
P2	5.5	6.0	6.6	6.6
P3	5.6	5.9	6.5	6.4
P4	5.6	5.9	6.5	6.6
P5	5.4	6.0	6.3	6.5

All treatment showed that the ammonia concentration increased in the final day of research (day 60th of culture) (Fig. 6). Abedin *et al.* (2017), reported the total ammonia concentration in Pangasius pond ranges from 0 to 5 mg/l with the mean value of 1.40 ± 0.18 mg/l. Ammonia concentration 12 mg/l or more which may become lethal to fishes.

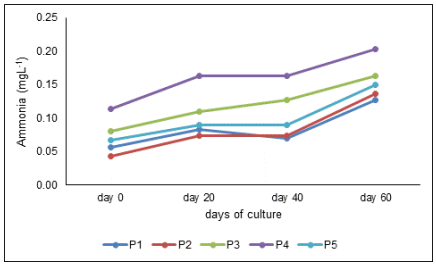

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Table 4. Growth performance and feed efficiency

Treatments	Absolute growth of		Feed efficiency (%)
	Lenght (cm)	Weight (g)	
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P2	9.74_{a}	29.31_{ab}	99.98
P3	10.48_{b}	32.08_{c}	96.96
P4	11.23_{c}	38.60_{d}	128.38
P5	9.94_{ab}	31.36_{bc}	94.57

$LSD_{0.05}$	0.61	2.18

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The highest feed efficiency was on fish cultured at ponds with liming combination calcite (50%) and cockle shells (50%). It is probably related to availability of plankton as natural feed of fish. The highest alkalinity shown at P_4 (Fig.5) and it will increase the carbondioxide for photosyntesis of phytoplankton. According to Hussan (2017), by maintaining pond pH at neutral to slightly alkaline levels, phosphorous is released from bottom sediments and made available to nourish phytoplankton that make up the base of the food chain. Thus, liming can improve phosphorus availability and greatly enhance pond productivity. Besides lime itself is considered as a fertilizer; it supplies calcium, which is an essential nutrient. Lime provides calcium and neutralizes acidic soils so that phosphate is released as calcium exchanges with aluminum and iron. Calcium phosphates are more soluble in water than aluminum phosphates or iron phosphates (Burtle, 2015).

12.Conclusions

The combination of 50% cockle shells lime and 50% calcite was the best treatments with pH of soil and water at day 60 were 8.07 and 8.31, respectively; highest maximal water pH value (3.31) and next liming was at day 224; highest alkalinity (153.33 mgL^{-1} $CaCO_3$ equivalent), and Ca (104.15 mgL^{-1}); highest feed efficiency (128.38%); and the best growth performance. The water quality including water temperature, dissolved oxygen and ammonia were in appropriate for *Pangasius sp*.with 100% survival rate.

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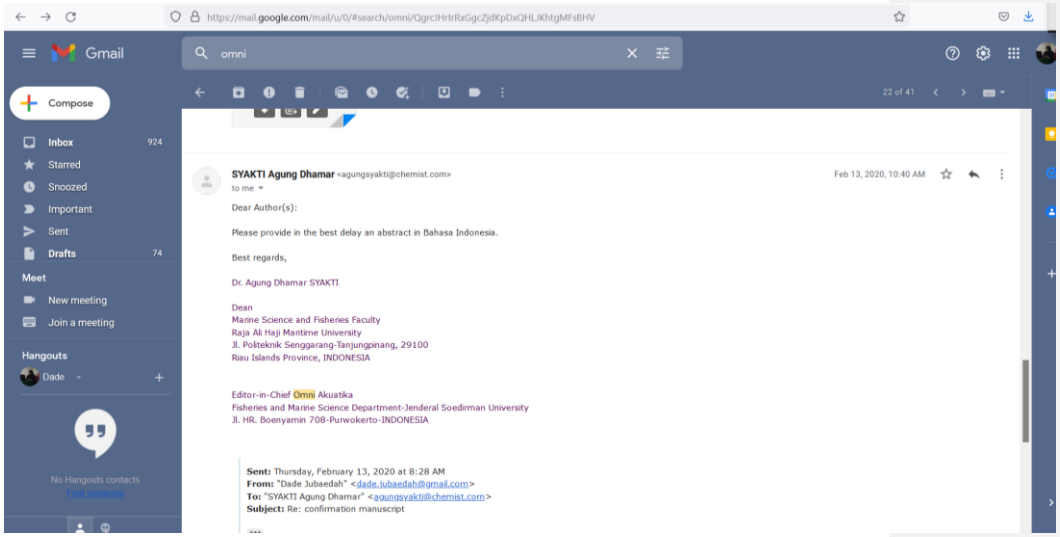

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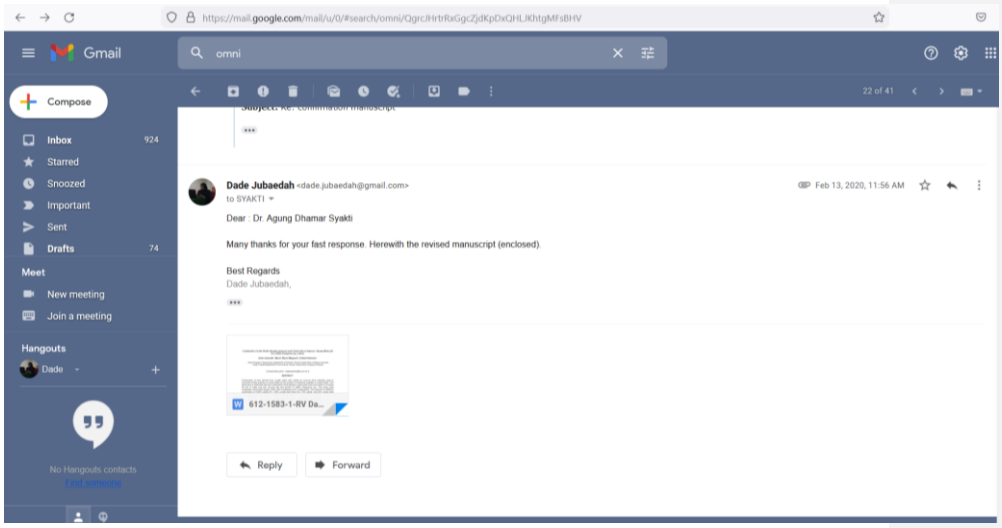

***Combination Cockle Shells (Anadara granosa) and Calcite Lime to Improve Swamp Water pH for Catfish* (*Pangasius* sp.) culture**

Dade Jubaedah[1], Marsi[2], Marini Wijayanti[1], Sofiatul Rahmani[1]

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ABSTRACT

Combination of lime derived from cockle shells with calcite as common lime materials used to overcome limited quantity of cockle shells as the problem of seasonal avaibility of cockle shells. This study aims to determine the best combination dose between cockle shell limes and calcite to increase the pH of water and soil, survival rate and growth of catfish *(Pangasius* sp*.).* The study used completely randomized design (CRD) with 5 treatments and 3 replications. The treatment of different combination of l100% calcite (P_1), 100% cockle shell limes (P_2), 75% calcite and 25% cockle shell limes (P_3), 50% calcite and 50% cockle shell limes (P_4), and 25% calcite and 75% cockle shell limes (P_5), dose of lime used as much as 7,000 kg/ha CaO equivalent. The result showed that P_4 was the best treatment according to data of swamp water pH was 8.13 and soil pH was 8.07 at final day (day 60), alkalinity 153.33 mgL^{-1} $CaCO_3$ equivalent, Ca 104.15 mgL^{-1},100% survival rate, 11.23 cm absolute growth of length, 38.60 g absolute growth of weight and 128.38% feed efficiency.

Key words: Calcite, Catfish, Cockle shells, Liming, Swamp

ABSTRAK

Kombinasi kapur dari cangkang kerang darah dengan kalsit sebagai materi kapur yang umum digunakan diperlukan sebagai cara untuk mengatasi terbatasnya ketersediaan cangkang kerah darah yang bersifat musiman. Penelitian ini bertujuan untuk memperoleh dosis terbaik kombinasi kapur cangkang kerang darah dan kalsit untuk meningkatkan pH tanah dan air, kelangsungan hidup dan pertumbuhan ikan patin (*Pangasius* sp). Penelitian menggunakan rancangan acak lengkap dengan 5 perlakuan dan 3 ulangan. Perlakuan yang diberikan meliputi: 100% kalsit (P1), 100% kapur cangkang kerang darah (P2), 75% kalsit dan 25% kapur cangkang kerang darah (P3), 50% kalsit dan 50% kapur cangkang kerang darah, 25% kalsit dan 75% kapur cangkang kerang darah. Dosis kapur yang diberikan sebesar 7.000 kg/ha setara CaO. Hasil penelitian menunjukkan bahwa P4 merupakan perlakuan terbaik berdasarkan data pH air 8,13 dan pH tanah 8,07 pada hari terakhir pemeliharaan (hari ke-60), alkalinitas 153,33 mgL^{-1} setara $CaCO_3$, Ca 104,15 mgL^{-1}, kelangsungan hidup 100%, pertumbuhan panjang mutlak 11,23 cm, pertumbuhan bobot mutlak 38,60 g dan efisiensi pakan 128,38%.

Kata Kunci : kalsit, kerang darah, patin, pengapuran, rawa

13.Introduction

Liming of soil is an effort to increase soil and waters pH of swamp fish ponds. According to Adhikari (2017), liming is the only way to improve water quality in ponds with acid soils. Liming compounds such as calcium carbonate (agricultural lime), calcium hydroxide (hydrated lime) and calcium oxide (quicklime) are applied during pond preparation to the water or sediment to neutralize acidity (Rico *et al.* 2012). An alternative liming material from domestic waste or by-product have an advantages, not only increase pH level, but also evironmentally acceptable. The

reseach showed that cockle shells (*Anadara granosa*) can be used to increase soil and water's pH of swamp fish ponds (Jubaedah *et al.* 2017).

According Wilkinson (2002), acid sulfate soils within a pond or its watershed must therefore be treated if the pond is to be used for production. However, large amounts of lime are typically required and the technique may ot be economically feasible. Seasonal avaibility of cockle shells need to combine with common agriculture limestone.

Calcite (Calcium carbonates, $CaCO_3$) is one kinds of agricultural lime stone that slowly react but simoultanosly safe to fish Nobre *et al.,* 2014; Hussan, 2017). Meanwhile lime as CaO short-therm acting but can be unsafe for fish (Nobre *et al.* 2014).

Calcium carbonates on cockle shells converted to calcium oxide through calcination process (Laonapakul, 2019). Based on Jubaedah *et al. (*2017), the results of calcination process of cockle shells using furnace temperature 800^{o}C for an hour was lime that containing CaO 61.16% and MgO 21.65%. According to Hussan (2017), the CaO lime is excessive alkaline. The application of this lime instantly increases the pH rapidly, and high toxicity of fish. The present work aimed to compare the pH of soil and water as well as survival rate and growth performance of catfish juvenile reared in ponds with aplication of combination of combination of calcite ($CaCO_3$) and lime as CaO derived from cockle shells.

14.Materials and Methods

2.1. Preparing Lime Materials and Liming Aplication

Calcination process of *A. granosa* shells according to Jubaedah *et al.* (2017), including burning process using furnace at temperature of 800^{o}C for an hour. The calcin then mashed and sieved with 60, 40 and 20 mesh-size sieves in order to get lime with 50 % passed 60 mesh-size sieve, 25 % passed 40 mesh-sized sieve, and 25 % passed 20 mesh-size sieve.

Five combination of lime were investigated, namely: P1) 100% calcite, P2) 100% cockle shells lime, P3) 75% calcite and 25% cockle shell limes, P4) 50% calcite and 50% cockle shell limes, and P5) 25% calcite and 75% cockle shell limes, dose of lime each used as much 7,000 kg/ha CaO equivalent. Lime were applied homogeneously on soil ponds and incubated for 7 days at field capacity soil moisture. Water was filled to the ponds and and let equilibrated for 3 days. Fish stocked on ponds and cultured for 60 days.

14.2. Fish Culture

Fiveteen unit of fish ponds filled swamp water with 500 L/ponds at 7 days after liming. Fish were aclimatized for one week before used in this research. The fiveteens of 5 $\pm$ 0.5 cm length *Pangasius sp* stocked for each ponds.

Starting from 10 days after liming, fish was cultured for 60 days. The fish were fed to satiation three times per day with an artificial diet containing 30% protein. Water samples were collected and analyzed, as well as growth of fish was measured every 20 days.

14.3. Experimental variables and analytical procedurs

Water quality, survival and growth performance variables were observed in the present work. The temperature, pH of soil and water were measured daily. The total alkalinity, and total ammonia were monitored every 20 day, Ca concentration analyzed every 30 days in all pond. The water pH, temperature and dissolved oxygen (DO) were measured by using a portable pH meter, a digital handy thermometer and DO meter, respectively. The analytical determinations of total alkalinity and total ammonia and Ca were carried out according to the guidelines presented by APHA (2012). The fish initial and final body weight and length, survival and feed efficiency were observed in all experimental units

14.4. Data Analysis

Water quality, survival and growth performance results were statistically analyzed according to the two-way Anova to detect if there was any significant influence due to experimental

treatments. When the influence was at least significant, the means were compared using Least Signifcant Difference (LSD) test.

15.Results and Discussion

The initial Soil pH used in this current study was 3.60 and then soil pH increased due to liming to pH 7.40–7.53 after incubated for 7 days (Fig. 1). The soil's pH tend to increase rapidly until neutral pH value at the begining of incubation, then increase slowly.

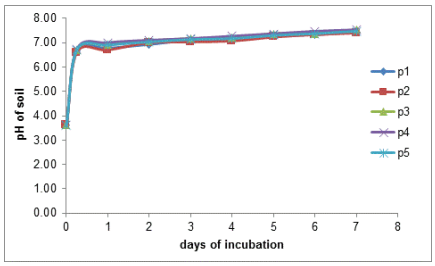

Fig.1. Soil's pH at 7 days of incubation

Regression between combination of limes and pH of soil and water showed polynomial quadratic patterns for day 0, 10, 20 and 30 (Fig. 2 and 3). The results showed combination of calcite (50%) and cockle shells lime (50%) has highest soil's and water's pH. The combination of cockle shells lime and calcite raise pH value higher than single lime, both cockle shells and calcite. The calcination process of cockle shells convert calcium carbonate ($CaCO_3$) to Calcium Hydroxide (CaO). Calcite ($CaCO_3$) is lime that increase pH slowly, but has low toxicity for fish. Otherwise, CaO increase pH rapidly, but high toxicity for fish (Nobre *et al.* 2014; Hussan (2017)..

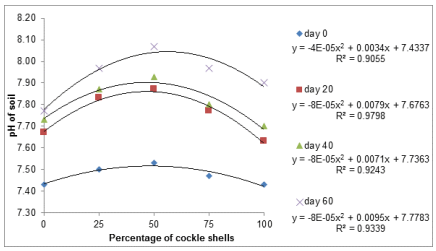

Fig. 2. Relationship between combination of cockle shells and calcite and pH of soil

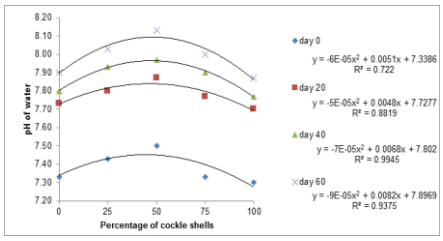

Fig. 3. Relationship between combination of cockle shells and calcite and pH of water

The initial water pH used in this research was 3.5, then water pH increased following polynomial quadratic patterns for 60 days of fish culture due to lime application (Fig. 4). According to equations shown in Fig. 3, the maximum pH and days after lime application to reach maximum water pH can be calculated. The maximum water pH and when it is were 7.85 at 50 days after liming, 7.82 at 50 days after liming, 7.93 at 50 days after liming, 8.31 at 89 days after liming and 8.03 at 59 days after liming, respectively for P_1, P_2, P_3, P_4 and P_5. According to Chakrabarti (2017), pH 7.5-8.5 is desirable for optimum production of fish

The highest maximum water pH among treatments was observed on P_4 (50% calcite and 50% cockle shell lime). Furthermore, based on the equations (Fig. 4) and minimum water pH (6.5) for optimal growth of *Pangasius sp*, the next lime application should be considered after day, 132th, 132th, 134th, 224th and 146th for P_1, P_2, P_3, P_4 and P_5, respectively.

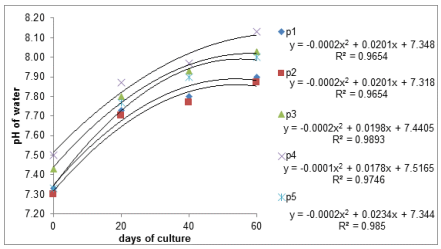

Fig 4. Relationship between days of culture and pH of water for each treatments

Liming not only increase pH value, but also alkalinity of water. Based on Fig. 5 showed that liming application of combination cockle shell limes and calcite affected to increase alkalinity of water. According to Hussan (2017), one of the benefit of liming fish pond is total alkalinity will increase and thus results more CO_2 for photosynthesis. Greater alkalinity after liming also prevents wide fluctuation of pH by establishing a buffer of CO_2 -CHO- $CaCO_3$. Most suitable range alkalinity for fish farming is 80-200 mg/l (Chakrabarti, 2017).

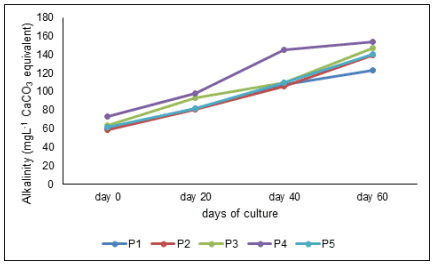

Fig. 5. Alkalinity for each treatment

Liming also related to calcium (Ca) concentration. According to Boyd (2015), calcium is important for fish, mainly for bone development. Calcium ions also affect the toxicity of trace metals to fish and other aquaculture species. The presence of calcium blocks the uptake of metal ions across the gills. The liming was gave significantly different to Ca concentration at final day of research (day 60th) (Table 1). Combination of cockle shell lime 50% and calcite 50% (P_4) has highest Ca, significance different with calcite 100% (P1) and cockle shell 100%(P2), but no significant different with combination cockle shell lime 75% calcite and 25% cockle shell limes(P_3), and 25% calcite and 75% cockle shell limes(P_5). Calcium Carbonate provides with 40% elemental calcium (Trailokya *et al.,* 2017), meanwhile lime derived fromcockle shells provides 61.16% of

calcium. The minimum calcium concentration for channel catfish hatcheries should be 10 mg/L (Boyd, 2015).

Table 1. Concentration of Ca in water

	Concentration of Ca (mgL^{-1})		
Treatment	Day 0	Day 30	Day 60
P1	45.77	68.70	69.69_{a}
P2	45.27	71.23	69.70_{a}
P3	53.70	74.07	101.32_{b}
P4	56.53	76.33	104.15_{b}
P5	48.93	72.33	79.61_{ab}
$LSD_{0.05}$			24.97

number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters means not significant ($p > 0.05$).

The water temperature (Table 2) ranged from 25.3 to 32.2 ^{0}C. The temperature of water was is still in optimal value of temperature for Pangasius. The research of Abedin *et al*. (2017), the water temperature of Pangasius ponds was 29 to 34^{o}C and the The optimum range of temperature for fish culture is generally considered between 25 to 32°C.

Table 2. The water temperature

Treatment	Range of water temperature (^{o}C)
P1	25.3 - 31.8
P2	25.5 - 32.0
P3	25.6 - 32.1
P4	25.4 - 32.2
P5	25.4 - 32.2

The Dissolved oxygen (DO) of ponds (Table 3) ranged from 5.4 to 6.6 mg L^{-1}, respectively No significant effect of lime application on dissolved oxygen at the day 0, 20,40 and 60 of culture period. The dissolved Oxygen was approriate for *Pangasius sp*. According to Chakrabarti (2017), the DO for fish culture pond water the lower value should not fall below 3.5 mg/l. The research of Abedin *et al.* (2017) showed the level of DO was varied from 2.00 to 6.00 mg/l in different culture period of Pangasius. Meanwhile, the DO of water pond for Pangsius sp culture using *Anadara granosa* as lime materials was 3.12 to 7.13 mgL^{-1} (Jubaedah *et al.,* 2017).

Table 3. Dissolved Oxygen

	Dissolved Oxygen (mgL^{-1})			
Treatment	day 0	day 20	day 40	day 60
P1	5.7	6.3	6.6	6.6
P2	5.5	6.0	6.6	6.6
P3	5.6	5.9	6.5	6.4
P4	5.6	5.9	6.5	6.6
P5	5.4	6.0	6.3	6.5

All treatment showed that the ammonia concentration increased in the final day of research (day 60th of culture) (Fig. 6). Abedin *et al.* (2017), reported the total ammonia concentration in Pangasius pond ranges from 0 to 5 mg/l with the mean value of 1.40 ± 0.18 mg/l. Ammonia concentration 12 mg/l or more which may become lethal to fishes.

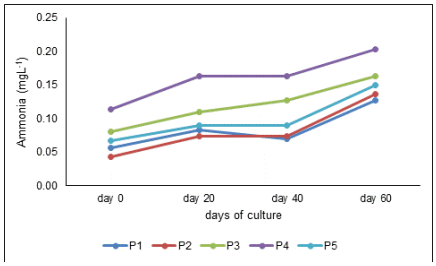

Fig. 6. Ammonia concentration

The survival rate of *Pangsius sp* were 100% for all treatments. The liming application using single lime materials both calcite 100% and cockle shells 100%, or combination of them can increase pH until optimum for fish. In general, the water quality supported for living of fish.

Table 4. Growth performance and feed efficiency

Treatments	Absolute growth of		Feed efficiency (%)
	Lenght (cm)	Weight (g)	
P1	10.00_{ab}	28.67_{a}	91.88
P2	9.74_{a}	29.31_{ab}	99.98
P3	10.48_{b}	32.08_{c}	96.96
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$LSD_{0.05}$	0.61	2.18	

Number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters means not significant ($p > 0.05$).

The growth performance and fed efficiency showed at Table 4. Based on analysis of variance showed that treatment gave an effect to growth performance of fish. The highest absolute growth (lenght and weight) of fishes was on combination 50% cockle shells and 50% calcite (P_4) and signficant difference with others.

The highest feed efficiency was on fish cultured at ponds with liming combination calcite (50%) and cockle shells (50%). It is probably related to availability of plankton as natural feed of fish. The highest alkalinity shown at P_4 (Fig.5) and it will increase the carbondioxide for photosyntesis of phytoplankton. According to Hussan (2017), by maintaining pond pH at neutral to slightly alkaline levels, phosphorous is released from bottom sediments and made available to nourish phytoplankton that make up the base of the food chain. Thus, liming can improve phosphorus availability and greatly enhance pond productivity. Besides lime itself is considered as a fertilizer; it supplies calcium, which is an essential nutrient. Lime provides calcium and neutralizes acidic soils so that phosphate is released as calcium exchanges with aluminum and iron. Calcium phosphates are more soluble in water than aluminum phosphates or iron phosphates (Burtle, 2015).

16.Conclusions

The combination of 50% cockle shells lime and 50% calcite was the best treatments with pH of soil and water at day 60 were 8.07 and 8.31, respectively; highest maximal water pH value (3.31) and next liming was at day 224; highest alkalinity (153.33 mgL^{-1} $CaCO_3$ equivalent), and Ca (104.15 mgL^{-1}); highest feed efficiency (128.38%); and the best growth performance. The water quality including water temperature, dissolved oxygen and ammonia were in appropriate for *Pangasius sp*.with 100% survival rate.

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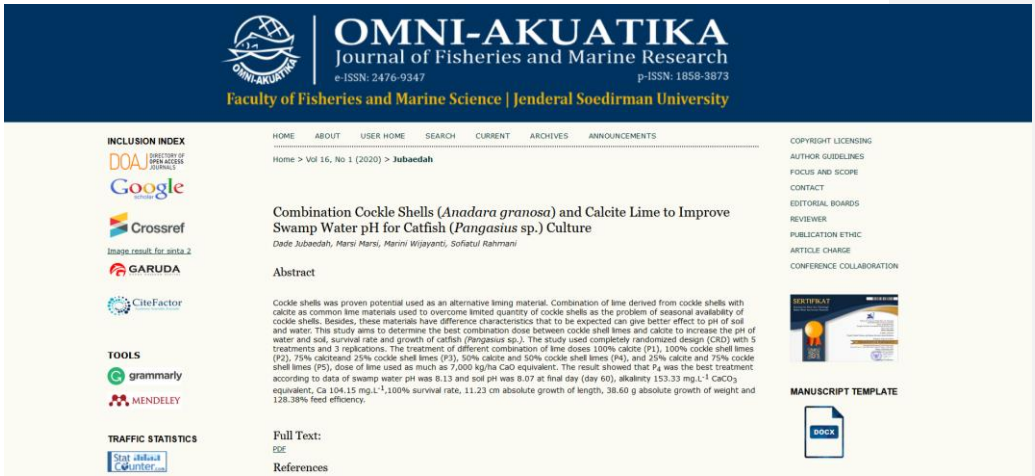

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Abstract

Cockle shells was proven potential used as an alternative liming material. Combination of lime derived from cockle shells with calcite as common lime materials used to overcome limited quantity of cockle shells as the problem of seasonal availability of cockle shells. Besides, these materials have difference characteristics that to be expected can give better effect to pH of soil and water. This study aims to determine the best combination dose between cockle shell limes and calcite to increase the pH of water and soil, survival rate and growth of catfish (*Pangasius* sp.). The study used completely randomized design (CRD) with 5 treatments and 3 replications. The treatment of different combination of lime doses 100% calcite (P1), 100% cockle shell limes (P2), 75% calciteand 25% cockle shell limes (P3), 50% calcite and 50% cockle shell limes (P4), and 25% calcite and 75% cockle shell limes (P5), dose of lime used as much as 7,000 kg/ha CaO equivalent. The result showed that P_4 was the best treatment according to data of swamp water pH was 8.13 and soil pH was 8.07 at final day (day 60), alkalinity 153.33 mg.L^{-1} $CaCO_3$ equivalent, Ca 104.15 mg.L^{-1},100% survival rate, 11.23 cm absolute growth of length, 38.60 g absolute growth of weight and 128.38% feed efficiency.

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References

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***Keywords**: Calcite, Catfish, Cockle shells, Liming, Swamp*

ABSTRAK

Cangkang kerang terbukti potensial digunakan sebagai bahan pengapuran alternatif. Kombinasi kapur yang berasal dari cangkang kerang dengan kalsit sebagai bahan kapur biasa digunakan untuk mengatasi jumlah cangkang kerang yang terbatas sebagai masalah ketersediaan musiman cangkang kerang. Selain itu, bahan-bahan ini memiliki karakteristik yang berbeda sehingga diharapkan dapat memberikan efek yang lebih baik terhadap pH tanah dan air. Penelitian ini bertujuan untuk menentukan kombinasi dosis terbaik antara cangkang kerang dan kalsit untuk meningkatkan pH air dan tanah, tingkat kelangsungan hidup dan pertumbuhan ikan lele (*Pangasius* sp.). Penelitian ini menggunakan rancangan acak lengkap (RAL) dengan 5 perlakuan dan 3 ulangan. Perlakuan kombinasi yang berbeda dari dosis kapur 100% kalsit (P1), 100% cangkang kerang (P2), kalsit 75% dan 25% cangkang kerang (P3), kalsit 50% dan 50% kerang kerang (P4), dan 25% kalsit dan 75% limun kerang (P5), dosis kapur yang digunakan setara dengan 7.000 kg / ha CaO. Hasil penelitian menunjukkan bahwa P4 adalah perlakuan terbaik menurut data pH air rawa adalah 8,13 dan pH tanah 8,07 pada hari terakhir (hari 60), alkalinitas setara 153,33 mg.L^{-1} $CaCO_3$, tingkat kelangsungan hidup Ca 104,15 mg.L^{-1}.100%, 11,23 cm pertumbuhan panjang absolut, 38,60 g pertumbuhan berat absolut, dan efisiensi pakan 128,38%.

***Kata Kunci**: kalsit, lele, cangkang kerang, pengapuran, rawa*

1. Introduction

Liming of soil is an effort to increase soil and waters pH of swamp fish ponds. Ponds can be limed with liquid lime, basic slag, or agricultural limestone (Wynne 1996; Boyd 1982, 1990; Wilkinson 2002). Common liming materials

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include agricultural limestone and liquid lime, calcium hydroxide, calcium oxide and basic slag. Peters (1996) described liming materials that was commonly used are calcitic aglime, dolomitic aglime, hydrated or slaked lime, quicklime or burnt lime, marl, and industrial by product.

An alternative liming material from domestic waste or by-product have an advantage, not only increase pH level, but also environmentally acceptable. The research showed that cockle shells (*Anadara granosa*) can be used to increase soil and water's pH of swamp fish ponds (Jubaedah et al. 2017). Initial soil's pH value from 3.9 increase to 7.2 as affected by 5 ton/ha lime derived from cockle shells application during 7 days incubation time and maximal water's pH value 7.9 at day 87. Next lime application should be considered after day 205.

According Wilkinson (2002), acid sulfate soils within a pond or its watershed must therefore be treated if the pond is to be used for production. However, large amounts of lime are typically required and the technique may not be economically feasible. Seasonal availability of cockle shells needs to combine with common agriculture limestone.

Calcite (Calcium carbonates, $CaCO_3$) is one kind of agricultural lime stone that slowly react but simultaneously safe to fish (Boyd, 1982; 1990) Calcium carbonates on cockle shells converted to calcium oxide through calcination process. CaO short-term acting but can be unsafe for fish (Nobre et al. 2014). The present work aimed to compare the pH of soil and water as well as survival rate and growth performance of catfish juvenile reared in ponds with application of combination of combination of calcite ($CaCO_3$) and lime derived from cockle shells.

2. Materials and Methods

2.1. Preparing Lime Materials and Liming Application

Calcination process of *A. granosa* shells according to Jubaedah et al. (2017), including burning process using furnace at temperature of 800°C for an hour. The calcin then mashed and sieved with 60, 40 and 20 mesh-size sieves in order to get lime with 50 % passed 60 mesh-size sieve, 25 % passed 40 mesh-sized sieve, and 25 % passed 20 mesh-size sieve.

Five combination of lime were investigated, namely: P1) 100% calcite, P2) 100% cockle shells lime, P3) 75% calcite and 25% cockle shell limes, P4) 50% calcite and 50% cockle shell limes, and P5) 25% calcite and 75% cockle shell limes, dose of lime each used as much 7,000 kg/ha CaO equivalent. Lime were applied homogeneously on soil ponds and incubated for 7 days at field capacity soil moisture. Water was filled to the ponds and and let equilibrated for 3 days. Fish stocked on ponds and cultured for 60 days.

2.2. Fish Culture

Fifteen unit of fish ponds filled swamp water with 500 L/ponds at 7 days after liming. Fish were acclimatized for one week before used in this research. The fifteens of 5 $\pm$ 0.5 cm length *Pangasius* sp. stocked for each pond.

Starting from 10 days after liming, fish was cultured for 60 days. The fish were fed to satiation three times per day with an artificial diet containing 30% protein. Water samples were collected and analyzed, as well as growth of fish was measured every 20 days.

2.3. Experimental variables and analytical procedures

Water quality, survival and growth performance variables were observed in the present work. The water's pH, total alkalinity, and total ammonia were monitored every 20-day, Ca concentration analyzed every 30 days in all pond. Besides, water temperature and pH were recorded daily. The water pH was measured by using a portable pH meter. The water temperature was observed by using a digital handy thermometer. The analytical determinations of total alkalinity and total ammonia and Ca were carried out according to the guidelines presented by APHA (2012). The fish initial and final body weight and length, survival and feed efficiency were observed in all experimental units.

Water quality, survival and growth performance results were statistically analyzed according to the two-way Anova to detect if there was any significant influence due to experimental treatments. When the influence was at least significant, the means were compared using Least Significant Difference (LSD) test.

2.4. Data Analysis

The fish survival rate was calculated from the initial number of fish and mortality after the experiment was completed. The absolute growth of fish was determined from the mean of initial and final weight and length of fish, respectively for absolute weight growth and length growth. Meanwhile, feed efficiency was calculated by the formula of NRC (1977).

3. Results and Discussion

The initial Soil pH used in this current study was 3.60 and then soil pH increased due to liming to pH 7.40–7.53 after incubated for 7 days (Figure 1). The soil's pH tends to increase rapidly until neutral pH value at the beginning of incubation, then increase slowly.

Regression between combination of limes and pH of soil and water showed polynomial quadratic patterns for day 0, 10, 20 and 30 (Figure 2 and Figure 3). The results showed combination of calcite (50%) and cockle shells lime (50%) has highest soil's and water's pH. The calcination process of cockle shells converts calcium carbonate ($CaCO_3$) to calcium oxide (CaO). According to Boyd (1982; 1990), reaction with acidity is faster than $CaCO_3$, but highly caustic and cause the water pH raise to levels toxic for fish. Calcite ($CaCO_3$) is agricultural limestone that is slow-acting product but generally the safest (Boyd 1982; Nobre et al. 2014). The combination of cockle shells lime and calcite raise pH value higher than single lime, both cockle shells and calcite.

The initial water pH used in this research was 3.5, then water pH increased following polynomial quadratic patterns for 60 days of fish culture due to lime application (Figure 4). According to equations shown in Figure 3, the maximum pH and days after lime application to reach maximum water pH can be calculated. The maximum water pH and when it is were 7.85 at 50 days after liming, 7.82 at 50 days after liming, 7.93 at 50 days after liming, 8.31 at 89 days after liming and 8.03 at 59 days after liming, respectively for P1, P2, P3, P4 and P5.

The highest maximum water pH among treatments was observed on P_4 (50% calcite and 50% cockle shell lime). Furthermore, based on the equations (Figure 4) and minimum water pH (6.5) for optimal growth of *Pangasius* sp., the next lime application should be considered after day, 132th, 132th, 134th, 224th and 146th for P1, P2, P3, P4 and P5, respectively.

Liming not only increase pH value, but also alkalinity of water. Based on Figure 5 showed that liming application of combination cockle shell limes and calcite affected to increase alkalinity of water. Greater alkalinity after liming also buffer water from drastic daily changes in pH (Boyd, 1990).

Liming also related to calcium (Ca) concentration. Fish will lose Ca to the water on extremely low Ca concentration in the water, even though the minimum acceptable Ca concentration in the water necessary to permit optimum fish growth has not been established (Boyd, 1990). The liming was giving significantly different to Ca concentration at final day of research (day 60th) (Table 1). Combination of cockle shell lime 50% and calcite 50% (P4) has

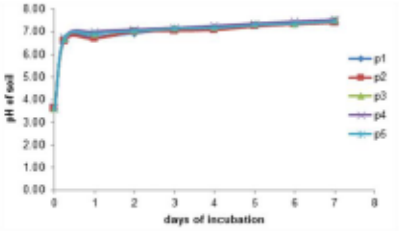

Figure 1. Soil's pH at 7 days of incubation

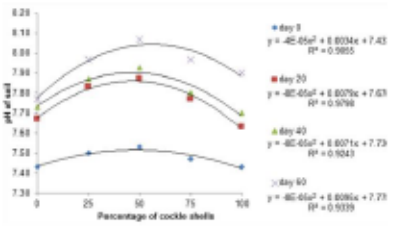

Figure 2. Relationship between combination of cockle shells and calcite and pH of soil

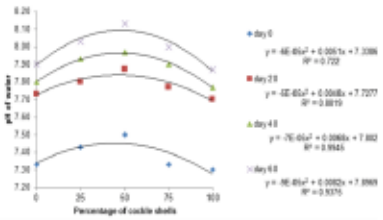

Figure 3. Relationship between combination of cockle shells and calcite and pH of water

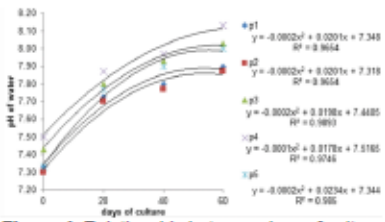

Figure 4. Relationship between days of culture and pH of water for each treatment

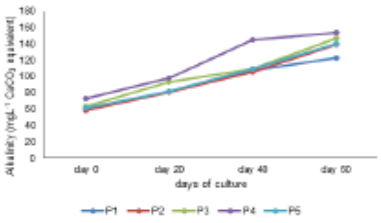

Figure 5. Alkalinity for each treatment

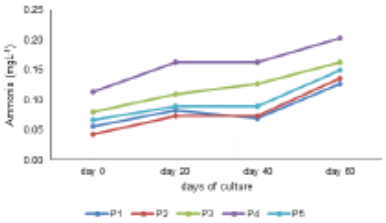

Figure 6. Ammonia concentration

highest Ca, significance different with calcite 100% (P1) and cockle shell 100% (P2), but no significant different with combination cockle shell lime 75% calcite and 25% cockle shell limes (P3), and 25% calcite and 75% cockle shell limes (P5). According to Boyd et al. (2002), Ca concentration from calcite is 40.08%, meanwhile based on the analysis of Ca content from cockle shells is 61.16%.

The water temperature and dissolved oxygen (DO) of ponds (Table 2) ranged from 25.3 to 32.2 °C and from 5.4 to 6.6 mg.L^{-1}, respectively. Based on National standardization Agency or Badan Standar Nasional Indonesia (BSNI, 2000), the temperature of water was exceed optimum ranged that is 27-30°C according to optimal value of temperature for *Pangasius* sp. but still in tolerance ranged for fish. Meanwhile, the DO was approriate for *Pangasius* sp. No significant effect of lime application on dissolved oxygen at day 0, 20,40, and 60 of the rearing period.

Table 1. Concentration of Ca in water

Treatment	Concentration of Ca (mg. L^{-1})		
	day 0	day 30	day 60
P1	45.77	68.70	69.69$_a$
P2	45.27	71.23	69.70$_a$
P3	53.70	74.07	101.32$_b$
P4	56.53	76.33	104.15$_b$
P5	48.93	72.33	79.61$_{ab}$
LSD$_{0.05}$			24.97

Number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters mean not significant ($p > 0.05$).

Table 2. The water temperature and dissolved oxygen (DO)

Treatment	Temp. (°C)	DO (mg.L^{-1})			
		day 0	day 20	day 40	day 60
P1	25.3 - 31.8	5.7	6.3	6.6	6.6
P2	25.5 - 32.0	5.5	6.0	6.6	6.6
P3	25.6 - 32.1	5.6	5.9	6.5	6.4
P4	25.4 - 32.2	5.6	5.9	6.5	6.6
P5	25.4 - 32.2	5.4	6.0	6.3	6.5

All treatment showed that the ammonia concentration increased in the final day of research (day 60th of culture) (Figure 6). The ammonia concentration at culture periods under maximal value for amonia for fish according to Indonesian environmental regulation or Peraturan Pemerintah Republik Indonesia (2001) that is >1 mg.L^{-1}.

The survival rate of *Pangsius* sp. Were 100% for all treatments. The liming application using single lime materials both calcite 100% and cockle shells 100%, or combination of them can increase pH until optimum for fish. In general, the water quality supported for living of fish.

The growth performance and fed efficiency showed at Table 3 Based on analysis of variance showed that treatment gave an effect to growth performance of fish. The highest absolute growth (length and weight) of fishes was on combination 50% cockle shells and 50% calcite (P_4) and significant difference with others.

The highest feed efficiency was on fish cultured at ponds with liming combination calcite (50%) and cockle shells (50%). It is probably related to availability of plankton as natural feed of fish. The highest alkalinity shown at P4 (Figure 5) and it will increase the carbon dioxide for photosynthesis of phytoplankton. According to Boyd (1982, 1990) and Wilkinson (2002), the positive effect of liming was increasing the alkalinity of water, thereby increasing the

Table 3. Growth performance and feed efficiency

Treatments	Absolute growth of		Feed efficiency (%)
	Length (cm)	Weight (g)	
P1	10.00$_{ab}$	28.67$_a$	91.88
P2	9.74$_a$	29.31$_{ab}$	99.98
P3	10.48$_b$	32.08$_c$	96.96
P4	11.23$_c$	38.60$_d$	128.38
P5	9.94$_{ab}$	31.36$_{bc}$	94.57
LSD$_{0.05}$	0.61	2.18	

Number with subscribe different letters in column are significantly different by the LSD test ($p < 0.05$). No letters mean not significant ($p > 0.05$).

availability of carbon dioxide for phytoplankton growth. Wilkinson (2002), from some references conclude that applying lime has been shown to increase soluble phosphorus concentrations as nutrient of phytoplankton. Lime provides calcium and neutralizes acidic soils so that phosphate is released as calcium exchanges with aluminum and iron. Calcium phosphates are more soluble in water than aluminum phosphates or iron phosphates (Burtle, 2015).

4. Conclusion

The combination of 50% cockle shells lime and 50% calcite was the best treatments with pH of soil and water at day 60 were 8.07 and 8.31, respectively; highest maximal water pH value (3.31) and next liming was at day 224; highest alkalinity (153.33 mg.L^{-1} $CaCO_3$ equivalent), and Ca (104.15 mg.L^{-1}); highest feed efficiency (128.38%); and the best growth performance. The water quality including water temperature, dissolved oxygen and ammonia were in appropriate for *Pangasius* sp. with 100% survival rate.

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