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ANALYSIS AND POTENTIAL THE ECO-ENZYME OF SEVERAL TYPES OF FRUIT PEELS IN LEACHATE REMEDIATION

Analisis dan Potensi Ekoenzim dari Beberapa Jenis Kulit Buah dalam Remediasi Air Lindi

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ABSTRACT

This research aims to determine the potential of ecoenzymes from several types of fruit peel in the process of reducing TDS levels of COD, BOD, ammonium and phosphate as well as the number of bacterial colonies in leachate water. So the research involved activities to make ecoenzymes from 4 types of fruit peel, namely banana, dragon fruit, pineapple and orange. Next, the ecoenzyme results were applied to leachate water to test its remediation potential in a ratio of 1:2 (10% ecoenzyme). This research uses a descriptive method, which uses parameters namely TDS, COD, BOD, phosphate, ammonium, and counting bacterial colonies. The results show that ecoenzymes have the potential to remediate leachate waste during five days of incubation, where it can be seen that ecoenzymes can reduce ammonium and phosphate levels but not BOD and COD. From the results, the average reduction in ammonia levels was higher for ecoenzymes from banana peel and pineapple fruit with an average value (mg/l) of P1=14.6; P2=0.55; P3=1.44; P4=0.675 and P5=2.44 (P1: Leachate; P2: Leachate + banana peel ecoenzyme; P3: Leachate + Dragon Fruit peel ecoenzyme; P4: Leachate + Pineapple Peel; P5: Leachate + Fruit peel Orange). Meanwhile, the highest reduction in phosphate was found in remediation using ecoenzymes from orange peel where the average value was P5=3.05 < P1=8.2. The results of ecoenzyme remediation from four types of fruit peel only have the potential to reduce ammonia levels, and likewise the reduction in phosphate occurs after adding orange peel ecoenzymes.

***Keywords**: Organic Matters; Eco enzyme; Leachate; Chemical Compounds.*

ABSTRAK

Penelitian ini bertujuan untuk mengetahui potensi ekoenzim dari beberapa jenis kulit buah dalam proses menurunkan kadar TDS COD, BOD, Amonium, dan fosfat serta jumlah koloni bakteri pada air lindi. Maka penelitian mlibatkan kegiatan pembuatan ekoenzim dari 4 jenis kulit buah yaitu pisang, buah naga, nenas dan jeruk. Selanjutnya hasil ekoenzim diaplikasikan ke dalam air Lindi untuk di uji potensi remediasinya dengan perbandingan 1:2 (ekonenzim 10%). Penelitian ini menggunakan metode deskriptif, dimana menggunakan parameter yaitu TDS, COD, BOD, fosfat, amonium, dan penghitungan koloni bakteri. Hasil menunjukkan bahwa ekoenzim memiliki potensi dalam meremediasi limbah air lindi selama lima hari inkubasi, dimana dapat dilihat bahwa ekoenzyme dapat menurunkan kadar amonium dan fosfat tetapi tidak pada BOD dan COD. Dari hasil rata-rata penurunan kadar amonia lebih tinggi adalah ekoenzim dari kulit buah

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pisang dan buah nenas dengan nilai rata-rata (mg/l) yaitu P1=14,6; P2=0,55; P3=1,44; P4=0,675 dan P5=2,44 (P1: Air lindi; P2: Air Lindi + ekoenzim kulit pisang; P3: Air Lindi + Ekoenzim kulit Buah Naga; P4: Air Lindi + Kulit Buah Nenas; P5: Air Lindi + Kulit buah Jeruk). Sedangkan penurunan fosfat paling tinggi terdapat pada remediasi menggunakan ekoenzim dari kulit buah jeruk dimana nilai rata-rata yaitu P5=3,05 < P1=8,2. Pada hasil remediasi ekoenzim dari empat jenis kulit buah hanya berpotensi dalam penurunan kadar amonia, dan begitu juga pada penurunan fosfat terjadi setelah penambahan ekoenzim kulit buah jeruk.

Kata Kunci: Materi Organik, Ekoenzim, Air Lindi, Komponen Kimia.

INTRODUCTION

In line with economic development and increasing living standards of the population in Indonesia, based on data from the National Waste Management Information System (SIPSN) of the Ministry of Environment and Forestry (KLHK) in 2022, 202 regencies/cities in Indonesia reported that the rate of increase in the number of national waste piles reached the figure 21.1 million tons, of which if we look at the total production, 65.71% (13.9 million tons) can be managed well, while the remaining 34.29% (7.2 million tons) cannot be managed. So if this is left for too long it will have an impact on the environment. One of them is the emergence of seepage water from waste heaps which contain high amounts of inorganic and organic components and can cause pollution to the air and soil, and this seepage water is called leachate. Pollution caused by leachate often causes a foul odor and the presence of pathogens. Naturally, leachate can undergo bioremediation (recovery) by itself because it contains a number of microorganisms which act as decomposers. The decomposer will break down complex organic materials into simpler ones so as to reduce the negative effects caused by leachate. However, often the amount of leachate input produced is greater and is not commensurate with the speed of the decomposer in breaking down the organic material. So the composition of leachate contains compounds that are toxic to the air and soil environmental ecosystem.

Some chemical compounds found in water include ammonia (NH3) and phosphate (PO4). Ammonia is a compound of organic substances produced from microbiological oxidation originating from industrial and household waste. In general, the concentration of ammonia in wastewater is in the range of small amounts up to 30 mg/l. Based on quality requirements, the ammonia concentration must be below 0.5 mg/l in river water and 0 in drinking water, but if it exceeds it, it indicates pollution (Youcai, 2018). Apart from ammonia, phosphate is also a chemical compound that occurs in nature in dissolved and insoluble form. In domestic waste generally there is phosphate in the form of polyphosphate and dissolved phosphate. According to (Karunanithi et al., 2016), domestic waste is relatively rich in phosphate. In general, P can cause pollution of aquatic ecosystems.

Proper waste management will be able to produce new products that are more valuable than before. One of them is that the use of eco-enzymes in bioremediation is more profitable compared to synthetic chemicals or specially produced enzymes because it does not require experienced experts and sophisticated infrastructure. In bioremediation with eco-enzymes no new biomass is produced which can often cause new problems too. Through the bioremediation process, it's hoped that leachate water will experience a reduction in pollution levels to become more stable and acceptable to the surrounding ecosystem (Youcai, 2018).

Subtantial of chemical components such as enzymes, organic acids and secondary metabolites dissolved in eco-enzyme solutions due to the process of decomposing organic waste by microorganisms makes it possible to have many positive effects not only for agriculture but can also be used as therapeutic treatment and remediation agents. For example the researces of *Galantin et all 2021* that the treatment process showed the enzyme solution

(10 %) was found more potent and economical in treating aquaculture sludge in which resulted in a reduction of 89 % of Total Suspended Solid, 78 % of Volatile Suspended Solid, 88 % of Chemical Oxygen Demand, 94 % of Total Ammonia Nitrogen and 97 % of Total Phosphorus. The eco enzyme material in previous research was still a mixture of several types of waste from vegetables and fruit, while there was no material with one type of fruit peel waste. Eco enzyme produced from the study has effectively acted as an environmentally friendly solution to reduce the composition of food waste in solid waste generation and has the potential to be applied in the wastewater industry. Enzymes include proteins that act as biocatalysts (accelerate) chemical reactions, precipitate and transform the chemical composition of pollutants into new and harmless products (Doukani, 2015). While the organic acid content is able to kill and destroy pathogens (Rasit et al., 2019). The chemical content of eco-enzymes can be different due to the composition of different raw materials. Some of the uses of eco-enzymes that have been reported, for example, can be used as a floor cleaner, disinfectant, biofertilizer, insecticide, antibacterial (Vama & Cherekar, 2020) and for environmental restoration (Rasit et al., 2019 ; Tang & Tong, 2011; Janarthanan et al., 2020; Galintin et al., 2021). So are other research has shown the benefits of ecoenzymes from orange and pineapple peels as detergent LAS remediation agents with the ability to reduce up to 41% (Gaspersz et all, 2022). So in this research, it is necessary to analyze the extraction of several fruit skins. The fruit peels used in this research were banana peels, dragon fruit peels, pineapple peels and orange peels. These four types of fruit peel are organic waste which is often thrown away and not reused into new products. Apart from that, the four types of fruit skin are sourced from types of fruit that still contain a lot of water and carbohydrate sources so that they meet the criteria for types of fruit that can be fermented using eco-enzyme technology.

A number of research results, it's known that the remediation process with eco-enzymes has not yet obtained maximum results. Water quality parameters such as Chemical Oxygen Demain (COD) and Biological Oxygen Demain (BOD) in wastewater remediated with eco-enzymes are still high and do not meet water suitability standards. This is due to the eco-enzyme solution contains BOD and COD values are also high. Furthermore, each type of fruit peel be fathomed contains a number of different chemical ingredients. The chemical content of eco-enzymes can be different due to the composition of different raw materials. So comprehensive data is needed regarding the chemical content of a particular eco-enzyme, it's necessary This regard to analyze the extraction of several fruit peel. The fruit peels used in this research are fruit peels that are known to have physical differences, namely banana peels, dragon fruit peels, pineapple peels and orange peels. Apart from that, it is known that wastewater treatment with ecoenzymes is very low cost compared to conventional wastewater treatment because organic waste is available in large quantities and Molasses or brown sugar is easy to get at a cheap price (Verma *et al,* 2019).

Apart from focusing on analyzing the physical values of the ecoenzymes used, this research was also carried out to determine changes in the values of physical-chemical factors during the leachate remediation process in the form of COD, BOD, TDS, Phosphorus levels and Ammonia levels. Meanwhile, biological factors are carried out by isolating microbes to determine variations in number and type during the remediation period. By obtaining complete data regarding the leachate remediation process using several types of ecoenzyme solutions, the differences, potential and opportunities arising from this research will be known.

MATERIALS AND METHODS

This research was carried out from January to June 2023, at the Wahdatul Ulum Integrated Laboratory, North Sumatra State Islamic University. This research activity includes making ecoenzymes from banana peels, dragon fruit, pineapples and oranges, which requires a long manufacturing process of 3 months (90 days). The materials used in the process of making this ecoenzyme are a glass container with a plastic lid, water, sugar and lectures from the four

types of fruit that have been mentioned. After that, chemical compounds were checked at UINSU Integrated Chemistry using Gas chromatography–mass spectrometry (GCMS). Next, the remediation process is carried out by adding an ecoenzyme solution to the waste leachate in a ratio of 1:2 for 10% ecoenzyme solution and leachate water. Remediation was carried out in a plastic-covered container and observed during day 1, day 3 and day 5. Then bacterial colony counting was carried out at the UINSU Integrated Microbiology Lab, colony counting using NA media with a dilution of 10-10. Calculations were carried out to see the effect of Eco-Enzyme on bacterial growth in leachate after an incubation period of 5 days. Next, TDS, COD, BOD, Ammonia and Phosphate were examined at the Class One Medan Balai Teknik Kesehatan Lingkungan dan Pengendalian Penyakit (BTKLPP).

RESULTS AND DISCUSSION

Eco enzyme Solution

Result of eco-enzyme fermentation of from banana, dragon, pineapple and orange peels produce different surface (Figure 1). The formation of this layer is due to the method used in this fermentation which is a slow method in a liquid medium which is only allowed to sit (without regular stirring) so that a film layer forms on the top surface (Hidayat, et al., 2000). This layer is formed from aerobic microbial activity at the top of the surface. The film layers in these four types of fruit peel fermentation have different thicknesses and textures. In the fermentation of banana and dragon fruit peels, it forms a thicker layer, while in the fermentation of pineapple and orange peels it produces a white powder-like layer on the surface of the solution.

The thick layer on the top surface of the fermentation (figures 1.a and 1.b) is a mass of cellulose that comes from the skin of fruit that is high in fiber such as banana peel and dragon fruit. The mass of cellulose arises from the ability of bacteria to form cellulose. In research by Nur'aini and Sari (2016), it was discovered that dragon fruit skin can produce layers of nata after fermentation with the addition of acid bacteria and a variety of sugars. Similarly, with the fermentation of banana peels carried out in Panjaitan and Sitompul's (2024) research, it is known that the longer the fermentation time, the greater the mass of bacterial cellulose.

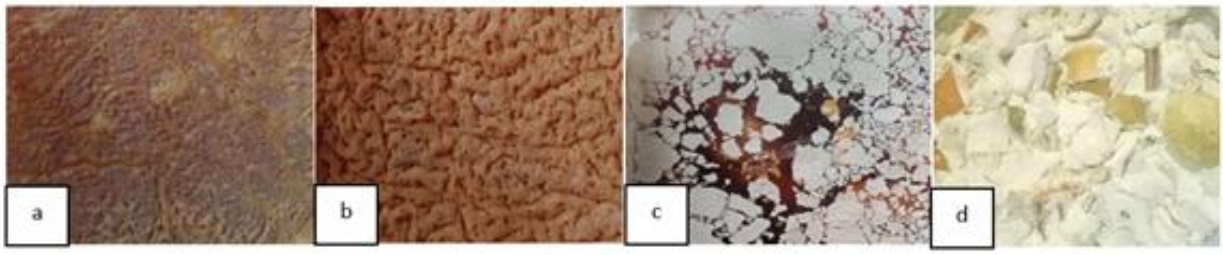

Figure 1. Surface texture of fermentation results for each fruit skin: a. Banana Peel; b. Dragon Fruit Skin; c. Pineapple Skin and; d. Orange Peel.

The formation of the white layer is thought to be from the Yeast group of fungi, namely fungi that produce vitamin B complex and vitamin C. Meanwhile, solutions that contain lots of enzymes are brown colored solutions. This enzyme solution can't expiretion. The longer it is stored, the stronger the enzyme will be. Enzymes perform better when water is added (Nazim, 2013). As in previous research, during the eco-enzyme fermentation process, a layer of white fungus also appeared and there was also a slightly yellowish color called Pitera, the appearance of the fungal layer in the fermentation solution is natural. This pitera fungus appears due to the fermentation process that occurs in the ecoenzyme solution. This mushroom has benefits for skin beauty because it is a rich source of amino acids, peptides, proteins, carbohydrates, organic acids and many other micronutrients such as vitamins and minerals (Titiaryanti, 2022).

Previous research also (Natasya et al, 2023) stated that fungi are more abundant in eco-enzymes whose organic material comes from pineapple flesh. The reason is, pineapple flesh contains more water than pineapple skin, thus supporting the emergence of more fungi in the eco-enzyme. Apart from that, conditions with high water content in organic materials are the right conditions for the growth of spores in fungi because fungi grow well in damp places (Amalia, 2013). Based on the explanation above, it can be said that there are differences in the eco-enzymes produced based on the type of plant used as organic material in making eco-enzymes. The evidence is that the fungus on the surface of the ecoenzymes of pineapple skin looks thinner compared to the skin of bananas, dragon fruit and oranges.

Figure 2. Solution of Ecoenzyme. the end results of the ecoenzyme solution in sequence (left to right) are the ecoenzymes of banana peel, dragon fruit peel, orange peel and pineapple peel.

The appearance of the fermentation surface on these four types of fruit skin does not directly affect the results of leachate remediation because the ecoenzymes used are the result of filtration which separates the liquid part from the solid part. The cellulose mass and fungal colonies floating on the surface of the solution will be separated and not used for leachate remediation. The liquid part (ecoenzyme solution) is used as a liquid waste remediation agent because the liquid form of the substance is more appropriate for remediating waste in liquid form as well. Meanwhile, ecoenzyme dregs are not used to remediate liquid waste because they still contain a lot of biomass and have the potential to hamper the remediation process.

However, of course, several types of microbes involved in the fermentation of these four types of fruit will produce different metabolites because each microbe has different enzymes. These enzymes have a very important role in converting substrates into certain products according to the metabolic pathways followed during the fermentation process (Istianah, et al., 2018).

In this research, four types of eco-enzymes were produced, namely banana peel eco-enzymes, dragon fruit peel, pineapple peel and orange peel (Figure 2). During the incubation period of the eco-enzyme solution, ozone and oxygen will be produced ie equivalent to that produced by 10 trees (Yuliana, 2022). Orange peel eco-enzymes tend to have a lighter solution color (orange yellow) than other types of eco-enzymes. The smell produced also varies depending on the basic ingredients it is made from. The smell produced also varies according to the basic ingredients it is made from and is more dominant with a pungent fresh sour smell. The pleasant smell of ecoenzymes is because the organic materials used are fresh and vice versa, resulting in little growth of microorganisms which produce lactic acid (Destyana et al, 2020). The four types of ecoenzymes are obtained through a filtering process. According to Viza 2022 research, the color change is caused by the fermentation process and depends on combination of organic materials used.

Leachate remediation

Measurement of Total Dissolved Suspended (TDS), Chemical Oxygen Demain (COD), Biological Oxygen Demain (BOD), Ammonia and Phosphate in treatments P1, P2, P3, P4 and P5.

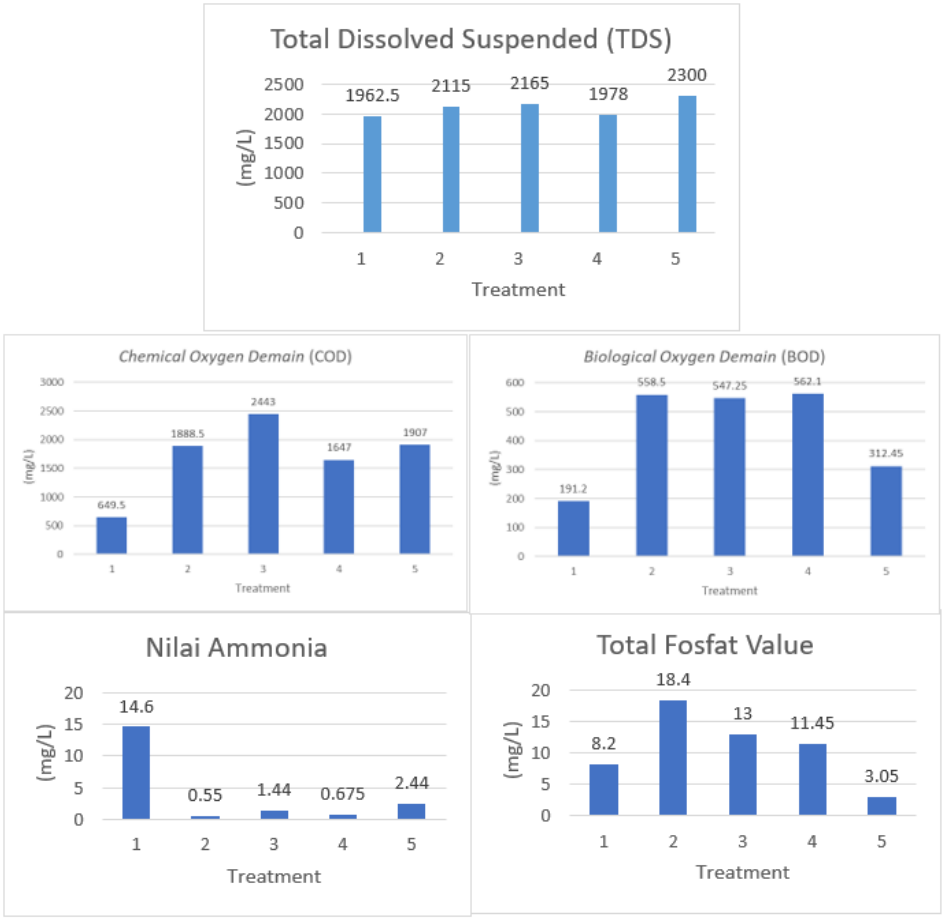

Figure 3. Results of changes in physical-chemical factor values (COD, BOD, TDS, Phosphorus levels, and Ammonia levels)

Reduction ammonia and phosphate (P5) levels can occur due to biological decomposition activities, while an increase in COD and BOD levels occurs due to changes in different sources of pollution as well as the addition of organic materials or other pollutants which worsen water quality. The BOD and COD values are high in the remediation results because the ecoenzyme solution still contains a lot of organic material originating from fruit peel waste and molasses sugar. According to Gaspersz & Fitrihidajati, (2022), a high BOD value indicates that there is also a lot of biodegradable organic substance residue. However, the high concentration of the enzyme solution can actually reduce the ammonia and phosphate values significantly (figure 3). Similar results were also found in research conducted by Tang & Tong, (2011) who found that an enzyme solution concentration of 9% was considered better for remediating wastewater because it could reduce the BOD5 value compared to an enzyme solution concentration of 25%-75%.

Reduction of Ammonia values can also be explained in (Wignyanto, 2020) who explains that organic compounds during wastewater treatment act as energy for microbial growth. The organic materials in waste water will be broken down into their constituent compounds, so that the contaminants which are generally in the form of organic materials will also be broken down into their constituent compounds, ultimately the levels of contaminants will decrease over time (Wignyanto, 2020). So that lower levels of ammonia were obtained in the treatment that added ecoenzymes compared to the control treatment. Reciprocally the GCMS

analysis test, it is known that dragon fruit peel ecoenzymes contain more organic compound components than the other three types of ecoenzymes. Some of the chemical compounds contained in the four types of ecoenzymes include β-carotene, naphthalene, estragole, azulene, indane, propylene glycol, cyclohexane.

Comparison of phosphate values shows that P5 treatment is able to reduce phosphate levels followed by P1 treatment as second place. Treatment P5 is a leachate treatment with orange ecoenzymes added. Compared to treatments that added other ecoenzymes, P5 treatment showed significant results in reducing phosphate levels. If to show attention to the results of the GCMS test analysis, there are compounds in the form of organic acids that belong to orange ecoenzymes, namely isopropyl phenylacetic acid, thioacetic acid, pyridineethane sulfonate acid. It is suspected that the chemical compound components in ecoenzymes can be a differentiator in the results of reducing the value of phosphate. Reciprocally the GCMS analysis test, it is known that dragon fruit peel ecoenzymes contain more organic compound components than the other three types of ecoenzymes. Some of the chemical compounds contained in the four types of ecoenzymes include β-carotene, naphthalene, estragole, azulene, indane, propylene glycol, cyclohexane.

In Rasit et al (2019) it was explained that the decrease in phosphate values occurred due to the presence of PAOs (Polyphosphate Accumulating Organisms) which form polyphosphates. During the process, acetate ions from ecoenzymes are used as a carbon source which will form polyhydroxyalkanoates (PHAs). PHAs provide energy for PAOs to bind Phosphorus thereby reducing levels from remediated wastewater.

The greated reductions in phosphate values in research conducted by Rasit et al.,(2019) also occurred in remediation using orange eco-enzymes compared to tomato ecoenzymes. Citrus eco-enzymes were better at reducing treatment parameter values than tomato eco-enzymes. This is because the organic acids in orange eco-enzymes are higher than tomato eco-enzymes.

The remediation process by ecoenzyme solutions can also be caused by the presence of citric acid and other amino acids contained in the fruit skin. These chemical compounds convert carbohydrates, fats and proteins into carbon dioxide and water to produce a form of usable energy. Organic acids help break down organic materials into biogas and water (Nazim, 2013).

Bacterial Colony Counting

The results of Total Plate Count are one of the parameters tested to see the effect of eco-enzymes on the growth of bacteria that degrade organic compounds contained in eco-enzymes and leachate waste. The results show that there are differences in numbers and differences in characteristics (Figure 4). This occurs due to the different basic organic waste materials used.

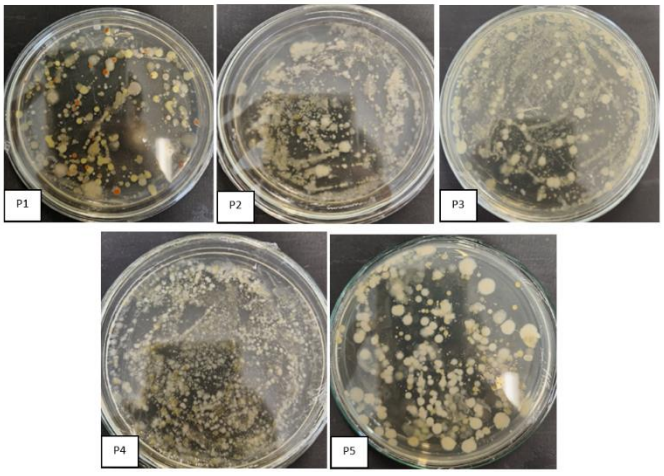

Figure 4. Total Plate Count results of bacterial isolates from treatment results for 5 days (P1; P2; P3; P4; P5)

Ecoenzymes that come from different organic materials have different types of microbes, namely bacteria and fungi (Ervinta et al., 2020). One of them is lactic acid bacteria which can be found in various fermented products such as durian, pineapple, soursop, cacao, bananas and oranges (Ismail et al., 2017).

The results of the treathed, the bacteria obtained did not only come from eco-enzymes but emerged from leachate because it is known that the leachate is dominated by the Firmicute bacteria group which will then contaminate the soil around the landfill. Bacterial contamination of leachate will damage the ecological function of the soil (Chen et al., 2021). So, if we see from observing the results of the characterization of bacteria that there are more types in the control, it is likely that these bacteria are contaminant bacteria, whereas in the eco-enzyme treatment there are fewer types (Aulia & Handayani, 2022). Therefore, it's can be concluded that eco-enzymes are able to inhibit the growth of contaminating bacteria originating from leachate and the ones that grow most are from these eco-enzymes. According to several studies, eco-enzymes are able to inhibit the growth of Staphylococcus aureus, Salmonella typhi and Candida albicans bacteria in vitro (Abdullah, 2022). In line with research results, the average pH of eco-enzymes is 4, which is still in the acidic category and based on the results of phytochemical compounds, ecoenzymes contain flavonoids, saponins and tannins. It is known that flavonoids and tannins are antimicrobial compounds. Apart from that, ecoenzymes also contain acetic acid which functions as an antibacterial (Rochyani et al., 2020).

CONCLUSIONS

Based on the research results, it can be concluded that the eco-enzyme from 4 types of fruit peel shows different characteristics in the results of eco-enzyme fermentation, including color and pH. Meanwhile, based on the application of eco-enzymes in remediating leachate waste, it shows less than optimal results in reducing COD and BOD but is very good in reducing ammonia and phosphate levels. Meanwhile, the TPC results for microbes in each treatment (P1, P2, P3, P4 and P4) showed differences in values ($155x10^{10}$, $314x10^{10}$, $375x10^{10}$, $435x10^{10}$, $113\ x10^{10}$) and bacterial characterization.

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