Determination of Liver Somatic Index (LSI) and *Gonadosomatic Index* (GSI) Value of Crap (*Cyprinus carpio*) and Nile tilapia (*Perca fluviatilis*)

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Abstract- Heavy metal contamination in water is very dangerous because of its toxicity. Exposure of heavy metal can accumulate in the body tissues of living things lived there. Cadmium (Cd), Lead (Pb) and Mercury (Hg) are heavy metals which highly toxic compared to other heavy metals. Carcinogenic properties of these metals potentially cause cancer in various organs. Kaligarang river is one of the rivers in Semarang which include to the target of Program Kali Bersih (Clean River Program). Its flow is met with the flow of Kreo river which is contamined by heavy metals. This study aimed to determine the exposure of Cd and Pb heavy metals in the Kaligarang river using *Cyprinus carpio* (Crap) and *Perca fluviatilis* (Nile tilapia) as a bioindicator. 200 samples of Crap and 200 sampels of Nile tilapia was used in this study to measure their Liver Somatic Index (LSI) and Gonadosomatic Index (GSI). The result showed that the LSI values of Crap in treatment and control group were respectively respectively (1.930 ± 0.186) and (2.756 ± 0.230). LSI values of Nile tilapia in treatment group and control group were respectively (2.244 ± 0.348) and (2.612 ± 0.451). GSI values of Crap in the control group and treatment group were respectively (0.268 ± 0.051) and (0.160 ± 0.039). GSI values of Nile tilapia in the control group and treatment group was respectively (0.230 ± 0.028) and (0.136 ± 0.026). The conclusion of this study is that there was a significant difference of the crap's LSI value of the control and treatment group, while there was no significant difference on the nile tilapia. For the GSI value, there was a significant difference between the control and treatment group of both the crap and nila tilapia.

Keywords- *Heavy metals, LSI, GSI*

I. INTRODUCTION

Organic and inorganic pollutants contaminate aquatic environments. Organic pollutants contaminate waters include DDT, PAHs, pesticides, insecticides, detergents and other household waste. While inorganic pollutants often found in waters are heavy metals Cd (cadmium), Pb (lead), Hg (Mercury),
As (Arsenic), Zn (zinc), Cu (copper), Ni (Nickel), and Cr (Chromium). The heavy metal pollutants are very dangerous if they contaminate waters because they are very toxic, carcinogenic, bioaccumulative and biomagnification [1], [2], [3]. Exposure of the heavy metal in the environment can accumulate in the body tissues of living things lived there. It can poison all biotic components (animals, plants, and humans) when reaching as toxic concentration and there is a multiplication of the contaminants content by organisms at higher trophic structure through the food chain.

Cadmium (Cd), lead (Pb) and Mercury (Hg) are a heavy metal which is highly toxic compared to other heavy metals. Carcinogenic properties of these metals potentially cause cancer in various organs. Cd, Pb and Hg pollutants can pollute the marine environment, air, and soil, but these contaminants eventually ended up in the water, then the water environment becomes the highest attention in environmental monitoring. In the river waters, Cd, Pb and Hg can be accumulated in the sediment, water or on the river biota [4], [5], [6], [7], [3].

Plaa [2] and Argawala [6] said that in the metal pollution monitoring, water biota analysis is more important than water analysis itself. Biota water is very well used as bio-indicators of the heavy metal pollution in the waters. Animals easily absorbs Cd, Pb and Hg from food and be accumulated in the body tissues such as the kidney, liver and reproductive organs [4], [2], [1]. In the aquatic environment, a contaminant enters to the tissues of an autotroph organisms by direct absorption. In fish, contaminants can enter through direct absorption process, which depends on the attachment site mainly through the gills (branchia) on the branchiale epithelium. Meanwhile, the contaminants enter indirectly by trophic way passing through the microvilli of the intestinal surface [5], [1], [7].

Kaligarang river is one of the rivers at Semarang which including to the priority target of Program Kali Bersih (Clean River Program) in Central Java Province. The river meets the river flow of the Kreo river and the Kripik river, further downstream canal merges with the Banjir Kanal Barat river of Semarang city. Water of the Kaligarang river is used as a water source for drinking water by Regional Water Company (PDAM) Semarang, and also used for agriculture, households and industry. Kaligarang gives the dominant water supply for the city of Semarang. Most of the people around the river, especially in downstream, use it to fish which is used for daily food or being traded.

However, the presence of heavy metals is feared at any time exceed the limit on the value of the Water Standard Quality, because of the community and industrial waste which are discharged every day is relatively high.

Badan Lingkungan Hidup Jawa Tengah's (Central Java Environment Agency) [8] research found that there was a heavy metals eg. Pb and Cd in sediment of the Kreo river streams from the landfill of Jatibarang Semarang, so it was possible that heavy metals found in the Kaligarang river then pollute its water. Kartini and Danusaputro [9] suggested that Kaligarang water contained the heavy metals. Various types of heavy metals, such as iron (Fe), Cadmium (Cd), lead (Pb), Nickel (Ni), copper (Cu) and Mercury (Hg) were found in various quantities of all kinds water samples taken, although not all heavy metals exceed the Quality Standard. However, the presence of heavy metals is worried to exceeds the Standard Quality value at any time, because the contribution of community and industrial waste are discharged relatively high every day.

The heavy metals of Cd and Pd pollution in the Kaligarang river can be detected by using a crap (*Cyprinus carpio*) and a nile tilapia (*Perca fluviatilis*) as an bioindicator by determining of fish's Liver Somatic Index (LSI) and Gonadosomatic Index (GSI).

II. MATERIALS AND METHODS

All samples of the crap (*Cyprinus carpio* L.) and the nile tilapia *(Oreochromis nilotucus* L.*)* were taken from the pool of Balai Benih Ikan Ungaran, Semarang Regency. Each of the Crap and the Nile tilapia was taken 200 then randomly divided into 2 groups, named the control and treatment groups, respectively 100 individuals. Fish samples of the control group were looked after in the Karamba Floating Net (KJA) in the pond of Fish Seed Ungaran Semarang Regency. While the fish samples of the treatment group were looked after in a Karamba Floating Net at the downstream of Kaligarang river. All fish were harvested after 1.5 months maintained to measure LSI and GSI.

Liver Somatic Index (LSI) Measuring Procedure

The procedures to measure LSI was each fish sample was measured its body weight and liver weight first. Then determine the LSI by a pattern bellow.

$$LSI = \frac{\text{The liver weight of fish}}{\text{The body weight of fish}} \times 100$$

***Gonadosomatic Index* (GSI) Measuring Procedure**

The procedures to measure LSI was each fish sample was measured its body weight and gonad weight. Then determine the LSI by a pattern bellow.

$$GSI = \frac{\text{The gonad weight of fish}}{\text{The body weight of fish}} \times 100$$

Statistical Analysis

The data had a normal distribution so this used Parametric Independent Sample t-Test for statistic analyses. This test was done to determine the differences of LSI and GSI on the fish of the control and treatment group.

III. RESULT

Liver Somatic Index (LSI) was a comparison between the liver weight and the body weight of the fish multipled by 100. The number of the crap's *Liver Somatic Index* (LSI) of the treatment and control group were respectively (1.930 ± 0.186) and (2.756 ± 0.230). The number of nile tilapia's *Liver Somatic Index* (LSI) of the treatment and control group were respectively (2.244 ± 0.348) and (2.612 ± 0.451). The Value of the Crap's and the Nile Tilapia's *Liver Somatic Index* (LSI) was shown in this table 1.

Table 1
The Value of *Liver Somatic Index* (LSI) on the Crap and the Nile Tilapia

Types	*Liver Somatic Index* (LSI)		p-value
	Control	Treatment	
Crap	2.756±0.230	1.930±0.186	0.000
Nile Tilapia	2.612±0.451	2.244±0.348	0.187

The crap's LSI value of the treatment and control group based on the result of the different test-*independent T-Test* showed the significant value 0.000 ($p < 0.01$), so there was a significant difference between the LSI value of the treatment and control group although the average value of the treatment group was lower than the control group. Meanwhile, the nila tilapia's LSI showed the significant value was 0.187 ($p > 0.05$), so there was no significant difference between the LSI value of the treatment and control group although the average value of the treatment group was lower than the control group.

Gonadosomatic Index (GSI) was a comparison between the gonad weight and the body weight of the fish multipled by 100. The number of the crap's *Gonadosomatic Index* (GSI) of the control and treatment group were respectively (0.268 ± 0.051) and (0.160 ± 0.039). The number of nile tilapia's *Gonadosomatic Index* (GSI) of the control and treatment group were respectively (0.230 ± 0.028) and (0.136 ± 0.026). The Value of the Crap's and the Nile Tilapia's *Gonadosomatic Index* (GSI)was

shown in this table 2.

Table 2
The Value of *Gonadosomatic Index* (GSI) on the Crap and the Nile Tilapia

Type	*Gonadosomatic Index* (GSI)		p-value
	Control	Treatment	
Crap	0.268±0.051	0.160±0.039	0.006
Nile Tilapia	0.230±0.028	0.136±0.026	0.001

Based on the results of the different test-*independent T-Test*, the crap's GSI value of the control and treatment group showed that the significant value was 0.006 ($p < 0.01$), so there was a significant difference between the GSI value of the control and treatment group although the average value of the treatment group was lower than the control group. Meanwhile, the nila tilapia's GSI showed that the significant value was 0.001 ($p < 0.01$), so there was a significant difference between the nila talapia's GSI value of the control and treatment group.

IV. DISCUSSION

The Nile Tilapia's LSI value of the control and treatment groups based on the statistical tests showed no significant difference ($p = 0.187$; $p < 0.05$), whereas the mean value of the crap's LSI value between control and treatment group was significantly different ($p = 0.000$; $p < 0.01$). This was because the crap was more sensitive to toxic compounds. As the opinion of Ossana et al [10] found that *Cyprinus carpio L*. (crap) was a species that was used as a test organism in toxicity bioassay because it had a physiological response to the presence of contaminants which was more sensitive than other fish species. De Conto Cinier et al [11] suggested the same thing that the crap immediately provided the physiological response to the heavy metals exposure. Therefore, considering this species was sensitive to the heavy metals exposure so it was easily adapted to laboratory conditions for experimental research. Based on the value of morphometric record showed that the metal exposure would affect the occurrence of stress on the crap soon, so that the toxic effects on the crap would be immediately known. Thus, the heavy metals exposure in *Cyprinus carpio* cause sub lethal acute, despite of the relatively short time exposure (five days) [10].

The LSI value of both the nile tilapia and crap treatment group was lower than the nile tilapia and crap control group. This suggested that heavy metals exposure resulted in the low of average LSI value. The low value of LSI might be occured when the waters polluted by heavy metals, then these heavy metals were absorbed through the epithelial membrane, especially the gills. These were carried to the liver by the blood, resulting in the accumulation of heavy metals in the liver; in addition to the heavy metal accumulation in the liver would result in malfunction of enzymes because of a bonding of heavy metal with sulfhydryl (-SH) group on the enzymes, thereby disrupting the body's metabolism and causing the fish liver became low so that the value of LSI decreased / low [7], [12]. Given the heavy metals were toxic and carsinogenic, then the accumulation of heavy metals in the liver would damage the liver tissue, so that the fish liver went to have swelling (hepatomegaly) first, but if the level of damage was getting worse due to the greater accumulation of heavy metals in the liver, then the liver would suffer necrosis and cirrhosis [13], [14]. Cirrhosis would decrease the liver size / shrinkage. The size of a small liver would lead to severe liver became low so that the value of LSI low / declining.

Swelling of the liver cells was reversible so that if the toxic compounds exposure did not occur then the cells could be returned to normal. However, if heavy metal exposure occured lasts longer so the cells could not tolerate the damage caused it. Azis and Ghazaly [15]; Marina and Martinez [13], suggested that the exposure of heavy metals caused swelling of hepatocytes as a direct result of the toxic substances which directly affect the ion transport mechanisms. Continued cell death would cause necrosis. Necrosis caused an inflammatory response in alive tissues around the necrosis area. The aim of this inflammatory response was to recover the tissue and suppress the causative agent of necrosis. When exposed to toxic substances continuously, it would cause the cells lost the regeneration ability which would trigger fibrosis. If the fibrosis extended to all parts of the liver, it would occur cirrhosis (hardening / reduce liver) causing liver failure. This was because of the hepatic portal vein hypertension which could interfere the blood flow that would hamper the supply of nutrients and oxygen exchange.

Larsson et al [16] and Sandstrom et al [17] suggested that LSI was a biomarker that indicated the status of feeding and metabolism. The liver size indicated the high of metabolic activity while the small size of the liver could be caused by lack of food. According to Van der Oost et al [18] Liver Somatic Index (LSI) were significantly decreased when exposed to organic pollutants exposure, such as OCPs, Polychlorinated biphenyls (PCBs) and Polycyclic Aromatic Hydrocarbons (PAH). This decrease was likely caused by the influence of the food limitations and the stress factors.

The result of the different test of the control and treatment group nila tilapia's GSI value showed significant difference ($p = 0.001$; $p < 0.01$). Whereas the different test result of the crap's GSI value of the control and treatment group showed significant difference ($p = 0.006$; $p < 0.01$).

The GSI value of both the nile tilapia and crap treatment group was lower than the control group. this showed that the heavy ,etals exposure affedcted to the GSI value. The heavy metals exposure caused the GSI value became less than fish group with no heavy metals exposure. The low of the GSI value caused by the heavy metal exposure migth be occured when the heavy metals contaminated aquatic environment, then it would be absorbed by epithelial membrane, espescially the gills, and then brought to some organs such as liver, gonad, kidney, muscles, and skin by blood. This would cause the heavy metals accumulation in those organs. The heavy metal accumulation in the gonad would cause damage of the gonad tissue because the heavy metal was toxic, carcinogenic and iritative. Thus, gonad would degenerate, smaller size, the low GSI value and affected the

reproductive ability so that caused the fertility decrease [16], [17]. Based on the Van der Oost *et al* [18], the GSI value including on the biomarker of effect group which was the biomarker related with the measurement of the pollutants pollution effect to the health.

However, Siah *et al* [19] suggested that the presence of the organic pollutants such as tributynil (TBT) in the water would cause the sexual maturation disruption and reducing the gonad size so that the GSI value lower. Therefor the opinion of Hanson *et al* [20] suggested that the organic pollutant such as PCBs and PAH in the water caused reducing gonad size of the perch fish (*Perca fluviatilis*) which caused the GSI value decrease.

V. CONCLUSION

The crap's *Liver Somatic Index* (LSI) value of the treatment group and control group was respectively (1.930 ± 0.186) and (2.756 ± 0.230). The nile tilapia's *Liver Somatic Index* (LSI) value of the treatment group and control group was respectively (2.244 ± 0.348) and (2.612 ± 0.451).

The crap's *Gonadosomatic Index* (GSI) value of the control group and treatment group was respectively (0.268 ± 0.051) and (0.160 ± 0.039). While the nile tilapia's *Gonadosomatic Index* (GSI) value of the control group and treatment group was respectively (0.230 ± 0.028) and (0.136 ± 0.026). There was a significant difference of the crap's LSI value of the control and treatment group, while there was no significant difference on the nile tilapia. There was a significant difference between the control and treatment group of both of the crap's and nila tilapia's GSI value.

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