JURNAL
KESEHATAN LINGKUNGAN
JURNAL DAN APLIKASI TEKNIK KESEHATAN LINGKUNGAN

ISSN 1829-9407 (Print)
ISSN 2581-0898 (Online)

Volume 21, No. 2, July 2024; Page: 263-268; *DOI: https://doi.org/10.31964/jkl.v21i2.758*

EFFECTIVENESS OF CORN SHELL ACTIVATED CARBON FILTERS IN REDUCING IRON (FE) LEVELS IN CLEAN WATER

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Article Info

Article history:
Received July 30, 2023
Revised June 28, 2024
Accepted July 01, 2024

Keywords:

Filter
Activated Carbon
Corn Husk
Iron (Fe)

ABSTRACT

Effectiveness of Corn Shell Activated Carbon Filters in Reducing Iron (Fe) Levels in Clean Water. Corn husk waste often accumulates and lacks optimal management, making its use as active carbon more valuable and beneficial to society. The principle of the activated carbon processing method involves adsorbing pollutants, thereby enhancing its capacity to absorb iron levels. Researchers must create filters using corn husk-activated carbon media to lower the iron levels in clean water. The research aims to determine the effectiveness of the thickness of corn husk-activated carbon filtration media, which can reduce iron levels in clean water. The research design is a True Experiment with Pretest-Posttest and Control Group Design, incorporating four variations in activated carbon thickness and six repetitions. Variations in thickness of corn husk activated carbon are 0 cm, 5 cm, 10 cm, and 15 cm. Data analysis used the Kruskal-Wallis test. The research showed that the iron level before treatment was 1.71 mg/L. After treatment with activated carbon thicknesses of 0 cm (0%), 5 cm (67%), 10 cm (80%), and 15 cm (86%), the iron content decreased. The statistical test results obtained a p-value ≤ α (0.05), indicating that all data groups had significant differences. The public can use filters with an activated carbon thickness of more than 15 cm as an alternative for reducing iron levels in clean water.

INTRODUCTION

Water is the most important element after air because living creatures require it for their daily lives. According to the Minister of Health's Regulation Number 2 of 2023, which implements Government Regulation Number 66 of 2014 concerning Environmental Health, the maximum level of Fe metal is 0.2 mg/L [1]. Excessive concentrations of Fe can be toxic to organisms and the environment, so it's important to exercise caution as large accumulations can be dangerous. [2].

Absorption (adsorption) is a process of separating materials from a gas or liquid mixture. The solid adsorbent's surface will attract and bind the material you want to separate [3]. Activated carbon, silica gel, natural zeolite, molecular sieve, bleaching earth, aluminium oxide, and others are common adsorbents [4]. Because of its large surface area and micropore volume, activated carbon is a highly effective adsorbent that is relatively easy to replace [5]. In this way, the adsorption energy becomes greater for dyes and odors. The surface area is wider because carbon has a hollow internal surface, so it has the ability to absorb gases, vapours, or substances that are in a solution [6].

Activated carbon, as an absorbent medium, can reduce iron levels. Filtration with activated carbon is one method for reducing iron levels [7]. Filtration reduces germs and removes the color, taste, and smell of iron and manganese [8]. The processing method using carbon is based on the principle of adsorbing pollutant materials with carbon media [7]. The adsorption process heavily relies on the media's surface area and its total pore area [9].

Traditional markets frequently feature corn husks as waste. According to statistical data from the Food Crops and Horticulture Service of South Kalimantan Province in 2021, corn production is the second largest commodity after rice, with 264,168 metric tons of milled dry grain [10]. Therefore, the production of waste is substantial and could yield greater value if utilized as active carbon. Corn husks have a composition of 15% lignin, 5.09% ash, 4.57% alcohol-cyclohexane (1:2), and 44.08% cellulose [11]. Because the bound OH- groups can interact with the adsorbate components, cellulose has great potential as an absorbent. An ion exchange mechanism is the absorption mechanism that occurs between the OH- group bound to the surface and the positively charged Fe metal ion (cation). [12].

According to research by Pujiasih et al. (2019), testing the filtration system with the addition of salak seeds' 10 cm-thick activated carbon could reduce the iron content from 2.63 mg/l to 0.01 mg/l, or 95.82% [13]. This research revealed that a thickness of 10 cm effectively reduced iron levels below the quality standard. This discovery prompted the researchers to proceed with the trial, setting a thickness of 10 cm as the intermediate value. So the thicknesses used in this research are 5 cm, 10 cm, and 15 cm.

Researchers conducted research to help people reduce iron levels in clean water by making carbon filters from activated corn husks with varying media thicknesses, namely 5 cm, 10 cm, and 15 cm. Researchers also utilized buffer media, specifically gravel and sponge.

MATERIALS AND RESEARCH METHODS

This study employs a true experimental design, aiming to assess the efficacy of corn husk activated carbon filters in lowering iron levels across thickness ranges of 5 cm, 10 cm, and 15 cm. This research employs a Pretest-Posttest with Control Group Design, utilizing randomization to divide the experimental and control participants into groups [14]. In this study, the independent variable was the thickness of corn husk activated carbon, and the dependent variable was the iron content in clean water. The control variables in this study are pH and temperature.

In this study, the population was water from one of the drilled wells in the village of Tambak Danau Rt.003, Astambul District, Banjar Regency. The drilled well has an iron content that exceeds quality standards. We used a portion of the population's water as the sample. We conducted testing on 4 treatment samples, 6 repetitions, and 6 pre-treatment samples, totaling 30 samples. The replication formula [15] determines the number of samples.

We conducted measurements of pH and water temperature in the field (in situ), and measured iron levels in the Environmental Health Department laboratory. Data analysis used the Kruskall-Wallis statistical test followed by the Mann-Whitney test.

RESEARCH RESULTS AND DISCUSSION

Before applying corn husk activated carbon to clean water, consider its iron content, pH, and temperature.

Table 1. Displays the average iron content, pH, and temperature of clean water prior to treatment with corn husk activated carbon

No.	Parameter	Checkup result	Quality standards
1.	Iron (Fe)	1.71 mg/L	0.2 mg/L
2.	pH	7.4	6.5 – 8.5
3.	Temperature	29.1ºC	Air temperature ± 3

The average iron content in the water samples before treatment was 1.71 mg/L with a pH of 7.4 and a temperature of 29.1 °C. The iron content still does not meet quality standards [1]. This high iron level can have an impact on health if consumed by the public [16]. K The dissolution of iron in water is due to rainwater entering the soil, experiencing infiltration containing FeO, then reacting with H2O and CO2 in the soil and forming Fe(HCO2). The more water seeps into the soil, the higher the iron solubility, because the oxygen in the water decreases [17]. So it is natural that deep-ground water has a fairly high iron content.

After treatment with corn husk activated carbon, the iron levels in clean water decrease.

Table 2. Iron levels in clean water after treatment with corn husk activated carbon

No	Thickness Variations Activated Carbon	Iron Content (Mg/l)						Average	Quality standards
		U1	U2	U3	U4	U5	U6		
1.	Before treatment	1.75	1.72	1.73	1.77	1.59	1.74	**1.71**	
2.	Control thickness 0 cm	1.75	1.72	1.74	1.74	1.54	1.77	**1.71**	
3.	Treatment I thickness was 5 cm	0.31	0.53	0.67	0.70	0.67	0.54	**0.57**	0.2 mg/L
4.	Treatment II thickness was 10 cm	0.38	0.35	0.42	0.30	0.29	0.27	**0.33**	
5.	Treatment III thickness was 15 cm	0.22	0.21	0.19	0.28	0.28	0.30	**0.25**	

Activated carbon from corn husks reduced the iron levels in clean water. The decrease occurred as the activated carbon thickness increased. The lowest average iron content was 0.25 mg/L, measured at a 15 cm variation in activated carbon thickness. This decrease was due to activated carbon filtration and adsorption processes. Filtration is the process of filtering suspended solid substances through porous media [18]. This filtration process allows for the absorption of suspended iron (Fe3). Meanwhile, adsorption is the process of attaching a particle due to the attractive forces between molecules [19]. Thus, the adsorption process will absorb dissolved iron (Fe2) with the right contact time.

After treating clean water with various thicknesses of corn husk activated carbon, we measured the pH and temperature.

Table 3. Displays the pH and temperature of clean water following treatment with varying thicknesses of corn husk activated carbon

No.	Thickness Variations Activated Carbon	Parameter	Repetition						Average	Quality standards
			U1	U2	U3	U4	U5	U6		
1.	Before treatment	pH	7.3	7.3	7.5	7.4	7.3	7.5	**7.4**	
		Temperature	29.3	28.9	29.1	29.3	28.8	29.3	**29.1**	
2.	Control thickness 0 cm	pH	8.0	7.7	7.7	7.5	8.3	7.6	**7.8**	
		Temperature	28.7	28.8	29.1	29.4	28.7	28.8	**28.9**	
3.	Treatment I thickness was 5 cm	pH	7.4	8.3	7.3	7.5	7.7	7.3	**7.6**	6.5-8.5 32.3°C Air Temperature (± 3)
		Temperature	28.5	29.8	29.5	28.8	29.6	29.9	**29.4**	
4.	Treatment II thickness was 10 cm	pH	7.3	7.7	7.8	8.0	8.0	7.4	**7.7**	
		Temperature	29.3	29.3	28.8	30.0	28.0	28.7	**29.0**	
5.	Treatment III thickness was 15 cm	pH	7.6	8.1	7.9	7.7	7.6	7.9	**7.8**	
		Temperature	28.6	28.1	29.5	29.7	28.7	28.7	**28.9**	

The average pH value of clean water after treatment using corn husk activated carbon ranges from 7.4 to 7.8 (neutral). After receiving the same treatment, the temperature of the clean water ranged from 28.9 to 29.4 °C. In general, water with high iron levels has a low pH (acid) [20]. In this study, the water samples had a neutral pH of 7.4 before treatment. The high air temperature at the time of measurement and the relatively shallow depth of the drilled well, namely 24 m, can influence this. The use of activated carbon as a filter medium caused the pH to increase after treatment [21].

The efficiency of variations in the thickness of corn husk activated carbon in reducing iron levels in clean water is being studied.

Table 4. Efficiency of Reducing Iron Levels in Clean Water by Using Corn Husk Activated Carbon

No.	Thickness Variations Corn Husk Activated Carbon	Decline Percentage Iron Content (%)
1.	0 cm	0
2.	5 cm	67
3.	10 cm	80
4.	15 cm	86

Iron levels due to the use of corn husk activated carbon with an activated carbon thickness of 0 cm did not decrease at all, which means that the buffer media (gravel and sponge) used had no effect on reducing iron levels. An activated carbon thickness of 5 cm achieved the lowest reduction efficiency (67%), and an activated carbon thickness of 15 cm achieved the highest reduction efficiency (86%).

The study presents the results of measurements of inlet and outlet water discharge for each variation of corn husk activated carbon thickness treatment.

For all faucets, regulate the inlet water flow to 1.67 ml/second, and let the water drip for 15 minutes. This aims to maximize the water's contact time with activated carbon so that absorption occurs more. Once the reservoir is nearly filled, we fully open the outlet tap and measure its output. We measure the water discharge that emerges from the corn husk activated carbon filter. The water discharge from a 0 cm thickness variation is 120 ml/second, 5 cm is 31 ml/second, 10 cm is 4.25 ml/second, and 15 cm is 1.8 ml/second. Thus, the discharge of clean water decreases as the thickness of the activated carbon increases. This is because the greater the thickness used, the higher the particle density, resulting in a smaller discharge of water. The longer the contact time, the greater the chance that the activated carbon particles will come into contact with the iron metal bound in the activated carbon pores. In order to extract more iron from the water, we need to increase the contact duration.

We used statistical tests to compare the average iron levels produced by each treatment.

Table 5. Presents the results of the test for normality of iron level data

Treatment	Sig.Shapiro-Wilk	Information
Thickness 0 cm	0.004	Not normally distributed
Thickness 5 cm	0.157	Normally distributed
Thickness 10 cm	0.647	Normally distributed
Thickness 15 cm	0.297	Normally distributed

The results of the normality test show that the control group data is not normally distributed because the p value is 0.004 <0x7E> 0.05, while treatment groups 1, 2, and 3 have a normal distribution. Therefore, the parametric test (One Way Anova) failed to meet the requirements, leading to the adoption of an alternative test, the Kruskal-Wallis test [23].

The Kruskal-Walli's test is a ranking-based nonparametric test that aims to determine whether there are differences between two or more groups of independent variables on the dependent variable on a numerical data scale (interval or ratio) and an ordinal scale. [24]. The results of the Kruskal-Walli's test show that the p value is 0.000 <0x7E> 0.05, which means there is a difference in iron content due to variations in the thickness of the activated carbon of 0 cm, 5 cm, 10 cm, and 15 cm. We then employ the Mann-Whitney test to observe variations in iron levels across each treatment.

Table 6. Presents the Mann-Whitney Iron Levels for all treatment groups

Treatment	Asymp. Sig. (2-tailed)	Information
Thickness 0 cm and Thickness 5 cm	0.004	There are significant differences
Thickness 0 cm and Thickness 10 cm	0.004	There are significant differences
Thickness 0 cm and Thickness 15 cm	0.004	There are significant differences
5 cm thickness and 10 cm thickness	0.016	There are significant differences
Thickness 5 cm and Thickness 15 cm	0.004	There are significant differences
Thickness 10 cm and Thickness 15 cm	0.030	There are significant differences

Table 6 reveals significant variations in iron content across all thickness variations of corn husk activated carbon, as evidenced by all p values being less than or equal to 25. The p value ranges from 0.004-0.030.

CONCLUSIONS AND RECOMMENDATIONS

Prior to treatment, the iron content in the sample water was 1.71 mg/L. After treatment with a thickness of 0 cm, 5 cm, 10 cm, and 15 cm, the iron content decreased to 1.71 mg/L, 0.57 mg/L, 0.33 mg/L, and 0, respectively. 25 mg/L. The percentage reduction in iron content for activated carbon thicknesses of 0 cm, 5 cm, 10 cm, and 15 cm is 0%, 67%, 80%, and 86%, respectively. To maximize contact time, the inlet water flow rate should be 1.67 ml/second. The outlet water discharge after contact with a 0 cm thickness is 120 ml/second, 5 cm is 31 ml/second, 10 cm is 4.25 ml/second, and 15 cm is 1.8 ml/second. According to statistical analysis, there are significant differences in each variation of the thickness of the activated carbon used in reducing iron levels in clean water. The public can use corn husk activated carbon filters as an alternative to reduce iron levels, and future researchers can further research variations in discharge and determine the saturation level of corn husk activated carbon.

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