Characterization of Leachate from the Integrated Solid Waste Treatment Plant at Diponegoro University, Indonesia

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Abstract. Leachate is generated during the decomposition process of solid waste and as a result of rainwater percolation through piles of garbage. Leachate composition is influenced by several factors such as the characteristic and density of solid waste, the amount of rainfall and the specific conditions of the disposal site. Once leachate reaches the surrounding soil and groundwater, high concentrations of organic substances will form and remain in the soil and groundwater for a long time. The well-known Indonesian Diponegoro University has built an integrated solid waste treatment plant (ISWTP) to manage the waste generated on site, which is mostly dominated by leaf litter, food waste, paper, and plastic. Organic solid waste goes through a decomposition process and produces leachate. In order to treat the leachate, it is necessary to identify its parameters. Thus, this study examines the effect of solid waste composition and density on leachate quality based on the conditions of the ISWTP. The results showed that the composition of solid waste altered the leachate quality while the density affected the decomposition rate and quantity of leachate.

Keywords: **Leachate; campus solid waste; decomposition, density.**

1 Introduction

The Integrated Solid Waste Treatment Plant (ISWTP) of Diponegoro University (Undip) was built in 2015 as a pilot waste management project and services all campus facilities, such as lecture halls, the rectorate, the campus mosque, integrated laboratories, a petrol station, the Diponegoro National Hospital, and also receives road sweeping debris. In 2017, the waste generation of Undip, based only on the Tembalang campus site, was about 850 kg/day with a volume of 22 m3/day. Generally, the composition of the waste consisted of organic matter (56.02%), paper (23.6%), plastic (13.23%), and other waste (7.15%) [1].

The ISWTP produces leachate, a liquid formed from the decomposition of organic waste due to percolation of rain water through piles of waste. Leachate composition is influenced by several factors such as characteristics, density and water content of solid waste. Leachate generation is also influenced by hydrogeological factors such as climate, elevation and soil type [2].

In general, leachate contains a large BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), inorganic salts, ammonia, heavy metals and xenobiotic organic compounds. The BOD value of leachate for 0-5 year old landfill ranges from 10.000 to 25.000, 5-10 years between 1000-4000, 10-20 years between 50-1000 and over 20 years the value is less than 50 [3]. The COD value of leachate for 0-5 year old landfill ranges between 15.000-40.000, 5-10 years between 10.000-20.000, 10-20 years between 1000-500 and over 20 years the value is less than 1000 [4].

Since no study has been conducted to analyse the quality of leachate generated from the activities in the ISWTP, such a study is urgently needed. The results of the study could be useful to improve the management of the ISWTP and prevent leachate pollution around the ISWTP area. The parameters observed in this study were pH (acidity degree), BOD_5, COD, NH_3-N (Ammoniacal nitrogen) and TKN (Total Kjeidahl Nitrogen).

2 Materials and methods

The study was conducted at the ISWTP (Figure 1) and was divided into several stages. The first stage sampled the composition of waste received through the ISWTP by referring to the Indonesian standard (SNI 19-3964-1994). Following the collection of waste, the composition was classified to discover the most common type of waste managed at ISWTP.

Fig. 1. Study Location

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Leachate was taken from four batches of cubes (75 x 75 x 75 cm) made of a combination of plastic and wood (Figure 2). The batch was left open (without a lid) and an outlet was installed to sample leachate from the bottom. Sample S1 contained 70% organic waste with a density of 250 kg/ton, S2 consisted of 70% organic waste with a density of 400 kg/ton, S3 had 40% organic waste with a density of 250 kg/ton, and S4 held 40% organic waste with a density of 400 kg/ton.

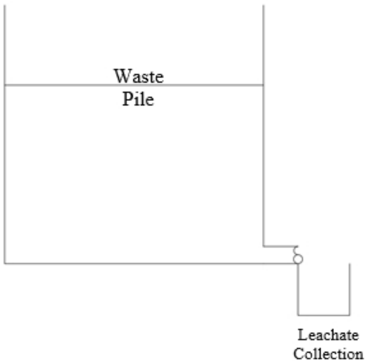

Fig. 1. Batch Reactor

The measurement of pH, BOD_5, COD, TKN, and NH3-N was based on the standards SNI 06-6989.11-2004, SNI 06-6989.72: 2009, SNI 06-6989.2: 2009, SNI 01-2354.4:2006, and SNI 06-6989.30: 2005, respectively.

3 Results and discussions

According to Table 1, the highest water content occurred in reactor S1 (69.61%), followed by reactor S2 (68.78%). Meanwhile, the lowest water content was found in reactor S3 with a value of 65.12%.

Table 1. Average water content and leachate volume

Sample	Water content (%)	Leachate volume (litres)
S1	69.61	10.82
S2	68.78	9.53
S3	65.12	8.13
S4	67.51	8.87

On the other hand, the highest and lowest volume of leachate was found in S1 (10.82 litres) and S3 (8.13 litres), consecutively. There is a linear correlation between the water content and leachate volume with the level of water content influencing the volume of leachate generated. This also certainly affected the rate of decomposition of the waste.

Figure 3 demonstrates the value of pH in reactors S1, S2, S3, and S4 from Day 5 to Day 60. The pH values of all reactors indicated an elevating trend. Reactors S1 and S2 had the lowest starting pH of 6.9 at Day 5 and reached the highest value of 8 after 60 days. Similar values were also observed in the other reactors. A pH of 7 occurred on Day 5 at reactor S3 then increased to the highest value of 7.9 by Day 60. An incremental pH trend also occurred in reactor S4 with the lowest pH value of 7.1 at Day 5 and reaching the highest value of 7.9 by day 60. The pH values tended to rise because of the activity of microorganisms in degrading the acids. Some unstable acids were decomposed into non-metallic oxides and water [4].

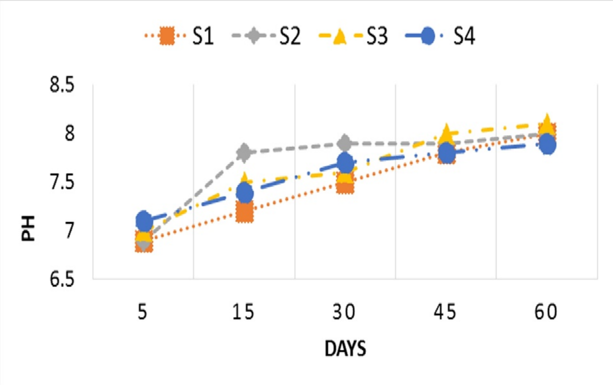

Fig. 3. pH value

Figure 4 illustrates the value of BOD_5 in S1, S2, S3, and S4 reactors from Day 5 to Day 60. Increasing trends could be seen in all reactors from Day 5 to Day 60, where S1 and S4 rose only slightly from the beginning to the end of the observation, while the BOD_5 values in S2 and S3 fluctuated. In S1 at Day 5, the BOD_5 started at 100 mg/l and ended with 160 mg/l of BOD_5 by Day 60. Meanwhile, S2 initially had a BOD_5 value of 116 mg/l then declined to 115 mg/l on Day 15, before finally rising to a final value of 169 mg/l by Day 60.

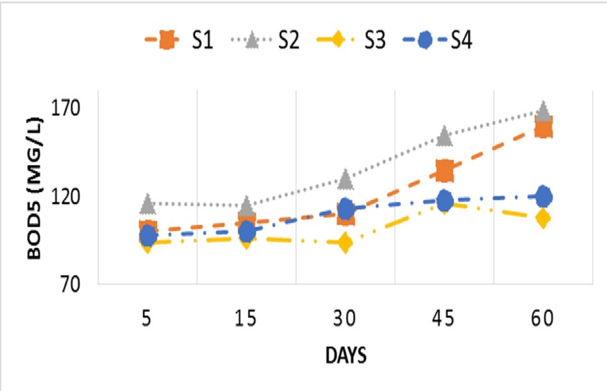

Fig. 4. BOD_5 value

A similar trend also occurred in reactor S3. The BOD_5 on Day 5 was 94 mg/l which escalated to 116 mg/l by Day 45 and then decreased to 108 mg/l by Day 60. However, an elevating BOD_5 trend was observed in reactor S4, starting at 98 mg/l on Day 5 and reaching 120 mg/l by Day 60. Increasing concentrations of BOD_5 are influenced by the presence of high organic and moisture content which results in an increase of biological activity [5].

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Figure 5 shows the COD values of S1, S2, S3, and S4 reactors from Day 5 to Day 60, with all reactors showing upward trends from Day 5 to Day 15 before rapidly falling to their lowest values by Day 60. In reactor S1, the COD value went from 8710 mg/l on Day 5 to 8910 mg/l on Day 15 and then decreased significantly to 7280 mg/l by Day 60. Meanwhile, in reactor S2, the initial COD concentration was logged at 9800 mg/l on Day 5 and remained relatively steady for 15 days. The COD value in reactor S2 then declined to 7700 mg/l by Day 60.

The COD value of reactor S3 at Day 5 was recorded at 7940 mg/l, followed by a rise to 8260 mg/l by Day 15, and then slid down to 6480 mg/l at the end of the experiment. In reactor S4, the value of COD began at 8590 mg/l on Day 5, reached 8810 mg/l by Day 15, and then declined to 6910 mg/l by Day 60. These trends are in line with a study by Kulikowska and Klimiuk [6] which indicated that the COD value continuously decreased from the start of observation until the end of the experiment. This means that young landfills would have higher COD values than the older ones.

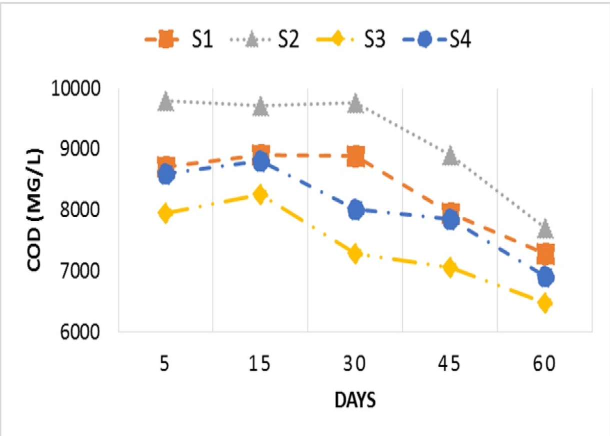

Fig. 5. COD value

Figure 6 depicts the NH_3-N value of reactors S1, S2, S3, and S4 from Day 5 to Day 60. The NH_3-N concentrations in all reactors were expected to increase with the waste decomposition time. The concentration of NH_3-N in reactor S1 started at 95 mg/l on Day 5 and reached 185 mg/l by Day 60. The NH_3-N value in reactor S2 started at 110 mg/l on Day 5 and increased to 190 mg/l by Day 60. The concentration of NH_3-N for reactor S4 rose from 86 mg/l on Day 5 to 170 mg/l by Day 60. Meanwhile, S3, which began with 77 mg/l of NH_3-N on Day 5, experienced a fluctuation, by decreasing from 110 mg/l to 90 mg/l between Day 15 and Day 30, before finally rising again to 130 mg/l by Day 60. Based on the study of De et.al [7], the average concentration of NH_3-N on active dumping sites was about 1600 mg/l. Thus, in comparison, the NH_3-N concentrations found in this study were much lower.

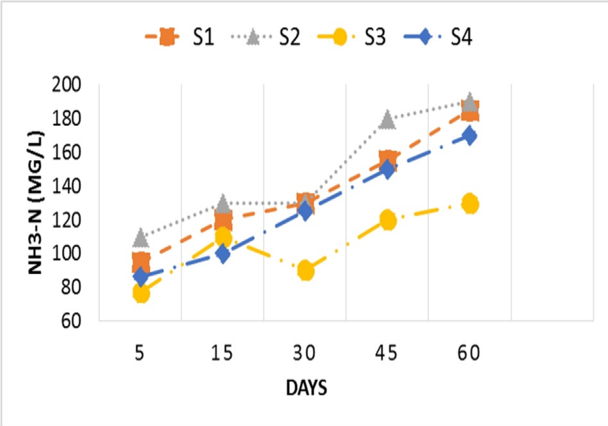

Fig. 6. NH_3-N value

Figure 7 displays the TKN values of S1, S2, S3, and S4 reactor from Day 5 to Day 60. All reactors show an increasing TKN trend with a slight fluctuation between Day 15 and 30. Starting at 480 mg/l, the value of TKN in S1 increased to 570 mg/l by Day 60. In S2, the initial value of TKN was 500 mg/l before finally rising to 660 mg/l by Day 60. Otherwise, both S3 and S4 had a value of 520 mg/l TKN on Day 5, and reached 630 mg/l and 620 mg/l, respectively, by Day 60. Based on an existing study, the value of TKN of young landfills was 100 mg/l, whereas the value of TKN on old landfills was about 2000 mg/l [7].

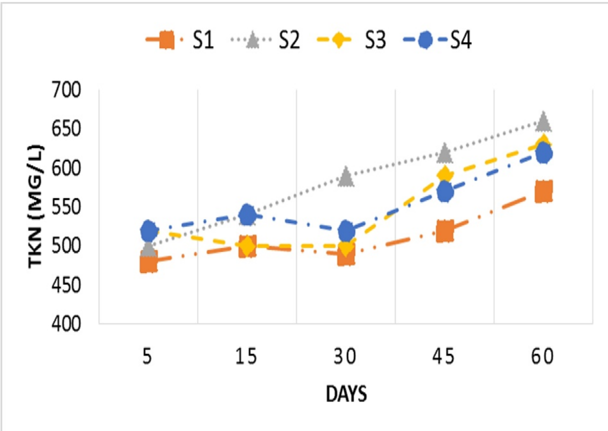

Fig. 7. TKN value.

Leachate generated by the waste decomposition process in the IWSTP had a range of pH values from 6.9 to 8.1, BOD_5 from 94 mg/l to 169 mg/l, COD from 6480 mg/l to 9800 mg/l, NH_3-N from 77 mg/l to 190 mg/l, and TKN values from 480 mg/l to 660 mg/l. The water content, pH, BOD_5, NH_3-N, and TKN tend to increased alongside the increasing leachate volume and production rate. On the other hand, the value of COD decreased as the rate of waste decomposition increased.

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