| J.Tek.Ling | Vol. 7 | No. 3 | Hal. 303-310 | Jakarta, Sept. 2006 | ISSN 1441 – 318X |
|---|---|---|---|---|---|

# CONTRIBUTION OF THE ORGANIC WASTE FROM FISH CULTURE ON THE DEGRADATION OF WATER QUALITY OF RESERVOIR CIRATA

**Yudhi Soetrisno Garno**

Researcher in Center for Environmental Technology
Agency for Asessment and Application of Technology.

## *Abstract*

*Cirata is one of three reservoirs lay in Citarum River, where the water body is used to fish culture in floating net. Lately, one or two times in a year, fish in the floating net die massly because of the water quality of reservoirs have worsen, which resulted from the entering of organic pollutant from human being activities in and outside of the Reservoir. This paper is written to reveal contribution of organic waste from fish culture in floating net represented human being activities inside of the Reservoir on the worsening of water quality Cirata. The result revealed that the Reservoir Cirata continually has been polluted by organic waste, which gradually resulted in the worsening of water quality indicated by increasing chemical oxygen demand (COD) and concentration of chlorophyll-a (Chl-a), and decreasing secchi disk. This study indicated that on 1997, fish culture using floating net (internal loading) in Reservoir Cirata contribute the nutrient three times than domestic and agriculture (external loading). This situation is guessed still going on hitherto, therefore the reservoir become very hypertrophic, as giant cesspools, and resulted in death of fish massly*

***Key words:*** Cirata, organic waste, fish culture, water quality.

## 1. INTRODUCTION.

### 1.1. Reservoirs in Citarum River.

Citarum is the biggest river in West Java; which on this river have been constructed three big reservoirs; namely Saguling in the upstream , Cirata in the middle and Juanda in the downstream. Initially reservoirs are constructed for hydroelectric power, flood control, and irrigation, but thereafter reservoirs also useful to water supply (industry & household), tourism and fish culture, and hence reservoirs is recognized also as the multipurpose reservoirs. Characteristics of these reservoirs are presented in Table-1.

Now besides the main function, economic social activities which is many conducted in reservoirs, is fish culture using floating net. Amount of the floating net in each resevoir, have increased at full speed till exceeded the carryng capacity. Consequently, floating net have been anticipated to become the source of organic pollutant.

Lately, it has been known that fish in the floating net often die massly. This phenomenon indicate that the water quality of reservoirs have deteriorated.

Previous papers[1,2,3] reveal that the worsening of reservoir water quality is resulted from the increasing organic waste, especially those which come from the floating net. Based on those informations, hence in attempt to pare the contribution of organic waste from fish cultur this paper is compiled. Furthermore, because of the highest amount of floating net was in Reservoir Cirata, hence this paper will pare only the organic waste in Cirata.

Table-1, Characteristics of reservoirs on Citarum watershed.

| Items | Saguling | Cirata | Juanda |
|---|---|---|---|
| Location | Bandung | Bandung, Cianjur, Purwakarta | Purwakarta |
| Year operation | 1985 | 1988 | 1967 |
| Altitude | 645 | 221 | 116 |
| Surface area (Ha) | 5.340. | 6.200 | 8.300 |
| Catchments area (Ha) | 334.300 | 603.200 | 659.000 |
| Volume ($10^3$ $m^3$) | 982 | 2.165 | 2.970 |
| Maximum depth (m) | 90 | 106 | 90 |
| Mean Depth (m) | 18 | 35 | 36 |
| Water level fluctuation (m) | 20 | 20 | 25 |
| Hydroelectric power (MW) | 700 | 1.000 | 150 |
| Main Function | Hydroelectric Power | | irigation |

Sources: Anonym[4] , Brahmana dan Akhmad[1] .

### 1.2. Aim of the paper

This paper is written to describe the contribution of organic waste from fish culture using floating net on the degradation of water quality of Reservoir Cirata.

## 2. Fish culture and their organic waste in Cirata.

### 2.1. Floating Net and Their development

Fish culture in Reservoir Cirata actually is an activity of fish fattening using a floating net. The floating net is made from nylon multifilament with mesh size 1–1.25 inch. The raft from bamboo, float from oil drum as 8-12 per unit, and binder of oil drum used wood, metal wire and plastic. The singker used to protect the net from water current. Every floating net was completed with guardhouses, and transportation facilities (boat, canoe and bamboo raft). Usually a unit floating net was consisting of 4 (four) set of floating nets. A set of floating net is 7 x 7 $m^2$ with 3 m depth.

Commonly. fish fattening is carried out with feeding 3 times in a day. Feeding is done till the cultured fish reject the fish food. This feeding strategy have been guessed to result in high organic waste because partly food is revomited. (superfluous feeding). With this strategy, a set of floating-net able to produce fish a. 4.5 $ton \cdot y^{-1}$ [5].

Fish culture using floating net in Reservoir Cirata was begun in 1988 with only 74 set of floating nets. Afterwards because of quality of water is still good and suited for fish, and also product marketable. The amount of floating net

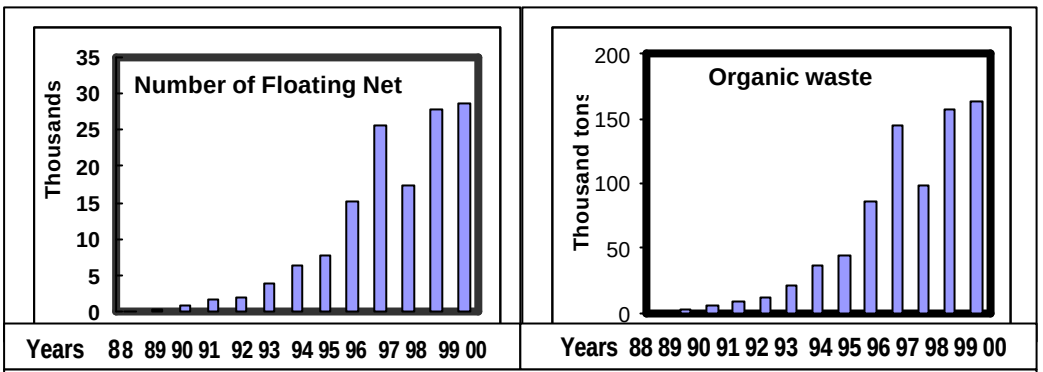


**Figure 1. Development of the floating net number and aproximation of their organic waste in Cirata reservoir.**

increased rapidly and attained the maximum amount 25.558 on 1997 (Figure-1). Figure-1 indicate that on 1998 the amount of floating net have time to decrease to become 17.477 and then increase again to 28.738 on 2000. It must be paid attention that, the decrease of the amount of floating net on 1998 was due to economic crisis in Indonesia, which it resulted in, price of fish food increase faster than fish meat price, and hence the farmers sustain a loss and the capital decrease. Thereafter there are no data of the number of floating net, but according to some farmers in Cirata (p.c), the number of floating net in Cirata after 2000 till now was relatively stable. Therefore it could be assume that since 1997 hitherto, the organic waste from the floating net, which enters to Reservoir Cirata, was same with those on 1997.

Figure-1 indicate that, as the tendency of net amount, the organic waste from the fish culture also increase gradually from 1988 to 1996, and thereafter the organic waste increase vigorously due to increasing the amount of net. The organic waste attain the maximum amount on 2000. It is 162,944 ton•organic, which contain of 7,119 ton•N and 1,018 ton•P

### 2.2. Fish Production and Their Organic Waste

In the previous publications; Iriana[5] reveal that in Reservoir Cirata, a set floating net in a year able to yield about 4.5 ton•fish•y$^{-1}$, whereas Garno[6] reveal that to yield fish 1 ton require fish food 1.51 ton. Base on these suggestions, the production and their organic waste is calculated. Production is obtained from multiplication of amount of net with 4.5 ton•fish•y$^{-1}$, whereas the organic waste is obtained with formula of Schmittou[7]. As an example, tabel-2 is calculation of organic waste from 28,738 floating net, which occured on 2000.

## 3. DISCUSSION

### 3.1 Worsening of the Water Quality of Reservoir Cirata.

Study on some refferences about concentration of organic matter in the water body of Reservoir Cirata yield figure-2. In general, figure-2 indicate that from 1991 till 2000 the concentrations of organic matter in water body, represented by COD and BOD increases markedly. Undoubtedly, it is due to increasing organic waste, enter from inside (internal loading) and outside (external loading) the Reservoir Cirata.

**Table-2. Calculation of organic waste from fish culture in Reservoir Cirata on 2000, with number of floating net is 28,738.**

| No | Item | Procentage (%) | Quantitiy (kg) | Note |
|---|---|---|---|---|
| 1 | Input<br>Fish food<br>water<br>N concentration<br>P concentration | <br>100.0<br>5.0<br>5.5<br>1.2 | <br>195,274,710<br>9,763,735<br>10,740,109<br>2,343,296 | <br>FCR = 1.51<br>Bervariasi 0.8-2.2% |
| 2. | Output<br>Fish (wet-weight)<br>Fish (dry-weight)<br>N concentration<br>P concentration | <br>100.0<br>25.0<br>11.2*<br>4.1* | <br>129,321,000<br>32,330,250<br>3,620,988<br>132,554 | <br>**28,738** x 4.500 kg<br>* : of dry weight |
| 3. | Metabolik waste<br>Organic<br>N concentration<br>P concentration | | 162,944,460<br>7,119,121<br>2,210,741 | Input-output dry weight<br>N food - N fish<br>P food - P fish |

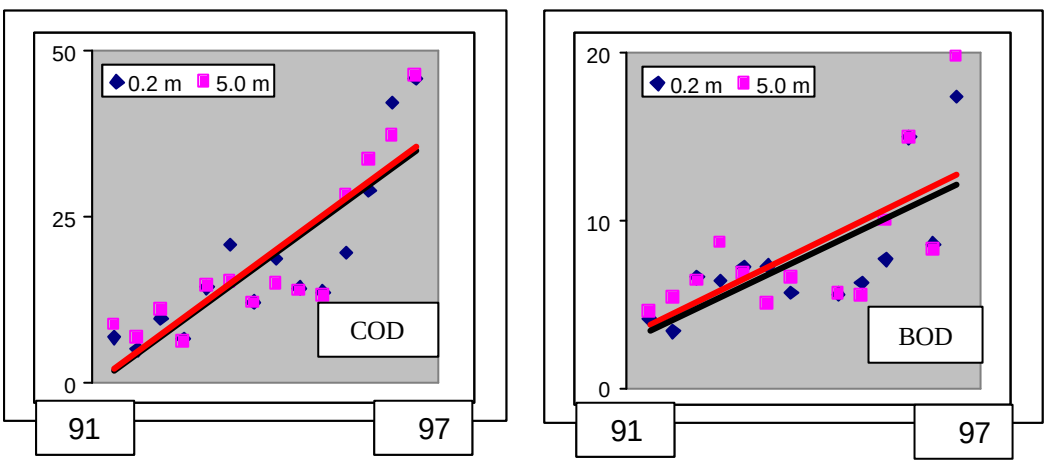


Figure-2. Changes in COD (mg•liter$^{-1}$) and BOD (mg•liter$^{-1}$) of Cirata Reservoir from 1991 to 1997.

In Reservoir Cirata, internal loading is represented by organic waste from the floating net, whereas external loading is represented by organic waste from domestic and agricultural activities. In attempt to known the contribution of organic waste in form of nutrient some result of study about organic waste in the form of nutrient is presented in table-3. Tabel-3 indicates that nitrogen and phosphorus, which enter from domestic is only 33 % and 29% of those from fish culture, whereas from agriculture is only 0.08% and 0.01% of those from fish culture. Because of the estimation of organic-waste from domestic only relied on the amount of resident with assumption without considering the existence of waste treatment and

missing before enter to reservoir, hence it can be guessed that percentage of nitrogen and phosphorus of domestic are lower than respective 33% and 29%. Thus it could be concluded that in Reservoir Cirata organic pollution, even eutrophication have been mastered by organic waste of fish culture using floating net. This situation is guessed still going on till now, because the accretion of agricultural activity and resident around Cirata are not as soon as the floating net. This phenomenon differs from similar case on the other reservoir, which the worsening of water quality is resulted in organic waste from human activity in the outside of reservoir (external loading).

Tabel-3. Prediction of nutrient enter to Reservoir Cirata from some sources (ton•th$^{-1}$• reservoir$^{-1}$).

| Pollutant sources | Nutrient | | References |
|---|---|---|---|
| | Nitrogen | Phosphorus | |
| Domestic | 2,111.20 | 276.64 | Brahmana dan Achmad, [1]. |
| Agricultural | 5.00 | 0.10 | Anonym [8]. |
| Husbandry/animals | - | - | |
| Industrial | - | - | |
| Fish culture | 6,331.36 | 966.12 | result of calculation above |
| Total (ton•y$^{-1}$•r.$^{-1}$) | 8,447.56 | 1,342.86 | |

**3.2. Decomposition and the effect on the water quality.**

It has been known that, the increase of organic waste in the water body either in, the water layer that aerob or anaerob will be followed by decomposition. In the aerobic water, decomposition consume oxygen and release nutrient, like nitrogen and phosphorus. It mean that more many organic waste entering and remain at aerobic water will more and more also require oxygen and releasing nutrient.

In Reservoir Cirata the increase of oxygen consumption to decompose organic waste, has resulted in decreasing oxygen concentration in the water body, even it has reduced the water thickness that aerobic. This phenomenon result in the thickness of aerobic layer in upper layer gradually becomes thin, whereas the thickness of anaerobic layer in deep layer gradually becomes thick. It has been reported that on the year of 1994 the dissolved oxygen in the Reservoir Cirata could be detected until the bottom (Anonym. 1995), on 1999 until the depth of about 8-10 m (Garno, unpublished data) , but lately it was only could be detected until the depth of 4-5 m (Garno et. al, 2007 in prep.).

Meanwhile, the nutrient that released from the decomposition, especially nitrogen and phosphorus resulted in the water body of Reservoir Cirata become eutrophic; and it has resulted in the density of alga increase sharply from year to year, which it is shown in table-4. Table4 reveal that from year to year the concentration of Chl-a increased sharply due to increasing alga density. It was 1.98-2.15 µg•l$^{-1}$ on the year of 1992; 7.7-10.6 µg•l$^{-1}$ on the year of 1996; 33.3-61.3 µg•l$^{-1}$ on the year of 1997 and 26.4-29.0 µg•l$^{-1}$ on the year of 2003. On the contrary, the water transparency tends to decrease from 180-220 cm on 1991 to 55-80 cm on

1997. This phenomenon occurred due to the increase of algal density result in decreasing the penetrability of sunshine. All the occurrences above are some of mark of the worsening of the water quality of Reservoir Cirata, which resulted from increasing nutrient (eutrophication).

Meanwhile, the nutrient that released from the decomposition, especially nitrogen and phosphorus resulted in the water body of Reservoir Cirata become eutrophic; and it has resulted in the density of alga increase sharply from year to year, which it is shown in table-4. Table4 reveal that from year to year the concentration of Chl-a increased sharply due to increasing alga density. It was 1.98-2.15 $\mu g \bullet l^{-1}$ on the year of 1992; 7.7-10.6 $\mu g \bullet l^{-1}$ on the year of 1996; 33.3-61.3 $\mu g \bullet l^{-1}$ on the year of 1997 and 26.4-29.0 $\mu g \bullet l^{-1}$ on the year of 2003. On the contrary, the water transparency tends to decrease from 180-220 cm on 1991 to 55-80 cm on 1997. This phenomenon occurred due to the increase of algal density result in decreasing the penetrability of sunshine. All the occurrences above are some of mark of the worsening of the water quality of Reservoir Cirata, which resulted from increasing nutrient (eutrophication).

Table-4. Changes in secchi disk, Chl-a and algal density in Reservoir Cirata between 1989-2004, and classification of trophic status by OECD*).

| Items | Year | | | | | | Eu-trophic | Hyper trophic |
|---|---|---|---|---|---|---|---|---|
| | '89 | '92 | '96 | '97 | '03 | '04 | | |
| Secchi disk (Cm) | 180-220 | 120 | - | 55-80 | - | - | 300-150 | <150 |
| Chl-a ($\mu g \bullet l^{-1}$) | | 1.98 s.d 2.15 | 7.7 s.d. 10.6 | 33.3 s.d 61.3 | 36.3 s.d 49.1 | 26.7 s.d 29.0 | 8.8-25 | >25 |
| Algal density ($10^6$) | | | - | 44.3 s.d 62.3 | | | | |

Source : Anonym [9,10].and Henderson dkk[11].
s.d = berkisar antara ..... sampai dengan.

Finally, It must be paid attention that, comparing data of 1997 at table-4 with the OECD suggestion about the classification of trophic status, is revealed that with secchi disk (transparency) 55 cm and Chl-a 33.3-61.3 $\mu g \cdot l^{-1}$, the water body of Reservoir Cirata is classified as hypertrophic waters. Those suggestion is supported by the density of alga which, on 1997 reached 44.80-62.28 $10^6 \bullet l^{-1}$. and dominated by microcystis, which it have been known as poisonous alga.

In previous chapter, it has been guessed that the thickness of anaerobic layer in Reservoir Cirata decrease gradually, which it is caused by the abundat organic compound in upper water deplete dissolved oxygen in those layer for decomposition. In this anaerobic layer, decomposition organic compound yield gass, like H2S, ammonia and metan, which at certain concentration level is poisonous and can endanger other organisms. This poisonous compounds are similar with the degradation of dissolved oxygen in aerobic layer that on certain concentration also will be able to kill the existing water organisms, even if big fish in the floating net.

Finally, it must be paid attention that besides causing degradation of

dissolve oxygen concentration and release poisonous compound that always harm and can cause death of organisms; decomposition also can create the suitable water body for live of microbe of fatogen; consist of microbe, protozoa and virus [12]. which after grown, every moment can attack and kill other organisms, like fish.

### 3.4. Organic Waste and phenomenon of death of fish massl y.

Base on discussion above, it could be stated that in ordinary day, water body of Reservoir Cirata consist of two layer; aerobic water body layer in upper water body and anerobic layer, which exist in under of aerobic wate body. Now, it is guessed that the anaerobic water body layer more and more thickly, and urgent the aerob water body layer to upper waters, so that aerobic water body layer remains only some metre. This condition very dangerous and unhealthy, because when happened lacking of oxygen supply ; the dissolved-oxygen can completely lost, and the poisonous compounds can emerge on the upper waters.

In Reservoir Cirata, the phenomenon was occurred every years, when the cloudiness occurred more than two days, implys there are no sunlight enter to water body. In condition unsufficient of light, photosynthesis do not occured and consequently there are no oxygen contribution from the alga, to refilling the used oxygen for decomposition. It means that, if the unsufficient of light occur continuously, hence the dissolved-oxygen in the water body will used up except topmost water layer, which it make contact directly with air. On this condition, fish only can life in upperest waters, even if there are small fish begin to die.

On the other hands, cloudiness more than three days can resulted in, a condition where the lower water layer become warmer than the upper water layer. If this difference of water temperature become big, consequently is the lower water layer, which become lighter because of warmer than the upper, will climb to surface by bringing organic waste and poison that exist on the layer. This occurence resulted in the water body totally become anoxic and poisonous, therefore organisms in reservoir die massly, including fish in floating net.

Finally it have been guessed that lately, the mass death of fish more and more hard due to the attack of Koi-herves-Virus, which able to lived better in the water body of Reservoir Cirata that it has worsen.

## 4. CONCLUSION

The present study revealed that the Reservoir Cirata continually has been polluted by organic waste, which gradually resulted in the worsening of water quality indicated by increasing chemical oxygen demand (COD) and concentration of chlorophyll-a (Chl-a), and decreasing water transparency (secchi disk). This study indicated that on 1997, fish culture using floating net (internal loading) in Reservoir Cirata contribute the nutrient three times than domestic and agriculture (external loading). This situation is guessed still going on hitherto, therefore the reservoir become very hypertrophic, as giant cesspools, and resulted in death of fish massly

## REFERENCES


1. Brahmana S.S. dan F. Achmad, (1997): Eutrophication in Three Reservoirs at Citarum River and Its relation to Beneficial uses. Workshop On Ecosystem Approach to Lake and Reservoir Management.

2. Sukimin, S., M. Ulama dan D.G. Bengen, 1997. Water Quality Observations and Floating Cages Arrangements For Fisheries at Juanda Reservoir. Work shop on Ecosystem Approach to Lake and Reservoir Management. *139-166*

3. Garno,Y.S (2002): Beban Pencemaran Limbah Perikanan Budidaya dan Yutrofikasi di Perairan waduk pada DAS Citarum. J. Tek. Ling. P3TL-BPPT. 3 (2): *112-120.*
4. Anonym, (1995): Laporan Hasil Penelitian Kualitas Air PLTA Cirata.Pusat Penelitian Sumber Daya Alam dan Lingkungan, Lembaga Penelitian Unpad, Bandung.
5. Iriana, D. (2000): Prospek Pengembangan Agribisnis Perikanan Di Danau Melalui Aspek Kemitraan. Pros. Sem-Nas. Pengelolaan dan Pemanfaatan Danau dan Waduk. UNPAD Bandung. II.1-15
6. Garno, Y.S (2000): Status Kualitas dan Struktur Fitoplankton di Bendungan Multiguna Cirata. Proseding Sem-Nas. Pengelolaan dan Pemanfaatan Danau dan Waduk. IPB, Bogor hal. XXV:1-8.
7. Schmittou, H.R., (1991): Cage Culture: A methode of Fish Production in Indonesia.
8. Anonym, (1998): Cirata and Saguling Environmental Studies and Training. Environmental Division, Directorate of Operation PT PLN.
9. Anonym, (1994): Data Tahunan Kualitas Air 1989, 1990, 1991, 1992. Pusat Penelitian dan Pengembangan Pengairan, Departemen Pekerjaan Umum.
10. Anonym. (1996): Laporan Hasil Penelitian Kualitas Air PLTA Cirata. Pusat Penelitian Sumber Daya Alam dan Lingkungan. Lembaga Penelitian Unpad. Bandung.
11. Henderson, B., Sellers dan Markland, H.R., (1987): Decaying Lakes "*The Origins and Control of Cultural Eutrophication"* John Wiley & Sons, Chichester- Singapore, pp. *254.*
12. Polprasert C. (1989): Oeganic Water Recycling. Jhon Wiley & Sons, Chichester.