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Phytoremediation of Leachate Processing at Griya Mulya Landfill, Sidoarjo, Indonesia with Continuous System

Laily Noer Hamidah¹, Atik Widiyanti²

^{1,2}Environmental Engineering Department, Universitas Nahdlatul Ulama Sidoarjo, Indonesia

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EMAIL

widiyantienviron@gmail
.com

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Address:
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No.100, Surabaya 60117,
Phone: 031-5997244

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ABSTRACT

Waste is a global problem that is very hard to solve. Waste generation produces leachate that is harmful to the environment. Leachate can seep into the soil causing direct soil and groundwater pollution. Phytoremediation is an effort to use certain plants and their parts to reduce chemical substances in waste and environmental pollution problems. In this study, the plants used were *Typha latifolia* by varying the number of plants: without plants, four, and five plants. The leachate used comes from the Griya Mulya landfill, Sidoarjo. The reactor used was 30×30×50 cm and the discharge used was 15 L/day. The reactor used is a continuous system. The parameters analyzed included TDS and NH₃. The results showed that the most significant decrease in TDS and NH₃ levels was obtained from the reactor of four and five plants with 700 mg/L of TDS and 10.65 mg/L of NH₃.

Keywords: Continues system; Leachate; *Typha latifolia*

ABSTRAK

Sampah merupakan salah satu masalah global yang sangat berat untuk diatasi. Timbunan sampah dapat menghasilkan lindi yang berbahaya bagi lingkungan. Lindi dapat meresap ke dalam tanah sehingga menyebabkan pencemaran tanah dan air tanah secara langsung. Fitoremediasi adalah upaya penggunaan tumbuhan tertentu dan bagian-bagiannya untuk mengurangi zat kimia pada limbah dan masalah pencemaran lingkungan. Dalam penelitian ini, tumbuhan yang digunakan ialah *Typha latifolia* dengan memvariasikan jumlah tumbuhan: tanpa tumbuhan, empat, dan lima tumbuhan. Lindi yang digunakan berasal dari TPA Griya Mulya, Sidoarjo. Reaktor yang digunakan berukuran 30×30×50 cm dengan debit yang digunakan sebesar 15 L/hari. Reaktor yang digunakan menggunakan sistem kontinu. Parameter yang dianalisis antara lain TDS dan NH₃. Hasil penelitian menunjukkan bahwa penurunan kadar TDS dan NH₃ terbesar diperoleh dari reaktor empat dan lima tumbuhan, yaitu sebesar 700 mg/L TDS dan 10,65 mg/L NH₃.

Kata kunci: Lindi; *Typha latifolia*; Sistem kontinu

INTRODUCTION

Waste is a global problem that is very difficult to overcome. Waste generation can produce a dangerous liquid called *leachate*. Leachate can seep into the soil cause direct contamination of soil and groundwater because of the organic and inorganic compounds contained in leachate. Some of the efforts for leachate processing are the method of landfilling waste with a sanitary landfill system. This sanitary landfill is a landfill method with open land with a leachate distribution channel at the bottom [1]. Griya Mulya landfill, Sidoarjo is a landfill located in Jabon, Sidoarjo, East Java, Indonesia. The leachate processing is still in the form of holding ponds without any other treatment.

Based on the preliminary test results, the concentrations of COD and BOD in Griya Mulya landfill leachate were 4,620 mg/L and 2,864 mg/L, respectively. So it needs to be processed better.

In addition to the sanitary landfill method, leachate processing methods can be in the form of phytoremediation methods. Phytoremediation uses certain plants to reduce chemicals in waste, both in-situ and ex-situ. Phytoremediation is influenced by the ability of plants to stimulate biodegradation activity by microbes associated with roots (phytostimulation), immobilization of contaminants in the soil by root exudates (phytostabilization), and the ability of plants to degrade contaminants (phytodegradation) [2].

Typha latifolia is a plant that usually lives in wetlands and can reduce chromium heavy metal levels in the soil [3]. Based on previous research, *Typha latifolia* was able to reduce the heavy metal content of Cd up to 59.05% [4], and able to reduce BOD concentration by 64.8% [5]. Based on Widiyanti research, the frequency of plants can affect the ratio of BOD/COD and C/N. The reactor with a density of 14 plants/0.12 m² produces the best BOD/COD ratio compared to 12 plants/0.12 m² in leachate treatment which has 330 mg/L COD [6]. Therefore, this study will examine the effect of *Typha latifolia* to reduce levels of TDS and NH₃ in the leachate of Griya Mulya landfill, Sidoarjo.

LITERATURE REVIEW

Leachate

Leachate is a liquid that seeps through piles of garbage carrying dissolved or suspended matter, especially the results of the decomposition process of waste material. Leachate is a liquid produced by heaps of organic and inorganic waste [7]. Leachate can seep into the soil, which can cause direct contamination of soil and groundwater. There are various kinds of organic and inorganic chemical compounds in leachate and some pathogens.

Each landfill has different leachate characteristics depending on the processes in the landfill, including physical, chemical, and biological processes. Al-Wabel conducted a study on the characteristics of leachate at a landfill in the city of Riyadh, Saudi Arabia found that the leachate at that location contains Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Electrical Conductivity (EC), and Total Suspended Solid (TSS) with high concentration but low pH value. In addition, leachate in the Riyadh City landfill contains Fe, Mn, Mo, Ni, Cr, Zn, and Cu [8].

According to Kurniawan, leachate characteristics are influenced by the age of the landfill. The leachate characteristics are presented in the Table 1 [9]:

Phytoremediation

Phytoremediation is an effort to use plants and their parts for waste decontamination and environmental pollution problems, either ex-situ using artificial ponds or reactors or in-situ or directly in the field on soil or areas contaminated with waste. Phytoremediation is also defined as the absorption of pollutants mediated by plants, including trees, grasses, and aquatic plants. Washing can mean the destruction, inactivation, or immobilization of pollutants to a harmless form. The results of this study were supported by Fao, who showed that the concentration of zinc (Zn) in the soil with certain levels showed the effect of growth on *Typha latifolia* [2].

Several phytoremediation methods have been used commercially and are still in the research stage, namely methods based on the ability to accumulate contaminants (phytoextraction) or on the ability to absorb and transpire water from the soil (creation of hydraulic barriers). The ability of roots to absorb contaminants in the tissue (phytotransformation) is also used in phytoremediation strategies.

Table 1. Leachate characteristic

Parameter	Value
BOD	4,000–13,000 mg/L
COD	6,000–60,000 mg/L
NH ₄ ⁺ -N	2,000–5,000 mg/L
BOD/COD Ratio	0.4-0.7

Phytoremediation is also based on the ability of plants to stimulate biodegradation activity by root-associated microbes (phytostimulation) and the immobilization of contaminants in the soil by exudates from roots (phytostabilization) as well as the ability of plants to absorb metals from the soil in large quantities and are economically used for remediation problem soil (phytomining).

Typha latifolia

Typha latifolia is an aquatic plant with many benefits as a countermeasure for liquid waste pollution, as shown in Figure 1. *Typha latifolia* belongs to the family of *Typhaceace* (*Cattails*), which is an upright rhizomatous plant and is a perennial plant. The broadly branched rhizome produces aerial shoots and grows to a shallow depth in the horizontal direction; the leaves are basal thin, erect, linearly flat, and 4–12 mm long when fresh and 3–8 mm dry. The large, brown spike-like flowers are cylindrical 15–50 cm long that blend into the plant and can produce up to 200,000 seedlings with a high percentage of viability.

Typha latifolia has a higher nitrogen reduction ability if the two plants are carried out in a single plant system because the mixed plant is antagonistic. Propagation is assisted by the wind because the flowers produced are monoecious. *Typha latifolia* is known to absorb metals. The soil becomes fertile again because plant roots secrete organic acids that can increase the soil's chemical, physical, and biological fertility. *Typha latifolia* reduced the concentration of COD, BOD, and TSS. *Typha latifolia* can absorb heavy metal Cd from its environment, namely contaminated soil planting media. In this case, there is a decrease in Cd heavy metal levels in the planting media, the soil used [10].

METHOD

The method used in this study was arranged in two stages: the acclimatization activity of the *Typha latifolia* plant and phytoremediation test.

Plant Acclimatization

Acclimatization was carried out by taking plants from nature and then replanting them in an acclimatization reactor with a volume of 40 L. Plants were observed for seven days.

Phytoremediation Test

The research method to be carried out is the phytoremediation method using *Typha latifolia* plants by varying the number of plants. The variations used were no plants, four plants, and five plants. So, there were three reactors. The phytoremediation reactor has dimensions of 30×30×50 cm, and the flow rate used is 15 L/day. The reactor consists of a reservoir reactor, a discharge control tank, a phytoremediation reactor, and an effluent tank (Figure 2). The media used in the three reactors were gravel, sand, and soil, each with a thickness of 10 cm.



Figure 1. *Typha latifolia*

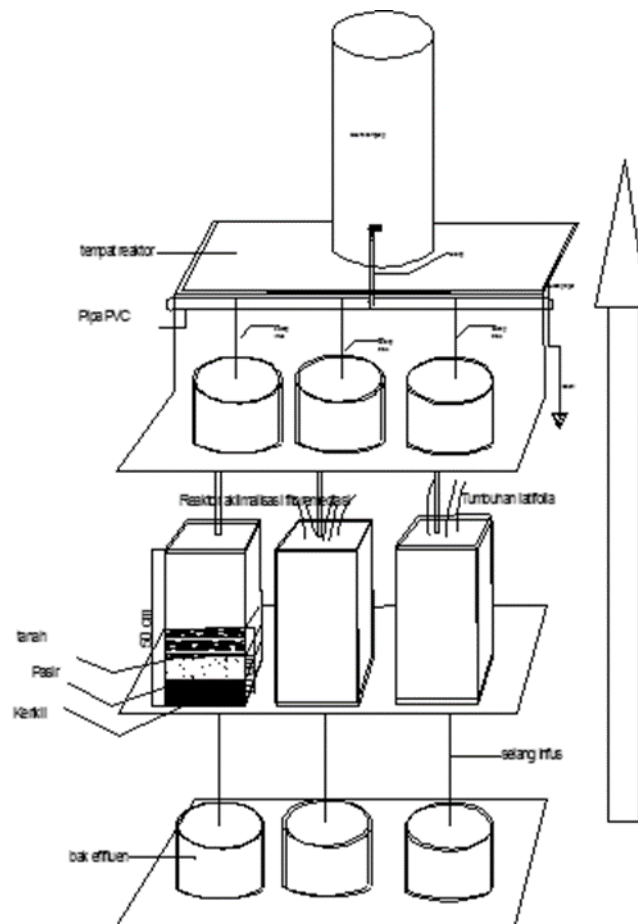


Figure 2. Reactor



Figure 3. Leachate Reservoir Reactor

Leachate of Griya Mulya landfill, Sidoarjo was taken from the leachate reservoir in the landfill (Figure 3). The leachate is taken using a jerry can and then put into the reservoir reactor. Parameter analysis was carried out every day until the fourth day. TDS analysis was carried out using a TDS meter, while NH_3 analysis was carried out using the spectrophotometer method.

The data obtained will be presented in the form of tables and graphs. Then the discussion is done by evaluating, describing, and investigating the results that have been obtained by comparing previous research.

Table 2. Result of TDS Analysis

Day <i>n</i> -th	TDS Concentration (mg/L)		
	Without Plants	4 Plants	5 Plants
1	979	704	885
2	944	700	857
3	704	703	700
4	713	710	704

Table 3. Result of NH₃ Analysis

Day <i>n</i> -th	NH ₃ Concentration (mg/L)		
	Without Plants	4 Plants	5 Plants
1	17,30	16,30	12,40
2	12,00	12,70	13,14
3	33,12	15,75	10,65
4	45,50	20,55	15,70

RESULTS AND DISCUSSION

This study used a continent system and planting media, namely gravel, compost, and soil. Each medium is inserted into the reactor to a height of 10 cm so that the total height of the media is 30 cm. In the first reactor, four plants were planted, in the second reactor, five plants were planted, and the third reactor was without plants. The variation in the number of plants aims to obtain the best effluent quality for leachate processing.

Effect of Plant Number on TDS Concentration

The results showed a decrease in TDS concentration in all three reactors (Table 2). Based on Table 2, it is known that TDS decreased in the reactor without plants, namely on the second and third days; this decrease was possible for the sedimentation process in the reactor. The number of plants influences the concentration of TDS. The best reduction was obtained from the reactor with four plants and five plants which are 700 mg/L. In the reactor, without plants and five plants, the concentration of TDS up to the third day decreased. But there was an increase on the fourth day. Meanwhile, in the reactor with four plants, there was a decrease on the second day and an increase on the third and fourth day.

Based on the table above, it is known that four plants and five plants occurred a decrease on the third day in the reactor. The research of Kustiyaningsih and Irwanto that the treatment with the *Sagittaria lancifolia* plant can reduce the concentration of TDS detergent [9]. In addition, this decrease in TDS concentration may be due to *Typha latifolia* root activity with waste. *Typha latifolia*, with a combination of rice fermentation and microbes, can reduce TDS up to 35% in batik wastewater [10].

Effect of Plant Number on NH₃ Concentration

Based on the NH₃ analysis table, there was an increase in the NH₃ content from the second to the fourth day in the reactor without plants. The best NH₃ concentration in five plant reactors was obtained, 10.65 mg/L on the third day. Meanwhile, in the reactor without plants, the lowest NH₃ concentration was 12 mg/L on the second day and 12.7 mg/L on the second day for reactors with four plants.

On the second day of the reactor with four plants and the fifth day of the reactor five plants, there was a decrease in NH₃ concentration due to the absorption of *Typha latifolia* roots and the growth and death of microorganisms. Microorganisms use ammonium in leachate for the biosynthesis of new cells. So that the concentration of ammonium in the environment is reduced [13]. Fluctuation of NH₃ can occur due to the release of nitrogen by plants after the decomposition process. According to Irmanto and Suyana, the presence of decomposition causes the solubility of organic matter to be reduced [14].

CONCLUSION

Based on the discussion, it can be concluded that the most significant decrease in TDS levels occurred in reactors with plants that is a concentration of 700 mg/L. For the reduction of NH_3 , the best reduction was obtained in reactor five plants which are 10.65 mg/L.

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