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Study of the Utilization of Liquid Organic Fertilizer from Leachate from Tlekung Landfill, Batu City Using Ecoenzyme as Biodegradation of Heavy Metals (Pb, Cu)

Luluk Indri Astuti[1], Arie Srihardyastutie[1*], Qonitah Fardiyah[1]

[1] Chemistry Department, Faculty of Mathematics and Natural Sciences, Universitas Brawijaya, Malang, Indonesia.

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Corresponding Author:
Arie Srihardyastutie
arie_s@ub.ac.id

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Abstract: Leachate is water produced from the waste processing process at the final disposal site (TPA). Leachate contains various organic substances, so many local people use leachate as fertilizer. However, on the other hand, leachate contains heavy metals. As an effort to reduce the content of heavy metals such as Pb and Cu, biological remediation techniques are used by adding ecoenzymes. This study aims to determine the effectiveness of ecoenzymes on leachate at the Tlekung TPA, Batu City. Leachate at the inlet point of Tlekung Landfill, Batu City was taken as much as 20 liters and the volume of ecoenzyme was varied, namely P1 (leachate 1000 ml), P2 (leachate 1000 ml + 1 ml ecoenzyme), P3 (leachate 1000 ml + 5 ml ecoenzyme), P4 (leachate 1000 ml + 10 ml ecoenzyme), P5 (leachate 1000 ml + 15 ml ecoenzyme). The research stages were carried out by testing the pH using a pH meter, testing the number of colonies using the Total Plate Count (TPC) method, testing the levels of lead (Pb) and copper (Cu) using the AAS method. The results showed that the addition of ecoenzyme to leachate affected the pH value, increased the number of colonies and decreased the levels of Pb and Cu metals. The addition of 10 mL of ecoenzyme in 1000 ml of leachate in the P4 treatment could increase the number of colonies and reduce the levels of Pb and Cu.

Keywords: Bioremediation; Ecoenzyme; Leachate; Liquid Organic Fertilizer

Introduction

Waste in the community environment has the potential to be waste that causes aesthetic disturbances and air pollution due to the pungent odor of waste. Most people assume that waste is useless material and must be removed from the surrounding environment, so that the amount of waste piles is getting bigger and proper processing is needed. Waste processing is an actual problem that requires special attention along with the increasing population growth rate with high consumption power (Abubakar et al., 2022; Anuardo et al., 2022). Most of the final disposal sites (TPA) in Indonesia have been adequately repaired using a controlled landfill system. One of the TPAs that has utilized this system is the Tlekung TPA, Batu City. In the controlled landfill system, waste is processed and managed in a controlled manner, so that it can reduce negative impacts on the environment such as soil, water, and air pollution. Waste disposed of in the TPA is compacted and covered with a covering material every day to prevent waste from being exposed and reduce methane gas emissions.

Waste processing in the TPA will experience a process of decomposition of organic waste which produces gases and leachate. Leachate produced from waste is treated using a leachate treatment system before being discharged into the environment (El-Saadony et al., 2023; Jagaba et al., 2021). Leachate is water produced

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from the waste processing process at the final disposal site (TPA). Leachate contains various substances and chemicals derived from waste, so many local people use leachate as fertilizer. This is because leachate contains nutrients such as nitrogen, phosphorus, and potassium which can be used to improve soil quality and plant growth (Lucero-Sobarzo et al., 2022; Cardoso et al., 2019). However, on the other hand, leachate contains various substances and chemicals derived from waste, such as heavy metals and other hazardous chemicals (H. Chen et al., 2024; Vaverková et al., 2020). Wdowczyk & Szymańska-Pulikowska (2020), Wang et al. (2024) stated that the results of the analysis of heavy metal levels in the Pakusari TPA monitoring well which has implemented a controlled landfill system in leachate are quite high, namely 0.141 ppm.

The use of leachate as fertilizer for plants for farmers in the Tlekung TPA environment is feared to have a negative impact on the soil and plants that will leave residues in the environment, in addition, it is also feared that it can have an impact on the health of the people who consume it, because of the nature of plants that are able to absorb heavy metals from the leachate (Hosseini Beinabaj et al., 2023; Yan et al., 2020). So it is necessary to have a proper leachate management method. One way to reduce pollutant levels in leachate has been carried out by several researchers with different methods such as the use of absorbents (activated carbon, zeolite and silica gel), and constructed wetlands (Khader et al., 2021; Liaquat et al., 2024; Akhtar et al., 2024). However, this method requires a lot of money and can produce new waste such as used absorbents, so an alternative method that is more economical and environmentally friendly is needed. One method that can be used is the use of bioremediation techniques (Kuppan et al., 2024). Bioremediation techniques that can be used for wastewater treatment are using ecoenzymes.

Ecoenzymes are complex organic solutions produced by the fermentation process of organic waste residues, water, and molasses (Natasya et al., 1970); Pasalari et al., 2024). (Martínez-Zamudio et al. (2024) and Janeeshma et al. (2024) stated that the use of ecoenzyme can be used to degrade pollutant compounds found in soil due to leachate pollution. Based on several studies that have been conducted, it can be seen that ecoenzyme has the potential as a bioremediation agent and as a liquid organic fertilizer. Therefore, this study is important to be carried out in finding facts related to the effectiveness of variations in the addition of ecoenzyme on reducing heavy metal levels and leachate quality in leachate treatment ponds at the Tlekung TPA. Therefore, leachate that has been properly processed can be utilized by local farmers to support agricultural activities.

Method

This research was conducted from March to August 2022 in the Microbiology laboratory, UPT Health Laboratory of Malang Regency, Biochemistry laboratory, and Chemistry Instrumentation laboratory, Faculty of Mathematics and Natural Sciences, Brawijaya University, Malang.

Tools and Materials

The tools used are atomic absorption spectrophotometer (AAS), BOD Track TMII (Hach), pH meter, micro pipette (0.5 ml, 1 ml, and 10 ml), measuring flask (50 ml, 100 ml, and 1000 ml), measuring pipette (10 ml and 100 ml), 20 ml test tube, beaker (150 ml and 500 ml), electric bath, spirit lamp, dropper, incubator (Memmert), Petri dish (Pyrex), test tube (Pyrex), autoclave (MY LIFE MA 635), measuring cup (Pyrex), 250 ml Erlenmeyer flask, water bath, test tube, hot plate stirrer (Favorite), digital scale (Analytical Balance Radwag As220/C/2), oven (Mido/4/ss/f), and sample bottle. The materials used in this study include, leachate from Tlekung TPA, Batu City, ecoenzyme, distilled water, Potassium Hydroxide pellets (Hach Cat.31425-ID), Respirometric BOD nutrient buffer pillows (Hach Cat.2962266), nutrient agar (NA), alcohol, metal-free distilled water, distilled water, nitric acid (HNO3), Pb stock solution 1000 mg/l, Pb standard solution 10 mg/l, Potassium Dichromate (K2Cr2O7), ferroin indicator solution, Ferro Ammonium Sulfate (FAS), COD standard solution 1000ppm, concentrated H2SO4, KH2PO4, (NH4)6MoO24.H2O, concentrated NH4OH, NH4VO3, Kjeldhal tablets, NaOH, C4H4O6KNa4H2O, KI, HgCl2, NaOH.

Research Preparation

Leachate at the inlet point of Tlekung Landfill, Batu City was taken as much as 20 liters and put into a sample container. Ecoenzyme was obtained from the ecoenzyme activist community in Malang City. After that, the leachate and ecoenzyme were varied in volume.

Leachate Volume Variation with Ecoenzyme

Leachate variation with ecoenzyme was carried out by adding 5 variations in the volume of ecoenzyme to the leachate, namely P1 to P5.

P1 = leachate (control)
P2 = 1000 ml leachate + 1 ml ecoenzyme
P3 = 1000 ml leachate + 5 ml ecoenzyme
P4 = 1000 ml leachate + 10 ml ecoenzyme
P5 = 1000 ml leachate + 15 ml ecoenzyme

The mixture of leachate and ecoenzyme was stirred until homogeneous and incubated for 24 hours. After 24 hours, the liquid and sediment were separated using a

centrifuge. In the liquid phase, pH, Pb, Cu, and colony count tests were carried out.

Research Stages

The research stages were carried out by testing the pH using a pH meter, testing the number of colonies using the Total Plate Count (TPC) method, testing the levels of lead (Pb) and copper (Cu) using the AAS method.

Data Processing and Analysis

The data obtained from the research results were tested using the SPSS Anova (Analysis of Variance) Test application. This test was carried out to see the difference in the average count for each treatment, namely by entering data into the SPSS one-way Anova program so that an SPSS output was obtained that showed the difference in treatment. Treatments that showed significant differences were then tested by the Duncan test with the aim of determining the level that produced differences in data on the effect of the treatment.

Result and Discussion

The results of the study are shown in detail in Table 1.

Table 1. Research Results for Each Treatment

Indicator	Treatment				
	P1	P2	P3	P4	P5
pH	8.12	7.82	7.69	7.37	7.20
Number of Colonies (CFU/ml)	6.80 $x10^7$	7.20 $x10^7$	8.80 $x10^7$	1.30 $x10^8$	7.20 $x10^7$
Increase in Number of Colonies (%)	0.00	5.88	29.41	91.18	5.88
Initial Pb Level (mg/L)	0.08	0.07	0.06	0.05	0.05
Decrease in Pb Level (%)	0.00	19.42	26.98	35.61	37.29
Initial Cu Level (mg/L)	0.12	0.10	0.09	0.09	0.09
Decrease in Cu Level (%)	0.00	12.74	21.44	22.45	22.53

pH

The results of pH (acidity level) measurements in each treatment showed almost uniform results with a pH value range from 7.20 to 8.10.

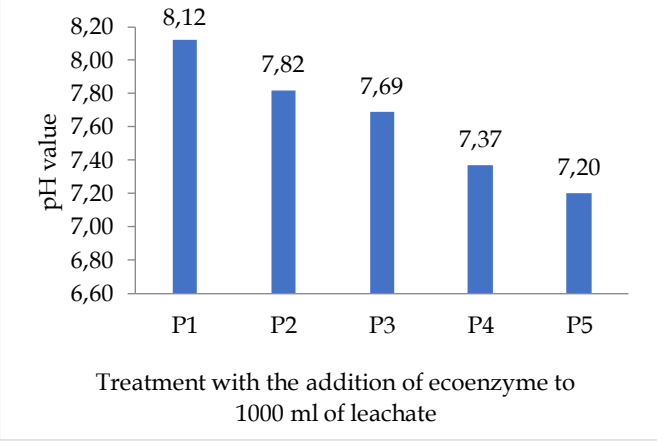

Figure 1. Graph of pH values in each treatment

The highest pH value was in treatment 1 (100% leachate) with a pH value of 8.1. Then the lowest pH value was in treatment 5 (1000 ml leachate + 15 ml ecoenzyme) with a pH value of 7.2. The results of the pH analysis shown in Figure 1 show that the more ecoenzyme added, the lower the pH. This is because ecoenzyme is acidic so that the greater the volume of ecoenzyme causes the acidity to increase. The results of treatments P1 to P5 have the potential as biological agents in the manufacture of liquid organic fertilizers because they have the pH required by (Minister of Agriculture of the Republic of Indonesia, 2011) Regulation of the Minister of Agriculture 15 Number 70/Permentan/SR.140/10/2011, which is 5-8.

Number of Colonies

Observations of the number of bacterial colonies in treatments P1 to P5 were carried out after 24 hours of incubation. The test results showed that the number of colonies in the P4 treatment experienced the highest increase reaching 1.3x 108 CFU/mL. The results of the P4 treatment have the potential as a biological agent in the manufacture of liquid organic fertilizer because it has the number of colonies required by (Minister of Agriculture of the Republic of Indonesia, 2011) Regulation of the Minister of Agriculture 15 Number 70/Permentan/SR.140/10/2011, which is ≥ 108 CFU/mL. The study (Effendi, 2003) shows that bacteria will grow well at neutral pH because the decomposition process of organic matter occurs faster.

In other treatments, the number of colonies decreased. This decrease is possible due to inappropriate pH conditions, nutrient intake or food sources for microorganisms have decreased so that many microorganisms die (Mafe et al., 2024; Z. Ma et al., 2024). This is in accordance with research conducted by Mukherjee et al. (2022) that microorganisms added to leachate utilize organic materials and other materials

contained therein as energy sources so that when the amount of energy sources decreases, there will be fluctuations in the number of bacterial colonies, colony growth is influenced by several factors including food nutrition, temperature, and acidity (pH) (Sanjaya et al., 2023).

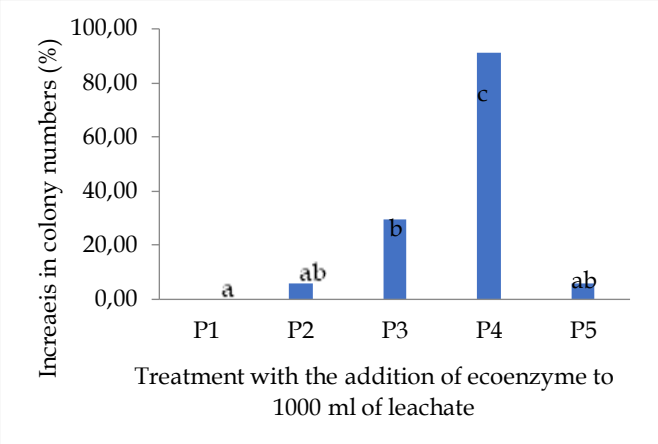

Figure 2. Graph of the number of colonies in each treatment

Lead (Pb) Levels

Based on the results of the lead (Pb) level test, the results showed that in the fourth and fifth treatments (P4 and P5) the Pb value decreased almost equivalently, namely 35.6% and 37.3%. The highest decrease in Pb content was in P5 with a value of 37.3%, where P5 was a treatment of 1000 ml leachate + 15 ml ecoenzyme. This shows that ecoenzyme is effective in degrading heavy metals in leachate. This is also in accordance with the test results Zhou et al. (2023) and Tang et al. (2024) that the addition of ecoenzyme greatly influences the decomposition process and helps the degradation of pollutants including heavy metals. X. Ma (2024) explained the decrease in heavy metal levels in leachate due to the activity of microorganisms such as lactic acid bacteria in ecoenzyme.

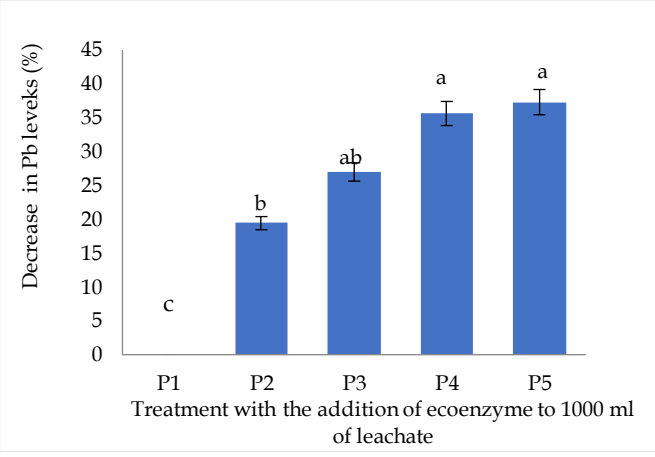

Figure 3. Graph of decrease in Pb levels in each treatment

The results of the analysis of Pb metal levels based on the test results also provided results that did not exceed the threshold required by Minister of Agriculture of the Republic of Indonesia (2011) Regulation of the Minister of Agriculture 15 Number 70/Permentan/SR.140/10/2011 with a maximum Pb metal threshold of 50 ppm

Copper (Cu) Levels

The copper (Cu) level test in each treatment decreased. The highest decrease occurred in treatment 5 (1000 ml leachate + 15 ml ecoenzyme) which was 22.53%. While treatments 3 and 4 were almost equivalent to treatment 5. In P3 and P4 the copper level decrease was 21.43% and 22.45%. The lowest Cu level was in treatment 1 (100% leachate) of 0.00%. According to Minister of Agriculture of the Republic of Indonesia (2011) Regulation of the Minister of Agriculture 15 Number 70/Permentan/SR.140/10/2011 the maximum Cu metal threshold is 5000 ppm. The results of research from Kang et al. (2021) and Williamson et al. (2021) show that if copper is detected from leachate, it is estimated that there is a copper metal deposit which is influenced by pH. The concentration of copper from leachate is influenced by copper salts, for example; copper carbonate (CuCO3), copper hydroxide Cu (OH)2, and copper sulfide (CuS) are not easily soluble in water.

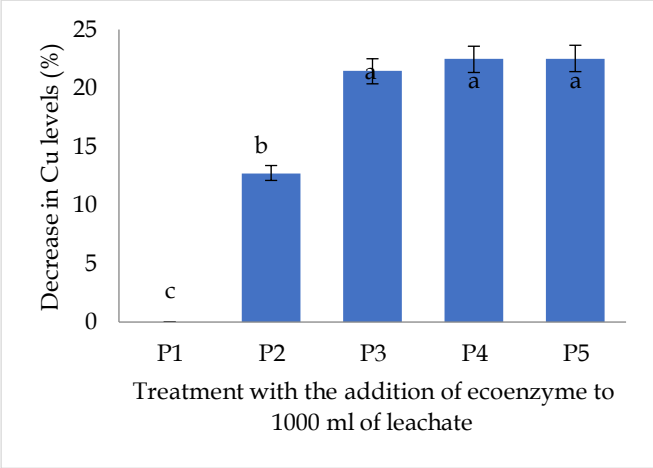

Figure 4. Graph of Cu level decrease in each treatment

Discussion

Leachate is water produced from the waste processing process at the final disposal site (TPA). Leachate contains various substances and chemicals derived from waste, so many local people use leachate as fertilizer. However, the high content of heavy metals in leachate, when applied to agricultural land without proper processing methods, will have an impact on the heavy metal content in the soil. Heavy metals in the soil are related to soil properties such as soil pH, organic

matter and soil clay content (Elnajdi et al., 2023). The availability of heavy metals increases inversely with soil pH and decreases inversely with soil organic matter content (X. Chen et al., 2024). Low soil organic matter content results in heavy metal pollution which will have a negative impact on the soil microbial community by inhibiting soil enzyme activity and thus affecting soil microbial metabolism.

High soil organic matter content means that the inhibitory effect of metal pollution on soil enzyme activity will gradually decrease (Enya et al., 2020; Yeboah et al., 2021). Heavy metal content that exceeds the threshold greatly affects plant production and quality (Angon et al., 2024; Briffa et al., 2020). So that testing was carried out with several treatments, where leachate was added with ecoenzyme. Based on the test results Dogan et al. 2022), Elleuch et al. (2018), Tang et al. (2023) ecoenzyme can be one way to reduce environmental pollution. Processing organic waste into ecoenzyme is an effort to optimize the use of resources in line with the zero waste concept. The results of the study showed that the most optimal treatment for each parameter was P4 (1000 ml leachate + 10 ml ecoenzyme). Where the test results showed a pH value of 7.4 and the number of bacterial colonies of 1.30 x 108 with an increase of 91.2%. The Pb and Cu values in leachate decreased by 35.6% and 22.45%. This shows that microorganisms in ecoenzyme are very important to help the decomposition process, nutrient transport, and degrade soil pollutants including heavy metals (Rashid et al., 2023; Pikuła & Stępień, 2021).

Many different types of microorganisms are produced during the natural fermentation process in ecoenzymes, especially lactic acid bacteria (such as Lactobacillus and Leuconostoc) and yeast (such as Pichia and Candida). Lactic acid bacteria are the most well-known probiotic microorganisms for reducing biocontamination. Yeast can also act as bioremediators for various heavy metals, including Cr, Cu and Cd, especially since it has various tolerance mechanisms against toxic metals.

Conclusion

Leachate is water produced from the waste processing process at the final disposal site (TPA). Leachate contains various substances and chemicals derived from waste, so many people around use leachate as fertilizer. However, on the other hand, leachate contains various substances and chemicals derived from waste, such as heavy metals. As an effort to reduce the content of heavy metals such as Pb and Cu contained in leachate, a biological remediation technique is used by adding ecoenzyme. The study was conducted using 5 parameters where each treatment was added with ecoenzyme. The results of the study showed that the maximum treatment for each parameter was P4 (1000 ml leachate + 10 ml ecoenzyme). Where the test results showed a pH value of 7.4 and the number of bacterial colonies of 1.30 x 108 with an increase of 91.2%. The Pb and Cu values in leachate decreased by 35.6% and 22.45%. So that at this level it is considered effective for managing leachate so that it can be used as organic fertilizer to increase the productivity of healthy plants.

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Author Contributions
Conceptualization; methodology.; validation; formal analysis; L. I. A.; investigation; resources.; data curation.; writing—original draft preparation. A. S.; writing—review and editing: visualization: Q. F. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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