ECO-TECHNOLOGICAL WATER TREATMENT FOR SMALL SCALE FISH FARMING IN URBAN SETTLEMENT

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ABSTRACT

Every day, domestic activities in every household result black water (septic tank wastewater), yellow water (urine) and grey water (kitchen and detergent). Based on the quantity of grey water and land availability for fish pond, it is estimated that the grey water can be used for fish ponds. In this research, grey water resulted from eco-technological treatment is re-used for small scale fish ponds which were built since 2007. The research was carried out at the Dano housing site, Kabupaten Sumedang, The applied study method evaluated pond water resources quality to the standard for fishery included in Criteria Class 2 of PP No: 82/2001. The research results show that treatment efficiency of eco-technology for BOD ranges between 37.8% - 44.4 %; COD: 47.5% - 61.3%; DO : 39 - 70 %. Water quality parameters of pH, temperature and DO are dominant factors to affect the growth of fish although BOD and COD parameters are not suitable with Criteria Class 2 of PP No: 82/2001. This phenomenon shows that grow of fish can be abundant in these waters. In addition, there are some other benefits of the re-use of fish pond water by eco-technological treatment i.e. improvement of protein need and family income, and conservation of the environment.

Key words: ***Eco-technology, re-used water, grey water, small scale fisheries***

SUMMARY

The study was carried out in the fish ponds of the housing complex 'Dano' in Sumedang-West Java that were operated since 2007. Water for the fish ponds were obtained from two sources: source 'a' (grey water resulted from Eco-Technology treatment, capacity 0.03-0.04 L/sec) and source 'b' (other sources supplied by the drainage system in paddy fields, capacity 0.09-0.10 L/sec). Ratio of other water resources is 2.5 to 3 times greater than the discharge resulted by grey water.

The applied study method evaluated pond water resources quality to the standard for fishery included in Criteria Class 2 of PP No: 82/2001.Objective of the study is identify the quality of grey water resulted by eco-technology for the use of small scale fish cultivation at urban settlement.

The three spacies of aquatic plants used are *Typha Sp; Pontederia Cordata* and *Cyperus Alternifoliu.* However, after one year only one species (*Cyperus Alternifolius)* had grown abundantly, shifting the area of the two other plant species.

Water quality parameters resulted from grey water treatment by Eco – Technology met the water criteria for fishery, i.e. DO, before treatment 3.1 - 3.3 mg/L after treatment increase to 4.3 - 5.6 mg/L (Criteria 4 mg/L). Five parameters (BOD, COD, T Phosphate, Detergent and Phenol) did not met the criteria for fishery water, due to treatment results exceeding the criteria namely : BOD 45 - 69 mg/L (Criteria 3 mg/L); COD 60 - 84 mg/L (Criteria 25

mg/L); T Phosphate 0.774 - 0.841 mg/L (Criteria 0.200 mg/L); Detergent 0.711 - 0.821 mg/L (Criteria 0.20 mg/L); and Phenol 0.024 - 0.028 mg/L (Criteria 0.001 mg/L).

The effluent resulted by Eco – Technology treatment did not show great influence as indicated by the content of BOD, COD, T Phosphate, Detergent and Phenol which indicated better quality than the fish pond although these parameters did not fulfil the water fishery criteria that is : BOD : 13 - 15; COD : 20 - 33 mg/L ;T Phosphate 0.326 - 0.439 mg/L; Detergent : 0.261 - 0.386 mg/L and Phenol:0.020 mg/L. This condition is occurred because of the aditional water supply from the drainage system of paddy fields.

Three fish pond water quality parameters (pH 7 - 7.1, temperatur 24 - 25.2 ^{o}C and DO 5.6 - 6 mg/L) are very dominant in fish growth although BOD and COD content are not meeting the criteria. This is indicated by the fish growth as follow : (1). 'Nila' : 20 young fish in 1 kg, after 6 months 10 grown fish in 1 kg; (2).'Bawal': 7 young fish in 1 kg, after 6 month 3 grown fish in 1 kg (3). Fish production per year showed 300 kg.

The advantage of grey water recycling for fish cultivation includes : (1) Increase of family protein consumtion from own fish pond and economizing food expenses with Rp 120,000 per month; (2). Non-consumed fish can also increase family income with 156 kg/year (Rp.1,950,000/year), so that breakdown of cost (Rp 5.5 M) can be reached after three years; (3). Conservation of the environtment, because Eco-Technology can decrease grey water pollutants such as BOD,COD, Detergent, etc

CONCLUSIONS

- Eco-technology uses three types of aquatic plants i.e. *Typha Sp; Pontederia Cordata* and *Cyperus Alternifolius.* Treatment results are then used for small scale fish ponds. The efficiency of eco-technology treatment is shown by the concentration of BOD: 37.8 - 44.4 %; COD : 47.5 - 61.3%; Detergent: 83.1 - 86.5%; T-Phosphate: 63.8 - 64.2 %; Phenol : 26.3 - 27.3 %.
- Water quality parameters of pH, temperature and DO are dominant factors for the growth of fish although BOD and COD parameters are not suitable and not meeting the class II criteria of PP No: 82/2001 it has not affected the water condition. This phenomenon shows that fish can grow well in such treated water.
- Grey water treatment contribution to fish ponds shows a percentage value of 25 – 29 %, however a grey water treatment discharge comparision ratio by Eco – Technology is to be found to other water sources, in order that fish pond water quality shall meet the set criteria
- Other benefits of re-used water for fish pond are the improvement of family protein need and income, economic value, and conservation of the environment.

INTRODUCTION

Every day, domestic activities in every household result black water (faeces), yellow water (urine) and grey water (kitchen and detergent wastewater). Up to current date, service coverage of centralised treatment of domestic wastewater has reached only 2.5 million or 1% of the Indonesian population, mainly in 11 (eleven) big cities like Balikpapan, Banjarmasin, Bandung, Cirebon, Denpasar, Jakarta, Medan, Prapat, Surakarta, Tangerang and Yogyakarta (Suprihanto Notodarmodjo, 2004). While, septic tanks are still commonly used in coping with domestic wastewater disposal in urban settlements throughout Indonesia (Ratna Hidayat, 2008).

Related with the above statement, the housing site at Dano, Kelurahan Kota Kaler, Kecamatan Sumedang Utara, Kabupaten Sumedang showed also a large use of septic tanks for black water treatment, while usually grey water is directly discharged into the sewer system. Quantitatively, the resulted grey water is enough to supply fish ponds, while quality is inappropriate with the fish farming standards due to BOD showing 81 - 111 mg/L; COD 155 - 160 mg/L; Detergent: 4.86 - 5.26 mg/L and DO 3.1 - 3.3 mg/L, where water quality standards for fish farming is BOD: 3 mg/L; COD: 25 mg/L; DO: 4 mg/L and Detergent 0.2 mg/L. Grey water treatment is therefore substantial for further use

Based on the quantity of grey water and land required for fish pond, it is estimated that grey water can be used for fish cultivation. Grey-water resulted from Eco – Technology treatment is re-used for small scale fish ponds which since 2007, has been developed in the research area.

Objective of the research is to understand the service ability of re-used water from Eco – Technology treatment for small scale fish farming in urban settlement

RESEARCH HYPOTHESIS

Wastewater treatment by Eco – Technology can improve the water quality of grey water, and the water can then be re-used for small scale fish farming in urban settlements.

MATERIAL AND METHODS

1. Grey Water Production at Dano Housing Site, Kabupaten Sumedang

There are approximately 150 households at the Dano housing site, however only 25 households (92 people) use grey water for fish ponds, as shown on Figure 1.

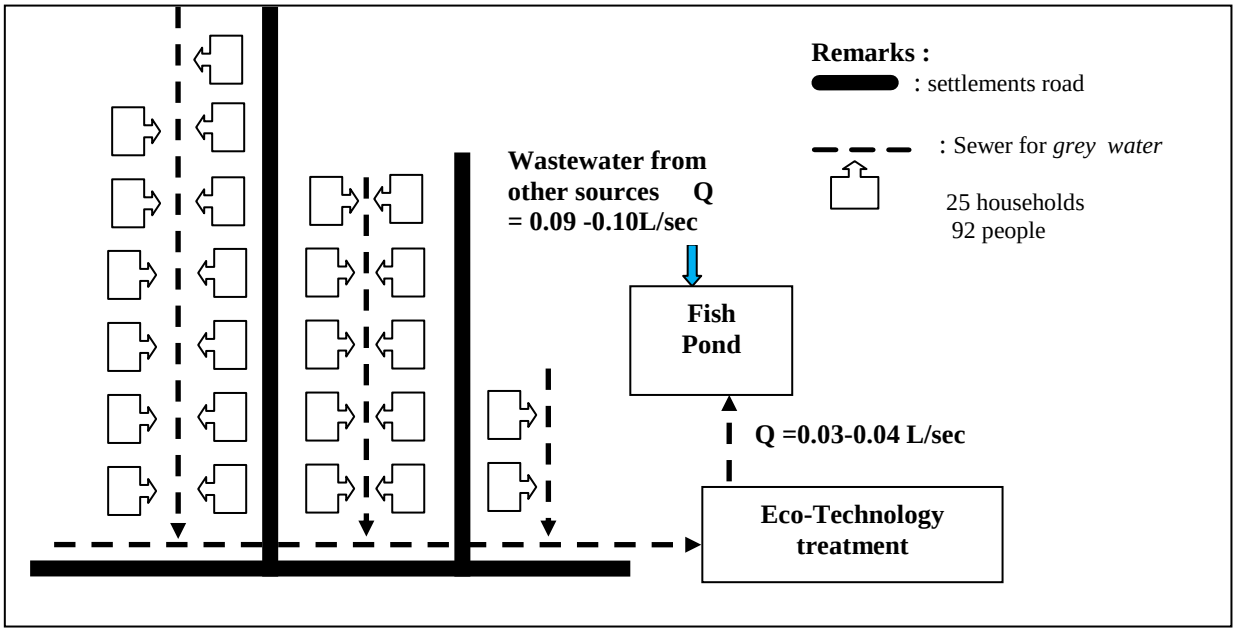


Figure 1. Diagram of Re-used Grey Water By Eco-Technology for Small-scale Fish Pond

2. Components of Small Scale Fish Farming in Urban Settlements

Small scale fish farming in urban settlements can produce the protein requirements for households. These fish ponds need a length, width and depth of 15 m, 11 m, and 1.20 m (+ 0.30m free board) respectively. Components of small scale fish farming include:

- Land for Eco-Technology application using aquatic plants for the treatment of grey water. An Eco – Technology treatment unit needs a length, width and depth of 3.m, 2.m and 0.75m (+ 0.25 m) respectively
- Adequate land slope for a gravitation flow system from grey water source into Eco-Technology unit, and from the treatment unit into fish pond.
- Suitable water quality for fish pond
- Suitable fish type and food

Research Method

This research of water quality is carried out in fish ponds at the Dano housing site, Kabupaten Sumedang that were built since 2007. Grey water treated by Eco-Technology can be re-used for fish farming.

Analytical Method

The analytical method includes: (1). Grey water quantity and quality measurements of January, 2009 (T1) and February, 2009 (T2); (2) Evaluation of Eco – Technology unit performance by comparing water quality at inlet and outlet; (3). Evaluation of water quality in fish pond treated by Eco-Technology and other sources to fish water criteria

RESULTS AND DISCUSSIONS

1. Water Quality Criteria for Fish Farming

The water quality specification for fish farming in compliance with PP No: 82/2001 on "Water Quality Management and Water Pollution Control", is classified into the Criteria Class II and III, that involve: (i). Physical parameters: Temperature; Dissolved Solids and Suspended Solids; (ii).Chemical parameters: pH; BOD; COD; DO; Total-phosphate; nitrate; free ammonia ; arsenic; cobalt; barium; boron; selenium; cadmium; chrome; copper; iron; lead; manganese; mercury; zinc; chloride; cyanide; fluoride; nitrite; sulphate; free chlorine; sulphur; (iii). Bacteriological parameters: Faecal and Total Coliform, and (iv). Organic chemistry: fat and oil; detergent, phenol and pesticide.

In this study, water quality specification for fish farming was restricted to Criteria Class II of PP 82/2001 because requirements of this criterion are stricter and therefore more applicable for safe fish farming. Since heavy metal was not detected, this parameter was neglected in the study. Apart from the identification of parameters, some scientists had determined water quality specifications for fish farming according to fish type (M.Ghufran H., Kordi K and Andi Baso Tancung, 2007). Therefore, water quality specification for fish farming can be based on:

- **Criteria Class II, PP 82/2001:** pH (6 - 9);BOD (3 mg/L); COD (25 mg/L); DO (4 mg/L); Total Phosphate (0.2 mg/L); Nitrate, NO_3-N (10 mg/L); Nitrite, NO_2-N (0.05 mg/L); Detergent (0.2 mg/L); and Phenol (0.001 mg/L)
- **Fish Type,** limited parameters i.e.: pH, temperature and Dissolved Oxygen (DO).

2. Quality and Quantity of Grey Water

Results of water quality measurements are shown on Table 1, with quality of grey water showing 0.167 - 0.170 L/sec.

Table 1: Grey Water Quality at Dano Housing Site, Kabupaten Sumedang

Parameter	Grey Water		Class II (Fish Farming Criteria)
	31 Jan, 09 :09.05	10 Feb, 09 :06.25	
Temperature, ^{0}C	24.5	22.9	Normal temperature
pH	7.8	7.6	6-9
BOD, mg/L	81	111	3
COD, mg/L	155	160	25
DO, mg/L	3.3	3.1	4
Detergent, mg/L	5.26	4.86	0.200
T Phosphate, mg/L	2.16	2.32	0.2
Nitrate, mg/L	0.128	0.121	10
Nitrite, mg/L	0.022	0.01	0.05
Phenol, mg/L	0.033	0.038	0.001

The water quality measurements resulted:

1). Grey Water Parameters Suitable with Criteria:

Temperature, pH, Nitrate and Nitrite

2). Grey Water Parameters Not Confirming with the Fish Water Criteria

- BOD : 81 - 11 mg/L (Criteria : 3 mg/L)
- COD : 155 - 160 (Criteria : 25 mg/L)
- DO :3.1 - 3.3 mg/L (Criteria : 4 mg/L)
- Detergent : 4.86 - 5.26 mg/L (Criteria : 0.20 mg/L)
- T-Phosphate :2.16 - 2.32 mg/L (Criteria : 0.20 mg/L)
- Phenol : 0.033 - 0.038 mg/L (Criteria : 0.001 mg/L)

Quality of grey water unsuitable with fish farming criteria is depicted in Figure 2 below.

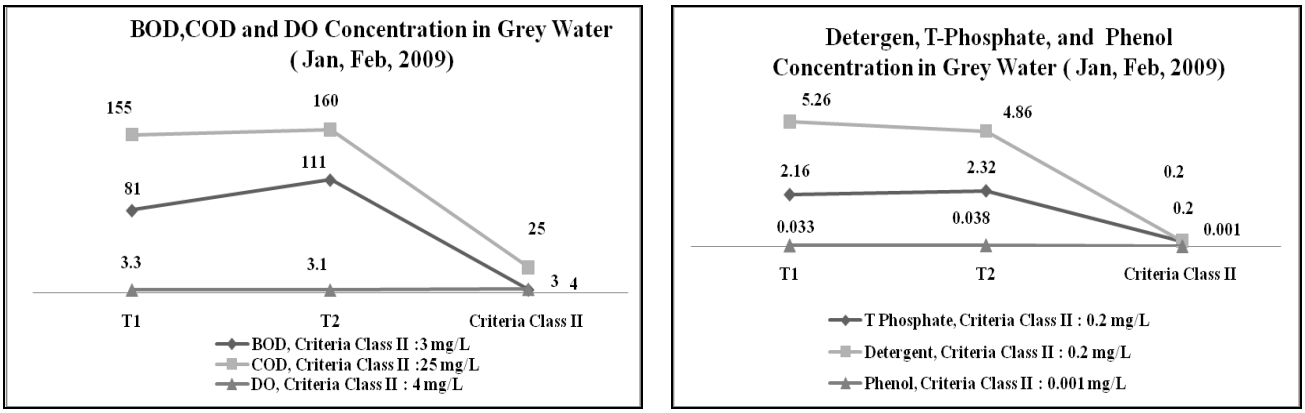


Figure 2. Grey Water Quality at Dano Housing Site, Kabupaten Sumedang (January, February, 2009)

Eco-Technology using aquatic plants can reduce pollutant parameters in order for the water to be re-used for fish farming.

3. Applied Eco-technology

a). Topography and Land Availability

Topographic conditions of the area are important factors for the use of gravitational flow because of cheap and easy operation and maintenance in Eco – Technology treatment. Estimation is a 2 (two) meters level difference between the sewer system and fish pond.

b). Dimension of the Eco – Technology Unit and Type of Plants

The dimensions of an Eco – Technology unit include length, width and depth of 3 m, 2 m, and 0,75 m (+0,25 m free board) respectively. Media of natural soil is used for the treatment of 0.167 - 0.170 L/sec of domestic wastewater inflow. Suitability of the Eco – Technology criteria can be checked by using the following formula in the analysis of hydraulic load:

$$\textbf{Hydraulic Load} = \frac{\textbf{Inflow Discharge } (m^3/day)}{\textbf{Area of Eco-Technology}}$$

Based on field measurements of wastewater inflow and unit area, the hydraulic loading of unit will be 2.405 - 2.448 $m^3/day/m^2$, while the design criteria determined by the U.S. Environmental Protection Agency (1988) is 0.014 - 0.047 $m^3/day/m^2$ (Metcalf & Eddy, 1991 and EPA, 1998). The area of an Eco-Technological unit is therefore smaller than the criteria.

c) Type of Plants

Aquatic plants selected for Eco – Technology treatment include the *Typha Sp;Pontederia Cordata and Cyperus Alternifolius (*Figure 3*). Cyperus Alternifolius sp.* grows faster the other plants, making it difficult for the other species to grow. However, plant growth is not affected by the quality of grey water.

Typha Sp ***Pontederia Cordata*** ***Cyperus Alternifolius***

Figure 3. Type of Aquatic Plants used in the Eco-Technology of Grey Water Treatment

4. Efficiency of Grey Water Treatment Eco-technology

Treatment results are shown on Table 3

Table 3. Grey Water Treatment by Eco – Technology

at 'Dano' Housing Site, Sumedang West Java

Parameters	T1			T2			Criteria Class II PP 82/2001
	1	2	3	4	5	6	
BOD, mg/L	81	45	44.4%	111	69	37.8%	3
COD, mg/L	155	60	61.3%	160	84	47.5%	25
DO, mg/L	3.3	5.6	41 %	3.1	4.3	28 %	4
Detergent, mg/L	5.26	0.711	86.5%	4.86	0.821	83.1%	0.200
T Phosphate, mg/L	2.16	0.774	64.2%	2.32	0.841	63.8%	0.200
Phenol, mg/L	0.033	0.024	27.3%	0.038	0.028	26.3%	0.001

Remarks:

1. Grey Water (Inlet Eco-Technology): 31 January, 2009 ; time: 09.05 am
2. Outlet (Treated by Eco-Technology / Inlet fish pond) , 31 January, 2009; time: 09.15 am
3 and 6 Treatment Efficiency
4. Grey Water (Inlet Eco-Technology) : 1 February, 2009; time: 06.50 am
5. Outlet (Treated by Eco-Technology / Inlet fish pond), 10 February, 2009; time: 06.54 am

Based on field measurements, results of Eco-Technology treatment can improve domestic waste water mainly for Dissolved Oxygen/DO. However, several parameters are still unsuitable with the fish farming criteria even though treated water is showing a high efficiency. These parameter results are:

- BOD : 45 - 69 mg/L (treatment efficiency: 37.8 - 44.4 %, criteria 3 mg/L)
- COD : 60 - 84 (treatment efficiency:47.5 - 61.3%, criteria 25 mg/L);
- Detergent: 0.711 - 0.821 mg/L (treatment efficiency:83.1 - 86.5 %, criteria 0.20 mg/L);
- T-Phosphate: 0.774 - 0.841 mg/L (treatment efficiency: 63.8 - 64.2 %, criteria 0.20 mg/L)
- Phenol: 0.024 - 0.028 mg/L (treatment efficiency: 26.3 - 27.3 %, criteria 0.001 mg/L).

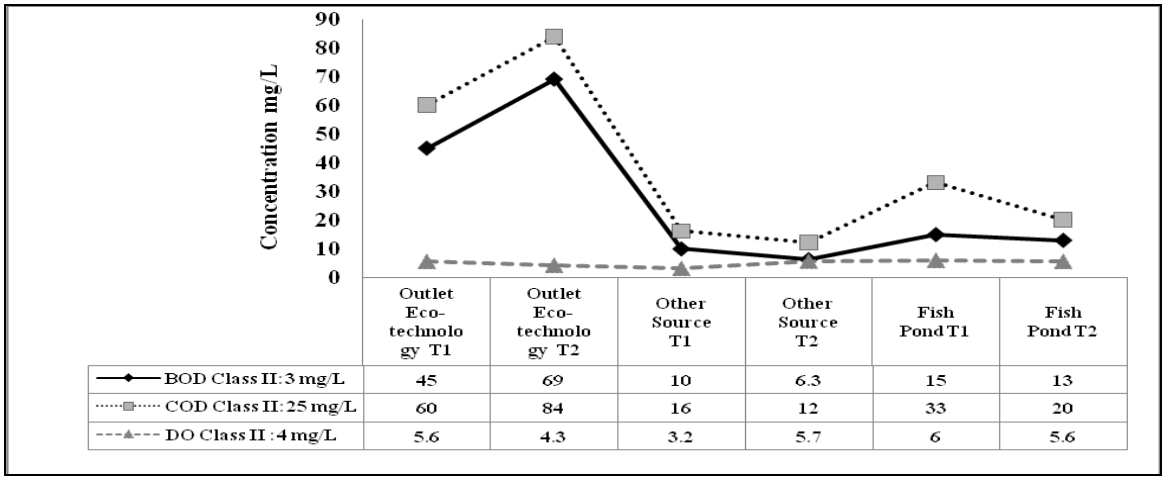
The treated grey water is then used in the fish ponds. Although some parameters of grey water are unsuitable according to the fish farming criteria, fish production has been normal since the operation in 2007.

5. Evaluation of Water Source Quality Based on Fish Farming Criteria

Evaluation for fish farming criteria had used the measurements T1 and T2 from water sources as the following:

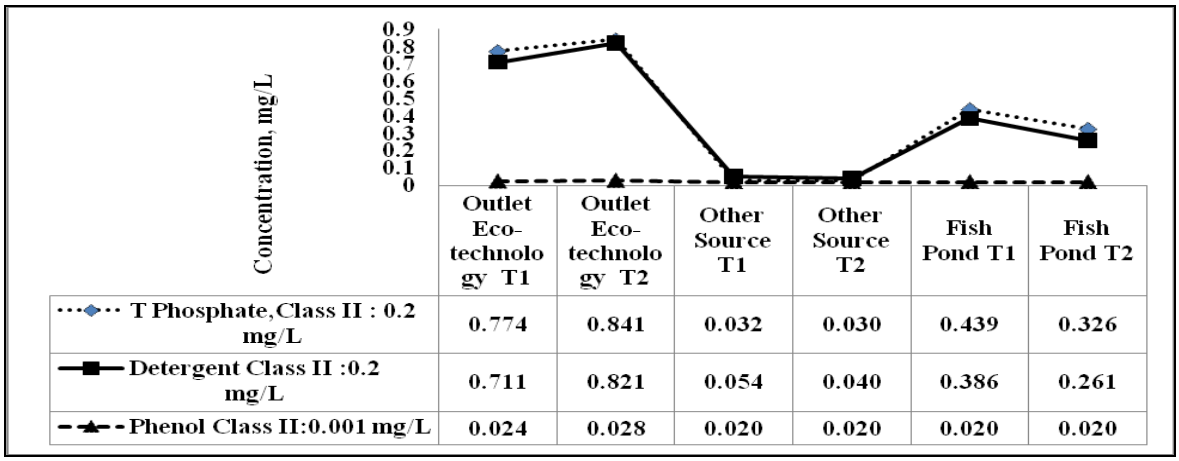
- Eco-Technology outlet: grey water treated by Eco – Technology as an inlet and water source of fish pond;
- Other source: drainage canal as raw water source for fish pond.
- Fish pond outlet: expected to be mixed due to outflow from fish pond

Water quality of the three sources and fish farming criteria are shown on Figure 4.



	Outlet Eco-technology T1	Outlet Eco-technology T2	Other Source T1	Other Source T2	Fish Pond T1	Fish Pond T2
BOD Class II:3 mg/L	45	69	10	6.3	15	13
COD Class II:25 mg/L	60	84	16	12	33	20
DO Class II :4 mg/L	5.6	4.3	3.2	5.7	6	5.6

(a)



	Outlet Eco-technology T1	Outlet Eco-technology T2	Other Source T1	Other Source T2	Fish Pond T1	Fish Pond T2
T Phosphate, Class II : 0.2 mg/L	0.774	0.841	0.032	0.030	0.439	0.326
Detergent Class II :0.2 mg/L	0.711	0.821	0.054	0.040	0.386	0.261
Phenol Class II:0.001 mg/L	0.024	0.028	0.020	0.020	0.020	0.020

(b)

Figure 4. Comparison of Water Quality at Eco-Technology Outlet, Other Source and Outlet of Fish Pond (a) BOD,COD & DO; (b) T Phosphate, Detergent & Phenol

Measurements of the compliance of water quality of the three sources with the fish farming criteria can be explained as follows:

1). Suitable According to Fish Farming Criteria:

- DO parameter for fish farming criteria is 4 mg/L, **best water quality** was found in fish pond (5.6 - 6 mg/L), **moderate** quality at outlet Eco – Technology, 4.3 - 5.6 mg/L and DO concentration at other source 3.2 - 5.7 mg/L.

2). Unsuitable According to Fish Farming Criteria:

- BOD parameter for fish farming criteria is 3 mg/L; **poor quality** - other sources (6.3-10 mg/L), **extreme poor** quality in fish pond (13 - 15 mg/L), and **poorest** quality at the Eco – Technology outlet (45 - 69 mg/L).
- COD parameter for fish farming criteria is 25 mg/L, **poor** water quality in other source (12 - 16 mg/L)**; poorer** quality in fish pond (20 - 33 mg/)L), and **poorest** quality at Eco – Technology outlet (60 - 84 mg/L).
- Total Phosphate parameter for fish farming criteria is 0.20 mg/L, **poor** quality of Total Phosphate concentration in other source (0.030 - 0.032 mg/L); **poorer** quality in fish pond

(0.326 - 0.439 mg/L), and **poorest** water quality in Eco – Technology outlet (0.774 - 0.841 mg/L).

- Detergent parameter for fish farming criteria is 0.20 mg/L; **poor** quality in other source (0.040 - 0.054 mg/L); **poorer** quality in fish pond (0.261 - 0.386 mg/L), and **poorest** quality in Eco – Technology outlet (0.711 - 0.821 mg/L).
- Phenol parameter for fish farming criteria is 0.001 mg/L, **poor** quality was shown by the phenol concentration from other sources and fish pond (from two measurements: 0.020 mg/L), and **poorer** at the Eco – Technology outlet (0.024 - 0.028 mg/L).

Above evaluation shows that only the DO parameter is meeting the requirement of fish farming criteria. The parameters BOD, COD, Total Phosphate and Detergent were not fulfilling the criteria and each parameter showed a poor condition in other sources, poorer in fish ponds and poorest condition in the outlet of Eco – Technology (inlet of fish pond). Similar condition was shown by the Phenol concentration where poor condition was shown in other sources and fish pond, and poorest quality in the outlet of eco-tech. Although BOD, COD, T Phosphate and Detergent and Phenol in the outlet of eco-tech indicated the poorest condition, however with the mixture from other sources, water quality in the outlet of fish pond had improved yet no fulfilling the water quality criteria for fish farming.
Field observation shows that the unsuitability of parameters at the outlet of fish pond is mainly due to the BOD and COD concentration caused by left over of fish food supplied everyday.

3). Comparision between Fishpond Water Quantity and Quality

With discharge ratio of other water sources 2.5 to 3 times discharges of grey water treatment by Eco - Technology, fish pond water quality will show parameters such as BOD : 13-15; COD : 20 - 33 mg/L ; DO : 5.6 – 6 mg/L; T Phosphate 0.326 - 0.439 mg/L; Detergent : 0.261-0.386 mg/L and Phenol:0.020 mg/L. Although, fish pond water quality is showing better result than the outlet Eco – Technology, nearly all water quality of measured parameters are not meeting the water quality for fish pond, except DO

5. Influence of Water Quality to Fish Growth

Fish farming in research area is only concentrated on growing fish, young fish is supplied from other places. Most dominant fish type in the fish pond is the Nila, whereas other types include the Mas (*Cyprinus carpio);* Nilem *(Osteochillus hasselti);* Lele *(Clarias batrachus);* Mujahir *(Oreochromis mossambicus);* Patin *(Pangasius, sp);* Bawal *(Collosoma macropomum)* and Gurami *(Osphronemus gouramy).*
Fish growth in the research pond can be considered as adequate, even though several parameters as mentioned above are unsuitable and not meeting the fish farming criteria. It is shown by the indicators as the following:

- **Nila**: 20 young fish in 1 kg, after 6 months 10 grown fish in 1 kg
- **Bawal:** 7 young fish in 1 kg, after 6 month 3 grown fish in 1 kg
- **Total fish production in fish pond with 198** m^3 (length 15 m, width 11 m, depth 1.20 m) is 300 kg of fish per year.
- The leftover of soybean used as fish food , feeding 1 kg per day, had also affected the fish growth in research pond

- The parameters pH, temperature and DO are meeting the fish farming criteria (M.Ghufran H .Kordi K and Andi Baso Tancung, 2007) as is shown on Table 4.

Table 4. Optimal Water Quality Based on Fish Type

Type of fish	Fish Farming Criteria(*)		
	pH	**Temperature (^{0}C)**	**DO mg/L**
Mas *(Cyprinus carpio)*	7 - 8	20 - 25	5 - 6
Nilem *(Osteochillus hasselti)*	7 - 8	25 - 32	5 - 6
Lele *(Clarias batrachus)*	6.5 - 9	25 - 30	3 - 4
Mujahir *(Oreochromis mossambicus)*	7 - 9	25 - 33	5 - 6
Patin *(Pangasius,sp)*	7 - 8	25 - 32	5 - 6
Bawal *(Collosoma macropomum)*	7 - 8	25 - 30	4 - 6
Gurami *(Osphronemus gouramy)*	6.5 - 9	25 - 33	3 - 4
Nila (*Orechromisniloticus*)	7 - 9	25 - 33	5 - 6
Water quality measurements in research pond (T1 and T2)	**7 - 7.1**	**24 - 25.2^{0}C**	**5.6 - 6 mg/L**

Note: A (B) = A : local name, B: Scientific name ;(*) M.Ghufran H .Kordi K and Andi Baso Tancung, 2007

6. Benefit of Reused Eco-technological Treatment for Small Scale Fisheries

a) Improvement of Protein Need and Income Family

Direct benefit of small scale fish farming using re-used water of Eco – Technology treatment can improve the family protein need and income. A family (example owner of fish pond) of six persons which consumes monthly 12 kg of fish can save approximately Rp.120.000,00 per month

b). Economic Opportunity

After one year operation, fish ponds in the research area can produce 300 kg of fish per year. When the owner has taken some of the fish for own consumption, the pond can produce 156 kg per year or at selling price Rp.1,950,000,- per year. When compared with the construction cost of Rp. 5,500,000,- (Rp. 5,000,000,- for construction of fish pond and Rp. 500,000,- for an Eco-Technology unit) an even break point can be achieved within three years of operation.

c). Environmental Conservation

The re-used water of an Eco – Technology treatment for fish pond can improve the environment of a housing site because it may not only increase the aesthetic of environment but may also reduce organic content as BOD, COD and Detergent

AKNOWLEDGEMENT

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