

Study of Water and Sediment Quality and Heavy Metal Pollution (Pb) at South Kalimantan Mangrove Ecosystem

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Study of Water and Sediment Quality and Heavy Metal Pollution (Pb) at South Kalimantan Mangrove Ecosystem

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Abstract. Changes in the water quality, sediment, and the presence of heavy metals in the environment have a close links with human activities including the presence of pollutants in the mangrove ecosystem. The purpose of this study is to compare water and sediment quality as well as heavy metal pollution from lead (Pb) in mangrove ecosystems affected by anthropogenic activities (oil palm plantations and mining) in South Kalimantan. The research was carried out for 4 months (June until September 2019) from four villages (Kuala Tambangan, Bunati, Angsana and Setarap) in South Kalimantan Province. The purposive sampling method is used for sampling, which is determined in estuary, middle and inland parts, based on the area division of mangrove ecosystem. Data analysis was performed descriptively while differences in each location were tested using bivariate analysis (Pearson). The results showed that the water quality at the four observation sites was above the standard of Government Regulation number 82 of 2001. There are four values with the highest parameters found in the village of Kuala Tambangan, the first is total dissolved solids (TDS) that reaching ± 8.005 mg / L, nitrite (NO₂) as N (± 0.13 mg/L), nitrate (NO₃) as N (± 0.11 mg/L) and color levels that reach ± 129.33 ptCo. The other two highest parameters in Setarap Village are turbidity and dissolved oxygen. Turbidity value reaches ± 16.01 NTU while dissolved oxygen (DO) value is around ± 5.92 mg/L. The highest pH value can be found in Bunati Village (± 7.54). The average value of heavy metals in Lead (Pb) is also above the standard of the Minister Decree of Environment in 2004, recorded in waters 0.04 - 0.36 mg/L (highest in Angsana Village ± 0.31 mg/L) and sediment 0.01 - 17.43 mg/L (highest in Angsana Village ± 15.05 mg/L). The highest water content in sediment comes from Kuala Tambangan village ($\pm 6.6\%$), while the highest organic sediment content is found in Angsana village ($\pm 7.8\%$). Bivariate analysis results used to determine differences between sampling locations showed that the levels of Nitrite (NO₂) as N ($\alpha = 0,000$), Nitrate (NO₃) as N ($\alpha = 0,000$), pH ($\alpha = 0,000$), Color $\alpha = 0,000$), and Dissolved Oxygen (DO) ($\alpha = 0,000$), sediment water content ($\alpha = 0,000$) and heavy metal Pb content in water and sediment ($\alpha = 0,000$) are differ between mangrove ecosystems in Angsana and Setarap Village.

1. Introduction

In this decade, the major problems that related with anthropogenic activities, technological, economic, climates change and environmental changes are caused by pollution enhancement in all of media both sediment, water, and air [1]. Heavy metals in the soils are difficult to migrate due to their long residual

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time, strong concealment, toxicity, and other characteristics. Therefore, the treatment of heavy metal pollution in river sediments and soils has become a hot and challenging research topic [2]. Heavy metal pollutants in aquatic systems have different properties because they are very sensitive to the gradual increase in metal content. This happens because of the increasing pollution originating from anthropogenic activity, so this should be a major concern. [3]. There are two mainly activities in South Kalimantan that has a big potential for produce pollution in heavy metal, from oil palm plantations and coal mining. As one of the highest quality materials for coastal protection and a high ability to filter pollution, mangrove ecosystems in South Kalimantan must be preserved from various disturbances, especially from heavy metal pollution. For this reason, the majority of pollution that occurs in mangrove ecosystems can be used as an indicator of changes in coastal conditions, although the changes occur within a small scope of the hydrological regime or its tidal conditions but can cause the death of several individuals as a whole [4].

The fact shows that heavy metal lead is released to the environment in addition to sourced from natural activities also sourced from activities carried out by humans, especially mining, industry, and vehicles. They leach into underground waters, moving along water pathways and eventually depositing in the aquifer, or are washed away by run-off into surface waters thereby resulting in water and subsequently soil pollution [5]. Heavy metals that present in water bodies will undergo some effects such as sedimentation and accumulation in sediments. This toxic substances can even accumulate in the bodies of biota that exist in waters either by diffusion or through the food chain and of course will eventually reach to the humans [6]. There are many types of contaminants in aquatic environments such as Hg, Pb, Cd, and Cu metals that are of high concern in many countries [7]. The pollutants like lead (Pb), is very harmful, toxic and poisonous even in ppb (parts per billion) range [8].

In 2007 the agriculture and mining sectors were still the most dominant sectors in supporting South Kalimantan's GRDP. Coal mining is the largest revenue contributor sector of total exports (71.4%) with a value of US \$ 1,208,774,000 [9]. However, heavy metal contamination in soils is a major environmental concern that affects large areas worldwide. Agricultural practices have been the main source of heavy metals in soil such as lead [10]. In South Kalimantan Province, the existence of coal and palm oil special ports has a very large share in the destruction of mangrove forests. In 2010 there were 10 coal special in the forest and conservation areas which were closed due to damage to mangroves [11]. The information about heavy metal pollution in the mangrove ecosystem of South Kalimantan has been done a lot, but very little is revealed about cases related to mining and oil palm activities. Besides it, this purpose of research is to study water and sediment quality and heavy metal pollution of the lead (Pb) at South Kalimantan Mangrove Ecosystem

2. Material and Methods

Study area and sampling sites. The mangrove ecosystem in South Kalimantan was chosen as the research area for this research. This is due to the phenomenon of coastal water desalination which has an effect on the fragility of the resilience of coastal communities, especially mangrove forests. Another impact is that beaches in South Kalimantan are more susceptible to more damage, especially damage to coastal vegetation and mangrove forests, which are most commonly found around river mouths [12]. Field sampling was carried out for three months from September to November 2019 on two types of mangrove ecosystems. The first is estimated to be affected by pollution from oil palm plantations (Kuala Tambangan and Angsana), and the second is estimated to be exposed to heavy metal pollution from coal mines (Setarap and Bunati). At each location, three observations were determined, namely the outer (OT), the middle (MI) and the inner (IN) as shown in Figure 1.



Figure 1: Four location of sampling sites in South Kalimantan mangrove ecosystems (Kuala Tambangan, Setarap, Angsana and Bunati Villages).

Sampling and assay. All samples were extracted from top horizon sediments (0–20 cm depth), and three or four samples were collected and pooled at each sampling point. Samples were air-dried, sifted, and then dried (105 °C) again prior to assays. Analysis of water content and sediment and heavy metal pollution on lead (Pb) has been carried out at the Office of Industry and Trade (Balai Perindustrian dan Perdagangan), Banjarbaru City, South Kalimantan. Water parameters tested were total dissolved solids, nitrate, nitrite levels, and turbidity. Sediment parameters tested were organic matter content and water content. The content of heavy metals tested were lead (Pb) and cuprum (Cu). Data analysis was performed descriptively while differences in each location were tested using bivariate analysis (Pearson) at a 95% confidence level [13].

3. Results

Differentiation between sampling locations. The situation between the sampling locations shows the difference ($\alpha = 0,000$) between the mangrove ecosystems affected by oil palm plantations (Angsana Village) and those affected by coal mining (Setarap Village). In this case, the differences found include: nitrite (NO_2) as N, nitrate (NO_3) as N, pH, color, dissolved oxygen (DO), water content in sediments and levels of lead heavy metals (Pb) in water and sediment.

TDS. The comparative of TDS from four mangrove ecosystem locations in South Kalimantan shows a large range of values. The lowest value is 29.52 mg / L and the largest is 15,268 mg / L. The highest value was found in Kuala Tambangan mangrove ecosystem (a place estimated to be affected by heavy metal pollution from oil palm plantations), especially in the middle part the value is 15.268 mg/L. The lowest value can be found in Bunati mangrove ecosystem ($\pm 32,64 - 35,02$ mg/L) and also from Angsana mangrove ecosystem with the range of value is $\pm 19,75 - 30,45$ mg/L (Figure 2.).

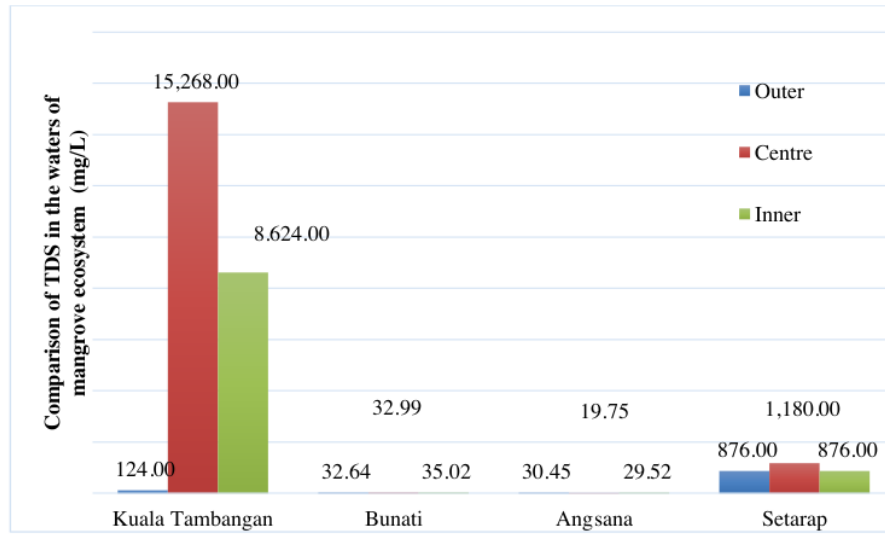


Figure 2. Comparison value of TDS (mg/L) from four location of South Kalimantan mangrove ecosystem

From Figure 2, it is known that the TDS of the mangrove ecosystem in the Village of Kuala Tambangan is above the government standard. As for the other values, they are still below limit of the tolerance. Based on SNI 06-6989.27-2005 determined that the highest TDS value is 1,000 mg/L [14]

Nitrite. Comparison value of Nitrite (NO₂) as N (mg / l) from the four mangrove ecosystem locations in South Kalimantan shows that the highest value (± 0.297 mg / L) is derived from the inside of the Kuala Tambangan mangrove ecosystem. This location is estimated to be affected by heavy metal pollution from oil palm plantations (See Figure 3.).

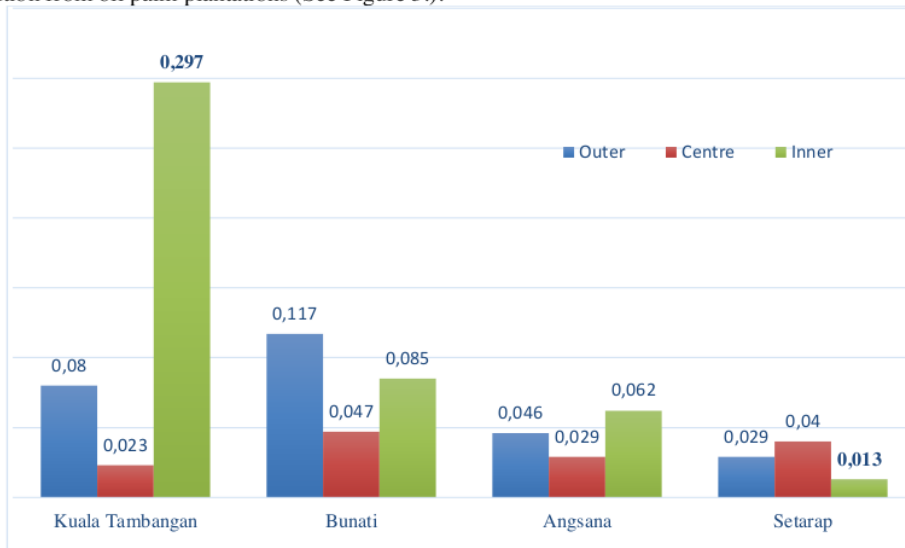


Figure 3. Comparison value of Nitrites (NO₂) as N (mg/L) from four location of South Kalimantan mangrove ecosystem

The measurement results show that the nitrite level (NO_2) as N (mg / L) obtained from several mangrove ecosystem areas in South Kalimantan is above the standards set by the National Standardization Agency (BSN = National Standardization Agency). In this case SNI 06-6989.9-2004 sets the highest level of nitrite (NO_2) as N allowed in water and wastewater is around <0.06 mg / L [14].

Nitrate. Measurements results of nitrate (NO_3) levels as N (mg/L) indicate that the highest value (0,259 mg/L) obtained from areas that affected by oil palm plantations (mangrove ecosystems in Kuala Tambangan Village). Whereas the lowest value (± 0.013 mg / L) is coming from locations that estimated to be affected by coal mining (mangrove ecosystems in Bunati Village) (Figure 4.).

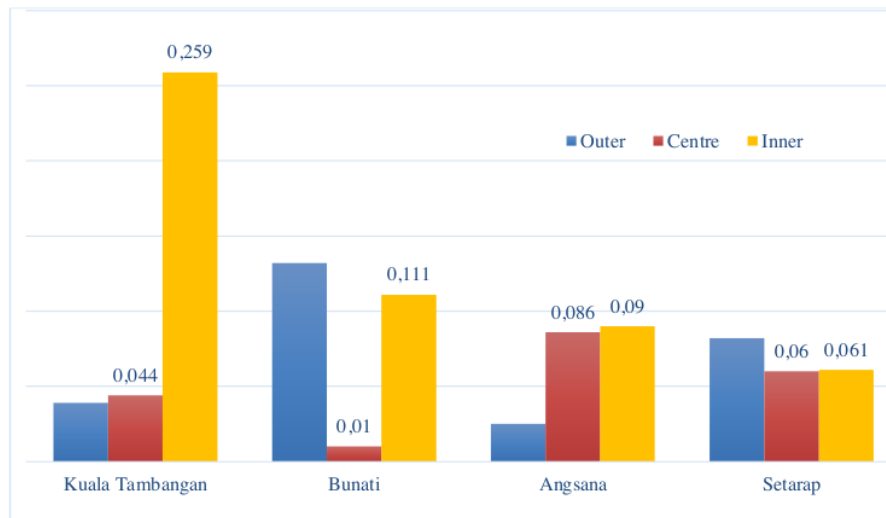


Figure 4: Comparison value of nitrate (NO_3) as N (mg/L) from four location of South Kalimantan mangrove ecosystem

The results of measuring nitrate (NO_3) as N (mg / L) as shown in Figure 4 above are classified as safe, because they are below the standards set by the National Standardization Agency [15]. Based on SNI 06-6989.9-2004 it is determined that the level of nitrate (NO_3) as N permitted is less than 10 mg / L for the class of water that can be directly consumed [16].

Turbidity. The highest comparative value of Turbidity (NTU) from four mangrove ecosystem locations in South Kalimantan (± 23.9 NTU) was generated on the inside of the mangrove ecosystem in Kuala Tambangan Village (which was affected by oil palm plantations). The second highest value (± 19.1 NTU) can be found in the middle of the mangrove ecosystem in Setarap Village (affected by coal mining) as shown in Figure 5.

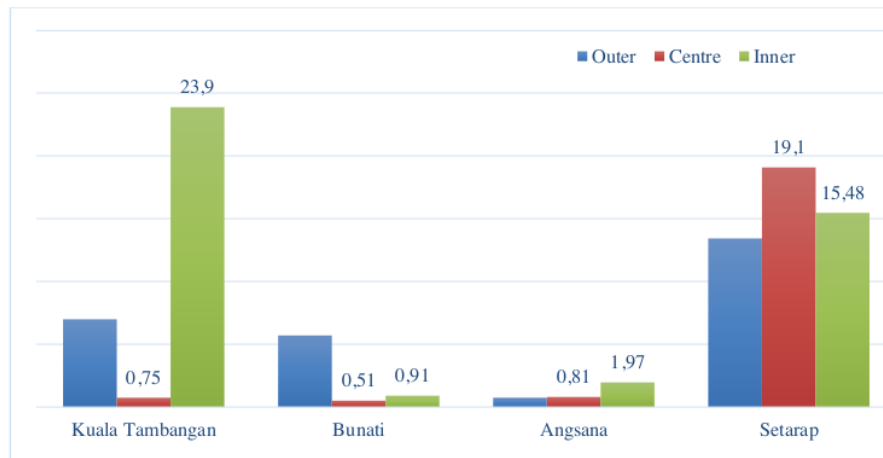


Figure 5: Comparison value of Turbidity (NTU) from four location of South Kalimantan mangrove ecosystem

Measurement results of Turbidity (NTU) from several mangrove ecosystem areas in South Kalimantan show a commonly value above the regulation standards of Minister of Health of the Republic of Indonesia number 32 of 2017 concerning environmental health quality standards and water health requirements for sanitary hygiene, swimming pools, and public baths. The quality standard value (maximum content) is 0.5 NTU [17].

Water content in Sediment. Sediment water content in all samples from South Kalimantan mangrove ecosystem has a value from $\pm 0.16 - 7.32\%$. The highest value of water content can be found in the outer part of Kuala Tambangan mangrove ecosystem ($\pm 7.32\%$), and the lowest in the centre part of mangrove ecosystem in Setarap Village. Comparison of the test results of water content (%) in sediments from four observation sites of the mangrove ecosystem in South Kalimantan is shown in Figure 6.

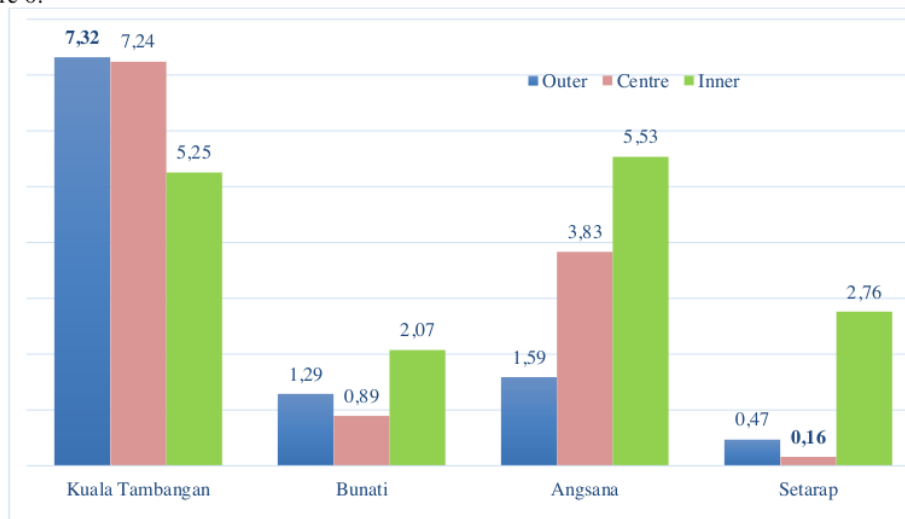


Figure 6: Comparison of water content (%) in sediments from four location of South Kalimantan mangrove ecosystem

The results of measurements of water content in the soil from several mangrove ecosystem areas in South Kalimantan show that the levels are around $\pm 0.16 - 7.32\%$ (Figure 6). This is due to mangrove soil having high salt and water content, high sulfuric acid, low oxygen content and other abrasive materials derived from marine fragments [18].

Organic component. The results of measurements of organic content (%) of several mangrove ecosystem areas in South Kalimantan show that their values vary based on each sampling station (Figure 7). The assessment standards used in this criterion, as explained by Reynolds (1971) are very high > 35%, high: 17-35%, moderate: 7-17%, low: 3.5-7%, and very low < 3% [19].

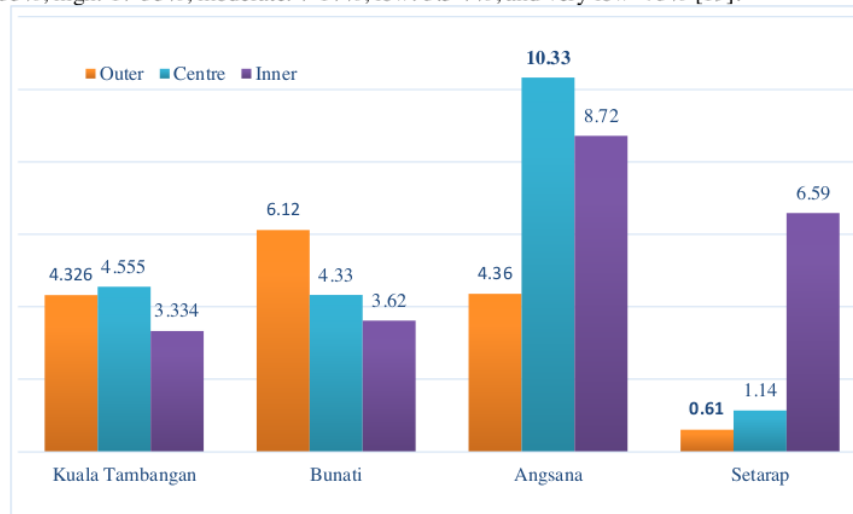


Figure 7. Comparison of organic content in sediments (%) from four location of South Kalimantan mangrove ecosystem

The highest ratio of soil organic matter (%) was found from the Angsana mangrove ecosystem in the middle of 10.33% (Figure 7). In general, the content of organic matter found from mangrove ecosystems in South Kalimantan ranged from 0.61 - 10.33% (very low to moderate category).

Heavy metal contents of Lead (Pb). The highest level of lead was recorded in Angsana Village (area estimated to be affected by heavy metal pollution from palm oil plantations) with a range of Pb heavy metal content of 0.276 - 0.336 mg/L. Likewise with the Village of Bunati (area estimated to be affected by heavy metal pollution from oil mining) the range of levels of heavy metals Pb therein is higher (0.274 - 0.361 mg/L). Comparison heavy metal of Lead (Pb) in water (mg/L) from four location of South Kalimantan mangrove ecosystem can be found in Figure 8.

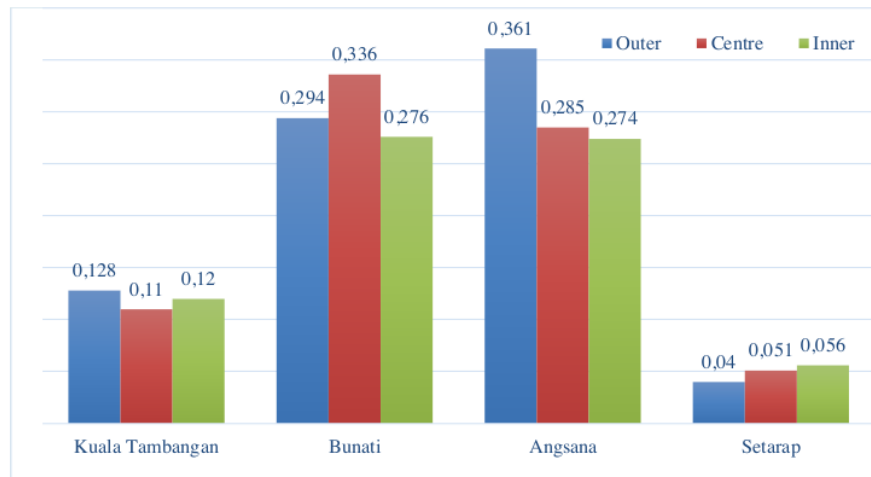


Figure 8: Comparison heavy metal of Lead (Pb) in water (mg/L) from four location of South Kalimantan mangrove ecosystem

The results of the lead content test (Pb) showed that the waters in Angsana, Bunati and Kuala Tambangan villages had been polluted based on SNI 7387-2009 regarding the maximum limit of heavy metal pollution. When compared with the results of the research of Selanno et al (2014) which obtained the Pb metal content in sediments in Waiheru District, Ambon around 0.7259 - 1.9129 ppm (mg / L), the results of this study were relatively low (0.04- 0.361 mg / L). It was said by Selanno et al (2014) that the low content of lead metal (Pb) was due to the type of sediment at this location classified as sandy substrate [20].

Heavy metal contents of Cu. Comparison heavy metal of Cuprum (Cu) in waters (mg/l) from four location of South Kalimantan mangrove ecosystem, shows the highest value (0,444 mg/L) found in Kuala Tambangan mangrove ecosystem. While the lowest value (0,003 mg/L) is found in Setarap mangrove ecosystem (area that estimated to be affected by heavy metal pollution from coal mining), as shown in Figure 9.

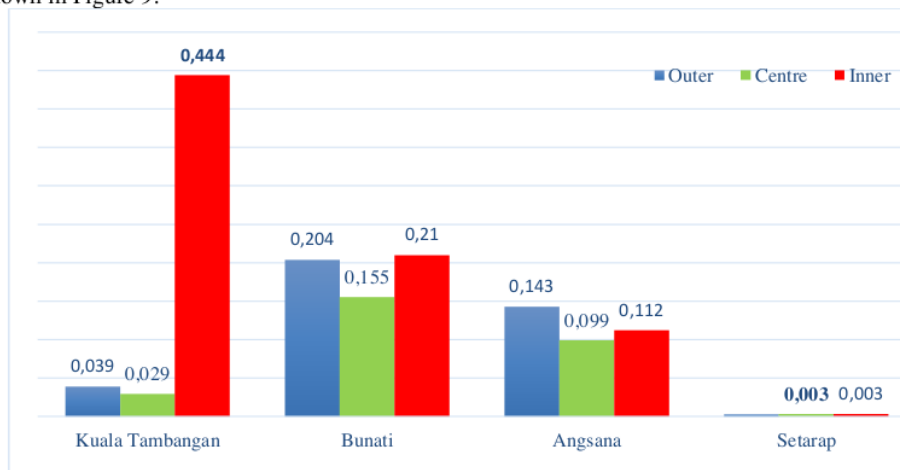


Figure 9: Comparison heavy metal of Cuprum (Cu) in waters (mg/l) from four location of South Kalimantan mangrove ecosystem

The measurement results of copper (Cu) in the waters from several mangrove ecosystem areas in South Kalimantan are in the range 0.003 until 0.444 mg/L. This shows that most mangrove waters in South Kalimantan are polluted by heavy metals from copper (Cu). According to the 1997 USEPA standard states that the permitted threshold for heavy metals of copper (Cu) in waters is 0.008 mg/L [21].

4. Discussions

Differentiation between sampling locations. Nevertheless, all the sampling areas should be given utmost importance for continuous monitoring of nutrients and heavy metals, which could be alarming for the habitat of the aquatic organisms in the near future [22].

TDS. The range of TDS observation data in the study is relatively tenuous in the range of 29.52 - 15.268 mg / L. In contrast to the results of the study of Jalal et al (2009) on Tuba Island, Langkawi, Malaysia where the range of TDS values found was relatively dense (32.27-32.77 mg / L) [23], because each observation station included an area polluted by human activity. According Suharyadi (2009) the smaller the size of the distance between the observation data, the characters shown are also better, because the data are compact [24].

Nitrite. Nitrite levels in this study were high (29.52 - 15.268 mg / L), especially compared to the study of Jalal et al (2009) on Tuba Island, Langkawi, Malaysia, which obtained results between 0.86 - 4.03 mg / L. Analysis of differences between stations from this study is significantly different ($P < 0.05$) while the study of Jalal et al (2009) found that there is no differences value between stations ($P > 0.05$) [25].

Nitrate. Nitrate value from this research lies at the range 0.013 - 0.259 mg/L. This means that the value is lower than the research of Jalal et al (2009) in Pulau Tuba, Langkawi, Malaysia (19). Their concentrations varied and ranged from 2.04–26.93 mg/L, respectively. Also said that that there are no significant differences ($P > 0.05$) among the physico-chemical profiles of the different stations, but in this research we found a difference in every source of the heavy metal pollution [26].

Turbidity. Turbidity is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky. Particulate matter can include sediment - especially clay and silt, fine organic and inorganic matter, soluble colored organic compounds, algae, and other microscopic organisms [27]. Turbidity measurements from this study ranged from 0.51 to 23.9 NTU (Nephelometric Turbidity Unit). The results of a study conducted by Lovelock et al (2015) stated that turbidity was useful in increasing ground surface height ($P = 0,0003$) and increasing ground surface area or accretion ($P = 0.0468$). But the data needed to present this relationship is very varied [28].

Water content on sediment. Water content, bulk density and porosity are important properties of soils and bottom sediments. It is important to note that in flooded soils, unlike terrestrial soils, these properties are uniquely inter-related [29]. The calculation of water content from this research study is lower ($\pm 0.16 - 7.32\%$) when compared to the result studies of [30] which tested the water content of andisol soils in Pamatang Sidamanik District, Simalungun Regency, North Sumatra. It was noted that average soil water content ranges from 7-10% which is optimum for plant growth because it is at the depth of the effective rooting of plants.

Organic compound. The results of this study were lower (0.61-10.33%) compared to the results of the study (Lestari, 2018) on Pannikiang Island, Balusu District, Barru Regency of Sulawesi, which is in the range of 2.58-32.83%. But if compared with Jalal et al (2009), this results is higher because the amount of organic carbon in the sediment ranged only from 1.92 – 3.0%. On the other side, Avnimelech et al (2001) wrote that the porosity of the sediment samples having more than 5% organic carbon is higher than 80% [30]

Heavy metal contents of Lead (Pb). When taking in consideration the mean concentrations of each heavy metal in all sites, the amounts from high to low showed a pattern of: Zn > Cu > Cr > Pb > As > Cd > Hg. Higher concentrations could be strongly linked to anthropogenic factors, and to the factor of water currents [31]. Compared to the results of measurements of Lead (Pb) levels by Jalal et al (2009) on Tuba Island, Langkawi, Malaysia at 3.15 mg/L [32], the results obtained from this study are comparatively lower at 0.04 - 0.336 mg / L. Nevertheless the study of Jalal et al (2009) also found the same thing as found from this study, namely the difference in lead levels (Pb) from each observation location. The sharpest significant difference ($P < 0.05$) occurred at the observation stations that were most affected by humans or waste material disposal sites [33].

Heavy metal contents of Cuprum. Cu content from this study was 0.003 - 0.444 mg / L or lower than the research of Funtua et al (2016) in the Lokoja metropolis of Kogi State - Nigeria where the concentration of Cu in water was 0.110 mg/L [34]. The obtained value was higher than research results of Putri and Purwiyanto (2016) in the Musi River downstream that the average concentration of Cu from 0.003 - 0.005 mg/L [35]. The heavy metal levels of Copper (Cu) in this study were also higher than the research of Permata et al. (2018) in the waters of the Lampung Bay industrial area. They found that the heavy metal concentration of copper (Cu) was signed at 0.008 mg / L [36].

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