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The Effectiveness of Bioadsorbent from Durian Peel Waste Activated with Phosphoric Acid (H_3PO_4) in Reducing Iron (Fe) Metal Levels in Dug Well Water

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ABSTRACT

The levels of iron (Fe) metal can be reduced by adsorption in water using durian skin waste adsorbent containing cellulose as the basic material for making activated carbon. Durian skin waste is cleaned with running water and then dried. After that, it is carbonized with a furnace at a temperature of 400 ° C for 2 hours and then chemically activated with 10% H_3PO_4 which is soaked for 24 hours. The activated carbon obtained is characterized using X-Ray Diffraction (XRD) and the parameters observed include water content (%), ash content (%), and iodine absorption (%). The absorption of iron (Fe) metal from dug well water is carried out using the static method at contact time variations of 60, 90, and 120 minutes. The levels of iron (Fe) metal are analyzed by Atomic Absorption Spectrophotometry (AAS). The results showed that the activated carbon produced was predominantly amorphous with a water content of 4.5%; ash content of 7.95%; and an iodine absorption value of 964.44 mg/g. Activated carbon from durian skin waste successfully absorbed Iron (Fe) metal and experienced a decrease with a percentage decrease in Iron (Fe) metal content against the length of contact time, respectively, were 83.55%; 93.88%; and 90% and the optimum contact time occurred at an adsorption time of 90 minutes. The modeling of the kinetics of durian skin activated carbon adsorption on Iron (Fe) Metal follows pseudo second-order modeling.

Keywords: Dug Well Water, Durian Peel, Phosphoric Acid, Activated Carbon, Adsorption

ABSTRAK

Kadar logam besi (Fe) dapat menurun dengan melakukan adsorpsi pada air menggunakan adsorben limbah kulit durian yang mengandung selulosa sebagai bahan dasar pembuatan karbon aktif. Limbah kulit durian dibersihkan dengan air yang mengalir lalu dikeringkan. Setelah itu dikarbonisasi dengan tanur pada suhu 400°C selama 2 jam lalu diaktivasi secara kimia dengan H_3PO_4 10% yang direndam selama 24 jam. Karbon aktif yang diperoleh dilakukan karakterisasi dengan menggunakan *X-Ray Diffraction* (XRD) dan parameter yang diamati mencakup kadar air (%), kadar abu (%), dan daya serap terhadap iodin (%). Penyerapan logam Besi (Fe) air sumur gali dilakukan dengan metode statis pada variasi waktu kontak 60, 90, dan 120 menit. Kadar logam Besi (Fe) dianalisis dengan Spektrofotometri Serapan Atom (SSA). Hasil penelitian menunjukkan karbon aktif yang dihasilkan bersifat dominan amorf dengan nilai kadar air 4,5 %; kadar abu 7,95%; dan nilai daya serap terhadap iodin 964,44 mg/g. karbon aktif dari limbah kulit durian berhasil menyerap logam Besi (Fe) dan mengalami penurunan dengan persentase penurunan kadar logam Besi (Fe) terhadap lama waktu kontak berturut-turut adalah 83,55 %; 93,88%; dan 90% dan waktu kontak optimum terjadi pada waktu adsorpsi 90 menit. Pemodelan kinetika adsorpsi karbon aktif kulit durian pada Logam Besi (Fe) mengikuti pemodelan pseudo orde dua.

Kata kunci: Air Sumur Gali, Kulit Durian, Asam Fosfat, Karbon Aktif, Adsorpsi

1. Introduction

Clean water is a fundamental and irreplaceable necessity for human life. Nearly all daily activities, from consumption and hygiene to industrial and agricultural activities, depend on the availability of water that meets health standards [18]. However, in several rural areas in Indonesia, such as Damai Village, Lubuk Pakam I-II District, communities still face challenges in obtaining clean, drinkable water.

Most villagers rely on dug well water as their primary water source due to its abundant availability and relatively low cost. Although adequate in quantity, the quality of dug well water often poses a serious problem due to its high dissolved iron (Fe) content. Based on Indonesian Minister of Health Regulation No. 02/MENKES/PER/II/2023, the maximum permissible iron content in drinking water is 0.2 mg/L. Exceeding this threshold can cause the water to change color to brownish-yellow, cause an unpleasant odor, stains on clothing, and even pose health risks such as diarrhea, nausea, and gastrointestinal irritation [1].

Efforts to reduce Fe levels in water can be carried out through various methods, one of which is adsorption. Adsorption is the process of absorbing dissolved substances from a liquid phase onto a solid surface (adsorbent). It is known to offer advantages such as ease of application, low cost, and relatively high efficiency [3] and [4]. Furthermore, this method allows the use of abundant local raw materials, such as organic waste, making it more environmentally friendly.

One organic waste with high potential as an adsorbent raw material is durian peel. Indonesia, as one of the largest durian producers, produces large quantities of durian peel waste that has not been optimally utilized. Durian peel contains approximately 50–60% cellulose and has a fibrous structure that supports pore formation during the carbonization process, making it a potential material for processing into activated carbon [15]. The chemical activation process is a crucial step in increasing adsorption effectiveness, including by increasing the surface area, improving the pore structure, and adding active groups to the activated carbon [14].

Activation using H_3PO_4 is reported to be more effective than other activators due to its dual role as both a dehydrating agent and a pore-forming agent. Unlike KOH or $ZnCl_2$ activation, which primarily function through physical etching, H_3PO_4 promotes the formation of phosphate and polyphosphate bridges between cellulose chains during pyrolysis. These bridges help maintain the pore structure and prevent excessive shrinkage during carbonization, resulting in activated carbon with higher surface area and a more developed porous network [17]. Furthermore, H_3PO_4 activation introduces phosphorus-containing functional groups on the carbon surface, which can enhance the adsorption of metal ions through complexation mechanisms. The relatively low activation temperature (400°C) required for H_3PO_4 activation makes it economically favorable compared to other chemical activation methods.

Previous research has shown that activated durian peel activated carbon with HCl and NaOH can reduce Fe levels in water with an effectiveness of more than 80%, while without activation it is only around 61.3% [16] and [6]. Activation using H_3PO_4 is also reported to be more effective than other activators due to its properties as a strong dehydrating agent, resulting in activated carbon with more open pores and a larger surface area [17]. However, research specifically examining the use of activated durian peel activated carbon with H_3PO_4 to reduce Fe levels in dug well water is still very limited.

The novelty of this study lies in several aspects: While the use of durian peel as an adsorbent has been previously explored, employing H_3PO_4 activation specifically for removing iron from actual dug well water—rather than synthetic solutions—represents a critical research gap that this study directly addresses. By utilizing real-world well water samples, this research accounts for the complex interference of coexisting ions and organic matter, thereby offering a far more realistic and rigorous assessment of adsorbent performance under field conditions. Furthermore, the systematic optimization of contact time for naturally contaminated water with an initial iron concentration of 1.8 mg/L yields practical, actionable guidance for direct field application. Finally, by conducting kinetic modeling on these non-ideal, complex environmental samples, this work significantly enriches the sparse existing literature regarding the adsorption mechanisms of iron onto biomass-derived activated carbons in the presence of real matrix effects.

This research contributes to the valorization of durian peel waste in Indonesia, one of the world's largest durian producers, by providing a sustainable and economical alternative for providing clean water in rural communities.

While studies have reported Fe adsorption using various biomass materials, research specifically examining H_3PO_4-activated durian peel for removing Fe from actual well water remains limited, particularly regarding the optimization of contact time and kinetic modeling under field-relevant conditions [16] and [6].

Based on these conditions, this study was conducted to evaluate the effectiveness of activated carbon from durian peel waste activated with H_3PO_4 in reducing iron (Fe) levels in dug well water. In addition, the study also aims to examine the effect of variations in contact time and determine the adsorption kinetics model that occurs. The results of this study are expected to contribute as an alternative solution for utilizing durian peel waste to provide safe and suitable clean water for rural communities.

2. Materials and Methods

2.1 Equipment

The equipment used in this study included a beaker, Erlenmeyer flask, measuring cylinder, volumetric pipette, dropper, rubber bulb, volumetric flask, porcelain cup, watch glass, distilled water bottle, glass funnel, stirring rod, spatula, analytical balance, aluminum foil, label paper, filter paper, cutter, black tape, universal indicator, stand and clamp, burette, pestle and mortar, sieve, oven, muffle furnace, desiccator, hot plate stirrer, magnetic bar, sample cup, Atomic Absorption Spectrophotometry (AAS), X-Ray Diffraction (XRD).

2.2 Materials

The materials used in this study included durian peel, 65% $HNO_{3\,(p)}$, 10% $H_3PO_{4(aq)}$, 1% starch $_{(aq)}$, N iodine $_{(aq)}$, distilled water $_{(l)}$, and well water.

2.3 Sampling and Preservation of Dug Well Water Samples

Samples were taken from a dug well in Damai Village, Lubuk Pakam District. Samples were taken in accordance with SNI 8995:2021. The samples were preserved using 65% HNO_3(p) until the pH was <2. Then, the bottle cap was tightened to eliminate air bubbles and the entire sample bottle was sealed with black tape.

2.4 Destruction Process and Determination of Iron (Fe) Content in Dug Well Water Samples

The test sample was homogenized. A 100 mL sample was taken and filtered. 5 mL of 65% HNO_3(p) was added. The sample was heated on a hotplate until the volume was 10-20 mL. This process was repeated until the metal dissolved and the dug well water sample became clear. Transfer the mixture to a 100 mL volumetric flask and dilute with distilled water to the upper limit. Then, homogenize the mixture and analyze the iron (Fe) content using Atomic Absorption Spectrophotometry (AAS) at a specific wavelength of 248.3 nm.

Prior to sample analysis, a calibration curve was constructed using standard Fe solutions at concentrations of 0.0, 0.2, 0.4, 0.6, 0.8, 1.0, and 2.0 mg/L, prepared from a 1000 mg/L Fe standard stock solution. The calibration curve exhibited a linear relationship with a correlation coefficient (R^2) of 0.9989. The AAS instrument was operated at a wavelength of 248.3 nm with a slit width of 0.2 nm. All measurements were performed in duplicate for the standards. Quality control was ensured through the analysis of blank samples and certified reference materials.

2.5 Making Activated Carbon from Durian Peel

The durian peel was thoroughly washed and cut into approximately 3 cm x 3 cm pieces. It was dried in the sun for 3 days and then oven-dried at 110°C for 30 minutes. It was fired in a Muffle Furnace at 400°C for 2 hours. After forming charcoal, it was cooled in a desiccator for 15 minutes. It was then ground and sieved using a 100-mesh sieve. Forty grams of the resulting carbon was soaked in 120 mL of a 10% H_3PO_4 solution for 24 hours. It was filtered through Whatman No. 42 filter paper and washed until the pH was neutral. Dry again in an oven at 110°C for 3 hours. Analysis: Moisture content, ash content, iodine value according to SNI, and characterization using X-Ray Diffraction (XRD) were performed.

2.6 Reduction of Iron (Fe) Metal Content by the Adsorption Method

A total of 0.5 grams of activated carbon was placed in a 250 mL Erlenmeyer flask. 100 mL of well water was added as a sample solution, and the container was covered with aluminum foil. The adsorption experiments were conducted at ambient room temperature (27 ± 2°C). The initial pH of the dug well water sample was measured using a pH meter and found to be 6.8 ± 0.2. The pH was not adjusted during the adsorption process to simulate real-world application conditions, where water treatment is typically performed at natural pH values. The temperature was maintained constant throughout the experiment using a temperature-controlled room.

The mixture was then stirred using a magnetic stirrer at 140 rpm for 60 minutes. It was then filtered through Whatman No. 42 filter paper. The filtrate was analyzed using an Atomic Absorption Spectrophotometer (AAS) at a wavelength of 248.3 nm. The same steps were applied for varying adsorption contact times of 90 minutes and 120 minutes. Finally, the percentage reduction in iron (Fe) content was calculated based on the analysis results.

Due to the limited volume of well water sample available and analytical constraints, the adsorption experiments were conducted as single measurements. However, the consistency of the results with theoretical models (R^2 = 0.9886) supports the reliability of the findings. Analysis: The adsorption kinetics modeling was determined based on the pseudo-first-order Lagergren model and the pseudo-second-order Ho & McKay model.

3. Results and Discussion

3.1 X-Ray Diffraction (XRD) Analysis

X-ray diffraction (XRD) is used as a material characterization method. It produces X-ray diffraction that interacts with the atoms in the sample to determine the crystal structure, crystal phase, and crystallinity of the material, as indicated by the peak pattern at an angle of 2θ. According to [11], the broad and less sharp peak shape in the XRD results indicates that activated carbon has an amorphous structure with a low degree of crystallinity. Figure 3.1 displays the diffraction results of activated carbon from durian peel activated using 10% phosphoric acid (H_3PO_4), which were then compared with the diffraction results of commercial activated carbon and reference data from JCPDS 41-1487 (Joint Committee on Powder Diffraction Standards).

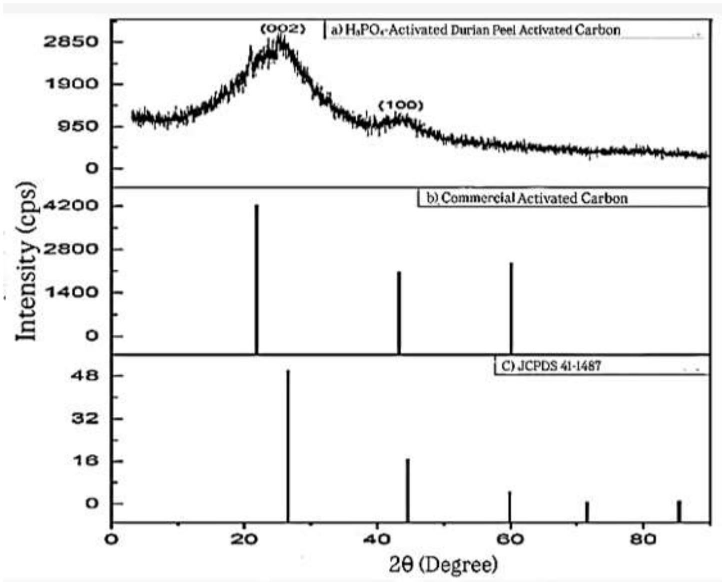


Figure 1. Diffractogram of Durian Peel Activated Carbon (a), Commercial Activated Carbon (b), and JCPDS 41-1487 (c)

The XRD diffractogram of durian peel activated carbon (Figure 1a) exhibited two broad diffraction peaks centered at approximately 2θ = 22-25° and 43°, corresponding to the (002) and (100) planes of amorphous carbon structures, respectively. The broad and diffuse nature of these peaks indicates a predominantly amorphous structure with a low degree of crystallinity. The absence of sharp, well-defined peaks suggests that the carbonization process at 400°C was sufficient to produce a disordered carbon structure, which is characteristic of activated carbon prepared from biomass precursors [11].

In comparison, commercial activated carbon (Figure 1b) showed a similar broad main peak at 2θ = 21.85° but also exhibited several weak peaks at 2θ = 43.26°, 60.01°, and 80.01°, indicating the presence of minor crystalline phases with low crystallinity. The standard graphite reference (JCPDS 41-1487, Figure 1c) displayed sharp, intense peaks characteristic of a highly ordered crystalline graphitic structure.

Weak and sharp peaks found at angles other than 20-30° such as commercial activated carbon samples indicate the presence (minor crystalline phase) of local atomic regularity structures in small amounts can be said to have a low level of crystallinity. The JCPDS 41-1487 data in Figure 1(c) serves as a standard reference for graphite crystallinity, with its very sharp peak patterns indicating the carbon has a pure, crystalline graphitic structure. These three patterns show that the durian peel and commercial activated carbon are predominantly amorphous, lacking the sharp peaks at the corners of the JCPDS 41-1487 data, indicating a crystalline (regular) structure.

The activation process using H_3PO_4 serves as a strong dehydrating agent that promotes pore development by removing volatile compounds and inhibiting the formation of graphitic crystal structures during carbonization. This results in an amorphous carbon matrix with enhanced porosity and surface area, which is highly beneficial for adsorption applications. The broadening of the (002) peak is evidence of reduced graphitic crystallinity, which correlates with increased amorphous character and the creation of more active sites for adsorption [19]. The amorphous nature of activated carbon significantly influences its ability to adsorb adsorbates, as its irregular structure creates numerous pores, which increase the surface area and efficiency of adsorption.

3.2 X-Ray Diffraction (XRD) Analysis Characterization of Activated Carbon

High water and ash content can reduce adsorption capacity because water molecules retained in the pores can block the entry of adsorbate molecules. Conversely, low water content allows more empty space within the pore structure. The iodine number is used as an indicator to assess the adsorption capacity of activated carbon. This value reflects the specific surface area and the number of micropores available to adsorb small molecules, such as iodine. The following are the results of the characterization test of durian skin activated carbon and reference parameters which can be seen in Table 1.

The activation with 10% H_3PO_4 improved the quality parameters of the resulting activated carbon. The iodine adsorption value of 964.44 mg/g obtained in this study is notably higher than the minimum SNI requirement of 750 mg/g, indicating the effectiveness of H_3PO_4 in developing microporosity. The phosphorus species introduced during activation likely contribute to the enhanced adsorption capacity by providing additional active sites for Fe binding. The moisture content (4.5%) and ash content (7.95%) values indicate that the activation process effectively removed impurities while maintaining structural integrity.

Table 1. Durian peel activated carbon test results parameters

No	Parameters	Research Results	SNI 06-3730-1995
1	Water content	4,5 %	Maks. 15%
2	Ash content	7,95 %	Maks. 10%
3	Iodine number I_2	964,44 mg/g	Min.750 mg/g

Overall, the test results for the three quality parameters indicate that activated carbon from durian peel waste, activated with 10% H_3PO_4, meets the Indonesian National Standard (SNI) quality criteria, making it suitable for use as an adsorbent in the process of purifying or reducing heavy metal content in water [13].

3.3 Effect of Adding Durian Peel Activated Carbon with Variations in Adsorption Contact Time on the Percentage (%) Reduction in Iron (Fe) Content

Contact time is a key factor influencing the adsorption process of durian peel-based activated carbon. In this study, contact time variations were conducted to evaluate the optimal duration required for the adsorbent to maximally absorb the adsorbate. In principle, the adsorption rate will increase with increasing contact time until equilibrium is reached. Increasing contact time allows for more interactions between the adsorbent and adsorbate, ultimately increasing the adsorption capacity [5]. The percentage (%) reduction in iron (Fe) metal levels in dug well water after adsorption using activated carbon from durian skin waste can be determined using the following equation:

$$\frac{\text{Initial Iron Metal Content (Fe)} - \text{Final Iron Metal Content (Fe)}}{\text{Initial Iron Metal Content(Fe)}} \text{x100\%}$$

The adsorption capacity (qe) at equilibrium for each contact time was calculated using the following equation:

$$qe = (C_0 - C_e) \times V / m$$

where qe is the adsorption capacity (mg/g), C_0 is the initial concentration (mg/L), C_e is the equilibrium concentration (mg/L), V is the volume of solution (L), and m is the mass of adsorbent (g).

Using the same equation, the percentage (%) reduction in iron (Fe) content can be calculated after the addition of activated carbon with adsorption contact times of 90 minutes and 120 minutes. The obtained values are then entered into Table 2.

Table 2 Data on the reduction in Iron (Fe) metal content (%) in dug well water after adsorption with the addition of durian peel activated carbon

No	Contact Time	Initial Concentration (mg/L)	Final Concentration (mg/L)	Percentage Reduction (%)	qe (mg/g)
1	60 minutes	1,8	0,26	85,55%	0.308
2	90 minutes	1,8	0,11	93,88%	0.338
3	120 minutes	1,8	0,18	90%	0.324

This study used contact time variations of 60, 90, and 120 minutes with an initial iron (Fe) concentration of 1.8 mg/L. The adsorption process was carried out using 0.5 g of durian peel activated carbon and a stirring speed of 140 rpm. The results of the absorption percentages from these variations are shown in Figure 2 below:

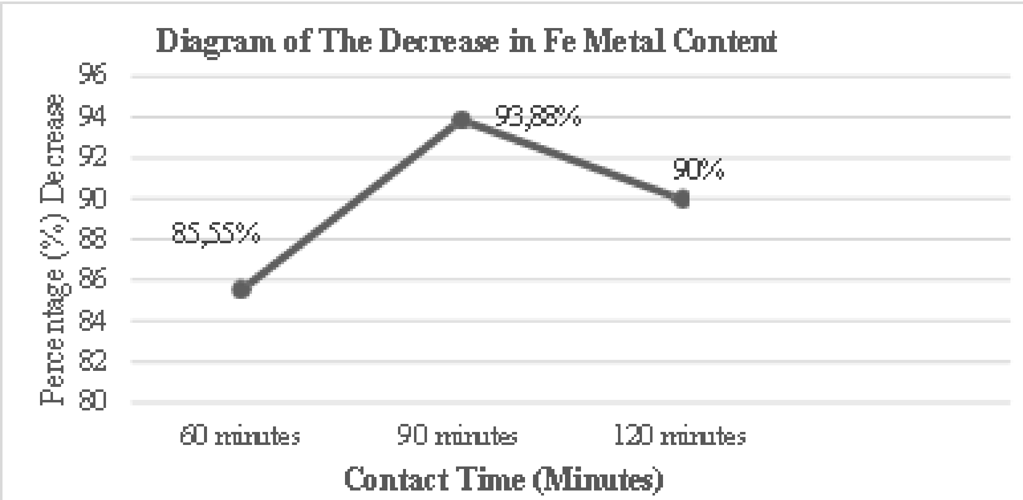


Figure 2. Percentage (%) of Decrease in Iron (Fe) Metal Content in Dug Well Water

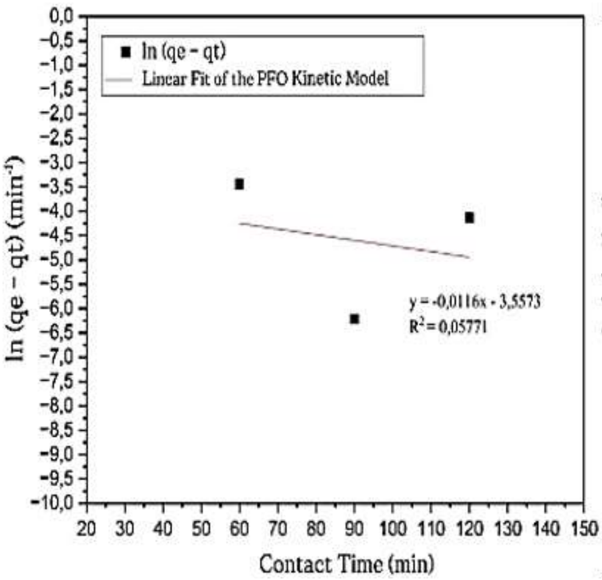
Research data shows that the initial level of 1.8 mg/L decreased to 0.26 mg/L, 0.11 mg/L, and 0.18 mg/L with contact times of 60 minutes, 90 minutes, and 120 minutes, respectively. The reduction in iron (Fe) levels after adsorption using activated carbon from durian peel waste at contact times of 90 and 120 minutes met the iron (Fe) quality standard set by the Indonesian Minister of Health Regulation No. 02 of 2023, which is 0.2 mg/L. The results in the figure show that a contact time of 60 minutes only reduced iron (Fe) levels by 85.55%, which is the lowest value compared to contact times of 90 and 120 minutes. This value indicates that a contact duration of 60 minutes is not sufficient to achieve optimal adsorption performance. Meanwhile, the highest adsorption efficiency was obtained at a contact time of 90 minutes, with a decrease in iron (Fe) metal levels of up to 93.88%, so that the final concentration dropped to 0.11 mg/L. This finding proves that extending the contact time to the optimum point can increase the effectiveness of activated carbon in reducing iron metal levels in dug well water. Previous research suggests that increasing contact time will increase the adsorption capacity until it reaches equilibrium conditions [12],

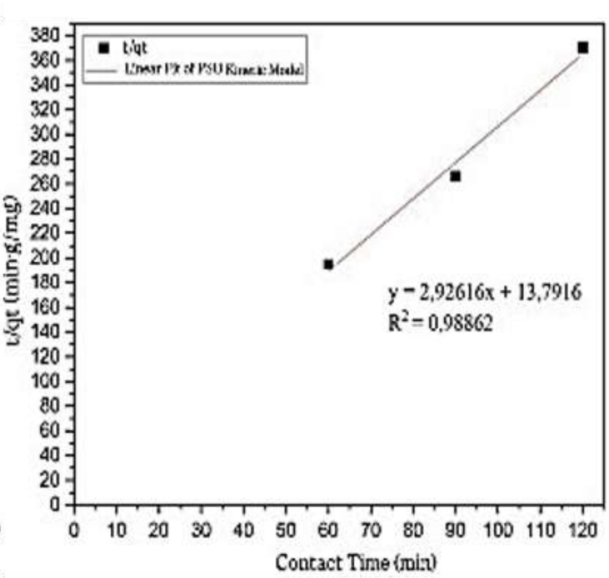
The high Fe removal efficiency of 93.88% at 90 minutes is primarily attributed to the physicochemical properties of the durian peel activated carbon, namely its high surface area and microporosity (iodine adsorption value of 964.44 mg/g) suitable for adsorbing small Fe ions, its amorphous structure rich in active sites as confirmed by XRD analysis, and its low ash content (7.95%) which minimizes pore blockage and provides additional sites from residual mineral components. This efficiency increased from 85.55% at 60 minutes to 93.88% at 90 minutes as the active sites were progressively utilized; however, a slight decrease to 90% at 120 minutes was observed, which could be attributed to several possibilities, such as site saturation, competitive effects from other cations (Ca^{2+}, Mg^{2+}) and organic matter, partial desorption of weakly bound Fe species, or Fe hydrolysis forming precipitates that block pores. Nevertheless, this decrease is relatively small (3.88%) and the final concentration at 120 minutes (0.18 mg/L) still meets the regulatory standard of 0.2 mg/L. Future studies using desorption experiments and surface characterization techniques (FTIR, XPS) could provide more definitive evidence regarding the mechanism of efficiency decline."

As a comparison in the manufacture of activated carbon that has been done by previous researchers such as coconut shell activated carbon is able to absorb iron ion levels in liquid waste up to 86.60% [16], activated carbon from KOH-activated banana stems shows an iron ion adsorption efficiency of 75.38%[2], and activated carbon from young banana peels activated by KOH shows an iron ion adsorption efficiency in wells of 69.90% [9]. These data prove that activated carbon produced from durian peels is able to act as an effective adsorbent to reduce Fe levels in dug well water, and offers better adsorption performance than other alternative raw materials.

The high iodine number (964.44 mg/g) of our activated carbon, which exceeds the SNI minimum requirement of 750 mg/g, indicates a well-developed pore structure that contributes to its performance compared to many alternative materials. The short equilibrium time (90 minutes) is also advantageous for practical applications compared to some other adsorbents that require hours to reach equilibrium.

3.3 Kinetics of Adsorption Iron (Fe) Metal Content in Dug Well Water on Durian Peel Activated Carbon (%)





(a) (b)

Figure 3 Pseudo-First Order (a) and Pseudo-Second Order (b) Adsorption Kinetic Models

Table 3 Kinetic parameters of pseudo-first order and pseudo-second order adsorption

Kinetic Modeling	K (minutes^{-1})	qe (mg/g)	Regression (R^2)
Pseudo First Order	0,01164	0,02852	0,05771
Pseudo Second Order	0,6208	0,34174	0,98862

Based on the data in Table 3, the pseudo-second-order (PSO) kinetic model exhibits agreement with the experimental data for Fe adsorption, as evidenced by its coefficient of determination (R^2) of 0.98862. This value is substantially higher than that of the pseudo-first-order (PFO) model, which yielded an R^2 of only 0.05771, indicating that the PSO model is statistically far more representative in describing the Fe adsorption mechanism onto durian peel activated carbon. The PSO model yields a theoretical equilibrium adsorption capacity (qe) of 0.34174 mg/g, which estimates the amount of Fe adsorbed per gram of adsorbent at equilibrium. The adsorption rate constant (k_2) is recorded as 0.6208 g/(mg·min). The exceptionally high fit to the PSO model scientifically indicates that the rate-limiting step in the Fe adsorption process is chemisorption, which involves valence interactions through electron exchange or sharing between Fe^{2+}/Fe^{3+} ions and surface functional groups (e.g., hydroxyl, carboxyl, or phosphate groups from H_3PO_4 activation) on the activated carbon, further reinforcing the evidence that the adsorption proceeds via relatively strong chemical bond formation rather than mere physical diffusion [10]. The conclusion of this study is also in line with several previous studies which found that the pseudo-second-order model is more suitable for describing the adsorption of iron metal and other metals. Examples include research on the adsorption of iron(II) using pineapple leaf waste [4], the adsorption of iron (II) by rice husks [2], and the adsorption of iron (II) using sweet orange peel waste [9]

The adsorption mechanism of Fe ions by H_3PO_4-activated durian peel activated carbon is a multi-mechanism process dominated by chemisorption through surface complexation and ion exchange, supported by physical adsorption within the micropores. H_3PO_4 activation plays a dual role: (1) developing the pore structure through the formation of phosphate bridges, and (2) introducing functional groups that serve as active sites for chemical bonding with Fe ions. This explains the high adsorption efficiency (93.88%) and the conformity with the pseudo-second-order kinetic model.

4. Conclusion

In conclusion, durian peel waste can be used as raw material for activated carbon production through dehydration, carbonization, and chemical activation with 10% H_3PO_4. In addition, Durian peel activated carbon activated using 10% H_3PO_4 meets the Indonesian National Standard (SNI) 06-3730-1995 requirements, including moisture content, ash content, and iodine adsorption capacity. Therefore, in this study, the optimum adsorption contact time reached equilibrium at 90 minutes, achieving a 93.88% reduction in iron (Fe) content in dug well water of 0.11 mg/L. The adsorption kinetics of iron (Fe) by durian peel activated carbon followed a second-order kinetic model with the highest linear regression value (R2) of 0.9886.

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6. Conflict of Interest

Authors declare no conflicts of interest

References

[1] Aba L, 2017. Dug Well Water Treatment with the Aeration Filtration Method Using Bubble Aerators and Rapid Sand Filters to Reduce Iron (Fe) and Manganese (Mn) Levels. Journal of Physics Applications, 13(2): 38-47.

[2] Adekola F. A, Hodonou DSS, Adegoke I, 201. Thermodynamic and kinetic studies of biosorption of iron and manganese from aqueous medium using rice husk ash. Applied Water Science, 6(4): 319–330.

[3] Anggriani, Ulfa M, Abu H, Indah P, 2021. Kinetics of Activated Carbon Adsorption in Reducing Copper (Cu) and Lead (Pb) Metal Concentrations. Journal of Kinetics, 12(2): 29-37.

[4] Ari S, Anis S, Intan S, 2017. Utilization of Pineapple Leaf Waste as a Basic Material for Activated Carbon for Fe(II) Adsorption. JKK, 6(3):66-74.

[5] Arief AR, 2014. Adsorption of Activated Carbon from Kluwak Shells on Phenol Reduction. [Thesis]. Makassar: Alauddin State Islamic University of Makassar.

[6] Arsal K, Wa N, Dwiprayogo W, Ilham, Sumarlin, 2022. Effectiveness of Dried Durian Peel-Based Water Filtration as a Filtration Media for Heavy Metal Levels of Cadmium and Lead. Journal of Geography, Education and Environment, 6(1):36-43.

[7] Berlianto A, Susanti D, Nurdiansah H, 2022. Analysis of the Effect of Activated Carbon (AC) Addition on the Photocatalytic Properties of CuO/Ac Composite Material in Reducing CO_2 to Methanol Under Visible Light Irradiation. ITS Engineering Journal, 11 (1).

[8] Fifi AIP, 2023. Utilization of Pulp Waste from PT. Toba Pulp Lestari as Activated Carbon in the Reduction of Zinc (Zn) Metal. [Thesis]. Medan.

[9] Hikmah M, Elwina, 2023. Making Activated Carbon from Sweet Orange Peel Waste as Iron (Fe) II Ions in Well Water. Jurnal Ristera, 2 (1): 2986-1799.

[10] Ho YS, McKay G, 1999. Pseudo-Second Order Model for Sorption Processes. Process Biochemistry, 34(5):451–465.

[11] Jayaraman VK, 2020. Durian Shell-Based Activated Carbon for Environmental Applications. Environmental Science and Pollution Research, 27(23): 28710–28730.

[12] Nasda M, Kurniawati D, Nasra E, 2023. The Effect of Contact Time and Stirring Speed on the Absorption of Methylene Blue Dye Using Matoa Peel Biosorbent. 12(2): 58–62.

[13] Nurrahman A, Permana E, Gusti DR, 2021. The Effect of Activator Concentration on the Quality of Activated Carbon from Lignite Coal, 6(4): 41–44.

[14] Risfidian M, Adi S, Nurlisa H, Aldes L, 2014. Study of the Interaction of Metal Ions with Cellulose from Sawdust. Journal of Chemistry, 8(1): 1-8.

[15] Sahara E, Dahliani NK, Manuaba IBPB, 2017. Preparation and Characterization of Activated Charcoal from Gumitir Plant Stems (Tagetes Erecta) with NaOH Activator. Journal of Chemistry, 11(2):174-180.

[16] Sukma BD, 2019. Characteristics of Bioadsorbent from Durian Peel Waste for Absorption of Heavy Metals Fe and Zn in Well Water. Journal of Process Technology and Industrial Innovation, 4(1).
[17] Verayana, Paputungan, Mardjan, Iyabu, Hendri, 2018. Effect of HCL and H_3PO_4 Activators on the Characteristics (Pore Morphology) of Coconut Shell Activated Charcoal and Adsorption Test on Lead (Pb) Metal. Journal of Entropy, 13(1):6-7.
[18] Wiryawan AGP, Saputra I, Ketut, 2016. Stages of Calculating Water Level in Rivers (Case Study of the Muara Tukad Unda Reservoir Dam).
[19] Zhang W, 2017. Characterization of Biochar Properties Affected by Different Pyrolysis Temperatures Using Visible Near Infrared Spectoscopy. Scientific Reports, 7: 44714.
[20] Zian U, Harmami, 2016. The Effect of Contact Time on Adsorption. Jurnal Sains dan Seni Institut Sepuluh November, 5(2): 107-110.