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Research Paper

Reducing Ammonia (NH_3) Levels in Fish Cage Water Using Activated Carbon Adsorbent Derived from Purple Corn Cob

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Abstract
Successfully made adsorbent of activated carbon made from purple corn cob which aims to minimize ammonia (NH_3) levels found in water in fish farming with cage ponds. Activated carbon using carbonization method with a change in temperature that is between 550°C, 600°C, and 650°C and activation using Na_2CO_3 solution as activator. Activated carbon that has been obtained has exceeded the standard of SNI No.06-3730-1995, with characteristics including carbon yield ranging from 79.71% to 89.85%, moisture content ranging from 11.3% to 25.4%, volatile matter content ranging from 10.10% to 24.5%, ash content ranging from 9.7% to 9.9%, and fixed carbon content ranging from 65.7% to 79.7%. Then test results were obtained such as CO_2 functional groups were found to enhance the adsorption process. Activated carbon displays the presence of a predominantly amorphous structure but also revealed a crystalline carbon structure. The highest peak was obtained at 29.7° with Miller index (201). The activated carbon displays the presence of pores on the scattered surface with carbon elements dominating. Adsorption mechanism to reduce ammonia (NH_3) using activated carbon due to intermolecular interaction process. So that when testing the application for ammonia absorption, the best results were obtained in the sample with an adsorbent mass of 1.50 g at a carbonization temperature of 650°C with an adsorption capacity value of 546.34 mg/g and ammonia reduction of 82%. This research can open up opportunities for the potential development of new materials, especially for fish farming through cage techniques.

Keywords
Activated Carbon, Adsorbent, NH_3, Na_2CO_3, Purple Corn Cob

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1. INTRODUCTION

Water quality management in the context of fish Cage cultivation is a crucial element that significantly influences the health and productivity of fish. The quality of water tends to decline with continuous water usage, emphasizing the importance of maintaining water usage quality. With the development of the fisheries industry, a deeper understanding of the factors affecting water quality becomes increasingly important in efforts to achieve sustainable fish farming (Anggoro et al., 2021). Optimal water quality is key to supporting the maximum growth, development, and reproduction of fish. Therefore, the condition of the fish farming site should always be controlled and always meet the standard of livability in fish ponds.

Based on the quality parameters of fish Cage water consists of Temperature with a value of 28.1 ± 0.200 °C, NH_4 with a value of 0.800 ± 0.010 mg/L, NH_3 with a value of 0.51 mg/L, pH with a value of 7.54 ± 0.070, DO (mg/L), and Salinity with a value of 32%. From these parameters, it can be said that it has good quality for fish farming (Fayed et al., 2019). One factor that needs attention is the level of ammonia in fish Cages because it has a significant impact. Ammonia is harmful, and one of the dangers is that it can easily diffuse throughout biological cells, meaning it can easily enter the body (Liu et al., 2022). When ammonia interacts excessively with water, it increases the acidity of the water. Furthermore, the deposition of ammonia in the water can increase its nitrogen content, leading to increased eutrophication. High concentrations of ammonia can poison fish, especially above 25 ppm, and can also have adverse effects on human health. Fish harvest failure is one indication of a decrease in water quality due to neglecting the Cage as a cultivation medium (Ayesh and El-Muraikhi, 2023). The safe ammonia nitrogen level for marine aquaculture is recommended at 0.02 mg/L, while for freshwater aquaculture, the tolerable threshold is 0.2 mg/L (Cong et al., 2017). Ammonia levels can change drastically in fish cages, one of the reasons is the presence of water pollution such as the accumulation of

household waste in the river and illegal factory wastewater. So it is very dangerous for the sustainability of fish cage cultivation.

To try to prevent such problems, various efforts are made, such as regularly changing the water in the fish Cage, providing vaccination, and using adsorbents to reduce ammonia levels. The use of adsorbents is considered a solution because it is environmentally friendly, cost-effective, and easy to use. The development of adsorbent types such as carbon-based materials, chelating materials, zeolite, biological adsorbents, MOFs, and others is designed to effectively adsorb ammonia (Binaeian et al., 2021; Ruiz-Bastidas et al., 2023). Carbon-based activated carbon is widely used in energy storage, water splitting, and building materials because of its large surface area, high pore volume, remarkable adsorption performance, varied chemical stability, and advantageous functional groups. Even though there are many different carbon-based materials that may be used to produce activated carbon, large-scale applications need a substantial initial expenditure. As a result, there is increasing interest in investigating unusual and reasonably priced sources, such industrial and agricultural waste (Shahrokhi-Shahraki et al., 2021).

Carbonization and activation are the two primary processes in the creation of activated carbon. Carbon-containing organic substances go through pyrolysis during the carbonization process, which releases non-carbon components as volatile chemicals, forms holes, and produces a solid product that is rich in carbon. Producing a material with the essential fundamental pores and mechanical strength appropriate for activation is the primary objective of carbonization. The pore structure is strongly influenced by the temperature during carbonization. Too low of a temperature will result in a product with insufficient mechanical strength. However, an excessively high temperature can have a detrimental effect on pore development during activation, which will reduce the activated carbon's ability to adsorb water vapor. Consequently, the consequences of different carbonization temperatures more especially, those exceeding 500°C will be examined in this study (Sun et al., 2020).

Furthermore, the activation process is crucial to this process because it can start the combustion process that creates new pores in the carbon-rich material, which will eventually result in the production of a well-organized pore system. Physical and chemical activation are the two available techniques. Chemical activation techniques provide several benefits over physical techniques, including smaller activation temperatures, shorter activation times, simpler reaction control, and greater specific surface area. Because of their enormous potential for producing high-efficiency activated carbon, chemical activation techniques are thus still being explored (Sun et al., 2019).

In producing activated carbon with the assistance of chemical activation, an activator agent is required. These activator agents include acidic activators (such as H_3PO_4, H_2SO_4, HCl, and so on), basic activators (like KOH, $K_2B_4O_7$, and the like), and finally, neutral activator agents or salts (such as $ZnCl_2$, $FeCl_3$, and others) (Chiu and Lin, 2019). Therefore, this research will use a neutral activator agent, namely Na_2CO_3. Na_2CO_3 is chosen because it is less hazardous and can increase the volume of pores significantly. Tubers like Purple Corn Cob not only contain silica but also have a substantial carbon content (Hamid et al., 2022). Purple Corn Cob (PCC) is one of the wastes obtained in large quantities during corn processing and, until recently, has had limited value addition and minimal exploration. However, several studies have reported that this by-product contains phytochemicals that have beneficial effects on human health (Gullón et al., 2020).

There have been many studies on the manufacture of activated carbon as an adsorbent to remove (NH_3). But the use of acid catalysts is more dominated than salt catalysts because it forms a good activated carbon surface. This convinced the author to use gram catalyst which is safer to use and environmentally friendly. Then the use of raw materials such as Purple Corn Cob is still very minimal and has enormous potential for the development of adsorbent materials because it is very abundant to find, especially in Southeast Asia (Hamid et al., 2024).

The quality of fish farming using cages is highly dependent on the water conditions in the river and sea. This is very risky, especially if there is pollution of the water environment such as household waste disposal, especially the increase in ammonia levels. Several studies have been developed such as using environmentally friendly bio adsorbents made from solid waste that effectively reduce ammonia levels (Dey et al., 2021). Based on Afifi et al. (2023), activated carbon has been made for the application of removing ammonia in the flow of the Nile River with an adsorption capacity value of 96.4 mg/g. Therefore, this research focuses on the utilization of Purple Corn Cob as a raw material for activated carbon designed to have a high activated carbon yield value. Then the use of activated carbon as an adsorbent to reduce ammonia (NH_3) levels prioritizes environmentally friendly processes and preparations as evidenced by the use of Na_2CO_3 salt catalyst

2. EXPERIMENTAL SECTION

2.1 Materials and Instrumentation

Zea mays var. Ceratina Kulesh, or purple corn cobs, were acquired in Medan, Indonesia. Water samples with ammonia were collected at Langkat, Indonesia. Distilled water and sodium bicarbonate (Na_2CO_3, 6%, Sigma-Aldrich). Subsequently, employ instruments like the Hot Plate Stirrer, Oven, Mortar, Furnace, 300 mL Beaker Glass, Panalytical X-ray Diffraction, Hitachi FLEXSEM 100 Scanning Electron Microscopy, and Shimadzu Fourier Transform Infrared.

2.2 Methods

2.3 Preparation of Activated Carbon

The raw material used in the production of activated carbon is purple corn cob. The material is first crushed into a powder and dried in a crucible furnace for two hours at 350°C. The calcined maize is then pounded some more in a mortar and sieved through a mesh screen with a mesh size of 100. The next step is to weigh the predefined masses (1.50 g, 2.00 g, and 2.50 g).

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Using a 6% Na_2CO_3 chemical solution and a 1:4 impregnation ratio, the weighted samples are activated for a duration of 24 hours. After that, each activated sample is cleaned with distilled water to bring its pH level back to normal. After measuring the wet mass of the neutral pH samples, which takes less than an hour to dry in an oven at 100°C, the sample mass is calculated. Following calcination, the purple corn cob's carbon is carbonized for two hours at temperatures of 550°C, 600°C, and 650°C in an environment of inert gas (nitrogen gas) (Hamid et al., 2023). To get rid of impurity chemicals, the findings are next washed with distilled water (Pimentel et al., 2023). As shown in Figure 1, samples that show the greatest drop in ammonia (NH_3) levels throughout the ammonia adsorption process will be characterized.

2.4 Testing of Activated Carbon (AC) Parameters

To determine the standard of activated carbon, the formula is utilized:

2.4.1 Yield of Activated Carbon

To find the Yield of activated carbon can use Equation (1):

$$\text{Yield of activated carbon} = \frac{W_b}{W_a} \times 100\% \quad (1)$$

where:

W_a = initial weight of the carbon (g)
W_b = weight of dried carbon (g)

2.4.2 Moisture Content

To ascertain the moisture content, it is determined by comparing the initial weight of the carbon with the weight of the carbon after drying. Initially, it is measured to acquire the starting mass, registering at 0.690 g. Subsequently, it undergoes drying at a temperature of 100°C for a duration of 1 hour. The water content is subsequently determined through the application of the Equation (2):

$$\text{Moisture Content} = \frac{W_a - W_b}{W_b} \times 100\% \quad (2)$$

where:

W_a = initial weight of the carbon (g)
W_b = weight of dried carbon (g)

2.4.3 Ash Content

To establish the ash content, it is computed by comparing the initial weight of the dried carbon with the weight of the resulting ash. As a result, the initial weight is recorded at 0.690 g, and after the incineration process. The Ash content is subsequently determined using the following Equation (3):

$$\text{Ash Content} = \frac{W_e}{W_f} \times 100\% \quad (3)$$

where:

W_e = weight of the ash (g)
W_f = initial weight of dried carbon (g)

2.4.4 Volatile Matter Content

To determine the evaporation substance content, purple corn cobs are carbonized, then finely ground, sieved using a 100 mesh sieve, and activated. They are then weighed to obtain their initial mass, which is 0.690 grams. Afterward, they are oven-dried at a temperature of 100°C for 5 minutes. The Volatile Matter Content is subsequently determined using the following Equation (4):

$$\%\text{Volatile Matter Content} = \frac{W_c - W_d}{W_c - W_b} \times 100\% \quad (4)$$

where:

W_c = weight of dried carbon + empty crucible weight + cover (g)
W_d = weight residue + empty crucible weight + cover (g)

(Zakaria et al., 2021)

2.4.5 Fix Carbon Content

Fixed carbon (FC) content is subsequently determined using the following Equation (5):

$$\%\text{Fixed Carbon Content} = 100\% - (\%\text{Ash Content} + \%\text{Volatile Matter Content}) \quad (5)$$

2.5 Characterization

2.5.1 X-Ray Diffraction (XRD)

Testing for X-ray Diffraction (XRD, X'Pert 3 Powder, PANalytical) was done in the two-hour range of 30° to 90°. The crystal structure of activated carbon obtained from Purple Corn Cob following activation was verified using the XRD spectrum.

$$Qt = \frac{C_0 - C_t}{M} \times V \quad (6)$$

$$\%\text{Removal} = \left(\frac{C_0 - C_t}{C_0}\right) \times 100 \quad (7)$$

where:

C_0 =initial ammonia concentration (mg/L)
C_t =final ammonia concentration (mg/L)
V =volume of the detection system
M =mass of the adsorbent utilized in the experiment (g)

The equilibrium adsorption capacity (q_e) of the adsorbent is attained when the adsorption process reaches equilibrium under the specified conditions (El-Shafey et al., 2014).

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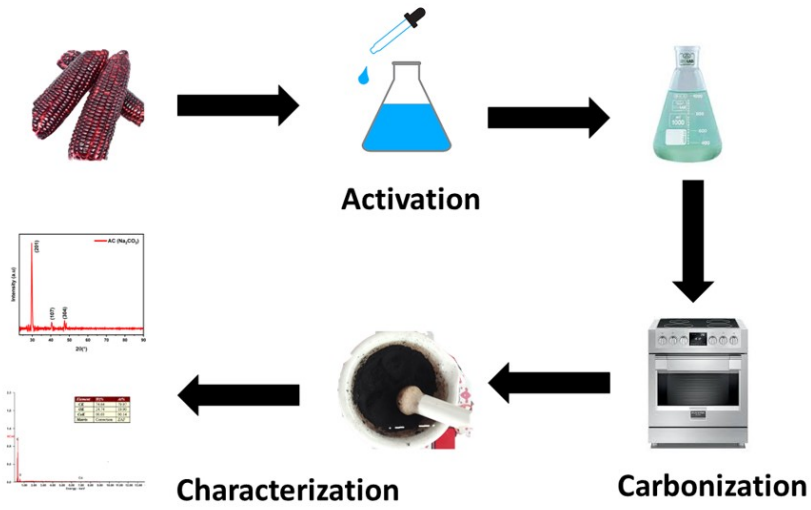

Figure 1. The Scheme of Activated Carbon Preparation

2.5.2 Scanning Electron Microscopy - Energy Dispersive X-ray (SEM-EDX)

SEM (Scanning Electron Microscopy) is a test used to visualize the microscopic properties of activated carbon derived from Purple Corn Cob. Additionally, SEM is equipped with EDX (Energy Dispersive X-ray) for investigating elemental mapping, operating at 15 kV, with the brand (SEM, HITACHI FLEXSEM 100).

2.5.3 Fourier Transform Infrared (FTIR)

Fourier Transform Infrared (FTIR, Shimadzu) at room temperature in the spectral region of 4000–400 cm^{-1}. The functional groups found in the activated carbon sample made from purple corn cobs are seen using the FTIR spectrum.

2.5.4 Adsorption of Mechanism

This study used an ammonia screening device (Sera Test, Sera device) to determine the decrease of ammonia (NH_3) as adsorbate. Three distinct types of samples were weighed at 550°C, 600°C, and 650°C the three different carbonization temperatures respectively. The weights were 1.50 g, 2.00 g, and 2.50 g for each temperature. After that, these samples were mixed with 1000 milliliters of ammonia (NH_3) that had been obtained from fish cage water, and they were agitated for 15 minutes at a concentration of 1 mg/L using a magnetic stirrer. The mixture was then filtered, and the amount of ammonia (NH_3) in the mixture was measured. Equations 6 and 7 were then used to calculate the adsorption capacity.

3. RESULTS AND DISCUSSIONS

3.1 Analysis of Activated Carbon Parameter

When making activated carbon, the criteria required are usually so that it can be said to be an activated carbon material according to the specifications outlined in Table 1.

Table 1. Activated Carbon Requirements SNI No.06-3730-1995

Requirements	Parameters
Moisture Content	± 15%
Yield of Actived Carbon	-
Ash Content	± 10%
Volatile Matter Content	± 25%
Fix Carbon Content	± 65%

From Table 1, there are several parameters such as Moisture Content, Ash Content, Volatile Matter Content, and Fix Carbon Content which are benchmarks in making activated carbon. Then in the results of making activated carbon from purple corn cobs, seen as follows in Table 2. In the results produced that each sample has met the requirements as mentioned in Table 1, so that the sample can be said to be activated carbon.

The yield of activated carbon as well as its different properties including its moisture, ash, volatile matter, and fixed carbon contents will be evaluated in this section. Equations (8), (9), and (10) illustrate the sodium carbonate activation pathway.

$$Na_2CO_3 + C \rightarrow 2CO + Na_2O \quad (8)$$

$$Na_2CO_3 \rightarrow CO_2 + Na_2O \quad (9)$$

$$Na_2O + C \rightarrow CO + 2Na \quad (10)$$

The presence of sodium in carbon causes the oxidation of interconnected carbon atoms and forms a slightly wrinkled, folded, or puckered shape. Then, here is an explanation regarding the results of testing the parameters of activated carbon (Hamid et al., 2023).

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Table 2. Result Parameter of Activated Carbon from Purple Corn Cob

Carbonization Temperature (°C)	Yield (%)	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)
550	89.8	25.4	9.7	24.6	65.7
600	85.5	16.9	9.8	20.2	69.9
650	79.7	11.3	9.9	10.1	79.9

3.1.1 Yield of activated carbon

The amount of activated carbon that was created was measured after the carbonization and oven drying phases. The yield of activated carbon attained by activation at various temperatures is shown in Figure 1. With the Na_2CO_3 activator, an active carbon yield of 79.7–89.8% was achieved (Lua, 2023). The yield of activated carbon obtained from Purple Corn Cobs reduces as the temperature of carbonization rises, from 500 to 650°C, in an inverse manner. The dissociation of steam or CO_2 indicates the presence of volatile components, which are produced at a high reaction rate between carbon and the activator chemical. Steam is more reactive than CO_2 during the activation process because it is considerably simpler to break the single hydrogen-oxygen link in water molecules than the double bond of carbon-oxygen (C=O). On the other hand, the greatest carbon burn-off occurs when steam and CO_2 are present at the same time (78.6%). The growth of the carbon structure is greatly impacted by the mix of steam and CO_2. The large size of CO_2 molecules is the cause of this phenomena because it breaks the char's outer layer and creates more active sites that allow steam to seep deeper into the carbon substance. This leads to the extraction of more volatile components that are confined inside the interior of the carbon (Zaini et al., 2023).

3.1.2 Moisture Content

Figure 2 displays the moisture content at different carbonization temperatures. When Na_2CO_3 was used as an activator, 11.3–25.4% of the generated activated carbon had moisture content. As the temperature of carbonization rises, the amount of moisture reduces due to the reduction in activated carbon pores. As a result, the activated carbon's hygroscopic qualities decrease. Because of the organic components in the pores, the moisture content of the raw material is lower than that of the activated carbon. The observed moisture content satisfies SNI 06-3730-1995's minimum 15% water content requirement for activated carbon quality criteria (Lv et al., 2020).

3.1.3 Ash Content

The ash content is shown in Figure 3 and shows that the ash content produced using Na_2CO_3 as an activator reaches 9.7–9.9%. The content of ash in activated carbon will increase with the rising temperature of carbonization. This finding suggests that higher carbonization temperatures impact the evaporation of certain volatile compounds within the particles. The ash content in the sample is affected by the silica content in the raw material, with higher silica content leading to increased ash content. Silica can obstruct the pores in activated carbon, thereby decreasing its surface area. Therefore, it is essential to perform carbonization on the sample at the appropriate temperature (Oladimeji et al., 2021).

3.1.4 Volatile Matter Content

The volatile matter concentration at different carbonization temperatures is displayed in Figure 4. The volatile matter content achieved with the Na_2CO_3 activator is then shown to be between 10.1% to 24.6%. The percentage of volatile matter reduces as the carbonization temperature rises, suggesting that higher carbonization temperatures promote greater non-carbon chemical breakdown in the activated carbon. This implies that low volatile matter content is the product of carbon burning and the creation of volatile matter. As temperatures rise, volatile stuff breaks down quickly until almost stable conditions are achieved. Since activated carbon is not greatly impacted by temperature, it may be seen to have good stability (Almahbashi et al., 2021).

3.1.5 Fixed Carbon Content

Figure 5 shows the fixed carbon content at various carbonization temperatures. Then, Figure 5 shows that the fixed carbon content obtained with Na_2CO_3 activator is 65.7–79.7%. Overall, fixed carbon content is the key parameter for determining the quality of activated carbon. For activated carbon to effectively and efficiently adsorb substances, it must have a high fixed carbon content. This is because fixed carbon consists of carbonaceous materials essential for adsorbing many adsorbates. The prepared adsorbent should have a fixed carbon percentage of at least 60%. Three factors affect the fixed carbon content: ash content, volatile matter, and moisture content of the activated carbon. Additionally, the fixed carbon content is influenced by the presence of materials such as lignocellulose, including lignin and cellulose, which can be modified in the raw material (Fito et al., 2023).

Based on the results obtained in the manufacture of activated carbon from Purple Corn Cob, when compared with other activated carbon materials such as Bambusa vulgaris striata with a carbon content value of 45%, and other materials as taken in Table 3. The results obtained are very good and can be recommended for further research development (Abelta et al., 2024).

3.2 Structure Analysis of Activated Carbon

An X-ray diffraction (XRD) structural investigation of purple corn cob is shown in Figure 3. Peaks at 29.7°, 40.4°, and 47.4° intensities, respectively, are associated with the Bragg

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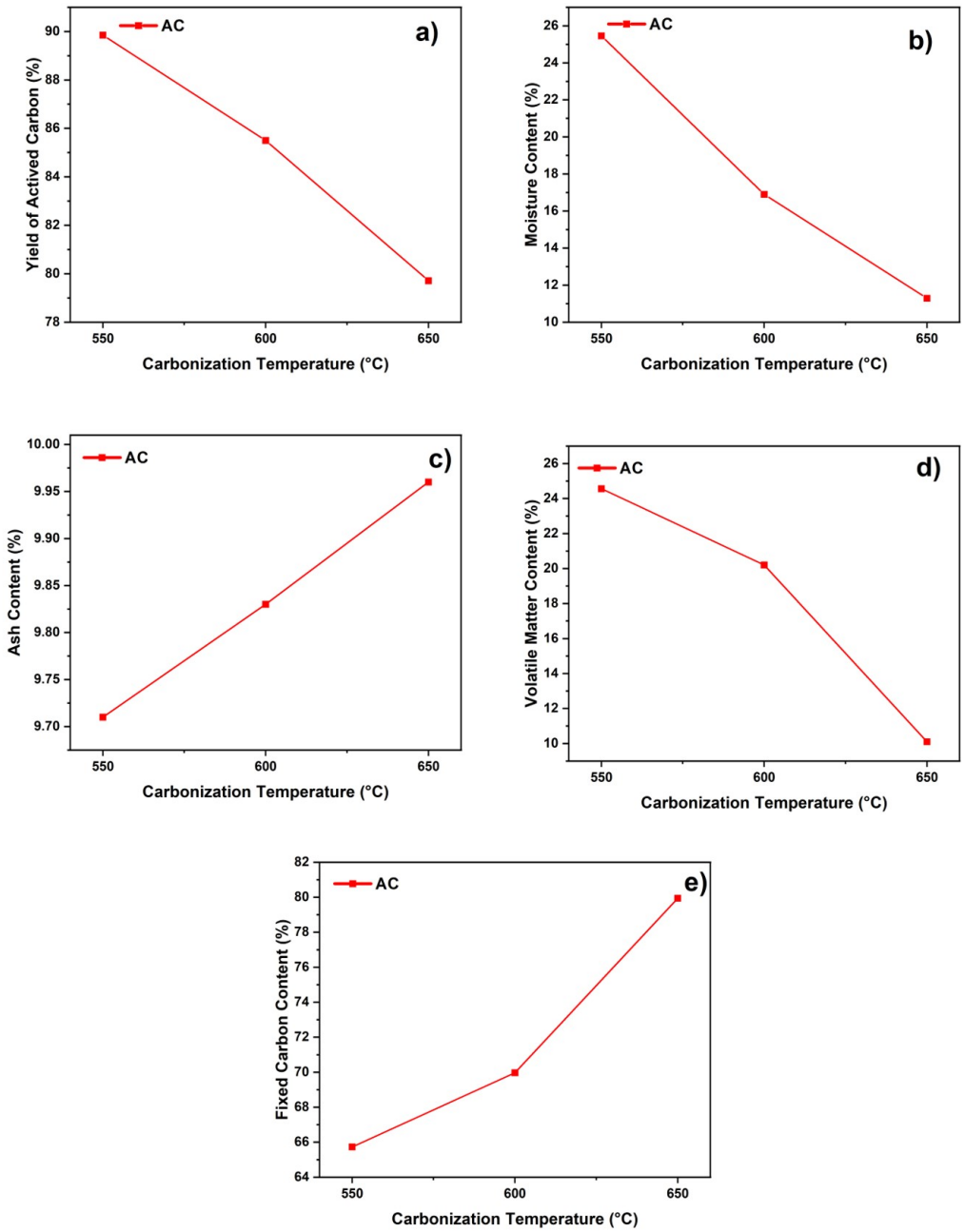

Figure 2. Effect Various Carbonization Temperatures at (a) Yield of Actived Carbon, (b) Moisture Content, (c) Ash Content, (d) Volatile Matter Content, and (e) Fix Carbon Content

reflection planes (201), (107), and (304), as reported in JCPDS 50-0926, suggesting the existence of a crystalline graphite structure. Changes in the crystalline structure result from the activation agent Na_2CO_3, which raises the carbon's surface porosity and adsorption capacity. The presence of this activation agent causes minor alterations in the activated carbon's XRD pattern (Ahmad et al., 2020). The characteristics of the activated carbon structure are also obtained from Figure 3, which includes the following values: micro strain (ε) = 0.24, dislocation (δ) = 4.92 nm^{-2}, interplanar d-spacing = 2.35 nm, and crystallite size = 0.74 nm.

3.3 Surface Morphology Analysis of Activated Carbon

SEM aims to analyze the surface of activated carbon shown in Figure 4. During the carbonization stage, the Na_2CO_3 activator will decompose to form carbon from sodium compounds; this

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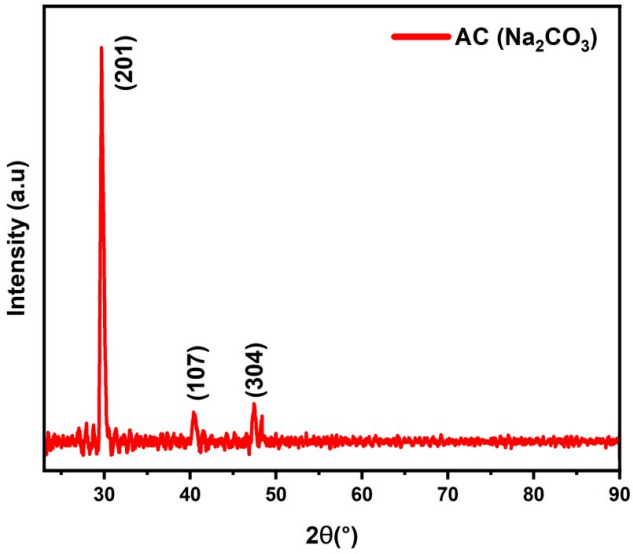

Figure 3. XRD Spectra from Activated Carbon with activation Na_2CO_3

Table 3. Comparison of Activated Carbon Manufacturing Results from Several References

Activated carbon	Carbon Content (%)	References
Bambusa vulgaris striata	45	(Mistar et al., 2020)
Platanus orientalis leaves	45.23	(Jiang et al., 2020)
Limonia acidissima shell	49.6	(Das and Mishra, 2020)
Exocarp of cocos nucifera (ECN)	22.49	(Anubriya et al., 2020)
Activated carbon from barley straw	45.4	(Pallarés et al., 2018)
Purple Corn Cob	65.7-79.9	This study

phenomenon can aid in the formation of pores and create good porosity. At high temperatures, pores are formed, and the mesoporous volume increases. In Figure 4, the morphology on the surface of activated carbon before 4(a) and after the activation stage is depicted 4(c). It shows an increase in pore formation and surface area, where Figure 4(c) has more pores compared to Figure 4(a) due to the activation process. This is affected by the presence of inorganic impurities that block the pores of the activated carbon (Zhang et al., 2020). Then based on Figures 4(b) and 4(d), the average particle distribution before activation with a value of 4.08 µm and after activation with a value of 6.34 µm. This occurs due to high temperatures making the pores in the sample to open and expand.

3.4 Elemental Analysis of Activated Carbon

Figure 5 shows the elemental analysis of purple corn cob analyzed using Energy Dispersive X-Ray (EDX). The EDX studies offered a quantitative analysis of the elemental composition in terms of weight percent and atomic percent. The results indicate that the primary element in activated carbon derived from purple corn cob is carbon (C). Figures 5(a) and 5(b) show the presence of elements C, O, and Co. Activated carbon is dominated by elements C and O, with Co elements relatively decreasing during the activation process. carbon elements dominate with a weight percent of 74.54% and an atomic percent of 79.97% which is then followed by oxygen elements with a weight percent of 24.74% and an atomic percent of 19.90%. The carbonization process creates numerous open pores, and the increased pores lead to an enhanced adsorption capacity of the adsorbent. During carbonization, high temperatures are generated, causing the biomass (organic carbon) to vaporize more readily than the carbon elements (Anita et al., 2023).

3.5 Functional Groups Analysis of Activated Carbon

The absorption approach, which depends on variations in the absorption of infrared light, is employed in this FTIR study for spectroscopic observation. The results of the FTIR study performed on the produced activated carbon are shown in Figure 4. The sample's functional groups are discernible in the 4000-400 cm^{-1} wavenumber region. After activation, the activated

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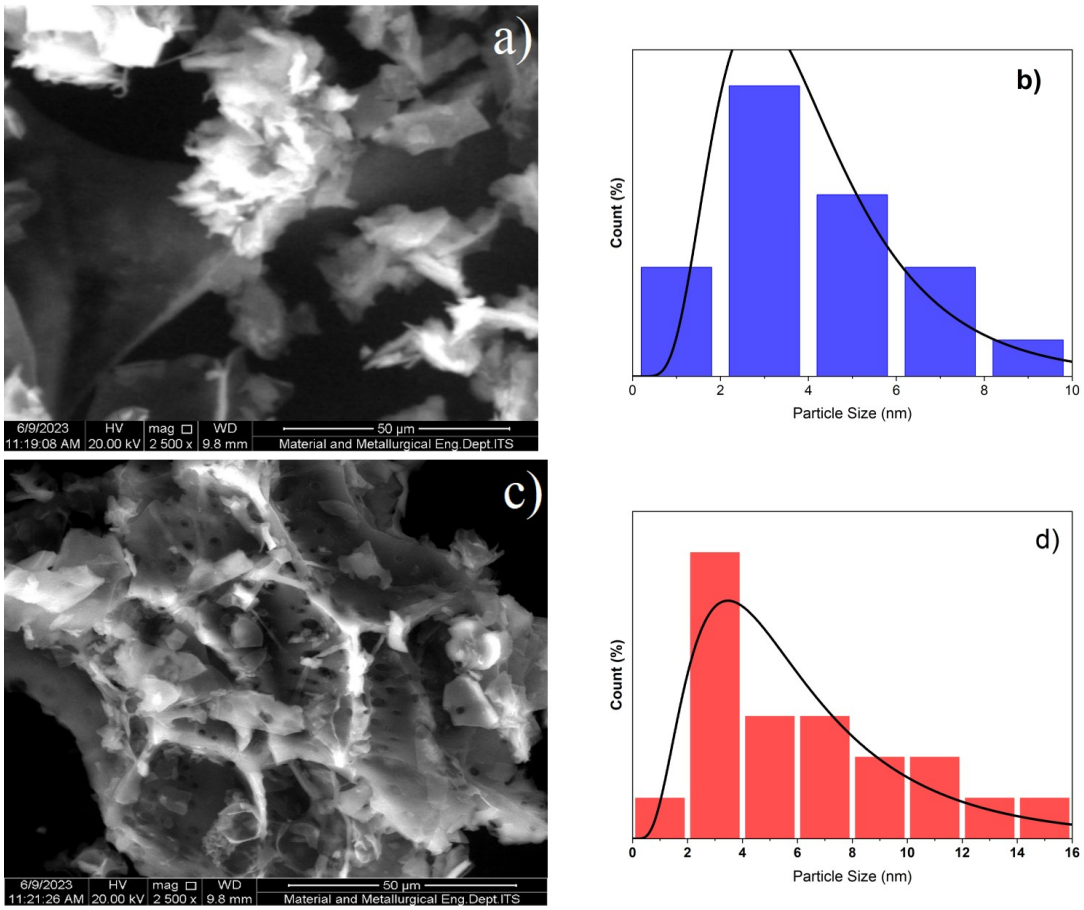

Figure 4. SEM Images of the Morphological Shape of Activated Carbon before Activation (a), Along with the Particle Distribution Graph (b), after Activation (c), and Distribution Graph (d)

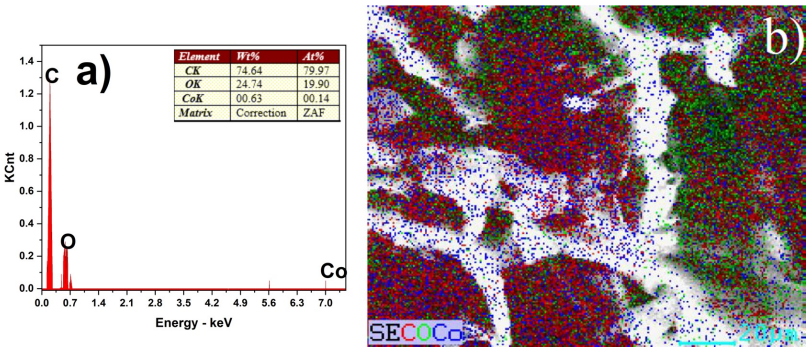

Figure 5. (a) Elemental Content of Purple Corn Cob Activated Carbon and Activated (b) Distribution of Element Content

carbon reaches an absorption peak at 3244.60 cm^{-1} owing to the action of Na_2CO_3, which exhibits an absorption peak at 3330.50 cm^{-1}. The existence of vibrational stretching of hydroxyl functional groups (O−H) is shown by the absorption peak at 3500-3200 cm^{-1} (Wang et al., 2021). The existence of CO_2 functional groups was then detected at a wavenumber of 2097.4 cm^{-1} (Singh et al., 2020). Then, functional groups implicated in the production of Na_2CO_3 may be assigned to wavenumbers of 2092.3 cm^{-1} and 2096.1 cm^{-1}. The FTIR spectrum of activated carbon shows absorption peaks at wavenumbers of 1557.5 cm^{-1} prior to activation and 1562.7 cm^{-1} following activation as a result of 1637.2 cm^{-1}. The presence of C=O groups, which are characteristic groups of activated carbon, is indicated by absorption peaks in the range of 1820–1550 cm^{-1}. These peaks show that activated carbon is the source of purple corn cob (Liang et al., 2020). C−H bend-

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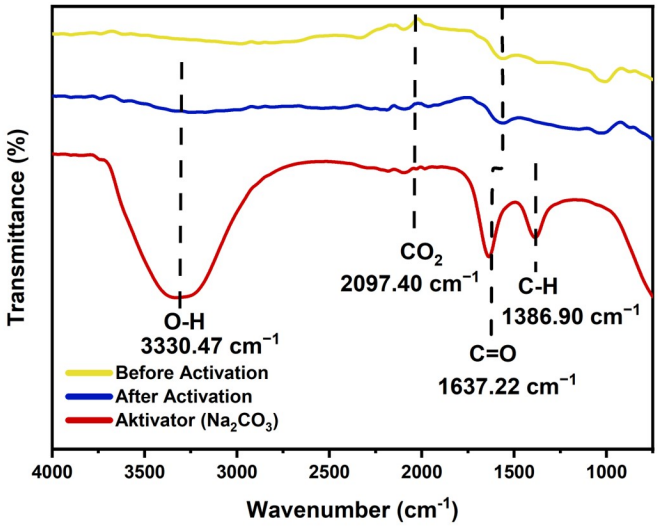

Figure 6. FTIR Spectra from Activated Carbon with Activation Na_2CO_3

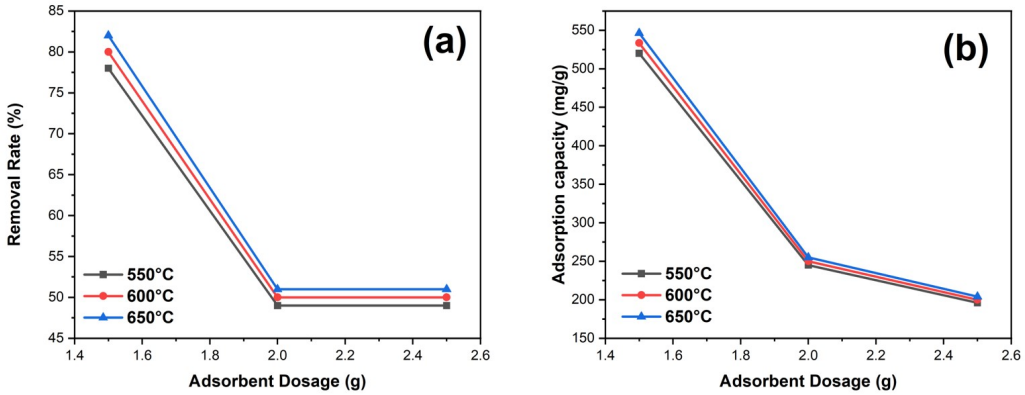

Figure 7. Effect of Adsorbent Dosage (a), Removal Rate (b) and Adsorption Capacity (mg/g)

ing bonds are also formed by the activator chemical Na_2CO_3 (Wang et al., 2021). The existence of aldehyde molecules is indicated by the spectra seen at wavenumber 1386.9 cm^{-1}. This confirms the result. The activated carbon derived from purple corn cobs has three different types of functional groups C=O, O−H, and CO_2 that are associated with molecules in the solution that are easily adsorbed (Białas et al., 2020).

3.6 Adsorption Properties Test

3.6.1 Ammonia Adsorption Capacity of Activated Carbon

To remove different ions, activated carbon from Purple Corn Cob was modified using Na_2CO_3. The ability of activated carbon to lower ammonia (NH_3) concentrations was tested under ideal conditions. Prior to treatment, the test's original ammonia (NH_3) concentration was 1 mg/L. Table 4 demonstrates the highest adsorption capacity of 546.3 mg/g at 650 °C and an 82% removal of ammonia (NH_3) at an adsorbent mass of 1.50 g. It was observed that the adsorption capability decreased with increasing adsorbent mass. It is also shown that for ammonia elimination, the distribution of pore sizes is more important than the average pore volume. Intermolecular interactions such as hydrogen bonding, electrostatic attraction, Van der Waals forces, and others affect this process (Zhang et al., 2022).

3.6.2 Effects of the Carbonization Temperature

In general, the adsorption properties of activated carbon are related to the temperature during carbonization. The adsorption capacity of carbon carbonized at a temperature of 550°C reaches its highest value of 520 mg/g with an ammonia adsorption efficiency of 78%. Then, the adsorption capacity of carbon carbonized at a temperature of 600°C reaches its highest value of 533.3 mg/g with an ammonia adsorption efficiency of 80%.

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Table 4. Results of Testing Ammonia (NH_3) Levels based on Variations in Mass and Temperature at the Time of Activation

Sample		pH	Concentration of Ammonia (mg/L)	Adsorption Capacity (mg/g)	Removal Ammonia (NH_3) (%)
Temperature (°C)	Mass of the Adsorbent (g)				
550	1.50		0.220	520	78
	2.00		0.510	245	49
	2.50		0.510	196	49
600	1.50		0.200	533.3	80
	2.00	7	0.500	250	50
	2.50		0.500	200	50
650	1.50		0.180	546.3	82
	2.00		0.490	255	51
	2.50		0.490	204	51

Table 5. Comparison with other Activated Carbon Materials

Activated Carbon	Method	Activated Agent	Adsorbate	Adsorption Capacity (mg/g)	References
Aloe vera waste leaves	Carbonized at 500°C	Activated H_2SO_4 and HNO_3	Cr(VI)	59.88	(Prajapati et al., 2020)
Coffee husk	Pyrolysis at 550°C	Heated up under a N2 atmosphere 800°C	Ni(II)	57.14	(Hernández Rodríguez et al., 2018)
Potato peel	Carbonized at 600°C	Activated H_3PO_4	Pb(II)	171	(Kyzas et al., 2019)
White sugar	Calcined at 700°C	Activated H_2SO_4 dan NaOH	Rhodamine B	123.46	(Xiao et al., 2020)
Agriculture waste	Calcined at 500°C	Activated HCl	Methylene blue	130	(Salem et al., 2020)
Purple Corn Cob	Carbonized at 550°C-650°C	Activated Na_2CO_3	Ammonia	200-546	This study

Finally, the adsorption capacity of carbon carbonized at a temperature of 650°C reaches its highest value of 546.3 mg/g with an ammonia adsorption efficiency of 82%. It can be concluded that the higher the carbonization temperature used, the higher the adsorption capacity of the resulting carbon according to Table 4 (Ma et al., 2013).

3.6.3 Effect of pH on the Adsorption Properties

pH greatly affects the ammonia (NH_3) adsorption process using activated carbon adsorbent because pH plays an important role in the structure of ammonia and the chemical properties of the activated carbon surface. Based on Table 4, the pH value is 7 which is the normal pH of Fish Cage Water. This is evidenced by the unchanged ammonia concentration between masses of 2 g and 2.5 g at each temperature due to the absence of differences in pH values that occur. The adsorption mechanism of activated carbon for ammonia (NH_3) adsorption can be influenced by various factors such as π-π dispersion interactions (Fulazzaky, 2019), donor-acceptor complexation, ion exchange, coordination reaction, lectrostatic interactions (Yi et al., 2020), solvent effects, and so on (Han et al., 2021).

3.6.4 Effect of Adsorbent Dosage

The influence of activated carbon dosage on ammonia adsorption is shown in Figure 7(a). As the activated carbon dosage continues to increase, the level of ammonia removal by activated carbon at each temperature will decrease. This occurs because at very high doses of activated carbon, there may be a transport phenomenon that inhibits contact between the ammonia in the solution and the activated carbon surface, such as hindered diffusion or the formation of thick adsorbate layers on the activated carbon surface. dosage, leading to a reduction in the concentration of ammonia in the solution, thereby diminishing the driving force for adsorption. The impact of activated

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carbon dosage on the adsorption of ammonia is depicted in Figure 7(b). As the dosage of activated carbon increases, the adsorption capacity gradually diminishes (Ren et al., 2021).

Based on the analysis of the characterization and testing above, activated carbon made from purple corn cob has good potential (Boulanger et al., 2024). To advance future research, adjustments and more intricate variations can be implemented to attain more precise characteristics. Table 5 presents the adsorption capabilities of various activated carbon materials. It is noted that activated carbon sourced from purple corn cob exhibits an adsorption capacity that is comparable to other materials. This suggests that activated carbon derived from purple corn cob biomass holds promising potential for reducing ammonia levels in Fish Cage Water (Neolaka et al., 2023).

4. CONCLUSIONS

The optimal results are achieved by utilizing Purple Corn Cobs as the raw material for activated carbon, which is then activated using Na_2CO_3 at temperature variations of 500°C, 550°C, and 600°C. The findings show that the range of values for the following parameters: moisture content (11.2% to 25.4%), volatile matter content (10.1% to 24.6%), ash content (9.71% to 9.96%), fixed carbon content (65.7% to 79.7%), and active carbon yields (79.7% to 89.8%). The optimal sample, with an adsorption capacity value of 546.3 mg/g and an ammonia removal rate of 82%, is then determined by assessing the adsorption characteristics of the sample at a temperature of 650 °C using an adsorbent mass of 2.50 g. In addition, after being activated with Na_2CO_3, the sample showed an amorphous structure along with some crystalline carbon structures. The sample showed advantages such improved surface pore expansion after carbonization and activation; its composition was mostly made up of carbon (C) and oxygen (O) components. Based on the obtained results, the developed activated carbon demonstrates efficient ammonia removal capability. Thus, the utilization of salt catalysts can be prioritized as an environmentally friendly catalyst in activated carbon production. Moreover, further research is required on the impact of adsorbent dosage on the adsorption process, as a higher mass of adsorbent used does not always lead to better ammonia removal.

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