STUDY OF CALCIUM HYDROXIDE ($Ca(OH)_2$) AND SODIUM BICARBONATE ($NaHCO_3$) TREATMENT ON THE DYNAMICS OF pH, COD, N/P RATIO AND PLANKTON ABUNDANCE

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Abstract

Environmental quality has a considerable influence on the survival and growth of aquatic organisms in aquaculture. Improvements on the culture environment to remain stable and optimum for aquatic organisms, including fish as aquaculture commodities become very necessary, namely for the parameters of $Ca(OH)_2$ (calcium hydroxide) and $NaHCO_3$ (sodium bicarbonate). The application of $Ca(OH)_2$ and $NaHCO_3$ in fish farming serves as the pH buffer of pond water. The use of both materials functions to degrade organic matter chemically, control the ratio N/P and the abundance of plankton in the water. This research aims to know the dynamics of pH value, COD, N/P ratio and plankton abundance by administering calcium hydroxide ($Ca(OH)_2$) and sodium bicarbonate ($NaHCO_3$) in the water. This research uses descriptive survey method. The results of the pH value measurement before the $Ca(OH)_2$ and $NaHCO_3$ application is 6,6-6,8 whereas after the application it is increased to 6,8-7,4. The results of COD measurement prior to the $Ca(OH)_2$ and $NaHCO_3$ use ranged between 72,5-32,5 mg/l while after the application it is increased to 26-55 mg/l, the N/P ratio prior to the $Ca(OH)_2$ and $NaHCO_3$ application ranged between 3,15 – 3,68 and changed to 8,67 – 8,8. Observations of total plankton abundance before $Ca(OH)_2$ and $NaHCO_3$ application is 206.250-1.103.125 $x10^4$ ind/l whereas after the application of $Ca(OH)_2$ and there is a decrease in the density of $NaHCO_3$ total plankton reach $9.375x10^4$ ind/l. The research concluded that the application of $Ca(OH)_2$ and $NaHCO_3$ could increase pH value and decrease the amount of COD, the ratio N/P, and total plankton density.

Keywords **:** pH, COD, N/P Ratio, Plankton abundance

INTRODUCTION

Water quality has a considerable effect on the survival and growth of aquatic organisms. A suitable environment is a hygienic environment for animals because it is needed for growth and survival (Asriyana and Yuliana, 2012).

Improvements to the environmental culture conditions to remain stable and optimum for aquatic organisms including fish as aquaculture commodities become highly necessary. Water quality improvements can be made in various ways, namely the application of $Ca(OH)_2$ (calcium hydroxide) and $NaHCO_3$ (sodium bicarbonate) (Karlina, 2010; Loyless and Malone, 1997).

$Ca(OH)_2$, also known as slaked lime, hydrated lime or limestone has a base characteristic. The application of $Ca(OH)_2$ in fish farming function as pH enhancer and buffers for pond water (Nontji, 2008). $NaHCO_3$ is commonly called baking soda, and its use is relatively easy. $NaHCO_3$ is safe, inexpensive, low-toxicity and risks, thus appropriate to be applied in fish farming. $NaHCO_3$ functions to maintain pH stability in water (Odum, 1971).

Both materials cause an increase in pH due to OH-radical ions. These ions can degrade organic matter and dissolved oxygen in the waters due to organic materials activity (Iman *et al.*, 2013). $Ca(OH)_2$ in the water can affect N/P ratio dynamics, especially the decrease in phosphorus so it can control the abundance of plankton dynamics. The binding of phosphate and calcium hydroxide by precipitation can decrease the phosphorus in water (Budi, 2006).

Administering $NaHCO_3$ may also supply the carbon in water in the form of

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CO_2, so it affects the N/P ratio dynamics and plankton abundance in water (Fauzi and Panji, 2002). Plankton has a crucial role for aquatic organisms and is divided into two, namely phytoplankton and zoo-planktonkton. Phytoplankton is the most significant oxygen contributor and produces energy from the rich organic material in water.

Phytoplankton is also one of the biological parameters that can be used as indicators to evaluate the quality and the level of fertility of an aquatic environment (Isnaini, 2011). Based on the description above this research was conducted to find out the effect of calcium hydroxide and sodium bicarbonate on the dynamics of pH, COD, N/P Ratio, and plankton abundance.

METHODOLOGY

Place and Time

This research was carried out on December 23-30th, 2016 in the Faculty of Fisheries and Marine, Universitas Airlangga, Surabaya.

Research Materials

The tools used in this research are DO meter, rope, pH pen, plankton net, dipper, hemocytometer, microscope, object glass, cover glass, sample bottle, burette, clamps, 100 ml measuring cup, 300 ml Erlenmeyer flask, 500 ml Erlenmeyer flask, 2 ml volumetric pipette, and bulb.

The materials used in the study are pond water samples, 1%, PP indicator, aquadest, H_2SO_4 0,02 N, Bromocresol Green, Methyl Red, Test Kits for ammo-nium, hardness, nitrite, nitrate, Phosphate, BOD and COD.

Research Design

Measurements of temperature, dissolved oxygen, pH, and plankton abundance are carried out twice a day at 05:00 pm and 01:00 pm. The time was chosen due to being the time of lowest and highest temperature for the day. Measurement of nitrite, nitrate, phosphate, ammonium, ammonia, COD, and BOD was performed every three days (APHA, 1988; Zaidy *et al.*, 2008).

Work Procedures

The study was started to know the water quality and plankton abundance condition before the shrimp is stocked on the next day. The research continued on the following day to assess the effect of the product application towards the dynamics of water quality and plankton abundance. From the research results, it was found that pH is lowest at 05:00 am so the products were applied at 03:00 am when changes in the water quality dynamics occurred.

The commercial products contain-ing calcium hydroxide ($Ca(OH)_2$) and sodium bicarbonate ($NaHCO_3$) has a con-centration of 1 ppm, so the dosage used is 815,31 gram. The product is a white powder that dissolves easily in water. The products are applied by first dissolving in water then spread evenly throughout the pond. The products were stocked when pH is low due to the products high solubility in water at such condition. Three points namely were decided in the pond as the observation point.

Water Quality Measurement Methods

Measurement of water temperature and dissolved oxygen was conducted using YSI DO 550 A. pH was measured using pH Senz and pH paper range 6,5-10 Merck KgaA. Nitrite was measured using spectrophotometry method with 543 nm wavelength based on SNI 06-6989.9-2004. Nitrate using spectophotometry with a wavelength of 410 nm based on SNI 06-2480-1991. Phosphate was measured using spectrophotometry with wavelengeth 880 nm, which is based on standard methods 20th edition 1998. Ammonium using a test kit. COD refluct closed method using spectrophotometer with a wavelength of 420 nm based on SNI6989.72:2009. Winkler titration method using BOD based on SNI 6989.2:2009. Plankton was observed using a hemocytometer and plankton identification book.

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Water sampling for ammonium, nitrate, nitrite, phosphate, BOD, and COD was tested using the closed bottle principle. The bottle is lowered in the water at a certain depth on a closed position. The bottle cap is opened in the water, so the desired sample entered the sample bottle. Samples can be maintained on a temperature of 40ºC.

Plankton Sampling and Observation Method

Plankton sampling is done using a plankton net with a mesh size of 20 microns. Approximately 50 liters of plankton is sampled in shallow water with around 1 m depth. The samples were filtered until the obtained volume is 100 ml. Samples are labeled containing the date, position, and water depth. The collected samples were immediately observed using binocular microscopes with a magnification of 100-1000.

Parameters observed for the plankton abundance include plankton identification, density, diversity, and dominance.

Data Analysis

The obtained data is presented in the form of tables.

RESULTS AND DISCUSSION

pH Dynamics

Based research results, it is known that pH values at 05:00 am and 01:00 pm range between 6,6-7,1 and 6,8-7,4. According to Robertson (2004), the range of pH in the morning and during the day is ideal for aquaculture activities to increase productivity, but the waters of pH values in the range 6,5 to 8,5. The result of the pH value dynamics at 05:00 am and 01:00 pm is presented in Table 1.

Table 1. pH dynamics in pond.

Parameter	Time	Point	Day							
			0	1	2	3	4	5	6	7
pH	05:00 am	1	6,6	6,8	7,1	7	7,1	7,1	7,1	7,1
		3	6,6	6,9	7	7	7,1	7,1	7,1	7,1
		5	6,7	7	7,1	7,1	7,1	7,1	7,1	7,1
	01:00 pm	1	6,8	6,9	7,1	7	7,1	7,1	7,2	7,2
		3	6,8	6,9	7,1	7,1	7	7	7,1	7,2
		5	6,8	7	7	7,1	7,2	7,4	7,4	7,4

The pH measurement values at 05:00 am prior to $Ca(OH)_2$ and $NaHCO_3$ application ranged at 6,6-6,7 whereas after the $Ca(OH)_2$ and $NaHCO_3$ application increased between 6,8-7,1. At 01:00 pm, before the application the pH was 6,8 whereas after the $Ca(OH)_2$ and $NaHCO_3$ application it increased to 6,9-7,4. The increase in pH is due to bicarbonate ions of $Ca(OH)_2$ and $NaHCO_3$ which buffer the water pH (Furtado *et al*., 2011).

Bicarbonate ion is a source of inorganic carbon that can be modified by phytoplankton into CO_2 as carbon source for photosynthesis. The photosynthesis process produce carbonate ions that would later be modified further into bicarbonate ion in waters and also produces hydroxyl ions, which has base properties in water (Wurts and Durborow, 1992).

A decrease in pH during the research might be caused of high rainfall. According to Mealy and Bowman (2012), the decreased pH in water is caused by an organism's respiration activity, high organic material and high rainfall. Rain can bind CO_2 in the atmosphere into the water.

COD Dynamics

Based on research results, the COD value before and after the $Ca(OH)_2$ and $NaHCO_3$ application experienced dynamics and is arguably optimal for fish farming activities in the range of 72,5-32,5 mg/l

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$CaCO_3$ and 19,5-55 mg/l $NaHCO_3$ respectively. According to Armita (2011), the range of COD value in uncontaminated water is usually <20 mg/l and may exceed 200 mg/l in polluted water. The COD value dynamics before and after the application of $Ca(OH)_2$ and $NaHCO_3$ is presented in Table 2.

Table 2. COD dynamics in pond.

Day	COD (mg/l)		
	Point 1	Point 3	Point 5
0	42	32,5	75,5
4	46	28,5	26
7	23,5	19,5	55

The OH^- ions causes the COD value decline on each point, which are obtained as the results of calcium hydroxide and sodium bicarbonate reaction in the water. According to Isyuniarto (2006), increasing OH^- in water can maintain the organic material in the water.

The COD increase in point 5 is due to the weather conditions at the time of sampling where it was raining accompanied with strong winds that allegedly led to upwelling that carry toxic gases from the base to the surface. Thus, the activity of organisms in elaborate on organic materials is increasing. Nevertheless, calcium hydroxide and sodium bicarbonate application are quite effective in lowering the value of COD.

N/P Ratio Dynamics

N/P ratio is obtained from the calculation of the total N divided by total P. Based on the research results, it can be shown that the N/P ratio ranges between 1,67 – 15,18. According to the Lagus (2009), the N/P ratio in water will affect the dominant plankton composition. N/P ratio above 20 showed that there is a diatom dominance, whereas the N/P ratio of 10 will be dominated with green plankton (*Chlorella* sp.). If the N/P ratio goes under 10, it is most suitable for blue-green algae (BGA). The N/P ratio results before and after the application of $Ca(OH)_2$ and $NaHCO_3$ is presented in Table 3.

Table 3. N/P ratio dynamics in pond.

Day	N/P Ratio		
	Point 1	Point 3	Point 5
0	3,15	3,68	3,65
4	8,67	8,74	8,8
7	15,13	13,8	15,18

The N/P ratio before application of $Ca(OH)_2$ and $NaHCO_3$ on points 1, 3 and 5 ranged at 3,15 – 3,68, while after the application of $Ca(OH)_2$ and $NaHCO_3$ on day 4 it decreases to 8,67 – 8,8. The N/P ratio rose back on the 7th day to 13,8 –15,18.

The phosphorus content influences the N/P ratio dynamics in water. This is in accordance with Lagus (2009), stating that phosphorus in water is a limiting factor. Higher N/P ratio showed a low concentration of phosphate and vice versa, thus leading to the diversity of plankton dynamics in the water.

Plankton Abundance

Based on the observations, 33 genera representing 9 classes of plankton were found namely Chlorophyta (9,09%), Diatoms (15,15%), 7 genus of Cyanophyta (28,21%), 3 genus of Desmidiacea (9,09%), 2 genus of Entomostraca (6,06%), 6 genus

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of Rotatoria (18,18%), Cilliata (3,03%), and Molluscs (3,03%).

The total plankton density at 05:00 am after $Ca(OH)_2$ and $NaHCO_3$ application has increased and decreased. The total plankton density at 05:00 am before $Ca(OH)_2$ and $NaHCO_3$ application on point 1, 3 and 5 is 1.103.125 x10^4 ind/l, 578.125 x10^4 ind/l and 678.500 x10^4 ind/l respectively. The dominating planktons are *Chlorella* sp., *Oocystis* sp., *Polyedrium* sp., *Dinophysis miles*, and *Glocotricha echinulata*. The total plankton density at 01:00 pm before $Ca(OH)_2$ and $NaHCO_3$ application on point 1, 3 and 5 respectively are 437,500 x10^4 ind/l, 206,250 x10^4 ind/l and 425.000 x10^4 ind/l. The dominating planktons are *Chlorella* sp., *Gonyulax polyderm*, *Calothrix* sp. and *Glocotricha echinulata*.

The drop in plankton density is caused by $Ca(OH)_2$, which can bind to phosphorus compounds in water. On the 4th day there is increased phosphorus caused by high rainfall intensity. The rain stirred the sediments or ground by rainwater. Phosphorus in waters can only be obtained on the soil base, sediments, rocks, and organic matter. Although the content of phosphorus in waters increased, it is only utilized by phytoplankton because phytoplankton is experiencing death due to heavy rain (Azwar, 2001).

Such dominance is caused by the presence of phosphorus compounds binding water by calsium hydroxide as seen in the decrease of phosphorus content on the 7th day. The rainy season can also increase the dominance of zooplankton because of the reduced penetration of sunlight into the water. Therefore, phyto-plankton was replaced by zooplankton as there is not enough sunlight for phyto-plankton photosynthesis (Root *et al*., 2004).

Water Quality Measurement

The measured water quality parameters include temperature, dissolved oxygen, nitrite, nitrate, ammonium, ammonia, phosphate, and BOD. The results are presented in the following Table 4.

Table 4. Water quality measurement.

Parameter	Time	Point	Day 0	1	2	3	4	5	6	7
Temperature (°C)	05:00 am	1	26,9	27	27,9	28,4	28,3	28,8	28,5	28,6
		3	26,9	27	27,9	28,3	28,3	28,7	28,4	28,6
		5	26,9	26,9	27,9	28,2	28,4	28,6	28,5	28,6
	01:00 pm	1	28,1	29,1	29,8	29,8	29,7	29,6	30	29
		3	28,1	28,9	29	29,7	29,5	29,5	29,7	29,5
		5	28,1	29	30	29,8	29,7	29,5	30	29,5
DO (mg/l)	05:00 am	1	4,71	4,88	5,32	4,13	4,11	3,88	3,58	4,47
		3	4,07	4,44	4,84	3,84	3,28	3,32	3,23	4,15
		5	5,44	5,44	5,60	5,26	4,61	4,07	3,53	4,67
	01:00 pm	1	7,19	7,63	8,41	7,02	7,13	5,11	5,79	6,12
		3	7,56	7,85	7,87	7,32	6,62	5,33	5,89	5,90
		5	7,95	8,13	8,90	7,89	7,78	6,38	7,03	7,25
Nitrite (mg/l)	05:00 am	1	0,011	-	-	-	0,014	-	-	0,026
		3	0,014	-	-	-	0,014	-	-	0,03
		5	0,013	-	-	-	0,014	-	-	0,03
Nitrate (mg/l)	05:00 am	1	0,1	-	-	-	0,24	-	-	0,345
		3	0,232	-	-	-	0,32	-	-	0,448
		5	0,216	-	-	-	0,278	-	-	0,356
Amonium (mg/l)	05:00 am	1	0,5	-	-	-	0,5	-	-	0,5
		3	0,5	-	-	-	0,5	-	-	0,5

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		5	0,5	-	-	-	0,5	-	-	0,5
Amonia (mg/l)	05:00 am	1	0,625	-	-	-	0,625	-	-	0,625
		3	0,625	-	-	-	0,625	-	-	0,625
		5	0,625	-	-	-	0,625	-	-	0,625
Phosphore (mg/l)	05:00 am	1	1	-	-	-	8,94	-	-	<0,22
		3	0,88	-	-	-	8,88	-	-	0,44
		5	0,88	-	-	-	8,82	-	-	<0,22
BOD (mg/l)	05:00 am	1	16,8	-	-	-	12,25	-	-	4,4
		3	14,02	-	-	-	5,6	-	-	8,87
		5	39,9	-	-	-	5,78	-	-	12,6

The temperature dynamics at 05:00 am on point 1 and 5 ranged from 28,6-26,9 °C and point 3 ranges 26,9-28,7 °C. At 01:00 pm on point 1 and 5, it revolved around 28,1-30 ºC and point 3 is around 28,1-29,7 ^{0}C. The temperature range can be said to be optimal for aquaculture because according to Bhatnagar *et al*. (2004), the optimum temperature range for aquaculture ranged at 15-35 °C.

The dissolved oxygen level in outdoor environment is optimum for culture activities. This goes in accordance with Wijayanti (2011) that plankton can live well on the oxygen concentration over 3 mg/l.

The levels of nitrites and nitrates can be said to be optimal for culture activities. According to Bhatnagar and Devi (2013), the range of optimum nitrite for culture is < 0,02 mg/l while the range of optimum nitrate is 0,1-4,5 mg/l. The ammonium and ammonia levels in the research can be tolerated for culture. According to Philminaq (2006), the range of ammonium and ammonia that can still be tolerated in culture is < 1 mg/l.

The levels of phosphorus can be said to be optimal for culture activities. According to Stone and Thomforde (2004), the ideal range of phosphorus in aquaculture is 0,01-3 mg/l. The BOD levels can be said to be unpolluted slightly polluted up to point 5. According to Marganof (2007), the range of the value of BOD > 10 mg/l is considered to have suffered contamination.

CONCLUSION AND SUGGESTION

Conclusion

The application of $Ca(OH)_2$ and $NaHCO_3$ is capable of increasing the pH and can lower the value of the COD, N/P ratio, and total plankton density. Changes in the dynamics is not only influenced by the material application but also environmental conditions such as rain.

Suggestion

Suggestions for research is expected to do further research about the application of $Ca(OH)_2$ and $NaHCO_3$ pH dynamics on COD, N/P Ratio, and plankton abundance in summer.

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