JPPIPA 9(5) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Processing of Leachate Water into Liquid Fertilizer (POC) for Increasing the Economy of Chrysanthemum Farmers

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Received: February 20, 2023
Revised: May 20, 2023
Accepted: May 25, 2023
Published: May 31, 2023

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DOI: 10.29303/jppipa.v9i5.3616

Abstract: The waste problem is a national problem that has derivative impacts, including the accumulation of waste in landfills which also causes pollution of locations around landfills for leachate production. TPST Piyungan which is the largest waste management site in Yogyakarta has a leachate treatment system but it does not work optimally. One of the leachate treatment technology options is a wetland system that can not only stabilize leachate by reducing heavy metal levels but can also produce liquid organic fertilizer (POC). This study aims to determine the performance of the wetland system using water bamboo to process leachate into liquid organic fertilizer and to determine the impact of testing on flower plants. Besides that, respondent analysis and economic analysis were also carried out. The results showed that the performance of the wetland system produced leachate NPK levels that were still below the standard liquid organic fertilizer, but its application to flower plants showed significant results in helping flower growth. The economic analysis also shows positive parameters and shows that this system is feasible for business development and has promising market potential.

Keywords: Economic analysis; Leachate; POCs; Rubbish

Introduction

Indonesia is facing an urgent waste problem because demographic and economic currents are increasing causing waste generation to continue to increase. The government has made efforts to increase efforts to reduce and handle waste, but the results achieved have not been by the targets set. The 2021 waste reduction target is 24%, while waste handling is expected to reach 74%. However, the data shows that this target was not achieved, with only waste reduction reaching 18% and waste handling only reaching 54%.

One reason for this low achievement is due to the low level of public awareness of waste management, with an index of community indifference of 79% (Herdiansyah et al., 2021). Waste management in most cities in Indonesia is still in the form of collecting and transporting and disposing of it at the Final Disposal Site (TPA), especially the open-dumping type, which does not cover waste such as a sanitary-landfill type TPA (Luthfiani & Atmanti, 2021). The achievement of waste handling will only reach 54% in 2021 so that almost half of the waste generated by the community is not handled by the government and is dumped into open land, rivers, or burned by the people themselves. Indonesia has 464 TPAs in 2021 with 49% having an operational controlled-landfill system, 36% having an open dumping system, and 14% having a sanitary landfill system. The total amount of waste going to landfills in Indonesia in 2021 will reach 89.7 million tonnes, but only 1.4% will be successfully processed using various management processes. Landfilling methods that are commonly applied still produce environmental impacts such as the production of leachate which has the potential to contaminate groundwater and water bodies around the landfill (Vaverková, 2019). Leachate is a liquid produced from the waste decomposition process which contains high pollutant characteristics (Lindamulla et al., 2022) and has a high organic, mineral, and heavy metal content (Hussein et al., 2021). An ideal landfill should have a leachate collection system and treatment facility with several treatment options such as

How to Cite:
Nasirudin, N., Rukmini, Diananto Prihandoko, Masrur Alatas, & Yeremias Yanuarius Sedik. (2023). Processing of Leachate Water into Liquid Fertilizer (POC) for Increasing the Economy of Chrysanthemum Farmers. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2403–2408. https://doi.org/10.29303/jppipa.v9i5.3616

activated sludge, aerated lagoons, and anaerobic treatment (Song et al., 2022). The Piyungan TPST is the largest TPA in the province of DIY, still operating in an open dumping controlled landfill manner even though it is past its age, exceeds its capacity, and has experienced several operational problems and blockages from residents. Another problem faced by the Piyungan TPST is the inefficient leachate treatment process, with an efficiency of only 16-20%. The toxicity test also shows that the leachate produced by Piyungan TPST still has high toxicity (Juliani et al., 2019).

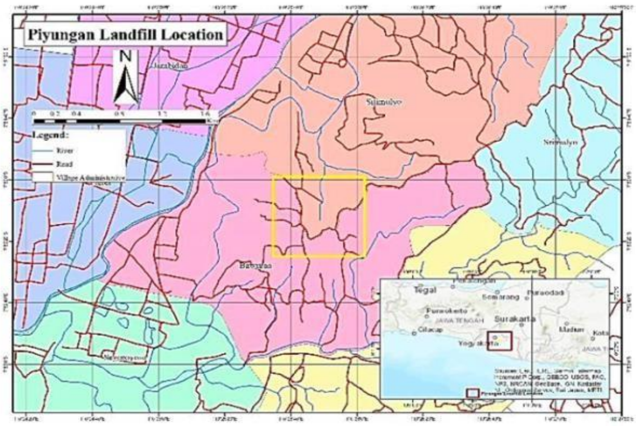

Figure 1. Location of the Piyungan TPST

The main challenge in implementing leachate treatment techniques such as constructed wetland systems is the high cost (Bakhshoodeh et al., 2020) and in-depth analysis of the characteristics of leachate which varies depending on the location and characteristics of the waste. The constructed wetland system is an artificial wetland system that is designed to imitate natural wetland systems and is proven to be able to process pollutants from wastewater (Nuamah et al., 2020), and able to reduce COD levels, ammonia, Nikel, and Cadmium in wastewater with an efficiency of 86-99%.

Leachate also contains high ammonium nitrogen (NH4) which has the potential to be used as a liquid fertilizer (Haslina et al., 2021). This system can also reduce the concentration of NH4-N in wastewater with an efficiency of 38-95% and can reduce the content of phosphorus and potassium with high efficiency. Feasible or not, liquid fertilizer produced from leachate, is determined by the levels of nutrients and pathogenic microorganisms (Kurniawan et al., 2023). Leachate from landfill waste can be used as liquid fertilizer, if it meets the minimum technical requirements for fertilizer (Wang et al., 2018).

Liquid fertilizer derived from city waste compost leachate has better fertilizer characteristics than commercial fertilizers (Pajura et al., 2023) and is considered to have lower production costs. This study aims to study the ability of a wetland system with aquatic bamboo plants to reduce NPK levels (not to reduce NPK levels but to reduce heavy metals) in Piyungan TPST leachate so that it can be used as liquid organic fertilizer for ornamental plants, as well as to analyze its economic potential.

Method

Leachate Treatment with Constructed Wetlands

The leachate sample was obtained from the Piyungan TPST IPAL, Bantul Regency, D.I Yogyakarta. One leachate sample was taken as a pre-treatment sample and one sample was used as an experiment in the wetland system. The quality of pre-treatment and pre-treatment leachate samples was processed in the laboratory to determine NPK levels. In the wetland experiment media, leachate flowed from a 180-liter plastic drum into a 60-liter media. The wetland media consists of zeolite, activated charcoal, sand, and water bamboo plants. There were 3 wetland trial media for variations of 2, 4, and 6-day trial times.

Function Test on Chrysanthemum Flowers

A function test was conducted to determine the effect of liquid organic fertilizer (POC) leachate on the growth of chrysanthemum flowers. There are 3 pots of chrysanthemum flowers as controls and 9 pots which will be watered with liquid organic fertilizer. POC doses used in the treatment were 50, 100, and 150 ml with 3 samples per dose. The chrysanthemum flowers used in the experiment were 3 months old with a stem diameter of 7.76 cm and a height of 30 cm. POC watering was carried out for 1 month and the growth parameters measured at the end of the experiment were the number of leaves, tree height, and diameter of buds.

Farmer and Florist Response Questionnaire

Interviews and questionnaires were conducted with ornamental plant sellers in Rejowinangun, Kotagede, and Yogyakarta to find out the response of ornamental plant sellers to the use of liquid organic fertilizer. The questionnaire used a Likert scale, while the sample selection used a purposive sampling technique by selecting respondents aged 18-65 and able to read and write. Respondents amounted to 20 people consisting of ornamental plant business owners and their employees.

Economic Analysis

Economic analysis is carried out by simple cash flow analysis and B/C ratio to determine potential income required investment, and sales projections for the next 5 years.

Result and Discussion

Quality of POC Leachate

The results of the Piyungan TPST leachate treatment showed that the highest concentration of NPK was achieved in the processing of the wetland system with a residence time of 6 days. The total NPK in the treatment for 6 days reached 0.24%. The NPK value is still far below the standard minimum technical requirements for the quality of liquid organic fertilizer stipulated in the Decree of the Minister of Agriculture Number 261 of 2019 concerning Minimum Technical Requirements for Organic Fertilizers, Bio Fertilizers, and Soil Improvers which require a minimum NPK content of 2-6%.

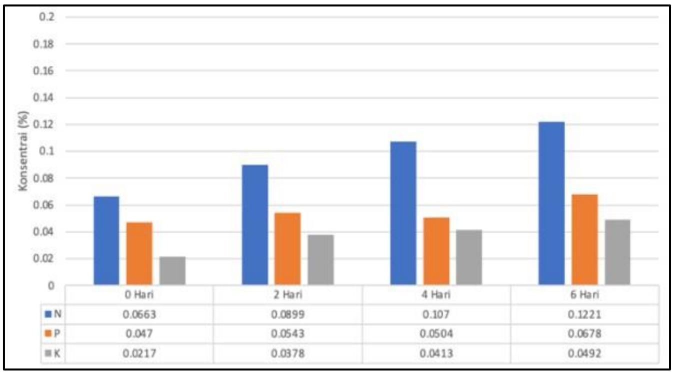

Figure 2. Variation of residence time on concentration NPK

Functional test results of applying POC leachate to Chrysanthemum Flowers In the functional test results of applying POC leachate to chrysanthemum flowers, the result was that a dose of 150 ml had the maximum results in terms of increasing number, tree height, and diameter of florets.

Table 1. Variation of Doses on the Number of Leaves, Tree Height, and Diameter of the Buds

Dosage (ml)	Number of leaves	Tree height	Floret diameter (cm)
0	160	22	2.3
50	250	27	3.5
100	320	32	4.2
150	532	35	6.1

Seller's Response to the Application of Leachate POC

Most (92%) florists in Rejowinangun knew about the existence of the Piyungan TPST, but 77% of respondents did not know about leachate and its potential to be processed into liquid organic fertilizer. Meanwhile, 85% of respondents said they had used liquid organic fertilizer in flower cultivation.

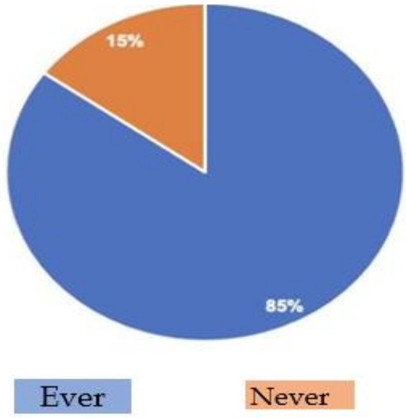

Figure 3. Knowledge of TPST

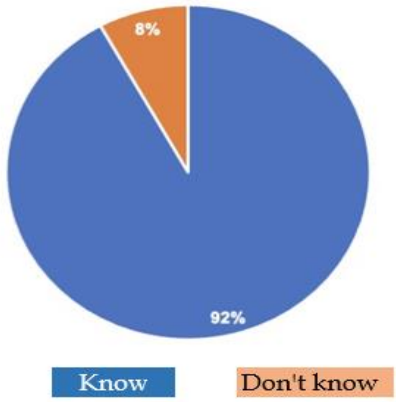

Figure 4. Knowledge of waste leachate

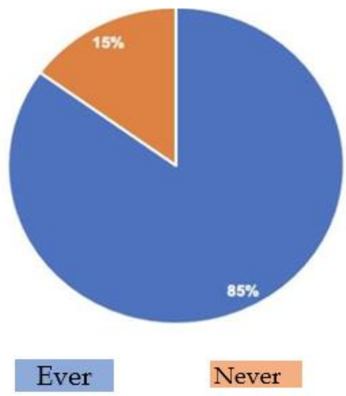

Figure 5. Never used POC

Based on the experimental results of processing 180L of leachate, the required Capital Expenditure is almost Rp. 5,000 per liter of leachate with details of capital expenditure including the purchase of jerry cans, plastic drums, and piping. Meanwhile, operational expenses (Operational Expenditures) reach IDR 14,250 per liter of leachate, including costs for purchasing wetland materials, lab tests, transportation, and electricity. Details of CAPEX and OPEX costs can be seen in Table 2.

Table 2. Details of OPEX and CAPEX Costs for a Wetland System with a Capacity of 180L

Capex	Information	Price (IDR)
Jerrycan		315.000
Plastic Drum		300.000
Pipe		274.000
Total Opex		889.000
CAPEX/Liter	IDR/liter	4.938.89
Opex	1 year	
Activated Charcoal	1 year	90.000
Sand	1 year	100.000
Zeolite	1 year	450.000
Water bamboo	1 year	225.000
Lab test	Assumed 1x test per 2 years	500.000
Transport	to Piyungan, assumed 180l/month	600.000
Electricity		600.000
Total Opex		2.565.000
OPEX/Liter	IDR/liter	14.250

Based on CAPEX and OPEX analysis per liter of leachate that is processed into POC, a cash flow economic model with a production scenario of 5 years can be made. It is assumed that production in the first year is 180/liter/month and increases for 5 years with a maximum capacity in the 5th year reaching 300/liter/month. POC production is assumed to be as much as 90% of the volume of treated leachate, and price the selling price for POC is IDR 25,000 per liter, according to the minimum selling price acceptable to flower growers based on the survey results. Based on the assumptions above, a cash flow model can be made as shown in table 3. Based on the results of the analysis, cash flow shows positive cash flow (NPV> 0), B/C ratio > 1, and a payback period of 1 year. This analysis shows that the production of POC from leachate with a wetland system is economically feasible to do.

Table 3. Cash Flow Models

Component cashflow	Information					Year to
Enter		1	2	3	4	5
Leached volume (liters)	The leachate volume is processed annually	2.160	2400	2640	3000	3600
POC production	assumed 90% x volume	1.944	2.160	2.376	2700	3420
Total income	Price (Rp) 25.000/liter) x production POC	48.600.000	54.000.000	59.400.000	67.500.000	81.000.000
Expenditure						
Carex	Total processing capacity year to 5 x CAPEX/liter	17.780.000				
Opex	Leachate volume x OPEX/liter	30.780.000	34.200.0.00	37.620.0.00	42.750.0.00	51.300.00.00
Part-time salary		6.000.000	7.200.00.00	8.400.00.00	9.600.00.00	10.800.00.00
Total Expenses		54.560.000	41.400.000	46.020.000	52.350.000	62.100.0000
Net		(5.960.000)	12.600.000	13.380.000	15.150.000	18.900.000
Cumulative		(5.960.000	6.640.000	20.020.00	35.170.0	54.070.00
NPV		34.599.300,46				
Total cost		256.430.000				
Total income		310.500.000				
B/C		1,21				
Payback period		1 year				

Various research results generally show that leachate can be processed into liquid organic fertilizer (Ye et al., 2019). Leachate has content organic matter which is the result of the decomposition of waste in the TPA (I Nengah Muliarta et al., 2023). The high content of organic matter and nitrogen-ammonia can be stabilized by natural phytoremediation processes that occur in the wetland system, besides that the plant roots in the wetland system also produce oxygen which stimulates the growth of bacteria that stratify ammonia (Hernández-del Amo et al., 2020).

Research has shown good results for applying POC to various crops even at low NPK concentrations. The application of leachate liquid organic fertilizer to rice plants at a dose of 40 ml/liter of water showed optimal and significant results in the parameters of plant height, biomass, and number of leaves even though the total NPK only showed a value of 0.53%, far below the standard value of liquid organic fertilizer (Suryanti & Santiasa, 2020).

The results of the study Pohan (2021) on the administration of leachate liquid organic fertilizer to land kale plants also showed significant growth results compared to general fertilizers. The trial results in this study indicated that the longer the residence time, the more NPK concentration would also increase. This shows that residence time is a significant factor in the process of transforming NPK concentrations in leachate (Roslan et al., 2021).

The optimum dosage for applying leachate liquid organic fertilizer for plants varies quite a bit in various literature (Hasnelly et al., 2021). Research

Petropoulos et al. (2022) on okra plants shows that the dose needed to achieve optimum results in terms of plant height, number of leaves, and dry weight is 450 ml. Meanwhile, research Santoso (2022) showed that statistically there was no effect of varying the dosage of leachate liquid organic fertilizer on the number of leaves of the mustard greens, even though the dose that showed the highest results was 100 ml.

The dosage variations shown from these various studies indicate that determining the optimum dose of liquid organic fertilizer from leachate must be determined case-by-case based on the type of plant (Singh et al., 2017) and the system used to process leachate into liquid organic fertilizer. From an economic perspective, the cost of making liquid organic fertilizer from leachate is relatively lower than commercial fertilizers (Kaya et al., 2022).

The business analysis in this experiment shows that the production and sale of leachate liquid organic fertilizer can show NPV> 0 and B/C> 1 which shows that implementing this business scheme is economically feasible. The maximum selling price that can be accepted by flower growers in the Yogyakarta Rejowinangun area is Rp. 25,000/liter as well the majority of respondents have used liquid organic fertilizer so it can be seen that farmers are familiar with the use and benefits of liquid organic fertilizer for flower plants (Irmawanty et al., 2021).

Conclusion

This study shows that a wetland system with water bamboo plants can treat leachate water from Piyungan TPST and produce liquid organic fertilizer that can be used to increase productivity.

Acknowledgments
Thanks to all parties who have supported the implementation of this research. I hope this research can be useful.

Author Contributions
Conceptualization, Nasirudin, Rukmini, Diananto Prihandoko, Masrur Alatas; Data curation, Masrur Alatas, Yeremias Yanuarius Sedik; Funding acquisition, Yeremias Yanuarius Sedik; Methodology, Diananto Prihandoko, Masrur Alatas, Yeremias Yanuarius Sedik, Visualization; Nasirudin, Rukmini; Writing–original draft, Rukmini, Diananto Prihandoko, Masrur Alatas; Writing–review & editing: Nasirudin, Rukmini, and Yeremias Yanuarius Sedik.

Funding
This research was independently funded by researchers.

Conflicts of Interest
No Conflicts of interest.

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