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Heavy metal bioaccumulation in mangrove ecosystem at the coral triangle ecoregion, Southeast Sulawesi, Indonesia

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ABSTRACT

This study aimed to determine the role of mangroves as a biofilter of heavy metals. The concentrations of heavy metals, namely copper, mercury, cadmium, zinc, and lead, in the mangroves *Rhizophora apiculata*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *Lumnitzera racemosa*, *Xylocarpus granatum*, *Sonneratia alba*, and *Bruguiera parviflora* at RAWN Park were determined using a Flame atomic absorption spectrophotometer. High concentrations of Cu (83.85 μg g^{-1}) and Hg (0.52 μg g^{-1}) were found in the tissues of *L. racemosa*, while high concentrations of Cd (10.81 μg g^{-1}), Zn (70.41 μg g^{-1}), and Pb (1.36 μg g^{-1}) were found in the tissues of *B. gymnorrhiza*, *B. parviflora* and *C. tagal*, respectively. The translocation and bioaccumulation factors of heavy metals by mangroves showed a variety of trends, which indicated the different partitioning and uptake capability of heavy metals in the tissues of various mangrove species. Thus, maintaining high diversity of mangroves is crucial to ensure the health and productivity of coastal zones.

Mangroves play an important role in the tropical and subtropical coasts by exporting organic matter to support a variety of organisms (Rivera-Monroy et al., 1995) and enhancing phytoplankton production (Rivera-Monroy et al., 1998). Unfortunately, wide areas of mangroves are being destroyed because of human intervention, including manufacturing and agro-based industries, urbanization (DOE, 1998), and fertilizers and pesticides from agricultural activities (Zarcinas et al., 2003; Hashim and Hughes, 2010). These factors largely contribute to the heavy metal input in coastal zones, including mangrove ecosystems, and have been addressed by many studies (Marchanda et al., 2006; Agoramoorthy et al., 2008; Sarika, 2008; Kamaruzzaman et al., 2009; Chen et al., 2010; Lewis et al., 2011; Usman et al., 2013; Anouti, 2014, Armid et al., 2014).

Mangrove sediments are known to be a buffer between potential sources of metalliferous pollutants and the marine ecosystem (Harbison, 1986; Saenger and McConchie, 1991; Marchanda et al., 2006); however, not much information is currently available on the biofiltering capacity of various mangrove species with regard to heavy metal concentrations. Some mangroves might grow better in the coastal areas because of their high capacity to absorb heavy metals, while other mangrove species might suffer from the direct effects of environmental pollutants (Cuong et al., 2005; MacFarlane et al., 2007). Previous studies have shown that mangroves might have the ability to accumulate metals and be tolerant to heavy metal pollution in their environment (Thomas and Ong, 1984; Usman et al., 2013; Zhang et al., 2017).

The coastal zone of Southeast Sulawesi including the Rawa Aopa Watumohai National (RAWN) Park is largely dominated by mangrove species such as *Rhizophora apiculata*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *Lumnitzera racemosa*, *Xylocarpus granatum*, and *Sonneratia alba* (Analuddin et al., 2013). These mangroves stock higher aboveground biomass (Analuddin et al., 2015, 2016) and are a potential source of antioxidants (Septiana et al., 2016). Various ongoing activities such as agriculture, human settlements, and gold and nickel mining in the terrestrial areas in this region possibly contribute to heavy metal deposition into the rivers and marine waters (Ido et al., 2015). To date, there are no reports on heavy metal bioaccumulation within the mangrove ecosystem in this region. Accordingly, better understanding of the bioaccumulation of heavy metals in the mangrove ecosystem of RAWN Park is important for managing the estuarine and coastal areas. Thus, the objectives of this study were (1) to determine the heavy metal

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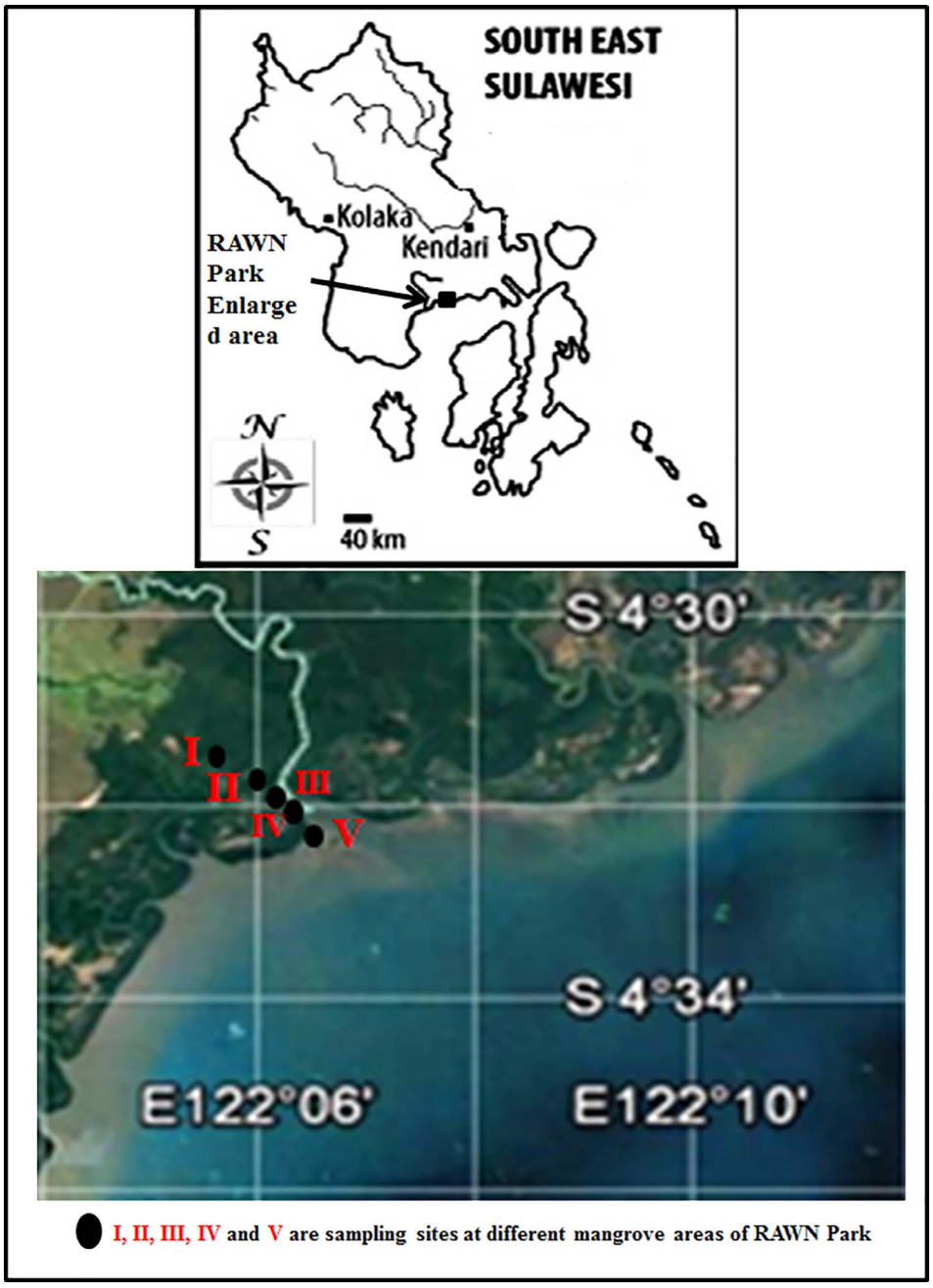

Fig. 1. Study site of mangrove forest at the RAWN Park, coral triangle ecoregion, Southeast Sulawesi. Black circles are sampling sites of sediments, seawater, and mangroves.

Table 1
Spatial trends in the heavy metals concentrations (mean ± standard error μg g^{-1}) of Cu, Zn, Hg, Pb and Cd in sediments of mangroves at RAWN Park, coral triangle ecoregion, Southeast Sulawesi. The similar letters indicate no significantly difference.

Sites	Cu	Hg	Cd	Zn	Pb
I	8.667 ± 0.333*a*	0.223 ± 0.002*a*	0.257 ± 0.002*a*	8.330 ± 0.019*a*	0.0125 ± 0.001*a*
II	7.940 ± 0.457*a*	0.185 ± 0.001*a*	0.320 ± 0.001*b*	24.790 ± 0.016*b*	0.0132 ± 0.001*b*
III	7.200 ± 1.908*a*	0.189 ± 0.002*a*	0.159 ± 0.002*c*	16.163 ± 0.013*c*	0.0133 ± 0.001*c*
IV	3.493 ± 0.460*b*	0.282 ± 0.001*b*	0.188 ± 0.001*d*	8.640 ± 0.013*a*	0.0127 ± 0.001*d*
V	5.533 ± 0.667c	0.390 ± 0.001*c*	0.181 ± 0.001*e*	8.520 ± 0.018*a*	0.0128 ± 0.002*e*

Heavy metals: Cu: Cooper, Hg: Mercury, Zn: Zinc, Cd: Cadmium, Pb: Lead.
Site I (*Xylocarpus granatum* and *Ceriops tagal*).
Site II (*Rhizophora apiculata*),
Site III (*Bruguiera gymnorrhiza* and *Lumnitzera racemosa*).
Site IV (*Bruguiera parviflora*).
Site V (*Sonneratia alba*).