Influence of Waters in Silvofishery Ponds on Wonorejo Mangroves That Contaminated by Heavy Metals Pb, Cd, and Cu toward Aquaculture Animals

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Abstract: Wonorejo silvofishery ponds obtained fresh water from two rivers, namely Jagir River and Afour River which flow through the city of Surabaya before entering Wonorejo mangroves area. The white shrimp and milkfish that have been cultivated in silvofishery pond often fail to be harvested. Preliminary observations found that Pb content in Wonorejo ponds reached 0.082 ppm. The purpose of this study is to determine the toxicity of waters in the Wonorejo silvofishery ponds that contaminated with heavy metals (Pb, Cd, and Cu) toward Chanos chanos and Penaeus merquiensis. The results of the tests revealed that the concentrations of Pb, Cd, and Cu in R. Avour were 0.284; 0.0380; and 0.017 ppm respectively. On the other hand, the concentration of Pb in the pond water is 0.304; 0.047; and 0.024 ppm. Laboratory test shows that milkfish can survive in the condition where water is contaminated by heavy metals until the concentration increases ten times from the concentration of metals in nature, as long as the other environmental parameters are appropiate. Meanwhile, white shrimp cannot survive more than two days in these conditions.

1 INTRODUCTION

Mangrove Wonorejo is part of mangrove ecosystem located on the shore of Pamurbaya (East coast of Surabaya). Currently, the Wonorejo mangrove is utilized by the community for the cultivation of traditional ponds with shrimp and milkfish commodities. Wonorejo Mangrove which is the conservation area of Surabaya City government is also managed for Mangrove ecotourism and Mangrove Information Center (MIC). One form of mangrove conservation management from MIC is Mangrove Pond (Silvofishery Pond).

Silvofishery pond is utilized for the cultivation of milkfish and shrimp by the management of MIC. In 2017 and 2018, there were also conducted a test of silvofishery cultivation of mangrove crabs for the research of the Ministry of Research, Technology and Higher Education of Republic of Indonesia (Ristekdikti) at the site. But the harvest was not good enough because the death rate was still high. It was suspected that this high death was caused by the quality of water in the Wonorejo Mangrove Pond which was low and polluted by the heavy metals. This reason was delivered because the cultivated biota in other farms were also experiencing mass death at the same time. The results of observations in previous studies showed that the average of heavy metals in the waters of the Wonorejo Mangrove Pond was above the quality standard of marine-life living needs. The highest heavy metal level was in cadmium elements. The heavy metal concentration of the Wonorejo mangrove pond water in the measurement of July 2018 resulted; Hg at 0.004 mg/l, Cd at 0,087 mg/l, and Pb at 0,022 mg/l. This heavy metal concentration led to the death of more than 50% of cultivated biota at the time. The regulation governing the quality threshold for marine life is the decree of the Minister of Environment No. 51 year 2004 about the quality standards for marine life, which are Hg at 0,001 mg/l, Cd at 0,001 mg/l, and Pb at 0,008 mg/l.

To find out whether this heavy metal content is always that high in the waters of Mangrove Pond Wonorejo and whether this heavy metal is indeed triggering the death of biota cultivation, it is considered necessary to conduct the toxicity test on cultivate biota in the Wonorejo Mangrove Pond, which are milkfish (Chanos chanos) and local white prawn (Penaeus merguensis). The purpose of this research is to know the level of water toxicity in the

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Wonorejo Mangrove Pond that is contaminated with heavy metals against cultivation biota in the pond.

2 RESEARCH METHOD

The method used in this research was an experimental method using milkfish (Chanos chanos), and local white prawns (Penaeus Sp.) as tested biota. Water from the Wonorejo Mangrove Pond and the Avour channel was used as a medium to create a test solution.

2.1 Time and Location

University Fishery Cultivation Laboratory, on May-June 2019 during the beginning of the dry season. Thus, the surface water discharge (run off) has begun to thinning and slightly diluted by rainwater. Location of the research was in the Wonorejo Mangrove Silvofishery Pond, by taking 3 points of observation station (Figure 1).

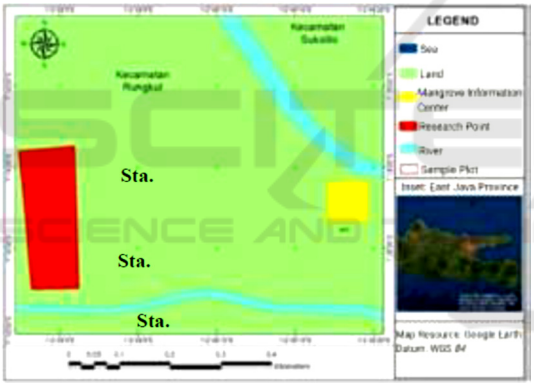


Figure 1: Location of Wonorejo Mangrove Pond.

Table 1: Tools and Materials Used during Research.

No	Tools and Material	Specification
1	Aquariums	sized 30 cm x 25 cm x 20 cm
2	Aerator	Out of gas 3L/min
3	Pond water	Clear water from silvofishery ponds
4	Sea water	Clear water from Wonorejo Beach
5	Cu solution	
6	Cd solution	
7	Pb Solution	
8	Milk fishes	*Chanos chanos*
9	Prawns	*Penaeus* Sp.

2.2 Research Plan

Job descriptions on this study include sampling, research preparation, toxic testing, processing and data analysis. The parameters of the heavy metals analyzed were Pb, Cd and Cu using the method of Atomic Absorption Spectrofometry (AAS). The tools and materials used in this research as shown in Table 1.

There were 12 aquariums (5 aquariums for 5 variations of concentration, 1 aquarium for control and experiments performed for 2 types of biota cultivation), 12 pieces of aerator (each aquarium was always given sufficient aeration. Each aquarium was filled with test water as much as 8 litres.

The experiment was conducted against 4-weeksold milkfish (C. chanos) with 6-7 cm length, and local white shrimp (Penaeus Sp.) with 5-6 cm length and the age of them were approximately 2 months. Milkfish seedlings were obtained from fish breeding in Gresik, while white shrimps were obtained from the pond in Wonorejo area. Each aquarium was filled by 8 tested biotas.

The stage of the toxicity test implementation for cultivated biota was done by maintaining tested biota in the water from the Wonorejo Mangrove Silvofishery Pond with variations of concentration made. The treatment of this experiment was carried out with 6 variations of concentration in pond water dilution; 100% (8 litres of Silvofishery pond water), 75% (6 litres of pond water and 2 litres of seawater + enriched by Pb solution), 75% (6 litres of pond water and 2 litres of seawater + enriched by Cd solution), 75% (6 litres of pond water and 2 litres of seawater + enriched by Cu solution), 50% (4 litres of silvofishery pond water and 4 litres of seawater), and 25% (2 litres of silvofishery pond water and 6 litres of seawater).

The method used to determine the toxin level was determined by the amount of death of the tested biota, at the 24th hour and the 48th hour.

3 RESULTS

3.1 Distribution of Heavy Metals in the Waters of Wonorejo Silvofishery Pond

Results of laboratory analysis on the heavy metal contents of Pb, Cu, and Cd in the waters and the sediment of the Wonorejo Silvofishery Pond are presented in Figure 2.

From the results of water analysis in several locations in the Wonorejo pond, it is apparent that the

contents of three types of metals (Pb, Cd, and Cu) have metallic contents that exceed the quality standards of water for marine life when compared to the appendix III of the Ministry of Environment decree No. 51 year 2004. The results of measurement at the Wonorejo Pond are; the content of Pb is 0.304 ppm (NAB 0.008 ppm); Cd is 0.047 ppm (NAB 0.008 ppm), and Cu is 0.024 ppm, (NAB 0.001 ppm). NAB is the quality default threshold value. The average content of all three types of metals can be seen in Table 2.

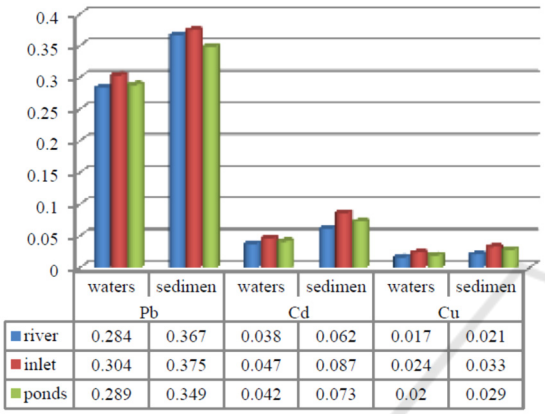


Figure 2: Distribution of heavy metals (Pb, Cd, and Cu) in Wonorejo Pond.

When compared between metal types, Pb has higher value which is 0.2923 in water samples and 0.3637 in sediment samples rather than Cd and Cu. While Cu is the lowest one than Pb and Cd whether in water and sediment samples. Metallic content on sediment samples shows the higher yield rather than on water samples.

Table 2: Average metals concentration at Wonorejo Mangrove.

		Avarage	Stdev	Treshold value of marine biota
Lead (Pb)	water	0.2923	0.0104	0.008
	sediment	0.3637	0.0133	
Cadmium (Cd	water	0.0423	0.0045	0.001
	sediment	0.074	0.0125	
Copper (Cu)	water	0.0203	0.0035	0.001
	sediment	0.0277	0.0061	

The metal content of the Wonorejo mangrove on all stations shows that those have exceeded the quality default threshold of marine-life living needs according to appendix III of the Ministry of Environment decree No. 51 year 2004 on the quality default of seawater for marine biota. The content of Pb (lead) has been 36 times compared to standardized quality standards. Cd (Cadmium) has even reached 42 times.

3.2 Influence of Heavy Metals against the Mortality of Cultivated Animals

Pond water with the condition of the metal concentration as presented above was then used to test the toxicity of the cultivated milkfish and shrimp. Six variations of concentration in silvofishery pond water dilution for test water is as presented in Table 3.

Table 3: Pond water quality used as test water.

Treatment	Dilution concentration	pH	DO (ppm)	Temp. °C
B1	25%	7,6	7,9	26,4
B2	25%	7,7	8,0	26,1
C1	50%	7,6	7,6	25,9
C2	50%	7,7	8	25,9
APb 1	75% +Pb	7,6	7,6	25,6
APb 2	75%+ Pb	7,5	7,3	25,5
ACd 1	75% + Cd	7,6	7,3	25,4
ACd 2	75% +Cd	7,6	7,8	25,1
ACu 1	75% + Cu	7,8	7,7	25
ACu 2	75% + Cu	8,1	7,6	25
K1	100%	7,7	8,2	26,5
K2	100%	7,8	7,6	26,6

Expl:
1 = milkfish
2 = white prawn
B = dilution 25%
C = dilution 50%
A = dilution 75%
K = dilution 100%

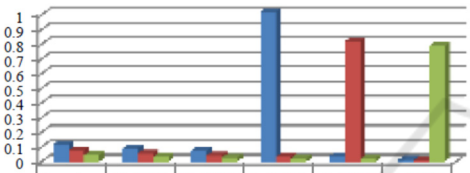
From the results of the water pond testing for the milkfish and shrimp protection, it is known that milkfish have not been found dead up to the 48th hour of observation time, on all concentrations of tested metals. While at the 24th hour observation time of shrimps, almost all prawns have been found 100% dead, except those on controls and Cd enrichment which are being dead yet. But at the 48th hour of observation time, all shrimp biota were found 100% dead.

Based on the results of this observation, it is seen that the milkfish have a higher tolerance ability to the

polluted waters rather than shrimps. The results of this observation are in accordance with the conditions in the silvofishery cultivation field in Wonorejo Mangrove. Pond farmer also stated that they often failed to harvest shrimp, while they succeeded to harvest milkfish sometimes.

3.3 Metal Content on Tested Biota

Tested biota which succeeded to live until the 5th day of subsequent testing were brought to metal level testing in its flesh. In this research, because the prawns were all dead at the 24th and the 48th hour, then the test of metal content was only done on milkfish. The test results of metal levels (Pb, Cd, and Cu) in milkfish are presented in Figure 3.



	kontrol 100%	C 50%	B 25%	A 75% + Pb	A 75% + Cd	A 75% + Cu
Pb (ppm)	0.117	0.089	0.075	1.02	0.038	0.014
Cd (ppm)	0.075	0.054	0.041	0.031	0.82	0.011
Cu (ppm)	0.043	0.032	0.027	0.024	0.019	0.79

Figure 3: Graph of heavy metal content in milkfish meat in test water with different concentrations.

The test result shows that the accumulation of metal in the milkfish meat will increase as the increase of metal concentration in the test water. Even in the metal-enriched test water, the accumulation of heavy metals in milkfish meat has a quite high increase.

On concentration of test water without heavy metal enrichment, the highest metal level in milkfish meat is the lead metal type (Pb), following by Cadmium metal (Cd) and copper (Cu). The Pb metal content of milkfish that is maintained on the test water (100% of the water pond with concentration of Pb 0,292 ppm) is 0.117 ppm.

3.4 Metal Contain on Milkfish Flesh in Wonorejo Ponds

Wonorejo ponds were found that some biotas in there like milkfish, crabs, etc containing heavy metals. It's because the ponds itself got fresh water supplied by Avour river which is along of this river there are many industries and factories that suspected pollute this river by its waste. It's proven by this Table 4.

Based on the table above, we could see that Pb contain in all of the point research was bigger than the others. It's because so many activities industry are using Pb as their material. Automatically, the waste of their industry contain heavy metals like Pb. This waste suspected pollute the Avour river which is the main of supplier fresh water for tradisional ponds and silvofishery ponds in its around. Basically, this metal was accumulated into the body of aquaculture animals there especially the
milkfish itself.

The research of Napitu (2010) show that the highest metal concentrations of Pb in the estuary of Blanakan River at 0.1445 ppm, while the Pb accumulation in milkfish amounted to 0.1962 ppm. Pb metal accumulation in milkfish body is higher than the concentration in the water. Pb accumulation in milkfish that cultivated in Blanakan Subang pond reaches 6,6 µg/kg, Heriyanto (2011).

Meanwhile in this study, the accumulation of Pb metal in Milkfish was still under the concentration of the Pb metal in the test water, allegedly because the time was only briefly exposed that for two days.
The content of Hg in Milkfish that live in ordinary ponds contains Hg 49 times higher than in mangrove forests and for shrimps can reach as high as twice Gunawan (2008).
The content of Cu is the lowest in mangrove of Wonorejo, however Cu is an essential metal for aquatic animals that is beneficial in the formation of Haemosianin blood system and in enzymatic aquatic animals (Darmono 2001). Metal Cu needed marine organisms as enzyme cofactors for the growth and development of his life. But if the amount of Cu in the body is excess, it will turn into toxins for the body (Palar, 2004).

Table 4: Metal contain on milkfish flesh.

	Pb (ppm)	Cd (ppm)	Cu (ppm)
Pond 1	0.181	0.019	0.0091
Pond 2	0.189	0.029	0.0095
Silvofishery Pond 1	0.114	0.015	0.0052
Silvofishery Pond 2	0.125	0.014	0.0072

When compared with the regulation of the Agency for Drug Control and Food No. 5 year 2018 about the maximum limit of heavy metal contamination in processed food, it is said that Pb metal is 0.20 mg/kg and Cd metal is 0.10 mg/kg. Then, Pb content in milkfish that live in the Mangrove pond water is still under the maximum threshold. Or it can be said that it is still safe to consume.

Similarly, the content of cadmium (Cd) and copper (Cu) on milkfish flesh reaches the highest of 0.075 and 0.043 respectively, which is still below the maximum limit of Cd and Cu for food. So, it is still safe to consume.

In milkfish that are kept in pond water enriched with Pb, Cd, and Cu with a concentration of 0.25 ppm, it indicates the presence of higher metal concentrations in milkfish meat; Pb reaches 1.02 ppm; Cd reaches 0.82 ppm; and Cu reaches 0.79 ppm. This concentration is still below the maximum limit for food as well. However, if food containing metals with such content is consumed continuously, it should be asked whether it has an impact on health or not. Surely, it requires further research.

4 CONCLUSIONS

The type of metals that pollute the water of the Wonorejo Mangrove Pond is the lead metal (Pb) with its highest concentration of 0.304 ppm, Cd metal with its highest one of 0.047 ppm, and Cd metal with its highest of 0.024 ppm. The metal concentration in sediment is higher than in the water pond. Pb, Cd and Cu metal pollutants in this concentration does not affect to the milkfish, as long as other environmental parameters are appropiate. But it caused more than 50% of shrimp deaths in the 24th hour.

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