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Research article
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Soil Colloids in Affecting pH of Various Types and Concentrations of Eco Enzymes

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Abstract: The eco enzyme (EE) is the result of the fermentation of organic waste that reacts with acid pH < 4. The purpose of the study was to determine the dynamics of changes in the pH of the EE solution because of the application of soil containing inorganic (clay minerals) and organic (humic) colloids. Several treatments were made by the concentration of EE solution starting from 0%, 5%, 10%, 20%, 30%, 40%, 50%, and 100%. The pH of the solution was measured at room temperature. The next treatment is to add soil (mineral and organic) as much as 0, 5, 10, and 15 g into the EE solution according to the concentration that has been made. The concentration of 5% EE solution significantly lowers the pH of the water compared to a solution without EE, and the pH continues to decrease as the EE solution becomes more concentrated (100%). The more soil colloids are added to various types of EE solutions, the soil pH tends to rise, and the pH containing organic colloids was higher than mineral colloids; this provided useful information when using EE solutions as liquid organic fertilizers in fields. The advantage of this study was that it is faster to obtain the results, but it must be tested further in the field. The application of EE solution as a liquid fertilizer is still safe against a decrease in soil pH and preferably the soil contains sufficient organic matter.

Keywords: eco enzyme solution; mineral soil; soil organic matter; pH; organic colloids; colloidal minerals

土壤胶体对不同类型和浓度生态酶的酸碱度值的影响

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摘要: 生态酶(电子工程)是有机废物发酵的结果，与酸性酸碱度< 4反应。该研究的目的是确定由于施用含有无机物的土壤而导致电子工程溶液酸碱度值变化的动力学（粘土矿物）和有机（腐殖质）胶体。通过从0%、5%、10%、20%、30%、40%、50%和100%开始的电子工程溶液浓度进行几种处理。在室温下测量溶液的酸碱度值。下一个处理是根据已制成的浓度向电子工程溶液中添加多达0、5、10和15 g的土壤（矿物质和有机物）。与不含电子工程的溶液相比，5%电子工程溶液的浓度显着降低了水的酸碱度值，并且随着电子工程溶液变得更加浓缩(100%)，酸碱度值继续降低。各类电子工程溶液中加入的土壤胶体越多，土壤酸碱度值有升高的趋势，含有机胶体的酸碱度值高于矿物胶体；这为在田间使用电子工程溶液作为液体有机肥料提供了有用的信息。这项研究的优点是可以更快地获得结果，但必须在现场进行进一步的测试。将电子工程溶液作为液体肥料施用对于土壤酸碱度 值的降低仍然是安全的，并且最好土壤含有足够的有机质。

关键词：生态酵素溶液； 矿质土壤； 土壤有机质； 酸碱度； 有机胶体； 胶体矿物质

1 Introduction

This eco enzyme (EE) solution was first introduced by Dr. Rosukon Poompanvong, the founder of the Thai Organic Farming Association. The idea of this project is to process organic waste into eco-enzyme products. Eco enzyme is the result of the fermentation of organic waste (fruit and vegetable waste), sugar (brown or cane sugar), and water in a ratio of 3:1:10. It is dark brown in color and has a strong sweet and sour fermented aroma[1]. [2] explained the conventional process of making EE solution for three months during the fermentation process. The mechanism for producing EE is a process that will produce bioethanol through fermentation. During the process of making bioethanol, after the hydrolysis process, it is followed by fermentation using the fungus Saccharomyces cerevisiae, which modified distilled glucose into alcohol. The manufacture of EE solution, through a continuous fermentation process until the alcohol and acetic acid products were mixed, takes a minimum of 8-10 days, with an alcohol content of 60-70%, and the pH of the EE solution reaches < 4. The eco enzyme has pH of about 3.5 with BOD concentration of about 150 mg/l. The EE solution is stated to be excellent for increasing soil fertility, but if observed from the very low pH of the EE solution, it is feared that it will interfere with plant growth. In this study, we determine the role of soil as a buffer in reducing the decrease in pH due to the application of the EE solution. Soil contains colloidal minerals and organic colloids that play a role in buffering sudden changes in pH.

The properties of soil buffers are defined as the ability of soil to withstand changes in pH under the influence of acids or bases that can change soil pH suddenly. Soil minerals containing many colloidal minerals have lower support capacity than colloid organic soils. The buffering properties are related to an equilibrium condition between the soil solution and the H^+ and Al^{3+} ions in the soil adsorption complex. When alkaline agents appear in the soil, H ions will reduce in the soil solution due to neutralization and form an adsorption complex. In other words, when H^+ ions are added to the soil solution, they are transferred to the sorption complex. In the second case, the soil pH did not change significantly until it was saturated from the sorption complex by other ions. The buffer properties of the soil are positively correlated with its sorption capacity[3]. The crop residue input and biomass disposal are the main factors. This study will prove the role of soil colloids from organic and mineral soils in the dynamics of changes in the pH of the EE solution. The roles of colloid organics and minerals differ in their buffering properties in soil.

On the other hand, if H^+ ions are added to the system, some additional H^+ ions will be adsorbed by the colloid minerals with the release of other ions. As a result, there will be a slight increase in active acidity and a corresponding decrease in soil pH. There are various factors that affect soil colloid buffers, the most important of which are the amount and type of clay, organic matter content, cation exchange capacity, carbonate, bicarbonate, phosphate content, and various organic acids[4]. Soils that contain a lot of clay (colloid minerals) and organic (humic) matter are said to buffer more strongly and require larger amounts of lime to reach certain pH changes than acid soils that contain a little clay and organic matter.

The purpose of the study was to determine the dynamics of changes in the pH of the EE solution because of the application of soil containing inorganic colloids (clay minerals) and colloid organics (humic substances).

2 Materials and Methods

This research has been conducted for four months. Research activities were carried out in the laboratory of the Faculty of Agriculture, University of Tamansiswa Padang, from April 2022 to July 2022. The materials included; fruit and vegetable waste, soil organics and minerals, aquadest, paper towels, and stationery. The tools used are plastic cups, shakers, stirring rods, spoons, measuring cups, pH electrodes, and spray bottles. An organic solution of eco enzyme (EE) was prepared by making 5 treatments with organic waste content (different fruit and vegetable waste materials). The stipulation in making the EE solution was to mix palm sugar (1 part) organic waste (3 parts) and water (10 parts). In this treatment, there are five types of organic materials derived from organic waste tested:

A. Orange peel;

B. Papaya peel + pear peel + watermelon peel + cucumber;

C. Orange peel + banana peel + sweet star fruit;

D. Banana leaves + papaya leaves + orange peel + kale + carrots;

E. Orange peel + dragon fruit peel.

The material is fermented in a wide-mouthed jar in airtight atmosphere; once a week, the lid is opened to release the gas and stir. It is then closed tightly again for up to three months. After the time came, all the EE solution was filtered with 80 mesh filter size, then diluted in several concentrations; then, the pH is determined. Treatments were made in the concentration of the EE solution for each treatment starting from 0%, 5%, 10%, 20%, 30%, 40%, 50%, and 100%. For example, how to make a 5% concentration is to take 5 ml of EE solution and then add distilled water to a volume of 100 ml, and so on to make solutions with different concentrations. Furthermore, the pH of the solution was measured at room temperature to obtain the pH value of each solution concentration.

The next treatment is to add 0, 5, 10, and 15 g of soil organics and minerals to the EE solution according to the concentration that has been made. The soil organic used is soil organic matter. Soil organic matter is the fraction of the soil that consists of the plant or animal tissue in various stages of breakdown (decomposition). Most of our productive agricultural soils have between 3% and 6% of organic matter. Soil organic matter (SOM) contains nearly all soil N and generates most CEC in most soils. Furthermore, SOM can adsorb toxic compounds, such as Al, thereby reducing soil toxicity with benefits to plants. Thus, soils with high SOM content are more fertile than soils with low SOM content[5]. The soil sample was mashed and then filtered to pass a maximum sieve of 2 mm hole size diameter in air-dry conditions. Soil organics as a source of colloid organic while soil minerals as a source of colloids inorganic (clay). The soil material that has been put into the EE solution, whose concentration has been determined, is then shaken using a shaker for 15 minutes; then, it sits for 10 min, and the pH is measured. The pH value is then defined as a pH measurement number that is influenced by soil colloids. The experimental results will be tabulated and presented in the form of tables and graphs, both bar graphs and linear regression, with a correlation test. The flowchart of the research methodology is presented in Fig. 1.

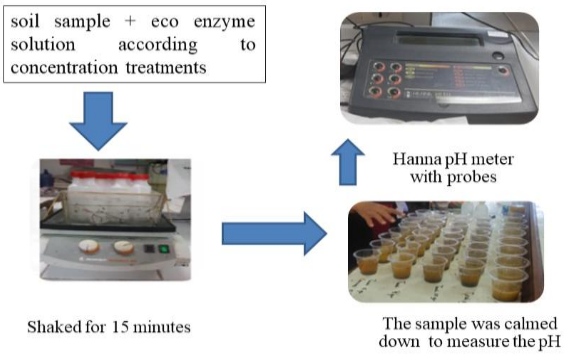


Fig. 1 The flowchart of the research methodology

3 Results

The EE solutions in various concentrations specified in pH are presented in Tab. 1 and Fig. 2. In general, for the solutions containing a concentration of 0% EE solution, the pH value is close to normal (6.39).

Tab. 1 The effect of various types of organic waste constituents of EE in various concentrations on the pH of the solution

Types of Organic Waste from EE	Concentration of eco enzyme products							
	pH							
	0%	5%	10%	20%	30%	40%	50%	100%
(A)	7.18	3.27	2.95	2.78	2.71	2.66	2.68	2.63

Continuation of Tab. 1								
(B)	6.35	3.34	2.99	2.88	2.80	2.77	2.74	2.72
(C)	6.41	3.63	3.32	3.11	3.03	2.99	2.93	2.83
(D)	6.38	3.38	3.09	2.95	2.90	2.89	2.85	2.83
(E)	5.65	3.47	3.02	2.85	2.73	2.66	2.64	2.55
Average	6.39	3.42	3.07	2.91	2.83	2.79	2.77	2.71

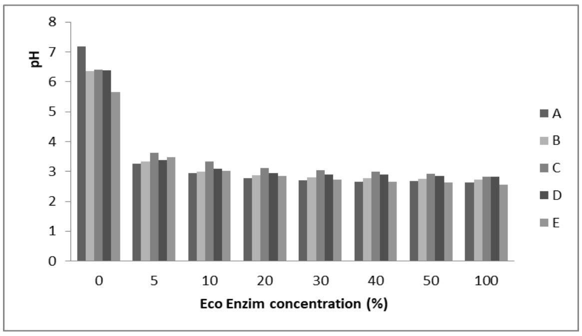


Fig. 2 The effect of various types and concentrations of EE solutions on changes in pH
Explanation: Orange peel (A); papaya peel + pear peel + watermelon peel + cucumber (B); orange peel + banana peel + sweet star fruit (C); banana leaf + papaya leaf + orange peel + kale + carrot (D); orange peel + dragon fruit peel (E)

4 Discussion

The EE solutions in various concentrations specified in pH are presented in Tab. 1 and Fig. 2. In general, for the solutions containing a concentration of 0% EE solution, the pH value is close to normal (6.39). If the concentration of EE solution is increased again, the pH of the solution will decrease significantly. The concentration of 50% and 100% of EE solution resulted in no significantly different pH. The starting Concentration from 5% to 100% EE solution continues to decrease in pH non-significantly.

Fig. 2 explains that there are small differences between the various types of organic waste that make up the EE solution on the pH of the solution. In the C treatment, the pH of the solution in various concentrations remained higher than others. The C treatment was prepared with organic waste consisting of; orange peel + banana peel + star fruit. The more organic acid produced from the fermentation of the organic waste, the lower the pH of the solution. It has been stated[6] that more organic acids found in the solution will lower the pH of the solution. The type of organic acid also greatly affects the pH of solution.

Fig. 3 shows that the EE solution diluted in water based on its concentration is indicated by a different color solution. The more concentrated EE solution is poured into water, the darker the solution color becomes. This occurs in two types of EE solutions.

Fig. 3 EE solution starting at a concentration of 0-100%, from the type of organic waste treatment A (top) and treatment C (bottom)

The characteristics of soil colloids in influencing the pH of the EE solution with concentrations of 5%, 10%, 10%, 20%, 30%, 40%, and 50%, can be seen in Fig. 4. The pH of the water that has not been added to the EE solution is close to neutral, and when water is added to the EE solution, the pH will decrease until it reaches < 4. However, if the concentration of EE solution is 100%, the pH of the solution is also not significantly different. It decreases significantly with 10% concentration of the EE solution. It turns out that water does not have buffer properties in influencing pH or maintaining pH if it gets an addition of EE solution.

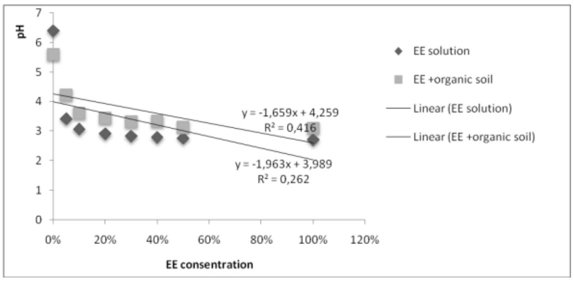


Fig. 4 EE solution based on various concentrations of initial pH measurement and after adding soil organic matter

The linear relationship of the solution is based on the concentration of the solution EE:Y = 1.963X + 3.989, R^2 = 0.262 (initial R). It can be observed here that the linearity relationship is very weak, indicating no effect of the concentration of the EE solution on the difference in the solution pH. After adding organic soil (colloid organics) to the EE solution, the soil pH increased, with the linear relationship being Y = 1.659X + 4.259, R^2 = 0.416 (final R). There was an increase in the pH of the solution after the addition of soil organics, and the correlation value was (final R^2) > (initial R^2). If a water solution (0% EE solution) is added to soil organics, there is a slight decrease in pH, but if various concentrations of EE solution are added by the soil organics, the pH increases compared to pH without soil organic matter.

This phenomenon can be explained by the fact that organic soil contains colloid organics or humus, which functions as a buffer in the soil. These buffer properties are very beneficial for nature and environment because colloids in the soil can defend pH from large pH fluctuations that are disserving for organisms in the soil. The nature of the buffer when associated with chemical reactions is to maintain equilibrium so that the cation exchangeable that works on the soil occurs properly. [4] explained that the greater the cation exchange capacity (CEC), the greater the buffering nature, and to achieve equilibrium, the more cations are required for being exchangeable in chemical reactions.

Tab. 2 and Fig. 5 show that the EE solution containing soil minerals (colloid clay) has lower buffering properties than soil organic matter containing colloid organics. The figure indicates that the higher the concentration of the EE solution, the lower the pH of the solution. However, the EE solution pH given mineral soil was lower than the EE solution pH given organic soil; this applies to the EE solution of types A and B.

Tab. 2 Effect of organic and inorganic colloid buffer properties on pH of EE solution

Types of Organic Waste from EE	Concentration of eco enzyme products							
	pH							
	0%	5%	10%	20%	30%	40%	50%	100%
A + (5 g organic soil)	5.76	4.00	3.81	3.33	3.08	3.58	2.86	2.70
B + (5 g organic soil)	5.94	3.86	3.33	3.20	3.03	2.94	2.87	3.03
C + (15 g organic soil)	5.45	4.77	3.88	4.18	4.49	4.14	4.09	4.35
D + (10 g organic soil)	5.67	4.96	3.83	3.61	3.28	3.31	3.26	3.19
E + (5 g mineral soil)	5.20	3.60	3.24	2.91	2.76	2.75	2.70	2.27

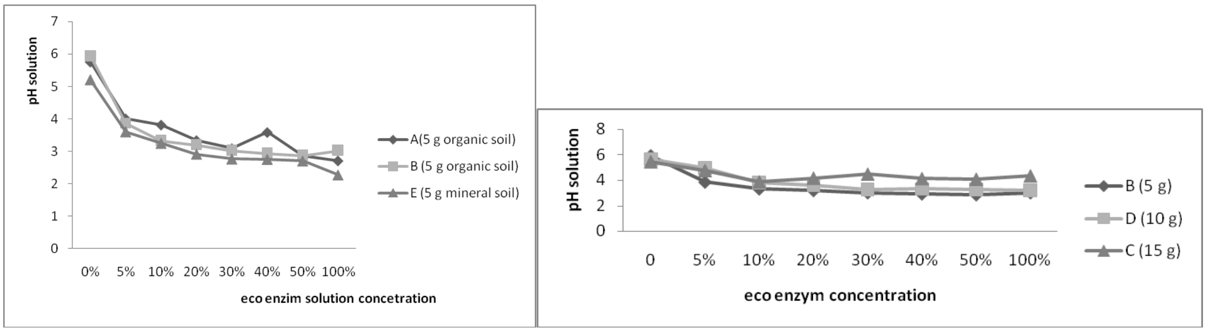


Fig. 5 pH of three EE solutions (A, B, and E) after adding organic and mineral soils (left) and pH of the solution of three EE (B, D, and E) after adding organic soil (5 g, 10 g, and 15 g) (right)

Explanation: Orange peel (A); papaya peel + pear peel + watermelon peel + cucumber (B); orange peel + banana peel + sweet star fruit (C); banana leaf + papaya leaf + orange peel + kale + carrot (D); orange peel + dragon fruit peel (E)

The same happens if different types of organic matter are used, the EE solution given the soil minerals still has the lowest pH of all solutions in different concentrations of EE. This showed that soil organics have buffering properties that are higher than mineral soils. [7] explained that the nature of the colloidal buffer of the soil is strongly influenced by the cation exchange capacity (CEC). Soil minerals containing colloidal clay have a cation exchange capacity (CEC) < CEC of soil organics containing humus (organic colloids). As reported by [8], clay colloids from various types of clay minerals will produce different CEC values. Furthermore, the CEC of sesquioxide clays is generally lower than that of 1:1 (kaolinite) or 2:1 (smectite) clays. Clay with type 1:1 has a lower CEC than clay with type 2:1[9]. The cation exchange capacity is described as the ability of a soil colloid to adsorb and release cations. Of course, the soil colloid is negatively charged, so it can bind cations[10]. If the pH of the solution is low due to the addition of acid, it indicates that the soil colloid has been dominated by H^+; on the other hand, if the pH has gone up due to the addition of organic colloids, OH^- is released in the solution.

In Fig. 6, the addition of organic soil up to 15 g was shown to increase the pH of the solution in various concentrations of the EE solution. The more organic soil is added, the higher the pH of the solution. It is proven that soil organics containing organic colloids are able to maintain soil pH not to reduce. The role of colloid organics in supporting the soil is very beneficial for the growth of plants and other living beings in the environment.

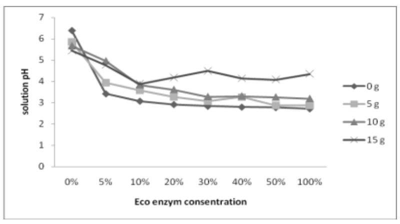


Fig. 6 pH of various concentrations of EE solution added with various doses of soil organics

If the EE solution was not put into water as a dilution (0%), then the application of soil organic and minerals produces the highest pH of 6. If 15 g of organic soil is put into it, the pH of the solution will increase. This can occur due to the increasing number of colloid organics so that they are able to donate much OH^- resulting in much H^+ being absorbed by organic colloids. Even soil organics contain clay colloids, so there is an increase in the adsorption of the organic soil colloids. [11] explained that the intercalation of OM by smectitic clay minerals may therefore increase the stable C reservoir in both soils and sediments. However, the precise mechanisms of adsorption and intercalation of myriad organic constituents by swelling clay minerals in soils and sediments remain unresolved. Model adsorption experiments with montmorillonite (Mt), a ubiquitous expanding layer silicate, showed that environmentally relevant fatty acids possessing long-chain alkyl C facilitate the adsorption and subsequent intercalation of fulvic acid (FA).

Fig. 7 presents an increase in pH if organic soil is given, even though the dose is the same as mineral soil for all EE solution concentrations ranging from 5% to 40%. However, for a concentration of 50-100% of EE solution, the increase in pH of the solution due to the addition of organic and mineral soils is not very significant. This is because 5 g of soil is not sufficient to neutralize the acidity caused by the EE solution in producing much H^+. It should also be noted that at least the soil is used to provide soil pH security so that the application of EE solution does not harm plant growth and the activity of beneficial microorganisms.

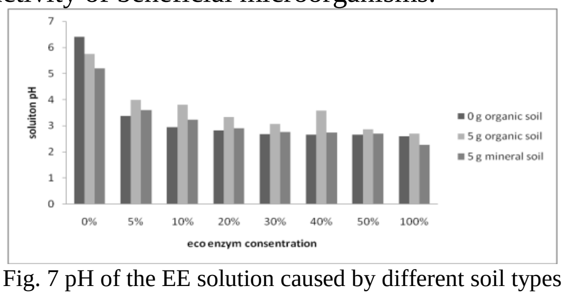
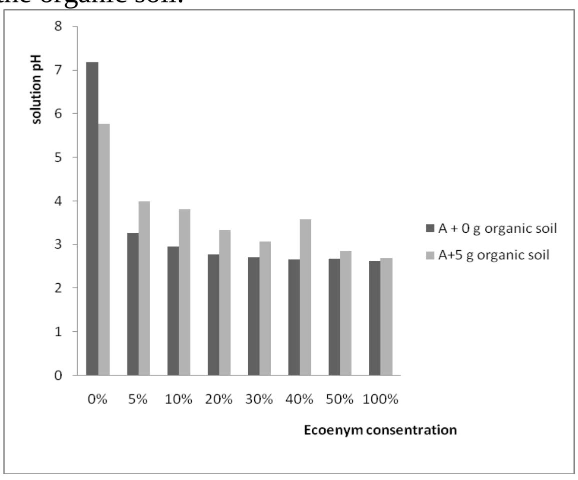


Fig. 7 pH of the EE solution caused by different soil types

The pH of the solution will reduce if there is an increase in the concentration of EE solution up to 10%; if the concentration of EE solution is increased more, the pH holds on. The addition of soil organics and soil minerals also affects the pH of EE solution. If soil organic matter is added, the pH of the solution increases, but this is not the case for mineral soils. Mineral soils will increase the pH of the EE solution if given to a solution containing an EE solution ranging from 0 to 30%. At the EE solution concentration of 40%-50%, the pH of the solution was the same between those given mineral soil and those without mineral soil; the more the EE solution concentration increased up to 100%, the more the pH of the solution reduced. The different happens when organic soil is added to the solution. The pH of the solution that received the addition of organic soil increased; even at 100% EE solution, the increase although was not significant.

This analysis can occur if it is related to the role of colloids in the soil, between organic (humus) and inorganic colloids (clay), which are buffers in the soil solution. The buffer of the two colloids maintains the pH to be close to normal so that the presence of these two types of colloids can preserve the environment and the stability of chemical reactions in the soil. The figure also shows that soil organic matter donated many organic colloids acts as buffer with a higher potential than soil (organic) minerals that contain many clay minerals. The buffering role of the two colloids is determined by the cation exchange capacity (CEC). The higher the CEC number in soil, the greater its buffering properties, and vice versa, if the CEC is low, the buffering properties are also low. [12] showed that the higher the C-organic content of the soil, the higher the CEC of the soil, but there was no relationship between high clay content and soil CEC.

Fig. 8 shows the relationship between the application of organic soil in EE solutions of types A and B in various concentrations. Both types of EE in some concentrations display similar pattern of decreasing pH. The pH of the EE solution containing soil organic matter will be higher than without organic soil. However, if the water solution is not added EE (0%), the addition of organic soil will lower the pH of the solution. This phenomenon can be explained by the contribution of organic acids that release H^+ from the organic soil.



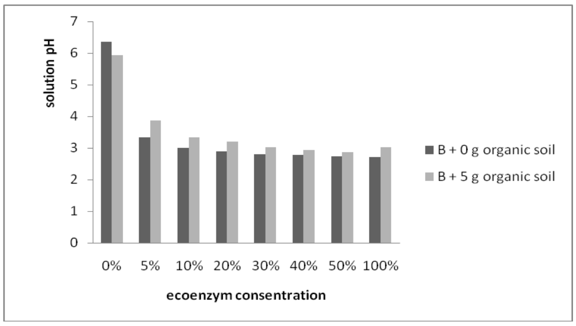


Fig. 8 Changing in pH of the EE solutions of types A and B at adding 5 g of soil organics

Fig. 9 shows the same as Fig. 7, although the type of EE is different. If viewed based on the kinds of EE, then type C (orange peel + banana peel + sweet star fruit) and type D (banana leaf + papaya leaf + orange peel + kale + carrot) have almost the same pH if without soil. The organic waste can contribute to acetaldehyde, ethanol, or succinic acid accumulation[13]; succinic, citric, malic, fumaric, tartaric, phenolic, vanillic, and ascorbic acid contents[14]. Malic acid has the highest content of organic acids. Orange peel flavonoid content; orange peel extract (OPE) had the highest content of polymethoxylated flavones, along with the greatest capacity to scavenge 2,2-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS), 2,2-diphenyl-1-picrylhydrazyl (DPPH), and 2,2′-azobis-2-methyl-propanimidamide, dihydro-chloride (AAPH) radicals and nitric oxide (NO)[15,16]. Banana peels may contain tannins, phenols, and flavonoids[17,18].

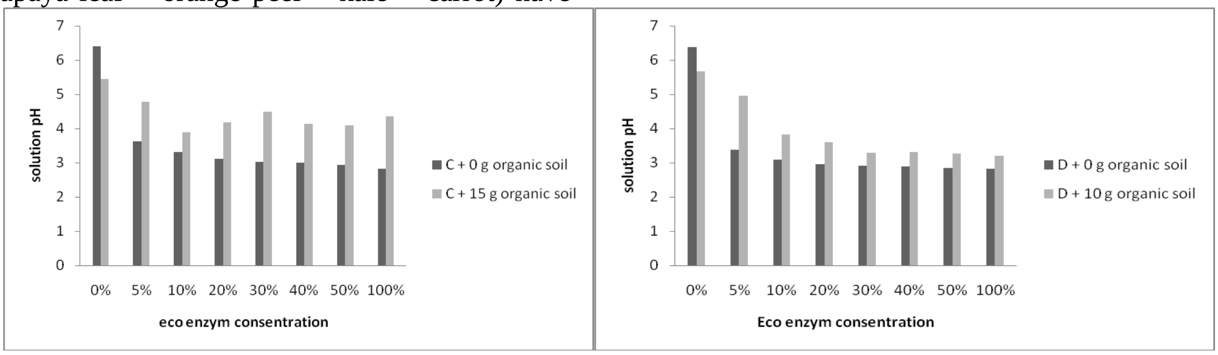


Fig. 9 pH of the EE solutions of types C and D at adding 15 g and 10 g of soil organics

The pH of EE solution will also increase as more soil is added to it. Even at the EE solution concentration of 5-100%, the pH of the solution was not significantly higher than that of the EE solution without soil if the soil was given 15 g. However, this is not the case if only 10 g of soil is applied; the pH of the EE solution is generally lower, and the difference between the pH of the solution without soil and the pH of the solution given 10 g of soil is negligible. What is unique is that it is different from the application of 15 g of soil organics, in the application of 10 g of organic soil the pH of the EE solution is almost the same if the concentration is 30-100%.

5 Conclusions

The EE solution concentration of 5% significantly lowers the pH of the water compared to a solution without EE, and the pH continues to decrease as the EE solution becomes more concentrated (100%). The more soil colloids are added to various types of EE solutions, the soil pH tends to rise, and the pH of organic colloids was higher than that of mineral colloids; this provided useful information when using EE solutions as liquid organic fertilizers in fields. The advantage of this study was that it is faster to obtain the results, but it must be tested further in the field. The application of EE solution as a liquid fertilizer is still safe against a decrease in soil pH and preferably the soil contains sufficient organic matter.

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