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Application of adsorptive stripping voltammetry for the determination of heavy metals Cd, Cu, Pb and Zn in the culture of fish floating net cages in Maninjau Lake, Agam, West Sumatra, Indonesia

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ABSTRACT

The culture of fish floating net cages is one of the main activities of fisheries in Maninjau Lake. Recent developments indicate that the various activities has caused various problems, such as the decline in lake water quality. The decrease in water quality has caused mass mortality of fish that are kept in floating net cages, for that the observation of water quality conditions especially tracemetals were done. The results showed Cd 1.11-32.65 µg/L, Cu 109.5-451.50 µg/L, Pb 0.16-27.66 µgL, and Zn 82.50 - 409.01µg/L. With reference to the quality standards of water quality according to Government Regulation Number 82 in 2001, it can be concluded water quality has not been entirely feasible for fish farming. These conditions will deteriorate further in the event that the timing of the upwelling process can not be predicted.

Keywords: Water Quality, Maninjau Lake, Mass Mortality, Trace Metals

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INTRODUCTION

Maninjau Lake is a tecto-vulcanic, located in the district of Tanjung Raya, Agam Regency, West Sumatra Indonesia, on geo- graphical position E: 00º12'26.63"- S: 0º25'02.80" and E: 100º07'43.74 "- E: 100º16'22.48", located at altitude of 461.50 m above sea level with the surface area 9737.50 ha. Based on the Schmidth-Ferguson climate classification, this lake has the characteristics of climate a types and annual rainfall around 3,490 mm. Maninjau Lake is a natural resource that has a very important role as a tourist destination, Hydroelectric Power Plants with a capacity of 64 MW, capture fisheries and floating net cages farming

Fish is one of the foods that contain a variety of substances, in addition to the price of which is generally less expensive, fish protein absorption is higher compared to other animal products such as beef and chicken, because the fish meat has protein fibers are shorter than the fibers beef or chicken protein. Kind is very diverse and has several advantages, such as omega 3 and omega 6, and completeness acid composition. Fish is also an excellent food nutritional quality, because it contains approximately 18 grams of protein for every 100 grams of fresh fish. Whereas dried fish can reach levels of 40 grams of protein in 100 grams of dried fish. Compared with other food ingredients, fish contain essential amino acids complete and very needed by the human body, and therefore the quality of fish protein comparable to meat protein quality [1].

Currently, concern for the aquatic ecosystem of Maninjau Lake increasingly less noticed by nearly all users of the aquatic ecosystem of the lake. Ecological principles that the waters of the lake has a carrying capacity of the waste that is limited is not understood by most people who use the lake. As examples of the use of the lake for aquaculture activities with fish floating net cages always increase every year [2-3]. Until the end of 2014, there were 20,000 fish floating net cages units operating in the waters of Maninjau Lake. This amount has exceeded the carrying capacity of the waters of the lake for fish floating net cages activities. This will put pressure on the lake waters is increasing.

On the one hand, the development of fish farming in the fish floating net cages will have a positive impact in the form of creation of new jobs and increase the income of local communities, but on the other hand, this effort will bring negative impact on the aquatic ecosystem of the lake. In this case, the fish farming activities with the fish floating net cages will directly affect (decrease) the quality of the waters of the lake. The influence caused by waste feed and pest eradication substances fisheries. If the concentration exceeds the threshold, can pollute and poison the waters of the lake biota [2-4].

Mass mortality of fish farming in Maninjau Lake due to occur as a result of up-welling phenomena at the beginning of 2008 until the end of December 2014, raises questions and highlighted the various parties. In this case aquaculture fisheries sector in particular is regarded as a trouble maker that causes degradation of water quality of Maninjau Lake, so that led to the unfortunate death of the fish. Although it has not been scientifically proven, but it is a challenge for the actors to be able to apply cultivation technology to minimize waste, especially waste from the rest of the fish feed.

The development unit floating net cages in a less controlled area of cultivation has negative impact on the aquatic environment. The negative impact is often caused partly due to lack of attention to the principles of technology in fish farming with floating net cages system. In an effort aquaculture, it is important to learn the condition of the quality of water to be used as an indication of the feasibility of a body of water for aquaculture. To manage fisheries resources are better then one of the requirements that must be considered is the quality of the waters [5]. Plants and aquatic organisms can grow and develop properly, these organisms require certain requirements in his habitat is water condition [6-7].

The problem that always arises in floating net cage aquaculture systems is environmental pollution caused by various activities around the waters and farming itself. This contamination can be physics-chemical pollution in particular (temperature, brightness, pH, Dissolved Oxygen, Biological Oxygen Demand, Carbon Oxygen Demand, nitrate, nitrite, ammonia, phosphate and sulfate). The results showed a temperature range 27.1-29.3^{o}C, brightness 76.1-83.5 cm, pH 8.7-9.8, the DO 8.04-8.91 mg/L, BOD 0.51-3,39 mg/L, Ammonia 0.47-0.50 mg/L, Nitrite 0.56-0.59 mg/L, Nitrate 0.43-0.47 mg/L, COD 2.71-9.28 mg/L, phosphate 4,63-5.04 mg/L and Sulfate 9.00-11.60 mg/L. With reference to the quality standards of water quality, it can be concluded water quality has not been entirely feasible for fish farming. These conditions will deteriorate further in the event that the timing of the upwelling process can not be predicted. For that we need to find solutions to prevent mass death by using Aquaponics [8].

Heavy metals found in all layers of nature, but in very low concentrations. In the sea water concentration ranges 10^{-5}-10^{-3} mg/L. At low levels, some heavy metals are generally required by living organisms for the growth and development of life. But on the contrary if the level is rising, heavy metal turns into a toxic properties [9]. Increased levels of heavy metals in seawater occurs because of the influx of waste containing heavy metals into the marine environment. Wastes that contain many heavy metals are usually derived from industrial activities, mining, housing and agriculture.

Presence of heavy metals in the waters has long been known to adversely affect the lives of aquatic organisms to the individual level and community structure. Human activity is the main source of metal inclusion into the aquatic environment. The main source of income metals is derived from mining activities [10], liquid household waste, sewage and industrial waste as well as the flow of agriculture. Research results [11] shows that it contains heavy metals Pb, Cd, Cr and Cu in sediments in Lake Rawapening that have exceeded the maximum threshold set by the Australian and New Zealand Environment and Conservation Council (ANZECC).

Based on the description above, it is necessary to study to obtain water quality data, especially heavy metals in order to know the extent of the carrying capacity of water quality for aquaculture floating net cages in Maninjau Lake with reference to Government Regulation No. 82 of 2001 on the Management of Water Quality and Water Pollution Control [12].

The research goal is to determine the parameters of heavy metals Cd, Cu, Pb and Zn on the location of floating net fish farmers belonging Fish Farmers Group Tantiok Jaya, Maninjau Lake Region, as well as determining the location of a suitable cultivation to support optimal growth.

EXPERIMENTAL SECTION

Water samples were taken from 8 sample locations in Maninjau Lake (Figure 1) using a Kemmerer water sampler volume of five liters with a depth of 0, 4, 8 and 12 m. Kemmener water sampler slowly lifted and opened the water faucets expenditure, then the water entered into the sample bottles of water and closed. Water sample for trace metal analysis, then preserved in nitrite acid 65%. to be analyzed at the Laboratory of Analytical Chemistry, Andalas University using AdSV (Adsorptive Stripping Voltammetry), [which has a precision of Cd 0.39%, Cu 0.74%, Pb 1.35% , Zn 0.04% and a minimum detection limit of Cd 1.021µg/L, Cu 0.987µg/L, Pb 0.972 µg/L, Zn 0.957µg/L]. In the measurement with this AdSV, each carried replay 3 times.

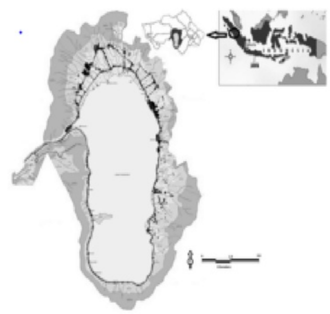

Figure 1. Map of Maninjau Lake

RESULTS AND DISCUSSION

Adsorptive stripping voltammetry was chosen as an alternative method of analysis because it has many advantages such as: high salt content of sea water does not interfere, high sensitivity, low detection limit in µg/L, simple and easy sample preparation, rapid analysis, less infra structure [13-17]. In addition, with this method it is possible to learn chemical species of heavy metals [18], which can not be done with other methods.

Comparison of the results from laboratory analysis using Adsorptive Stripping Voltammetry with quality standards for freshwater fish farming activities (class II) according to Regulation 82 of 2001, can be seen in Table 1.

Table 1. Heavy metals in water at different location and different day sample

No	Parameters	Results of laboratory analysis 10^{-3} (mg/L)	Quality standards for freshwater fish farming activities (class II) according to Regulation 82 of 2001 (mg/L)
1	Cd	1.11-32.65	0.01
2	Cu	109.5-451.50	0.02
3	Pb	0.16-27.66	- 0.03
4	Zn	82.5-409.01	0.05

Based on Table 1 obtained by the measurement of heavy metals Cd in most of the research and sampling locations on different days showed large variations, ranging from (1.11 -32.65)10^{-3} mg/L, with an average value 18.12x10^{-3} mg /L. Furthermore, from Figure 2, it was found that the average value of Cd is high on the location of the sample 2 and 8, as well as the value of Cd in the second sampling is higher than the first sampling. The main cause was a rainy day at the second sampling, and suspected metal cadmium (Cd) into the waters of Maninjau Lake environment as a result of human activity. Cd source thought to have come from air pollution, cigarettes, water wells, fungsida, fertilizer, dust, waste water processing and wastewater[19]. In general, the average value of Cd is above the value of the quality standards set by Government Regulation No. 82 of 2001 which is lower than 0.01 mg/L, so that the waters of Maninjau Lake is not entirely suitable for the cultivation of freshwater fish.

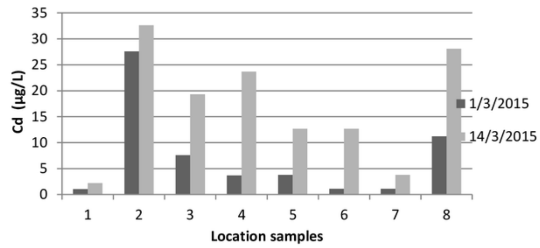

Figure 2. Heavy metal Cd in different location and day samples

Copper (Cu) is a heavy metal found in natural waters and is an essential element for plants and animals. Results of the study of heavy metal content of Cu as shown in Table 1 showed the results of measurements of Cu in the majority of research and sampling locations on different days showed large variations, ranging from (109.5-451.50)10^{-3} mg/L, with a mean value 247.19.65 x10^{-3} mg/L. Furthermore, from Figure 3, it was found the average value of Cu was higher second sampling. The main cause was a rainy day in the second sampling. Cu source derived from erosion events (erosion) mineral rocks, dust and particulate Cu in the layer of air, while the non-naturally derived from human activities, among others, of the shipbuilding industry, wood processing industry and household waste [19]. The existence of Cu in the waters of Maninjau Lake could be derived from the erosion in river catchment areas around the area of Maninjau Lake, household waste and wood processing industry for the manufacture of a motor boat. In general, the average value of Cu is above the value of the quality standards set by Government Regulation No. 82 of 2001 is equal to 0.02 mg/L, so that the waters of Maninjau Lake is not entirely suitable for the cultivation of freshwater fish.

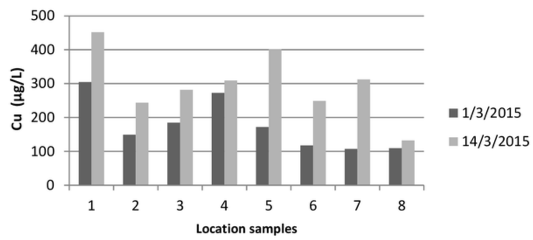

Figure 3. Heavy metal Cu in different location and day samples

Based on Table 1, Pb heavy metal content in the water in most of the research and sampling locations on different days showed large variations, ranging from (0.16-27.66) 10^{-3} mg/L, with an average value 13.91x10^{-3} mg/L. Furthermore, from Figure 4, found the average value of Pb is high on the location of the sample 8, also the value of Pb in the second sampling is higher than the first sampling. The main cause was a rainy day at the second sampling, and allegedly metallic lead (Pb) into the waters of Maninjau Lake environment as a result of human activity. Increased levels of Pb in the waters of Maninjau Lake sourced from motor vehicle exhaust emissions and industrial waste using Pb. The waters of Maninjau Lake Pb heavy metal content results can be derived from the exhaust emissions of motor boats used for tourism activities and transportation for fishing activities. In general, the average value of Pb are below the quality standards set by Government Regulation No. 82 of 2001 is of 0.03 mg/L, so that the waters of Maninjau Lake suitable for freshwater fish farming.

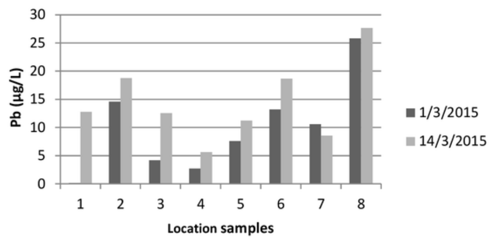

Figure 4. Heavy metal Pb in different location and day samples

Results of the research content of heavy metals Zn as shown in Table 1 shows the results of measurements of Zn in the majority of research and sampling locations on different days showed large variations, ranging from (82.5-409.01)10^{-3} mg/L, with a mean value 245.76 x10^{-3} mg/L. Furthermore, from Figure 5, the average values obtained Zn were higher in second sample, the main cause is the heavy rain. The quantity of zinc pollution in Maninjau Lake caused by domestic sewage from communities around the industrial waste stream and a relatively high daily input of pollutants entering the river upstream to Maninjau Lake. In addition, zinc pollution comes from natural sources such as residual mineral rock erosion along stream and zinc particles are carried through the air [20]. In general, the average value of Zn are below the quality standards set by Government Regulation No. 82 of 2001 is equal to 0.05 mg/L, so that the waters of Maninjau Lake suitable for freshwater fish farming.

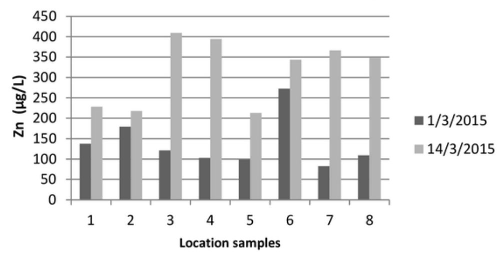

Figure 5. Heavy metal Zn in different location and day samples

CONCLUSION

The development unit floating net cages in a less controlled area of cultivation has negative impact on the aquatic environment. The negative impact was often caused partly due to lack of attention to the principles of technology in fish farming with floating net cages system. In an effort aquaculture, it was important to learn the condition of the quality of water to be used as an indication of the feasibility of a body of water for aquaculture. The results showed Cd 1.11-32.65 µg/L, Cu 109.5-451.50 µg/L, Pb 0.16-27.66 µg/L, and Zn 82.50-409.01 µg/L. With reference to the quality standards of water quality according to Government Regulation Number 82 in 2001, it could be concluded water quality had not been entirely feasible for fish farming

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