Bioconcentration of Chrome (Cr) Metal in Three Types of Sponge (*Callispongia* sp., *Xetospongsia* sp. and *Petrosia* sp.) from Ambon Bay

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Abstract

Research about bioconcentration of Chrome metal in three types of sponge (*Callispongia* sp., *Xetospongia* sp., and *Petrosia* sp.) from Ambon Bay. This research main is to know the most effective type to accumulate Cr metal in water. The Cr concentration measurement of water, sediment, and sponges at each location shows that metal concentration is 0.001-0.030 ppm in sediment higher than 0.001-0.003 ppm in water. Concentration based on sponges type *Callispongia* sp., *Xetospongia* sp., and *Petrosia* sp. are 0.001-0.262 mg/kg dry weight: 0.001-0.134 mg/kg dry weight, 0.001-0.330 mg/kg dry weight, respectively. The adsorption factor (AF) of Cr metal ranges from 0.000-0.028 ppm. Bioconcentration factor (BCF) based on sponges type *Callispongia* sp., *Xetospongia* sp., and *Petrosia* sp. are -0.011-0.261 mg/kg dry weight, -0.001-0.132 mg/kg dry weight, and -0.001-0.329 mg/kg weight dry, respectively. Sponges type that suitable used as Cr metal pollution monitoring media is *Callispongia* sp. and *Xetospongia* sp.

Keywords: Bioconcentration, Callispongia sp., *Cr metal*, *Petrosia* sp., *Sponges, Xetospongia* sp.

INTRODUCTION

Heavy metals have been recognized as harmful things to the environment. Much research has been done to analyze the heavy metals content in environmental samples, especially for sea samples such as seawater, sediments, and organisms. Wibowo et. al (2020) has been doing an analysis of Nickel in seawater and its distribution at Kendari Bay (Dwiprayogo Wibowo et al., 2020). A year before, Rustiah et. al (2019) has been studied the distribution of Pb and Cd in sediments along estuary area and sea at Spremode, South Sulawesi (Waode Rustiah, Alfian Nurfadilah Nurfadilah, 2019). Besides the study on environmental samples, Mariwy et. al (2020) has been developed a method to monitoring mercury accumulation by using Awar-awar plants (*Ficus Septica Burm F*) (Abraham Mariwy, Yeanchon H. Dulanlebit, & Fian Yulianti, 2020).

The research about sea water shows that sources of pollutants that cause deterioration of seawater quality around the sea comes from the Tuban Beach, ship waste, waste from fish auctions, garbage disposal waste to the sea and residential areas in the Coastal Tuban (Spanton & Saputra, 2017). Irzon (2017) found that the there is anomaly is detected in Ni-Cr content whilst most of rare earth elements show minimum outliers. Anthropogenic activities most possibly influence the high Ni and Cr composition in samples near the mouth of Serang River. On the other hand, the two heavy metals are relatively low in the samples in Congot because they are influenced by Bogowonto River which flows through a rural area. Cr and Ni are more concentrated in the surface, whilst Rb, Sr, Zr, and Ba are in the subsurface sample of polluted locations. Folk gold mining activity in Sangon is rather correlated with Cr, Pb, Y, and Ba concentrations but not Ni and Cr

Zhitkovich (2011) has been done an overview about the Chromium sources in drinking water. The results shows that the presence of Cr(VI) in drinking water results from bothanthropogenic and natural sources. Limited epidemiological studies are insufficient to establish carcinogenic risks of Cr(VI) ingestion in humans. Consumption of Cr(VI) through drinking water produced clear carcinogenic effects in both sexes of mice and rats, and Cr(VI) has a firmly established potential to cause human respiratory

cancers. Since Cr(VI) is taken up via ubiqui-tously expressed transporters and metabolized by ubiquitously present cellular reducers, cells of the human digestive system arealso expected to form cancer-promoting Cr-DNA damage. Multispecies and multisite carcinogenicity of Cr(VI) along with its broad genotoxicity provide a strong basis for a classification of Cr(VI) exposures through drinking water as likely to be carcinogenic to humans. Diverse lines of evidence demonstrate the importance of a DNA-reactive mutagenic mechanism in Cr(VI) carcinogenicity, lending mechanistic support for a linear low-dose extrapolation of cancer risks in humans. The bioavail-ability results and kinetic considerations indicate incomplete gastric detoxification of Cr(VI) at environmental levels ofexposure, predicting its uptake and genotoxic metabolism inthe small intestine (Zhitkovich, 2011).

Chrome is a metal element on the periodic table, group 16, with the atomic number 24. Cr metal is one of many large elements on earth and is also found in many oxidation numbers such as Cr(0), Cr(III), Cr(IV), and Cr(VI). Chrome metal that usually environmentally polluted is Cr(III) and Cr(IV), which come from leather, textile, paint, and steel industry (Nuraini, Endrawati, & Maulana, 2017). Printing and pipe coating industries used Cr as a non-corrosive agent, also as additional material in paint mixing, even as a coloring agent because of its low solubility in water (Arifin & Fadhlina, 2010).

High concentration Cr metal in water could be toxic effect because of bioaccumulation in the water organism's body and continues until this organism can not tolerate that metal concentration(Andini, 2017). Therefore, Cr metal can solve into the water in low concentration, but in sediment, this bioaccumulation could be higher because of physic, chemistry, and biology water process where biomagnification could happen in an organism's body.

The sponge is one demersal organism that lives at corals. Ambon Bay water has corals as long as Ambon Island coastal (Melawaty et al., 2014). The sponge is used as a biological indicator of water pollution level because of its habit and large distribution in Ambon Bay. This statement is suitable for (Melawaty et al., 2014) opinion of sponge has an ideal basic property that can accumulate metal based on dietary (filter feeder), where seawater contains solved particles as foods then filtered through its pores (Melawaty et al., 2014). Siahaya, Noor, Sukamto, & de Voogd, (2021) and Pawar & Al Tawaha, (2017) also have the same opinion that explains that metal concentration in

sponges has a strong correlation with industry water waste from the environment.

METHODOLOGY

Materials and Instrumentals

Some materials that used in this experiment are sponges sample, water sample, sediments sample, nitric acid, chloride acid, Ammonium Pyrolidin Dithio Carbamat (APDC), Methyl Iso Butyl Ketone (MIBK), double distilled water, Whatman 42 Filter Paper, and cellulose nitrate filter paper 0.45 µm.

Water sampler, separating funnel, polyethylene sample bottle, Teflon bottle, Oven (Merck), mortar, pH meter, flowmeter, thermometer, Bechman salinometer, Global Position System (GPS), analytical balance, desiccator, stirring rod, and ICP-OES Perkin Elmer 3000.

Methods

Sediments Sample Preparation

Water and sediment samples were carried out from sponges around the area by using a water sampler. Sediment samples were put in polyethylene bottles that had been washed with HNO_3 6N and rinsed with aquadest. In the laboratory, sediment was put into a Teflon bottle and dried in the oven at 105 °C for 24 hours. After drying, the sample was rinsed three times with aquabidest. Then this drying procedure was repeated. After that sediment sample crushed in a beetle. The amount of 5 grams sediment samples were destructed in Teflon beaker with HNO_3/HCl mixture at 100°C and then filtered. Its filtrate was put into a volumetric flask of 250 mL, and its volume was adjusted with aquabidest. This solution was analyzed by ICP-OES Perkin Elmer 3000.

Water Sample Preparation

Water samples were taken at the location and immediately filtered with cellulose nitrate filter paper, which washed previously with HNO_3 1N. After that, this sample was preserved with HNO_3 1N. The amount of 250 mL water sample put into Teflon separating funnel, then extracted with APDC-NaDDC/MIBK. The organic phase was extracted again with HNO_3 6N. This solution was filtered and then analyzed by ICP-OES Perkin Elmer 3000.

Sponges Sample Preparation

Sponges sample that has been dried in total form and also the frame carefully weighed for 0.5 g in each beaker glass with 5 mL HNO_3 addition. This solution was heated at 150 °C for two hours then cooled at room temperature. After that, the sample was filtered with

Whatman 42 filter paper. The sample solution was diluted in a 250 mL measuring flask by using aquabidest then analyzed by ICP-OES Perkin Elmer 3000.
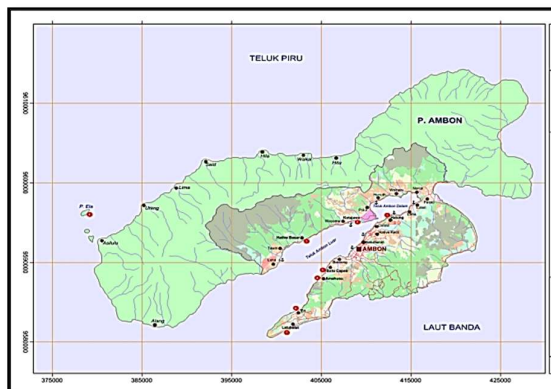

Figure 1. Sampling Location Site (●)

RESULTS AND DISCUSSION

Chrome Concentration in Water and Sediments

The results of the analysis of the Cr metal concentration using ICP-OES perimeter 3000 in water and sediment shows in Table 1.

Table 1.The concentration of Cr metal in the water at the study site

| Location	Water (ppm)	Sediment (ppm)
Halong	0.002	0.005
Kota Jawa	0.001	0.001
Hative Besar	0.001	0.006
Amahusu	0.002	0.004
Batu capeo	0.003	0.005
Ery	0.002	0.03
Latuhalat	0.004	0.01
Pulau tiga	0.001	0.001

The result data (Table 1) showed that the Cr metal concentration of Cr at each study location ranged from 0.001 ppm to 0.003 ppm in water. Cr metal concentration value was highest at the Latuhalat location (0.004 ppm), and the lowest was at the location of the Kota Jawa and Hative Besar, which had the same concentration value of 0.001 ppm. When compared with normal Cr metal concentrations in seawater naturally is 0.00005 ppm (Onchoke & Sasu, 2016), so that the overall Cr metal concentration in the Bay of Ambon is already worrying. This value is following Palar's (2008) opinion that metal Cr and its alloys are widely used as plating materials on various equipment, ranging from household appliances to

modern materials such as cars. Furthermore, according to the study location where metal concentrations are generally high for locations close to the city center of Ambon (Palar, 2008).

Cr metal is a metal that is easily soluble in water, as in the opinion of Shama et al. (2015), where the reaction of high-charged Cr metal is strongly hydrolyzed in aqueous solutions with a small equilibrium constant (K), for example, the water solution with an equilibrium constant (K) small:

$$Cr(H_2O)_6^{3+} + H_2O \leftrightarrow Cr(H_2O)_5OH_2^+ + H_3O^+$$
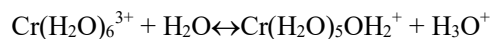
Subsequent hydrolysis can occur by losing one or more protons from coordinated water.

$$Cr(H_2O)_5OH_2^+ + H_3O^+ \leftrightarrow Cr(H_2O)_4(OH)_2^+ + H_3O^+$$
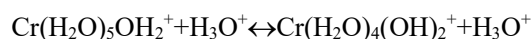
The results of the analysis of Cr metal concentration on sediments in the study location (Ambon Bay) showed in Figure 2.

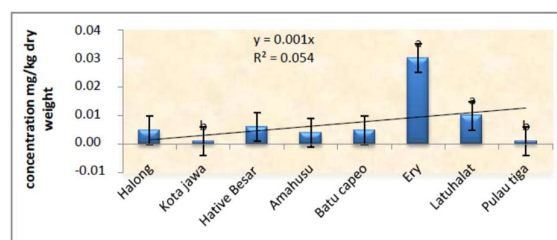
Figure 2. The Cr metal concentration in sediment at each study location (different letter showed significant differences at $\alpha < 0.05$

Data from the analysis of Cr concentration in sediments ranged from 0.001 to 0.003 ppm. The highest concentration value in the Ery location was 0.030 ppm, and the lowest was in the location of the Kota Jawa (0.001 ppm). The concentration of metal Cr when compared to the control location ($p<0.05$) showed very differently. The same pattern of Cr concentration in the water due to the current influence so that for control location. Furthermore, the comparison of Cr metal concentration in water is higher than in sediment.

Chrome Concentration in Sponges

The results of Cr concentration analysis in sponge *Callispongia* sp., *Xestospongia* sp., and *Petrosia* sp. shown in Table 2, where the concentration of metal used is the approach of total metal concentration and sponge frame because the sponge is an animal that does not have a complete organ (Pawar & Al Tawaha, 2017) so that it analytical called concentration in the network,

namely, total metal concentration versus metal concentration in the frame.

Data from the analysis using ICP-OES showed that the sponges of *Callispongia* sp., *Xetospongia* sp., and *Petrosi* sp. at each study location of the Kota Jawa, Halong, and Hative Besar had a Higher concentration of Cr metal compared to other locations. However, when compared with Cr concentration in water and sediment, it is inversely proportional, wherein these three locations, it turns out that the concentration is low.

Table 2. Cr metal concentrations in *Callispongia* sp., *Xestospongia* sp. and *Petrosia* sp. sponge at locations

Location	Concentration mg/kg weight dry		
	Callispongia sp.	*Xestospongia* sp.	*Petrosia* sp.
Halong	0.098	0.134	0.181
Kota Jawa	0.262	0.056	0.330
Hative Besar	0.035	0.009	0.025
Amahusu	0.007	0.001	0.001
Batu capeo	0.001	0.001	0.001
Ery	0.013	0.002	0.002
Latuhalat	0.001	0.001	0.002
Pulau tiga	0.001	0.001	0.001

The possibility is related to the nature of the metal itself, as stated by Pawar (2017) that the nature of Cr metal is easily hydrolyzed in water to form Cr^{3+} and also easily oxidized from Cr^{2+} to Cr^{3+} and due to reduction and oxidation changes (Pawar & Al Tawaha, 2017b). This factor causes chelation so that Cr metal is easily bioaccumulated in the sponge. Thus the redox environment is a source of bioaccumulation of metal concentrations in the biota network. In this case, according to Palar (2008), the solubility of metal elements in water bodies is controlled by pH, type of metal and chelate concentration, state of the oxidized mineral components, and the redox system of the environment (Palar, 2008).

Data analysis of bioconcentration of Cr in *Xestospongia* sp. and *Callispongia* sp. is more suitable for bioaccumulation of Cr metal concentrations compared to *Petrosia* sp. In this case, according to the opinion of Shama et. al (2015) which states the concentration of metals accumulated in a sponge is influenced by the type and habitat of the sponge (Shama, Moustafa, & Gad, 2015).

The results of bioconcentration factor analysis in Table 3 shows that the bioconcentration value of Cr based on the type of sponge is: 1) *Callispongia* sp., (0.011-0.261 mg/kg dry weight) and the highest concentration in the location of Kota Jawa and the lowest in Batu Capeo location.

Table 3. Bioconcentration of Cr metal factors at location research locations

Location	Bioconcentration factor of Cr metal in sponges (mg/kg dry weight)		
	Callispongia sp.	*Xetospongia* sp.	*Petrosia* sp.
Halong	0.096	0.132	0.179
Kota Jawa	0.261	0.055	0.329
Hative Besar	0.034	0.008	0.024
Amahusu	0.005	-0.001	-0.001
Batu Capeo	-0.002	0	-0.002
Ery	0.011	-0.002	0
Latuhalat	-0.003	-0.003	-0.002
Pulau Tiga	0	0	0

2) *Xetospongia* sp. (-0.001-0.132 mg/kg dry weight) with the highest concentration in Halong and the lowest in Amahusu. 3) *Petrosia* sp. (-0,001- 0,329 mg/kg dry weight), with the highest concentration, is at Kota Jawa and the lowest at Amahusu.

CONCLUSION

Based on the research result of Cr concentration in water, sediment, and three types of sponges (*Callispongia* sp., *Xetospongia* sp., and *Petrosia* sp.) at each observation location, there is some conclusion that Cr metal concentration ranges from 0.001 – 0.003 ppm in water. The highest found at Latuhalat (0.004 ppm) and the lowest at Kota Jawa and Hative Besar with the same concentration is 0.001 ppm, and also control area 0.001 ppm; in sediments ranged from 0.001-0.030 ppm and at control area 0.001 ppm. The Cr metal concentration in sediment is higher than in water. The concentration value based on *Callispongia* sp. type is 0.001-0.262 mg/kg dry weight, *Xetospongia* sp. is 0.001-0.134 mg/kg dry weight and *Petrosia* sp. is 0.001-0.330 mg/kg dry weight. The study site at Kota Jawa, Halong, and Hative Besar have higher metal concentrations compared to other locations. The highest bioconcentration factor (BCF) value based on sponge type is *Callispongia* sp. -0.011-0.261 mg/kg dry weight with the highest concentration is at Kota Jawa, and the lowest is at Amahusu location, this value is inverse to AF value. Therefore, the type of sponges that could use as monitoring media for Cr contamination is *Callispongia* sp. and *Xetospongia* sp.

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