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Research article

The Effectiveness of Reducing Ammonia Content Using Phytoremediation Methods in Domestic Waste of Pelita Bangsa University

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Abstract
Pelita Bangsa University is a private university with an increasing number of students every academic year. The increase in the number of students causes an increase in the amount of domestic waste generated. This study aims to determine the effectiveness of reducing Ammonia content in Pelita Bangsa University Domestic Waste by phytoremediation method using Apu Wood (Pistia stratiotes L.) and Kana Flower (Canna Indica) as well as the use of coffee grounds as activated carbon. The first step in this research is the manufacture of activated carbon from coffee grounds. The next step is to take samples of the Pelita Bangsa University domestic waste test. The test samples were brought to the laboratory, and the Ammonia parameter was tested to determine the initial concentration of the waste. Then the next step is the acclimatization process of plants and then continued with the Range Finding Test process. After that, the waste treatment process is carried out with a phytoreactor. Furthermore, the waste from the phytoreactor processing is taken to the laboratory for testing the ammonia parameters. The last step is to analyze the test results data. Based on the results of laboratory tests, the ammonia content after the phytoremediation process with and without a filter is <0.1 mg/L with the effectiveness of reducing the ammonia concentration by 97.10% with the addition of coffee grounds activated carbon filter and 96.7% for the use of the phytoremediation method without filters.

Keywords: ammonia, phytoremediation, domestic waste

1. Introduction

The number of cases of environmental pollution, especially water pollution in developing countries such as Indonesia, has resulted in various severe symptoms and must be dealt with immediately. The cause of pollution does not only come from industrial waste. However, it can also come from the results of domestic activity waste originating from households, trade, schools, offices, and similar facilities and disposing of the domestic wastewater without prior treatment into the environment. Then, on the other hand, as the population increases and the development of an area can cause an increase in the amount of domestic waste produced. Higher education is an educational institution that carries out the tri dharma, namely education and teaching, research, and community service. In carrying out the tri dharma, all activities carried out by the academic community can produce domestic waste. Domestic waste generated comes from soapy water and fecal water. One of the growing universities is the private university of Pelita Bangsa University, located in the Bekasi Regency. Pelita

Bangsa University has an area of 21,103 m2 consisting of two main buildings. Pelita Bangsa University is overgrowing, which means that the university has an increasing number of students every academic year. The increase in the number of students can lead to an increase in the amount of domestic waste produced. Currently, Pelita Bangsa University, in processing domestic waste, has a WWTP. Previous research on domestic waste treatment has been carried out by Nurhidayanti & Ardiatma (2020), which states that the use of phytoremediation methods with apu wood and kana flowers with activated charcoal filters from coffee grounds can reduce TDS by 98.20%, TSS by 98.20%, pH of 0.39% and Biological Oxygen Demand of 76.04%.

The Wastewater Treatment Plant (IPAL) building, owned by Pelita Bangsa University, uses a submerged biofilter technology process. The principle of this submerged biofilter technology process is to drain domestic wastewater into a biological reactor equipped with a buffered media. Aerobic or anaerobic processes can carry out this process. In the aerobic process, oxygen is needed using aeration used to decompose organic substances, while in the anaerobic process, it does not require oxygen (aeration) to decompose organic substances.

According to Saputro's (2016) research, phytoremediation by utilizing apu wood as a biofilter in hospital wastewater can reduce ammonia levels by 97.323% by using eight plants of apu wood in 15 liters of wastewater. Then in Choirunisa's research (2020), the highest efficiency in reducing iron (Fe) content with the phytoremediation method was obtained at 80.64% using eight apu wood plants and eight papyrus plants. Hydroponic phytoreactors can optimize the performance of wastewater treatment plants (WWTP) in reducing ammonia content by adding the percentage of ammonia removal on the 7th day using lettuce plants 18.72% and using kale plants by 20.17% (Hendriarianti & Ratna, 2018). Medusa's research (2017) showed that phytoremediation using Jirangau plants and being given aeration was more effective than without aeration, which reduced ammonia levels by 99.49%. Research on the phytoremediation process using kana flower and apu wood with an activated carbon filter has also been carried out by (Nurhidayanti & Ardiatma, 2020) with the effectiveness of reducing TDS parameters by 98.20%, TSS parameters by 98.20%, pH parameters by 0, 39%, Biological Oxygen Demand parameter is 76.04%. Oil and the fat parameter is 0%. Baryatik et al. (2016) has also carried out the use of activated carbon from coffee grounds as an adsorbent, with the results that it can reduce the total chromium metal (Cr) content in batik wastewater. Based on the results of previous studies, researchers tried to combine phytoremediation methods using Kayu Apu and Bunga Kana plants and using coffee grounds as an ingredient in making activated carbon filters. This phytoremediation method requires low cost and can beautify the campus environment.

This study aims to determine the effectiveness of reducing Ammonia content in Pelita Bangsa University domestic waste using phytoremediation methods using apu wood and kana flower plants and coffee grounds as activated carbon. The formulation of the problem in this study focuses on how effective the apu wood and kana flower plants are in reducing the ammonia content with the phytoremediation method using an activated carbon filter and without using an activated carbon filter. Researchers hope this research can provide benefits and dedication to treating domestic waste at Pelita Bangsa University to meet environmental quality standards according to applicable regulations.

2. Materials and Methods

2.1 Materials

There are four main parts of the tools needed in this research. In the first part, a tub measuring 550 mm x 360 mm x 300 mm with a volume of 50 liters is used as a container for domestic liquid waste, which is connected to a PVC pipe with a diameter of 2/3 inch and is equipped with two pumps with a speed of 500 liters/hour. The second part is an activated carbon filter tube made of cans measuring 173 mm x 142 mm x 240 mm with a volume of 6 liters which contains three layers, namely on the top layer, there is activated charcoal carbon, in the middle layer, there is silica sand, and on the bottom layer, there is gravel. Then, in the third part, three reactor tanks are made of plastic measuring 550 mm x 360 mm x 300 mm with a volume of 50 liters. The three reactor tanks are used to grow the Apu Wood (Pistia stratiotes L.) plant, in which there is a 2/3 inch PVC pipe that is interconnected. There are ten reactor tanks made of plastic measuring 100 mm x 80 mm x 80 mm with 8 liters in the fourth part. This reactor tub is used to grow the Kana Flower (Canna Indica) plant, equipped with an 11 mm hose to connect the Kana Flower tub to the Kayu Apu plant tub, and is equipped with a faucet so that it can regulate the discharge to be issued.

After passing through the four sections, the domestic waste treated is returned to the first section of the tub using a 2/3 inch PVC pipe. In the middle of the pipe, a faucet lever is given to sample the results of domestic waste treatment. The equipment used in testing ammonia is following SNI 06.6989.30-2005). Researchers make tool designs as an illustration of the shape of the phytoreactor that will be used. The design of the tool and the series of phytoreactor equipment is presented in Figure 1 and Figure 2 as follows:

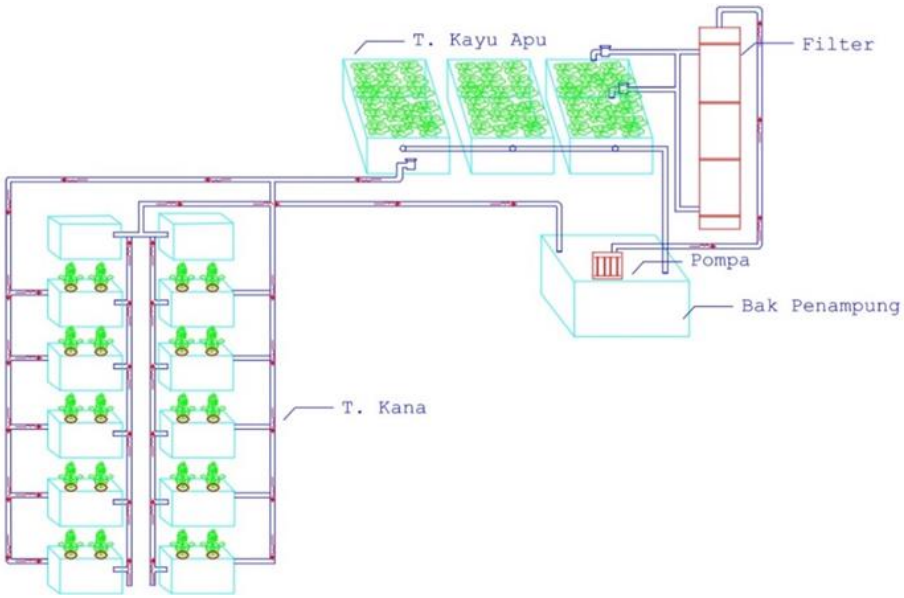

Figure 1. Design of a Domestic Waste Treatment System with Phytoremediation

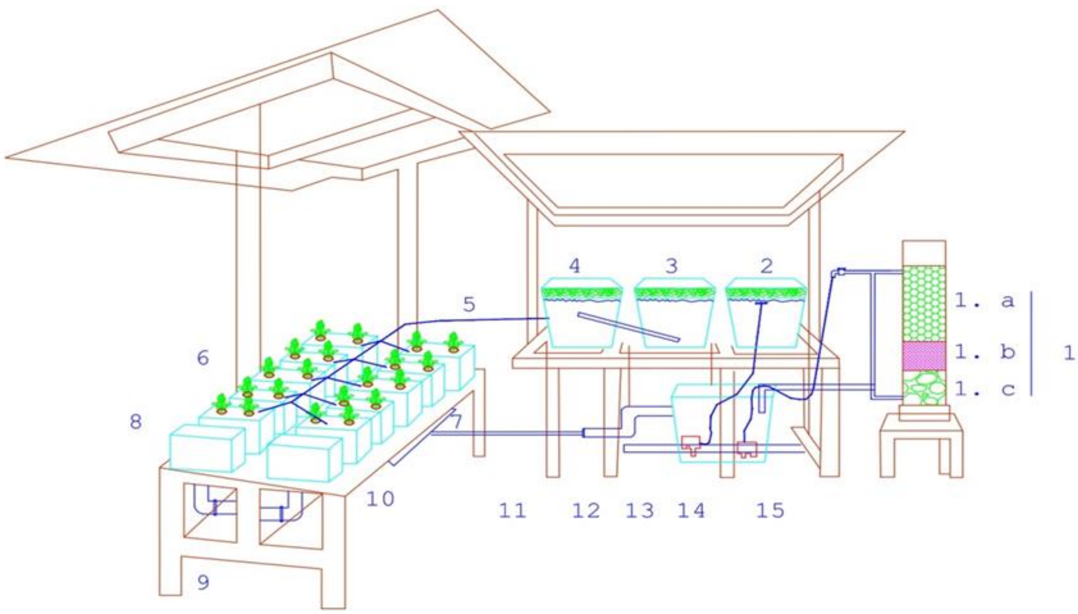

Figure 2. Phytoreactor Tool Circuit with Filter

The above set of equipment consists of:
(1) Activated Carbon Filter Tube consists of:
1a Activated Charcoal Carbon
1b Silica
1c Pebbles
(2) Apu Wood Plant Reactor l
(3) Apu Wood Plant Reactor ll
(4) Apu Wood Plant reactor tank lll
(5) Connecting hose
(6) Kana l Flower Plant Reactor
(7) Kana ll Flower Plant Reactor
(8) Body Control l
(9) Connecting pipe for Kana Bunga Flower Reactor Body

(10) Control Body ll
(11) Connecting pipe to Domestic Liquid Waste Tank
(12) Outlet Result Faucet
(13) Domestic Liquid Waste Container
(14) Pump to Apu Wood Plant Reactor Tub
(15) Pump to filter

The materials needed in this research include domestic waste from Pelita Bangsa University WWTP, apu wood plants (Pistia stratiotes L.), and kana flower plants (Canna Indica). The materials used for the filtration process include coffee grounds as raw material for activated carbon, firewood for the carbonization process of coffee grounds, 0.1 N HCl solution, and zinc chloride powder used to activate activated carbon from the coffee grounds. In addition, there are materials used for testing, namely for ammonia parameters using a Spectrophotometer following SNI 06.6989.30-2005 (Phenol, Sodium Nitroprusside, Sodium Hypochlorite, 95% Ethyl Alcohol and Alkaline Citrate Solution), for iron (Fe) parameters.) using ICP-OES by APHA 3120B Edition 23 the Year 2017 (Nitric Acid and Distilled Water).

2.2 Method

2.2.1 Activated carbon preparation

Coffee grounds are used as the primary ingredient for making activated carbon. The first step is to reduce the water content by drying the coffee grounds under the hot sun. After drying, the coffee grounds are carbonized by burning in a tin box at a temperature of ± 400 oC for 3 hours and then chilling. After that, the coffee grounds were ground and sieved through an 80-mesh sieve and then weighed. The next step is activating activated carbon for 24 hours in a 30% zinc chloride solution with a mass ratio of 2:1. A zinc chloride activator is used because it can dissolve impurities that cover the pores of activated carbon. Impurities that cover the pores of activated carbon can inhibit the adsorption process so that if the impurities dissolve, the carbon pores will become more open and become active (Manurung et al., 2019). After that, the activated carbon was washed using warm water at 80 oC for 20 minutes and using 0.1 N HCL solution at a ratio of 1: 1 for 20 minutes. The activated carbon washing step is carried out until no air bubbles are formed. The last stage is that the activated carbon is formed into a circle using a cloth.

2.2.2 Domestic Waste

The method of taking test samples is carried out using a combined technique of place and time. The test samples are taken from several points at the exact location, the same volume but at different times so that the test samples' results are taken, representative. The process of taking test samples was carried out following SNI 6989.59:2008.

2.2.3 Domestic Waste Sample Test

The testing process for this domestic waste sample is carried out at the Testing Laboratory of PT Medialab Indonesia, accredited by the National Accreditation Committee with the accreditation number LP-627-IDN. Parameters tested include parameters of Ammonia and Iron (Fe).

2.2.4 Plant Acclimatization

Apu (Pistia stratiotes L.) and Kana (Canna Indica) mature plants were planted in each reactor tank to ensure that both plants had adapted to the media to be used in the Range Finding Test (RFT) and phytoremediation testing. The acclimatization process is carried out for seven days.

2.2.5 Range Finding Test (RFT)

The Range Finding Test process is carried out to determine the critical limit of concentration. The Range Finding Test process uses five kinds of volume per volume (v/v) concentration between domestic waste and clean water. The concentration made includes a concentration of 10% (v/v) were from the total volume of 200 liters of water, 20 liters of domestic wastewater are needed, and the rest is clean water. Then the concentration of 20% (v/v) was from the total volume of 200 liters of water, 40 liters of domestic wastewater are needed, and the rest is clean water. Furthermore, 40% (v/v) concentrations were from the total volume of 200 liters of water, 80 liters of domestic wastewater are needed, and the rest is clean water. Then a concentration of 60% (v/v) was from the total volume of 200 liters of water, 120 liters of domestic wastewater are needed, and the rest is clean water.

Furthermore, the final concentration is 80% (v/v) were from the total volume of 200 liters of water, 160 liters of domestic wastewater are needed, and the rest is clean water. This process is carried out without an activated carbon filter and uses the same plants and phytoreactors in the acclimatization process. The concentration results of the Range Finding Test process that did not give a death effect on Kayu Apu (Pistia stratiotes L.) and Bunga Kana (Canna Indica) plants were then tested for parameters of ammonia and iron (Fe). Sampling was carried out in the afternoon on day 0, day 1, day 3, day five, and day seven as much as 2 liters.

2.2.6 Waste Treatment Process with Phytoreactor

This process is carried out after passing the acclimatization process and the Range Finding Test (RFT) to obtain the right concentration of domestic waste. This process is carried out using an activated carbon filter and using the same plants and phytoreactors in the acclimatization process, then adding domestic wastewater that has been prepared into the phytoreactor. After that, ammonia and iron (Fe) parameters were tested by taking 2 liters of test samples in the afternoon on day 0, day 1, day 3, day 5, and day 7.

2.2.7 Test Method

Ammonia testing on wastewater samples was carried out using the reference method of SNI 06-6989.30-2005. The results of laboratory tests were then analyzed using Microsoft Excel quantitatively. Equation one can calculate the effectiveness of domestic waste treatment using phytoremediator as follows (Maryana, 2020):

$$Efectivity(EF) = \frac{Co-Ct}{Co} x100\% \qquad (1)$$

Information:
EF = Efectivity (%)
Co = Initial concentration (mg/L)
Ct = Final concentration (mg/L)

3. Result and Discussion

3.1 Domestic Waste

Data from laboratory test results for WWTP Pelita Bangsa University domestic wastewater (before treatment with phytoremediation) has an ammonia concentration of 3.4 mg/L.

3.2 Plant Acclimatization Process

The purpose of the acclimatization process of apu wood (Pistia stratiotes L.) and kana flower (Canna Indica) is to adapt to their new environment to grow well. Plant acclimatization can be said to grow well. It can be seen from the physical condition of the plant, including the plant remains green and does not wither. The acclimatization process of this plant was carried out within seven days. According to Nurmalinda et al. (2018), plants must pass the acclimatization stage as an initial stage before the phytoremediation process is carried out. Then after passing the acclimatization stage, the plants that remained green and did not wither continued to the next stage, namely the Range Finding Test (RFT).

3.3 Range Finding Test (RFT)

RFT testing was carried out on wastewater samples with 20%, 40%, 60%, and 80% concentrations. The results of observations on Apu (Pistia stratiotes L.) and Kana (Canna Indica) plants showed that both plants could grow well at 80% v/v domestic waste concentration. This observation process was carried out for seven days. The results of the Range Finding Test (RFT) are shown in Figure 3.

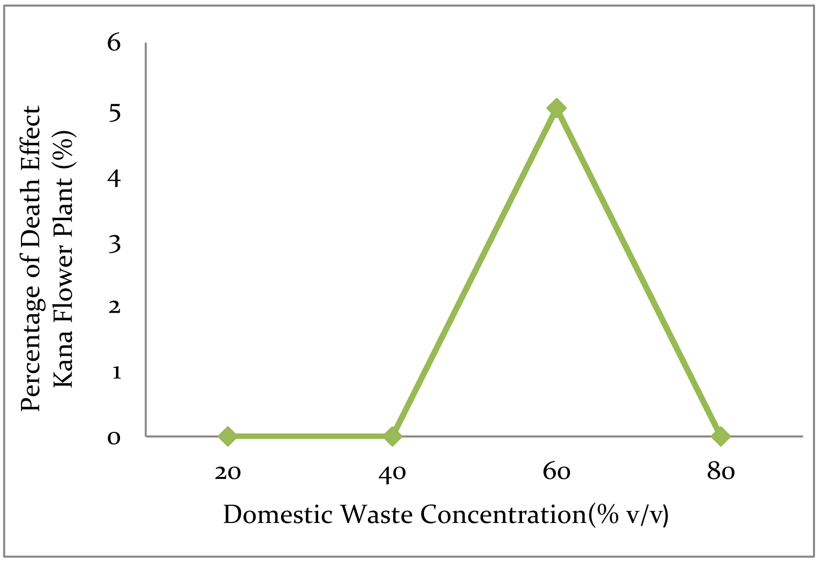

Figure 3. Graph of Domestic Waste Concentration on Mortality Percentage of Kana Flowers

Based on the picture above, it can be seen that the peak percentage of kana flower (Canna Indica) mortality of 5% occurred at a concentration of 60% (v/v) domestic waste. At a domestic waste concentration of 60% (v/v), the physical condition of the kana flower (Canna Indica) showed that the leaves were dry, yellowed, and withered. Then at a concentration of 80% (v/v) domestic waste, there was a drastic decrease in the percentage of deaths; namely, there were no deaths in kana flowers (Canna Indica). Plants can survive if they get proper and sufficient nutrition from domestic wastewater. Therefore, at a high concentration of domestic waste, namely at a concentration of 80% (v/v), the nutrients of the kana flower plant are sufficient, so there is no death in the kana flower (Canna Indica). This has been done by previous researchers (Nurhidayanti & Ardiatma, 2020); at a concentration of 80% v/v, there was no death in kana flowers (Canna Indica) because at high concentrations of domestic waste, there was the absorption of nutrients by kana flowers so that kana flowers can develop well.

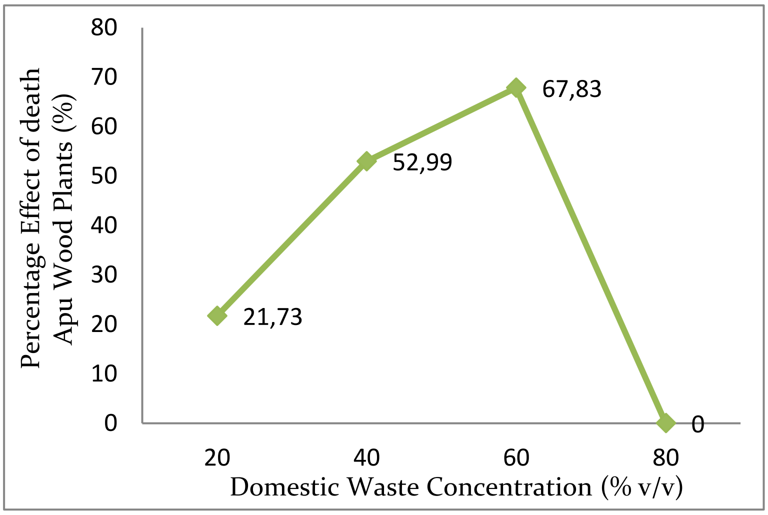

Figure 4. Graph of Domestic Waste Concentration to Percentage of Mortality of Apu Wood Plants

Based on the picture above, it can be seen that the percentage of mortality effect on apu wood (Pistia stratiotes L.) increased with increasing concentration. However, at a concentration of 80% v/v, a very drastic decrease was seen. A concentration of 20% v/v showed the percentage of death in apu wood (Pistia stratiotes L.) of 21.73%, then at a concentration of 40% showed an increase in the percentage of apu wood to be 52.99%. The peak percentage of death for apu wood (Pistia stratiotes L.) occurred at a concentration of 60% v/v, i.e., the mortality percentage was 67.83%. The death of apu wood plants can be seen from their physical condition. Changes in physical conditions in apu wood (Pistia stratiotes L.) are characterized by yellowing of the leaves and the tips of the roots turning black until some roots fall out (Choirunnisa, 2020). Then at a concentration of 80% v/v, there was a drastic decrease with no deaths in apu wood (Pistia stratiotes L.). This is due to the absorption of nutrients in domestic waste at high concentrations by apu wood plants. According to Putra (2017), the apu wood can effectively be used in the phytoremediation process.

3.4 Ammonia

The results of laboratory tests for ammonia parameters at a concentration of 80% (v/v) domestic waste are shown in Figure 5 as follows:

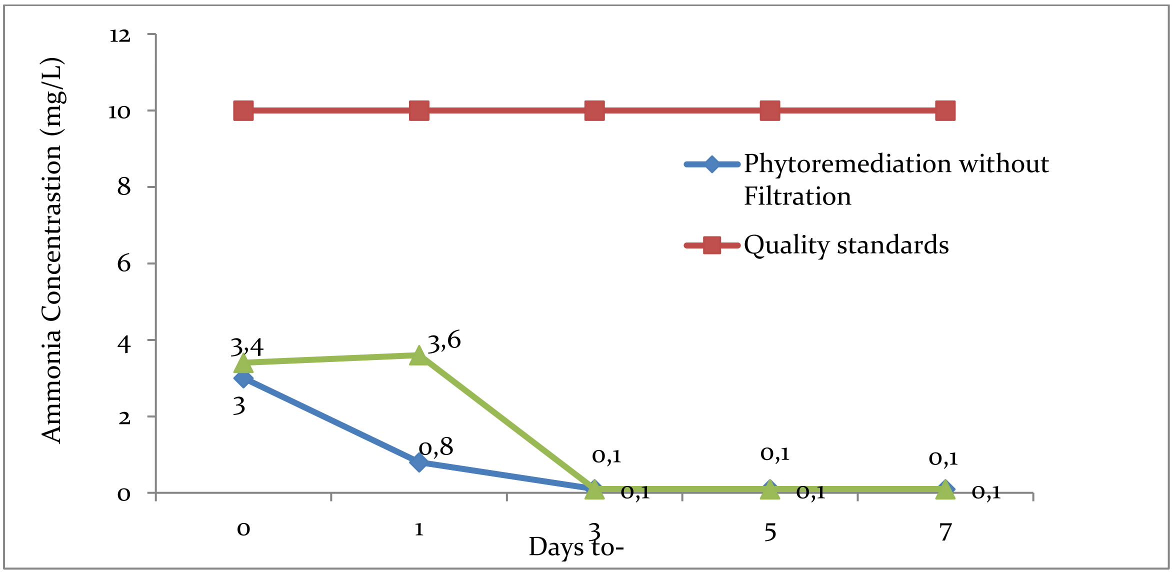

Figure 5. Graph of Ammonia Reduction Results during the phytoremediation process

Following the graph above, the ammonia content using a filter or without a filter decreased the concentration from the initial concentration of ammonia until the seventh day. Pelita Bangsa University WWTP domestic waste has an ammonia content of 3.4 mg/L. The initial ammonia content of 3.4 mg/L was due to the main source of ammonia coming from domestic activities such as fecal water and laundry wastewater. On day zero, the concentration of ammonia with a filter did not change, while the content of ammonia without using a filter decreased, so the concentration became three mg/L. On the first day, the ammonia content with the filter increased to 3.6 mg/l, while the unfiltered ammonia content decreased again; the concentration was 0.8 mg/L. However, on the second day, the ammonia content with filter and without filter both decreased. The ammonia content with the filter on the second day decreased quite drastically, from 3.6 mg/l down to <0.1 mg/L. Likewise, the unfiltered ammonia content decreased from 0.8 mg/L to <0.1 mg/L. On the 5th to the seventh day, the ammonia content with filter and without a filter was <0.1 mg/L, respectively. The laboratory tests for ammonia parameters before processing with phytoremediation and after processing with phytoremediation both with filters and without using filters still meet environmental quality standards that refer to the Minister of Environment Regulation regulation Number 68 of 2016.

The reduction in ammonia content tends to be higher without using a filter than using a filter. The ammonia content with the filter increased from day zero to day one, then decreased on day three to day seven. This is because activated carbon takes time to absorb the substances contained in the waste. According to Winoto et al. (2020), an adsorbent needs time to reach equilibrium in absorbing the pollutant load. Then on the 5th to the 7th day, the ammonia content with the filter did not increase, i.e., each concentration remained at <0.1 mg/L. This happens because the filter containing the activated carbon has worked optimally.

The lowest decrease in ammonia content with filter and without filter occurred on the third to the seventh day. According to Hendriarianti and Ratna (2018), this happens because the longer the plant contact time with wastewater in the phytoremediation process, the lower the ammonia concentration value. According to Sari et al. (2020), the more kana flower plants and apu wood plants develop, the more organic substances will be absorbed by plants, and microorganisms will degrade less organic substances. The less organic matter that is degraded by microorganisms caused the ammonia content to become lower. The cause of the high content of ammonia in domestic wastewater is the decomposition of organic substances by microorganisms because most of the presence of ammonia is produced from the decomposition of organic matter by microorganisms (Yuni et al., 2014).

3.5 The Effectiveness of Modified Phytoremediation Process Filters on Reducing Ammonia Content

The effectiveness of reducing ammonia content using the phytoremediation method with or without using a filter is shown in Figure 6. Following the diagram below, it can be seen that the effectiveness of reducing ammonia content with the filter modified phytoremediation method is 97.1%. In comparison, the effectiveness of reducing ammonia content without a filter is 96.7%. Based on these data, it can be concluded that the phytoremediation process with Kana Flower (Canna Indica) and Apu (Pistia stratiotes L.) plants modified by activated carbon filter from pulp is more effective in reducing ammonia content. This is also following previous research that stated that using the phytoremediation method with an activated charcoal filter from coffee grounds effectively reduced the ammonia content in wastewater (Saputra, 2016; Aman et al., 2018).

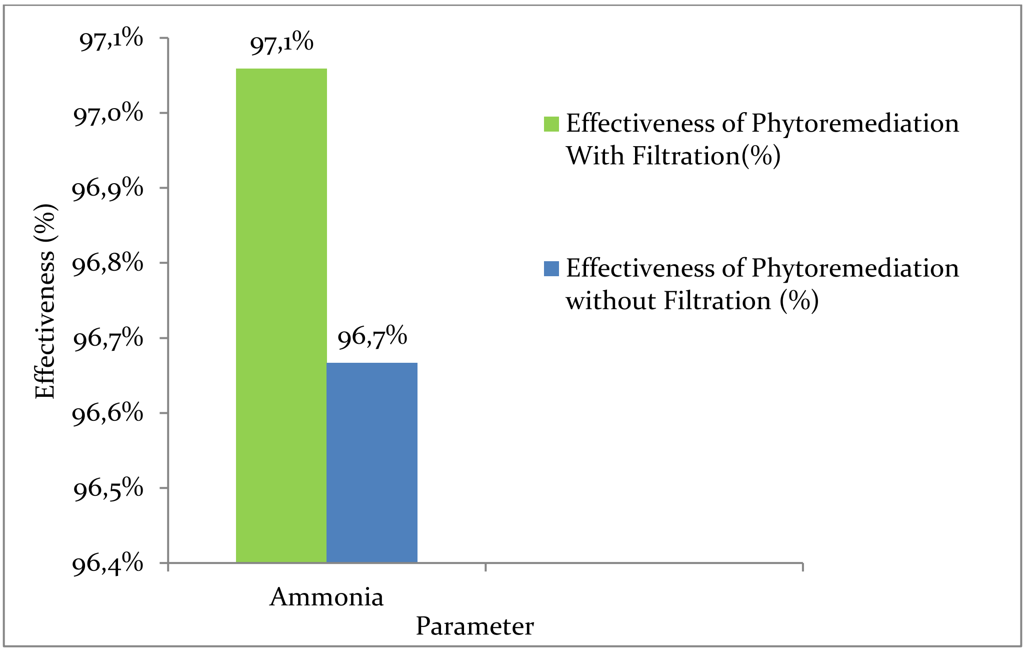

Figure 6. Comparison graph of the effectiveness of reducing ammonia using phytoremediation with and without coffee grounds activated carbon filter

4. Conclusion

The phytoremediation method using apu wood (Pistia stratiotes L.) and kana flower (Canna Indica) with activated charcoal filter from coffee grounds effectively reduces the ammonia content in domestic wastewater. Effectiveness of 97.1% while the method phytoremediation using apu wood (Pistia stratiotes L.) and kana flower (Canna Indica) without activated charcoal filter reduced ammonia 96.7%. The use of phytoremediation reactors (phytoreactors) can optimize the performance of Pelita Bangsa University WWTP in reducing Ammonia content. Further researchers can further investigate the effectiveness of other parameters such as detergent/MBAS parameters, phosphate, nitrate, heavy metals, and supporting parameters such as temperature, pH, and dissolved oxygen. Then this phytoremediation method needs to be further developed by changing the types of plants used, for example, water hyacinth, water jasmine, to find out how effective the phytoremediation method with different plants is reducing pollutant concentrations in wastewater.

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