Development of Biomarker in Surface Water Quality Monitoring by Using Culture Fishery
(Case Study: Saguling Reservoir, West Java, Indonesia)

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Abstract
Saguling reservoir is one of reservoir that located in West Java Province in Indonesia. Originally this reservoir was plan for single purpose to generate the electricity and received water from Citarum River. Water quality in this reservoir is depends on the water quality of Citarum River which have face significant change because of the increased of land use along Citarum River basin and ineffective effluent and stream standard. Parameter that tends to increased is heavy metal especially mercury from industries and agriculture discharge. The studies conduct in Saguling culture fishery using two dominant species of fish *Oreochromis niloticus* and *Cyprianus carpio* as biomarker. Mercury concentration in fish was analyzing based on Standard Nasional Indonesia (SNI) 06-264-1991. High concentration of mercury found in *Oreochromis niloticus* (16.8470 $ppb_{wetweight}$) and 12.8943 $ppb_{wetweight}$ for *Cyprianus carpio*. These results are still below the permissible limit but still high compare to control samples. These sampling point was located in the same area and received water discharge from agriculture and domestic area which have contribution of mercury discharge. Biomarker by culture fisheries can be used as monitoring method to maintain the water quality in Saguling reservoir.

Keywords: Biomarker, Mercury, Saguling, Reservoir, *Oreochromis niloticus*, *Cyprianus carpio*

1. Introduction
Saguling reservoir is an artificial lake that located at 6:50 S, 107:25E, 643 m above sea level or 40 km from Bandung City . The surrounding area of Saguling reservoir was hilly, while the river that goes to reservoir has many tributaries. This condition makes the Saguling reservoir different with other reservoir in West Java such as Jatiluhur and Cirata Reservoir. Population that lived surrounding reservoir is dense and predominately by farmer population with extensive agricultural lands. The catchments area of the reservoir or the upper Citarum river faced high population pressure especially from farmer population.

This reservoir also received water from Citarum river basin with 7 sub river basins which are the water quantity and quality depend on the quality of Citarum river Basin. Upper Citarum river receives discharge water from domestic and industrial activities resulting water quality degradation such as the increasing of heavy metals concentration. The rapid change of land

used in Citarum River also effected the quality of Saguling reservoir water. Wangsaatmaja (2004) state that land used for urban area has increased for 49% and 35% for industrial area. Originally this reservoir was planned for single purpose dam to generate the electricity but along the year it re-planned to multi purposes dam such as fisheries, agriculture, tourism and their multiple effects. On the other hand, the people also used for domestic purposes like washing and bathing. Poor management of Saguling reservoir made the water quality became worse.

Water quality monitoring is common methods to maintain Citarum river water and Saguling reservoir water quality by using chemical and physical parameter. Stream and effluent standard were use as an instrument in monitoring river water quality. According to Citarum river water quality monitoring in 2001 only 1.4% of total 146 sampling location fulfill the requirements river water quality standard in Government of West Java Province Decree No.39/2000 (Wangsaatmaja, 2001). These facts demonstrate that monitoring methods by using only chemical and physical parameters was ineffective to monitoring and maintain the reservoir.

Fisheries using cage (net) culture was rapidly increased through the year and it was supported by fishing activities-tourism in the reservoir. There were 5.000 fisheries using cage (net) culture were recorded, this number was still below the limit according to Government of West Java Province Decree No.41/2002 that only 12.000 fisheries (Kompas Newspaper, July 2004). There are two dominant species of fish that were found in fisheries at Saguling reservoir, the first one is *Oreochromis niloticus* ("Ikan Nila") and *Cyprianus carpio* ("Ikan Mas"). Most of the fresh water fish for West Java consumption was supply by Saguling and Cirata reservoir fisheries (Oktaviatun, 2004). *Oreochromis niloticus* and *Cyprianus carpio* can be used as biomarker as the availability of the fish in Saguling reservoir.

2. Material and Methods

Sampling points selected among fisheries which cultivated *Oreochromis niloticus* and *Cyprianus caprio* with age 3-4 month (± 250gr) or ready to harvest. Two samples of fish was taken each fish cage culture and put in the cooler box. In the laboratory, fish was fillet and cut into small pieces, after that the sample was destructed using nitric acid (HNO_3) pa and analyzed with *Atomic Absorption Spectrophotometry* (AAS) specific Hg-analyzer. This method is referred to SNI 06-2464-1991 (Indonesian National Standard) and USEPA 1991-d. The results was calculated and presented in $ppb_{wet\ weight}$. Samples of water were also taken during sampling to measured pH and mercury concentration. To compare mercury concentration in fish, samples from control location (unpolluted) area also measured.

Location of sampling points was pointed by GPS (*Global Positioning Satellite*) and plotted into map of Saguling reservoir and control location. Observation and interviewed was done during sampling especially to find out the data of fish such as fish seed, fish feed and condition surrounding cage culture.

Correlation between mercury levels in fish and water, field condition surrounding the fisheries and potential source of mercury was analysis. The results could be used for an indicator of environment degradation which can be develop the monitoring system in Saguling reservoir and a recommendation for integrated water quality management in Saguling reservoir.

3. Results and Discussion

Location of sampling was shown in Figure 1, point 1,3,4,6,7,9,10,11,12,13 for both fish and water sampling while point 2,5,8, and 14 only for water sampling because fisheries in this point was not available. On the other hand, control point was selected in Subang district, the north of Bandung City. These fisheries received water from upper Cipanagara and Ciasem rivers which was land used dominated by forest and the activities of domestic and agricultural were still low.

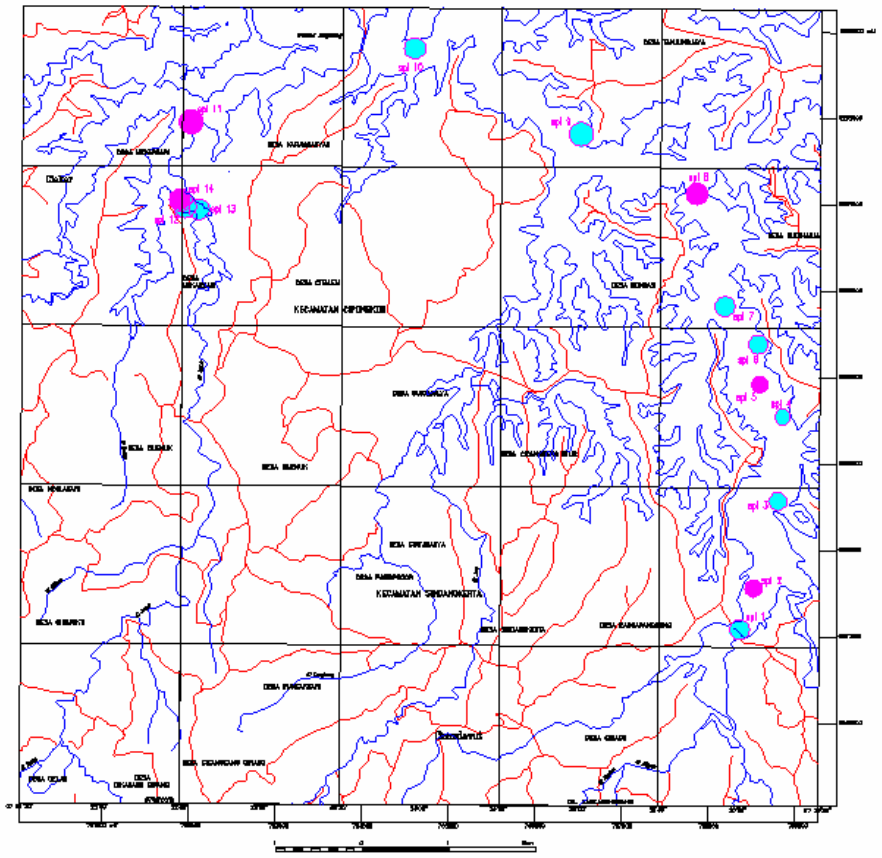

Figure 1 . Location of sampling in Saguling reservoir

Concentration of mercury in *Oreochromis niloticus* and *Cyprianus carpio* for each sampling point was described in the Table 1. Average concentration for both species was similar although the minimum concentrations for *Oreochromis niloticus* lower than concentration in *Cyprianus carpio*. This concentration still below the permissible level for consumption according to FAO Fisheries Circular No.765/825 which is range between 0,1-1 mg/Kg $_{\text{wetweight}}$. Highest concentration of mercury in *Cyprianus carpio* found in point 6 which value 16.8470 ppb$_{\text{wet weight}}$ and for *Oreochromis niloticus* was found in point 4. These results relatively higher compare to control samples which have average concentration 3.51 ppb $_{\text{wet weight}}$ for *Cyprianus carpio* and 3.62 ppb $_{\text{wet weight}}$ for *Oreochromis niloticus*.

Mercury concentration in water was described in Table 2 which have range between <0.06 – 0.18 ppb and still in permissible limit according to Government Decree No.82/2001 which is 1 ppb for mercury. High concentration were found in point 2, 3, 4 (12 ppb) and 7 (18 ppb) while mercury concentration in control location was <0.06 ppb.

Table 1. Concentration of Mercury in *Oreochromis niloticus* and *Cyprianus carpio* at October 2004

Location	**Fish ($ppb_{wet\ weight}$)**	
Point	***Cyprianus carpio***	***Oreochromis niloticus***
1	2.3459	4.1094
3	1.1833	4.9504
4	3.1478	12.8943
6	16.8470	3.1645
7	4.4677	2.3640
9	na	0.5203
10	na	11.5230
12	3.5431	0.4838
13	na	3.5345
Average	**5.2558**	**4.8382**
Maximum	**16.8470**	**12.8943**
Minimum	**1.1833**	**0.4838**

Table 2. Concentration of Mercury in water each sampling points at October 2004

Location	**Consentration (ppb)**	**Location**	**Consentration (ppb)**
1	<0.06	8	<0.06
2	0.12	9	0.06
3	0.12	10	<0.05
4	0.18	11	<0.06
5	0.06	12	<0.07
6	0.06	13	0.06
7	0.12	14	0.06

Saguling map describe that point 4, 6, and 7 was located in the same area which is positioned near the river tributaries and received water discharge from agriculture and domestic activities. According to observation these locations were surrounding by agriculture and domestic area. Mercury can be found in organic form such as phenyl mercury ($C_6 H_5$-Hg), methyl mercury (CH_3-Hg) and alkoxyalkyl mercury or methyoxy-ethyl mercury (CH_3O-CH_2-CH_2-Hg^+). One of mercury source is mercury in organic form which is came from uncontrolled dosage pesticides for agricultural activities (Budiono, 2003). Hadisantosa (2006) also state that Citarum river basin were predominantly used for agricultural activities and using pesticides. On the other hand, these areas also very dense by people who live near the fisheries using floating house. They are doing their daily activities like washing, bathing even they have small chicken husbandry above the cage culture (Figure 2).

The used of soap for washing from the domestic activities influenced the pH which has range 7.3- 8.9. Mercury has characteristic low solubility in the water and depends on the pH of water. The solubility will be higher if the pH low (acid) and the contrary will les soluble in pH high (Lloyd, 1992). According to the sampling pH relative neutral or above pH 7, this condition made the mercury will less soluble in water. The others parameters that measured during the sampling was temperature which has range 27-29°C and Conductivity Level with range 252-685 μmhos/cm.

Figure 2. Condition of fisheries in Saguling Reservoir.

Mercury concentration in fish food was also analyzed and the results have range between 1-1.5 $ppb_{wetweight}$. From interview, there were four types of food that were used for almost fisheries. Three of them were produced by factory and the other food was made by the people who take care the fisheries (usually they are not the owner of fisheries) which made by cassava and vegetables. This food may also contribute for the mercury concentration in fish. Mercury uptake can be trough by both bioaccumulation and biomagnifications process (Soemirat, 2003 and www.ehu.es/europeanclass2003)

Even though mercury concentration in fish still below the permissible limit, but higher compare to control point. In February 2003, mercury concentration in Saguling reservoir reach 0.06 mg/L according to Saguling reservoir management (Oktaviatun, 2004). Although the mercury concentration in water fluctuated, the concentration tends to increased along the year. The change of land used along Ciratum river basin become industries and domestic area influenced mercury concentration in Citarum river and Saguling reservoir. Painting and paper industries have contribution to mercury discharge. The other study also mentions that there are several gold plating industries that using mercury for their process. These gold plating industries is illegal and the activities is not regularly. (Hadisantosa, 2006).

According to the results, common water quality monitoring using chemical and physical parameter still ineffective to monitoring and maintains Citarum river and Saguling reservoir. Biomarker using culture fishery in Saguling reservoir as monitoring system could be used as monitoring methods especially for heavy metal parameters which have characteristic bioconcentration, bioaccumulation and biomagnification. Better management in Saguling reservoir should develop to reach better condition such as people prohibited lived near fisheries using floating house, limitation of fisheries number, and controlling tourism activities. If mercury concentration in water increase rapidly and concentration in fish above the permissible limit, fish from Saguling reservoir must not be consumes but only for monitoring purpose.

Monitoring of water quality in Citarum river and Saguling should be integrated by good cooperation between government, industry, stakeholders and community such as tight implementation of stream and effluent standard, monitoring using culture fish as biomarker, measuring, controlling heavy metal concentration in fish feed for Department of Fisheries

recommendation and controlling pesticides dosage for Department of Agriculture recomendation.

4. Conclusion

Mercury level in *Oreochromis niloticus* and *Cyprianus carpio* still in permissible limit with concentration maximum 16.8470 $ppb_{wetweight}$ for *Oreochromis niloticus* and 12.8943 $ppb_{wetweight}$ for *Cyprianus carpio* but still higher compare to control samples

Mercury concentration in point 6 and 4 were high, these location received water discharge from river tributaries which is the land used predominantly by agriculture and domestic area.

Saguling water quality influenced by Citarum River quality which effected by industries discharge from paper and painting industries, illegal gold planting industries, uncontrolled pesticides used, and domestic waste.

Biomarker using culture fish in Saguling reservoir as monitoring system could be used as one of monitoring methods for heavy metal parameters especially for mercury which have characteristic bioaccumulation and biomagnification.

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