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SPECIES DENSITY AND LEAD (Pb) POLLUTION IN MANGROVE ECOSYSTEMS, SOUTH KALIMANTAN

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Abstract. *Its crucial to get information about lead (Pb) heavy metal pollution from mining and oil palm plantation on species density in mangrove ecosystem, to anticipate its impacts. This study aimed is to compare the types and densities of vegetation in mangrove ecosystems allegedly due to mining in Setarap village, Tanah Bumbu Regency and oil palm plantations in Kuala Tambangan Village, Tanah Laut Regency. We also analysis the condition of waters (TDS, pH and DO) and organic content in sediments to acquire data from the South Kalimantan mangrove ecosystems. The results showed there were four species of true mangroves (Avicennia alba, Acanthus ebracteatus, Nypa fruticans and Rhizophora apiculate) could live well in the environment affected by mining or oil palm plantations. The species density for trees was low (933 ind/ha) for mangroves affected by coal mines, while those affected by oil palm plantations had higher densities (1,067 ind/ha). pH value of waters in affected area by coal mining showed more acidic value (pH 5.76) especially at the back, while those by palm oil plantations are more acidic (pH 6) in the estuary. Organic matter content in sediments affected by coal mines was in the range of 0.61-6.59%, while those affected by oil palm plantations showed higher values (0.12-2.19%). Lead heavy metal content (Pb) in waters affected by coal mines was 0.031-0.056 mg/L, while the area affected by oil palm plantations was of higher value (0.110-0.128 mg/L). Lead (Pb) levels in sediments indicate higher values than waters, which reach 3.512-6.046 mg/Kg (affected by coal mines), and in areas affected by oil palm plantations reaching 6.658-6.66 mg/Kg. The general conclusion is that vegetation densities in areas affected by coal mines are lower than oil palm plantations. The level of lead (Pb) pollution in the sediments is higher than in the waters.*

Keywords: *coal, heavy metals, mangroves, vegetation*

Citation
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INTRODUCTION

The greatest threat to ecosystem damage comes from the increasing disturbance of anthropogenic activities, such as deforestation, land-use change and other disruptions both on a small and large scale (Chapin III et al., 2002) that hit various levels of the ecosystem equally starting from the back (upstream) to the front (downstream). Legal and illegal coal mining, as well as land conversion to oil palm plantations, are two concrete pieces of evidence of anthropogenic activity which cause the loss of about 70 percent of biodiversity and damage to mountainous and coastal areas in Indonesia with a mechanism that is not much different (Tamtanus, 2016).

The condition of mangroves in Indonesia particularly in South Kalimantan continues to decline both qualitatively and quantitatively (Safitri et al., 2012). The existence of the rampant coal mines in this region has caused severe environmental problems in the coastal areas where mining excavate. This is not only polluting many rivers and estuaries on the coast (Sahayu, 2017) but also causes environmental degradation that ultimately will affect the preservation of overall mangrove ecosystem functions (Supriyantini et al., 2017). On the other hand, the expansion of oil palm plantations has also spurred destruction of ecosystems that are faster and take place simultaneously (Dolorosa, 2013). The presence of the oil palm industry which generally generates toxic liquid waste that not only potentially contain heavy metals such as Cd, Fe, Cu, Cr, Zn, Ni and others (Febriana et al., 2016) but also highly toxic to natural resources and the environment (Wulandari et al., 2016).

Research on mangrove damage in South Kalimantan as a whole has never been conducted yet, but information on areas that have suffered severe damage are able to be known, including in the Aluh-aluh, Banjar and Kuala Lupak districts in Barito Kuala Regency. The problem of coal and palm oil mines is indeed an interesting issue to be raised because the existence of a special port (pelsus) coal and palm oil has a large share in the destruction of mangrove ecosystems (Aziz, 2011). The study of vegetation density and the content of Pb in the waters and sedimentation of mangrove ecosystems affected by coal mining activities and oil palm plantations is an effort that needs to be done immediately to save the survival of mangrove ecosystems. Quality management and pollution control in the mangrove ecosystem need to be done not only for the current and future interests but also for maintaining ecological, economic and socio-cultural balance (Hamuna et al., 2018).

The purpose of this study was to compare the types and densities of vegetation in mangrove ecosystems affected by coal mining activities (Setarap Village - Tanah Bumbu Regency) and oil palm plantation activities (Kuala Tambangan Village - Tanah Laut District). This research also compared water conditions (TDS, pH, DO value), organic material content in sediment and lead (Pb) content both in waters and sediments. The results of this study can be used as basic information in the planning of sustainable management of mangrove and coastal ecosystems based on ecological, economic and social aspects (Ratini, 2014).

MATERIALS AND METHODS

Time and Place

Data collections were carried out in two regions of mangrove ecosystems in South Kalimantan Province, namely Kuala Tambangan Village - Tanah Laut District, and Setarap Village - Tanah Bumbu Regency (Figure 1). This research was conducted for three months from June to August 2019.

Figure 1. Location of sampling for vegetation inventory and heavy metal pollution in mangrove ecosystems in Kuala Tambangan Village - Tanah Laut District, and Setarap Village - Tanah Bumbu District (photo taken from the site https://www.google.com/maps/place)

Geographically, Kuala Tambangan Village is located at the point of 3°9'26.5"S 114° 37'47.1"E to 3°56'05.5"S 114°40'30.9"E with the the population of 1,973 people; 984 male (49.87%) and 989 female (50.13%). From the overall profession, as many as 314 people or 78.5% in this village work as fishermen. (Iriadenta, 2003). The total area of this village is 5,920 Ha (59.20 Km^2) with an approximate population density of 33 people/Km^2 (Iriadenta, 2009). The threat to biodiversity management in the mangrove ecosystem in this village is thought to originate from the community conflicts with oil palm entrepreneurs, especially during fertilization and the run-off of palm oil fertilizer waste that pollutes river within the mangrove forest area. The area of mangrove forests that are still in a good in Kuala Tambangan Village is approximately 390 hectares that are the surrounding by 1,364 hectaresoil palm plantations (Kuala Tambangan Village Government, 2017). Liquid waste from the palm oil industry also needs to be a concern, because in each process of processing fresh fruit bunches it contributes 60% compared to other waste. (Budianta, 2004).

The village of Setarap is located at coordinates of 3°48'42.8"S 115°28'46.3"E - 3°45'44.8"S 115°30'37.0"E with an area of 49.07 Km^2. The population consists of 392 families, 739 male and 777 female with a total population of 1,516 people in 2019. Setarap Beach can be reached by road as far as 192 Kilometers from Banjarmasin. The path to the Setarap beach is taken through the Angsana village road then passes through Sumber Baru village, the area of oil palm plantations then the grassland forests around 5 kilometers. The

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total distance from the asphalt road to Setarap beach is around 12.8 Km (Satui, 2019). The presence of a special coal port in Setarap Village (Iriadenta, 2009) has a significant share in accelerating damage to mangrove ecosystems in general (Aziz, 2011). Another potential threat is the high household capture fishery value (88%) compared to the surrounding villages (Sungai Cuka and Satui Barat) (Tanah Bumbu District Government, 2009).

The Type and Density Observation of Mangrove Affected by Coal Mining Activities and Oil Palm Plantations.

The identification of mangrove vegetation was carried out through observations on roots, stems, leaves, flowers, and fruit, based on instructions from Kitamura et al. (1997) and Onrizal et al. (2005). Sampling was carried out at three different stations, namely: Station 1 (the outermost (estuary) near the settlement), Station 2 (the central part of the forest) and Station 3 (the back forest bordering the Galam forest swamp). The position of the sampling point was determined using the Geographic Positioning System (GPS) in the Google Earth application (Figure 2). At each station, three observation plots of 10 m x 10 m were made for observing vegetation at the level of tree life. The number of individuals was calculated to determine the density value to discover the importance of vegetation (Mueller-Dumbois and Ellenberg, 1974). The general equation of density (individual ha-1) is the number of individuals of a species divided by the area of the entire observation plot (Barbour et al., 1999).

(a) (b)

Figure 2. Tracks for inventorying vegetation density and heavy metal pollution in mangrove ecosystems in South Kalimantan Province, (a) Mark by number 1, 2 and 3 in Kuala Tambangan Village - Tanah Laut District and (b) Mark by number 4,5 and 6 in Setarap Village - Tanah Bumbu District (personal documentation)

Analysis of Waters, Sediments and Lead (Pb) Content

Water and sediment sampling were carried out in situ, and then the samples were taken to the laboratory for analysis. Water condition parameters measured including pH, TDS, nitrate, nitrite, color, turbidity and heavy metal lead (Pb) content. While sediment parameters measured including organic matter, water content and heavy metals lead (Pb) content. PH levels were measured using SNI 06-6989.3-2004, TDS (Total Dissolved Solution) values were measured using a test method based on SNI 06-6989.27-2005, nitrate, nitrite, and colour levels were measured using spectrophotometric methods, and turbidity was tested using the nephelometric method. The spectrophotometric method and the gravimetric method were used to determine organic matter and water content respectively. The Pb content was determined using the AAS (Atomic Absorbent Spectrophotometry) method. The next step was a descriptive analysis of species data, vegetation density, water content and sediments as well as lead (Pb) in water and sediments.

RESULTS AND DISCUSSION

Plant Species in Mangrove Ecosystems Affected by Coal Mines and Oil Palm Plantations.

Inventory results (Table 1) shows the types of *Avicennia alba*, *Acanthus ebracteatus*, *Nypa fruticans* and *Rhizophora apiculata* were found in the edge of mangrove forests in villages affected or not affected by coal mine pollution. *Bruguiera gymnorrhiza*, *Ceriops decandra* and *Xylocarpus granatum* types were found in mangrove ecosystems affected by oil palm plantations.While the types of *Rhizophora mucronata*, *Sonneratia alba* and *Sonneratia caseolaris* were found in mangrove ecosystems affected by coal mining.

Table 1. Comparison of mangrove vegetation types from villages affected by coal mining (Setarap - Tanah Bumbu Regency) and those affected by oil palm plantations (Kuala Tambangan - Tanah Laut Regency).

Found in mangrove ecosystems affected by coal mining and palm oil plantation	Found in mangrove ecosystems affected by coal mining (Setarap Village)	Mangrove ecosystems affected by oil palm plantation (Kuala Tambangan Village
Avicennia alba (api-api putih) *Acanthus ebracteatus* (holly mangrove) *Nypa fruticans* (nipa palm) *Rhizophora apiculata*	*Rhizophora mucronata* (red mangrove) *Sonneratia alba* *Sonneratia caseolaris* (mangrove apple)	*Bruguiera gymnorrhiza* (large-leafed mangrove) *Ceriops decandra* *Xylocarpus granatum* (cedar mangrove)

According to Kitamura et al. (1997) mangroves consist of true mangroves and mangrove associates. The true mangrove is a type of plant that lives in the tidal region and able to absorb salts as well as having an adaptation system to remove unneeded excess salt through its stems and leaves. The associated mangroves are the type of mangrove species that able to adapt to coastal ecosystems, and unable to remove excess salt from the body (Ibrahim, 2016). The results on comparison of the density of mangrove vegetation affected by coal mines with oil palm plantations (Figure 3). Total vegetation density at the tree level is low (933±142.34 individual/Ha) for mangrove ecosystems affected by coal mining (Setarap Village) while for mangrove ecosystems affected by oil palm plantations (Desa Kuala Tambangan) is in the medium category (1.067±159.25 ind/ha).

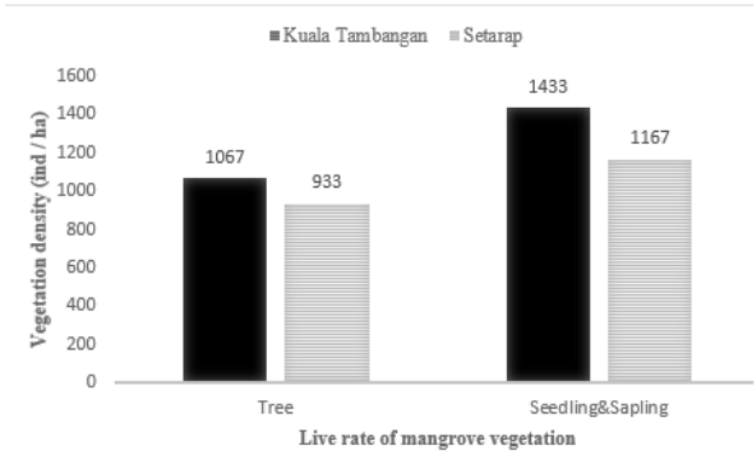

Figure 3. Density of mangrove vegetation (ind/ha) in the research sites (Kuala Tambangan Village and Setarap Village)

The results obtained from this study were considered lower when compared with the results of the study by Susiana (2011) which obtained data on the density of natural mangrove vegetation classified as very dense (1,917 ± 532 ind/ha), although the amount is still lower than the density of vegetation in rehabilitated mangroves (2,933 ± 1,437 ind/ha). The study by Susiana (2011) also revealed that environmental factors are suspected to influence vegetation density. The density of natural mangroves considered high because of its location in a estuary that made high fluctuations fluctuations in environmental characteristics. While for the location in mangrove rehabilitation, the value of environmental parameters is not notably different between each parameter measured.

Distribution of Mangrove Species

Comparison of vegetation distribution in mangrove ecosystems as presented in Table 2 shows that the front or estuary of mangrove ecosystems suspected of being affected by oil palm plantations (Kuala Tambangan Village) is dominated by *Avicennia alba* and *Rhizophora apiculata* with a percentage of 33.3%, while in the middle and the back part types *Rhizophora apiculata* are more dominant (42.9% and 44.4% respectively). On the contrary, in the mangrove ecosystem in Setarap Village (affected by coal mines), the front part is dominated by *Sonneratia caseolaris* with the value of 33%, while the middle and back part are dominated by *Rhizophora apiculata* with a percentage of 36.4% and 62.5% respectively.

The number of vegetation obtained from mangrove ecosystems affected by coal mines or oil palm plantations was less than those obtained by Katiandagho (2015) on the East Biak coast which found 8 types of mangrove vegetation. While this number was relatively the same when compared to research by Fahmi (2014) in the Makassar River Tallo River which found as many as 5 species of mangroves (*Avicennia marina*, *Nypa Frutican*, *Rhizopora apiculata*, *Rhizopora mucronata* and *Sonneratia caseolaris*). According to Dahuri (2003) the composition of the flora in the mangrove ecosystem is determined by several important factors, such as soil type conditions and tidal inundation due to this type of mangrove can live well on the mud substrate.

Measurement of Water and Sediment Quality Parameters

The results of measurements of several water quality and sediment parameters in the mangrove ecosystems affected by the coal mine (Setarap Village) and affected by oil palm plantations (Kuala Tambangan Village) showed varying values. The result of these parameters presented in Table 3.

Table 2. Comparison of the distribution of mangrove vegetation from areas suspected of being affected by oil palm plantations (Kuala Tambangan Village) and those affected by coal mines (Setarap Village) expressed in %

Vegetation type	Kuala Tambangan Village (%)			Setarap Village (%)		
	Front	Middle	Back	Front	Middle	Back
Avicennia alba	33.3	0.0	0.0	22.2	0.0	0.0
Nypa fruticans	0.0	14.3	33.3	0.0	27.3	62.5
Rhizophora apiculata	33.3	42.9	44.4	11.1	36.4	12.5
Bruguiera gymnorrhiza	22.2	14.3	11.1			
Ceriops decandra	0.0	14.3	0.0			
Xylocarpus granatum	11.1	14.3	11.1			
Rhizophora mucronata				22.2	18.2	12.5
Sonneratia alba				11.1	9.1	12.5
Sonneratia caseolaris				33.3	9.1	0.0
Amount (%)	100	100	100	100	100	100

Table 3. The results of of water and sediment parameters measurement in mangrove ecosystems from areas affected by coal mines (Setarap Village) and affected by oil palm plantations (Kuala Tambangan Village)

Water parameters	Kuala Tambangan Village (%)			Setarap Village (%)		
	Front	Middle	Back	Front	Middle	Back
Total Dissolved Solids (TDS) (mg/L)	±124	±152.68	±86.27	±876	±876	±436
pH	±6	±7.14	±7.42	±6.34	±6.2	±5.76
Dissolved Oxygen (DO) (mg/L)	±5.75	±7.3	<0.01	±36	±40	±47
Sedimen parameters						
Organic compound (%)	±0.12	±1.83	±2.19	±0.61	±6.59	±3.04

TDS value obtained from areas suspected to be affected by coal mining (Setarap Village) was in the range of 436 - 876 mg/L while in waters suspected of being affected by oil palm plantations (Desa Kuala Tambangan) the value was higher (86.27 - 124 mg/L). These values were still below the permissible quality standard threshold, where TDS maximum value for drinking water is 1,000 mg/L (WHO) (Arlindia & Afdal, 2015). Compare to other studies, the TDS value obtained in this study was higher from Marganof (2007) taken from Lake Maninjau, West Sumatra (115.83 mg/L), but much lower than Rinawati et al. (2016) in Lampung Bay (27,868 - 36,642 ppm) and also Erari et al. (2012) in Papua Youtefa Bay (Papua) 34,400 ppm). TDS value is an indicator of water pollution levels, where the high TDS value indicates the high mineral content in seawater. According to Mukhtasor (2007) TDS contains various dissolved substances (whether organic, inorganic, or other material) with a diameter of <10-3 μm. In this case, changes in the concentration of solutes will disturb the balance of aquatic biota, changes in the biodiversity index, as well as the emergence of intolerant types, as well as highly toxic to organism at a particular life stage (Weber-Scannell & Duffy, 2007).

The results of pH measurement in the mangrove ecosystem of Kuala Tambangan showed more alkaline from the estuary to the back (pH of 6, 7.14 and 7.42 respectively). On the other hand, pH in the mangrove ecosystem of Setarap tended to be more acidic (pH 6.34 in the estuary, the middle 6.22 and the back 5.76). The pH values obtained are still below the standard sea water quality according to Decree State Minister for the Environment No. 51 of 2004 pH ranges from pH 7.0 to 8.5. Compared to the results of the study by Erari et al. (2012) which obtained the pH of the waters of the Gulf of Papua Youtefa which ranged from 6.28 - 8.7 in the sea and 7.25 - 7.76 in waters near the river front, the results of this study are still in the normal range for fish life.According to (Rinawati et al., 2016) high or low pH of water is influenced by compounds contained in the water.

The value of dissolved oxygen in the mangrove ecosystem of Kuala Tambangan was in the range of 5.75 - 7.53 mg/L, while the mangrove ecosystem of Setarap had a higher value (36 - 47 mg/L). The amount of organic waste brought into these waters can affect the aquatic ecosystem and disrupt the aquatic ecosystem that can be reflected from the water lower fertility rate. One indicator of water fertility is dissolved oxygen. The level of dissolved oxygen decreases along with the increasing organic waste in these waters. This is due to the oxygen needed by bacteria to break down organic matter into more and more inorganic substances (Simanjuntak, 2007).

The results of the analysis of organic matter content in mangrove ecosystems of Kuala Tambangan were in the range of 0.12 - 2.19% with the highest value in the back. Conversely, organic matter content in the mangrove ecosystem of Setarap is in the range of 0.61 -6.59% with the highest value in the middle. According to Djaenudin et al. (1994) criteria for high or low organic substrate-soil content are <1% = very low; 1-2% = low; 2.01-3% = moderate; 3.01-5% = high; and> 5% = very high. Litter from mangrove plants is deposited on the bottom of the water and accumulates then becomes a sediment that is rich in nutrients (Gimin, 2004) . This situation encourages the survival of collectors in tidal areas such as amphibians, crabs, gastropods, and mudskipper (Hogarth, 2007).

Lead Content in Water and Sediment

Lead (Pb) contents in the waters from Kuala Tambangan village (impacted by oil palm plantation) were about 0.11±0.04 - 0.128±0.06 mg/L. In the area impacted by coal mining (Setarap village) the value was smaller with the range from 0.04 – 0.056 mg/L (Figure 4). This indicates that Lead (Pb) pollution is above the threshold quality standard. Lead (Pb) content in water from this study was higher when compared with Nugraha (2009), examined in Bangkalan Regency with values ranging from 0.00001 to 0.00002 mg/L for Socah waters and in waters Kwanyar ranges from 0.00012-0.078 mg/L.

In the sediments, lead (Pb) contents from Kuala Tambangan village were higher (almost 10 times) than waters with a range value of 9.11±2.04 – 17.45±7.69 mg/Kg. In Setarap village, the highest content of Lead (Pb) obtained from the back (headwaters) with a value of 6.046±3.04 mg/Kg (Figure 5). As for the lead (Pb) content in sediments, from this study found higher than Syahminan et al. (2015) with the average horizontal Pb metal content in sediments reaching 12.69 µg/g while the average vertical value in the upper layer (0-2 cm) was 9.08 µg/g. If examined closely, the condition of the coastal and marine areas in South Kalimantan, in general, has not been indicated to get heavy pollution due to industry or other business activities. But the potential damage that occurred on the coast and the sea has begun to be visible, including the damage of mangrove ecosystems due to the opening of the pond area, logging of raw wood for building materials, conversion of mangrove areas for the construction of special port infrastructure for coal transportation as well as other coastal and marine damage (Pemerintah Kabupaten Tanah Bumbu, 2009).

This study has analyzed the mangrove densities and the quality of water and sediment of valuable mangrove ecosystems in South Kalimantan derived from coal mining activity. The density of vegetation in mangrove ecosystems affected by coal mines was lower (933±142.34 ind/ha) compared to mangrove ecosystems affected by oil palm plantations (1,067±159.25 ind/ha). Some values of water, sediment and heavy metal parameters measured in mangrove ecosystems that are suspected to be affected by coal mines (Setarap Village) as well as those affected by oil palm plantations (Kuala Tambangan Village) have exceeded the specified quality standard. This illustrates that there are many natural resource exploitation activities that neglecting the carrying capacity of mangrove ecosystems (Tanah Bumbu Regency, 2016). Thus, various preventive and persuasive steps are needed to manage them sustainably.

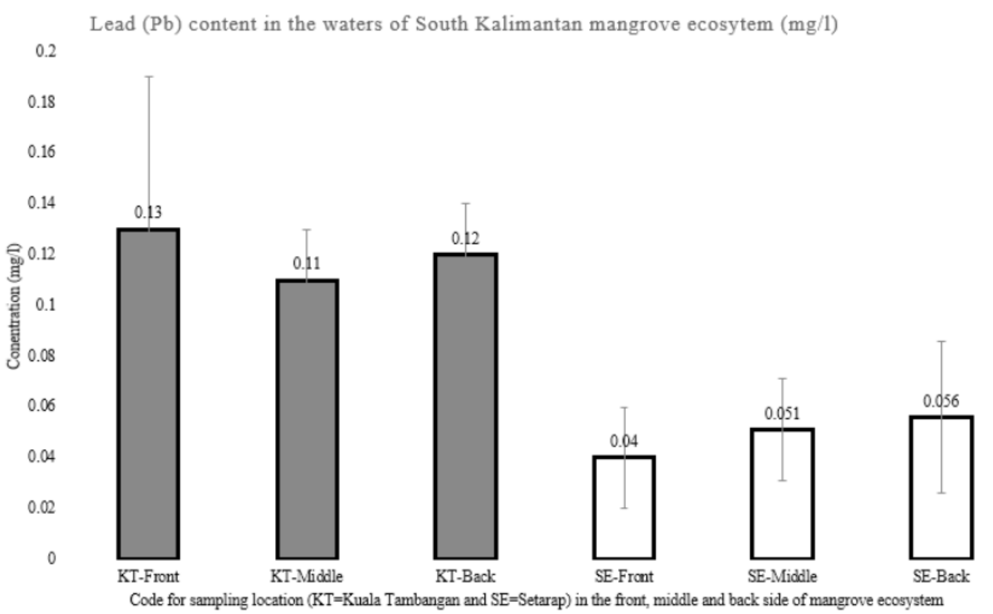

Figure 4. Analysis results of Lead (Pb) content in the waters (mg/liter) from Kuala Tambangan and Setarap mangrove ecosystems of South Kalimantan

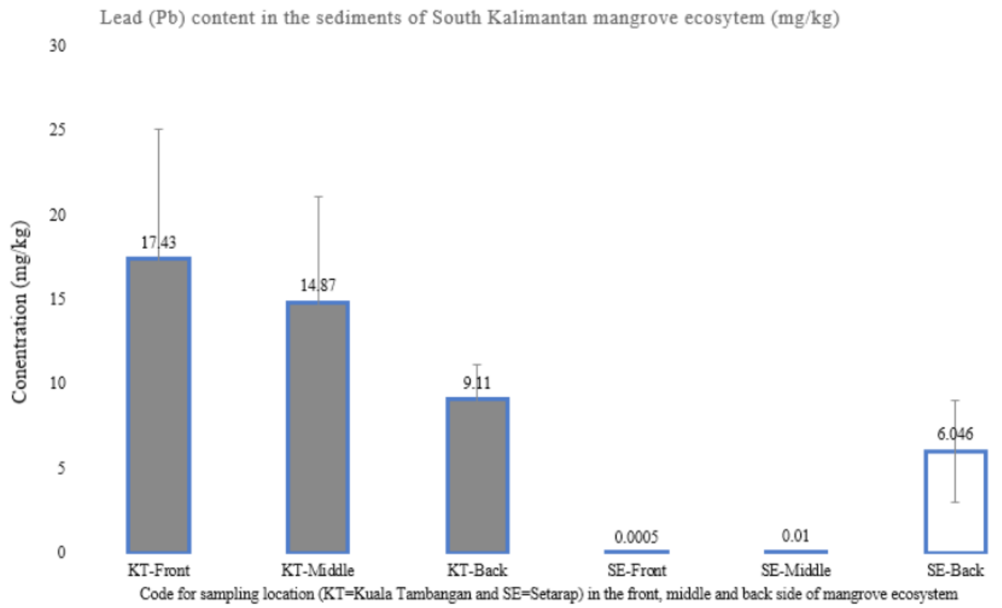

Figure 5. Analysis results of Lead (Pb) heavy metal content in the sediments (mg/kg) from Kuala Tambangan and Setarap mangrove ecosystems of South Kalimantan

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