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Laboratory Liquid Waste Processing Effots Using Pineapple Skin Extract (Ananas Comosus (L) Merr.) To reduce Cuprum (Cu) Concentration

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Abstract

The Waste from chemistry practical activities is classified as Hazardous and Toxic Materials (B3). B3 waste must undergo processing because it can seep into the soil and potentially damage groundwater quality and health risks to the public. High levels of Copper (Cu) are toxic and accumulate in vital organs, affecting human health. The importance of wastewater treatment efforts in laboratories. Utilizing Cayenne pineapple peels as a waste treatment medium has economic value. Cayenne pineapple skin is high in potassium and acids, which can precipitate Cu. The aim of the research is to reduce the concentration of Cu in liquid waste using pineapple peel extract. Methods: Experimental research with Cuprum parameters using spectrophotometry and Total Plate Count (TPC). Results: Pineapple peel extract is capable of reducing copper levels (sig. 0,047;BF 44,75), meaning there is a difference in the addition of pineapple peel extract with copper levels. Extract 10% pineapple peel (30%). Extract 20% pineapple peel (5%-48%). Extract 30% pineapple peel (6%-29%). Extract 40% pineapple peel (74%). The addition of a 50% pineapple peel (20%-71%). The results of the pineapple skin extract's effect on the reduction of germ counts show a not significant difference in the laboratory wastewater samples.

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INTRODUCTION

The impact of declining water quality is influenced by the amount of waste and the characteristics of the waste. The use of chemicals has become commonplace in production activities or household, industrial, healthcare laboratory, and educational institution settings (Riyanto, 2014, p. 89). Educational institutions like universities that have chemistry laboratories also use chemicals as reactants or solvents in practical activities in the chemistry laboratory. The activity uses strong or weak acid-base chemicals and produces at least 1000 ml of liquid waste. Its waste is classified as hazardous and toxic materials (B3). Characteristics of hazardous waste (B3) are irritant, corrosive, and highly flammable (Nurulasyrof, et al., 2023, pp. 19-22). Usually, waste is stored in a simple liquid waste holding tank that consists of 1-3 containers made of brickwork that has been concreted, with a capacity of 250 liters, based on the principles of flocculation and clarification.

Hazardous waste (B3) should not be disposed of directly into the environment but must undergo a treatment process to reduce the levels of hazardous B3 substances so that it does not threaten the environment, especially the quality of groundwater in the surrounding area of the laboratory. B3 liquid waste can seep into the soil, potentially causing adverse effects on water quality due to groundwater contamination by B3 waste. Heavy metals contaminate water through processes of absorption, precipitation, and ion exchange. Groundwater contaminated with B3 waste can lead to ecosystem damage, decreased water quality, and disruption of the hydrological cycle, such as atmospheric damage and damage to water bodies. Heavy metals pose a potential risk to health and natural ecosystems through direct contact (contaminated soil) from drinking water that has been contaminated by these heavy metals (Eko Handayanto, 2017, pp. 1-4). Water pollutants (heavy metals, nitrogen, phosphorus, dissolved organic matter, etc.) can change the physical and chemical properties of water. As a result, it alters the organoleptic qualities of water, making it murky and smelly, and also affects the water content, which can lead to a decline in water quality (V Karthik, 2022, p. 13). High levels of copper can damage water pipes, leading to an increase in copper levels in the water. The community uses groundwater to meet daily needs, and if humans consume groundwater contaminated with hazardous waste from chemical laboratories, it can threaten public health. High levels of copper are toxic and accumulate in vital organs, which can affect human health (Prastiwi & Kuntjoro, 2022, pp. 405-411). The impact on public health is causing toxicity, health disturbances such as poisoning, dysentery, anemia, nausea, diarrhea, anemia, nerve damage, kidney damage, liver damage, depression, and even cancer as long-term effects (Astuti, et al., 2023, p. 39).

The disposal of waste that does not meet liquid waste quality standards requires proper treatment to avoid negative impacts on the environment (Rafi, 2023). The treatment of liquid waste aims to clarify, remove, or reduce toxic components and lower the concentration of substances that cannot be degraded in water (Nithiya Arumugam, 2018, p. 14). The waste processing can be done through physical, chemical, and biological methods. Physical waste processing requires a long time and a large space. Meanwhile, chemical waste processing needs to be minimized to reduce negative impacts on human health and the environment. Biological waste processing using natural materials is considered cheap and efficient (Yuliwati, 2020, pp. 6-8). The results of the compilation of hazardous waste reporting in Indonesia in 2024 come from 19,559 companies. The recap of hazardous waste in Indonesia in 2024 comes from 19,559 companies with waste production totaling 66,064,151 tons, of which 46,194,677 tons are further managed, while 19,959,473 tons of waste are only stored in temporary disposal facilities (TPS). Data on hazardous waste (B3) per sector shows that the infrastructure sector produces hazardous waste amounting to 183,249 tons, with 70,946 tons already managed and a residual hazardous waste of 112,302 tons stored only in temporary disposal sites TPS (Kehutanan, 2024). The observational data on December 12, 2023, the examination of the Copper (Cu) content in the liquid waste of the "X" University laboratory was 2.7494 mg/L or 2.7497 ppm, exceeding the quality standard set by the Minister

of Environment of the Republic of Indonesia Regulation Number 5 of 2022 concerning Liquid Waste Quality Standards, which is 2 mg/L for type I and 3 mg/L for type II (KemenLH, 2022). Waste processing can be done through physical, chemical, and biological methods. Physical processing requires a long time and a large space. Chemical processing needs to be minimized to reduce negative impacts on human health and the environment. Biological waste processing using natural materials is considered cheap and efficient (Yuliwati, 2020, pp. 6-8). Rice husk is utilized for the absorption of metal ions Cu and lead in laboratory wastewater (absorption of lead at 99.39% and absorption of Cu at 98.63%, with the optimum pH for Cu at ph 6 (Abdul Halim, 2021, p. 66). The Cobalt Ferrite (CoFe2O4) nanoparticle method is capable of reducing Cu levels by 99.70% at a temperature of 60°C (Femila Amor Nurdila, 2015, p. 23). Research using clay through adsorption can reduce the levels of Cu and Cr maximally at room temperature with rapid agitation for 15 minutes (10-30 minutes) (Giyatmi, 2008, p. 6)

In the last five years, Indonesia has been the world's third-largest exporter of pineapples. Pineapple is a tropical fruit that has economic value and is rich in benefits. The waste from pineapple skins in the industry amounts to 135 thousand tons annually. Considering the prospects for the demand for pineapples in both international and domestic markets, efforts are needed to utilize pineapple skins. Several studies have found that pineapple skin contains 81.72% water, 20.87% crude fiber, 17.53% carbohydrates, 4.41% protein, and 13.65% reducing sugars (Adi Prasetya Kusuma, 2019). The calcium content in lowland cayenne pineapple is 13.81 mg/100g, while highland queen pineapple has 4.13 mg/100g. Pineapple contains 47.8 mg of vitamin C. Furthermore, the yellow skin of the pineapple contains higher levels of the enzyme bromelain, ranging from 0.05-0.075%, as well as organic acids such as citric acid, aspartic acid, and chlorogenic acid. The potassium content in lowland pineapple is 115.59 mg/100g and in highland pineapple is 70.95 mg/100g (Reva Divantary, 2017). The sodium content in lowland pineapples is 4.63 mg/100g and in highland pineapples is 2.65 mg/100g (Lubis, 2020, p. 22). Cayenne pineapple skin contains higher levels of potassium and high acid content, which potentially precipitates copper based on the theory of blooming and ion exchange. Potassium can precipitate Cu in liquid waste through complex formation. (Phongthon saengchut, 2024)

Researchers feel the need to use cayenne pineapple skin (which contains high potassium and acids) as an extract to reduce copper levels in laboratory wastewater based on the principle of ion exchange theory.

METHOD

This research is a Quasi-Experiment Design using a Nonequivalent Control Group Design with Two Experimental Groups. The sampling technique of this research is purposive. The sample population in this study consists of 2, namely the liquid waste from the laboratory of institution "X" and institution "Y". The population is divided into 2 groups, namely the experimental group and the control group, which are taken non-randomly. The experimental group consists of 2 units from the laboratory waste groups of institutions “X” and “Y”. The second group serves as the control group using raw cuprum water with a concentration of 3 ppm. The raw water used as a control employs CuSO4 (p.a.) chemicals that are measured carefully to ensure a concentration of exactly 3 ppm and can be used as a control in this study. The experimental group and the control group underwent an initial test (pre-test), followed by the addition of pineapple peel extract as treatment, and were measured for the post-test results. The difference between the pre-test and post-test is used as an analysis guide. This study uses 5 types of treatments, namely the addition of 10%, 20%, 30%, 40%, and 50% pineapple peel extract with 3 replications. The measurement of cuprum levels was analyzed to determine the effectiveness of pineapple peel extract using colorimetric methods with a spectrophotometer, evaluated in parts per million (ppm).

From the observations obtained, it will be followed up with TPC to determine whether pineapple skin extract is also effective in reducing germs in waste. Data analysis in this study uses

descriptive analysis (understanding the distribution and characteristics of the research data). Wastewater samples planted on Nutrient Agar plates, and then the growth of bacteria is calculated, which will be used as a benchmark for the results of the TPC test.

The research results showed that the data were not normally distributed (p-value <0.05). Therefore, a non-parametric test, namely the Kruskal Wallis test, was performed. The Kruskal Wallis test results showed a significance value of 0 < 0.05, it is concluded that there is no relationship between the addition of pineapple peel extract and the number of bacteria in wastewater.

RESULTS AND DISCUSSIONS

Relationship of Copper Concentration Measurement

Based on the research results regarding the addition of pineapple peel extract to wastewater to determine its effectiveness in reducing copper levels, the pretest results from the measurements of 2 experimental groups (X and Y) and 1 control group (raw water CuSO4 3 ppm) showed that the copper content in the laboratory chemical wastewater "X" was 3.645 ppm and "Y" was 2.812 ppm, while the copper level in the control group was 3 ppm. The research continued with experimental trials of adding pineapple peel extract at concentrations of 10%, 20%, 30%, 40%, and 50% with 3 replications, resulting in 30 samples. The results of this experimental trial are on table 1.

From the laboratory test results, it can be seen that the control group experienced a decrease in cuprum levels with the addition of 10% pineapple skin extract, from 3 ppm to 1.470 ppm. The dissolution of cuprum derived from pure CuSO4 is quite difficult because pure materials have higher stability compared to cuprum formed from naturally occurring reaction processes (Cao, et al., 2019). The Cu2+ ions strongly bind to water molecules, requiring a strong reductant and an electrode standard potential of approximately ±0.34 volts (Galván-García, et al., 2017). The precipitation of Cu2+ ions is also influenced by acidic pH conditions and reactions with sulfide (S2-) (Persson, et al., 2020). Copper in its pure form has stable resistance and is difficult to decompose (M. Vázquez Vázquez, 2023). herefore, the diluted extract of pineapple peel may have less strong ability to break down copper in the control of raw water.

In the experimental group, samples X and Y showed a decrease in cuprum levels with the addition of 10% pineapple skin extract. A significant decrease in cuprum levels in the experimental group was observed with the addition of 40% pineapple skin extract, which measured 0.940 (sample X) and 0.722 (sample Y). The determination of the normalization test results was conducted using the Shapiro-Wilk test (significance value p>0.05), concluding that the data is normally distributed, allowing for the continuation with ANOVA testing.

Table 1. Result of Pretest and Postest

Sampel	Kadar Cuprum (ppm)					
	Pretest	EKN 10%	EKN 20%	EKN 30%	EKN 40%	EKN 50%
Kontrol	3,000	1,470	2,940	4,774	4,855	3,081
Sampel X	3,645	2,543	3,432	3,419	0,940	1,038
Sampel Y	2,812	1,944	1,449	2,974	0,722	2,239
Minimal	2,812	1,470	1,449	2,974	0,940	1,038
Maksimal	3,645	2,543	3,432	4,774	4,855	3,081
Rata-rata	3,178	1,993	2,552	3,773	2,414	2,099
SD	0,384	0,481	0,909	0,826	1,959	0,917
CL 95%	0,403	0,504	0,954	0,866	2,056	0,962

Table 2. Result of Anova Test

	Sum of square	df	Mean Square	F	sig
Between Groups	8,315	5	1,663	2,447	0,047
Within Group	32,618	48	0,680		
Total	40,932	53			

The ANOVA test yielded a significance value of 0.047, resulting in a p-value < 0.05. A Post-hoc test was conducted, but the results were not able to detect which group experienced a significant decrease in cuprum levels. To confirm the hypothesis, a Bayesian Test was performed with a Bayes Factor (BF) of 44.75, indicating that there is a difference in the addition of pineapple peel extract with cuprum levels.

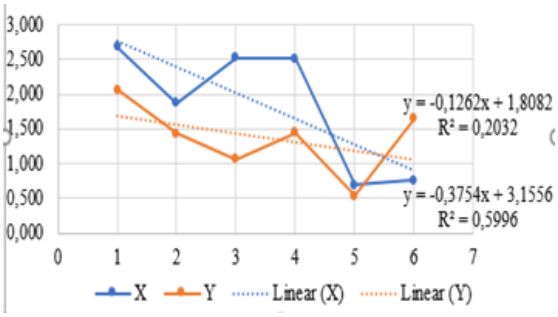


Figure 1. Curve of Copper Concentration Effect

The coefficient values for samples X and Y are both positive in the square regression values, indicating a direct relationship of 0.5996 (sample X) and 0.2032 (sample Y). A 10% pineapple skin extract is quite effective in reducing the cuprum content by 30%. A 20% pineapple skin extract is quite effective in reducing the cuprum content by 5%-48%. A 30% pineapple skin extract can reduce cuprum content by 6%-29%. A 40% pineapple skin extract can reduce cuprum content by 74%). The addition of a 50% pineapple skin extract can reduce cuprum content by 20%-71%. Therefore, it can be concluded that the addition of pineapple skin extract with a minimum concentration of 10% is already capable of reducing cuprum content in laboratory wastewater samples.

2. Relationship of Microbial Count Measurement

The data analysis showed a decrease in the number of bacteria from an average of 18.356 in the pretest to 2.50 in the posttest, indicating a difference in the average number of bacteria between the pre-test and post-test. To test this difference, a Paired T-Test was conducted with a significance value (2-tailed) of 0.003 < 0.05, thus H0 is rejected and H1 is accepted. It can be concluded that there is a difference in the average results between the pre-test and post-test concerning the number of bacteria after the addition of pineapple skin extract.

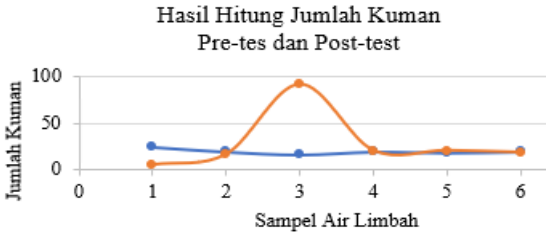


Figure 2. Results of Bacterial Count

The correlation test of pre-test and post-test variables showed a correlation coefficient of 0.058 with a significance value of 0.821. Since the significance value of 0.821 is greater than the probability of 0.05, it can be concluded that the number of bacteria after the addition of pineapple peel extract does not correlate directly with the number of bacteria at the pre-test stage.

Table 3. Results of Kruskal Wallis

	Jumlah Kuman
Kruskal-Wallis H	2.228
df	5
Asymp. Sig.	.817

a. Kruskal Wallis Test

b. Grouping Variable: Konsetrasi Ekstrak Kulit Nanas

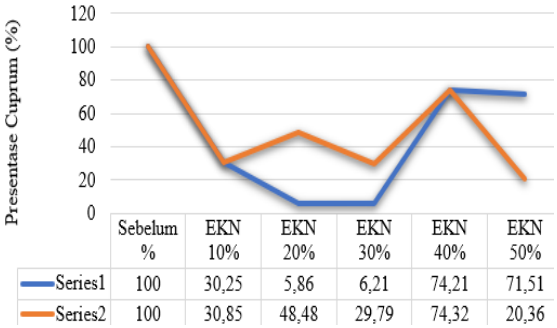
From this Kruskal Wallis test, it can be concluded that there was no significant difference between the average bacterial counts between the pre- and post-tests. This means that the addition of pineapple peel extract did not affect the bacterial count.

From the analysis and reference study, it was found that this research can be influenced by the characteristics of the laboratory wastewater sample, pH, temperature, and time. The characteristics of the wastewater can be affected by pH (particularly influencing the efficiency of heavy metals), temperature, composition, or the amount of compounds present in the wastewater (Phongthon Saengchut, 2024). In wastewater with a pH higher than 8, the efficiency in removing copper levels is slightly higher (Mohamed Charif Benalia, 2022). Copper that

comes from pure form has stable resistance and is difficult to decompose (M. Vázquez Vázquez, 2023). As a result of the relatively stable nature of cuprum at pH 7, while at acidic pH (less than 7) cuprum begins to bind, leading to a decrease in cuprum levels, it is better to incubate it with a contact time of 120 minutes (Syazana Sulaiman, 2021). The Cu2+ ion binds water molecules strongly, requiring a strong reducer and an electrode standard potential of ±0.34 volts (Galván García, et al., 2017). The precipitation of Cu2+ ions is also influenced by acidic pH conditions and reactions with sulfide (S2-) (Persson, et al., 2020). Factors that hinder the decrease of cuprum levels in laboratory wastewater can also be influenced by the order of heavy metal removal, which can be optimized in the following sequence: Ag > Fe > Hg > Cu > Cr > Zn > Mn > Pb (Dhenkula, et al., 2025).

The data from the diagram above shows that in the sample of waste X treated with pineapple peel extract, there is generally a decrease in copper content, although the results of the decrease are fluctuating, inconsistent, or uncertain (Xin-Hua Lu, 2014). Fluctuating results can also be influenced by changes in flavonoids (Minal Mhatre, 2009). In the combination reaction between the neutralization principle and the coagulation-flocculation principle (Alum ~330-350 mg/L + Cationic Polyelectrolyte ~1.5-3 mg/L) has the potential to remove heavy metals from wastewater (Dhenkula, et al., 2025).

In the addition of pineapple peel extract to the waste sample, there is a contact time where copper will react with the adsorbent, so the longer the contact time, the easier it is for copper to bind. Conversely, the shorter the contact time, the adsorption process between copper and the adsorbent will not be optimal, leading to a lack of significant reduction in copper levels (Seleman, et al., 2023). Pineapple peel extract used as an absorbent solution is a natural material that may have limited adsorption capability to reduce cuprum levels in waste samples (Hu, et al., 2011). The wastewater sample comes from a chemical laboratory where the copper content may originate from pure chemicals or from reactions between various chemical reagents that create complex reactions, making it difficult to be maximally absorbed by pineapple skin extracts. Environmental factors that influence the copper concentration results include temperature, light intensity, and the presence of other contaminants that can also hinder the reduction of copper levels, as well as the dosage of the biosorbent and the method of intra-particle diffusion (Hanan Sayahi, 2022). The results of the measurement of the percentage decrease in cuprum levels in laboratory wastewater are calculated from the reduction of cuprum levels before the addition of pineapple peel extract with the cuprum levels after the addition of pineapple peel extract divided by the cuprum levels before. The results will be reported in percentage form.



	Sebelum %	EKN 10%	EKN 20%	EKN 30%	EKN 40%	EKN 50%
Series1	100	30,25	5,86	6,21	74,21	71,51
Series2	100	30,85	48,48	29,79	74,32	20,36

Figure 3. Decrease in Copper Levels

The results of the percentage reduction in cuprum levels in the wastewater from laboratories X and Y show that the addition of 10% pineapple peel extract alone was able to reduce the cuprum level by 30% in the laboratory wastewater. With the addition of 40% pineapple peel extract, the reduction in cuprum level was 74%. Meanwhile, with the addition of 20%, 30%, and 50% pineapple peel extract, the percentage reduction in cuprum levels was between 5% - 71% The differing reductions between samples X and Y may be influenced by the characteristics of the laboratory wastewater itself. The characteristics of wastewater can be affected by pH (specifically influencing the efficiency of heavy metals), temperature, and the composition or quantity of compounds present in the wastewater (Phongthon Saengchut, 2024).

Research that has been conducted states that pineapple peel contains high levels of antioxidants and also has antimicrobial properties that can kill germs due to the presence of the enzyme bromelain (Bienvenu Gael Fouda-

Mbanga, 2022). Biochar derived from plant residues or agricultural waste can serve as an effective surface adsorbent in treating mixed waste, but its capacity needs to be evaluated (Chen, et al., 2011). From this reference, the researchers are interested in applying pineapple peel extract as a material to reduce copper and the number of microorganisms in laboratory wastewater. The isoelectric point property of Cu2O is optimal at a water pH of ~5, and at pH 7, it will form CuI-O- which can damage the lipid and peptidoglycan structures in bacteria. However, previous studies found no antibacterial activity from water containing copper at pH levels higher than 7 (Bezza, et al., 2020). It can be influenced by the effects of pH and the duration of laboratory testing, where the waiting time allows the carbohydrates contained in the pineapple peel extract to decompose by bacteria, causing gas formation, and the pH environment becomes alkaline, which allows the number of microbes to increase.

CONCLUSION

The treatment of laboratory wastewater is often overlooked and does not receive special attention. Hazardous laboratory wastewater must be processed before being disposed of in the environment. If not treated, it can contaminate groundwater, damage ecosystems, and pose health risks to humans. This research utilized pineapple peel as a material for the treatment of laboratory wastewater. From this research, it was found that laboratory wastewater contains copper levels that exceed the standard quality limits. Therefore, efforts are needed to treat laboratory wastewater to ensure its content meets the standard quality limits. The results of the study indicated that the pineapple peel extract was capable of reducing copper levels and showed a significant average difference between the pre-test and post-test results regarding the amount of bacteria in the laboratory wastewater samples. Biochar derived from plant residues or agricultural waste can serve as an effective surface adsorbent in treating mixed waste, but its effectiveness needs to be evaluated (Chen, et al., 2011).

The research results show that pineapple peel extract can reduce cuprum levels, with an ANOVA test result showing a significance value of 0.047 ($p<0.05$). This means that there is a significant difference in the group (H0 is rejected). To strengthen this assumption, a Post-Hoc test was conducted (with a significance value > 0.05), indicating that this Post-Hoc test could not demonstrate the overall differences between groups due to a small sample size, making it less detectable. Subsequently, a Regression ANOVA test was carried out to evaluate overall data and compare the variance between groups. The Regression ANOVA test yielded a significance value of 0.047 ($p<0.05$), indicating that there is indeed a variance difference between the data groups.

To clarify whether pineapple peel extract can reduce the cuprum levels in wastewater, a Bayesian test was necessary. The Bayesian test was conducted to decide whether to accept or reject the hypothesis. The results of the Bayesian test in this study obtained a Bayes Factor (BF) value of 44.75, meaning the BF value strongly supports H1, leading to the conclusion that there is a difference in the addition of pineapple peel extract concerning cuprum levels. A 10% concentration of pineapple peel extract is quite effective in reducing cuprum levels by 30% (with a very strong correlation value of 0.782). A 20% concentration of pineapple peel extract is effective in reducing cuprum levels by 5%-48%. A 30% concentration of pineapple peel extract can reduce cuprum levels by 6%-29%. A 40% concentration can reduce cuprum levels by 74%. Adding a 50% concentration of pineapple peel extract can reduce cuprum levels by 20%-71%. It can be concluded that the addition of pineapple peel extract, with a minimum concentration of 10%, is already capable of reducing cuprum levels in laboratory wastewater samples.

The research results indicate that pineapple peel extract could not reduce the number of bacteria in laboratory wastewater samples. The analysis data showed a decrease in the average number of bacteria from a pretest value of 18.356 to 2.50 in the posttest. This implies that there is a difference in the average number of bacteria between the pretest and posttest. To test the

difference in the addition of pineapple peel extract to laboratory wastewater, a Kruskal Wallis test was conducted which produced a significance value of 0.817 > 0.05, so that H0 was accepted and H1 was rejected. It can be concluded that there was no significant difference between the average pre-test and post-test results regarding the number of bacteria.

This study is distinct from others as many previous investigations employ electric waves to lower copper levels in lab wastewater by using the electrode to reduce metal ions. Investigations employing a straightforward filtration technique have attracted attention from numerous researchers to lower copper concentrations. Investigations utilizing natural jackfruit seed waste via Biochar activation can effectively decrease metal ions in wastewater. Studies employing natural banana peels have also been conducted to decrease copper levels in wastewater. Studies employing coconut lignin absorbents for the treatment of liquid waste. Numerous studies utilize natural materials since they are cost-effective and do not inflict additional damage to the environment and ecosystem

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