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Development of Aquaculture Environmental Management for the Improvement of Production Capacity for Sustainable Aquaculture Activities

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Abstract. **This study is aimed to develop the environmental management of fish farming in order to support sustainable farming activities in the form of production of high protein fish pellets using local natural biotas, especially freshwater clams (*Anodonta woodiana* Lea) and golden snails (*Pomacea sp*.) and efforts to increase the carrying capacity of water environment of Rawapening. Biosecurity application includes the identification and prevention of disease, controlling the quality of the environment, and implement eradication programs when an outbreak of disease occurs. Physical, chemical and biological tests suggested that pellet using *A. woodiana* Lea and *Pomacea sp.* as protein sources is better than commercial pellet. Diseases that generally attack the culture of tilapia (*Oreochromis niloticus*) in Rawapening waters include parasite *Trichodina sp*, *Trichodinella sp*, fungi *Saprolegnia sp*, and bacteria *Streptococcus sp*.**

***Index Term*— fish farming, fish pellets, biosecurity application**

I. Introduction

A. Background

In general, freshwater fish farming in Indonesia is still using the traditional system and does not use good business management so that fish production may not be controlled both quantity and quality. An area of water potentially used as a fish farming cage system is Rawapening. Utilization Rawapening as areas of fish farming cage system has traditionally been developed by local people since 1997 in the middle of the lake. Along with increasing number of the cages, since 1999, more cages were located at the edge of the lake, especially the downstream region adjacent to Asinan village. The practice of traditional cage system in the waters prioritize on biomass production with a specific target without regards to local environmental carrying capacity, so environmental problems potentially occur, such as pest and disease, environmental pollution, organic enrichment of waters, and water hyacinth weed population explosion.

Intensification is defined as an increase in yield by increasing the production inputs without any expansion of farm area. Intensification is done by maximizing the carrying capacity of existing area for increased production (Malison & Hartleb, 2005). Problems began to arise if the activity is not offset by the application of good environmental management, because the organic materials generated from farming activities could cause an ecological imbalance in the region, so that it could threaten the sustainability of its business. This is because the organic matter can be deposited in the bottom area of the farms, affecting ecosystems around the area of fish farming. Organic material can also spread in the area that is not be a place of fish farming, and the process towards ecosystem recovery generally take a long time (Putro *et al*., 2006; Putro, 2007). Based on field surveys, many of the farmers lack of understanding that cultivation in semi-enclosed area with low water flow like Rawapening waters need a good environmental management. To realize sustainable aquaculture, management systems and aquaculture technology that needs to be a seriously concerned is the environmental management of aquaculture development through the application of biosecurity (Lee, 2007; Findlay, 2003; Francis-Floyd, 2003). Implementation of biosecurity is expected to solve the problems of fish farming cages, especially sudden death and parasitic diseases of fish. In addition, to utilize local natural resources and increase production capacity and to enhance community empowerment fish farmers, it is necessary to manufacture high-protein pellets using local biotas as sources of protein (Arkani, 2007).

B. Objectives

Specific objectives to be achieved from the research include:
1. To carry out series of activities to develop environmental management of aquaculture through the application of biosecurity to support sustainable farming activities.
2. To conduct community empowerment activities through the production of high protein fish pellets by using local natural resources, freshwater clams (*Anodonta woodiana* Lea) and golden snails (*Pomacea sp*.) as a source of high protein to support fish farming activities.
3. To improve the use efficiency and optimize Stratified Double Floating Net Cages (KJAB) through modification.

II. Method

A. Survey Research Field and Determining Location

Field surveys have been conducted on the floating net cage aquaculture area (KJAB) belonging to Farmers Group of Ngudi Makmur, Krajan , Asinan Village. Since its installation by a team of KKN PPM 2008, the cage has been in operation for one year with a stocking density of 3000 tilapia fish ($4x4m^2$) (Putro & Suhartana, 2008). Coordination with the the farmer group was made to socialize the program, so hopefully there will be transfer of knowledge from researchers to the target audience (the farmers of floating net cages/KJA). Some stations were selected for the purpose of monitoring of water quality (Fachrul, 2007; Kristanto, 2002).

B. Modifikacation of KJAB

Some modifications were made to optimize the function of the cages (KJAB), based on the evaluation results during the previous year of operation by Farmers Group of Ngudi Makmur. These modifications include:
1. Installation of net rolling components was placed in one corner of the cage to simplify the process of harvesting fish
2. Changing mesh size of 0.5 inch to 1 inch, especially at the bottom to reduce the inhibition of the remaining pellets of fish from the nets I (upper net) leading to the nets II (bottom net).
3. Replacement of zinc-oil drum with plastic drum with a diameter of 75 cm as a floater in order to prolong the life of KJAB
4. Replacement of larger size ropes to increase the strength of nets of KJAB

C. Biosecurity Application

1. Collecting data / list of diseases that existed during farming practice based on interviews and direct observation in the area of cultivation.
2. Selecting healthy juveniles and controlling the growth of the fish.
3. Conducting control of water environment quality of Rawapening
4. Doing eradication programs when an outbreak of disease and antibiotic treatment if necessary.

D. Preparation of fish pellets

1) The determination of pellet formulations

Calculation of feed formulation was done using squares method in assessing the quantity of raw material feed required. Despite based on the calculation itself, making fish feed can also use the example of an existing formula. Determination of material composition began with separating the material into two kinds of >20% proteins (protein supplement) and <20% protein (Basal Food) (Khairuman and Amri, 2002).

2) Pellet Quality Tests

a. Physical Test

Physical tests include testing the floatation of pellets, level of its endurance in the water, and the hardness of pellets. The floatation test was made in two places in the aquarium and at the farm location.

b. Chemical Test

Chemical test was conducted to determine the nutrient content of fish pellets created. Samples of pellets were tested include 3 types, namely high-quality commercial fish pellets, commercial fish pellets medium quality, and fish pellets alternative. Both of these commercial fish pellets are commonly used pellets of fish communities.

c. Test of Water Content

Pellets that have been produced were tested their water content, to determine how the percentage of water content in the pellet. This test should be given because pellets containing too much water content may be easily contaminated by fungus and causes unwanted odour caused by bacterial activity.

d. Biological Test

Biological test performed to determine the effect of pellets on the growth of fish. Test parameters include body weight and body length as a measure of fish growth. Red tilapia (*Oreochromis niloticus*) were used in the average length of 6-8 cm, which were placed in the + 30 liters aquarium. Test was carried out with 2 treatments, ie pellets of alternative/experimental and commercial pellets. Each treatment was repeated 3 times. The treatment performed for 4 weeks that preceded a 3-day acclimatization stage. Pellets were given 3 times a day at 5% weight of fish. Measurement of weight and body length of fish was done 3 days. The data obtained was analyzed and compared so that the level of influence on the growth of fish can be assessed.

E. Collection and analysis of data

The data was collected periodically every three months for three times to know the development of water quality after the application of biosecurity. While the manufacture of pellets will be tested with several parameters, among others: another physical test (floatation, durability of pellets in water, the hardness of pellets), chemical test (nutrient content), the biological test (preference test fish to pellets).

Abiotic data collection of farm area as part of biosecurity applications included measurement of physical-chemical parameters of aquatic farming area. Analysis of variance (ANOVA) was used to compare differences in water quality in the area of farming and references in the three times of sampling time. Before analysis, data were tested using Komogorov-Smirnov's test for normal distribution and Levene's test for homogeneity of variance test (Clarke & Warwick, RM, 2001, Clarke & Gorley, 2006).

III. RESULTS AND DISCUSSION

A. The Improvements / Modifications KJAB

Several modifications have been made to optimize the function of cage (Figure 1). Addition of components as net rolling to simplify the process of harvesting the fish, replacement 0.5-inch mesh to 1 inch at the bottom of the cage to reduce the inhibition of the remaining pellets of fish from the nets I (upper net) leading to the nets II (bottom net). It also carried out replacement of drum flotation device made of iron/zinc into plastic drums. Replacement is expected to reduce the risk of corrosion, thus extend existence of the cages. Processing Pellets using Local Biotas as Protein Sources

Fig 1. Several modifications were made to optimize function of KJAB: a). Modification of net retrievement using *net roller*; b) replacement of zinc oil drum by plastic drum; c) replacement to bigger rope size; d) replacement of bottom net from 0,5 inchi to 1 inchi net size.

a. Fish Pellet Materials

The raw material of pellets was tested as a source of protein food is freshwater clams and golden snails that are present abundantly at the location. Initial stage was producing snail flour. For additional material as an ingredient is rice bran. All materials were then dried and crushed in order to get the form of flour to make it easier at the time of mixing with other ingredients.

b. Process of Producing Fish Pellet

Snail flour was made from raw snail meat that has been separated from its shell. The meat was then rolled, dried, ground and sifted. Freshwater clams as pellet material was also through the same process as snails to obtain flour. The additional materials were rice bran, which is mixed with fine bran derived from rice whitening process, and cassava leaf, adhesive materials and additional vitamins. The best adhesive is starch. Adhesive material serves to condense and dough pellets before making granules. Adhesive used was wheat flour and starch. Wheat flour comes from grain. Nutrient content of wheat flour is 8.9%, proteins 1.3% fat, and 77.3%. carbohydrate. Vitamins (Biovit) was added at 1 - 2 g / kg of pellets.

Calculation of feed formulation using squares method was employed to calculate the needs of quantity of raw material. Beside based on the calculation itself, making fish feed can also use the example of an existing formula. Determination of material composition was done by separating the material into two kinds of > 20% proteins

Fig 2. Process of producing snail flour: (a). Crushing snail flesh using grinder; (b). Drying grinded snail flesh; (c). Dried snail flesh was ready to crush; (d). Process of crushing dried snail flesh to be snail flour.

(protein supplement) and <20% protein (basal food) (Arkani, 2007).

In terms of producing pellets, the determination of material composition depends on the desired protein and protein content of each ingredient. Experimental pellets have been designed to have a protein content of 30%.

B. Pellet Quality Assessment

a. Physical Test

Physical tests include testing the floatation of pellets, endurance test of pellet in the water, and the hardness of pellets.

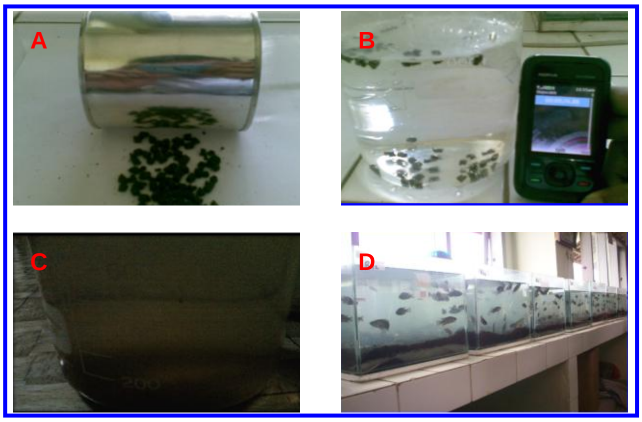

Fig 2. Physical tests of pellets : A) Testing of pellet hardness; B) test the floatation of pellets; C) pellets in the water resistance test, and D) a biological test using tilapia (*Oreochromis niloticus*).

The floatation test was made in two places in the aquarium and at the edge of the lake. Pellets tend to have relatively more time floating than commercial pellets. More details are presented in Table 1 below:

TABLE I
RESULT OF PHYSICAL PELLET TEST

Type of Physical Test	Procedure	Result	Conclusion
Floatation of pellet	Pellet was spreaded into glass box containing water. Time needed by pellet from the beginning to become sinked is the level of floatation.	First minute: 50 % of pellets were sinked Fifth minute: 6 % of pellets were sinked Tenth minute: 6 % of pellets were sinked Fiftienth minute: 15% of pellets were sinked	Pellet are categorised as sinking type of pellets
Level of enduran ce of pellet	Put pellets into the water until deteriorated and dissolved	18 hours 10 minutes	Pellet has adequate level of endurance
Pellet hardness	Giving particular weight load on the pellet	Pellets were not destroyed after a given load 500gr	Pellets have hard textured

b. Chemical Test

Chemical test conducted to determine the nutrient content of fish pellets are created. Samples of pellets were tested include 3 types, namely high-quality commercial fish pellets, commercial fish pellets medium quality, and the pellet experiment. Both of these commercial fish pellets are commonly used pellets of fish communities. The results show that high-quality commercial fish pellets has a protein content of 35%, pellets with a quality medium has a protein content of 16%, while the alternative pellet has a protein content of 20%. Next test the fat content, crude fiber and carbohydrates to the three types of pellet experiments indicate pellets have sufficient characteristics (fat: 11.8%, crude fiber 12.11; carbs: 38.3%), as shown in Figure 3.

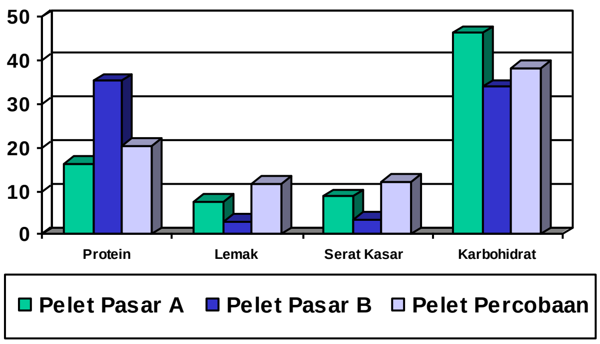

Fig 3. Comparative analysis of nutritional components of high quality commercial pellets (A), medium quality (B) and pellet experiment

c. Test of Water Content

Results from testing the water content of pellets such as pellets of 7.22% water-yield experiments, pellets of high quality commercial-grade water and pellets of 8.57% medium quality water yield 7.34%. This shows that the pellets produced have a lower water content (7.22%) than on commercial pellets (8.57). This can occur because of differences in drying time. The lower the moisture content of pellets will prolong the storage time. The water content in the pellets affect the durability of pellets for contamination of organisms, especially fungi / yeast. Pellets that are too damp can cause the pellets quickly moldy during storage.

d. Biological Test

Results of measurement of length and weight of the fish showed the longer the fish the heavier weight of fish. This indicates a positive correlation between weight and fish weight (R2 = 0671), both of fish fed experimental pellets or commercial pellets (Figure 4).

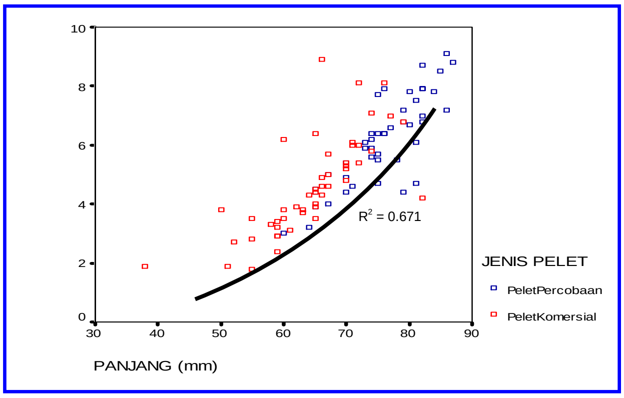

Fig 4. Scatter-plot graph illustrates the linear relationship (R2 = 0671) between the length and weight of fish, and fish length and weight growth of a better use of pellet experiments.

C. Application of Biosecurity

Control of the disease is necessary in order to improve the quality of aquaculture products and ensure business continuity. The use of drugs and vaccines are generally able to overcome permasalahn, but in the awareness of the potential of usage requires resistance and environmental pollution (Subasinghe, 2003). Control of diseases is one application of biosecurity program. Applications that have been done padapenelitian biosecurity include: doing a clean cage area anorganikdan KJAB of organic garbage that float, perform data collection and monitoring of kesehatanikan, and monitoring the water quality Rawapening. Data Collection / list of diseases that never existed during the practice of farming is based on interviews and direct observation in the area of cultivation. Some diseases found in the field and which often appear when rearing fish cage system include:

a. Fish Parasites

Some fish are found in the field have symptoms such as: fish movement is weak / not aggressive, body produce excessive mucus than normal fish, partial fin loss and skin irritation to the epithelial cells. This is caused by a parasite *Trichodina sp.* and *Trichodinella sp* (Figure 6).

b. Unicellular fungi/moulds

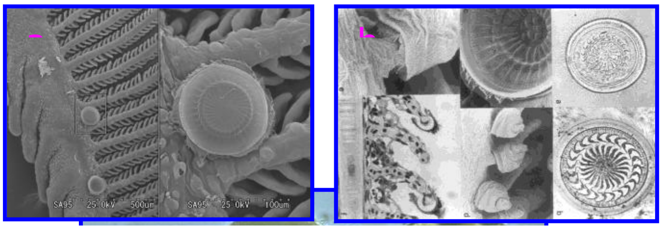

Fig 6. Morphology of parasites *Trichodina sp* (a) dan *Trichodinella sp* (b).

Some of the fish at a location found to have cuts on the external wound was detected ikan. Pada have some kind of fungus that is commonly found on tilapia aquaculture. Fungi that attack the fish is Saprolegnia sp (Figure 7).

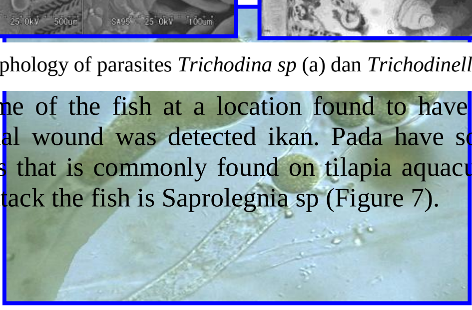

Fig 7. The morphology of the fungus *Saprolegnia sp.*

c. Bacteria

When the fish are still small (cm 3-5), approximately 10% of the stocked fish population in KJAB experiencing sudden death. Death occurs when stocking fish from 0 days to 14 days. Identify in the lab indicate an attack by the bacteria Streptococcus sp. Before dying, the fish are attacked by this bacterium has the characteristics: frequent seizures, bleeding / wounds on the body, bloated abdomen (dropsy) and protruding eyes (exopthalmia) (Figure 8).

E. The quality of Rawapening waters

The measurement results of water quality parameters at each sampling location are presented in Figure 9. Data are based on the average of direct measurements (in situ) were performed in 3 times the sampling time with the 3 replication.

In general, the quality of surface waters (30-60cm) in the three sampling locations are still within the normal range, among others, measured from the mean of DO (5.0 to 8.0 mg / l), pH (5.8 to 9.7), turbidity (15.8 to 57.3 NTU), conductivity (0.2 -0.3 mS / cm), temperature (27.0 to 31.0 ^{o}C), and brightness (34.3 -66, 3 cm).

Strong currents (water current) in the vicinity of the estuary of the River as the location Tuntang Rawapening Lake lying water discharge (outlet) from an average of 12.5 cm / sec or slightly weaker than the control site or the middle Rawapening Lake lying (16 cm / sec), as presented in Table 2.

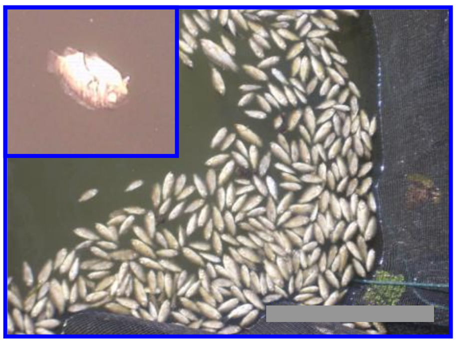

Fig 8. Several populations of tilapia seeds that die during the process of enlargement. Inset: dead fish by the bacterium Streptococcus sp

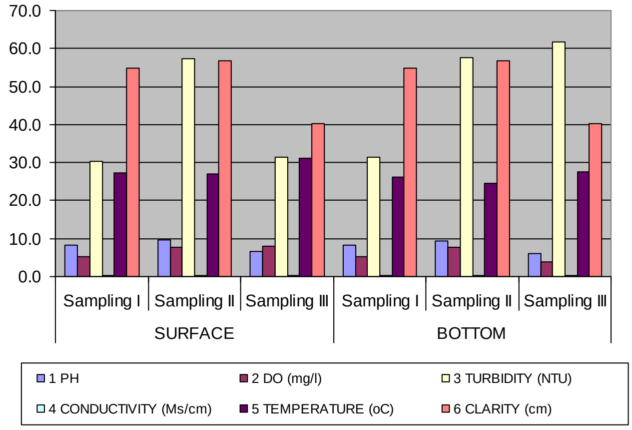

Fig 9. Results of water quality measurement

In general, conditions are still conducive Rawapening hydrodynamic region as an area of cultivation, because the strong currents still ranged between 9.98 -12.21 cm / sec (Bierman in Putro, 2006; Lumb, 1989). Location Tuntang River estuary is a location that is widely used as an area of fish farming cage system. Based on the survey location, approximately 60% of the population cages in the waters Rawapening step on pickled Village area located in the area.

Number of suspected cage installation is a major cause weakening of the strong currents in the area. However, the strong currents in the range is still possible the organic matter either dissolved or tersedimentasi can shift or move from the source (farming activities), thus reducing the risk of organic material accumulated during cultivation practices take place (Putro, 2006). Further expressed by Lumb (1989), organic enrichment (organic enrichment) of a water due to cultivation activities are influenced by bottom type, water depth, and strong currents. If a culture has a strong current of less than 5 cm / sec may occur serious environmental degradation (<1 mg / l DO,> 2.5 mg S / g acid volatile sulfide) caused by excessive accumulation of nitrogen (> 3 mg / g) derived from farming activity (Yokoyama et al., 2006; Levin & Gage, 1998).

IV. CONCLUSION

Based on the results and discussion of the research, conclusions can be drawn as follows:

1. Based on monitoring conducted at the location, Rawapening water is still within the normal range of hydrodynamic conditions, thus are still favorable as fish farming area using KJAB system.
2. Applicatiion of biosecurity is needed to maintain the sustainability of farming activity and productivity of fish farming operated at Rawapening Lake.

3. The quality of the pellets made from local raw materials (golden snail and mussels swamp) as sources of protein showed good quality and can be applied as an alternative of commercial pellets.
4. Diseases which generally attack the culture of red tilapia (*Oreochromis niloticus*) in the Rawapening waters include parasites *Trichodina sp* and *Trichodinella sp*, fungus *Saprolegnia sp*, and bacteria *Streptococcus sp*.

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