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The Effect of Sublethal Exposure of Chlorpyrifos to Nile Tilapia (*Oreochromis niloticus*): Case Study of Twin Lakes of West Sumatra, Indonesia

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ABSTRACT

Chlorpyrifos is one of the toxic organophosphate insecticides that is often used by farmers in West Sumatra Province. This research was conducted with the aim to analyse the level of consumption, conversion ratio, and growth rate in fish cultivated in the twin lakes of West Sumatra. The concentration variations are 1/7 and 1/14 LC_{50}-96h of chlorpyrifos. The study was conducted for 14 days. Research data analysis found the values of R = 0.75-1 for the relationship of oxygen level, conversion ratio, and growth of tilapia to the duration of exposure which means having a strong correlation. The results obtained were due to chlorpyrifos insecticide exposure on day 1 to day 14. At a concentration of 0.0054 mg/L, there was a decrease in the level of oxygen consumption of 0.0159 mgO_2 /L, an increase in feed conversion ratio of 0.8253, and the deviation flow of 2.7048%. Whereas at a concentration of 0.0108 mg/L, there was a decrease in the oxygen level of 0.0213 mgO_2 /L, increase in feed conversion ratio of 0.8201, and deviation growth by 2.7048%.

INTRODUCTION

West Sumatra is a province in Indonesia where most of the population lives from agriculture. Based on the data from the Indonesian Central Statistics Agency, as much as 64% of the area of West Sumatra is used for agricultural activities. Agricultural activities cannot be separated from the use of pesticides by farmers in supporting increased yields (Abhilash & Singh 2009, Lu & Kacew 2010, Soemirat 2009). One type of pesticide that is widely used by farmers in West Sumatra is chlorpyrifos (Food Crops and Horticulture Protection Center 2016).

Chlorpyrifos is in the form of white crystals that have a sharp odour. When chlorpyrifos enters the waters, it will kill aquatic biota such as shrimp and fish. Chlorpyrifos insecticide is non-systemic, which works when there is contact with skin or ingested and inhaled (DAS 2013, World Health Organization 2010).

Agricultural activities are also carried out in the Twin Lakes of West Sumatra because they can be used for irrigation. The Twin Lakes area is unique in that there are two lakes named Dibawah lake and Diateh lake. The area around the lakes below is used for agriculture, and the irrigation water flows to the lake Diateh area, which is a fish farming area. The results of measurement of chlorpyrifos concentration in the location of fish cultivation in lake waters are equal to 0.007 mg/L (Ihsan et al. 2018).

This agricultural activity not only triggers water pollution by pesticides but will have an impact on aquatic biota that lives in the lake (Banaee et al. 2011, Sun & Chen 2008, Zahran et al. 2018, Zhang & Zhao 2017), including fish that are cultivated by people in the twin lakes area. One fish that is usually cultivated by the community is Nile tilapia (*Oreochromis niloticus*) that will be used as a test animal in this study

Tilapia is often used as a bioindicator of water pollution because it is sensitive to physical changes and pollutants in water. In addition, tilapia is easy to cultivate and its position is at the top of the food chain in the aquatic systems (Suyanto et al. 2010).

Based on that, to see the sublethal effect of chlorpyrifos insecticide on tilapia, it is necessary to conduct sublethal toxicity tests on the parameters of oxygen consumption level, feed conversion ratio and growth of tilapia before seeing subacute potential for humans who consume (Zeljezic et al. 2017), especially cultured fish from the twin lake areas of West Sumatra.

MATERIALS AND METHODS

Tilapia acclimatization was carried out for 14 days (Halappa & David 2009). During acclimatization, test animals were fed 3 times a day, 3% of fish weight per day (Suyanto 2010). Test water was replaced by 60% when it is cloudy, and

cleaning of fish dung was done 3 times a day. The population of test animals is considered eligible for testing if death is <3% of the test animal population for 48 hours (United States Environmental Protection Agency 2002). Environmental factors measured during acclimatization were dissolved oxygen levels measured by DO meters and pH levels measured by pH meters, to monitor the right environmental conditions during the tilapia acclimatization period.

Sublethal toxicity test was carried out for 14 days which aimed to determine the effect of sublethal chlorpyrifos insecticides on tilapia (Halappa & David 2009). The experiment was carried out with three times repetition of each concentration used. Parameters observed were oxygen consumption level, feed conversion ratio and tilapia growth.

The variation of the concentration used was kept below the LC_{50}-96 h value of 0.076 mg/L (Ihsan et al. 2018) varying from 1/7 of 0.076 mg/L (0.011 mg/L) to 1/14 of 0.076 mg/L (0.005 mg/L).

The level of oxygen consumption was calculated using the volume of water in the aquarium, dissolved oxygen concentration, weight of tilapia, and duration of observation. The oxygen consumption rate was calculated using the following equation (Liao & Huang 1975).

$$OC = [(V) \times (DO_0 - DOt)] / [(W) \times (t)] \quad \ldots(1)$$

Where, OC = Oxygen Consumption Level (mgO_2/g/hour)
V = Volume of water in container (L)
DO_0 = Initial Dissolved oxygen concentration (mg/L)
DOt = Final Dissolved oxygen concentration t (mg/L)
W = Weight of testing fish (g)
t = research time (hour)

Feed conversion ratio was calculated by using the data of the amount of feed given to tilapia, the weight of tilapia at the beginning of observation, and the weight of tilapia at the end of the observation (day t).

The amount of feed conversion ratio was calculated using the following equation (Tacon 1987)].

$$FCR = \text{Feed fed (g)} / (Wt - Wo)\ g \quad \ldots(2)$$

Where, FCR= Feed Conversion Ratio
Wo = Initial weight (g)
Wt = Final weight (g)

Tilapia growth rate was calculated using the weight data of tilapia at the beginning of the observation, the weight of tilapia at the end of the observation (day t), and the time of observation. The growth rate of tilapia was calculated using the following equation (Tacon 1987).

$$SGR = [(\ln Wt - \ln Wo) / t] \times 100\% \quad \ldots(3)$$

Where, SGR = Specific Growth Rate
Wt = Final weight (g)
Wo = Initial weight (g)
t = research time (day)

The data obtained were analysed using regression-correlation statistical analysis. In the analysis of the relationship between observation time and test parameters, variable X is the time of observation and variable Y is the data of each test parameter at each concentration of chlorpyrifos used.

RESULTS

Acclimatization and observation were carried out for 14 days with the aim that the test animals can adapt to the physical state of the laboratory. Based on the observations during acclimatization, the death of test animals <3% for 48 hours was 2%, so that test animals can be used for toxicity testing. During the acclimatization period, the environmental conditions of the aquarium must be adjusted to the environmental conditions that are suitable for the maintenance of tilapia.

During the observation period, the quality of the water was monitored in order to keep the tilapia fish rearing requirements. The environmental parameters monitored were dissolved oxygen (DO), pH and temperature. Environmental conditions during acclimatization and observation can be seen in Table 1.

Table 1: Conditions during acclimatization and observation of the fish.

No.	Parameters	Acclimatization	Observation	Range based on USEPA
1	DO (mgO_2/L)	7.3-8.2	5.8-7.4	>4
2	pH	6.8-7.5	7.8-8.1	6-9
3	Temperature (^oC)	28.6-29.7	25.7-28.2	25-30

Oxygen Consumption Level

The level of oxygen consumption is an important parameter to observe the effect of a toxic substance on fish because toxic substances that enter the body of the fish will interfere with the respiratory process. The data of oxygen consumption level analysed were the relationship between oxygen consumption level on day 1, day 4, day 7, day 10 and day 14 on control, concentration 0.0054 mg/L, and concentration 0, 0108 mg/L. The graph of the relationship between the level of oxygen consumption of tilapia and the observation time can be seen in Fig. 1.

Feed Conversion Ratio

Under normal circumstances, the lower the feed conversion value, the better because the amount of feed spent to produce a certain weight will be less (Lall & Tibbetts 2009). The graph of the relationship between the ratio of tilapia

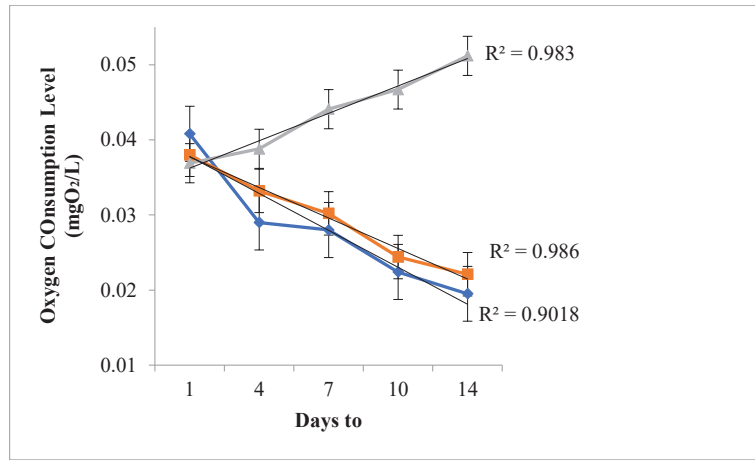

Fig. 1: The level of oxygen consumption of tilapia.

feed conversion to observation time can be seen in Fig. 2.

Growth rate

Under normal circumstances, if metabolic activity goes well, there will be an increase in the rate of growth of fish. The graph of the relationship between the growth rate of tilapia to the observation time can be seen in Fig. 3.

DISCUSSION

Oxygen Consumption Level

Based on Fig. 1, it can be seen that the level of oxygen consumption of tilapia exposed to chlorpyrifos insecticide has decreased from observations on day 1 to day 14. At a concentration of 0.0108 mg/L obtained a coefficient of determination of 0.901, and a concentration of 0.0054 mg/L of 0.986, with a correlation coefficient ranging from 0.800-1,000, which means that the relationship is very strong between observation time and oxygen consumption level of tilapia. The decrease in oxygen consumption level on day 1 to day 14 at a concentration of 0.0054 mg/L was 0.0159 mgO_2 /L and at a concentration of 0.0108 mg/L was 0.0213 mgO_2 /L.

A decrease in oxygen consumption occurs after tilapia is exposed to chlorpyrifos insecticide. This is because the chlorpyrifos insecticide is a nerve poison that will damage the respiratory nervous system of tilapia and will affect the process of oxygen diffusion resulting in a decrease in the level of oxygen consumption (Bonifacio et al. 2017, Chebbi & David 2010, Padmanabha et al. 2015). For longer the tilapia is exposed to chlorpyrifos insecticides, the level of oxygen consumption will decrease.

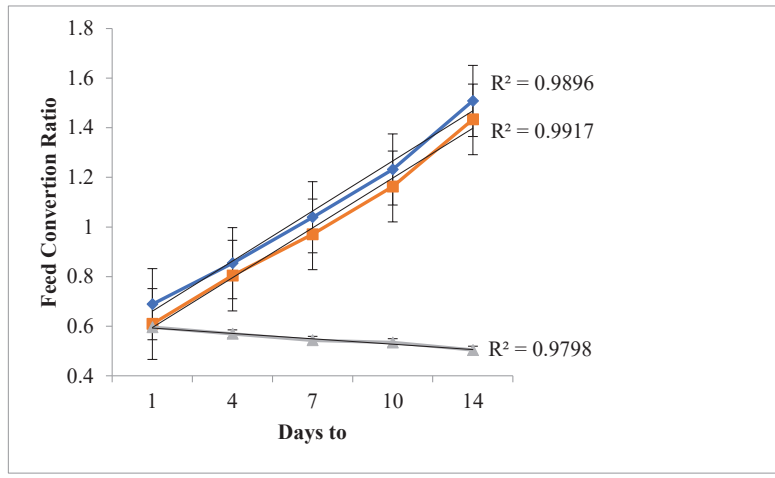

Fig. 2: The ratio of tilapia feed conversion.

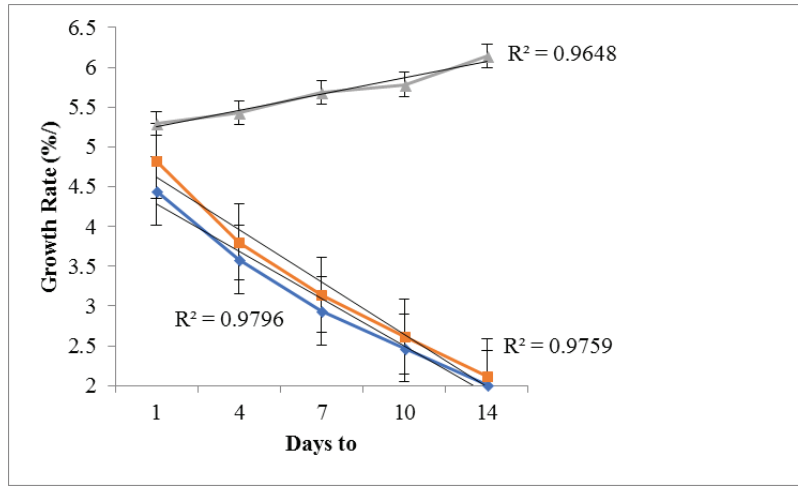

Fig. 3: The growth rate of tilapia.

Feed Conversion Ratio

Based on Fig. 2, there was an increase in the ratio of feed conversion of tilapia fish exposed to chlorpyrifos insecticide from day 1 to day 14, with a coefficient of determination of 0.989 (concentration of 0.0108 mg/L) and 0.991 (concentration of 0.0054 mg/L). Correlation coefficients ranged from 0.800 to 1.000, which means that the relationship is very strong between the test time and the tilapia feed conversion ratio. The increase in feed conversion ratio on day 1 to day 14 at a concentration of 0.0054 mg/L was 0.8253 and at a concentration of 0.0108 mg/L was 0.8201.

The lowest feed conversion ratio occurred on day 1 and the highest feed conversion ratio occurred on day 14. The increase in the value of the feed conversion ratio occurs because of the toxic effects of pesticides in the fish's body, which interfere with the function of respiration and inhibit the metabolic activity of the fish's body so that the process of digestion of food will also be disrupted (Imanpoor et al. 2011, Padmanabha et al. 2015, Saradhamani & Kumari 2011, Sunanda et al. 2016).

Growth Rate

Based on Fig. 3, it can be seen that there was a decrease in the growth rate of tilapia exposed to chlorpyrifos insecticides during the test day. At the concentration of 0.0108 mg/L, the coefficient of determination was 0.979, and at concentration of 0.0054 mg/L it was 0.975. Based on these two coefficients of determination, the correlation coefficients ranged from 0.800 to 1,000, which means that the relationship is very strong between the test time and the growth rate of tilapia. The decline in growth rate on day 1 to day 14 at the concentration of 0.0054 mg/L was 2.7048%, and at the concentration of 0.0108 mg/L was 2.4294%. Decreasing the growth rate of fish occurs due to disruption of the metabolic processes in the fish's body due to damage to the respiratory nervous system (Amiri et al. 2018, Botté et al. 2012, Floyd et al. 2008; Kim et al. 2018, Kusriani et al. 2012).

CONCLUSIONS

The longer the exposure time and the higher the concentration of chlorpyrifos insecticide exposure, the level of oxygen consumption of tilapia will decrease. The level of oxygen consumption of tilapia decreased at a concentration of 0.0054 mg/L by 0.0159 mgO_2/L, and at a concentration of 0.0108 mg/L by 0.0213 mgO_2/L.

The longer the exposure time and higher the concentration of chlorpyrifos insecticide exposure, the tilapia feed conversion ratio will increase. The increase in tilapia feed conversion ratio at a concentration of 0.0054 mg/L is 0.8253, and at a concentration of 0.0108 mg/L is 0.8201.

The longer the exposure time and higher the concentration of chlorpyrifos insecticide exposure, the growth rate of tilapia will decrease. The growth rate of tilapia decreased at the concentration of 0.0054 mg/L by 2.7048%, and at the concentration of 0.0108 mg/L by 2.4294%.

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