Proceedings of International Conference : Problem, Solution and Development of Coastal and Delta Areas
Semarang, Indonesia – September 26th, 2017
Paper No. C-07

The ability of *Avicennia marina* (Api-api putih) to Uptake Heavy Metal of Chromium at Wonorejo Coastal in Surabaya

Herman Pratikno[1*], Harmin Sulistyaning Titah[2], Handayanu[1], Bintang Respati Dwi Harnani[2]

[1]Department of Ocean Engineering, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember (ITS), Keputih, Sukolilo, 60111 Surabaya, Indonesia

[2]Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Institut Teknologi Sepuluh Nopember (ITS), Keputih, Sukolilo, 60111 Surabaya, Indonesia

hermankelautan@gmail.com
harminsulis@gmail.com

Abstract- The increasing of industries and population growth are the main sources of contamination in the river. Wonorejo river is one of rivers in Surabaya that flow to east coast Surabaya. Concentration of Chromium (Cr) at estuary of Wonorejo River was 0.0325 mg/L and it was 2.7761 mg/L in sediment in 2007. Meanwhile, Cr at east coast of Wonorejo was 0.418 µg/L, it was indicating that upper than standart for biota in sea, 0.005 µg/L (KepMenLH No. 51 tahun 2004). In this research will be measured concentration of Cr from sediment and roots of Avicennia marina at Wonorejo River estuary. And then, it was calculated Bio-consentration Factor (BCF) value of A. marina. Transect method was used to determine the sampling point of mangrove root A. marina and sediment at estuary of Wonorejo River. Mangrove and sediment roots were analyzed using the Atomic Absorption Spectrophotometer (AAS) method, previously samples of roots and sediments were extracted using the wet destruction method. Parameters supporting in this research were measured include temperature using thermometer, salinity using salinometer and pH using pH meter for sediment. Based on the results, the average concentration of Cr in the sediment in transect 1 were 47 mg/kg until to 66.5 mg/kg. The concentration of Cr in roots of A. marina were 28 mg/kg until to 92.25 mg/kg. The BCF value in A. marina were 0.89 to 1.35. Based on the BCF value, it indicated that A. marina was a hyperacumulator species for heavy metals of Cr.

Keywords: *Avicennia marina, BCF, coast, chromium, root, sediment*

1. Introduction

Wonorejo River is one of the river that discharge into East Coast in Surabaya. This river also content of wastewater from industrial and household that can be polluted at estuary area in Surabaya (BLH, 2012). Generally, wastewater can be categorized as highly toxic, if wastewater is a chemical waste (chemical compound or only in the form of an element or ion). Usually, toxic chemical compounds on living organisms and humans were chemical compounds with an active ingredient of heavy metals. The toxicity by the active ingredient of heavy metals was occured by an enzyme inhibiting on physiological or metabolical processes. In addition, toxic substances from chemical compounds can also accumulate in the body, resulting in the problem of chronic poisoning (Palar, 1994). Chromium (Cr) is one of the heavy metals in VIB class on the periodic table with the atomic number of 24 and the mass number of 52. Usually, Cr can be found in river and coastal from electropleting waste, the textile industry, the paint, the

tannery, the metal coating, and battery (Ackerley et al., 2004). The accumulation of large amounts of Cr in the human body can lead to liver, kidney and toxic damage to protoplasm of living things, and also carcinogenic (cancer-causing), teratogens (inhibits fetal growth) and mutagen (Schiavon et al., 2008).

Mangrove is one type of plant that can survive in high salinity area. Many functions of mangrove were as a habitat of fish, breakwater seawater, phytoremediation process due to the ability to uptake heavy metals form water and sediment. Based on Surabaya's Biodiversity Profile 2012, Surabaya East Coast Area (Pamurbaya) is designated as a conservation area within the *Rencana Tata Ruang Wilayah* (RTRW) of Surabaya City. So that the quality standard for Pamurbaya is the quality standard of sea water for marine biota. The concentration of Cr at estuary of Wonorejo river reached 0.0325 mg/L and in sediments of 2.7761 mg/L in 2007. When, the concentration of Cr at estuary of Wonorejo reached 0.418 µg/L, it indicating it was above water quality standard Sea for marine biota (KepMenLH No. 51, 2004) that is 0.005 µg/L.

Many spesies of mangrove can grow at Wonorejo coastal area. *Avicennia marina* is one of mangrove spesies that can be found at Wonorejo coastal area. The aims of this research were to determine the concentration of Cr that can be uptaken by *A. marina* at Wonorejo coastal area and to determine the value of Bioconcentration Factor (BFC) on Cr by *A. marina*.

2. Materials and Methods

2.1. Sampling Location

Transect quadrat sampling method was a sampling method of a population with a sample plot approach that was on a line drawn through the ecosystem (KepMen LH 201, 2004). The dimension of one quadrant was 10m x 10m. Figure 1 showed the sampling location and Tabel 1 showed types of samples for every point sampling location.

Fig. 1. Sampling location in quadrat A

Table 1. Types of samples for every point sampling location

No	Sampling Point	Code	Explanation
1	Location of A	M11A	Sampel of *A. marina* roots 1
2	Location of A	M12A	Sampel of *A. marina* roots 2
3	Location of A	S11A	Sample of sediment 1
4	Location of A	S12A	Sample of sediment 2
5	Location of A	L11A	Sample of water 1
6	Location of A	L12A	Sample of water2
7	Location of B	M11B	Sampel of *A. marina* roots 1

No	Sampling Point	Code	Explanation
8	Location of B	M12B	Sampel of *A. marina* roots 2
9	Location of B	S11B	Sample of sediment 1
10	Location of B	S12B	Sample of sediment 2
11	Location of B	L11B	Sample of water 1
12	Location of B	L12B	Sample of water2
13	Location of C	M11C	Sampel of *A. marina* roots 1
14	Location of C	M12C	Sampel of *A. marina* roots 2
15	Location of C	S11C	Sample of sediment 1
16	Location of C	S12C	Sample of sediment 2
17	Location of C	L11C	Sample of water 1
18	Location of C	L12C	Sample of water2
19	Location of D	M11D	Sampel of *A. marina* roots 1
20	Location of D	M12D	Sampel of *A. marina* roots 2
21	Location of D	S11D	Sample of sediment 1
22	Location of D	S12D	Sample of sediment 2
23	Location of D	L11D	Sample of water 1
24	Location of D	L12D	Sample of water2
25	Location of E	M11E	Sampel of *A. marina* roots 1
26	Location of E	M12E	Sampel of *A. marina* roots 2
27	Location of E	S11E	Sample of sediment 1
28	Location of E	S12E	Sample of sediment 2
29	Location of E	L11E	Sample of water 1
30	Location of E	L12E	Sample of water2

2.2. Procedure to take brackish water, sediment and roots of mangrove samples

Brackish water sampling, sediment sampling and root of *A. marina* sampling were conducted at the designated sampling sites using Transect quadrat sampling method. Sampling was conducted when the level of sea water was not too low and not too high at around 07.00 am. According to Usman and Mohamed (2009), sediment sampling was carried out by random sampling with a depth of 0-30 cm.

2.3. Extraction of sediment and roots of mangrove samples and analysis of chromium

First, preparation of sediment samples and roots of mangrove plants before those was analyzed using Atomic Absorption Spectrophotometer (AAS). Roots of *A. marina* were dried prior to the extraction procedure. In this experiment, Cr extraction from the plants was performed using a modified wet digestion method (Titah et al. 2013). Meanwhile, the sediment extraction was conducted using EPA method 3050B (1996).

Instrument of AAS was be used to measure the concentration of Cr in brackish water, sediments and roots of *A. marina*. The AAS that be used was Rayleigh WFX 210 (China) at Laboratory of Affiliation Team and Industry Consultation (TAKI) at Chemical Engineering Department of ITS.

2.4. Calculation of Bioconcentration Factor

Based on Bini et al. (1995), Bioconcentration Factor (BCF) or Biological Accumulation Coefficient (BAC) calculation calculation was used in order to gauge ability the of plants to uptake metal from the substrate (Idris et al. 2016). The determination for BAC was based on the following equation (Usman dan Muhamed, 2009):

$$BCF = \frac{C_{roots}}{C_{media}} \quad (1)$$

The results of the determination of BCF were matched with categories of plants (Table 2) to classify which plants are hyperaccumulator plants or otherwise (Bini et al. 1995).

Table 2 Category of BCF

Category	Range
High accumulator plants	1-10
Moderate accumulator plants	0,1 – 1
Low accumulator plants	0,01 – 0,1
Non accumulator plants	< 0,01

3. Results and Discussion

Results of monitoring parameter i.e temperature, salinity and pH at sediment showed that value of those parameters acceptable for mangrove growth. Range of temperature were 28-30^{o}C. pH was in normal range. Range of salinity was 8- 11‰, indicating that salinity included in brackish water (0,5 - 30‰).

3.1. Concentration of Chromium in brackish water, sediment and roots of mangrove

Fig. 2(a) showed the concentration of Cr in brackish water every sampling point. Based on the graph, the range of Cr concentration at Wonorejo coastal were 0,43-0,88 mg/L. The Cr concentration were above the seawater standard for biota (KepMenLH No. 51, 2004) with value of 0,005 mg/L.

Concentration of Cr in sediment were 47 mg/kg until to 66.5 mg/kg (Fig. 2(b)). Based on *Interim sediment quality guidelines* (ISQGs) (Canadian Council of Ministers of the Environment, 1999), Cr concentration at that location were above the standard (52,3 mg/kg).

Based on Fig. 2(c), the concentration of Cr in roots of *A. marina* were 28 mg/kg until to 92.25 mg/kg. It indicating that *A. marina* could uptake Cr and accumulate it in their roots. Overall, the concentrations of heavy metals were higher in plant roots as compared to water and sediment samples. According to Almahasheer et. al (2014), grey mangrove or *A. Marina* could absorb and accumulate higher quantities of many heavy metals such as Cu, Fe, Mn, Zn, B, Ni, Pb and Cd. Weeradej et al. (2017) reported that *A. marina* could uptake and accumulate of Zn, Cr, and Pb in their roots.

3.2. BCF Value

Calculation of BCF were conducted based on equation 1. Based on Fig. 3, the average BCF were > 1 for Cr on *A. marina* in the water. Meanwhile, the BCF value on *A. marina* in sediment were 0.89 to 1.35. According to Usman et al. (2013), BCF on *A. marina* for heavy metals (Cu, Cd, Ni, Pb, Zn and Cr) in the mangrove for surface sediments obtained values were too high (>1).

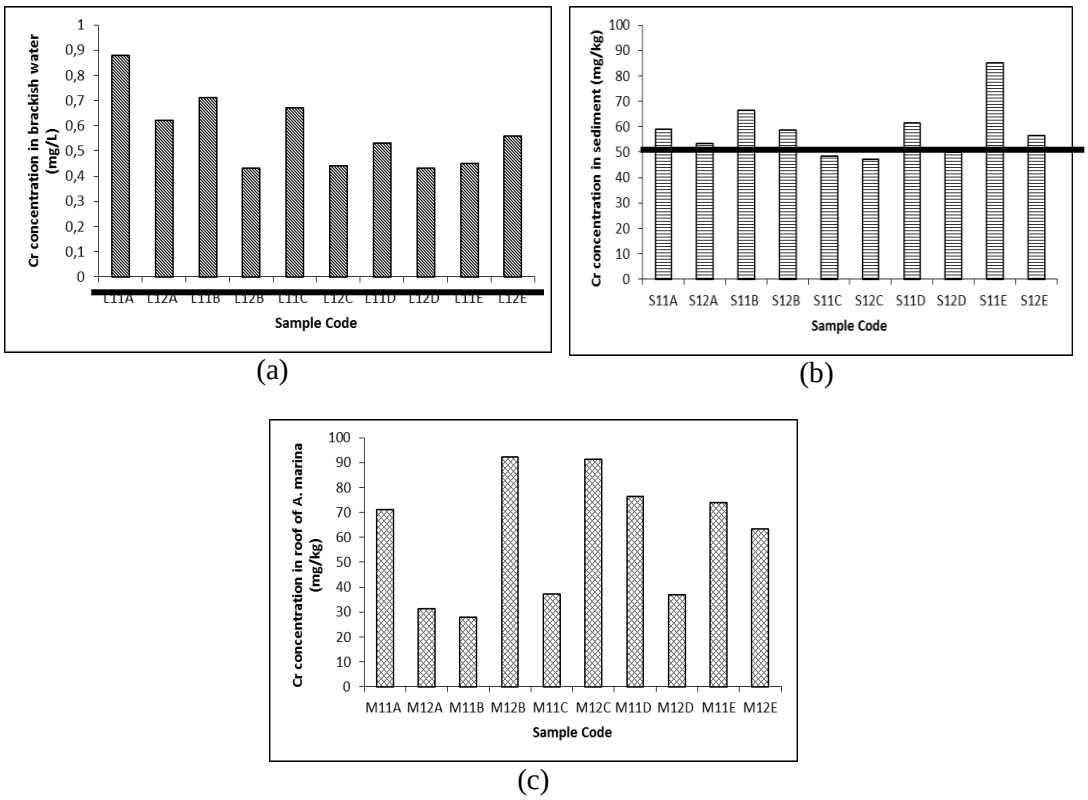

Fig. 2 (a) Concentration of Cr in breackish water, (b) Concentration of Cr in sediment (c) Concentration of Cr in roots of *A. marina*

4. Conclusion

Based on data, the range of Cr concentration at Wonorejo coastal were 0,43-0,88 mg/L. Theaverage concentration of Cr in the sediment in Wonorejo coastal were 47 mg/kg until to 66.5 mg/kg. The concentration of Cr in roots of *A. marina* were 28 mg/kg until to 92.25 mg/kg. The BCF values on *A. marina* in sediment were 0.89 to 1.35. Meanwhile, all of BCF value in water showed value > 1. Based on the BCF value, it indicated that *A. marina* was a hyperacumulator species for heavy metals of Cr. Mangrove *A. marina* has potentially to be used in Cr phytoremediation at coastal area.

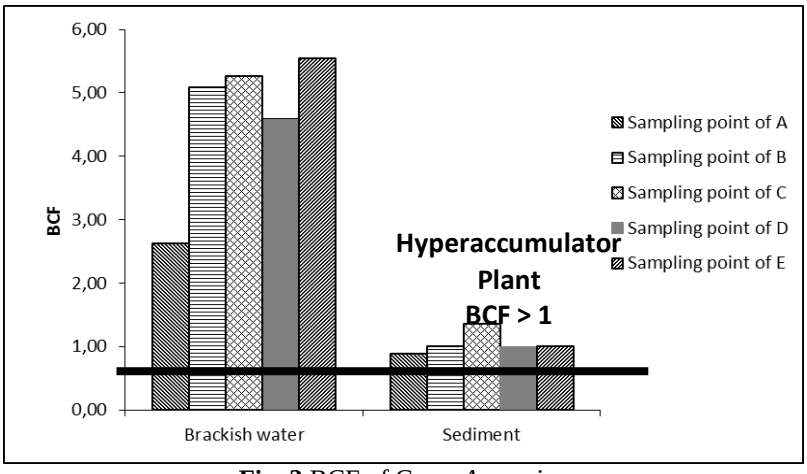

Fig. 3 BCF of Cr on *A. marina*

Acknowledgements

The authors would like to thank Lembaga Penelitian dan Pengabdian kepada Masyarakat, Institut Teknologi Sepuluh Nopember - LPPM ITS, Kementerian Riset, Teknologi dan Pendidikan Tinggi through Skem Penelitian Laboratorium of No. 697/PKS/ITS/2017 for funding this research.

References

Ackerley, D.F, Gonzales.C.F, Park, C.H, Blake,R. Keyhan, M.& Martin,A.2004. Chromat Reducing Properties of Soluble Flavoprotein from *Pseudomonas putida* and *Escherichia coli*."Applied and Environmental Biology", 70,(2), 873-882.

Almahasheer, H.B., Al-Taisan, W. A., Mohamed1, M. K. (2014). Metals Accumulation in Grey Mangrove (*Avicennia marina* (Forsk. Vierh.) Inhabiting Tarut Bay, Eastern Saudi Arabia. "Journal of Agricultural Science" , 6,1,137-140.

Badan Lingkungan Hidup Kota Surabaya. (2012). Laporan Pengendalian Kawasan Pesisir dan Laut Tahun 2012.

Bini, C.L., Gentili,L., Maleci, B.,Vaselli,O. (1995). Trace elements in plant and soils of urban parks. *Annexed tocontaminated soil prost*. INRA, Paris.

Canadian Council of Ministers of the Environment. (1999). Canadian Sediment Quality Guidelines for the Protection of Aquatic Life.

EPA. (1996). Method 3050b acid digestion of sediments, sludges, and soils.

Idris, M., Abdullah, S.R.S., Titah, H.S., Latif, M.T., Abasa, A.R., Husin, A.K., Hanima, R.F., Ayub, R. 2016. Screening and Identification of Plants at a Petroleum Contaminated Site in Malaysia For Phytoremediation. Journal of Environmental Science and Management 19(1): 27-36.

Keputusan Menteri Negara Lingkungan Hidup Nomor : 201 Tahun 2004 Tentang Kriteria Baku dan Pedoman Penentuan Kerusakan Mangrove.

Keputusan Menteri Negara Lingkungan Hidup Nomor 51. 2004. Baku Mutu Air Laut.

Palar, H. (1994). "Pencemaran dan Toksikologi Logam Berat" Rineka Cipta, Jakarta.

Schiavon, M. E., Pilon. A. H., Smits, M. Wirtz, R. Hell and Malagoli, M. (2008). Interactions Between Chromium And Sulfur Metabolism In Brassica juncea. "Journal Of Enviromental Quality", 37,1536-1545.

Titah, H.S., Abdullah, S.R.S., Mushrifah, I., Anuar, N., Basri, H., and Mukhlisin, M. (2013). Effect of applying rhizobacteria and fertilizer on the growth of *Ludwigia octovalvis* for arsenic uptake and accumulation in phytoremediation. "Ecological Engineering", 58,303-313.

Usman, A.R., Alkredaa, R.S., Al-Wabel, M.I. (2013). Heavy metal contamination in sediments and mangroves from the coast of red sea: avicennia marina as potential metal bioaccumulator. "Ecotoxicol Environ Saf. " 97,263-70.

Usman, A.R.A., Mohamed, H.M. (2009). Effect of microbial inoculation and EDTA on uptake and translocation of heavy metals by corn and sunflower. "Chemosphar",76: 893-899

Weeradej, M., Kaewtubtim, P, Seepom, S., Pichtel, J. (2017). Metal Uptake and Accumulation by Mangrove Plant Species in Pattani Bay, Thailand. "Proceedings of the 3rd World Congress on New Technologies (NewTech'17)" , *Rome, Italy – June 6 – 8*.