STUDY OF LANDFILL LEACHATE WATER AS A SOURCE OF PLANT NUTRITION IN CENTRAL KALIMANTAN

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ABSTRACT

This study aims to examine the physical and chemical characteristics of leachate from the final waste processing site (FPS) in Palangka Raya City Central Kalimantan Province. The research was carried out at the final waste processing site in Palangka Raya City and at the Laboratory of the Center for Standardization and Industrial Research Banjarbaru, in April-May 2021. The method used was purposive sampling method for leachate sampling. Leachate samples were grouped into 4 station categories (S), namely S_1, samples sourced from active waste landfill leachate (age < 5 years); S_2, sample sourced from passive waste-backfill leachate (aged 5 - 10 years); S_3, the sample is sourced from leachate in the inlet pond of the Leachate Water Treatment Plant (WWTP); S_4, the sample is sourced from leachate from the WWTP outlet pond. The research data were statistically analyzed comparatively from each station. Parameters observed included: DOC (Dissolved Organic Carbon), P-Total (PO_4), K-Total, N-Total, Nitrate (NO_3^-), and Sulfate (SO_4^{2-}). The results showed that leachate from the final waste processing site in Central Kalimantan had DOC was45.57-817.50 mg L^{-1}, PO_4Total was 0.001-0.031 mg L^{-1}, K-Total was 11.65-11.95 mg L^{-1}, and N-Total was 69.79-586.24 mg L^{-1}, Nitrate (NO_3^-) was 0.098- 0.283mg L^{-1}, and sulfate (SO_4^{-2}) of 44.80-149.25 mg L^{-1}. Landfill leachate in Palangka Raya FPS contains nutrients that have the potential and are suitable for use as organic fertilizer as a source of nutrients for plants.

Keywords: *landfill waste,* chemical properties of leachate, plant nutrition

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INTRODUCTION

Central Kalimantan's wastedumpis still an urgent issue. The average amount of wastedumped into each city's Final Processing Site (FPS)is 261 tons.day^{-1}, or 746 square meters.day^{-1}. The main problem of waste dumpislocated in FPS as the downstream part of waste management. (Purwanta and Joko, 2017). Garbage in the landfill will decompose, creating leachate that might contaminate the water supply and surrounded environment(Zubair et al., 2015; Kale et al., 2010; Mor et al., 2018; Naveen et al., 2018; Paul et al., 2019; Hussein et al., 2021).

Generally, Central Kalimantan's FPSare often constructed utilizing a landfill control pattern; nonetheless semi-open dumping system is dominatesin FPS (Naveen et al, 2016). Dissolved compounds in the landfill may be washed away by the addition of outside water, altering the leachate's physical and chemical properties. Therefore, the integrated waste management is a solution to these issues (Aziz et al., 2010; Gunarathne et al., 2020).

A landfilling zone lined with geotextiles and geomembranes and surrounded by an embankment constitutes the control landfill pattern. There is no overburden in the semi-open dumping design, including at the passive backfill While the leachate from the active backfill zone is directed to the wastewater treatment plant (WWTP) via an open dumping pattern (without a bottom and embankment) (Naveen et al, 2016). Several factors, including the type of trash dumped, the quantity of rainfall in the landfill region, and the conditions at the disposal site, affect the chemical make-up of the leachate (Ali, 2011; Anilkumar et al., 2015). Leachate's physical and chemical qualities greatly affect its quality, which in turn affects how well a landfill is managed (Adhikari et al., 2014; Mitali et al., 2018).

Damanhuri and Padmi (2019) state that the variety in the content of the buried wasteis the primary factor influencing leachate quality. This variety is more likely to be found in domestic solid trash than in non-domestic solid waste. According to Adhikari et al. (2014), the decomposition process that occurs in landfills also affects the characteristics of the leachate that is collected from each dump. It was also noted by Bhalla et al. (2012) that the features of the leachate would be influenced by the age of the landfill. The biological oxygen demand (BOD), chemical oxygen demand (COD), pH, nitrate (NH_3), sulfate (SO_4), total dissolved solids (TDS), dihydrogen liquate (DHL), and ferric (Fe) content of leachate Several studies (Zainolet al., 2012; George, 2014; Fard et al., 2017)

In the FPS, when the garbage pile rots, it releases a leachate that is particularly rich in nitrogen (N) due to the presence of all the leftover meat and dairy. Elements such as phosphate, potassium, sulfur, iron, nitrate, dissolved organic matter, and ammonia are also produced by the decomposition of waste organic matter, as is nitrogen, which in turn affects the pH of the leachate. Therefore, leachate may serve as an organic fertilizer for plants due to the presence of the nutrients N, P, and K.

Research methods

Research Time and Place

The research was carried out in April – May 2021 during the rainy season, located at the final waste processing site in Palangka Raya City.

Materials and tools

The materials used in this study were waste landfill leachate in Palangka Raya City, chemicals in the laboratory for analysis of leachate nutrients. While the tools used are GPS, hoe, shovel, sample bottle, sample storage box, camera, 20 liter jerrycan, 2 L jerigan, 10 L bucket, dipper, thermometer, funnel, filter device, camera..

Implementation Method

The research was conducted with a quantitative descriptive approach using the Purposive Sampling method. The stages in the study include: determining the leachate source (station), determining the sampling point at each station, and taking leachate samples. The leachate samples were taken from the FPSarea and were grouped into 4 stations, namely samples from active waste landfill leachate with an age of <5 years (S_1=station 1); the sample from passive waste-backfill leachate with an age of 5 - 10 years (S_2=station 2); samples from leachate in the inlet pond oftheLeachate Water Treatment PlantWWTP (S_3=station 3); the sample from the WWTP outlet pond (S_4 = station 4). The location for taking the leachate sample is presented in Figure 1.

Figure 1. Location of Leachate Sampling in FPS

Sampling of leachate at station 1 (S_1) and station 2 (S_2) was carried out using a stemmed dipper and samples of leachate at station 3 (S_3) and station 4 (S_4) were carried out using a bucket from the WWTP pond. Leachate samples were composited from each station into a 10 L volume bucket, then filtered, put into a 2 L volume bottle, labeled according to the FPSstation, and brought to the laboratory of the Center for Standardization and Industrial Research Banjarbaru

Variables

The variables observed in this study were the chemical characteristics of the leachate consisting of DOC (Dissolved Organic Carbon), P-Total (PO_4), K-Total, and N-Total, Nitrate(NO_3^{-1}) Total Ammonia (NH_3-N), Fe-Total, Sulfate (SO_4^{-2}).

Data analysis

The leachate measurement data from each station were tabulated and statistically analyzed using comparative analysis, and presented in graphical form.

RESULTS AND DISCUSSION

The chemical properties of the leachate were tested in situ and ex-situ. In situ tests were carried out on pH and ex situ tests for the parameters of DOC (Dissolved Organic Carbon), P-Total (PO_4), K-Total, and N-Total were carried out in the laboratory (Table1).

Table 1. Chemical Properties of FPSLeachate for each Observation Station

No	Parameter	Unit	Station			
			S_1	S_2	S_3	S_4
1.	DOC	mg L^{-1}	817.50	206.45	45.57	53.17
2.	Nitrogen Total (N-total)	mg L^{-1}	586.24	309.31	69.79	86.54
3.	Total Fosfat (PO_4) sbg P	mg L^{-1}	0.031	0.001	0.026	0.018
4.	Kalium (K) total	mg L^{-1}	11.95	11.77	11.70	11.65
5.	Nitrat (NO_3^-) sebagai N	mg L^{-1}	0.235	0.113	0.098	0.283
6.	Sulfat (SO_4^{-2})	mg L^{-1}	149.25	138.52	44.80	45.53

Information:

S_1 = Sample of active waste backfill leachate (age < 5 years) from station 1;

S_2 = Sample of passive waste backfill leachate (aged 5 - 10 years) from station 2;

S_3 = Sample of leachate from the inlet pond of the Leachate Water Treatment Plant (WWTP) from station 3;

S_4 = Sample of leachate from the WWTP outlet pond from station 4.

Table 1 shows that the DOC value of leachate from the Palangka Raya FPS is on average below the quality standard with values ranging from 45.57-817.50mg L^{-1}. Total nitrogen content (N-Total) is quite high and is above the quality standard with values ranging from 69.79-586.24 mg L^{-1}. The value of total phosphate content (PO_4) ranged from 0.001-0.031 mg L^{-1}, total potassium (K-total) ranged from 11.65-11.95mg L^{-1}, nitrate (NO_3^-) as N ranged from 0.098 – 0.283mg L^{-1}, and sulfate (SO_4^{-2}) ranged from 44.80 – 149.25mg L^{-1}. The quality of leachate is strongly influenced by the chemical characteristics contained and is a determinant of the success of management in a landfill (Gao et al., 2015; Mangimbulude et al., 2016; Mitali et al., 2018;Sughosh et al., 2021; Saha et al., 2021). The pattern of landfill use will affect the quality of leachate, related to the availability of oxygen in the landfill. The composition of leachate is influenced by several factors, such as the type of waste deposited, the temperature and amount of rainfall in the landfill area, and the specific conditions of the disposal site (Ali, 2011; Naveen et al., 2018; Sauve& Van Acker, 2020; Leluno, 2020).

Dissolved Organic Carbon(DOC)

The pH value is a very important factor in the decomposition of organic waste. The value of DOC acts as a source of dissolved organic carbon originating from the decomposition process of organic waste. DOCs fromthe Waste Landfill at Several Observation Stationsare presented in Figure 2

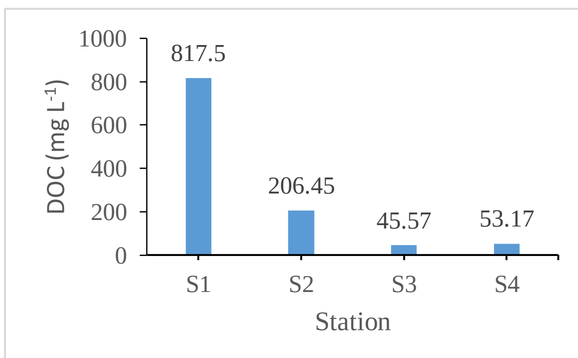


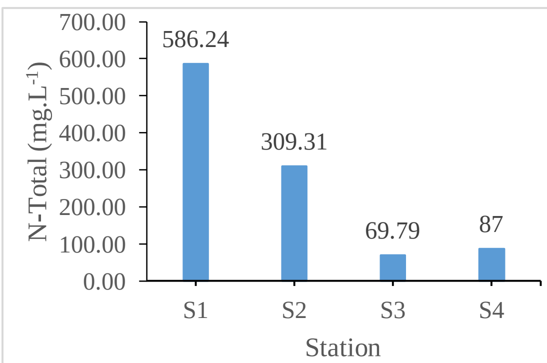
Figure 2. Contents of DOC Leachate from the Waste Landfill at Several Observation Stations

The DOC concentration in landfill leachate ranges from 45.57 mg L^{-1} to 817.5 mg L^{-1}, as depicted in Figure 2. Leachate at station 1 had a DOC value of 817.50 mg L^{-1}, while leachate at station 2 had a DOC value of 206.45 mg L^{-1}. The leachate DOC concentrations at stations 3 and 4 were 45.57 mg L^{-1} and 53.17 mg L^{-1}, respectively. It is hypothesized that the high volume of organic waste in the backfill (TPA cells) serves as a source of dissolved organic carbon that can leach out, particularly from materials that are quickly degraded. Since the DOC values for leachate at stations 2, 3, and 4 are lower, it is suspected that organic matter in passive waste has decomposed, resulting in a lower organic matter concentration.

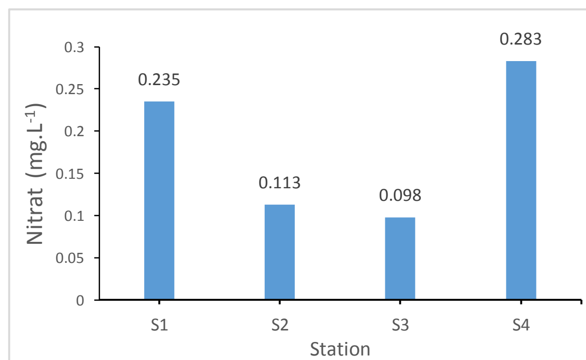
Ritson et al. (2014), Maanoja et al. (2021), and Eckbo et al. (2022) state that the greater the volume of organic material backfill, the more DOC will leach. In accordance with Fujii et al. (2011) and Dou et al. (2017), it is hypothesized that the amount of DOC leached is also connected to the quality of the waste, namely the composition of the type of organic waste material and the degree of decomposition. According to Ritson et al. (2014) and Hansson et al. (2010), the amount of DOC leached increases as the rate of organic matter decomposition rises. According to Pinem et al. (2014) and Malik et al. (2021), the DOC flow of landfill leachate was favorably linked with C-organic, total-N. Physically, chemically, and biologically, organic matter plays a crucial role in regulating the fertility of soil. Leachate from landfills containing DOC can be used as a source of liquid organic fertilizer for plant growth.

Nitrogen (N-Total and Nitrate (NO_3^-)

The value of nitrogen contained in leachate from landfill waste is a source of nitrogen in leachate as a source of organic nitrogen fertilizer for plant growth. Chen et al. (2004); Kalaria et al. (2018), adding that N is a constituent of chlorophyll, the chlorophyll formed is directly proportional to the need for N. The values of N-Total and Nitrate (NO3) in leachate at several landfill locations are presented in Figure 3.



a. Content of N-Total in leachate



b. Content of Nitrate (NO_3) in water

Figure 3. Contents of N-Total (a) and Nitrate (NO3) (b) Leachate from the Waste Landfill at Several Observation Stations

Figure 3a demonstrates that the total N content of landfill leachate is a source of nitrogen in the form of organic N fertilizer for plant growth. At Palangka Raya, Central Kalimantan FPS, the concentration of total N in leachate ranged from 69.79 mg L^{-1} to 586.24 mg L^{-1}. Leachate at station 1 contained the greatest concentration of total N, 586.24 mg L^{-1}, followed by leachate at station 2 with a value of 309.31 mg L^{-1}, station 4 with a concentration of 86.54 mg L^{-1}, and station 3 with a concentration of 69.79 mg L^{-1}.

The high content of total N at station 1 is likely attributable to the fact that the source of leachate is continuously adding new trash, including quickly decomposable food residues as the primary source of total N in leachate. It is suspected that the source of total nitrogen in the passive waste landfill, where most of the easily decomposed waste materials have decreased and the remaining solid waste materials are difficult to breakdown, decreased by 47% between stations 1 and 2. The total N concentration of leachate at stations 3 and 4, which originated from stations 1 and 2, decreased drastically by 84% and 81%, respectively. ammonium form. In addition, a portion of the total N in organic form sinks to the bottom of the WWTP pond as silt.

According to Mikutta et al. (2010), Watanabe et al. (2014), Heinz et al. (2015), and Sun et al. (2015), the majority of nitrogen in water is bonded as organic nitrogen, specifically in proteinaceous substances. According to the findings of Naveen et al. (2014), leachate resulting from the biodegradation of municipal garbage has large amounts of organic and inorganic compounds, which serve as a source of nitrogen in leachate. Cheng et al. (2017) reported that the protein in biodegradable trash can liberate ammonia from leachate. The newly dumped trash undergoes a great deal of breakdown and generates leachate with a high concentration of nitrogen, especially from protein-rich waste. The presence of adequate oxygen for the breakdown process by microbes such as Rhizobium, Acetobacter, and Nitrosomonas will raise the concentration of N. (Shen et al. 2010). According to research conducted by Naveen et al. (2014) in the Mavallipura TPA, India, the N concentration of leachate in the Pongalahan pond was 22.36 mg L^{-1}, which was lower than the N concentration in the WWTP pond of the Palangka Raya TPA, Central Kalimantan.

Figure 3b demonstrates that the Nitrate (NO_3^-) concentration in leachate at several observation locations ranges from 0.098 mg L^{-1} to 0.283 mg L^{-1}. NO_3^-leachate at the WWTP outlet has a substantially lower concentration.

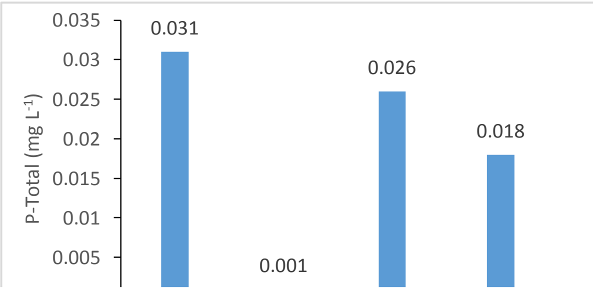
It is believed that the elevated concentration of NO_3^- at station 4 relative to other stations is attributable to the action of microorganisms oxidizing nitrate in the leachate and silt of the WWTP pond. Nitrate is created through the biodegradation of organic substances to ammonia, which is then oxidized to nitrate. According to Adesuyi et al. (2015), nitrification is an essential process in the nitrogen cycle and occurs under aerobic conditions at station 4 (retention pond/outlet). Station 1 had the second-highest concentration of nitrate, likely as a result of daily rotation of the rubbish to ensure adequate aeration for the aerobic decomposition process that generates nitrate in the leachate. According to Sang et al. (2012), nitrate is produced through the nitrification process in which ammonium is transformed to nitrate via nitrite in an aerobic process aided by bacteria.

The concentration of NO_3^-at station 3 is low, presumably because it is a WWTP inlet pond that receives deep leachate, hence reducing the oxygen concentration under anaerobic circumstances, particularly near the pond's bottom, where a large number of organic compounds accumulate. Adesuyi et al. (2015) reported that if the dissolved oxygen concentration is low and the organic matter content is high, the oxidation of ammonia to nitrate will be slowed, resulting in a low nitrate concentration. The concentration of dissolved oxygen in leachate will impact the availability of nitrate in leachate. In the presence of sufficient oxygen, nitrosomonas bacteria convert ammonia to nitrite and nitrobacter bacteria convert ammonia to nitrate. The drop in nitrate concentration was produced by nitrosumonas bacteria and other microorganisms in the leachate. If the oxygen content is sufficient, according to Naveen et al. (2016), the presence of bacteria will convert nitrite to nitrate. Station 2 is a passive waste backfill with the lowest NO_3^- concentration, likely because the nitrogen source is largely degraded and further decomposition has occurred to diminish the oxygen content of the fill. This has an effect on the development of NO_3^-, which will flow as leachate. In addition, Bhalla et al. (2012) asserted that as landfills aged, nitrate use by bacteria under anaerobic circumstances lowered nitrogen content.

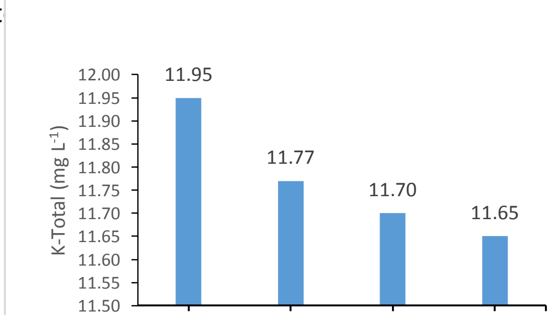
PO_4-Totaland K-Total

The value of PO4-Total and K-Total contained in leachate from landfill waste is a source of P and K nutrients in leachate as a source of phosphate fertilizer and organic Potassium for plant growth. According to Iyagba et al. (2013), that the main role of NPK is to accelerate overall growth, especially stems and leaves. The values of PO4-Total and K-Total in leachate at several landfill locations are presented in Figure 4.

Figure 4. Total PO4-Total (a) and K-Total (b) Leachate Wat



a. Content of PO_4-Total in landfill leachate



b. Content of K-Total in landfill leachate

Figure 4a shows that the concentration of PO_4-Total in leachate at the Palangka Raya FPS, Central Kalimantan, ranges from 0.001 mg L^{-1} – 0.031 mg L^{-1}. The highest leachate PO4 concentration was at station 1, which was 0.031 mg L^{-1}, while the lowest PO4 leachate concentration was at station 2, which was 0.001 mg L^{-1}. Station 3 and station 4 had concentrations of $PO_4$0.026 mg L^{-1} and 0.018 mg L^{-1}, respectively.

The high concentration of PO4 at station 1 is thought to be the influence of active waste backfill, which is dominated by organic waste. In addition, the landfill is suspected of containing household activity waste containing synthetic detergents, industrial waste and fertilizer residues in waste materials. According to Yusoff et al. (2013), that the waste that enters the TPA cell is generally anthropogenic waste, namely from agricultural waste, household waste and other activities that have been degraded. In line with Patty et al. (2015), that the presence of phosphate in wastewater can be caused by the presence of pseudomonas bacteria which utilize organic compounds in leachate as an energy source and produce simpler compounds such as phosphate.

The lowest concentration of PO_4 at station 2 (passive backfill) is thought to be most of the phosphate sources that have been degraded in the previous decomposition. According to Ziyang (2009) in Bhalla et al. (2012) stated that landfill leachate for young age (< 5 years) was around 3.49 mg L^{-1} and for medium-aged backfill (5-10 years) was 0.062 mg L^{-1}.

Phosphate at station 3 and station 4 is lower, it is suspected that the leachate in the WWTP pond is influenced by decomposition factors and phosphate suspension. According to Adesuyi et al. (2015) leachate in WWTP ponds will undergo further decomposition with the help of bacteria or through abiotic processes to produce phosphate compounds. In line with Karil (2015) that some of the phosphate in the form of organic phosphate will be suspended or bound in the cells of organisms in water.

Organic phosphate is P that is bound to organic compounds, will be suspended in water and bound in the cells of organisms in water. Phosphorus compounds bound in sediments can decompose with the help of bacteria or through abiotic processes to produce dissolved phosphate compounds that can be diffused back into the water column. Yuli et al. (2011) stated that the availability of phosphate in water is influenced by microorganisms that remodel phosphate will decrease, resulting in decreased phosphate content in water.

Figure 4b shows that the total K concentration in the leachate at the landfill observation station ranged from 11.65 mgL^{-1}– 11.95 mg L^{-1}. The highest total K concentration in leachate was at station 1, which was 11.95 mg L^{-1}, followed by leachate at station 2 at 11.77 mgL^{-1}, station 3 at 11.70, and at station 4 mgL^{-1} at 11.65 mgL^{-1}. The concentration of potassium in waste leachate is thought to be due to the decomposition of organic matter to form organic acids which can increase K in leachate, especially at station 1.

Moody and Townsend (2017) estimate that potassium levels can be affected by the amount of rainfall, supporting the leaching of potassium ions from piles of organic matter, such as at station 1 and station 2. In landfilling the activity of microorganisms will degrade organic matter and synthesize potassium such as Pseudomonas and mycorrhizae then soluble in leachate led to the availability of K. Engelmann et al. (2018) and Naveen et al.(2017) stated that microbes in the decomposition process of organic matter reduce K, the intensiveleachate decomposition occurs, the more use of K by microbes and causes the concentration of K to decrease. Wdowczyk's statement (2021) argues that in Poland the concentration of K in the passive FPSis 189.7 mgL^{-1}, the active TPA is 213.8 mgL^{-1}.

Sulfate (SO_4^{2-})

The concentration of SO_4^{2-} in the leachate at the Palangka Raya City FPSobservation station is presented in Figure 5.

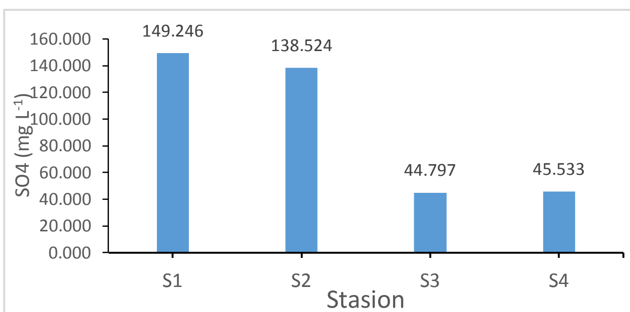


Figure 5. SO_4 Content of Leachate Water from Palangka Raya FPS

The concentration of SO_4^{2-} in leachate ranged from 44,797 mgL^{-1} 149,246 mgL^{-1} The concentration of SO_4^{2-} in leachate at station 1 was the highest compared to other stations, namely 149,246 mgL^{-1}, followed by leachate at station 2 with a concentration of 138,524 mg L^{-1}. , station 4 with a concentration of 45,533 mgL^{-1}, and station 3 with a concentration of 44,797 mgL^{-1}. The concentration of SO_4^{2-} in the landfill was the highest at station 1, which is an active waste landfill cell, where there is high organic matter causing more active decomposition. Meanwhile, the concentration of SO_4^{2-} leachate at station 2 did not have a big difference. It is suspected that there was an influence of rainfall at the time of sampling so that SO_4^{2-} was leached from the backfill. When compared to the concentration of SO_4^{2-} at station 3 and station 4, there is a significant difference where the decrease in the concentration of SO_4^{2-} is 70%

from station 1. This difference is presumably because at station 3 and station 4 part of the sulfur is deposited at the bottom of the pond in organic and inorganic forms. and the existence of a further decomposition process in the WWTP ponds and leachate drains. If the leachate does not contain oxygen and nitrate, the sulfate acts as a source of oxygen in the oxidation process carried out by anaerobic bacteria.

Fullazzaky (2013) stated that the sulfate concentration can also be influenced by the age of the waste and the availability of oxygen in the leachate. Under anaerobic conditions H_2S gas will be formed and if the dissolved oxygen concentration is large enough then the H_2S gas formed will be converted into sulfate (SO_4^{2-}) by sulfate bacteria.

CONCLUSION

The results of this study found that leachate from the final waste processing site in Palangka Raya, Central Kalimantan had a DOC of 45.57-817.50 mg L^{-1}, PO_4^-Total of 0.001-0.031 mg L^{-1}, K-Total of 11.65-11.95 mg L^{-1}, and N-Total is 69.79-586.24 mg L^{-1}, Nitrate (NO_3) is 0.098-0.283 mg L^{-1}, and Sulfate (SO_4) is 44.80-149.25 mg L^{-1}. Thus, it can be concluded that the leachate from the Palangka Raya TPA in Central Kalimantan contains nutrients that have the potential and are suitable for use as organic fertilizer as a source of nutrients for plants.

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