JCNaR
Journal of Chemical Natural Resources
Journal homepage: https://jcnar.usu.ac.id

Reduction of Metal Density of Iron (Fe) and Natrium Minerals (Na) in Boring Water Using Rubber Fruit Sheets Active Archoic

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ARTICLE INFO
Article history:
Received 22 April 2024
Revised 19 May 2024
Accepted 19 October 2023
Available online 20 May 2024

E-ISSN: 2656-1492

How to cite:
Zul Alfian, Uly Ashari. Reduction of Metal Density of Iron (Fe) and Natrium Minerals (Na) in Boring Water Using Rubber Fruit Sheets Active Archoic. Journal of Chemical Natural Resources. 2024, 6(1):22-29.

https://doi.org/10.32734/jcnar.v6i1.16221

ABSTRACT
Activated carbon is a highly popular adsorbent for the absorption of metal ions. Lignocellulosic materials can be used to produce activated carbon, which is both renewable and abundant, as well as being cost-effective. The objective of this research is to investigate the reduction of iron (Fe) and sodium (Na) levels in the artesian well by utilizing activated carbon made from rubber shells. The materials utilized include rubber shells, a solution containing 10% H_3PO_4 (phosphoric acid), water from an artesian well, and distilled water (aquadest). The carbonization process was conducted at 300º C for 1 h, using an adsorbent size of 120 mesh. In addition, chemical activation was performed using a 10% H_3PO_4 solution for 24 h, followed by physical activation through heating in a furnace at a temperature of 500ºC for 1 hour. The acquired activated carbon is utilized for the absorption of Fe and Na. The activated carbon was characterized using X-ray diffraction (XRD), and the concentration of Fe and Na minerals was determined using an Atomic Adsorption Spectrophotometer (AAS). The results indicated a reduction of 97.9% in the concentration of iron (Fe) and a decrease of 90.01% in sodium (Na) levels.

Keywords: Activated Carbon, Adsorption, Rubber Shell, SSA, XRD.

ABSTRAK
Karbon aktif merupakan adsorben yang sangat populer untuk penyerapan ion logam. Bahan lignoselulosa dapat digunakan untuk menghasilkan karbon aktif, yang terbarukan dan melimpah, serta hemat biaya. Penelitian ini bertujuan untuk mengetahui penurunan kadar besi (Fe) dan natrium (Na) pada sumur artesis dengan memanfaatkan karbon aktif berbahan cangkang karet. Bahan yang digunakan terdiri dari cangkang karet, larutan yang mengandung H3PO4 (asam fosfat) 10%, air sumur artesis, dan air suling (aquadest). Proses karbonisasi dilakukan pada suhu 300º C dengan durasi 1 jam, menggunakan adsorben berukuran 120 mesh. Selain itu dilakukan aktivasi kimia menggunakan larutan H_3PO_4 10% dengan durasi 24 jam, dilanjutkan dengan aktivasi fisik melalui pemanasan dalam tanur pada suhu 500ºC selama 1 jam. Karbon aktif yang diperoleh digunakan untuk penyerapan Fe dan Na. Karbon aktif dikarakterisasi menggunakan Difraksi Sinar-X (XRD), dan konsentrasi mineral Fe dan Na ditentukan menggunakan Spektrofotometer Adsorpsi Atom (AAS). Hasil penelitian menunjukkan adanya penurunan konsentrasi zat besi (Fe) sebesar 97,9% dan penurunan kadar natrium (Na) sebesar 90,01%.

Kata kunci : Adsorpsi, Arang Aktif, Cangkang Buah Karet, SSA, XRD.

1. Introduction

Water is a basic human need, so it can be said that humans cannot live without water [1]. In Indonesia, clean and drinking water generally comes from surface water, groundwater, and rainwater. One groundwater source is clean water, both deep well water and shallow healthy water (Sutrisno, 2004). The use of boreholes is one way to obtain groundwater [2].

Clean water can be polluted by various industrial, agricultural, and household wastes that can endanger the community and interfere with the survival of humans and other living things [3]. People in Tangkahan Lagan Village Alur Dua Baru Sei Lepan District Langkat Regency use boreholes to meet their daily needs for bathing, washing, and drinking water. This well water does not have good water quality; the water is smelly, oily, and yellowish murky.

Atomic Absorption Spectroscopy (SSA) data shows the results of Iron (Fe) metal content that exceeds the threshold limit according to the Minister of Health Regulation No. 416/Menkes/Per/IX/1990, which is 0.6205 mg/L. Groundwater has a reasonably high mineral content. The mineral content of groundwater includes Na, Mg, Ca, Fe, and O_2 [4]. Fe is an example of an essential heavy metal that is needed to help the physiological processes of living things, but excessive amounts can cause health problems (Siagian et al., 2019). Sodium is an essential mineral that the body needs. However, it can harm the body and cause edema or swelling caused by excess fluid trapped in body fluids [5]. According to Minister of Health Regulation No. 416/Menkes/Per/IX/1990, the maximum limit of metal content in drinking water is 0.3 mg/L for Fe, and according to WHO, Na is 2.4 mg/L.

Therefore, borehole water treatment is needed before the community utilizes it. One of the most widely used adsorbents to absorb metal ions is activated charcoal. Activated charcoal is a solid, porous material from the combustion of materials containing 85-95% elemental carbon [6]. Activated charcoal can be made from many sources, such as coconut shells, peat, black ash, charcoal, lignite, coal, and petroleum coke [7].

Activated carbon from lignocellulosic materials, significantly activated carbon produced from agricultural waste, is renewable, abundant, available, and inexpensive. The utilization of rubber plants is still limited to the sap, while other parts of this plant, such as stems, fruits, and rubber fruit shells, are waste that has not been utilized. Utilization of rubber fruit shells can be used as raw material for making activated charcoal [7]. From the above data, it can be seen that the rubber fruit shell is a very potential raw material for activated charcoal.

Waste from rubber plantations in the form of rubber fruit shells also has the potential to be used as a primary material for making activated charcoal because it contains 50% carbon [8-9]. Arofah, et al (2019) conducted research on the manufacture of activated charcoal rubber fruit shells with an H_3PO_4 activator for the adsorption of iron (III) metal in the solution, where the study produced the best-activated carbon in samples of 120 mesh size and temperature of 500º C. For the adsorption of activated carbon against iron (III) metal solution, the best contact time is 90 minutes, with a mass of 0.5 grams of activated carbon showing a sorption efficiency of 68% [10].

Therefore, researchers are interested in conducting applications to previous research, namely "reducing levels of iron metal (Fe) and sodium minerals (Na) in borehole water using rubber fruit shell activated charcoal."

2. Materials and Methods

2.1 Equipment

The tools used in this research are bottles of distilled water, measuring cups, beakers, Erlenmeyer, measuring flasks, volume pipettes, dropper pipettes, universal indicators, funnels, spatulas, magnetic bars, hot plates, analytical balances, filter paper, sieves, mortars, furnaces, ovens and Atomic Absorption Spectrophotometer (SSA).

2.2 Materials

The materials used in this study are rubber fruit shells, rubber fruit shell activated charcoal, Fe 1000 mg/L standard solution, Na 1000 mg/L standard solution, $HNO_{3\,(p)}$, distilled water, borehole water, and 10% H_3PO_4.

2.3 Research procedure

2.3.1 Preparation of Rubber Fruit Shell Activated Charcoal

Rubber fruit shells are cleaned with distilled water and then dried in an oven at 110ºC for 3 hours. Furthermore, the rubber fruit shells were charred at 300ºC and then mashed and sieved using a 120 mesh sieve. Then, it is chemically activated using 10% H_3PO_4 solution for 24 hours, washed with distilled water until the pH is neutral, and oven-dried at 110ºC for 3 h. Next, the charcoal was physically activated by heating in a furnace at 500ºC for 1 h. Characterization was tested using XRD.

2.3.2 Determination of Water Samples

Determination of samples taken is borehole water, which has the following characteristics:

- Yellowish turbid water
- Water that tastes salty
- Smells
- Has Fe levels of more than 0.3 mg/L, according to the Minister of Health
- Has a Na level of more than 2.4 mg/L, according to WHO

2.3.3 Water Sampling

Sampling points were taken from 3 residents' houses with a distance of ± 5 m to ± 10. Then, the water was taken using a 1-liter plastic bottle rinsed with distilled water, HNO_3, and sample water. Then, the sample is preserved by adding HNO_3 until pH = 2 (SNI 6989.58.2008).

The adsorbed sample was selected by purposive sampling at 1 borehole from 3 borehole samples with the criteria of having Iron (Fe) and Sodium (Na) content exceeding the respective thresholds of 0.3 mg/L for Fe and 2.4 mg/L for Na.

2.3.4 Preparation of Iron (Fe) Standard Solution

2.3.4.1 Preparation of 100 ppm Iron (Fe) Standard Solution

Iron (Fe) standard solution of 1000 ppm was pipetted as much as 10 mL, then put into a 100 mL volumetric flask, and then diluted with distilled water.

2.3.4.2 Preparation of 10 ppm Iron (Fe) Standard Solution

Iron (Fe) standard solution of 100 ppm was pipetted as much as 10 mL, then put into a 100 mL volumetric flask, and then diluted with distilled water.

2.3.4.3 Preparation of Iron (Fe) Standard Series Solution 0.2, 0.2, 0.6, 0.8 and 1 ppm

Iron (Fe) standard solution of 10 ppm was successively pipetted 2, 4, 6, 8, and 10 mL, then each was put into a 100 mL flask and then diluted with distilled water.

2.3.4.4 Preparation of Iron (Fe) Calibration Curve

The blank solution (0.0) mg/L was measured for absorbance using SSA at a specific λ of 248.3 nm. The treatment was carried out three times. The same was done for Iron (Fe) standard series solutions of 0.2, 0.4, 0.6, 0.8, and 1 ppm.

2.3.5 Preparation of Sodium (Na) Standard Solution

2.3.5.1 Preparation of 100 ppm Sodium (Na) Standard Solution

Standard sodium (Na) solution of 1000 ppm was pipetted at as much as 10 mL, then put into a 100 mL volumetric flask, and then diluted with distilled water.

2.3.5.2 Preparation of 10 ppm Sodium (Na) Standard Solution

Standard sodium (Na) solution of 100 ppm was pipetted at as much as 10 mL, then put into a 100 mL volumetric flask, and then diluted with distilled water.

2.3.5.3 Preparation of Sodium (Na) Standard Series Solution 0.2, 0.4, 0.6; 0.8 and 1 ppm

Sodium (Na) standard solution of 10 ppm was successively pipetted 2, 4, 6, 8, and 10 mL, then each was put into a 100 mL measuring flask and then diluted with distilled water.

2.3.5.4 Sodium (Na) Calibration Curve Preparation

The blank solution (0.0) mg/L was measured for absorbance using an atomic absorption spectrophotometer (SSA) at a specific λ of 589.0 nm. The treatment was done three times. The same was done for sodium (Na) standard series solutions of 0.2, 0.4, 0.6, 0.8, and 1 ppm.

2.3.6 Determination of Iron Metal (Fe) and Sodium Metal (Na) Levels in Samples Before Adsorption by Atomic Absorption Spectrophotometer (SSA)

2.3.6.1 Sample Preparation

100 mL of water samples were filtered using ordinary filter paper. Then the filtrate was put into a 250 mL beaker, 5 mL of HNO_3, heated on a hotplate until the volume of the solution became ± 15 mL, and 50 mL of distilled water, put into a 100 mL flask through Whatman filter paper no. 42, diluted with distilled water.

2.3.6.2 Determination of Fe and Na Content in Samples

The prepared sample solution was analyzed quantitatively by measuring its absorbance using SSA for Fe at specific λ = 248.3 nm and Na at specific λ = 589.0 nm.

2.3.7 Metal Adsorption

Rubber fruit shell activated charcoal was weighed as much as 0.5 g, put into an Erlenmeyer, and added 100 mL of borehole water samples. The mixture was stirred using a stirrer with a contact time of 90 minutes at room temperature (25ºC). Filtered the mixture to separate the precipitate from the filtrate. Then, the filtrate obtained was analyzed by SSA atomic absorption spectrophotometer for Fe at λspecific = 248.3 nm and Na at λspecific = 589.0 nm.

3. Results and Discussion

3.1 Activated Carbon Rubber Fruit Shell

The raw materials used for rubber fruit shells, such as hazelnut and cashew shells, have a somewhat rigid structure. To degrade all the components of the rubber fruit shell and facilitate carbon synthesis, particularly lignin, a furnace is employed at 500ºC. According to research by Polleto et al. (2010), lignocellulosic biomass undergoes degradation in different phases. First, hemicellulose degradation occurs at temperatures ranging from 180-300ºC [11]. This is followed by cellulose degradation at temperatures between 275-300ºC. Finally, the lignin component is degraded at higher temperatures, specifically between 250ºC and 500ºC. The pyrolyzed carbon underwent activation with H_3PO_4 at 500ºC for 24 h in a furnace. This process aimed to produce activated carbon with increased porosity [12], eliminate tar compounds from the carbon pores[13], and enhance the carbon surface through oxidation. These modifications were intended to optimize the utilization of the activated carbon, particularly for its application as an adsorbent.

3.2 X-Ray Diffraction (XRD) Analysis

XRD analysis was conducted to determine the crystal structure of rubber fruit shell-activated charcoal. The XRD test is characterized by peaks at 2θ angles, as shown in Figure 1.

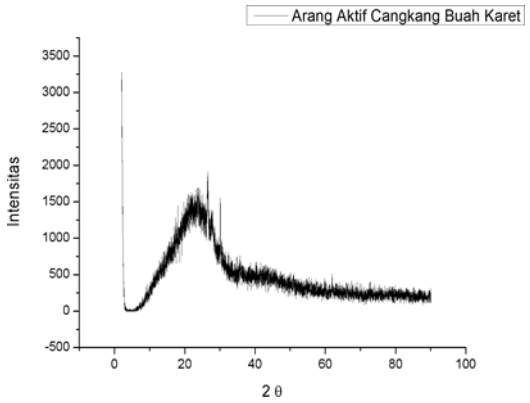

Figure 1. XRD Diffractionogram of Rubber Fruit Shell Activated Charcoal

The diffraction pattern produced by the active charcoal of rubber fruit shells exhibits prominent peaks in the [002] and [001] plane orientations. These peaks are observed at 2θ angles ranging from around 23o to 25o and 42o to 44o, respectively. The image exhibits a broad range of angles and a gradually inclining peak, suggesting that the activated charcoal derived from rubber fruit shells is amorphous. The activation process induces a transition in the hexagonal plate from a highly regular (crystalline) state to an irregular (amorphous) state, influencing the high and low peaks observed in the XRD analysis.

The activation method effectively eliminates surface contaminants on the carbon while simultaneously opening and organizing pores. This results in an enhanced crystallinity compared to carbon without undergoing the activation process. The activation process using H_3PO_4 resulted in a carbon content of 97%. These findings align with the research conducted by [10], which demonstrated significant changes in the characteristics of activated carbon derived from rubber fruit shells before and after activation with a 10% H3PO4 solution, as determined by XRD analysis. Before activation, the carbon atom in the carbon has a carbon content of 78%, which increases to 97% following activation. These findings suggest that H_3PO_4 is the optimal catalyst for activating carbon derived from rubber fruit shells.

3.3 Effect of Rubber Fruit Shell Activated Charcoal Addition on Percentage (&) Reduction of Iron (Fe) and Sodium (Na) Metal Concentrations

Table 1. Data on the percentage (%) decrease in the concentration of iron metal (Fe) in well water with the addition of rubber fruit shell activated charcoal

Activated Charcoal Mass (g)	Concentration (mg/L)		Absorbent concentration (mg/L)	Percentage concentration decrease (%)
	Before addition	After addition		
0.5	2.6576	0.0555	2.6021	97.9

Table 2. Data on the percentage (%) decrease in sodium concentration in well water with the addition of rubber fruit shell activated charcoal

Activated Charcoal Mass (g)	Concentration (mg/L)		Absorbent concentration (mg/L)	Percentage concentration decrease (%)
	Before addition	After addition		
0.5	8.9261	0.8914	8.0347	90.01

The obtained data indicate a decrease in iron metal (Fe) and sodium mineral (Na) content by 97.9% and 90.01%, respectively. The iron (Fe) concentration in well water was 2.6576 mg/L before the addition of activated charcoal. However, following the addition of activated charcoal, the concentration decreased to 0.0555 mg/L. The concentration of sodium (Na) minerals in well water is 8.9261 mg/L before activated charcoal is added. After adding activated charcoal, the concentration is reduced to 0.8914 mg/L.

These findings demonstrate that activated charcoal derived from rubber fruit shells may effectively adsorb iron metal and sodium minerals. The charring process leads to the formation of pores, while activation is achieved by adding 10% H_3PO_4 activating material. This material enlarges the pores of activated charcoal, allowing it to absorb iron metal and sodium minerals effectively. This is demonstrated by the successful absorption of iron and sodium minerals in previous experiments. According to Arofah et al.'s (2019) research, H_3PO_4 is the appropriate activator for activating carbon from rubber fruit shells [10].

3.4 Adsorption Isotherms

To determine the Langmuir and Fruendlich isotherm equations, the prices of x/m, Ce/(x/m), log Ce/(x/m), and log Ce were calculated as shown in Tables 3 and 4.

Table 3. Isotherm model processing data on Fe

Co	Ce	Xm/m	Ce/(Xm/m)	Log Xm/m	Log Ce
2.6484	0.0469	5.2968	0.0088	0.7240	-1.3288
2.6583	0.0556	5.3166	0.0104	0.7256	-1.2549
2.6662	00642	5.3322	0.0120	0.7269	-1.1924

Table 4. Data processing results of Freundlich Isotherm model on Na

Co	Ce	Xm/m	Ce/(Xm/m)	Log Xm/m	Log Ce
8.7862	0.8773	17.724	0.0499	1.2448	-0.0568
8.8904	0.9061	17.816	0.0509	1.2499	-0.0428
9.1015	0.8908	18.2003	0.0489	1.2601	-0.0502

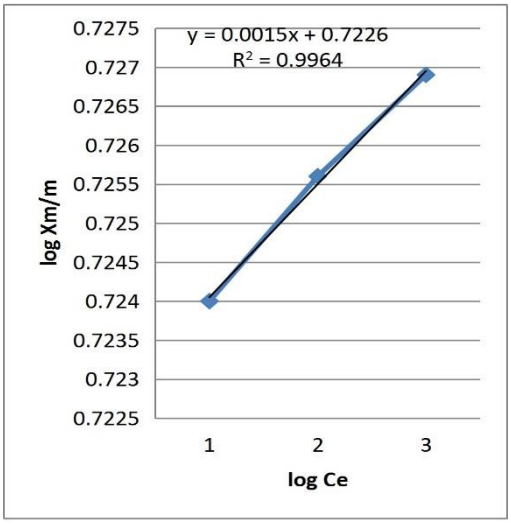

Figure 2. Relationship curve of log Xm/m and log Ce for Fe (Freundlich Fe)

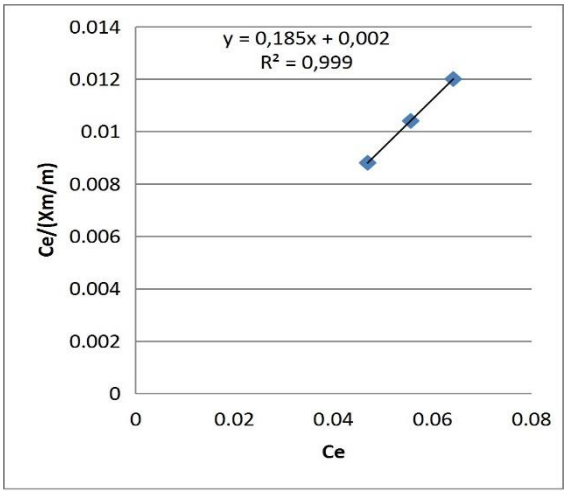

Figure 3. Relationship curve of Ce and Ce/(Xm/m) for Fe (Langmuir Fe)

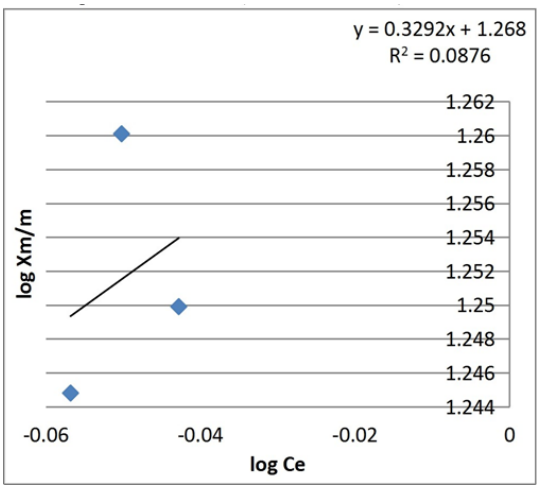

Figure 4. Relationship curve of log Xm/m and log Ce for Na (Freundlich Na)

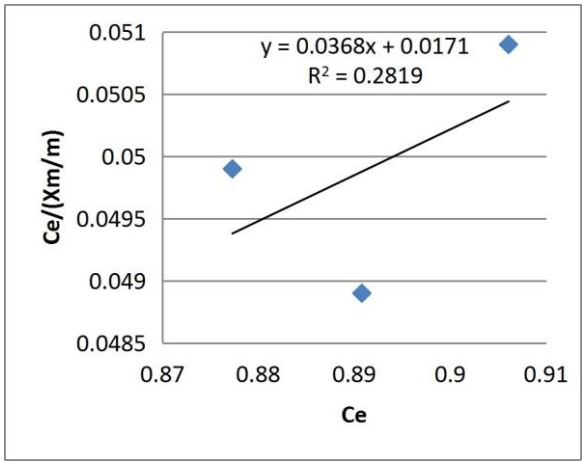

Figure 5. Relationship curve of Ce and Ce/(Xm/m) for Na (Langmuir Na)

Figures 2 and 3 demonstrate that the adsorption equation of Fe metal by rubber fruit shell adheres to the Langmuir adsorption equation (R^2 = 0.999) and the Freundlich adsorption equation (R^2 = 0.996). This suggests that the Langmuir and Freundlich equations are suitable for describing the adsorption of Fe metal ions by rubber fruit shell-activated charcoal. Figures 6 and 7 indicate that the adsorption equation of Na metal by rubber fruit shell does not satisfy the Langmuir adsorption equation (R^2 = 0.281) or the Freundlich adsorption equation (R^2 = 0.087). This indicates that the Langmuir and Freundlich equations are unsuitable for describing Fe metal ions' adsorption by rubber fruit shell-activated charcoal. The Freundlich equation model postulates the presence of many surface layers (multilayer) and a heterogeneous side characterized by varying binding energies on each side. The adsorption process on each side of the adsorbent follows the Langmuir isotherm. Hence, the Langmuir adsorption equation is employed to calculate the maximum adsorption capacity of activated charcoal made from rubber fruit shells in absorbing Fe metal. This calculation assumes that only a single layer of Fe metal ions is adsorbed on each surface of the activated charcoal. The units used to express the adsorption capacity are mg of adsorbed Fe metal ions per gram of activated charcoal. Regarding sodium minerals, it is imperative to investigate adsorption isotherm models, such as BET or similar models.

4. Conclusion

1. The concentration of Iron (Fe) metal and Sodium mineral in the borehole water of Tangkahan Lagan Alurdua Baru Village residents used as clean water and drinking water is 2.6576 mg/L and 8.9261 mg/L, respectively.
2. Iron metal (Fe) in the well water before the addition of activated charcoal has a concentration of 2.6576 mg/L and, after the addition of activated charcoal, reduced to 0.0555 mg/L. Sodium (Na) minerals in well water before the addition of activated charcoal have a concentration of 8.9261 mg/L and, after the addition of activated charcoal, reduced to 0.8914 mg/L.
3. Rubber fruit shell activated charcoal can absorb Iron (Fe) metal by 97.9% and absorb Sodium (Fe) mineral by 90.01%.

5. Acknowledgements

We thank the Analytical Chemistry Laboratory of Universitas Sumatera Utara for facilitating the implementation of this research

6. Conflict of Interest

Authors declare no conflicts of interest

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