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Streamer biofilm as a biomonitoring agent of mercury and hexavalent chromium In Bulak canal Kenjeran Surabaya

Ion Tarsardo Sianturi[1], Sri Andayani[2], Andi Kurniawan[2,3] and Lutfi Ni'matus Salamah[3]

[1]Postgraduate Program, Faculty of Fisheries and Marine Science, University of Brawijaya,Malang, **Indonesia.**
[2]Faculty of Fisheries and Marine Science, University of Brawijaya, Malang, **Indonesia.**
[3]Coastal and Marine Research Center, University of Brawijaya, Malang, **Indonesia.**

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***Correspondence:** sianturinoi@gmail.com **Accepted: 18** Sep. 2019 **Published online: 30** Sep 2019

Water pollution that occurs in the Bulak canal Kenjeran Surabaya was caused by heavy metal Hg^{2+} and Cr^{6+} which have characteristics of preservation, bioaccumulation and bioaugmentation. The presence of heavy metal results in decreased water quality. One way to monitor the presence of heavy metals is to use organisms in an indicator or called bio-monitoring. The organisms recommended as bio-monitoring agents are biofilms. The purpose of this study was to analyze the content of Hg^{2+} and Cr^{6+} in biofilms, sediments and water in the Bulak canal, Kenjeran, Surabaya. The results showed that Hg^{2+} concentration on biofilm (93.12 mg/L) was higher than on sediment (1.70 mg/L) and water (1,06 mg/L). The Cr^{6+} concentration on biofilm (55,50 mg/L) was also higher than on sediment (0,31 mg/L) and water (0,42 mg/L). The results of Anova test showed that the values were significantly different between biofilms with sediment and water. While the results of water quality analysis were showed in normal condition; salinity (1 ppt), temperature (25-32°C), current (0,035-0,081 m/s), depth (32-34 cm), DO (1,32-1,59 mg/L) and pH (7,14-7,7). Based on this study biofilms can be used as biomonitoring agents in lotic ecosystem.

Keywords: Bio-monitoring, Streamer Biofilm, Mercury and Hexavalent Chromium. Bulak Canal

INTRODUCTION

Water pollution is the entry of living things, substances, energy or other components into the waters by human activities so that water quality decreases (Law No. 23, 1997). One dangerous pollutant is heavy metal Hg^{2+} and Cr^{6+} (Yudo, 2006). The metal is one of the most persistent pollutants in the water (Salem et al., 2000). Besides that it is very reactive and can accumulate in food chain (Ayangberno and Babalola, 2017). These heavy metal ions will be bound by low-level organisms after that through the food chain they will be consumed by humans and can cause neurological disorders and prevent DNA replication (Fahruddin, 2014; Singh et al., 2019; Zeng, et al., 2019), therefore it is necessary to monitor water quality

A common way to monitor water quality is to measure content of pollutant such as heavy metals in water, but this method has the disadvantage of moving the mass of water through the currents. This situation is utilized by those who are not responsible for disposing of waste at certain times (night or when it rains) so that the presence of the waste cannot be detected and tends to potentially cause harmful and toxic pollutants in the waters (Hidayati et al., 2014; Xiong et al., 2019; Torkashvand et al., 2019;

Cánovas et al., 2019; Sawyerr et al., 2019). Therefore, the most effective method is needed to monitor water quality in the lotic ecosystem.

So that the selection of bio monitoring agents becomes very important. The characteristics of the selection of biomonitoring agents, which are living permanently, can accumulate heavy metals, are very sensitive to changes in water quality, are easy to find, have sufficient density and sampling is easy using simple tools (Mauru, 2012; Lee et al., 2019; Tovar-Sánchez et al., 2019; Bonnail et al., 2019). Based on these characteristics biofilms can be used as an alternative bio monitoring agent. Therefore this study aimed to analyze the content of Hg^{2+} and Cr^{6+} in biofilms, sediments and water in the Bulak canal, Kenjeran.

MATERIALS AND METHODS

Biofilm, sediments and water samples this study were obtained from the Bulak canal, Kenjeran Surabaya. The method used to collec biofilms sampel by *brushing* method. The procedur was brushed the entire stone surface. While the chemicals used in this study are HgS04, K2Cr2O7, HNO_3. The concentration of Hg^{2+} and Cr^{6+} was measured using AAS (Atomic Absorption Spectrophotometry), besides that the tool used to measure water quality parameters was the thermometer, pH meter, current meter, DO meter and AAQ (Aqua Quality Sensor).

Procedure reaction

Sampling

Biofilm, sediment and water sampling were carried out at each station where there are 3 stations. The location station 1 close to the factory, station 2 between stations 1 and 3 and station 3 close to the river, each sample taken with 3 replications. Water and sediment samples were taken as much as 250 ml and ± 1 gram. Biofilm samples in the stone are cleaned of sediment and attached organisms, then brushed and weighed 0.8 gram and stored in a container containing 80 ml of aquadest. Furthermore, the three samples were put into a cool box with a temperature of ± 40°C and brought to the laboratory.

Analysis of Hg^{2+} and Cr^{6+} in Biofilms, Sediments and Water

Biofilm samples were centrifuged for 5 minutes at 6,500 RPM whereupon the supernatant formed was analyzed using AAS. Whereas, the sediment and water samples were suplemented HNO3 which functions as a metal binder so that the Cr^{6+} and Hg^{2+} metals are not separated from the sample

Water Quality Analysis

The water quality parameters observed in this study were pH measured using pH meter, temperature measured using thermometer, dissolved oxygen measured using DO meter, current measured using current meter, depth measured using rope that was weighted and salinity and turbidity measured using AAQ.

RESULTS

Analysis of Hg^{2+} and Cr^{6+} Concentrations in Biofilms

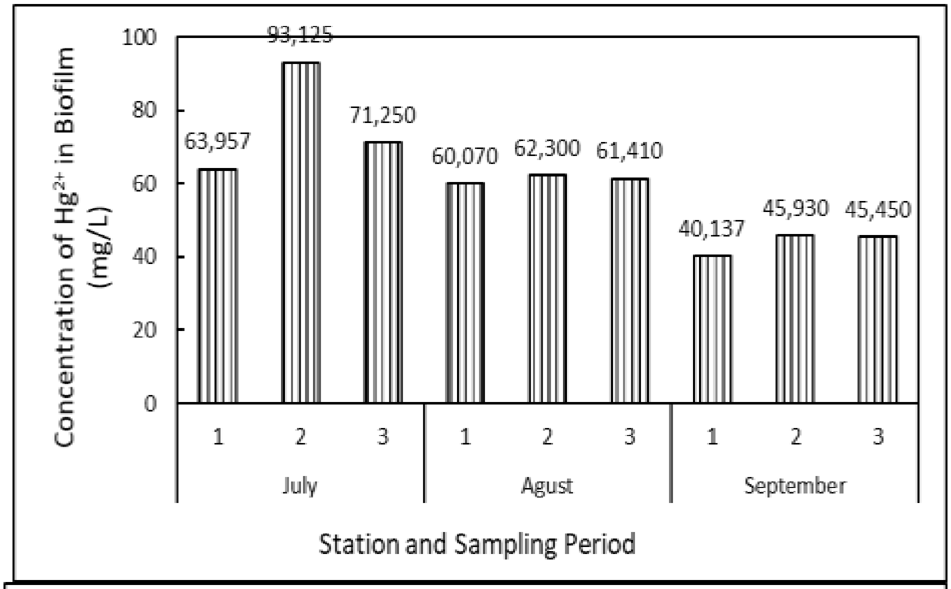
The results of observing Hg^{2+} in biofilms are presented in Figure 1 (a). In July, August and September the highest concentration at station 2 was 93.1; 62.3 and 45.9 mg/L. While the lowest concentration at station 1 was 63.9; 60.1 and 40.1 mg/L respectively. Whereas the observations of Cr^{6+} on biofilms are presented in Figure 1 (b). In July, August and September the highest concentration at station 2 was 45.8; 55.5 and 29.0 mg/L. While the lowest concentration at station 1 was 35.9; 48.3 and 25.1 mg/L respectively.

Becouse of in the station 2 low current value of 0.054; 0.037 and 0.035 m/s was figured small adsoption. Kurniawan and Yamamoto (2013), reported that the accumulation of heavy metals is strongly influenced by the velocity of the current. In odherwise, other factors are contact time, the higher water flow, the shorter the time of heavy metal contact (Kurniawan, 2012)

The results of observations of Cr^{6+} in sediments and water are shown in Figure 2 (b). In July and August the highest concentration at station 2 was 0.36 and 0.31 mg/L in the sediment then in the water was 0.32 and 0.42 mg/L, while the lowest concentration at station 1 was 0.21 and 0.29 mg/L in the sediment then in water was 0.26 and 0.34 mg/L. Whereas in September the highest concentrations in sediment and water at station 3 was 0.21 and 0.40 mg/L and the lowest concentration at station 1 was 0.10 and 0.20 mg/L respectively.

The results of the concentrations of Hg^{2+} and Cr^{6+} in sediments and water after the Anova test showed values that were not significantly different. This is probably due to the high value of the turbidity in the water, which ranges from 41.02 to 67.88 ppm. Turbidity or suspended solids will contribute significantly in binding metals in the water (Arifin and Fadhlina, 2009; Shao et al., 2019) so that the value of metal concentrations in water and sediments is not significantly different. Both metals Hg^{2+} and Cr^{6+} are dissolved in water (Suprihatin and Indrasti, 2010).

A



b

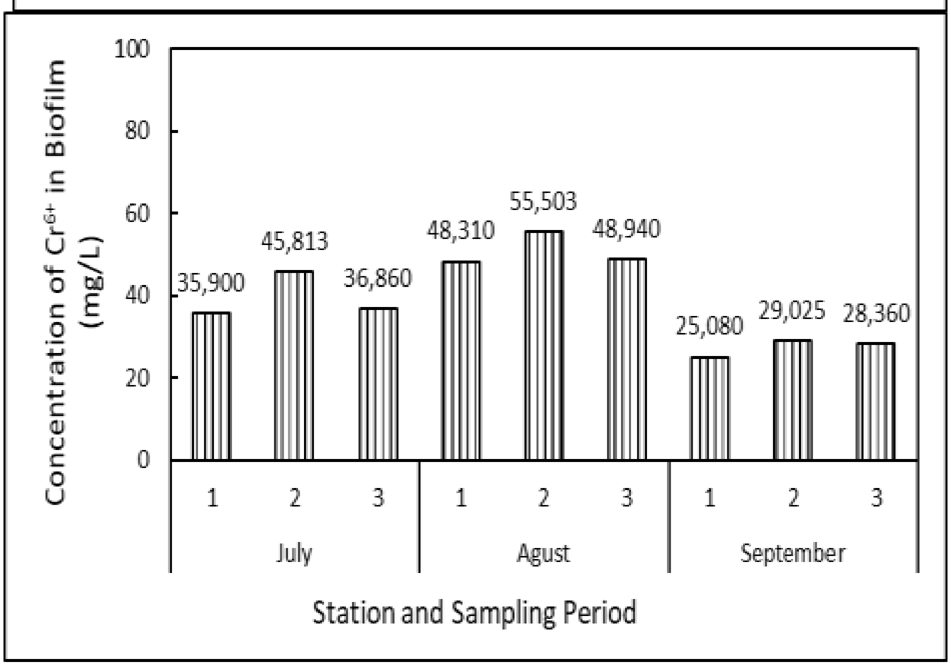


Figure 1; Concentrations of Hg^{2+} (a) and Cr^{6+} (b) in Biofilms in the month: July, August, and September

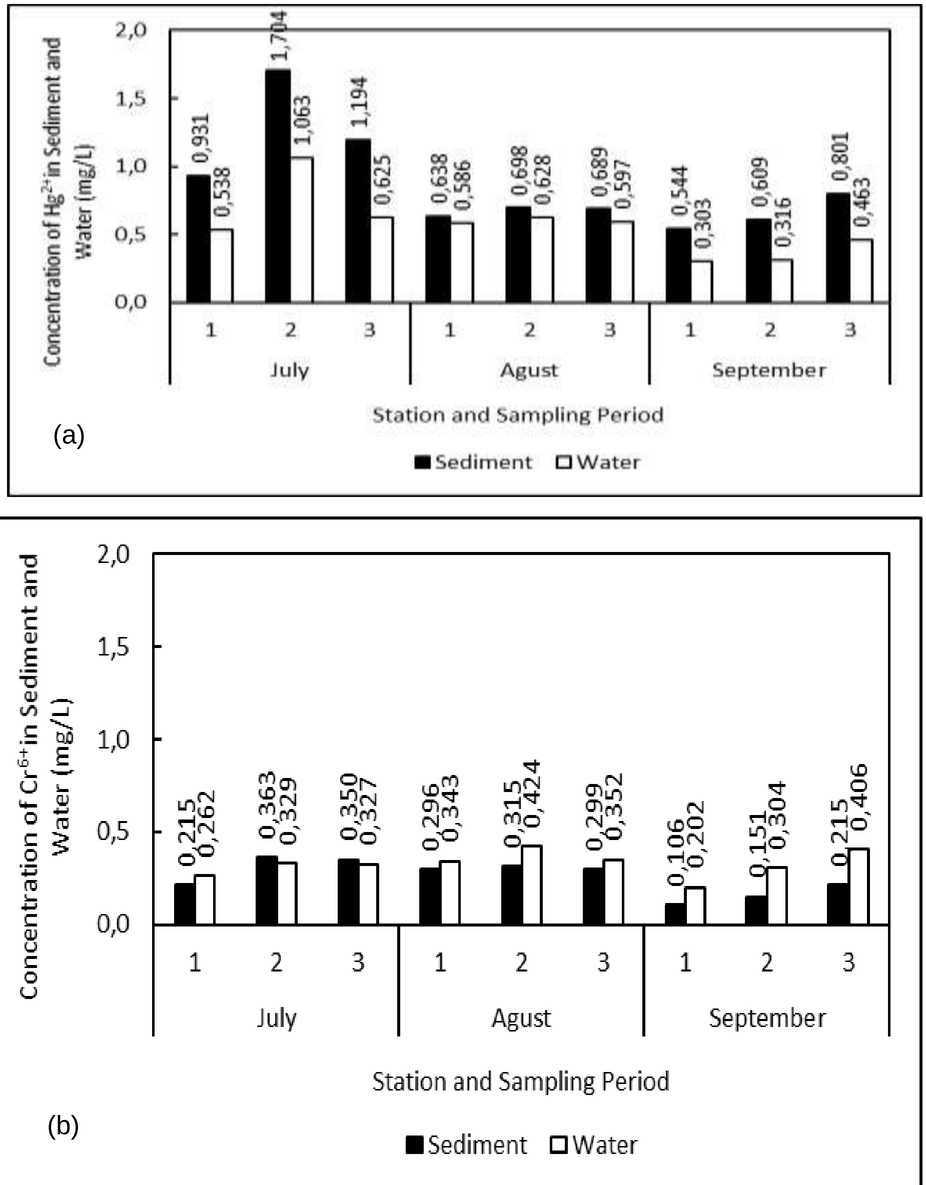


Figure 2; Concentrations of Hg^{2+} (a) and Cr^{6+} (b) in Sediment and Water in the month: July, August, September.

Comparison of Hg^{2+} and Cr^{6+} Concentrations in Biofilms, Sediments and Water

The results of the comparison of Hg^{2+} on biofilms, sediments and water are presented in Figure 3 (a), in July the highest concentration in biofilms was 93.12 mg/L higher than sediment and water was 1.70 and 1,06 mg/L. In August the highest concentration of biofilms was 62.30 mg/L higher than sediment and water was 0.69 and 0.62 mg/L. Whereas in September the highest concentration in biofilms was 45.93 mg/L higher than sediment and water was 0.80 and 0.46 mg/L.

The results of the comparison of Cr^{6+} on biofilms, sediments and water are presented in Figure 3 (b) in July the highest concentration in biofilms was 45,81 mg/L higher than sediment and water was 0,36 and 0,32 mg/L. In August the highest concentration of biofilms was 55,50 mg/L higher than sediment and water was 0,31 and 0,42 mg/L. Whereas in September the highest concentration in biofilms was 29,02 mg/L higher than sediment and water was 0,21 and 0,40 mg/L respectively.

The results of the data comparison of Hg^{2+} and Cr^{6+} on biofilms, sediments and water after the Anova test showed that the values were significantly different between biofilms with sediment and water.

This is because biofilms have a fast adsorption ability, Kurniawan and Yamamoto (2013), reported stating that the biofilm adsorption process occurs quickly. The porous of biofilms are supporting adsorption process quickly through diffusion and water transmission (Zhang et al., 2018).

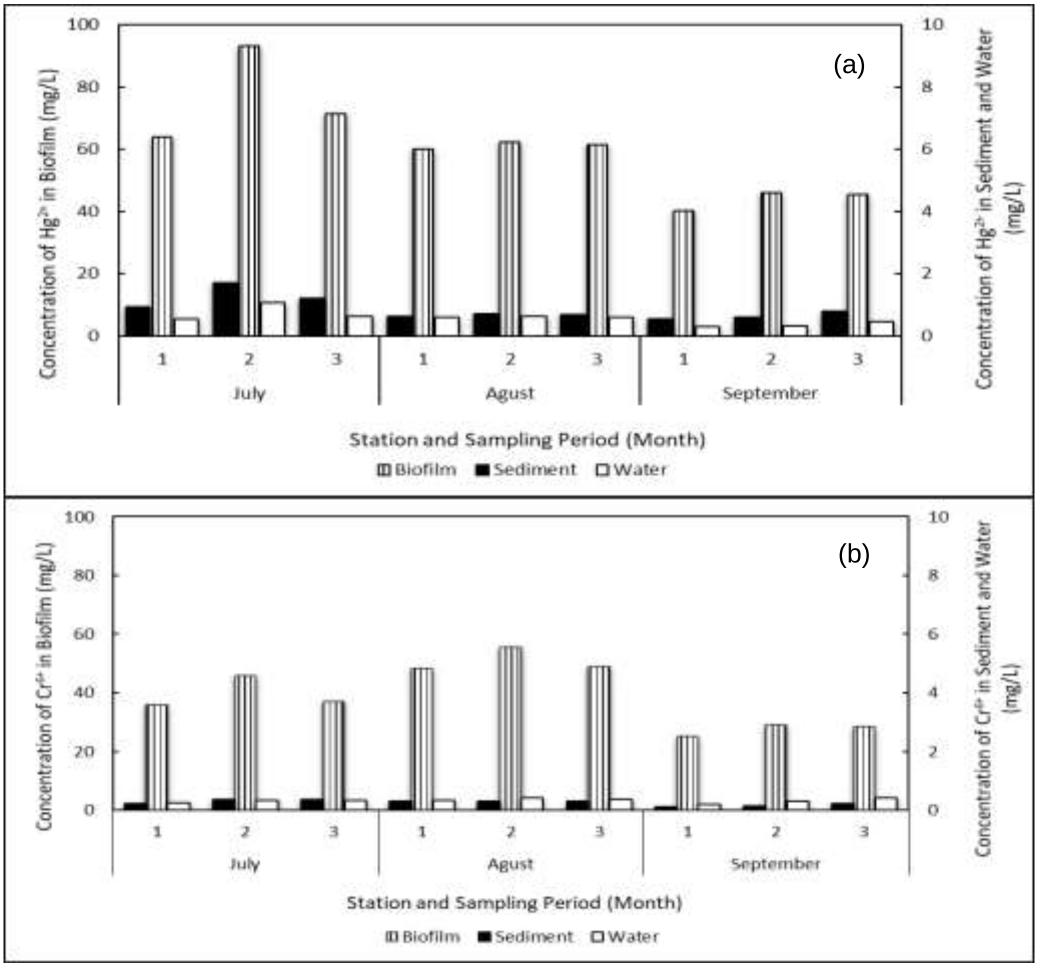


Figure 3; Comparison Concentration of Hg^{2+} (a) and Cr^{6+} (b) in Biofilms, Sediment and Water in the month: July, August, September

Table 1; Water Quality Analysis

Parameter	JULY			August			September		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Salinity (ppt)	1	1	1	1	1	1	1	1	1
Temperature (^{0}C)	27.8	28.3	28.4	28.5	28.7	29.9	30.51	29.58	31.03
Current(m/s)	0.076	0.054	0.082	0.048	0.037	0.053	0.044	0.035	0.056
Depth (cm)	32	34	32	32	34	33	33	34	34
DO(mg/L)	1.53	1.59	1.53	1.54	1.42	1.45	1.54	1.49	1.32
pH	7.27	7.51	7.42	7.14	7.21	7.32	7.75	7.77	7.61

Description:S1 = Station 1 (close to a factory suspected of producing Hg^{2+} and Cr^{6+} waste),S2 = Station 2 (between station 1 and 3),S3 = Station 3 (close to a big river)

Water Quality Analysis

The results of measurements of physical and chemical environmental parameters in the Bulak canal Kenjeran Surabaya during the study presented in Table 1. Based on salinity measurements in each month and stations obtained values of 1 ppt according to Astuti et al., (2007), the maximum salinity of fresh water was 1 ppt. Temperature measurement values ranged from 27.8-31.03˚C where general water temperatures ranged from 25.0-32.0˚C (Mulyanto, 1992). The value of current measurement ranges from 0.035-0.081 m/s. According to Usman et al., (2013), currents play a role in the distribution of heavy metals throughout the waters and fast water caused the adsorption getting smaller value. The value of depth measurements was ranges from 32-34 cm including shallow waters. Maslukah (2013), reported the high and low content of heavy metals in the waters was related to depth. Content of heavy metal in shallow water was higher than deep water. DO measurement was showed range from 1.32-1.59 mg/L, Happy et al., (2012), reported low dissolved oxygen values are a strong indication of contamination. The pH measurement was showed range from 7.14-7.7 those is still ideal range for freshwater organisms range from 6.8 to 8.5 (Tatangindatu et al., 2013).

CONCLUSION

Biofilm concentrations were higher than sediments and water, this was because biofilms have a high absorption capacity in odherwise to sedentary biofilms and were very sensitive to changes in water conditions. So that /therefor biofilms could be used as an alternative bio-monitoring agent, reference, consideration in monitoring water quality and are expected to reduce pollution in waters flowing throughout Indonesia.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All the authors have contributed: ITS as data collection, data analysis and writing manuscript, SA, AK, and LNS contributed to review of manuscripts

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