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Treatment of Water River with Activated Carbon from Coal and Palm Shells as Adsorbent

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Abstract

Water has a very important role in supporting household activities such as drinking, cooking, washing, and other necessities. If the water has started to be polluted, it will cause various diseases. The purpose of this study is to treat polluted river water into water that is suitable for consumption. In this study, river water treatment was carried out using the adsorption method by using activated carbon from palm shells and coal as an adsorbent. Activated carbon is made by carbonization means of palm shells and coal at a temperature of 500°C for 45 minutes. Water quality parameters treated were dissolved oxygen (DO), biochemical oxygen demand (BOD), total-N, total-P, and total solid suspended (TSS). The results showed that activated carbon from coal has a better ability than activated carbon from palm shells. Water treatment using activated carbon from coal for 6 hours can reduce BOD from 5.11 mg L^{-1} to 1.13 mg L^{-1}, total-N from 21.331 mg L^{-1} to 2.986 mg L^{-1}, total-P from 0.322 mg L^{-1} to 0.141 mg L^{-1}, and TSS from 53 mg L^{-1} to 7 mg L^{-1}. While the DO parameters were relatively unchanged, from 1.81 mg L^{-1} to 1.83 mg L^{-1}.

Keywords: activated carbon, palms shells, coal

INTRODUCTION[1]

Karang Mumus River is one of the Mahakam tributaries that divides the city of Samarinda, East Kalimantan. The strategic location that crosses the city, as well as its role as a water source and water transportation route, makes the Karang Mumus River a residential area for migrants and community activity centers on the banks. In line with rapid population growth, the settlements along the Karang Mumus River banks are getting denser and more slum. Various economic activities along the river such as markets, tofu, and tempeh industries make the Karang Mumus River polluted.

Pollutant compounds such as heavy metals, dissolved organic compounds, dyes, phenols, suspended solids are contained in domestic and industrial wastewater. Many pollutants cannot be biodegradable, thus inhibiting river purification itself and conventional waste treatment [1]. Conventional processing involving biological mechanical processes is ineffective so it needs additional treatment [2]. One process that is often used is adsorption with activated carbon.

Activated carbon has the ability to absorb pollutants that cannot be biodegradable. Activated carbon is an adsorbent with wide use because it has a large porosity and surface area, and surface chemistry that can react with molecules that have specific functional groups [3]. Activated carbon has exceptional adsorption quality, so it is widely used in decolorization, purification, recovery and odor removal in an efficient and low-cost [4]. Lately, commercial activated carbon has begun to be replaced with activated carbon which is synthesized from biowaste, especially agricultural waste, because the cost is relatively cheap. Several studies have reported the manufacture of activated charcoal from biomass residues from agricultural wastes such as coconut shells [5], palm shells [6], sawdust [7], tropical wood [8], coffee residues [9], walnut shells [10], bamboo [11], coal [12], corn cobs [13], and much more.

The removal of organic pollutants from wastewater by adsorption activated carbon from bamboo was investigated by, Ademiluyi *et al* [14]. The organic concentration in wastewater expressed as chemical oxygen demand (COD) was reduced from an initial value of 378 mg L^{-1} to 142, 143, 152, 152, and 156 mg L^{-1}. for the first, second, third, fourth dan final hour, respectively. Khenniche and Benissad-Aissani [15] prepared

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activated carbon from coffee residue. They studied equilibrium, kinetics, and thermodynamics for adsorption phenol onto the activated carbon. Odubiyi *et al* [16] investigated removal Pb and Cu from wastewater by activated carbon from cocoa pod husk. The maximum removal efficiency was 78% for Pb and 97% for Cu. Qiu and Huang [17] prepared activated carbon from sewage sludge of the wastewater plant to removal of dyes (methylene blue and acid scarlet GR) from solution. Yakhout and Mostafa [18] investigated of kinetics adsorption nitrate from wastewater by activated carbon from rice straw. Kanawade dan Bhusal [19] prepared activated carbon from wood to reduce BOD and COD value. Oghenejoboh *et al* [20] compared of activated carbon prepared from fermented cassava peels (CPB), unfermented cassava peels (CPA) and commercial activated carbon (CAC) in the efficiency to reduce of COD, BOD, Pb, and phenol. CPB was found the most efficient to removal COD, BOD, Pb and phenol from wastewater. Junoh *et al* [21] prepared active carbon from coal. Bacillus sp and Escherichia sp were grown and immobilized on the activated carbon from coal to create a biofilm on this surface. This adsorbent used to bioremediate process and can reduce of BOD, color, COD, TSS, nitrate, sulfate, and phosphate as much 71.4; 91.1; 96.4; 98.8; 80.3; 90;3; and 60.3% respectively. Egbon *et al* [22] prepared to activate carbon from corn cob to remove pollutant from the environmental. The activated carbon can reduce pH from 10.05 to 7.10, change color from greyish-white to colorless, reduce BOD from 20.27 to 5.19, and increase DO from 13.47 to 28.56 mg L^{-1}. Firdaus *et al* [23] prepared activated carbon from rice straw and palm midrib was used as an adsorbent to remove color intensity and other pollutants such as nitrate, phosphate, and COD.

Even though the Karang Mumus River is polluted, it is still consumed for various daily needs. To improve the quality of Karang Mumus River water before consumption, we conducted research on the water treatment of Karang Mumus River contaminated by the adsorption method with activated carbon as adsorbent. The parameters tested in water treatment are DO, BOD, N-total, P-total, and TSS. Activated carbon is made from palm shells and coal. Palm shells and coal are selected as the basic ingredients for making activated carbon because of their abundant presence in East Kalimantan. The ability to eliminate BOD, N-total, P-total, and TSS compared to activated carbon from palm shells and coal.

MATERIAL AND METHOD

Materials

The materials used were $MnSO_4$ (Merck, Germany), H_2SO_4 (Merck, Germany), $Na_2S_2O_3$ (Merck, Germany), NaOH (Merck, Germany), borate acid (Merck, Germany), potasium antimonil tartrate (Merck, Germany), and phenolptalien indikator. The water sample is from the River Karang Mumus Samarinda, Indonesia. Coal as a base for making activated carbon from Kutai Kertanegara, Indonesia. Whereas palm shells from Pasir, Indonesia.

Instrumentations

The surface morphological image of adsorbent was obtained by scanning electron microscopy (FEL, Inspect-S50). The total phosphor concentration was analized by UV-Visible spectrophotometer (Spectronic 20D). The carbonization was conducted by the muffle furnace (Carbolite CWF 1200).

Preparation of activated carbon

The palm shells and coal cut into small pieces and washed with water to remove sand and dust. The palm shells and coal were dried under sunlight irradiation to remove moisture. Carbonization was done by heating at 500°C for 45 minutes in a muffle furnace with poor oxygen. The activated carbons were cooled at room temperature, crushed with mortar and pestle, and sieved through an 8-10 mesh. Before use, activated carbons were washed with distilled water, then dried at 110ºC for 24 hours and stored in a desiccator.

Water treatment

Water treatment equipment is arranged as shown in Figure 1. River water with a discharge of 6.62 mL s^{-1} flows through a water treatment system (system up flow) that contains activated carbon with particle sizes of 8-10 mesh. The raw water produced was analyzed for parameters, DO, BOD, total-N, total-P, and TSS at 6 hours, 12 hours, and 24 hours.

RESULT AND DISCUSSION

Activated carbon characteristics

The characteristics of the activated carbon made from coal and palm shells (water content, ash content, fixed carbon and adsorption of iodine) are given in Table 1 below.

Determination of water content aims to determine the hygroscopic nature of activated carbon. Determination of water content of activated carboncarbon is done by heating the activated carbon into an oven with a temperature of 105^{o}C until the weight is constant. The sample is then cooled in a desiccator before weighing it. From the results of the analysis show that the water content of activated carbon from palm shell is 8.456% and the activated carbon from coal is 1.017%. The expected water content of activated carbon is as low as possible because high water content will reduce the absorption of activated carbon.

Determination of ash content is the content of metal oxides in activated carbon. Ash consists of K, Na, Mg, Ca, and components in small amounts which spread in the activated carbon lattice. The expected level of activated carbon has a lot of influence on the quality of activated carbon. Excessive ash will cause blockage of activated carbon pores so that the surface area becomes reduced. The results of analysis show that the ash content of activated carbon from palm shells is 7.253% and activated carbon from coal is 3.823%.

Fixed carbon is a carbon fraction (C) which is bound to activated carbon in addition to the fraction of water, evaporating substances, and ash. The expected carbon content bound to activated carbon is as high as possible. In this study, the carbon content of activated carbon from palm shell was obtained at 67.54% and the activated carbon from coal was 81.72%.

Water treatment

Table 2 shows water quality parameters before and after the adsorption process by activated carbon from coal and Table 3 shows water quality parameters before and after the adsorption process by activated carbon palm shells.

From the two tables (Tables 2 and Table 3), in general, the maximum decrease in parameter BOD levels, N-total, P-total, and TSS occurred at 6-hour processing, after which an increase occurred. This is because there are still many active sites of activated carbon which have not absorbed pollutants at the beginning of up to 6 hours. After 6 hours the pollutant levels increased again because there were many active sites in activated carbon that absorb pollutants and finally all the free active sites will run out or have been maximized in absorption of pollutants so that the pollutants in the flowed samples cannot be adsorbed anymore.

From the results of the study, it was found that the adsorption ability of activated carbon from coal was better than that of activated carbon from palm shells. This is because activated carbon from coal has more active sites than the active sites of activated carbon from palm shells, this is supported by the absorption of iodine of activated carbon from coal (800 mg g^{-1}) which is greater than the activated carbon from palm shells (665 mg g^{-1}). Iodine absorption is an important indicator in assessing the quality of activated carbon. Adsorption of iodine indicates the adsorption ability of activated carbon, the higher the adsorption of iodine the greater the adsorption capacity of activated carbon. In addition, from the analysis of surface morphology with SEM (Figure 2), the surface of activated carbon from coal is seen to be relatively cleaner and has more pores than the activated carbon from palm shells.

Table 1. Characteristics of activated carbon from palm shells and coal

Parameters	Palm shells	Coal
Water content (%)	8.456	1.017
Ash content (%)	7.253	3.823
Fixed carbon (%)	67.54	81.72
Adsorption of iodine (mg g^{-1})	665	800

Source : Result of Analysis 2018

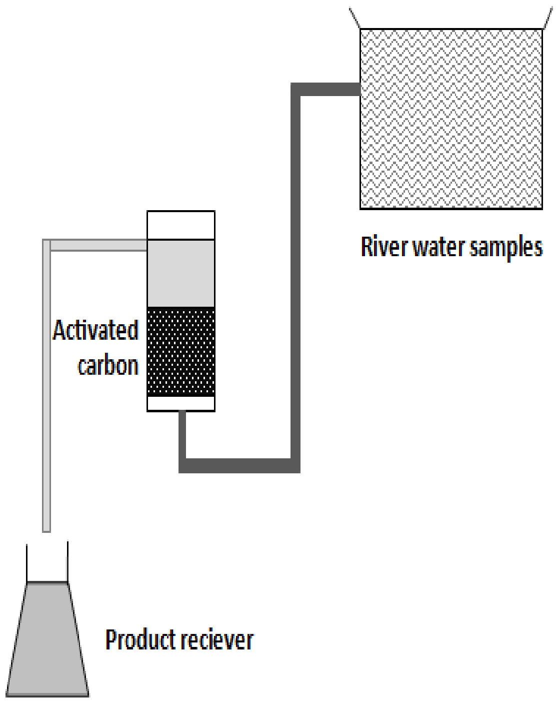


Figure. 1 Schematic diagram of Experimental set up

Table 2. Water quality parameters before and after adsorption process by activated carbon from coal.

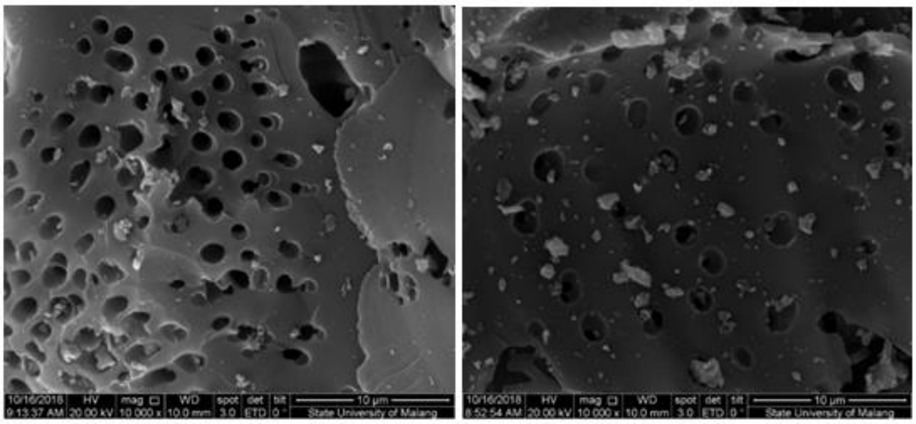
Parameters	Before treatment	Effluent after treatment (mg L^{-1})			Reduction (%)		
		6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
DO	1.81	1.83	1.92	1.94	-	-	-
BOD	5.11	1.13	2.43	4.21	77.61	52.45	17.61
Total-N	21.372	2.986	9.852	15.421	86.03	53.90	27.85
Total-P	0.322	0.141	0.167	0.253	56.21	48.14	21.43
TSS	53	7	12	37	86.79	77.36	30.19

Source : Result of Analysis 2018

Table 3. Water quality parameters before and after adsorption process by activated carbon from palm shells.

Parameters	Before treatment	Effluent after treatment (mg L^{-1})			Reduction (%)		
		6 hours	12 hours	24 hours	6 hours	12 hours	24 hours
DO	1.92	2.17	1.98	1.83	-	-	-
BOD	4.82	1.95	3.22	4.63	59.54	33.20	3.94
Total-N	23.112	4.422	11.219	17.319	80.86	51.46	25.07
Total-P	0.312	0.172	0.211	0.268	44.87	32.37	14.10
TSS	50	9	15	40	82	70	20

Source : Result of Analysis 2018



(a) (b)

Figure 2. SEM pictures of activated carbon fom coal (a) and (b) palm shells (10,000-fold magnification)

CONCLUSION

Activated carbon from coal and palm shells can be used as an adsorbent in river water treatment. The parameters that can be derived are BOD, N-total, P-total, and TSS. Whereas for DO parameters there is no change. Activated carbon from coal has more ability than activated carbon from palm shells to reduce these pollutants.

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