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The Utilization of Zeolite from Laundry Waste Processing as a Soil-zeolite Growing Media for Corn Plant

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ABSTRACT

Laundry waste containing detergent can release large amounts of Linear Alkylbenzene Sulfonate (LAS), as an active compound, and phosphates into the groundwater. One method for solving this problem is adsorption using natural zeolite. In this study, an innovation was made to utilize zeolite resulting from the processing of laundry wastewater as a growing media with soil for corn plants. The research methodology included activation of Bayah-Banten natural zeolite, adsorption process of LAS and phosphate from laundry waste by varying the contact time (0-60 minutes) and stirring speed (150-350 rpm), analysis of LAS and phosphate content, application of zeolite, obtained from waste treatment, as a soil-zeolite growing media for corn plants, and analysis of corn morphology (stem height, stem circumference and number of leaves). The results showed that the treatment of laundry waste using the adsorption method can reduce the concentration of LAS and phosphate in wastewater. The lowest LAS concentration was obtained at a stirring speed of 300 rpm and a contact time of 60 minutes, from 0.206312 mg/L (initial LAS) to 0.13747 mg/L (final LAS). The lowest phosphate concentration was obtained at a stirring speed of 350 rpm and contact time of 60 minutes, from 0.272184 mg/L (initial phosphate) to 0.06658 mg/L (final phosphate). The application of zeolite as a growing media with a ratio of soil and zeolite of 75:25 showed a good result in the morphology of corn plants, growth in stem height of 67.74% and stem circumference of 41.67%.

Keywords: *Adsorption, Corn, LAS, Phosphate, Zeolite*

1. INTRODUCTION

Nowadays, some people usually use laundry services because they do not have enough time to wash and iron their clothes. Laundry services usually use high concentrations of household detergent. Commonly, household detergents come from complex formulations containing more than 25 different ingredients. These materials can be categorized into several main groups such as surfactants (surface active agents), builders, bleaching agents, and auxiliary agents (additives). The most frequently used surfactants are Alkylbenzene Sulfonate (ABS) and Linear Alkylbenzene Sulfonate (LAS) which can cause some problems to the environment (Utami et al., 2013; Luo et al., 2023). One of the problems is water pollution from laundry waste containing detergents. Continuous utilization of detergent causes the release of large amounts of hazardous compounds into water and soil (Smulders, 2002; Ryu and Spuller, 2021). Another component contained in detergent waste with a high concentration is phosphate, where the presence of abundant phosphate ions in the water can cause eutrophication (uncontrolled plant growth) which results in environmental pollution (Aprianti et al. 2015; Devlin and Brodie, 2023).

One method that can be used for laundry waste treatment is the adsorption method using zeolite. Natural zeolite is a potential material for water and wastewater treatment. Compared with other adsorbent materials such as organic resins, zeolite has several advantages such as low price, excellent selectivity at low pressure, non-toxic cations which can be exchanged into the environment, easy operation and easy maintenance (Agustina et al. 2014).

Natural zeolite is an inorganic microporous mineral of volcanic origin with a highly regular porous structure consisting of SiO_4 and AlO_4 (Zorpas et al, 2012; Margeta et al., 2013). Zeolite can be applied in agriculture, especially to improve soil properties and as a fertilizer with a plant growth efficiency of around 7.5%. For long-term land use, the application of zeolite is very beneficial because zeolite does not damage the soil. Zeolite has a high cation exchange coefficient (CEC), a high ability to absorb ammonium ions, and a porous structure that can be used as a soil enhancer, especially in soils with low CEC (Sabilu, 2016).

Therefore, in this study, laundry wastewater was treated using zeolite to adsorb the LAS and phosphate contained in wastewater. The zeolite resulting from the processing of laundry wastewater was then used as a growing media with soil for corn plants. Zeolite from laundry wastewater processing under the best conditions was directly used as a growing media, with the hope that the LAS and phosphate contained in the zeolite become the additional nutrients in the soil. In this study, the growth of corn plants was identified through the morphology of the plant including stem height, stem circumference, and number of leaves. The morphology of the plant is influenced by the development of corn roots based on the depth and distribution, tillage, physical and chemical soil, soil water conditions and fertilization.

2. METHODS

2.1 Materials

The natural zeolite used in this study was obtained from Lebak Regency, Banten Province, Indonesia, which mainly contained Mordenite and Clinoptilolite. The zeolite was crushed using a mortar and sieved to obtain a particle size of 100 mesh. The chemicals used in this study were 6 M hydrochloric acid (HCl) and distilled water.

2.2 Zeolite Activation

The 100-mesh zeolite as much as 100 g was washed using 500 ml of distilled water while stirring with a magnetic stirrer for 2 hours. Then, the zeolite was separated and dried for 2 hours at 110 °C, then activated using 200 mL of 6 M HCl while stirring using a magnetic stirrer until homogeneous and kept for 24 hours. The zeolite was then washed and dried for 2 hours at 110 °C.

2.3 Adsorption of LAS and Phosphate

In the adsorption process, the contact time of the zeolite with wastewater and the stirring speed were varied. The amount of activated zeolite used was 20 g, while the volume of the laundry waste sample used was 1000 mL. The adsorption process was carried out by adding activated zeolite to the waste sample with a variation of stirring speed of 150, 200, 250, 300 and 350 rpm, and a variation of contact time of 40, 45, 50, 55 and 60 minutes. The authors chose variation in stirring speed and contact time because a previous study (Ramadhani and Kurniawati, 2021) reported that they were important factors in the adsorption process. After the adsorption process, the zeolite was filtered and dried. Meanwhile, the concentrations of the LAS detergent and phosphate in the solutions were analyzed using a UV-Vis Spectrophotometer.

2.4 Concentration of LAS and Phosphate analysis

The concentration of LAS and phosphate were analyzed using a UV-Vis spectrophotometer. The stock solutions of LAS with a concentration of 1000 ppm were prepared. From those stock solutions, a series of standard solutions of known concentration were measured at a wavelength of 652 nm to generate a calibration curve. After that, the sample solution of LAS was prepared. A 100 mL sample solution of LAS was added with 3-5 drops of phenolphthalein and also 1 N NaOH until the colour changed to pink. Then, 1 N H_2SO_4 was added drop by drop until the pink colour disappeared. After that, 25 mL methylene blue and 10 mL chloroform were added. The mixture was shaken for 30 seconds. Then the mixture will separate into two phases. The chloroform phase was collected to measure its LAS concentration at a wavelength of 652 nm.

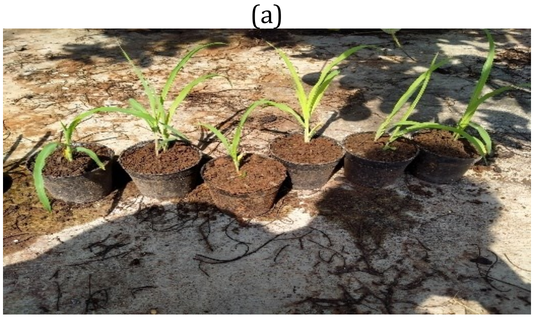
The stock solutions of phosphate with a concentration of 500 ppm were prepared. From those stock solutions, a series of standard solutions of known concentration were measured at a wavelength of 880 nm to generate a calibration curve. The sample solution of phosphate was also prepared by using a 50 mL sample solution. Into the sample solution, phenolphthalein was added drop by drop until the colour changed to pink. Then 5 N H_2SO_4 was also added drop by drop until the pink colour disappeared. The sample was measured at a wavelength of 880 nm.

2.5 Application of Zeolite for Mixed Growing Media

The dried zeolite from the adsorption process was applied as a growing media with soil for corn plants with variations in the mass ratio of red soil without fertilization and zeolite of 100%:0%, 95%:5%, 90%:10%, 85%:15%, 80%:20% and 75%:25% with a total mass of 500 g. The same variations were also applied to the soil with the addition of 1 g of NPK fertilizer in 1000 mL of water. Observations were conducted every 5 days for 20 days.

As a base, the corn plants used were saplings as high as 10 cm. The corn plants were divided into two major groups, corn plants with a soil-zeolite growing media without the addition of NPK fertilizer, and corn plants with a soil-zeolite growing media with the addition of NPK fertilizer (Fig. 1).

(a)



(b)

Fig. 1. Initial Conditions of Corn Plants (a) With NPK, (b) Without NPK on day 0

3. RESULTS AND DISCUSSION

3.1. Adsorption Process for Laundry Waste Treatment

In this adsorption process, the parameters to be considered were the stirring speed and contact time. The effect of stirring speed on decreasing LAS concentration is shown in the Fig. 2.

Based on Fig. 2, the adsorption process occurred well along with a long contact time. Meanwhile, for the aspect of the stirring speed, by increasing the speed, the adsorption process becomes more optimum. In the adsorption process, the stirring speed aims to speed up the contact between the LAS and the zeolite surface so that the adsorption process can take place more quickly. In this study, a variation in the stirring speed was investigated. If the stirring speed was slow, the adsorption process was also slow, but if the stirring was too fast, the adsorbent structure was quickly damaged, so the adsorption process was not optimal.

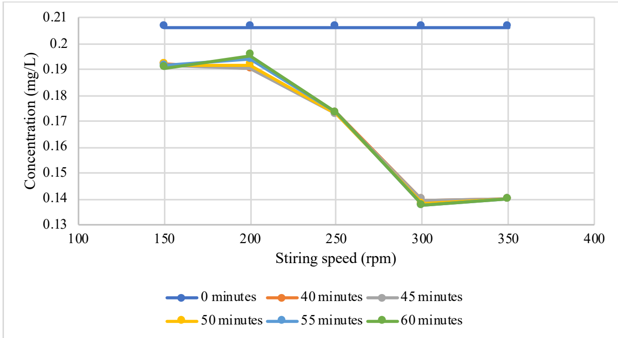


Fig. 2. Effect of Stirring Speed on LAS Concentration in Wastewater

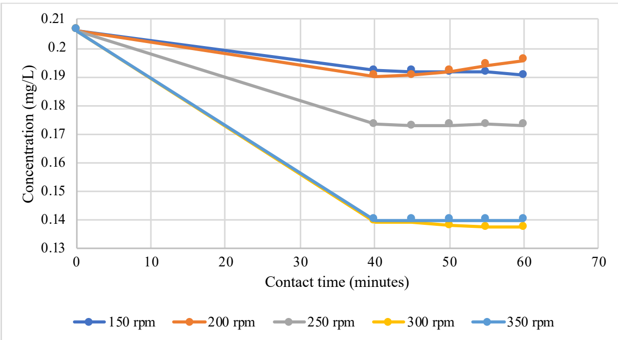


Fig. 3. Effect of Contact Time on Decreasing LAS Concentration in Wastewater

The effect of contact time on decreasing LAS concentration is shown in Fig. 3. Based on Fig. 3, the LAS concentration decreases significantly with the increase in contact time. At the condition with a stirring speed of 300 rpm and contact time of 60 minutes, the concentration of LAS reduced maximally, from the initial concentration of 0.206 mg/L to 0.137 mg/L, with a reduction percentage of 33.37%. This result was achieved because by the increasing contact time between the adsorbate and the adsorbent, the more collisions occurred and then the more adsorbate was adsorbed (Putri et al., 2014).

The effect of stirring speed on decreasing the concentration of phosphate can be seen in Fig. 4. Based on Fig. 4, there was a decrease in the concentration of phosphate as the contact time changed. The stirring speed of 350 rpm can reduce the concentration of LAS maximally (or the optimum point) from the initial concentration of 0.272 mg/L to 0.067 mg/L, with a reduction percentage of 75.54%. Wirosoedarmo et al

(2019) stated that the stirring speed plays an important role in the adsorption process of atoms or molecules. The lower the stirring speed, the slower the adsorption process will be, but if the stirring speed is too high, the adsorbate will be released back into the solution (Sari et al., 2016).

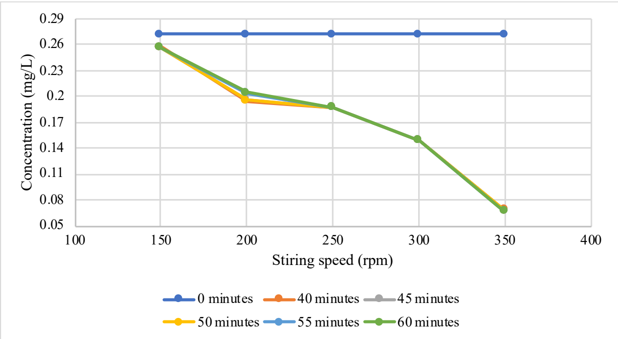


Fig. 4. Effect of Stirring Speed on Phosphate Concentration in Wastewater

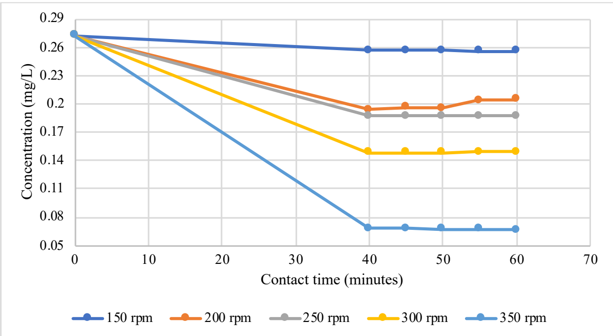


Fig. 5. Effect of Contact Time on Phosphate Concentration in Wastewater

The effect of contact time on decreasing the concentration of phosphate can be seen in Figure 5. Based on Fig. 5, there was a less significant decrease in the phosphate concentration as the contact time changed. The contact time of 60 minutes can reduce the LAS concentration maximally (or the optimum point) from the initial concentration of 0.272 mg/L to 0.067 mg/L, with a reduction percentage of 75.54%. The results presented in Figure 5 show that the adsorption equilibrium time to reach the maximum adsorption of phosphate was 60 minutes. In the first 40 minutes, the phosphate anions were adsorbed only in a small amount. Furthermore, the adsorbed phosphate anions increased quite high at minute 45 and slightly increased at minute 50, then the amount of adsorbed phosphate increased significantly until it reached the optimum time (minute 60). After reaching the optimum time and equilibrium, the amount of adsorbed phosphate anions was constant (Wirosoedarmo et al., 2019).

Based on the results, the optimum conditions in the adsorption process of LAS using zeolite were the stirring speed of 300 rpm and contact time of 60 minutes, resulting in a removal percentage of 33.37%. Meanwhile, optimum conditions in the adsorption process of phosphate were the stirring speed of 350 rpm and contact time of 6 minutes, resulting in a removal percentage of 75.54%. However, a previous study (Ramadhani and Kurniawati, 2021) reported that the optimum conditions in the adsorption process of Methylene Blue Dyes Using Longan Shell (Euphoria longan L.) were the stirring speed of 200 rpm and contact time of 150 minutes. The different findings were caused by the difference in adsorbents and pollutants.

3.2. Application of Zeolite from Laundry Waste Processing as Media for Corn Plants

Observation of corn plant growth focused on three parameters, stem height, number of leaves, and stem circumference. The results of the observations showed quite fertile growth in corn plants from day to day. The differences in stem height, number of leaves, and stem circumference of each plant were quite significant.

Fig. 6. Growth of Corn Plants on Day 5

The effect of adding zeolite to the growing media on the growth of corn plants on day 5 can be seen in Fig. 6. After 5 days of planting the corn plants, it can be seen in Fig. 6 that the corn plants started to grow. The group of plants that were given NPK fertilization (b) looked fresher than the group without NPK fertilization (a).

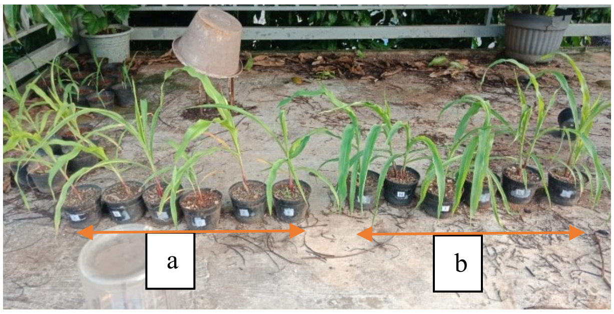


Fig. 7. Corn Plant Growth on Day 10

The increase in stem height was increasingly visible on the 10th day of observation as shown in Fig. 7. In addition, the number of leaves also increased. The leaves of the plants also began to show a yellowish colour. The yellowish colour of the leaves was more obvious in the plant group without fertilization (a) because the plants in the group without NPK fertilization lacked nitrogen. The leaves in this group turned yellow due to a lack of chlorophyll (Pohan et al., 2016).

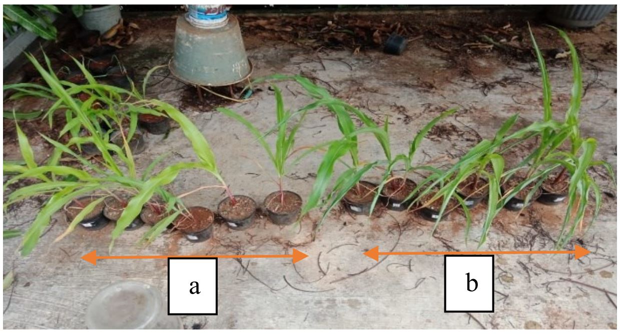


Fig. 8. Growth of Corn Plants Day 15

Stem height continued to grow after 15 days of observation as shown in Fig. 8 because the plants were still receiving the element of Phosphorus (P) which is a constituent component of several enzymes, proteins, ATP, RNA, and DNA and the element of phosphorus was obtained from phosphate which was absorbed by the zeolite during the adsorption process. In this observation, the leaves of some corn plants began to fall because the plants were increasingly deficient in nitrogen so the yellow leaves then fell (Pohan et al., 2016). The yellowish colour was also seen more clearly in the group of plants without NPK fertilization and looked less fresh.

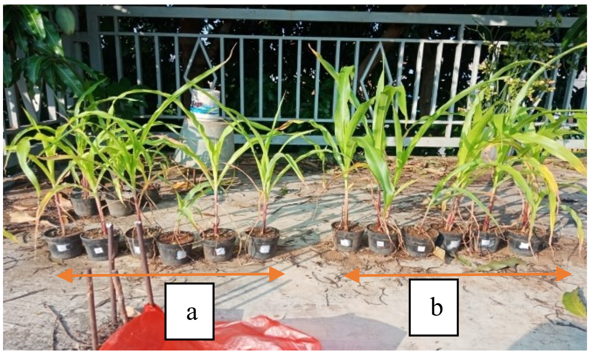
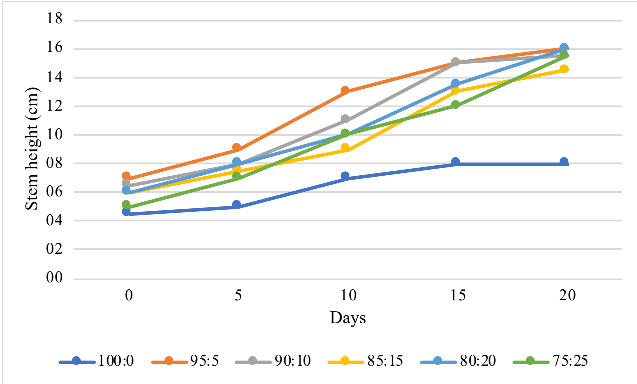


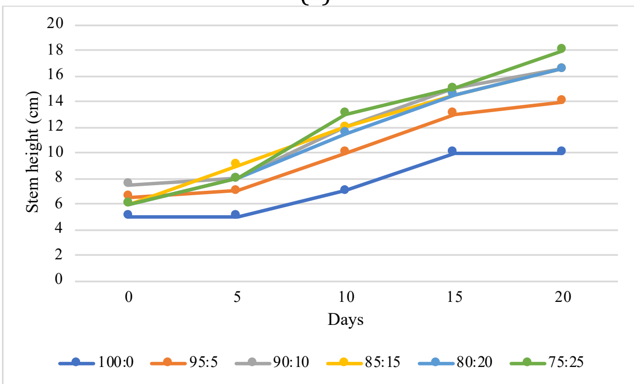
Fig. 9. Growth of Corn Plants Day 20

On the 20th day of observation, the height of the corn stalks increased rapidly. The leaves also experienced a rapid increase in number and width as shown in Fig. 9. Significant differences were also very visible in the plants that were given the addition of zeolite and NPK fertilization (b).

The height of the stems of each corn plant was measured and the results are shown in Fig. 10. Based on plant samples A (soil without zeolite) and G (soil without zeolite and with NPK fertilization), it was seen that there was no significant increase in stem height when compared to other plant samples using a soil-zeolite growing media. It showed that the addition of zeolite to the growing media has a good effect on plant height because the zeolite used was zeolite from laundry waste processing, which already contained phosphate. The phosphate was needed by plants for cell formation in growing root and shoot tissues (Subekti et al., 2007). In addition, zeolite can help bind nutrients in the soil, functioning as nutrients for plants.



(a)



(b)

Fig. 10. Height of Corn Stem (a) Without NPK, (b) With NPK

The difference in the increase in plant height can also be seen between the plant group with fertilizer and the plant group without fertilizer. The increase in plant height was seen to be more significant in the group of plants with fertilizer compared to the group of plants without fertilizer. This showed that the addition of fertilizer had a good effect on the growth of stem height because the addition of fertilizer enriched the nutrients needed by plants to grow so the plants could grow well. The difference in the height of the stalks of the corn plants was caused by the intake of the P element which was absorbed differently by each plant. The presence of the P element served as energy storage and transfer for all plant metabolic activities so the presence of the P element accelerated the growth and development of root tips and growing points in plants, as well as strengthened stems so they did not collapse easily and increase absorption at the start of growth.

The number of leaves of each corn plant was measured and the results are shown in Figure 11. Based on Fig. 11, it can be seen that there was an increase and decrease in the number of leaves on certain days. The addition of the number of leaves occurred on the 5th and 10th days of observation. This was because the nutrients absorbed by corn plants were sufficient for leaf growth on corn plants. However entering the 15th day of observation, it was seen that there was a reduction in the number of leaves, which was caused by a lack of intake of nutrients, especially nitrogen (N). For groups of plants using NPK, this happened because fertilization was only done on day 0. This showed that the nutrients needed by corn plants were very important for the growth process.

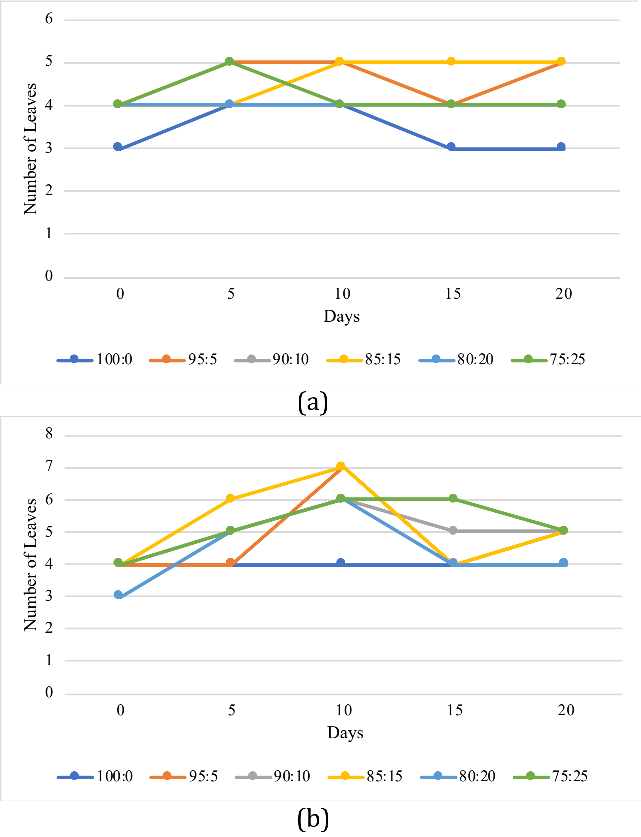


Fig. 11. Development of the Number of Corn Leaves (a) Without NPK (b) With NPK

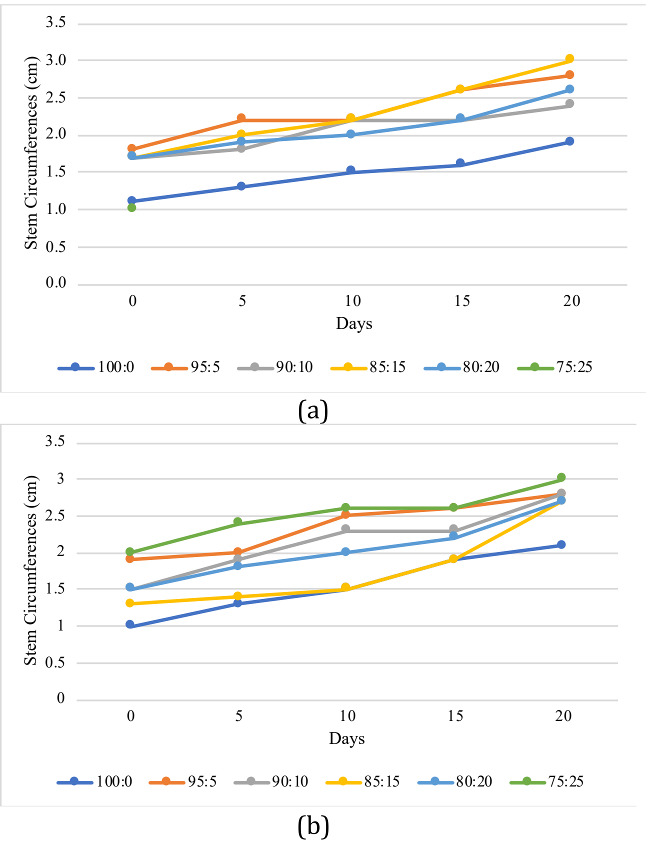


Fig. 12. Graph of Corn Stem Circumference (a) Without NPK, (b) With NPK

The stem level of each corn plant was measured and the results are shown in Fig. 12. Based on Fig. 12, the group of plants with fertilizers had a more significant stem circumference growth compared to the group of plants without fertilizers. This result was in line with a study by Mamonto (2005) reporting that NPK fertilizer was needed by plants to stimulate plant stem diameter enlargement (Liferdi et al., 2010). Purbayanti et al. (1995) also stated that N and P elements would be formed into proteins, carbohydrates, and nucleic acids which were used for plant growth, which would later be translocated by K element (Mamonto, 2005). Thus, a deficiency of K nutrients in plants will affect the development of stem diameter. In addition, proteins, carbohydrates and nucleic acids formed by nutrients N and P cannot be translocated properly.

Element K played a role in facilitating the process of photosynthesis and helped the formation of proteins and carbohydrates. The good photosynthesis process supported the formation of carbohydrates so that there was an increase in the formation and development of new cells which ensured good growth in stem height, stem circumference and leaves. Enlargement of the stem occurred because nutrients were present in sufficient quantities, causing the metabolic activity of the plant to increase.

A deficiency of the K element can cause delays in the process of enlarging the stem circumference. The stem circumference in plant A (plant without NPK or zeolite) experienced stunted growth due to the lack of the K element. The plant of G that was given fertilizer experienced better stem circumference growth compared to the plant of A due to the addition of NPK fertilizer.

4. CONCLUSION

Based on the research data and the objectives of this study, the following is obtained:

1. The laundry waste treatment process using the adsorption method using natural zeolite can reduce LAS and phosphate concentrations in wastewater. With this method, the lowest LAS concentration was obtained at a stirring speed of 300 rpm and contact time of 60 minutes, from an initial concentration of 0.206 mg/L to 0.137 mg/L, with a reduction percentage of 33.37%. The lowest phosphate content was obtained at a stirring speed of 350 rpm and contact time of 60 minutes, from an initial concentration of 0.272 mg/L to 0.067 mg/L, with a reduction percentage of 75.54%.
2. The application of zeolite from the laundry waste treatment which was used as a soil-zeolite growing media showed good growth results for corn plants in the addition of stem height, stem circumference, and number of leaves.
3. Observations on plant morphology showed that the growing plant from a mixture of red soil and zeolite with a composition of 75:25 gave good growth of stems with a growth percentage of stem height of

67.74% and stem circumference of 41.67%, but not good enough on leaf growth. Meanwhile, the growing media with the addition of NPK fertilizer provided good growth for stems and leaves.

4. The experiment about the effect of the mixture of red soil and zeolite on the nutrient contents (carbohydrate, protein, and lipids) should be carried out in the future.

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