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PERFORMANCE OF SPENT COFFEE GROUNDS ACTIVATED CARBON AND RIVER SAND AS FILTRATION MEDIA FOR TOTAL SUSPENDED SOLIDS REMOVAL IN ABATTOIR WASTEWATER TREATMENT

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Abstract

Abattoir wastewater contains high levels of total suspended solids (TSS) and might cause negative impacts on the environment if discharged directly without being treated in advance. Filtration methods can be used to treat abattoir wastewater, especially in TSS removal, utilizing filtration media such as sands. and activated carbon. The objective of this research is to discover the potential of spent coffee grounds (SCG) activated carbon and river sand as filtration media for TSS removal in abattoir wastewater treatment. The research was conducted by using dual media filtration, consisting of SCG activated carbon and river sand, 15 cm and 30 cm in thickness, respectively. The result shows that the combination of SCG activated carbon and river sand can reduce the TSS levels of abattoir wastewater from 164 mg/L to 37 mg/L, with a 77.43% removal percentage, and meet the quality standard, which is 100 mg/L. Based on the result, it is concluded that the combination of SCG activated carbon and river sand has good potential as filtration media for TSS removal in abattoir wastewater treatment, and further improvements can be conducted to enhance the efficacy.

Keywords: *spent coffee grounds activated carbon, river sand, filtration, total suspended solids removal, abattoir wastewater*

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1. Introduction

Abattoir wastewater contains high levels of total suspended solids (TSS), which mainly originated from blood, tissue fragments, and digestive system contents of the slaughtered animals. At a high level, TSS might cause turbid conditions in the water, blocking the passage of sunlight in the water and inhibiting the growing ability of plants

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and algae (DataStream Initiative 2021). When the plants and algae are unable to grow properly, the ability to produce oxygen will be limited; thus, it might cause hypoxic and anoxic conditions in the water, and this condition might lead to several other negative chain effects (U.S. EPA 2021). Therefore, before being discharged to the environment, abattoir wastewater must be treated in advance to meet the required quality standard given. According to the Regulation of the Minister of Environment of the Republic of Indonesia No. 5 (2014), the allowable TSS level for abattoir wastewater before discharge is 100 mg/L.

Filtration is one of several methods that are mainly being used to treat TSS, utilizing filtration media such as sand, activated carbon, fibers, etc. to separate the solids from the water. The mechanism of the removal process consists of several phenomena, including straining, sedimentation, adsorption, and biological growth (Metcalf & Eddie et al 2014). Not only capable of removing solids, the filtration unit may also remove bacteria, color, odor, taste, iron, and manganese from the water (Masduqi and Assomadi 2010). The important design parameters for filtration media include flow rates, bed depth, and media characteristics (Riffat 2013).

As filtration media, sand can strain particles that are larger than its pore size while allowing smaller particles, like water particles, to pass through. Due to its abundance in nature and preparation convenience, sand is considered a simple and practical material to be mainly utilized as filtration media. The source of sand may vary and may be found in many forms and characteristics, including from a river.

Activated carbon is one of the materials that are often utilized as filtration media, utilizing the pores on its surface to adsorb the particles. Activated carbon can be produced by physically or chemically activating carbonized material derived from woods, nutshells, seeds, and other carbon-rich materials. Coffee grounds are a product derived from coffee beans that have been through several processes and are being utilized to make coffee-based beverages. Containing more than 50% carbon content (Jeníček et al. 2022) and already carbonized by the roasting process, spent coffee grounds (SCG) have the potential to be processed into activated carbon as filtration media. The processes to turn SCG into activated carbon include cleaning, drying, and activation (Rahman et al. 2025). Not only does it have the potential to be utilized as filtration media, but the utilization of SCG may also prevent environmental pollution, since SCG might cause a negative impact when being disposed of excessively (Priena et al. 2023), especially in soil. As reported by Hu et al., SCG might inhibit plant growth due to its phytotoxicity (2025); hence, before being accumulated in the environment and causing negative impact, SCG should be utilized.

The potential of carbon-rich materials to be utilized as activated carbon for TSS removal has been well proven time after time. However, the performance of SCG activated carbon combined with river sand as filtration media for TSS removal has not been studied or reported sufficiently. The objective of this research is to discover the potential of spent coffee grounds (SCG) activated carbon, combined with river sand, as filtration media for TSS removal in abattoir wastewater treatment. The result can be used to support the future development of the utilization of SCG activated carbon and river sand as an alternative media for TSS removal in abattoir wastewater treatment.

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2. Method

2.1 Sampling Location

In this research, the abattoir wastewater sample was collected from the Regional Technical Implementation Unit of the Abattoir of Banda Aceh City, located at Gampong Pande Village, Kuta Raja District, Banda Aceh City. The sample of abattoir wastewater was visually brown-colored and turbid, containing a suspension of solids. The visual appearance of pretreated abattoir wastewater in this research is shown by Figure 1.

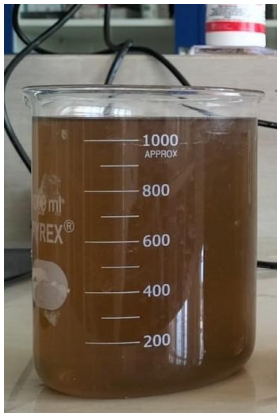

Figure 1. Pretreated abattoir wastewater

2.2 Activated Carbon and River Sand Preparation Stages

The SCG used in this research is robusta coffee grounds, which were obtained from SMEA Premium Kopi Lamnyong Coffee Shop, located at Lamnyong Village, Syiah Kuala District, Banda Aceh City. The preparation steps for SCG activated carbon in this research were as follows:

1. 5 kg of SCG was rinsed by using water to clean it from dirt.
2. Cleaned SCG is being dried under direct sunlight for ±50 hours.
3. Dried SCG is being carbonized using a furnace for 2 hours at 400°C.
4. The carbonized SCG was sieved using a no. 40-mesh sieve.
5. The sieved SCG was chemically activated using 0.1 M HCl for 48 hours.
6. Activated SCG was then rinsed with distilled water until the rinsed water reached a neutral pH of 7.
7. The SCG was dried again by using an oven for 2 hours at 105°C.
8. The SCG, as activated carbon, was ready for use.

The river sand in this research was obtained from a construction material supplier located in Aceh Besar Regency. The obtained river sand was already in a clean condition, although it still needed to be re-sieved to obtain the proper size for the research. The river sand was being sieved through no. 40 (to separate the oversized sand) and no. 100 mesh sieves (to separate the undersized sand). After being re-sieved, the river sand was ready to be used.

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2.3 Experimental Filtration Unit Configuration

The filtration experiment was conducted by utilizing a filtration unit constructed from a 4" PVC pipe with 85 cm in height, filled with pebbles, river sand, and SCG activated carbon. The SCG activated carbon and river sand were used as the filtration media, with thicknesses of 15 cm and 30 cm, respectively, and the pebbles, with 20 cm of thickness, functioned as a buffer for the river sand. The design of the filtration unit for this research is shown in Figure 2.

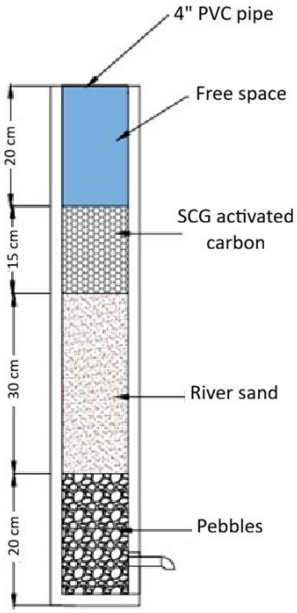

Figure 2. Filtration unit design

The experiment was conducted by discharging 10 L of abattoir wastewater into the filtration unit, which flowed through the filtration media with a 0.05 m/s flow rate. The filtered water that was flowing out through the outlet was collected in a collecting bucket and then tested to obtain the removal rate of TSS levels.

2.4 Sample Analysis Method

The filtered water was tested in the laboratory to obtain the post-treatment TSS levels, referring to SNI 06-6989.3:2019, Indonesian National Standard for TSS level testing with the gravimetric method for water and wastewater (2019). After being tested, the percentage of removal was calculated by using the following formula:

$$R(\%) = \frac{C_0 - C_e}{C_0} \times 100\% \quad \text{..... (1)}$$

R is the removal percentage, C_0 is the pre-treatment TSS levels, and C_e is the post-treatment TSS levels. R values determine the performance of the combination of SCG activated carbon and river sand in TSS removal; the higher the value of R, the higher the performance.

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3. Result and Discussion

The result of this research shows that the initial TSS levels of the abattoir wastewater were 164 mg/L, exceeding the quality standard given by the government, which is 100 mg/L. The combination of SCG activated carbon and river as filtration media can reduce the TSS levels in the abattoir wastewater from 164 mg/L to 37 mg/L, successfully meeting the quality standard given, which is 100 mg/L. The recapitulation of the experimental result of this research is shown by Table 1.

C_0 (mg/L)	C_e (mg/L)	R (%)	Quality Standard (mg/L)
164	37	77.43	100*

* Regulation of the Minister of Environment of the Republic of Indonesia No. 5, 2014

As shown in Table 1, the removal percentage calculated by using Equation (1) of this experiment is 77.43%, indicating that the combination of SCG activated carbon and river sand as filtration media has good potential to be utilized as filtration media. The removal percentage is achieved by both the performance of SCG activated carbon and river sand. When the wastewater was flowing through the filtration media, the flow rate was being inhibited by river sand, providing enough time for SCG activated carbon particles to make contact with suspended solids. When poured, the wastewater in this experiment took 17 seconds until it came out through the outlet.

During the filtration process, some of the suspended solids were being trapped in the SCG activated carbon pores by the adsorption mechanism, while the rest were kept drifting through the pores of the river sand. The adsorption ability of SCG activated carbon is due to its large specific surface area (SSA), which may reach 1199 m^2/g (Rosson et al. 2020). With large SSA, activated carbon might accommodate more space to trap the particles on its surface. As the suspended solids drift through the pores of the river sand with the permeability mechanism, some of the suspended solids with sizes bigger than the sand pores are being trapped in the pores, and the smaller ones will keep drifting and manage to exit through the outlet along with the treated water. The appearance of posttreated abattoir wastewater for this research is shown by Figure 3.

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Figure 3. Posttreated abattoir wastewater

From the visual appearance of posttreated abattoir wastewater compared to pretreated abattoir wastewater (Fig. 1), it is shown that the abattoir wastewater after being treated with the combination of SCG activated carbon and river sand in this research has become clarified significantly.

Several studies utilizing carbon-rich materials such as activated carbon combined with sand for TSS removal have been conducted, such as cocoa peels for tofu industrial wastewater treatment (Alief 2024), candlenut shell for abattoir wastewater treatment (Rizqi 2023), and mahogany fruit peel for abattoir wastewater treatment (Aini 2026) with 70.09%, 57%, and 82% removal percentages, respectively. The performance of SCG activated carbon in this research, with a 77.43% removal percentage, shows that SCG has good potential to be utilized as an alternative material for filtration media. However, further improvement is still necessary to be conducted to increase the efficacy. To increase the filtration rate and the efficacy of separation, using additives like coagulating and peptizing agents may improve filterability, alter the filtration cake properties, and lower the flow resistance (Cheremisinoff 2002). In addition, increase the thickness of SCG activated carbon, and investigating the optimum effective size and uniformity coefficient of the river sand for TSS removal in abattoir wastewater treatment is recommended to optimize its performance.

4. Conclusion

The results show that the combination of SCG activated carbon and river sand as filtration media performs well in reducing TSS levels in abattoir wastewater treatment. The combination reduced TSS levels from 164 mg/L to 37 mg/L, with a percentage of efficacy of 77.43% and successfully met the quality standard (100 mg/L). The combination of SCG activated carbon and river sand can be utilized as an alternative filtration media in TSS removal for abattoir wastewater treatment. Although the combination of SCG activated carbon and river sand has met the quality standard, it still needs further improvements to optimize the performance so it can reach higher efficacy.

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AI Writing Statement

The researcher would like to declare that no generative AI or AI-assisted tools were used in the writing, translation, analysis, or preparation of this manuscript.

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