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ADSORPTION OF CARBON MONOXIDE (CO) IN A ROOM BY COCONUT SHELL AND DURIAN SKIN ACTIVATED CARBONS

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Abstract

Cigarettes contain more than 4.000 elements, at least 200 of them are harmful to health. The main toxins are tar, nicotine, and carbon monoxide (CO). The purpose study was to know ability of coconut shell and durian skin activated carbon as adsorbent of CO. The study was pre-experimental with randomized control group only design. Independent variables are types of activated carbon, the dependent variable is concentration of CO. The results showed the lowest in durian skin activated carbon that 29 ppm. The average CO decreased on coconut shell is 68,7 ppm, durian skin is 77,478 ppm. One way anova test to see the difference CO in various of activated carbon p value 0,0001, independent t test to see the difference CO reduction between 2 types activated carbon with p value is 0,0001. Conclusion: there is a differences adsorbtion of CO between coconut shell and durian skin activated carbon.

Introduction

Indoor air pollution becomes more serious health problems than the outdoors. This is because in general, most of the time spent by people is indoors. At an air conditioned room, more pollutants do not flow freely, but instead, it is accumulated. The causes of Sick Building Syndrome are closely linked to the room air ventilation which is inadequate and uneven air distribution as well as lack of proper maintenance of ventilation facilities. Air pollutants that may be present in the room can be CO, CO2, some types of bacteria, fungi, animal feces, formaldehyde and various other organic materials (Keman, 2005). The advances in technology have encouraged the creation of a variety of products. On the other hand, it gives a negative effect because it contains a variety of toxic substances. Air pollutants from inside the building can be derived from the materials which are commonly used for consumer needs such as pesticides, cleaning rooms, air fresheners, furniture upholstery, wall paint, cigarette smoke, and so on.

Cigarettes contain more than 4.000 more elements and at least 200 of which are harmful to human's health. Toxic chemicals which have health risks that exist on a cigarette are tar, nicotine, lead, and carbon monoxide. Of all these materials, the main toxins in cigarettes are tar, nicotine, and carbon monoxide (CO) (Sundari, et al., 2015)

The exposure to carbon monoxide on human body has negative impact such as dizziness, discomfort in the eyes, headache, nausea, increased heart rate, feeling depressed in the chest, breathing difficulty, muscle weakness, disorders of the cardiovascular system, heart attacks and death. A research on the effects of cigarette smoke exposure on lung function and urine cotinine of cafe and restaurant employees in Semarang shows that 20% of respondents have experienced a mild restriction, 2.9% mild obstruction and 2.9% moderate obstruction (Nurjanah, et al., 2014). The result from other studies shows a weak association between smoking in the house with Acute Respiratory Illness (ISPA) in Toddlers (Suryani, et al.,

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2015). Smoking is known as a risk factor for atherosclerosis and cardiovascular disorders. Effect of smoking on platelets can lead to increased atherosclerosis and atherosclerotic disease risk factors as a result of the increase in mean platelet volume (MPV). Conclusions from Sundari's research shows that smoking duration and number of cigarettes consumed is negatively correlated with the number of platelets, MPV, platelet distribution width (PDW), platelet crit (PCT) (Sundari, et al., 2015). In addition to the direct impact on human health, CO is also one pollutant, known as greenhouse gas which is very reactive to the Earth's protective ozone layer.

The effort to reduce the hazardous impact on ambient of air pollution globally is pretty much done, but the polluters in the room are still lack of getting attention. Some people even consider it to be more secure and comfortable in the room and do not realize the danger of pollutants indoors. Therefore, we need an effort to reduce pollutants around us. One of the materials that can be used to reduce gas contamination is activated carbon.

Activated carbon contains metal ions and water molecules. Under normal circumstances, the space between the layers of the activated carbon is filled by free water molecules located around cations. When activated carbon is heated to a temperature of 100 ° C, the water molecules will evaporate, so that the spaces between the molecules which are vacant can be filled by the gases from outside. Thus, the activated carbon can serve as gas absorbers.

Activated carbon can be made from the animals, plants, waste or mineral which contain carbon such as bone, soft wood, husks, corn cobs, coconut shell, coconut husk, bagasse sugar mill, pulp papermaking, sawdust, hardwood and coal (Komariah , et al., 2013). In the market, coconut shells are activated carbon which are widely sold and remain unused for other uses. The benefits of coconut shell as activated carbon are well known. On the other hand, many of the ingredients can actually be used, for example durian skin. Durian skin has not been widely used. They are still considered as waste that is difficult to untangle because the surface is spiky and hard. These conditions result in the natural decomposition of durian skin which takes quite a long time so it is considered damaging to the environment. Not many people want to compost the skin of durian given the decay process which is longer than the other organic materials.

The research on activated carbon and CO show that utilization of durian skin (Durio zibethinus) as raw material for the manufacture of activated carbon can reduce the concentration of CO gas from motor vehicles (Dirga, 2014).

This study aims at analyzing the ability of coconut shell and durian skin activated carbons as CO gas adsorbent material in the room that comes from cigarette smoke. This study also tries to analyze and compare the effectiveness of two types of activated carbon materials.

Method

This study is a pre-experimental research which means the experimental design which does not fulfill all the requirements from a true experimental design. The design was randomized control group design, where the study population was randomly divided into 2 groups. The first group was given a treatment unit for the trial and the second group served as control group. From both groups, the difference between the mean measurements was counted. This difference was considered to be the result from the treatment (Murti, 2011).

This research was laboratory-scale research. The test was done in the box which was assumed as the room in general. The exposure to carbon monoxide was from smoking cigarettes without filter.

There were three experimental treatments namely using carbon adsorbent from coconut shell, durian skin and the control group (without using any adsorbent). Another parameter that was measured was the temperature of the room.

In the experimental study, replication / repetition was required. Based on the calculation of replication, to ensure minimum error in replication or repetition of the experiments, the following formula was used:

$$(t - 1) \times (r - 1) >= 15$$

The value of t is the number of treatment, while the value of r is the number of replication. With the amount of treatment from 3 groups, there were 9 repetitions for each treatment.

In this study, activated carbon used was in the form of a fine powder. The second texture was smooth and soft. In each treatment, 1 kg activated carbon was used. With 9 repetitions, the total need of each activated carbon was 9 kg.

The experiment boxes were made of sheet with a size of 1x1x1 m, so the volume of the room was $1m^3$. Boxes should be made as close as possible to avoid the release of CO gas from the experiment box. On one side of the box, a hole to show the CO meter monitor tool with sizes ranging from 10 x 10 cm was made. The hole was made approximately 25 cm from the top of the box. CO meter was installed at a distance of 25 cm from the top of the right boxes in the hole made for the monitor. Furthermore, the hole was sealed with transparent plastic and did not allow the hole to discharge exposure to cigarette smoke.

One kilogram of adsorbent was included in a container with holes. The container containing the adsorbent was put into experiment box right in the middle of the box. Then the experiments box was sealed, all the holes that still let the air out were sealed with duct tape.

At the bottom of the CO meter at a distance of 25 cm from the monitor, a small hole was mad to expose smoking. Lighted cigarette had been put through a small hole approximately 4 cm. Cigarette smoke was presented at the experiment box for 5 minutes. After 5 minutes of exposure, the smoke was stopped and the hole for the entry of non-sealed with transparent plastic. After given time for about 1 minute, the measurement of carbon monoxide level was conducted by turning on the CO meter. The monitor displayed the measurement of CO levels until the numbers was stabilized. This stabilized number served as CO concentration result. In addition to measurements of CO level, the air temperature was also measured.

CO level measurement results from three treatments (including controls) were analyzed by 1-way ANOVA test with α 5% to see the difference in the levels of CO. Then, the differences between adsorption levels of coconut shell and durian skin activated carbons were measured. For this analysis, the difference in value between the levels of CO from each adsorbent with the control group was calculated. The differences of the two adsorbents were tested by independent t test with α 5%.

Results and Discussion

The study was conducted during the day with a range of times at 8 until 12 at noon. This assumption is based on the conditions of temperature, humidity and lighting which are almost the same during this period.

The air temperature when the research was conducted was an average of 30.1 ° C. The study was conducted at the same place and just carried on sunny weather so that the temperature, humidity, and lighting can be considered the same; they do not distract the results of measurements of CO in the experiment room.

The exposure of cigarette smoke was from cigarettes without filter. The exposure was carried out for 5 minutes, in which the process was non-flammable approximately for 2 cm. After smoke exposure was stopped, the exposure hole was then sealed and allowed to stand 1 minute to allow the binding of carbon monoxide gas by the adsorbent. After 1 minute, CO meter was turned on until the numbers on the monitor showed the stable number (not changing anymore). The results of measurements of CO levels in the treatment group and the control group are shown below.

Experiment boxes are divided into two treatment groups and one control group. The number of repetitions is 9 times. Before getting smoke exposure, the coconut shell (9 boxes) and durian skin (9 boxes) activated carbons were placed inside the experiment boxes. The control group box is left empty. After exposure for 5 minutes, the levels of CO in the experiment boxes are measured.

Measurement result shows that the average concentration of CO gas inside the room after the experiment using coconut shell activated carbon is 41 ppm, durian shell is 31.8 ppm, while the control group is 109.7 ppm.

From the whole groups, the minimum

value in the group is from activated carbon of durian skin which is at 29 ppm. The highest value is in the control group which is 120 ppm. And the standard deviation is 35.606.

The average value of coconut shell activated carbon clusters is higher than the durian skin activated carbon. Although the average is over durian skin activated carbon, the adsorption with coconut shell activated carbon is large enough when compared to the control group. More measurement results are shown in Table 1.

Table 1. The Concentration of CO Gas in the Experiment Box After the Adsorption Using Different Adsorbents of Activated Carbons

Repetition	Coconut Shell (ppm)	Durian Skin (ppm)	Control Group (ppm)
1	41	30	120
2	40	30	120
3	46	29	115
4	43	31	112
5	38	36	110
6	41	31	102
7	39	32	105
8	39	35	98
9	42	39	105
Minimum	38	29	98
Maximum	46	36	120
Average	41	31,8	109,7

As compared to the standard of the Minister of Health No. 261 / Menkes / SK / II / 1998 on Work Environment Health Requirements, the threshold values of CO gas in the room is 25 ppm. All the observed subjects are still above the threshold value permitted by the regulation. A minimum value in the group is 29 ppm durian skin. However, it is still above the threshold value, thus still in early stages of an impact on human health.

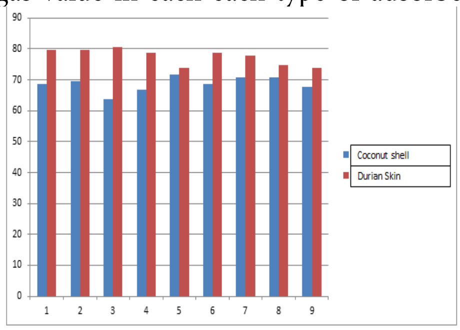
The test results one way ANOVA with a significance level of 95% produces p value of 0.000. Therefore, it can be concluded that there is significant differences in the concentration of carbon monoxide gas after adsorption with various types of activated carbons.

From the post hoc test results in Table 2, it appears that there are significant differences in the concentration of CO gas after adsorption process between each compared groups of adsorbent.

Table 2. Differences CO Concentration Test after Adsorption Process between Experiment Groups

Compared Groups	P value
Coconut Shell – Durian Skin	0,001
Coconut Shell – control	0,0001
Durian Skin – control	0,0001

To compare the absorption effectiveness of activated carbon between coconut and durian skin, the measurement toward the decreasing of CO gas concentration is performed. Decreasing the concentration of CO gas is calculated by reducing the average value of CO gas concentration in control group with CO gas value in each each type of adsorbent.

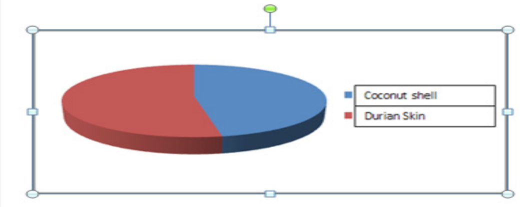


Graph 1. Decreasing concentration of CO gas in the Experiment boxes after adsorption with Different Activated Carbons

The minimum decline value of CO concentration is 63.7 ppm (in coconut shell group), the maximum value is 80.7 ppm (in durian skin group). The average value of decline coconut shell group is 68.7 ppm with a standard deviation of 2.45, the durian skin group is 77.478 ppm with a standard deviation of 2.73. It appears that an average decline of CO gas concentration in the group of coconut shell activated carbon is lower than the durian skin group.

Independent t-test result shows that the value of p is 0.000. Therefore, it can be concluded that there is no difference in decreasing the concentration of CO gas between groups of coconut shell activated carbon with durian skin.

In order to see the decline of CO gas concentration reduction between the two types of activated carbons, graph 2 is presented below:



Graph 2. Comparison of CO Concentration Decrease in Experiment Boxes after adsorption with Coconut Shell and Skin Durian Activated Carbons

The main toxins in cigarettes are tar, nicotine, and carbon monoxide (CO). CO which enters the body will be easily attached to blood hemoglobin. Hemoglobin which is supposed to bind to O2 and send it to the entire body will easily release O2 in the body when there is CO. Research on traffic police shows strong correlation between tenure with COHb levels (Ahirawati, et al., 2009).

CO is one of the most widely distributed of pollutants in the air. CO is a very dangerous pollutant because of its characteristics that is colorless, odorless and tasteless. The concentration of carbon monoxide in 1600 ppm within 20 minutes can cause headaches, rapid heart contractions, dizziness and nausea, and within 2 hours can cause death (Yuliusman, et al., 2013). Exposure to carbon monoxide can poison the central nervous system, heart, and gives adverse effects to the baby of a pregnant woman. Smoking behavior in a period of more than one year will create some symptoms such as skin wrinkles, cough, short breath, decreased stamina and blood circulation. If the symptoms are already apparent in smokers, the smokers will strive to immediately quit smoking. If they continue smoking, the risk of lung cancer and heart disease will be higher (Rosita, et al., 2012).

There is relationship between air emissions and lung vital capacity on the workers and the public toward dust parameter (Odds Ratio p = 0.033 and OR = 1.584) and CO (Odds Ratio p = 0.0001 and OR = 2.558), whereas NO2 and SO2 do not affect lung vital capacity (Rahmawati, 2013). Other research suggests that the most influential factors on the incidence of lung problems in workers of PT. Semen Tonasa - Pangkep are the use of PPE (OR = 3.289; p value = 0.012) and smoking (OR = 2.764; p value = 0.046) (Mengkidi, 2006).

In a crowded housing, smoking habits of parents is a critical factor of indoor air quality, and thus it becomes health risk factors for the residents (Purnama, 2007). Based on this phenomenon, the exposure to CO in around us should be reduced or eliminated. One of them is by using activated carbon.

In the industrial world, activated carbon is commonly used to remove the odor, flavor, color, and other organic contaminants. Activated carbon is one of the organic materials with the quite extensive usage, both in large and small industries. Activated carbon is usually used as a catalyst, deodorizing, color absorption, purification material, and so forth. For the industry in Indonesia, the use of activated carbon is still relatively high (Dewi, et al., 2009).

Activated carbon is carbon compound that has improved its power absorption with the activation process. Activated carbon is composed of 87-97% carbon and the remaining substances are hydrogen, oxygen, sulfur, nitrogen, and other compounds in small quantities. In the activation process, the removal of hydrogen, water, gases from the carbon surface occur, causing physical changes in the surface. Activation occurs because the active groups are formed by interaction of free radicals on the carbon surface with atoms such as O2 and N2. In the activation process, new pores are also formed because there is erosion of the carbon atoms through oxidation / heating. This new pores make activated carbon has a surface area and hollow with a layered structure.

Activated carbon is composed by carbon atoms which are covalently bonded in a hexagonal lattice. Activated carbon is a form of amorphous carbon material that has a very large surface area up to 300 to 2000 m2 / g. A very large surface area is due to a porous structure. The pores are what causes the activated carbon has the ability to absorb. The ability of activated carbon to adsorb is determined by its chemical structure namely atoms C, H, and O bound chemically to form functional groups (Dahlan, et al., 2013).

Adsorption is the absorbing process of substances in the form of gas, vapor and liquid by the surface or interface without penetration. The most important factor in the adsorption process is the surface area. One molecule on the surface experiences imbalance. As a result, molecules on the surface are easy to attract other molecules, so that the force balance is achieved. From this adsorption process, the technical term for the substance being adsorbed is adsorbat and adsorbing substance is absorbent (Ramdja, et al., 2008).

The CO presented in experiment boxes will be accumulated on the surface of the adsorbent. The new pore formation of adsorbent activation further expand the surface area of activated carbon so that more area which adsorbs the materials on the outside. Furthermore, CO gas that is accumulated on the surface of the adsorbent will undergo absorption by the adsorbent and occupy the empty spaces. This happens both on coconut shell and durian skin activated carbons. In the control group which has not been given any absorbent material, CO gas is not experiencing absorption but only accumulated indoors. With this reason, there are differences in the concentration of CO gas in the experiment box between the treatment group and the control group.

The literature study shows that the smaller the tendency of activated carbon, the activated carbon produced has a high absorption. The number of molecules into the pores of the carbon will be constrained by the volume of the carbon pores so that at certain moments, adsorption will be in equilibrium along with the full volume of the carbon pores by adsorbate. At a time when a number of active centers as adsorbent has been fully occupied by molecules of adsorbate, there will be saturation in the pores of the resulting carbon adsorption reactivity to be minimal and adsorption equilibrium will occur (Komariah, et al., 2013).

In researching the use of coconut shell charcoal as an adsorption medium of CO and NO2 in the exhaust emissions of motor vehicles, it is known that activated carbon media that is placed along the 5 cm, 10 cm and 15 cm on the tube adsorption will decrease the concentrations of CO gas amounted to 77.50% , 80.70% and 83.90% (Basuki, et al., 2007).

In the market, the available activated carbon is from coconut shells, and not from other ingredients. One of the conditions why material is considered to be made as activated carbon is its high carbon content. Durian skin (Durio zibethinus) has been considered as waste. In general, durian skin can rot so that it can be used as compost. However, this is rarely done because it is hard and sharp. Durian skin decay process is taking longer than other organic materials. In addition, for all this time, durian skin waste treatment is only to burn it. This can increase the concentration of CO2 gas which is one of the greenhouse gases depleting the ozone layer in the atmosphere.

Durian skin has a great potential to be harnessed and used as activated carbon. Durian skin cellulose is high at around 50-60%, so there is an active carbonyl groups, hydroxyl, and ether potentially in the process of adsorption (Dirga, 2014). In addition to containing carbon and cellulose, both coconut shell and durian skin contain carbonyl, carboxyl, phenol, lactone, quinone and ether groups. Durian skin (Durie Zibertinus Murr) contain cellulose which is high (50-60%) and low lignin (5%) and starch (5%), as well as pectin so it is potential to be biosorbent metal ions.

The big difference in decreasing the concentration of CO gas between the coconut shell and durian skin is assumed because of varying levels of phenol, cellulose and oxide in both types of material. In durian skin, the phenol content is 74.49 ug / mL (Muhtadi, et al., 2014), while the coconut shell has 10-200 mg / kg. Phenol has properties that tend to be acidic, meaning that it can release H + ions of the hydroxyl groups. The release of H + ions disallows an empty space on the surface of the adsorbent so is will be easily filled by other materials that exist outside. In this study, self-loading material is carbon monoxide gas.

Cellulose indicates the existence of active groups of carbonyl, hydroxyl, and ether in the adsorption process. In coconut shell, cellulose content is 38.9% - 63.89%, while the durian skin is 50-60%.

Oxide on the surface of activated carbon is generally derived from the raw materials, from the air or from moisture. The oxide is usually acidic so it affects its active carbon. The oxide functional group makes the surface of active carbon to be chemically reactive and affects the nature of its absorption.

In general, the percentage reduction in CO gas with an adsorbent coconut shell is 62.6%, while the durian skin is 70.6%. Therefore, the general ability of the durian skin activated carbon in adsorbing CO gas is higher. The result of this study is supported by similar studies with exposure to a motor vehicle in which the activated carbon from durian skin can reduce the concentration of CO gas from motor vehicles as many as 0.604% to 0.192% with the adsorption capacity of 68.2% (Dirga, 2014). Likewise, the study of CO in emissions of motor vehicles concludes that there is a decrease in the levels of exhaust emissions of carbon monoxide (CO) with the addition of activated charcoal in a motor vehicle. At 50 grams of variation activated carbon, the percentage is decreased by 2.57%, 21.29% variation of 100 grams, 150 grams of 45.68% (Maryanto, et al., 2009).

Conclusion

The decline percentage in CO gas with coconut shell adsorbent is 62.6%, while the durian skin is 70.6%. There is a significant difference after the concentration of CO gas is adsorbed by various types of adsorbent with a p-value of 0.000. There is a difference between the adsorption capabilities of coconut shell and durian skin activated carbons with a p-value of 0.000. Durian skin activated carbon is more effective in adsorbing CO gas than coconut shell.

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