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Zeolite Synthesis from Rice Husk Ash (*Oryza Sativa* L.) as an NH3 Adsorbent for the Making of Eco-Friendly Cat Litter

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ABSTRACT

This study aims to synthesize zeolite from rice husk ash (Oryza sativa L.) as an ammonia (NH_3) adsorbent for eco-friendly cat litter applications. The hydrothermal method was used to produce zeolite from rice husk ash and aluminum hydroxide, varying the Na_2SiO_3:Al_2O_3 ratio. The synthesized zeolites were characterized physically and chemically through moisture content, ash content, and FTIR spectroscopy analyses. Ammonia adsorption efficiency was assessed using UV-Vis spectrophotometry at initial concentrations from 5% to 25%. All zeolite variants succeeded in reducing ammonia content, with final filtrate concentrations increasing at higher initial levels. Zeolite 3 exhibited the most stable adsorption efficiency, ranging from 33% (at 5% initial NH_3) to 18% (at 25% NH_3), and was also the most crystalline with the lowest moisture and ash contents. These results indicate that synthetic zeolite derived from rice husk ash, particularly with the optimal ratio found in Zeolite 3, is highly suitable for use as an eco-friendly cat litter material, offering effective ammonia control and supporting sustainable agricultural waste utilization.

Keywords: zeolite, rice husk ash, ammonia adsorbent, cat litter, adsorption efficiency.

1. INTRODUCTION

Indonesia has abundant natural resources, including mineral materials and agricultural waste that have the potential to be used in various industrial applications. The use of these resources is in line with the goals of the Sustainable Development Goals (SDGs), especially in supporting sustainable production and more effective waste management1. One of the most widely used materials in industry is zeolite, which is known as an effective adsorbent in various purification and waste treatment processes2. The synthesis of zeolite from natural materials, such as rice husk ash, is an innovative solution that not only reduces agricultural waste, but

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also results in environmentally friendly products with high absorption of pollutants, including ammonia (NH_3)[3].

Zeolite is a porous material that is widely used in various industrial applications, especially as an adsorbent in purification and waste treatment. One potential source for zeolite synthesis is rice husk ash which is rich in silica content. The use of rice husk ash as a zeolite raw material not only offers an environmentally friendly solution to agricultural waste, but also produces materials with high adsorption power1. The development of zeolite from rice husk ash not only provides an innovative solution in agricultural waste management, but also supports efforts to reduce air pollution due to ammonia gas produced from pet feces, especially cats. In addition, the use of rice husk ash as a raw material for zeolite is a strategic step in optimizing Indonesia's abundant local natural resources, while supporting the principles of sustainability and circular economy through waste reduction and the use of renewable natural materials3,4.

Research shows that conventional clay-based cat litter has limitations in absorbing ammonia effectively. Ammonia (NH_3) is a major pollutant in household and factory waste, and can contaminate the environment, especially in things like cat litter used for sanitation5.

The synthesis of zeolite based on rice husk ash as an NH3 adsorbent has the potential to increase the effectiveness of cat litter while reducing agricultural waste that has not been optimally utilized1. Zeolite has a porous structure that is able to capture and retain ammonia molecules, thus significantly reducing bad odors2. The utilization of this technique can produce zeolites with a pore structure suitable for ammonia adsorption6. In addition, the use of alumina sources such as aluminum sulfate in the synthesis process can improve the stability and adsorption capacity of the zeolite produced [7].

Therefore, this study aims to synthesize zeolite from rice husk ash and test its effectiveness in absorbing NH_3 for environmentally friendly cat litter applications, so that it can be an innovative solution in reducing the impact of ammonia pollution and optimizing the use of agricultural waste in Indonesia.

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

2.1.1 Materials used

The materials used in this study include rice husks as much as 1 kg as a source of silica, 2M sodium hydroxide (NaOH) for the activation process, Aluminum Hydroxide $Al(OH)_3$ as a source of alumina, and deionized water for washing and dissolving. In addition, filter paper is used for the separation and filtration process during zeolite synthesis.

2.1.2 Equipment used

The equipment used in this study includes analytical scales for measuring the mass of materials, beakers with capacities of 500 mL and 1000 mL, and measuring flasks measuring 250 mL, 500 mL, and 1000 mL to prepare solutions. The glass mixer rod is used for the homogenization of the solution, while the hot plate serves as a heater, and the Oven is used in the process of heating and synthesis of zeolite, as well as helping in the process of drying the sample. A 100 mesh sieve is used to filter fine particles, with the help of Whatman No. 42 filter paper. In addition, pH meters are used to measure the acidity level of the solution, thermometers for temperature monitoring, as well as analytical balances for weighing materials with high accuracy.

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2.1.3 Instrumentation

The functional groups of the synthesized zeolite samples were analyzed using Fourier Transform Infrared (FTIR) spectroscopy to identify the characteristic chemical bonds and confirm the formation of the zeolite framework. In addition, the NH_3 absorption efficiency was evaluated using a UV–Visible (UV–Vis) spectrophotometer by measuring the absorbance of the samples before and after the absorption process.*2.2. Research Procedure*

2.2.1 Procedure for Making Zeolite as Cat Litter

1. Preparation of ingredients

   The husks are burned at 506°C for 5 hours until they turn to ashes. The cooled ash is sifted with a 100 mesh sieve to obtain uniform particle sizes.
2. Extraction of silica from rice husk ash
   Silica was extracted from rice husk ash using a ratio of 10 g of rice husk ash to 100 mL of 2 M NaOH solution. Since the total volume of sodium silicate solution required for the five synthesis variations was 820 mL (100, 120, 160, 200, and 240 mL), 82 g of rice husk ash was mixed with 820 mL of 2 M NaOH solution, which was prepared by dissolving 65.6 g of NaOH in distilled water and adjusting the final volume to 820 mL. The mixture was heated at 90°C with continuous stirring for 2 h to extract silica from the rice husk ash. After the extraction process, the mixture was filtered to separate the sodium silicate solution (filtrate) from the solid residue. The resulting sodium silicate solution was then divided into five portions of 100, 120, 160, 200, and 240 mL for use in the subsequent zeolite synthesis. Chemical reaction:
   SiO2(s) + 2NaOH(aq) → Na2SiO3(aq) + H2O(l)……………………………………….……….... (1)

3. Manufacture of Sodium Alumine solution
   The sodium aluminate solution was prepared by dissolving aluminum hydroxide [$Al(OH)_3$] and sodium hydroxide (NaOH) in hot water according to the required composition for each synthesis variation. For Variation 1, 7.80 g of $Al(OH)_3$ and 18.33 g of NaOH were dissolved in 50 mL of hot water to obtain 100 mL of sodium aluminate solution. For Variation 2, 6.24 g of $Al(OH)_3$ and 14.66 g of NaOH were dissolved in 40 mL of hot water to produce 80 mL of solution. Variation 3 was prepared by dissolving 3.12 g of $Al(OH)_3$ and 7.34 g of NaOH in 20 mL of hot water to obtain 40 mL of solution. For Variation 4, 3.90 g of $Al(OH)_3$ and 9.17 g of NaOH were dissolved in 25 mL of hot water to produce 50 mL of solution. Finally, Variation 5 was prepared by dissolving 9.36 g of $Al(OH)_3$ and 21.98 g of NaOH in 60 mL of hot water to obtain 120 mL of sodium aluminate solution.
   Chemical reaction:
   $Al(OH)_3(s) + NaOH(aq) \rightarrow NaAlO_2(aq) + 2H_2O\ (l)$.. (2)

4. Zeolite Synthesis

   The sodium silicate and sodium aluminate solutions were subsequently mixed according to the predetermined volume ratios for each synthesis variation. In Variation 1, 100 mL of sodium silicate solution was mixed with 100 mL of sodium aluminate solution. Variation 2 consisted of 120 mL of sodium silicate solution and 80 mL of sodium aluminate solution, while Variation 3 used 160 mL of sodium silicate solution and 60 mL of sodium aluminate solution. For

Variation 4, 200 mL of sodium silicate solution was mixed with 50 mL of sodium aluminate solution, whereas Variation 5 employed 240 mL of sodium silicate solution and 120 mL of sodium aluminate solution. The resulting mixtures were then used for the subsequent zeolite synthesis process.

Each mixture is stirred using a magnetic stirrer for 1 hour until a homogeneous gel is formed. This gel is then left at room temperature for 24 hours (aging process). After *aging,* the gel is transferred to the oven and heated to 100–160°C for 5–7 hours (hydrothermal process). After crystallization is complete, the formed zeolite product is cooled, then filtered, washed with water to pH neutral, and dried in the oven at 105°C for 1 hour1. The chemical reactions that occur at this stage are:
Na_2SiO_3 (aq) + $NaAlO_2$ (aq) + H_2O (l) → Zeolite (gel)... (3)

5. Zeolite precursors

The zeolite precursor gel is transferred to a clean oven, then heated to 160°C for 7 hours for a hydrothermal crystallization process. Once crystallization is complete, the oven is cooled to room temperature before opening. The zeolite that has been formed is separated from the solution by filtering it using filter paper, then washed repeatedly with deionized water until the filtrate pH is close to neutral so that the remaining sodium silicate and impurities are completely removed1,8.

2.2.2 Post-Research Instrumentation Testing

1. Analysis of Water Levels and Ash Levels

A homogeneous and dry zeolite sample was prepared prior to analysis. For moisture content determination, 5 g of the sample was weighed (W) and placed in a pre-weighed heat-resistant crucible. The sample was dried in an oven at 105°C for 3 h, after which it was cooled in a desiccator to prevent moisture absorption from the atmosphere and then reweighed to obtain the dry weight (W_1). The moisture content was calculated using Equation (1). Calculate the moisture content using the formula:
Moisture Content (%) = ((W-W1)/W) x 100...(1)

For ash content determination, 2 g of the zeolite sample was placed in a pre-weighed porcelain crucible and heated in a muffle furnace at 550°C for 4 h. After ashing, the crucible was cooled in a desiccator and weighed to determine the weight of the ash residue. The ash content was then calculated using Equation (2). Calculate the ash content using the formula:
Ash content (%) = (Residual weight/initial weight) x 100%.. (2)

2. FTIR Analysis

Approximately 1 g of calcined and dried zeolite from each $Na_2SiO_{32}O_3$ ratio variation was used for Fourier Transform Infrared (FTIR) analysis. If necessary, the samples were further dried and then ground using a mortar and pestle to obtain a fine and homogeneous powder. Prior to analysis, the sample holder was cleaned to remove dust and other contaminants. The FTIR instrument was turned on, calibrated when required, and the spectral scanning range was set according to the measurement conditions. Each sample was placed in the sample holder and scanned individually. After each measurement, the sample holder was cleaned with alcohol and lint-free wipes before being reused for the next sample. The obtained spectra were saved and recorded for further analysis. The FTIR spectra of all variations were then compared to evaluate differences in the zeolite framework and functional groups. In particular, the absorption band intensity and peak shifts associated with different $Na_2SiO_{32}O_3$ ratios were analyzed to assess the effect of the precursor ratio on the zeolite structure. All spectral data were stored digitally and interpreted based on the characteristic absorption bands of zeolite.

3. UV-Vis Analysis
   The NH_3 concentration was determined using a UV–Visible spectrophotometer based on the indophenol blue method. Prior to analysis, the UV–Vis spectrophotometer was warmed up for 10–15 min to ensure stable operation and calibrated using deionized water as the blank to obtain zero absorbance. The instrument was optimized, and the required reagents, including phenol solution, sodium nitroprusside solution, and oxidizing solution (hypochlorite), were prepared according to the standard analytical procedure. Subsequently, 25 mL of the ammonia solution (standard or sample) was transferred into a 50 mL Erlenmeyer flask. Then, 1 mL of phenol solution, 1 mL of sodium nitroprusside solution, and 2.5 mL of oxidizing solution were added sequentially, with thorough mixing after each addition. The flask was covered with plastic or paraffin film and allowed to stand at room temperature for 1 h to facilitate the formation of the indophenol blue complex. After incubation, the reacted solution was transferred into a spectrophotometer cuvette, and the absorbance was measured at a wavelength of 640 nm. The residual NH_3 concentration was determined from a previously established calibration curve, and the NH_3 absorption efficiency was subsequently calculated. Calculate adsorption efficiency:
   (E) = Initial Concentration (Initial Concentration− Final Concentration)×100%........................ (3)

3. RESULTS AND DISCUSSION

3.1. Research Results in the form of Ziolite Products

Zeolite products are synthesized from husk ash where each variation of the ratio of Na_2SiO_3:Al_2O_3 has a varied color and physical shape, depending on the number of variations used. Generally, zeolite products are in the form of fine powders that are grayish-white and white. Signifies the successful formation of this synthetic zeolite. This color variation can be influenced by the suboptimal variation of silica and alumina used. The results of the Zeolite Product Synthesis from rice husk ash can be seen in Figure 1.

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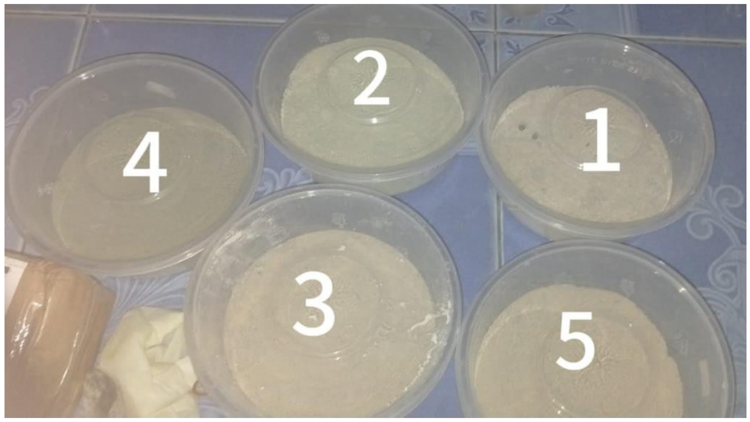

Source: Personal Documentation, 2025

Figure 1. Zeolite Results Synthesis from Variation 1 - Variation 5

Zeolite products synthesized from rice husk ash show variations in color and physical shape in each ratio of Na_2SiO_3 : Al_2O_3. Generally, the zeolite obtained is grayish-white to white, indicating the success of the synthesis process. This difference in visual appearance is also an important factor in organoleptic assessment. Based on the survey results, the third variation (Z3) received the most votes, showing the texture and appearance of this product most liked by respondents. This is supported by low moisture content (1.6%) and ash content (0.75%), which are well below the SNI 06-3730-1995 standard for active zeolite (max. 15% moisture content and max. 10% ash content).

Furthermore, the characterization with FTIR of each variation showed the formation of typical zeolite peaks, especially in the wavenumber range of 995–1010 cm^{-1}, which indicates the successful formation of the aluminosilicate skeleton. The peak vibrations in the FTIR of all five variations are relatively standard-bearing, although there are slight shifts in some wavenumbers, indicating differences in composition or crystallization rates between variations.

Ammonia adsorption ability tests using UV-Vis spectrophotometers were also performed to evaluate the efficiency of zeolite. This effectiveness is then compared to commercial cat litter through weight measurements after the adsorption process. As a result, zeolite cat litter on some test dates had a higher final weight, indicating a higher amount of ammonia absorbed and good absorption performance.

Overall, the synthetic zeolite products from rice husk ash in each variation not only meet quality standards based on moisture and ash content, but also show excellence in organoleptic aspects and ammonia adsorption ability. The tests carried out include: measurement of moisture content, ash content, determination of crystal structure using FTIR, and adsorption efficiency of ammonia solution. The results of this data further became the basis for the recommendation for the use of synthetic zeolite of husk ash as an environmentally friendly adsorbent material, especially in the application of cat litter which is effective in controlling ammonia odors and providing a more economical and sustainable alternative.

Table 1. Results of Synthesis Zeolite Analysis from Rice Husk Ash

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Variations Zeolite	Physical Properties Parameters		
	Moisture Rate (%)	Rates Ash (%)	Respondents' Choice (Questionnaire)
ZI	4,8	1,93	95
Z2	1,6	0,93	60
Z3	1,6	0,75	197
Z4	5,6	2,13	20
Z5	6,7	2,42	14
SNI 3730-1995	15	10	

Table 4.2 Characteristics of Synthetic Zeolite by FTIR

Variations	Function Clusters	Number of Waves (cm^{-1})	Standard (cm^{-1})
Z1	-OH	3395	3438–3464
	H-O-H *bending*	1634	1645–1655
	Yes–O / Al–O	996	995–1010
	Si–O-Si *ext*	781	~550
	Yes–O/Al–O *bend*	484–517	462–472
Z2	-OH	3360	3438–3464
	H-O-H *bending*	1635	1645–1655
	Yes–O / Al–O	1003	995–1010
	Si–O-Si ext	781	~550
	Yes–O/Al–O *bend*	572, 516	462–472
Z3	-OH	3392	3438–3464
	H-O-H *bending*	1636	1645–1655
	Yes–O / Al–O	1003	995–1010
	Si–O-Si ext	781	~550
	Yes–O/Al–O *bend*	483–527	462–472
Z4	-OH	3357	3438–3464
	H-O-H *bending*	1642	1645–1655

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	Yes–O / Al–O	967	995–1010
	Yes–O/Al–O *bend*	516, 484	462–472
Z5	-OH	3391	3438–3464
	H-O-H *bending*	1631	1645–1655
	Yes–O / Al–O	1009	995–1010

Table 3. Adsoprcy Efficiency with UV-Vis

Initial Ammonia Concentration (%)	Z1 (%)	Z2 (%)	Z3 (%)	Z4 (%)	Z5 (%)
5	30	32	33	18	15
10	25	27	28	14	10
15	20	22	23	10	7

Table 4.4 Mass Comparison of Commercial Cat Sand and Ammonia-Absorbing Zeolite Cat Sand

Yes	Date	Commercial Cat Litter (g)	Zeolite Cat Sand (g)
1	01/06/2025	22	35
2	02/06/2025	31	28
3	05/06/2025	26	42
4	07/06/2025	40	30
5	08/06/2025	23	38
6	13/06/2025	48	45
7	14/06/2025	29	50
8	16/06/2025	35	33
9	20/06/2025	44	27
10	23/06/2025	39	53

3.2 Discussion

3.2.1 Analysis of Function Groups Using the FTIR Tool

Fourier Transform Infrared Spectroscopy (FTIR) is an important analysis method used to identify

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functional groups and chemical structures in aluminosilicate-based materials. By examining vibration patterns at specific wavelengths, FTIR can reveal details regarding chemical bonds and material composition, such as the presence of hydroxyl groups, Si–O–Al connections, and tetrahedral skeleton structures. Saraswati in 2015 stated that changes in material composition and synthesis conditions affect the position and intensity of the peak FTIR, so this technique is very effective for combining the qualities and characteristics of synthetic products derived from natural materials9.

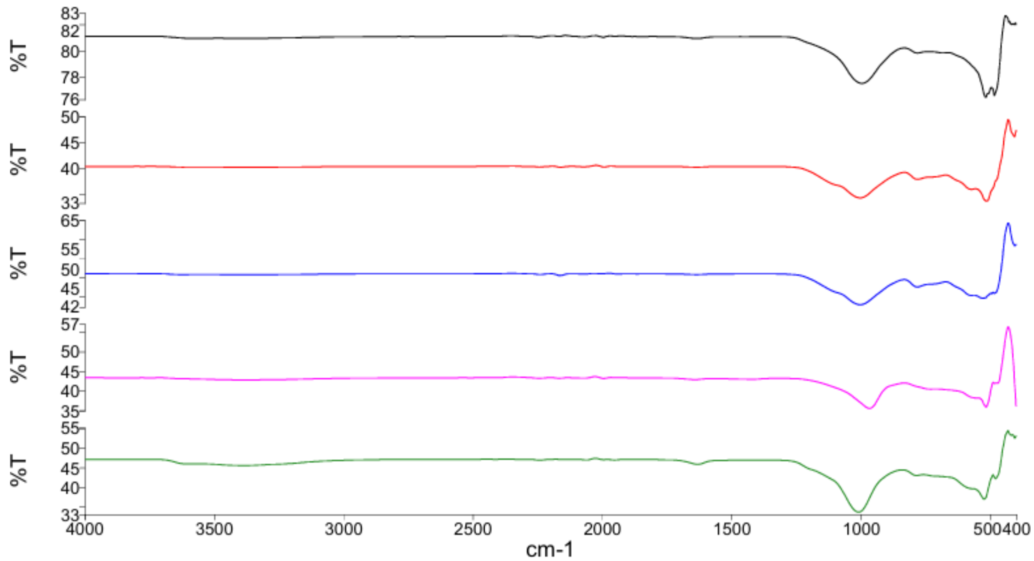

Figure 2. FTIR Zeolite Curve 1-5

The three zeolite variations show quality differences based on Si/Al ratios, FTIR spectrum patterns, and crystallinity that affect the stability and performance of their applications. Zeolite 3 is of the highest quality with high crystallinity, characterized by the 10 main peaks of FTIR indicating the formation of a stable and homogeneous type A zeolite skeleton. Peaks such as those at 3393 cm^{-1} (O–H) and 1003 cm^{-1} (T–O–T) indicate the presence of hydroxyl groups and optimal aluminosilicate structures, thus supporting effective adsorption activity and high thermal stability. The Zeolite 3 synthesis process successfully produces a good structure with superior performance for industrial and environmental applications.

In contrast, Zeolite 1 and Zeolite 2 have lower characteristics than Zeolite 3, with Zeolite 1 exhibiting a fairly homogeneous structure but slightly lower crystallinity and peak FTIR amount, while Zeolite 2 has a higher Si/Al ratio which improves thermal stability but slightly decreases ion exchange capacity. Zeolite 5 exhibits the lowest quality, with low FTIR transmittance and the possibility of amorphous phases and suboptimal crystallinity, which negatively impacts purity and adsorption performance. Overall, this third variation confirms the importance of controlling the Si/Al ratio and synthesis conditions to obtain zeolites with physical and chemical properties that suit the needs of the application.

3.2.2 Analysis of NH3 Absorption Efficiency Using UV-Vis Tool

Measurements using UV-Vis spectrophotometers were carried out to determine the concentration of

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ammonia in the solution before and after the adsorption process with zeolites. The absorbance data obtained at a given wavelength is used to calculate the concentration of ammonia filtrate. These results were then analyzed to see how effective zeolite was at adsorbing ammonia at various initial concentrations.

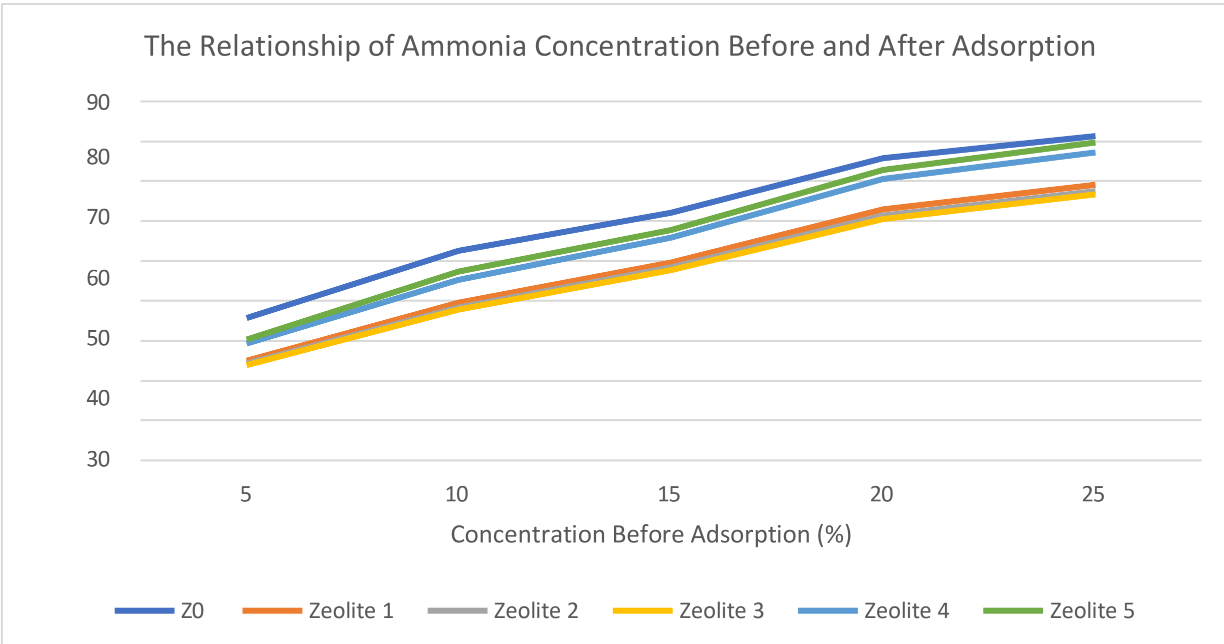

Figure 3. Ammonia Concentration Relationship Curve Before and After Adsorption

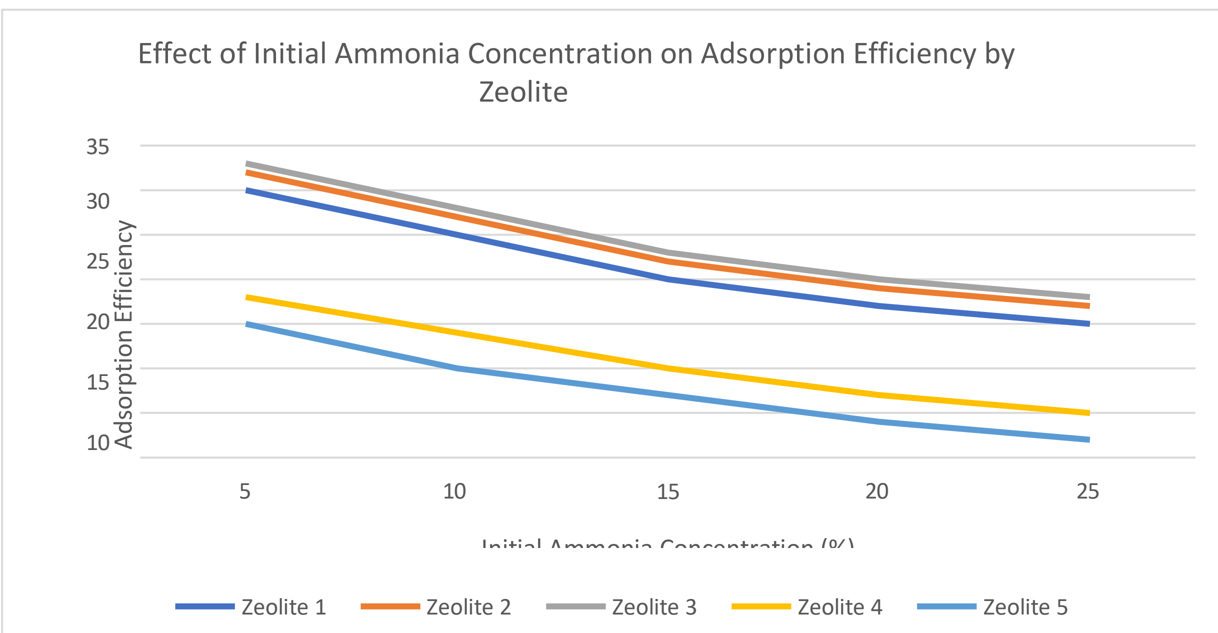

Figure 4. Curve of the effect of ammonia concentration on adsorption efficiency

Zeolite 1 showed a significant decrease in ammonia adsorption efficiency, from 30% at a concentration of 5% to 15% at a concentration of 25%, which indicates a limitation of adsorption capacity because the active site of zeolite is rapidly saturated when ammonia concentrations increase10. Zeolite 2 has a more stable adsorption efficiency, ranging from 32% to 17% with slower degradation, supported by better physical characteristics and crystal structure11,12. Meanwhile, Zeolite 3 showed the highest efficiency with the slowest decrease, from 33% to 18%, reflecting superior micropore and ion exchange capacity that was able to maintain more stable adsorption performance at various concentrations13.

In contrast, Zeolite 4 and Zeolite 5 show low and unstable adsorption efficiency. Zeolite 4 experienced a sharp decline from 18% to 5%, which is likely due to the limited number of active sites and the uneven distribution of pores, as seen in the bar diagram and supported by studies related to zeolite morphology12. Zeolite 5 was the worst with an efficiency of only 15% at a concentration of 5% and a drastic drop to 2% at a concentration of 25%, indicating very limited absorption and suboptimal crystallinity14. Overall, Zeolite 3 is the best choice for ammonia adsorption due to its superior stability and adsorption capacity at various concentrations.

3.2.3. Moisture and Ash Analysis

Based on the SNI 06-3730-1995 standard, the maximum moisture content for active zeolite is 15%, while the maximum ash content is 10%. Moisture content testing was carried out by drying method at a temperature of 105 ± 5°C to a fixed weight to determine the hygroscopic properties of zeolites, where low moisture content indicates that zeolite pores are more open, thus increasing adsorption ability. The ash content is a combustion residue that indicates the mineral content in zeolites, which is measured by combustion at 550 ± 25°C; A low ash content indicates a higher purity of the material. The results of the test of the moisture and ash content of synthetic zeolite generally meet this standard, with an average moisture content of about 3% and an ash content below 10%, so that the quality of zeolite as an adsorbent and catalyst remains optimal15,16,17.

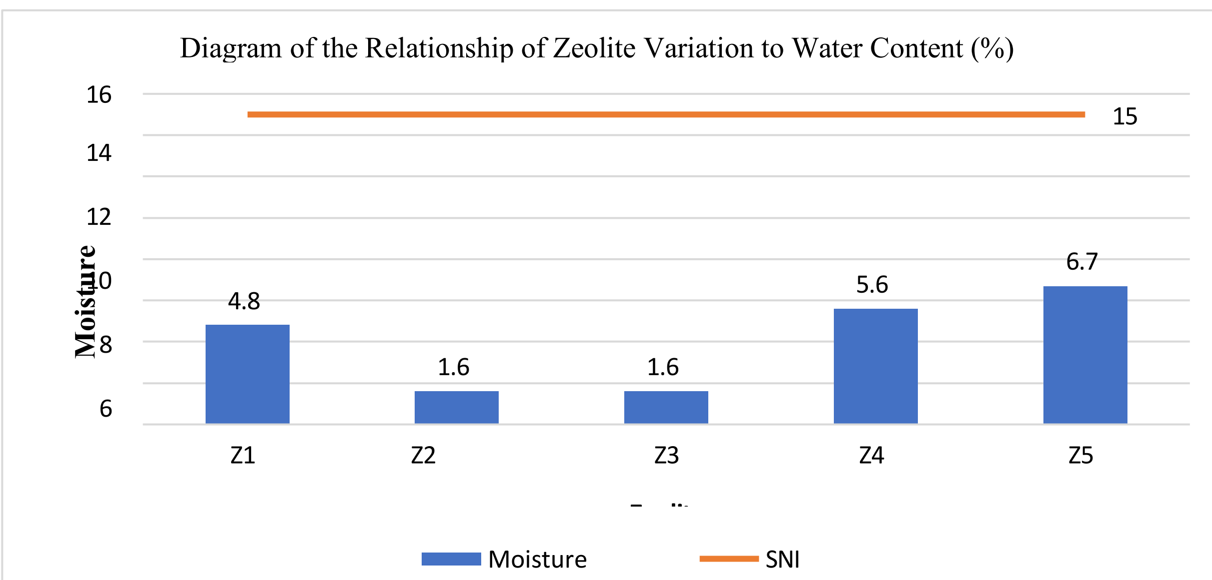

Figure 5. Diagram of the Relationship of Zeolite Variation to Water Content (%)

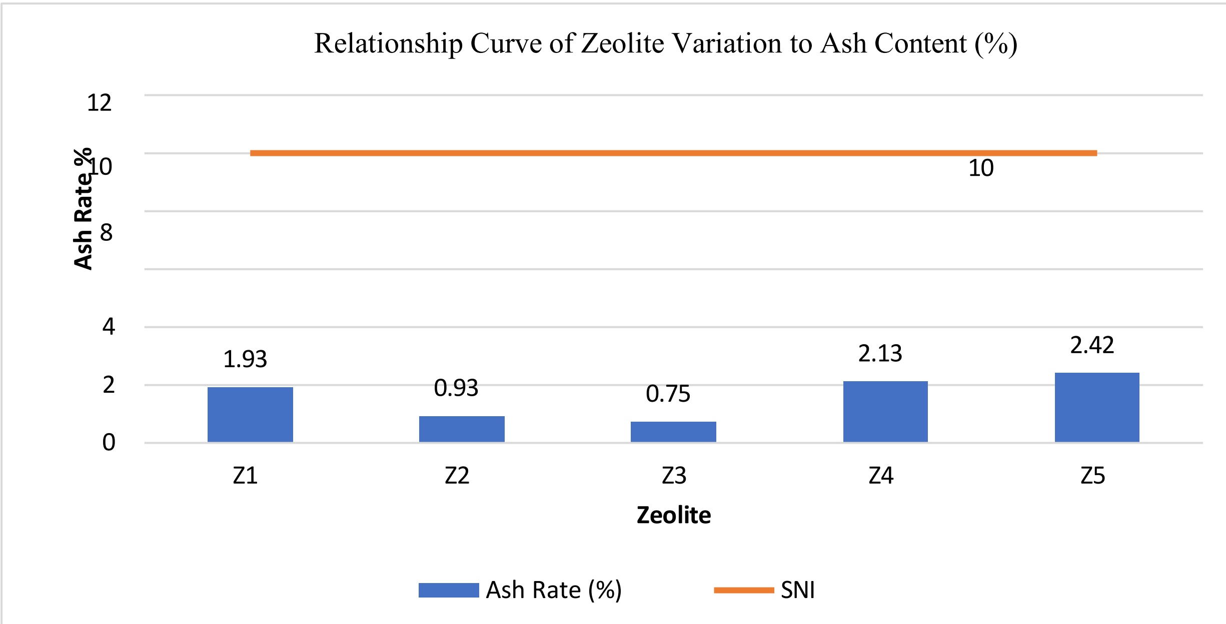

Figure 6. Diagram of the Relationship of Zeolite Variation to Ash Content (%)

From the variation in the volume of sodium silicate and sodium aluminate used in zeolite synthesis, it can be seen that there is a significant influence on the moisture content of the final product. Variations 2 and 3, with a higher ratio of sodium silicate (120 mL and 160 mL) than sodium aluminate (80 mL and 60 mL), resulted in the lowest moisture content of 1.6%. The increase in sodium silicate as a source of silica strengthens the structure of zeolite by forming a denser and more stable crystal skeleton, so that the pores of zeolite absorb less water. In contrast, variation 5 that uses the most sodium silicate (240 mL) and high sodium aluminate (120 mL) produces the highest moisture content (6.7%), as excess aluminette causes zeolite structures to become more amorphous and large porous, thus absorbing more water. This moisture content is in accordance with the SNI 13-3496-1994 standard which sets a maximum moisture content of 10% for natural zeolites, so that all variations are still within acceptable quality limits18,19.

When viewed from ash content, variations with a balanced ratio of sodium silicate and aluminin tend to result in lower ash content, as in variations 2 and 3 with ash levels of 0.93% and 0.75%, respectively. This low ash content signifies high zeolite purity due to the mineral residue left after slight combustion, which comes from perfectly bonded alumina and silica compounds during synthesis. Variation 5 has the highest ash content (2.42%) due to an excess of sodium aluminate resulting in a non-zeolitic phase or other mineral residues that are not converted during the synthesis process. The SNI 06-3730-1995 standard sets a maximum ash content of around 10% for similar mineral materials, so that the ash content in all these variations still meets the standard. The ratio of sodium silicate to alumina greatly determines the quality of synthetic zeolite, particularly in terms of purity and crystal structure20.

3.2.4. Organoleptic

To find out the most preferred zeolite variety based on visual and aromatic assessments, a survey was conducted of several respondents with 20 question criteria. The assessment includes aspects of smell, color, texture, and the visual appeal of the product as environmentally friendly cat litter. The results of all responses are then recapitulated in the form of the number of votes for each zeolite variation (V1 to V5). The diagram below shows the total distribution of votes obtained by each variation, illustrating the level of respondents' preference for each variation.

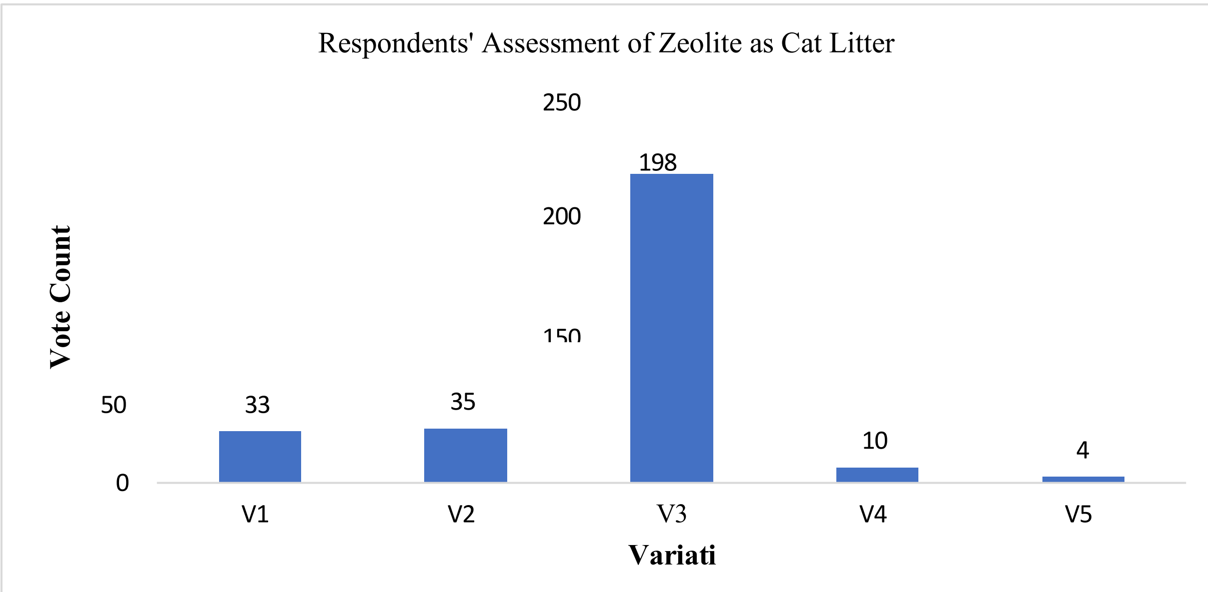

Figure 7. Organoleptic Test Results of Synthesis of Zeolite from Five Variations

Based on the results of the assessment of five zeolite variations (V1 to V5) on various criteria for odor quality, color, texture, and product suitability, the V3 variation showed the best performance consistently. This variety gets the highest score on the most neutral aspects of smell, comfortable scent, the brightest and most natural colors, and the smoothest texture suitable for cat litter. This indicates that V3 is the most preferred and suitable choice for cat litter products, both in terms of aesthetics and user comfort. In contrast, the V4 and V5 variations tend to have low scores in many aspects, making them less desirable. This assessment is important to determine zeolite formulations that are not only functionally effective but also sensorially acceptable to consumers21.

Recent research also supports the importance of zeolite's physical and chemical characteristics in its application to ammonia adsorption. Aksa 2020 shows that activated natural zeolite has good ammonia adsorption capabilities, while retaining attractive physical properties for product applications21. In addition, that particle size and contact time greatly affect the adsorption efficiency of ammonia, which impacts the quality of the final product. Therefore, the selection of the optimal zeolite variety must consider the adsorption effectiveness of ammonia as well as sensory aspects such as smell, color, and texture so that the final product is well received by consumers and effective in its application [21].

3.2.5. Mass Comparison of Commercial Cat Sand and Ammonia-Absorbing Zeolite Cat Sand

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The weight test of commercial cat litter and zeolite cat litter was carried out to see which of these two types of sand was superior in absorbing ammonia when applied as cat litter. The weight of sand after use reflects the amount of liquid and ammonia absorbed. Zeolite sand is known to have a porous structure that is effective in binding to ammonia and reducing odors, so it is expected to weigh differently than regular commercial sand10.

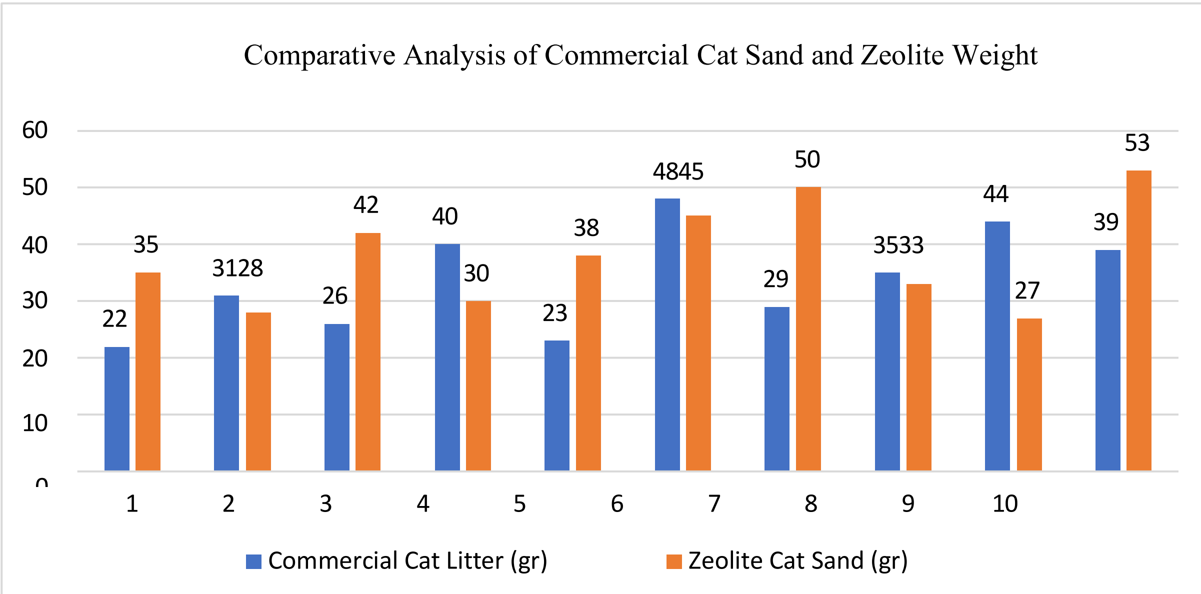

Figure 4.8 Weight Comparison of Commercial Cat Sand and Zeolite

From the bar diagram, it can be seen that zeolite sand has a greater weight when weighed after cats pass urine compared to commercial sand made of *bentonite*. This shows that zeolite sand has a higher urinary absorption ability than commercial. Zeolite sand is known to absorb ammonia ions and odors effectively like a sponge, although it does not clump, so it gains significant weight after absorbing urine22. In contrast, *bentonite* sand that clumps when exposed to urine does facilitate cleaning, but the fluid's absorption is more limited because the urine is locked in dense clumps of relatively smaller volumes23.

According to Mursalim, zeolite cat sand is more environmentally friendly and safe because it does not produce excessive dust that can interfere with the cat's breathing. This sand is also effective in removing odors and bacteria. Therefore, the higher weight of zeolite sand after urine absorption reflects its advantages in maintaining the hygiene and health of cats24.

4. CONCLUSION

Type A zeolite was successfully synthesized from rice husk ash as a source of silica and aluminum hydroxide as a source of alumina through hydrothermal methods. The results of FTIR characterization confirmed the formation of a typical aluminosilicate structure of type A zeolite, with properties influenced by the ratio of Na_2SiO_3:Al_2O_3. Among all the variations, Zeolite 3 exhibits the best crystallinity and homogeneity of the structure.

Ammonia adsorption tests showed that all zeolites were able to absorb NH_3, with Zeolite 3 providing the highest and most stable adsorption efficiency at a wide range of concentrations. These results show that the use of rice husk ash as a raw material for zeolite has the potential to produce environmentally friendly adsorbents for ammonia control while increasing the added value of agricultural waste.

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