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THE ECO ENZYME APPLICATION ON INDUSTRIAL WASTE ACTIVATED SLUDGE DEGRADATION

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ABSTRACT

Aim: This study aims to determine whether the application of eco enzyme affects the industrial waste activated sludge degradation and to compare the effects of eco enzyme made from oranges and tomatoes. **Methodology and results:** The experiments were done on the laboratory scale for 12 days by applying 10% of eco enzyme in the sludge samples. It showed both tomatoes and oranges eco enzymes can decrease the pH from 6.9 to 4.7 compared to control which was stable at 6.9. The reduction of COD, TSS, and VSS by tomato eco enzyme applications were 61%, 39% 41% respectively compared to by orange eco enzyme application that showed a higher reduction of 78%, 45%, 46% respectively. The control samples also show the reduction of COD, TSS, and VSS by 21%, 23%, 30% respectively. The reduction of organic content in the control samples of sludge (8.9%) was higher than the samples with eco enzyme (3.5%). **Conclusion, significance, and impact study:** The results showed that eco enzyme application significant statistically affected reduction of pH, COD, organic content, but not significant statistically on TSS and VSS reductions. Comparing the application of orange and tomatoes eco enzyme did not show the significant different treatment.

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- COD
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- Sludge Treatment
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1. INTRODUCTION

The background of the research was that two important considerations related to each other, that was the need for a sludge treatment generated from WWTP (Wastewater Treatment Plant), and the need for reusing of organic waste as the materials that can be used WWTP process. Industrial waste activated sludge (WAS) is a by-product of the WWTP's activated sludge process. WAS management is a high component cost in industrial waste treatment. In addition, following Government Regulation of Republic Indonesia Number 22/2021 and Minister of Environment and Forestry Regulation Number 6/2021, WWTP sludge is included in the classification of hazardous and toxic waste.

The hazardous and toxic waste requires specific management and costly disposal provisions. The degradation of pollutant load in the WWTP sludge means reducing the level of danger to the environment and also reducing the significant burden of WWTP operational costs. This research has a high urgency because of the need for organic waste management solutions. City organic waste can reach 39% of the total (Siami, Sotiyorini, and Janah, 2019). Meanwhile, the processing of hazardous waste also needs to be immediately engineered to reduce the concentration of pollutants to prevent the potential for hazardous waste pollution from getting worse (Hakiki, 2019).

Wastewater Treatment Plant 2 (WWTP-2) in the Jababeka industrial area was selected considering its large processing capacity of 9,000 m^3/day with a current processing load of 5,000 m3/day. WWTP-2 receives wastewater from more than 100 industrial and commercial companies. With this capacity, the volume of by-product sludge from the WWTP is 50 m^3/month so its management requires significant resources.

The main objective of this study was to determine the effect of eco enzymes application made from oranges and tomatoes to industrial waste activated sludge (WAS) with parameters of pH, COD (Chemical Oxygen Demand), TSS (Total Suspended Solid), VSS (Volatile Suspended Solid) and organic content. The orange and tomatoes' eco enzymes were selected in this research due to the significant previous research results on their application in the aquaculture sludge. Meanwhile, the specific objective was to compare the effect of eco enzymes made from oranges and tomatoes on the characteristics of the WAS sludge.

Eco enzyme was first introduced by Dr. Rosukon Poompanvong, a researcher from Thailand who has researched garbage enzymes for more than 30 years (Tong and Liu, 2020). Eco enzyme

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is very easy and simple to make by fermenting waste from fruits and vegetables with a ratio of water: organic waste: molasses = 10: 3:1 for at least 3 months. The use of eco enzymes in the domestic environment is growing rapidly, especially in Southeast Asia and Japan because of their economic value and environmental friendliness. The results showed that the eco enzyme had an increasing effect on the effectiveness of nitrogen, organic matter, and potassium in agricultural soil, thereby increasing soil fertility (Tong and Liu, 2020). The use of eco-enzyme made from a mixture of fruits to improve the pH of the water showed the pH to be close to neutral, which was 6.6 from 9.2 after 270 minutes, but the use of eco-enzyme from vegetables did not succeed in lowering the pH of the contaminated water sample from the initial pH of 11.2 (Janarthanan, Mani, and Raja, 2020). In eco enzyme fermentation, the factors that must be considered are time, temperature, pH, carbon sources, and nitrogen sources (Larasati, Astuti, and Maharani, 2020).

The eco enzymes application in lake waters was reported to have succeeded in reducing the concentration of Total Solids (TS) from 884 to 745 mg/L, as well as reducing Total Suspended Solids (TSS) from 121 to 47 mg/L, while the hardness and chloride levels were not affected. The treatment by eco enzyme with a concentration of 0.5% in drainage water was able to reduce Biochemical Oxygen Demand (BOD) from 690 to 231 mg/l and Chemical Oxygen Demand (COD) from 537 to 384 mg/l, nitrate from 5.54 to 3.39 mg/L, and Coliform reduction by 10% (Kumar *et al.,* 2019). Eco-enzyme made from a mixture of pineapple-orange and papaya with pure use without dilution was reported to have an effective antimicrobial effect compared to 2.5% NaOCl (Mavani *et al.,* 2020). The benefits of eco-enzyme in domestic life, among others, can smooth clogged drains, water plants will give better fruit, flower, or harvest yields, and can repel insects and nuisance pests (S *et al.,* 2018). Eco enzyme can be used as the food preservative agent refer to the research that showed the best fruit preservation conditions are in red grapes by spraying eco-enzyme without dilution of the watermelon rind. (Sari, Astuti, and Maharani, 2020)

The application of eco enzymes in wastewater treatment with various dosage concentrations of 0%, 5%, 10%, 20%, and 25%, after 5 days showed a decrease in Total Solids (TS) respectively by 5.13%, 82%, 89%, and 85 %. With the same dose, the reduction in total suspended solids (TSS) were 83%, 94%, 90%, and 92%, respectively, while the Total Dissolved Solids were 4.9%, 80%, 89%, and 87% (Deepak, Singh, and A.K, 2019). The addition of eco

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enzyme from orange waste organic matter for 5 days in wastewater treatment showed good effectiveness in reducing TS by 32.5%, TDS by 39.5% and TSS by 33.0%, and BOD from 80.0 mg/L decreased to 22.3 mg/L (Hemalatha and Visantini, 2020).

Research on eco enzymes application in aquaculture sludge showed the ability of eco enzymes to dissolve complex compounds consisting of soluble and insoluble organic compounds that can increase anaerobic degradation to produce methane gas and hydrogen gas (Arun and Sivashanmugam, 2015b), (multi-hydrolytic enzymes that help dissolve activated sludge in WWTP (Arun and Sivashanmugam, 2017). The increased hydrolytic activity of enzymes in decomposing activated sludge of WWTP can be utilized to produce energy sustainably through anaerobic fermentation degradation processes (Arun and Sivashanmugam, 2017), that can be processes by electrolyzed or conventional methods. (A *et al.,* 2020).

2. RESEARCH METHODOLOGY

2.1 Research Framework

Several steps were carried out on this research including the preparation step, main laboratory experiments, data analysis that lead to the conclusions and recommendations. The orange and tomato eco enzymes were prepared in 3 months duration to make sure that the fermentation process occurred. The initial condition of eco enzyme and industrial waste activated sludge were characterized in the laboratory to find out the initial properties of both materials. The treatment effects were then studied with the application of 10% dilution of the produced eco enzyme (both for tomatoes and oranges) for 12 days periods of the anaerobic degradation process, with the control sample without addition of diluted eco enzyme. The changes in pH, COD, TSS, VSS, and organic content were measured for day 0, 3rd, 6th, 9th, and 12th as indicators of the degradation process. The research framework can be seen in Figure 1.

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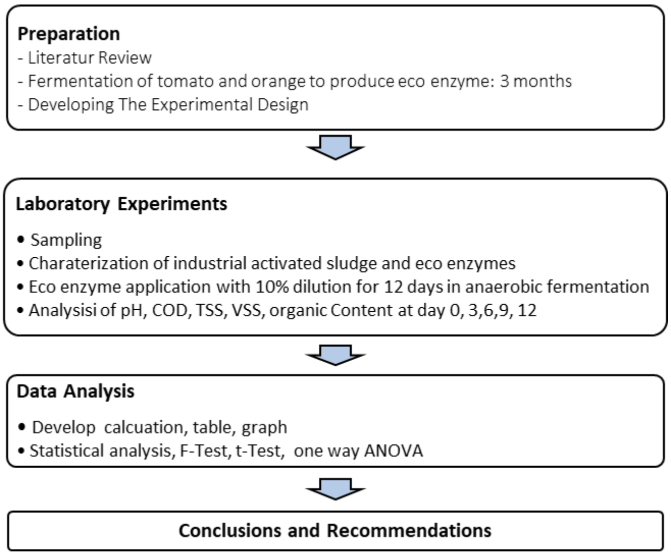

Figure 1 Research framework

2.2 The Experimental Steps

2.2.1 Preparation of Eco enzyme

Some materials and tools are involved in this research, such as industrial waste activated sludge (WAS) as the object that will be treated with the "3 month-prepared eco enzyme". It was prepared by anaerobic fermentation of orange peel and tomato separately within 3 months. The composition was water: organic waste: brown sugar with a ratio of 10:3:1 (Tong and Liu, 2020), see Figure 2.

(a) (b) (c)

Figure 3 Materials (a) industrial WAS; (b) tomato eco enzyme; (c) orange eco enzyme)

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2.2.2 Industrial Sludge Sampling

Random grab sampling was carried out to recirculate industrial waste-activated sludge of WWTP2 Jababeka from the final sedimentation tank after aerobic biological processes, as can be seen in Figure 3. Eco enzyme sampling was also carried out by random sampling on eco enzyme liquid that had been filtered with Whatman 40 paper. The eco enzyme filtration is required to minimize the colloidal particles that might interfere with the next experimental process and results.

Figure 3 Sampling location

2.2.3 Chemicals Reagents and Laboratory Tools

Chemical reagents for Chemical Oxygen Demand (COD) analysis which consist of K2Cr2O7 Potassium Dichromate Solution, concentrated Sulfuric Acid, according to the standard method of SNI-6989.2.2019. Continuous agitation of the sludge sample at 4800 rpm was conducted to assure the homogenous of the sample. It was filtered with a minipump equipped Buchner funnel to determine TSS concentration, both for initial condition and also after the treatment. Heat treatment is in a Muffle Furnace Barnstead Thermolyne 47900 was also given to the sample to determine VSS in an operating temperature of 550^{o} C. The VSS analysis procedure was followed the Standard Methods Number 2540-E for solids analysis that adopted into SNI 6989.3-2019. To determine COD concentration digestion with closed reflux COD reactor HANNA - HI 839800 was necessary then followed by the colorimetric measurement with a double beam UV-VIS spectrophotometer UNICO SQ-4802.

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2.3 Data Collection and Laboratory Analysis Methods

The research method was experimental through laboratory-scale experiments. The data taken was from the results of direct measurements (observations) in the laboratory as primary data. The experiments were duplicated. The reported data is the average value. The laboratory-scale experimental design was made based on variations in the types of eco enzymes that was tomatoes and oranges with the same concentration, which was 10%. The selection of 10% pure eco enzyme n the sludge mixture was considered to the previous research result that the optimum concentration in degrading aquaculture by tomatoes and oranges eco enzyme was 10% (Rasit, Fern, and Ghani, 2019).

The experiment was 12 days, and at every 3 days, the parameters were measured for pH, COD, TSS, VSS, and the calculation of organic. The laboratory analysis method references can be seen in Table 1.

Table 1 Laboratory analysis methods

Parameter	Analysis Methods	Reference
pH	Potentiometric	SNI-6989.11:2019
COD	Closed Reflux-Spectrophotometric	SNI-6989.2.2019
TSS	Gravimetric	SNI 6989.3:2019
VSS	Gravimetric & Furnace	SNI 6989.3:2019

2.4 Data Analysis Methods

The hypothesis in this study was that the addition of eco enzyme can reduce pollutant levels in waste activated sludge for COD, TSS, and VSS parameters. Hypothesis Ho, if $\mu_A = \mu_B$ it means that the COD, TSS, and VSS parameter values in the sample given the eco enzyme are the same or not lower than the control sample. Ha or Ho is rejected, if $\mu_A \neq \mu_B$ the parameter values of COD, TSS, and VSS in the sample given the eco enzyme are lower than the control sample. Statistical analysis for this is a one-way t-test with a value of P =0.05, that was performed with Microsoft Excel software.

ANOVA test was also conducted to determine whether there were differences between treatments, which were with and without eco enzyme application. Hypothesis Ho, if $\mu_A = \mu_B$ it

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means that there is no difference between treatments. Ha or Ho is rejected if $\mu_A \neq \mu_B$ it means that there is a difference between treatments. Meanwhile, for the observation of pH and organic content, the effect was analyzed in line with the exposure time.

3. RESULTS AND DISCUSSION

3.1 Characterization of Eco Enzyme and Industrial Wastewater Treatment Sludge

3.1.1 Eco Enzyme Characterization

The results of the eco enzyme analysis used in this sludge treatment study after the filtering process with Whatman 40 paper can be seen in Table 2. Eco enzymes from oranges and tomatoes have almost the same pH, at 3.47-3.50, but eco enzymes from oranges have a COD value of 21.7% higher than those made from tomatoes.

Table 2 The characteristics of tomato and orange eco enzyme

Eco enzyme	pH	COD (mg/L)
Tomato	3.50	17,108
Orange	3.47	20,817

The results of eco enzyme analysis from tomatoes and oranges had almost the same at pH of 2.79-2.86, and the COD value of eco enzyme from oranges was 96,000 mg/L or 20% higher than that of tomatoes of 80,000 mg/L (Rasit, Fern, and Ghani, 2019).

The results of eco enzyme analysis from tomatoes and oranges also contain biocatalysts, which are protease, amylase, and lipase. The results of the eco enzyme showed the concentration of citric acid which plays a role in the acidic properties of the eco enzyme. The levels of citric acid in the eco enzyme from oranges (35 mg/L) were much higher than those from tomatoes (14 mg/L) (Rasit, Fern, and Ghani, 2019).

The pH of the eco enzyme from tomatoes and oranges had almost the same at a pH of 3.2 – 3.4, and the concentration of citric acid in eco enzymes from oranges (4.40 mg/L) was much higher than eco enzymes made from tomatoes (1.48 mg/L). (Arun and Sivashanmugam, 2015b).

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3.1.2 Industrial Waste Activated Sludge Characterization

The analysis results of the Waste Activated sludge (WAS) of the parameters pH, COD (Chemical Oxygen Demand), TSS (Total Suspended Solid), VSS (Volatile Suspended Solid), and the calculation results of the organic can be seen in Table 3.

Table 3 The characteristics of industrial waste activated sludge

Sludge	pH	COD	TSS	VSS	Organic Content
Unit	-	mg/L	mg/L	mg/L	%
Value	6.90	22,400	15,300	9,580	62.6

The quality of the sludge taken from the integrated WWTP of the Jababeka Industrial Estate according to Table 3, when compared with the quality of the sludge from the WWTP from the dairy industry shows almost the same characteristics in the parameters of pH, COD, and TSS, pH = 6.7-7.2, COD = 24,094 mg/L, TSS = 5.034 mg/L, but has significantly different concentrations of VSS and organic, VSS = 4.971 mg/L and % organic = 98.7% (Arun and Sivashanmugam, 2015b). Research on the application of eco enzymes from mixed organic materials was also carried out on aquaculture sludge. The results of the initial quality analysis of the aquaculture sludge have different characteristics from the integrated WWTP and dairy industry sludge, those were COD = 64,197 mg/L, TSS = 3,066 mg/L and VSS = 988 mg/L, and organic was 32% (Galintin, Rasit, and Hamzah, 2021).

3.2 The Effect of Eco Enzyme application on pH

The results of the pH analysis of the control sample that was without the addition of eco enzyme and the samples that were each given 10% of the orange and tomato eco enzyme from day 0 to day 12 can be seen in Figure 4.

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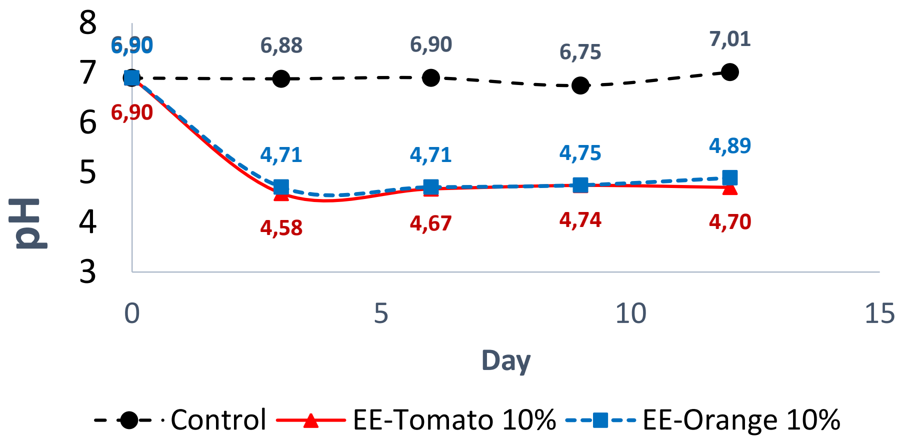

Figure 4 The effect of eco enzyme application on pH

From Figure 4, it can be seen that the pH value of the control sample was relatively stable from day 0 to day 12, while the samples added by orange and tomato eco enzyme showed a decrease in the range of 4.6-4.7 since the 3rd day of observation and were relatively stable at values of 4.7-4.9 until day 12. Although the use of eco enzyme was only 10%, it can significantly reduce pH because of the citric acid contained in the eco enzyme and the content of biocatalysts of proteases, amylase, and lipase (Rasit, Fern, and Ghani, 2019). These biocatalysts can take a role in the reduction process of ammonium or nitrate as electron acceptors, also in the absorption of substrates for cell growth resulting in changes in pH (Burgess and Pletschke, 2008).

The results of the statistical analysis of changes in pH by comparing the pH value of the control sample with the sample given tomato eco enzyme showed one way (1 tail) P(T<=t) value of 0.0084, and two ways of P(T<=t) 0.0167. This indicates that there was a significant decrease in pH. The same statistical analysis result on the comparison of the pH value of the control sample with the sample given the orange eco enzyme, P(T<=t) in one way of 0.0084, and P(T<=t) in two ways of 0.0168. The ANOVA analysis single factor for comparing the addition of orange or tomato eco enzyme did not show any difference between the two, which was indicated by the P-value in the ANOVA analysis of P = 0.9113 < 0.05.

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3.3 The Effect of Eco Enzyme Application on COD

The results of the COD (Chemical Oxygen Demand) analysis of the control sample and samples that were each given 10% of orange and tomato eco enzyme from day 0 to day 12 can be seen in the graph in Figure 5.

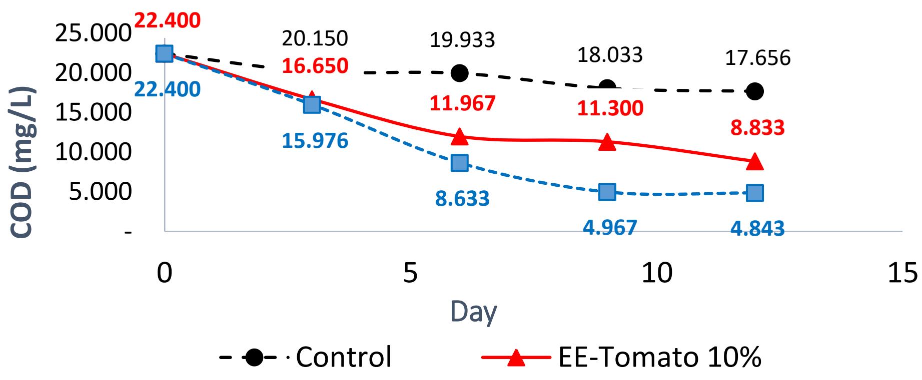

Figure 5 The effect of eco enzyme application on COD

From the results of the COD analysis in Figure 5, it was shown that there was a decrease in COD in the three samples, but the samples that were given eco enzyme showed a greater decrease. On day 12, the decrease in COD in the control sample was 21%, while in the sample added with tomato eco enzyme it could reach 61%, even with an orange eco enzyme it could reach 78%.

The addition of eco enzymes increases the solubility of organic compounds in the sludge through the mechanism of enzyme bio-catalysis thereby increasing the biodegradability and bioavailability of the sludge as indicated by a decrease in the COD value (Arun and Sivashanmugam, 2015a). With the increasing solubility of sludge, the degradation of sludge by organisms will be easier in the anaerobic process to produce biogas (Arun and Sivashanmugam, 2015a). The increase in the solubility of the sludge increases the sCOD (soluble chemical oxygen demand) in the liquid phase of the sludge which can improve the release of protein and carbohydrates in the organic sludge floc, therefore encouraging the hydrolysis process. The research of Chen *et al.,* (2017) reported that after 8 hours of hydrolysis with lysozyme, the net sCOD in the reactor increased 2.23-fold with proteases and 2.15-fold with alpha-amylase enzymes. The combination of lysozyme with proteases can improve cell lysis of organisms and

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the degradation of extracellular polymeric substances (Chen *et al.,* 2017).

The decrease in sludge COD indicates the presence of biocatalytic activity in the eco enzyme which acts as a catalytic agent in the hydrolysis process. The reduction of COD occurs through changes in the molecular structure of the sludge. The decrease in sludge COD is also an indication that the sludge contains high dissolved substances because organic particles become dissolved and facilitate further anaerobic degradation processes to produce biogas (Galintin, Rasit, and Hamzah, 2021).

The research of Rasit *et al.,* (2019) in a study of the potential for aquaculture sludge treatment for 10 days showed a 77% decrease in COD at the concentration of eco enzyme made from orange organic matter by 10%, and a decrease in COD by 70% in eco enzyme from tomatoes. Increasing and decreasing the eco enzyme concentration did not indicate a better significant COD reduction result. This showed that in research, the optimum concentration of eco enzyme is 10% (Rasit, Fern, and Ghani, 2019)

Research by (Galintin, Rasit, and Hamzah, 2021) (showed a decrease in the COD concentration of aquaculture sludge up to 88.2% (from 64,197 to 7,556 mg/L) using eco enzyme derived from various fruit and vegetable wastes with a concentration of 10%. The high decrease in COD in aquaculture sludge indicates the biocatalytic activity contained in the eco enzyme of the mixture of organic materials. The use of 10% eco enzyme is the optimum concentration because increasing to 15% does not show a significant increase in COD reduction (94%) (Galintin, Rasit, and Hamzah, 2021)

The decrease in COD concentration in orange eco enzymes was higher than that of tomato eco enzymes, mainly because of the citric acid produced from the fermentation of orange peels and fruits. Citric acid can play a role in decomposing EPS (extracellular polymeric substances) and releasing hydrolytic enzymes (Arun and Sivashanmugam, 2015b)

The statistical analysis results of COD reduction by comparing the COD value of the control sample to the sample treated with tomato eco enzyme showed one way P(T<=t) value of 0.0443 <0.05, by orange eco enzyme, was P(T<=t) value of 0.0084, and two ways by orange eco enzyme was P(T<=t) value of 0.0178. This indicates that there was a decrease in COD for both orange and tomato eco enzyme, and even a decrease significantly for the orange eco enzyme. ANOVA analysis on a single factor for comparing the addition of eco enzyme treatment of tomatoes and oranges did not show a difference between the two which was indicated by the P-value in one-

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way ANOVA analysis of P = 0.8668 > 0.0.

3.4 The Effect of Eco Enzyme Application on TSS and VSS

The analysis results of the TSS and VSS reduction on day zero to day 12 can be seen in Figure 6 and Figure 7. The decrease in TSS and VSS is a determinant of the effectiveness and stability of the sludge treatment process (Arun and Sivashanmugam, 2015b).

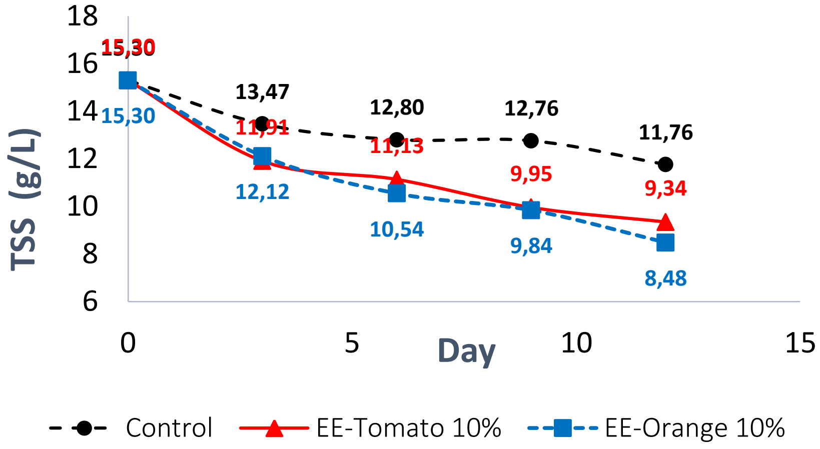

Figure 6 The effect of eco enzyme application on TSS

The TSS data analysis in Figures 6 showed that the three samples experienced a decrease in the concentration of TSS in line with increasing observation time, but the %-decrease in TSS in the samples treated with eco enzyme was greater. In the control sample TSS decreased by 23%, with tomato eco enzyme TSS decreased by 39%, and the use of orange eco enzyme could reach 45%. According to Figure 7, it can be seen that the decrease in VSS in the control sample was 30%, while the tomato eco enzyme sample was 41%, and the orange eco enzyme sample was 46%.

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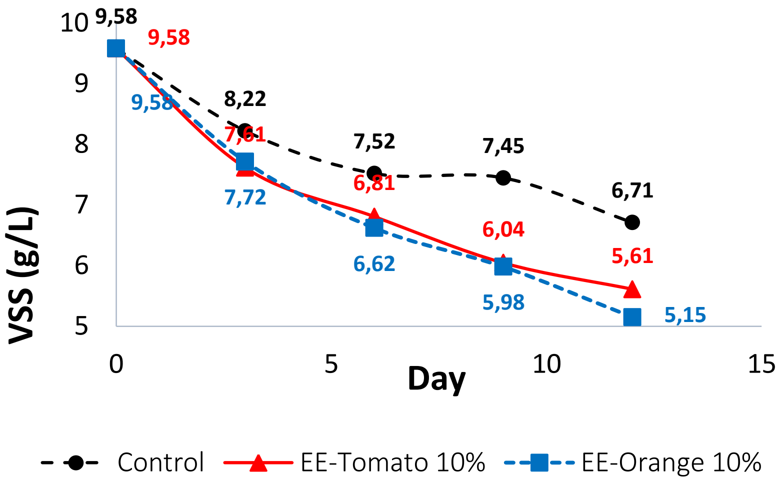

Figure 7 The effect of eco enzyme application on VSS

Organic molecules such as proteins, carbohydrates, and lipids, which are commonly found in sludge, are easily broken down by protease, amylase, and lipase enzymes from eco enzymes (Arun and Sivashanmugam, 2015a).

The presence of biocatalytic activity in the eco enzyme affects the solubility of the sludge, and the presence of citric acid can also act as a catalyst in sludge degradation resulting in a decrease in TSS and VSS in the sludge by eco enzyme activity (Galintin, Rasit, and Hamzah, 2021). Based on an analysis in research (Arun and Sivashanmugam, 2015b) and (Rasit, Fern, and Ghani, 2019) the concentration of citric acid in orange eco enzymes was higher than those from tomatoes, which means that the catalytic power of eco enzymes was higher. This was proven in this study, the TSS reduction value in the sample given the orange eco enzyme was higher than the tomato eco enzyme.

In the control sample, there was also a decrease in TSS, this is because the sample also allows for the presence of Exoenzymes. Exo enzymes such as lipase, glucosidase, protease, and others can be produced from one of 3 sources, which are the untreated domestic wastewater, the activated sludge autolysis process, and active secretory processes from cells (Burgess and Pletschke, 2008)

This study results showed a lower TSS reduction compared to research (Rasit, Fern, and Ghani, 2019) in a 10-day study of aquaculture sludge treatment, with the results of a TSS reduction of (87% with the use of orange eco enzymes and a TSS reduction of 80% with the

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addition of tomato eco enzymes in the same concentration of 10%. This is because the use of sludge from industrial areas may have characteristics that are more difficult to degrade than aquaculture sludge. Research of (Arun and Sivashanmugam, 2015b) for 60 hours on dairy industry sludge showed a decrease in TSS of 18% with the use of orange eco-enzymes at pH 3.5 and increased to 19% at pH 7.

Meanwhile, the use of eco-enzyme tomatoes can reduce TSS by 22% at pH 3.5 and be 27% at pH 7. The use of 10% eco enzyme from a mixture of organic materials in the dairy industry sludge showed a decrease in TSS of 18% for 120 hours and increased to 37.2% with an increase in the eco enzyme to be 20% (Arun and Sivashanmugam, 2015a). The experiment was carried out with continuous stirring of 250 rpm, but in this research, there was no stirring applied. Research on aquaculture sludge with 10% eco enzyme concentration succeeded in reducing TSS by 89% from the initial 3,066 mg/L. (Galintin, Rasit, and Hamzah, 2021)

The research by (Galintin, Rasit, and Hamzah, 2021) on aquaculture sludge showed a decrease in VSS of 88% with the same eco enzyme concentration as this study, which was 10%. Meanwhile, research by (Rasit, Fern, and Ghani, 2019) in treating aquaculture sludge for 10 days showed a 67% decrease in VSS. The study by Galintin *et al.,* (2021) on aquaculture sludge showed a decrease in VSS of 88% with the same eco enzyme concentration as this study, which was 10%. Meanwhile, research by (Rasit, Fern, and Ghani, 2019) in treating aquaculture sludge for 10 days showed a 67% decrease in VSS. Research with a lower concentration of eco enzyme to 5% showed a decrease in VSS of 50%, while the use of eco enzyme with a concentration of 15% only slightly increased the reduction of VSS to 90%. Therefore the use of 10% eco enzyme is the optimum concentration (Galintin, Rasit, and Hamzah, 2021).

The results of the statistical analysis of the decrease in TSS and VSS by comparing the TSS and VSS value of the control sample to the samples that were given tomato or orange eco enzyme showed one way P(T<=t) value were > 0.05. This shows that the decrease in TSS and VSS is not proven statistically. The ANOVA analysis on a single factor for comparing the addition of tomato and orange eco enzyme did not show any difference between the two, which was indicated by the P-value in the ANOVA analysis of P > 0.05 in both TSS and VSS.

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3.5 The Effect of Eco Enzyme Application on Organic Content

From the data obtained from the analysis of TSS and VSS, the organic content is represented by VSS content in the sample (SNI 6989.3-20119), as presented by VSS /TSS. The results of these calculations can be seen in Figure 8. It showed that by comparing day 0 and day 12, there was a decrease in organic content in the control sample from 62.6% to 57% (8.9% reduction), but in the sample given eco enzyme, the decrease in organic content was lower from 62.6% to 60.1% - 60.7% (3.5 % reduction). It showed that the sludge samples with eco enzyme addition have more organic content than the sample control from day 3 until day 12.

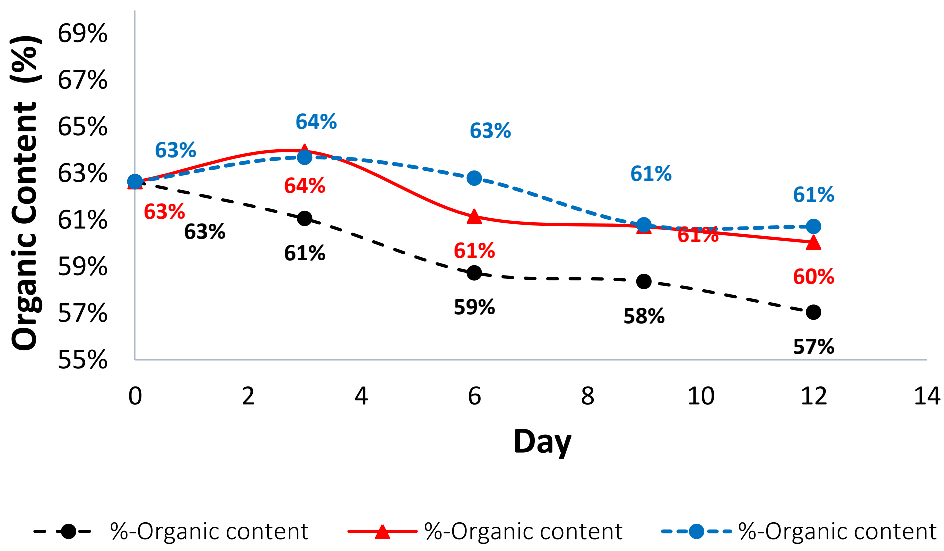

Figure 8 The effect of eco enzyme application on organic content

Research by Rasit *et al.,* (2019) showed an increase in % organic from the original 32% to 64% in the use of eco-enzymes made from tomatoes and from 32% to 56% by using orange eco enzymes. An increase in % organic means an increase in the percentage of biodegradable sludge compared to non-biodegradable sludge. This occurs because the biocatalytic activity in the sludge promotes an increase in the solubility of the sludge (Galintin, Rasit, and Hamzah, 2021).

The results of the statistical analysis of the organic decrease by comparing the organic value of the control sample to the sample given eco enzyme showed one way P(T<=t) value of 0.0598 >0.05 for tomatoes and P (T<=t) value of 0.02962729 <0.05 for oranges. This indicates a

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decreased organic is a statistically proven eco enzyme made by oranges, but not a statistically proven eco enzyme made by tomatoes. The results of the ANOVA analysis on a single factor for comparing the addition of tomato and orange eco enzyme treatments did not show a difference between the two, which was indicated by the P-value in the ANOVA analysis of P = 0.65789103 >0.05.

4. CONCLUSION

The results showed that eco enzyme application significant statistically affected the industrial sludge degradation on pH, COD, organic content reduction, but not significant statistically on TSS and VSS reductions. The lowering pH up to 4-5 has to be considered in the application. Comparing the application of orange and tomato eco enzyme did not show the significant different treatment according to ANOVA single factor analysis. This research result can be considered as the alternative treatment for improving sludge degradation.

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