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Phosphor-based carrying capacity of Riam Kanan river, South Kalimantan on caged fish farming

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Abstract. Caged fish farming at Riam Kanan Rivers, South Kalimantan has been done by the local farmers since 1986. The huge profit from this business triggers exploitation of the rivers without environmental consideration. As a consequence, it increased the fish mortality rate and the decrease of fish farmers' income. In order to control the number of fish cages, a study in regard of its condition and/or carrying capacity is needed. The objective of this study was to estimate the amount of phosphorus (P) waste produced by the fish farming activity. The research was conducted from six cages with the size of 2.5 x 1.75 x 1 m^3: three cages with capacity of 220 fish per cage and the rest of 3 cages with capacity of 500 fish per cage. Cultivated fish is common carp (*Cyprinus carpio* L.) with the size of 5-7 cm long. Two times feeding per day with 5% body weight was applied. The cultivation was done for 16 weeks. The daily distribution of P of the caged fish farming was calculated based on the total amount of leftover food and the feces in 12 hours. The weight of leftover food and the feces, collected from the net surrounding the cages, were sampled every two weeks. The result indicated that the total P increased with the length cultivation. The total amount of P in every cage with capacity of 220 and 500 fish were approximately 0.035 g day^{-1} and 0.207 g day^{-1}, respectively. Hence, the optimum number of cages on Riam Kanan Rivers based on the existing P was as follow, cages with 220 and 500 fish were 60-64 and 10-12 units per 100 m, respectively.

Key Words: water pollution, sustainable aquaculture, river carrying capacity, cage fish farming.

Introduction. The caged fish farming on Riam Kanan River, Sungai Alang village, South Kalimantan province has been done by the local people since 1986. The biggest number of the cages, as many as 6,800 cages, was in 2001. The number decreased to 4,667 cages in 2006 (Department of Marine and Fishery in Banjar Regency 2007). There had been 698 cages used by people of Sungai Alang village until April 2011. Out of those 698 cages, 680 cages were used for cultivating carp fish (*Cyprinus carpio*), 14 cages for Nile tilapia fish (*Oreochromis niloticus*), and 4 cages for pomfret fish (*Colossoma macropomum*). The decrease was caused by high mortality of the fish cultivated, which ranges between 30-50% (Wahyuni 2009).

The system that is used by the people of Sungai Alang village in cultivating the fish is an intensive fish cultivation that depends mostly on synthetic fish food to trigger the fish growth. McDonald et al (1996) identified that 47.5-51% of the food that is given to the fish would dissolve in the water and enrich the water with organic materials. The waste from the fish cultivation contains organic materials and high nutrition which come from the leftover food and the feces dissolved in the water (Johnsen et al 1993; Buschmann et al 1996; McDonald et al 1996). The nutrition from the intensive fish cultivation gives potential to the change of the water quality (Phillips et al 1993; Boyd 1999).

River carrying capacity estimation to support caged fish cultivation is a quantitative measure that will show how many fish may be farmed within predetermined area without causing degradation to the environment and the surrounding ecosystem (Meade 1989). If the number of cultivated fish in the cages has been determined, the estimations focused on how many units of cages may be used in the already predetermined area. The approaches used for estimating the carrying capacity for the development of fish cultivation in public waters are the approaches based on P amount discharged into the aquatic environment (Beveridge 1984).

Caged fish cultivation business run by people on Riam Kanan river has generated multidimensional benefits, i.e. as source of animal protein, source of family income and also source of employment. In order to maintain the sustainability of caged fish cultivation on Riam Kanan River, the number cultivation cages used must comply with river carrying capacity. Therefore, a thorough study should be conducted in determining Riam Kanan river carrying capacity in regards to total amount of P discharged by caged fish.

Material and Method. The study was conducted on Riam Kanan river which is located in Sungai Alang, Karang Intan, Banjar Regency, South Kalimantan Province on June-November, 2016. The detail location of the research was depicted on Figure 1.

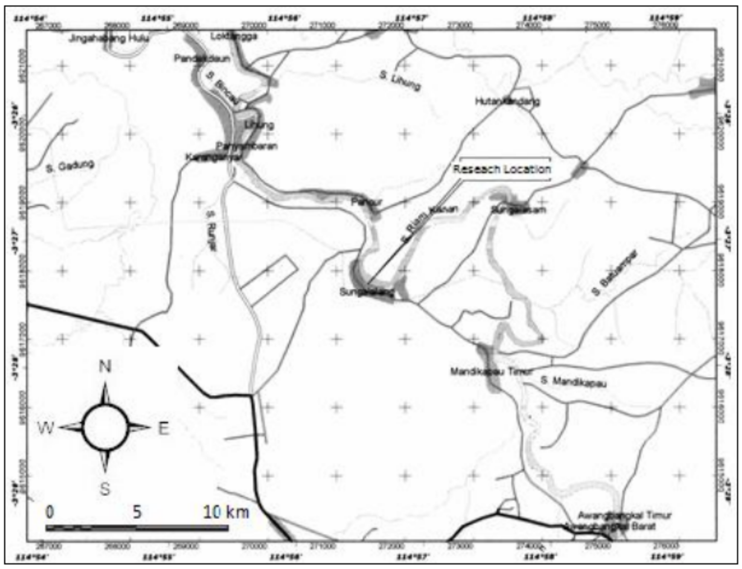

Figure 1. Location of the research (original).

Fish cultivation experiment. The duration of fish cultivation was sixteen weeks. Fish cultivation experiment was conducted by using six cages with the size of 2.50 m, 1.75 m, 1.00 m in length, width, and height, respectively. Both cage units were filled with carp in size of 5-7 cm. During cultivation, fish were fed twice as much as 5% of their body weight (BW) per day (Schmittou et al 2004). Fish feed was manufactured by Centra Proteina Prima Co. type 189-4 with composition of 27-29% protein, 5% fat, 6% fiber, 13% ash, and 12% water (Rahman 2012).

The first cage unit (I) is used to identify the total input of P which was taken from caged fish with the density of 220 fish per cage unit. The second cage unit (II) is used to identify total input P which was taken from caged fish cultivation operated by fish farmers in Sungai Alang with density of 500 fish per cage unit. Three replications were applied for the P analysis.

The amount of P total input of caged fish cultivation was calculated based on the total of leftover food and feces excreted. The leftover food and feces excreted fall into fine net placed at all sides of the cage. Every two weeks, the leftover food and feces excreted in 12 hours are weighed to determine daily P total input.

Phosphorus analysis. The calculation of P total level was determined using Amino naphthol Sulfonic method (Apriyantono et al 2003). P total input was calculated based on total P amount per day. P total amount resulted from caged fish cultivation is determined by converting P total percentage (%) found in leftover food and fish feces into daily weight (g day^{-1}) using the following formula:

$$P_{load} = W_{load} \times P_{sample}$$

where: P_{load} = P total amount (g day^{-1}); W_{load} = leftover food amount and fish feces (g day^{-1}); P_{sample} = P total level (%) analyzed in laboratory.

Water quality analysis. The measurement of water quality for P total parameter is conducted at two-week intervals throughout the study. Water measurement points and samplings are at ±50 m upstream cages, in the cages and at ±50 m downstream cages at a depth of 40-50 cm from water surface. The volume of water samples taken is 1,000 mL. The water samples taken for laboratory analysis purposes are put into glass bottles, cooled at ±4°C, labeled and then put into a cool box.

River carrying capacity based on total P waste is determined by using procedure proposed by Beveridge (1984) and modified by David et al (2015) which is as follows:

$$\Delta[P] = [P]_f - [P]_i$$
$$\Delta[P] = L_{fish}\ (1-R_{fish})/Z\rho,$$
$$L_{fish} = \Delta[P] * Z * \rho\ /1-R_{fish}$$
$$R_{fish} = x + [(1-x)R], \text{ where } R = 1/(1 + 0.515\ \rho^{\ 0.551})$$

where: $\Delta[P]$ is P total (g m^{-3}); $[P]_f$ = P maximum that can be taken by the river; $[P]_i$ = P level in the water before it is used for caged fish cultivation; L_{fish} is P total of caged fish cultivation activity (g m^{-2} y^{-1}); Z = river depth average (m); ρ = flushing coefficient, R_{fish} = P total; x = P total dispersed permanently into sediment.

Result and Discussion. The weight of leftover food and feces produced by cultivated fish which plunge into the river per measurement time could be seen in Table 1.

Table 1
Average amount of organic waste produced from caged fish cultivation during the study

Cultivation period (week)	*Cage unit I (g day^{-1})*	*Cage unit II (g day^{-1})*	*Weight difference (g)*
0-2	18.696±0.099	218.607±0.903	199. 911
2-4	22.100±0.236	212.940±0.910	190.840
4-6	30.709±0.287	203.700±0.520	172.991
6-8	39.981±0.217	200.071±1.047	160.090
8-10	51.354±0.281	262.856±1.888	211.502
10-12	77.415±0.428	387.860±1.892	310.445
12-14	92.803±0.901	531.960±5.373	439.157
14-16	112.710±1.105	596.736±5.383	484.026

Note: Cage unit I = 220 fish; Cage unit II = 500 fish.

The weight of daily organic waste was influenced by fish size and stocking density (Figure 2). This condition is related to the amount of fish feed. The larger stocking density needs more fish feed, resulted in the bigger amount of leftover feed and feces plunged into the river. The amount of feed will affect the accumulation of waste in the environment. Intake of feed and chemical waste affect the environmental condition (Lupatsch & Kissil 1998; Haya et al 2001).

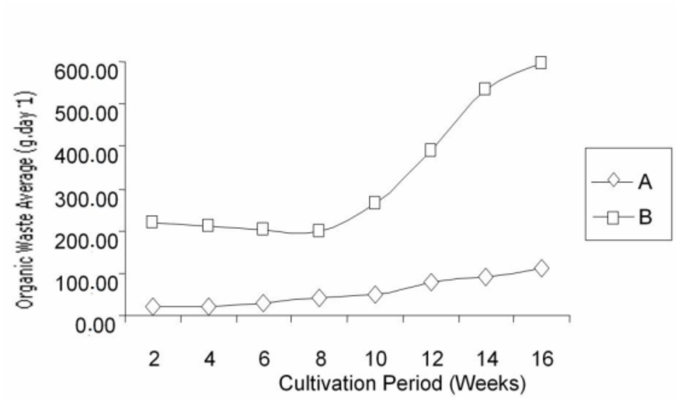

Figure 2. Organic waste (g day^{-1}) released from caged fish cultivation. A: cage unit I, with the stocking density of 220 fish per cage unit, B = cage unit II, with the stocking density of 500 fish per cage unit.

On the cage I, the lowest average of organic waste amount (18.696±0.099 g day^{-1}) was obtained from week 0-2 of cultivation. The highest average of organic waste amount is 112.710±1.105 g day^{-1} during weeks 14-16 of cultivation. The rate of organic waste daily weight gained within two week intervals ranged from 18.207 to 50.748%. On the cage II, the lowest average of organic waste amount (200.071±1.047 g day^{-1}) was generated from week 6-8 of cultivation and the highest average of organic waste amount was 596.736±5.383 g day^{-1} on the week 14-16 of cultivation. The rate of organic waste daily amount gained with two week interval ranged from 2.592 to 47.556%.

The average of organic waste produced by cage unit I with stocking density of 220 fish during the first two weeks is 18.696±0.099 g day^{-1} which was lower than that of the average of organic waste produced by cage unit II with stocking density of 500 fish (218.607±0.903 g day^{-1}). The different stocking density influenced the results in the amount of organic waste. It was noted a difference of 199.911 g day^{-1} in the first two weeks. Stocking density proportion increase (228%) is lower compared with organic waste proportion increase (1,169%). Total organic waste released into the river during 16 week cultivation is 6240.761±46.188 g for cage unit I and 36606.217±198.824 g for cage unit II. This result was the same as the report of Machbub (2010). He reported the increase of discharged organic waste into Saguling, Cirata and Jatiluhur reservoirs due to the increase number of floating net cages. It would led the increase of feed where finally affected the organic waste. It was also reported by McDonald et al (1996) that the increase of fish feed was directly followed by an increase in organic waste, due to the fact that 25-30% of feed is excreted by the fish.

Phosphorus waste. The total of P waste on Riam Kanan river which came from caged fish cultivation activity was measured by multiplying organic waste amount and total P level in the organic waste. The total of P on organic waste of caged fish on Sungai Alang is shown in Table 2.

The total of P level generated from activity of caged fish cultivation increased following the periods of cultivation. The lowest P level was found in the first second weeks of cultivation. The highest P level was noted in the last period of cultivation (sixteen weeks). This result suggested that the bigger and the older the fish, the higher P level would be produced.

The total of P level was influenced by the stocking density. The higher stocking density (cage unit II) produced more than seven times higher of P total compared to the lower stocking density (cage unit I). This result was corroborated by the studies of Boyd et al (1998) and El-Naggar et al (2008). They concluded that the higher the stocking density, the higher P total amount found in the river.

Table 2

Total of P level in leftover feed and feces of caged fish cultivation

Cultivation period (week)	*Total P (g day^{-1})*	
	Cage unit I	*Cage unit II*
2	0.012	0.138
4	0.014	0.135
6	0.019	0.129
8	0.025	0.127
10	0.033	0.166
12	0.049	0.246
14	0.059	0.337
16	0.071	0.378
Total	3.952	23.184

River carrying capacity. In this research, the level of river carrying capacity used for caged fish cultivation was determined by P total content of water. Total P in fish feed is a source of water pollutant which usually causes eutrophication (Machbub 2010). Thus, this parameter is used as river carrying capacity for caged fish in Riam Kanan river (Costa-Pierce 1998; Lin et al 2003; Nabirye et al 2016).

To determine river carrying capacity for caged fish cultivation based on P total waste amount we used the approach proposed by David et al (2015). Total of P waste amount was calculated based on the river capacity to receive tolerable P total waste amount from activity of caged fish cultivation so that the fish farmers can have caged fish cultivation sustainable. Determining the capacity is based on the measurement of P total ambience and tolerable P total clarity threshold for fresh water fish cultivation.

Based on the calculation of P total waste amount of caged fish cultivation, the maximum capacity of allowed P total was obtained, $L_{fish} = \Delta P * \acute{Z} * \rho /(1- R_{fish}) = 508.9482$ mg m^{-2} = 0.509 g m^{-2}. Then P total amount per cage unit compliant with river carrying capacity was L_{fish}* cage size = 0.509 g m^{-2} * 4.375 m^{2} = 2.2266 g. The number of cages that can be sustainable used was determined by dividing carrying capacity per cage unit with P total amount produced by cage unit I and II. The number of cage unit I is 2.2266 g/0.035 g + 63.618 units (63-64 units). The number of cage unit II = 2.2266 g/0.207 g = 10.757 units (10-11 units). The average P total level per cage unit with stocking density of 50 fish m^{-2} is 0.035 g P total day^{-1}. The average P total level per cage unit with stocking density of 114 fish m^{-2} is 0.127 g P total day^{-1}.

The number of cages with stocking density of 114 fish m^{-2} in compliant with river carrying capacity is 2.2266 g/0.127 g = 17.5323 (17-18 units). The number of cages with stocking density of 50 fish and 114 fish m^{-2} along 100 m of the river with 16 week cultivation time and producing 84.7 kg and 172.5 kg each cage -1 ranges from 63-64 and 17-18 units. The layout consisting of 60 cages with stocking density of 220 fish and with the measurement of 2.5 m in length, 1.75 m in width and 1 m in height is as follow:

- the number of cages in across position is 4 units. There is one meter gap every 2 cage units;
- the number of cages in longitudinal position is 15 units. There is an 8 meter gap every 3 cage units;
- 1/3 part of the river transverse space is used.

Conclusions. The level of P total resulted from caged fish cultivation was varied based on organic waste amount produced. Although there was a tendency of increasing amount of P total as the fish grew.

To support the sustainability of caged fish cultivation in Sungai Alang, the number of cage units must be limited. The size of the cage suggested is 2.5 m x 1.75 m x 1 m. There should be only around 60 units of cages every 100 m with stocking density of 50 fish m^{-2}. The allocation of space for cages across the river is 4 cage units which there should be 1 meter gap every 2 units. The number of cages in longitudinal position is 15 units which there should be 8 meter gap every 3 units of cages.

References

Apriyantono A., Hermanianto J., Nurwahid, 2003 [Guide for halal production]. Department of Religion, Jakarta, Indonesian Republic, 133 pp. [in Indonesian]

Beveridge M. C. M., 1984 Cage and pen fish farming. Carrying capacity models and environmental impact. FAO Fisheries Technical Paper, No. 255, 131 pp.

Boyd C. E., 1999 Management of shrimp pond to reduce the eutrophication potential of effluents. The Advocate, December 1999, pp. 12-14.

Boyd C. E., Massaut L., Weddig L. J., 1998 Towards reducing environmental impacts of pond aquaculture. INFOFISH International 2:27-33.

Buschmann A. H., Lopez D. A, Medina A., 1996 A review of the environmental effects and alternative production strategies of marine aquaculture in Chile. Aquacultural Engineering 15(6):397-421.

Costa-Pierce B. A., 1998 Constraints to the sustainability of cage aquaculture for resettlement from hydropower dams in Asia: an Indonesian case study. Journal of Environment and Development 7:333-368.

David G. S., Carvalho E. D., Lemos D., Silveira A. N., Dall'Aglio-Sobrinho M., 2015 Ecological carrying capacity for intensive tilapia (*Oreochromis niloticus*) cage aquaculture in a large hydroelectrical reservoir in Southeastern Brazil. Aquacultural Engineering 66:30-40.

Department of Marine and Fishery in Banjar Regency, 2007 [Banjar Regency Marine and Fishery Statistic Annual Report Year 2006]. South Kalimantan Marine and Fishery Department, 139 pp. [in Indonesian]

El-Naggar G. O., Ibrahim N. A., Abouzead M. Y., 2008 Influence of fertilizers' types and stocking density on water quality and growth performance on Nile tilapia-African catfish in polyculture system. 8th International Symposium on Tilapia in Aquaculture, pp. 157-170.

Haya K., Burridge L. E., Chang B. D., 2001 Environmental impact of chemical wastes produced by the salmon aquaculture industry. ICES Journal of Marine Science 58:492-496.

Johnsen R. I., Grahl-Nielsen O., Lunestad B. T., 1993 Environmental distribution on organic waste from a marine fish farm. Aquaculture 118:229-224.

Lin C. K., Yi Y., Phuong N. T., Diana J. S., 2003 Environmental impacts of cage culture for catfish in Chau Doc, Vietnam. Aquaculture Collaborative Research Support Program. Sustainable Aquaculture for a Secure Future. Available at: http://pdacrsp.oregonstate.edu/pubs/workplns/wp_10/10ER3.html. Accessed: May, 2017.

Lupatsch I., Kissil G. W., 1998 Predicting aquaculture waste from gilthead seabream (*Spams aurata*) culture using a nutritional approach. Aquatic Living Resources 11 (4):265-268.

Machbub B., 2010 [Model for the carrying capacity calculation of pollution in lake and water reservoir]. Jurnal Sumber Daya Air 6(2):103-204. [in Indonesian]

McDonald M. E., Tikkanen C. A., Axler R. P., Larsen C. P., Host G., 1996 Fish simulation culture model (FIS-C): a bioenergetics based model for aquaculture waste load application. Aquacultural Engineering 15(4):243-259.

Meade J. W., 1989 Aquaculture management. An Avi Book, Van Nostrand Reinhold, 175 pp.

Nabirye H., Mwebaza-Ndawula L., Bugenyi F. W. B., Muyodi F. J., 2016 The evaluation of cage fish farming effects on water quality using selected benthic macro-invertebrate community parameters in the Napoleon gulf, Northern Lake Victoria. International Journal of Fisheries and Aquatic Studies 4:42-50.

Phillips M. J., Clarke R., Mowat A., 1993 Phosphorous leaching from Atlantic salmon diets. Aquacultural Engineering 12:47-54.

Rahman M., 2012 [Carrying capacity analysis of aquatic environment for cage fish cultivation development at Riam Kanan stream]. PhD thesis, Postgraduate Program, Faculty of Agriculture, Brawijaya University, 101 pp. [in Indonesian]

Schmittou H. R., Cremer M. C., Zhang J., 2004 Principles and practices of high density fish culture in low volume cages. American Soybean Association. Available at: http://www.soyaqua.org/asaimusbtech/lvhdcagemanual/prefacetoc.pdf. Accessed: May, 2017.

Wahyuni S. L., 2009 Water quality status at Riam Kanan Stream. Case study at Water body of West Awang Bangkal Village. Master Thesis, Program Study of Environmental Resources Management Post graduate of Lambung Mangkurat University, 126 pp.

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