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Activated Carbon Adsorption Effectiveness in Coconut Shell Lowers Carbon Monoxide Indoor Air

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Abstract
The concentration of air pollutants in the home is greater than the outside and most of the pollutants come from the combustion gas containing carbon monoxide (CO) that are harmful to human health, it is necessary innovation air control to reduce levels of CO gas by using coconut shell charcoal. The aim to determine the effectiveness of coconut shell activated carbon adsorption in carbon monoxide gas reduction in indoor air. The research method using one group pre-post test design and analysis of data using paired t test. The results showed that decreased levels of CO gas after recovery tool room air through the use of coconut shell charcoal with a suction flow of 2.2 l/min at 185.3 ppm and percentage decline 73.9%. The results showed that there was a significant difference in reduction in carbon monoxide gas.
Keywords: CO gas, activated carbon, adsorption, air space

1. Introduction

Air is a mixture of several gases that comparison is not fixed, depending on the air temperature, air pressure and the surrounding environment. The composition (the composition of) the air is clean and dry, composed by Nitrogen (N_2) 78.09%, Oxygen (O_2) 21.94%, argon (Ar) 0.93%, Carbon dioxide (CO_2) and other gases contained in the air. If the composition of the air composition has undergone a change and has been said to be abnormal then interrupt live like human beings, then the state of the air has been polluted (Wardhana, 2001).

Air pollution is very detrimental to the health of living beings (Beelen et al., 2013; Hoek et al., 2013) and previously had been thought to cause human death from 3 to 7 million per year (Yang et al., 2010). Furthermore, a recent report from the Global Burden of Disease (GBD) has given a report that ranks the top ten causes of air pollution is a killer in the world and as the sixth biggest killer in South Asia (Murray et al., 2013). Air pollution is associated with adverse health effects in individuals especially cardiovascular pulmonary disease (Pirrozzi et al., 2015) and systemic inflammation (Hajat et al., 2015). Air pollution is associated with increased morbidity and mortality for some health indicators, including heart disease, acute respiratory infections, asthma, and pregnancy outcome (Glinianaia et al., 2004 ;. Kampa & Castanas, 2008; Lacasana et al., 2005 ;. SRAM et al., 2005). Increased levels of air pollution would increase the increase in the number of premature deaths among the population groups (Pope et al., 2011; Atkinson et al., 2011) and increase the risk of preterm delivery through processes associated with inflammation, oxidative stress, endocrine disorders, and disruption of transportation oxygen through the placenta (Slama et al., 2008).

The rapid development of industrial technology has significantly increased concentrations of greenhouse gases such as CO2, CH4, HFC, PFC and in the atmosphere. The greenhouse effect of these gases cause environmental pollution, worsen global warming, increasing sea levels, and affect the balance of the ecosystem. Among the greenhouse gases, the greenhouse effect of CO_2 has the greatest impact on global warming (Figueroa et al., 2008; Yang et al., 2008). Porous carbon-based material has a thermal stability and high chemical and good adsorption capability (Figueroa et al., 2008; Huang et al., 2014; Belhalchemi et al., 2014; Huang & Wen, 2014). Low cost and recyclability makes them ideal for the prevention of pollution (Foo & Hameed, 2009; Nowicki et al., 2010; Chen et al., 2013).

Problems in the indoor air pollution is the main pollutant concentrations are found more in the house (indoor) than outdoors (Minnesota Department of Health in Saragih, 2011). Saragih (2011), the presence of pollutants in indoor air can cause disturbances in good health in the long term or short term with a source of air pollution can come from household activities from the kitchen, smoke, building materials and others. Guritno (2012), states that indoor air pollutants are found from the smoke of burning gas containing carbon dioxide as a result of incomplete combustion. For humans, the CO gas is a gas component that is highly toxic to the body because it is faster to bind hemoglobin into carboxyhaemoglobin, causing inhibition of the flow of oxygen (O2) to bind to hemoglobin. Lack of oxygen supply to a certain extent will lead to the risk of death (Zulfa, 2011). Therefore, the government made a rule related to the presence of CO gas in indoor air contained in Permenkes No.1077 of 2011 on Guidelines for Indoor Air Health Home with the required maximum levels of 9.00 ppm/8 hours. The need for the handling of CO gas that are in this room is needed in order to realize healthy air and away from indoor air pollution.

Human healthy air is needed in order to realize a better quality of life, but with the situation which has now become the opposite, it is necessary to restructure the air. Restructuring the air itself is an effort made to keep the air that is around us did not experience any contamination that may have an impact on health, while further

deepened further restructuring related indoor air. Regulation of the minister of health of the Republic Indonesia Number 1077 at 2011, the attempt to rescue the substance of indoor air include physical, chemical and biological. Chemical substance which one is the source pencemarnya CO gas, it is very necessary to the penyehatannya as soon as possible, because if the air quality does not meet the requirements of the chemical as a result of risk factors, it can cause serious health effects. Basuki et al. (2008) stated that the use of coconut shell charcoal is effective in reducing the levels of carbon monoxide.

Coconut shell charcoal is the raw material that has the potential for the production of activated carbon, because it has an excellent natural structure and low ash content. Conversion coconut shells into activated carbon which is better (Huang et al., 2015) and can be used as an adsorbent that is inexpensive to absorb heavy metals in the solution of industrial waste water (Song et al., 2013; Rajput et al., 2015), helps reducing waste disposal costs and provide alternatives that could potentially cheaper to carbon existing commercial (Bansode et al., 2003; González et al., 2006; Ioannidou and Zabaniotou, 2007; Li et al., 2008; Chengwen et al., 2014; Etim et al., 2015).

2. Literature Review

2.1. Air

Air has a very important meaning in living creatures and the presence of other objects. So that the air is a natural resource which must be protected for life, human life and other living things. This means that its utilization should be done wisely by taking into account the interests of present and future (Depkes, 2002). Air is a substance that is most important after the water in the giving of life on this earth. In addition to providing oxygen, air also serves as a sound conductor and sounds, cooling hot objects, and can be a medium for the spread of disease in humans (Chandra, 2007). The air is said to be "Normal" and can support human life if the composition is as above. While in case of the addition of other gases that cause interference and changes in the composition, then the air is said to have been contaminated / polluted (Kastiyowati, 2011).

Clean air is a gas that is invisible, odorless, colorless and tasteless. But the air is really clean has been difficult to obtain, is because many natural activities and human activities that can damage the environment and human life. Means less environmental damage (damage to) the natural carrying capacity which in turn reduces the quality of human life (Wardhana, 2001).

2.2. Indoor air pollution

Indoor air quality is a problem that needs attention because it will affect human health. According to the National Institute of Occupational Safety and Health (1997), causing the problem of indoor air quality is generally caused by several things, namely the lack of ventilation by 52%, the sources of contaminants in the room by 16%, contaminants from the outside a whopping 10%, 5% microbe, building materials amounted to 4%, and the other 13% (Depkes, 2002). According to Hunte (2004), indoor air pollution becomes more serious health problem than outdoor air pollution, because on average we spend 75% of time to be in the room. According to the EPA and Lunau (1990) in Fitria et al. (2008), the main problems are often obtained from a variety of research on indoor air quality includes three general categories are sorted by frequency of occurrence, which is the highest is not strong ventilation, chemical contamination, and the lowest is microbiological contamination. Maryanto et al. (2009), based air pollution effects on health disorders can be divided into 3 types: irintasi, asfixia, and anesthesia.

2.3. Carbon monoxide

Carbon monoxide or CO is a gas that is colorless, odorless and tasteless. CO gas can be liquid at a temperature of -1920C. CO formation reaction is faster than the reaction of formation of CO2, so the final result is still possible there is a gas combustion CO (Wardhana, 2001). According to the WHO report (1992) in Atmoko (2012), at least 90% of the CO gas in urban air comes from vehicle emissions, in addition to cigarette smoke also contains CO gas. According to the Ministry of Health (2002), the CO level will be higher when the room where the cooker is working is inadequate ventilation. But generally the exposure comes from indoor cooking activity levels are lower than the levels of CO exposure to cigarette smoke results.

3. Methodology

The study was conducted at the Laboratory of the Department of Environmental Health Studies Program D-III Environmental Health Campus Surabaya, Polytechnic of Health and the Center for Environmental Health Engineering - Disease Control Surabaya in January-July 2014. The research sample that CO gas that comes from the burning cigarette smoke. The samples for the measurement of CO gas levels by purposive sampling. This study is penilitian experiment using one group pretest posttest design and data analysis using the paired t test.

4. Result and Discussion

4.1. Result

4.1.1. Preparation of activated carbon

Preparation of activated carbon is an early stage in the research activities in order to prepare for CO gas

adsorption media. The purpose of preparation of activated carbon that is to provide a standard use of adsorption media used to adsorb CO gas. The standard form of activated carbon material, grain size (mesh) activated carbon, as well as the weight of activated carbon. To achieve these standards, then measures its implementation, the choice of active carbon used is activated carbon from coconut shell. Subsequently homogenize the size of the active carbon with a grain size of less than or equal to 125 um with the aid of 120 mesh. To obtain the grain size of the activated carbon crushed using a blender and sieved using a 120 mesh to obtain an average diameter of not more than 125 um, which are categorized as the most fine powder. Furthermore, activated carbon is washed to remove the ash that covers the pores in activated carbon and inhibiting the adsorption process. After the activated carbon is inserted in glass bottles which then heated in an oven at a temperature of 120^0 C for 24 hours to evaporate the water molecules located in the pores of activated carbon activated carbon so that the humidity becomes very low. In this process also affects the weight of activated carbon. Activated carbon weight loss results after being washed and heated in an oven at a temperature of 120^0 C for 24 hours are shown in Table 1.

Table 1. Percentage weight activated carbon

Weight petridisk	Initial weight activated carbon	Final weight of activated carbon	Difference decrease	Percentage decrease
96,4 g	20 g	18,1 g	1,9 g	19 %
55,2 g	20 g	18,7 g	1,3 g	13 %
95,6 g	20 g	18,6 g	1,4 g	14 %
Total			4,6 g	46 %
Average			1,53 g	15,3 %

Table 1 shows that the weight of active carbon highest level of decline is in the number 1 with a decline of 1.9 g and a weight-activated carbon lowest rate of decline is at No. 2 with a decrease of 1.3 g. The average weight loss in the amount of active carbon is 1.53 g or 15.3% of initial weight every 20 g of activated carbon. Activated carbon which is ready to adsorb CO gas adsorption reactor is placed in a whole range of tools available on the room air sanitation and filled in full.

4.1.2. Measurement of CO gas levels through the before and after restructuring tool room air conditioners

Measurement of CO gas levels before going through the room air recovery tool are shown in Table 1.

Table 2. Measurement of levels of co gas before restructuring through tool room air conditioners

No. Test	Date	Sampling time (5 sec)	Gas concentration CO (ppm)
1.	July 20, 2014	13:05 pm	241 ppm
2.	July 20, 2014	13:15 pm	276 ppm
3.	July 20, 2014	13:30 pm	258 ppm
4.	July 20, 2014	13:39 pm	267 ppm
5.	July 20, 2014	13:47 pm	257 ppm
6.	July 20, 2014	13:53 pm	273 ppm
7.	July 20, 2014	13:60 pm	276 ppm
8.	July 20, 2014	14:06 pm	207 ppm
9.	July 20, 2014	14:14 pm	222 ppm
10.	July 20, 2014	14:20 pm	224 ppm
Total			2501 ppm
Average			250.1 ppm

Table 2 shows that the sampling of CO gas comes from cigarette smoke are included in a replica of the room inlet for 5 seconds 10 times the test sequentially, obtained the highest score for the levels of CO gas is 276 ppm while the lowest value of the levels of CO gas obtained is 207 ppm , The average levels of CO gas before the room air through the device restructuring amounted to 250.1 ppm. Table 3 shows the measured levels of CO gas after recovery tool room air through.

Table 3. Measurement of CO gas levels after recovery tool room air through

No. Test	Date	Sampling time (after a stable gas CO)	Gas concentration CO (ppm)
1.	July 20, 2014	13:10 pm	40 ppm
2.	July 20, 2014	13:20 pm	68 ppm
3.	July 20, 2014	13:35 pm	53 ppm
4.	July 20, 2014	13:44 pm	69 ppm
5.	July 20, 2014	13:51 pm	81 ppm
6.	July 20, 2014	13:55 pm	94 ppm
7.	July 20, 2014	13:65 pm	80 ppm
8.	July 20, 2014	14:11 pm	50 ppm
9.	July 20, 2014	14:18 pm	49 ppm
10.	July 20, 2014	14:24 pm	62 ppm
Total			646 ppm
Average			64,6 ppm

Table 3 shows that the sampling of CO gas after going through the process of adsorption of tools restructuring room air with the sampling time in terms of the stability of the value shown on the display or the display in Gas Alert Micro Clip XT and 10 times the test according to the test sequence, obtained the highest score of CO gas concentration is 94 ppm and the lowest rate of CO gas concentration of 40 ppm. The average levels of CO gas by means of restructuring after the room air that is equal to 64.6 ppm.

4.1.3. Gas content analysis of CO

The percentage decrease in the levels of CO gas after recovery tool room air with the greatest percentage decline is the first to test the value of 83.4% and for the smallest percentage reduction is on tests to 6 with a value of 65.56%. The average percentage decrease in the levels of CO gas in room air recovery tool that is equal to 74.27%. The percentage decrease in the levels of CO gas in room air recovery apparatus shown in Figure 1.

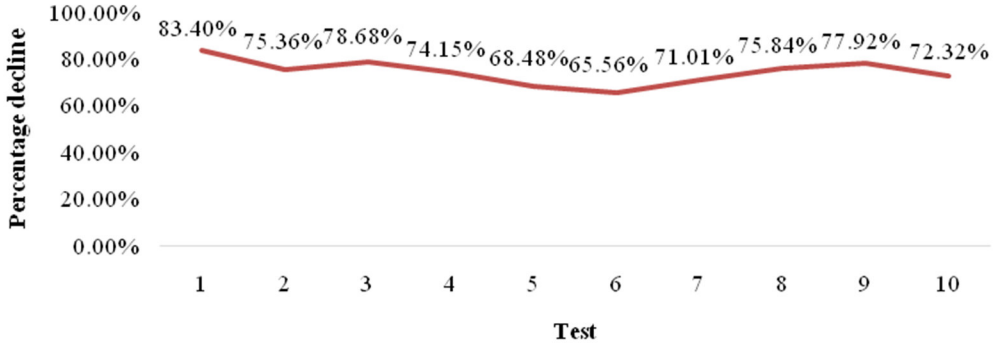

Figure 1. Percentage decrease in levels of CO gas in room air sanitation equipment

Figure 1 shows that the percentage decrease in the levels of CO gas in room air recovery tool to experience the graph decreases from test to test to 1 to 2, which is then increased back one level in the test to 3. The movement of the fall looks back up at 6 and returned to the test again increased up to 9 test and decreased in 10. the percentage decline to test the levels of CO gas in room air recovery tool highest percentage is in test 1 with 83.40%, while the lowest percentage drop is the test to 6 with 65.56 %. Based on the test results obtained Paired t test $P = 0.011 < \alpha$ (0.05), which indicates that there is a significant difference between the reduction in CO gas levels before and after the room air through a restructuring tool.

4.1.4. The ability of activated carbon to reduce levels at CO

Evaluation of the ability of the room air recovery tool to reduce levels of CO gas in terms of a few things, namely in the form of air vacuum capability, the ability of activated carbon as adsorbent media and the ability of the tool to the room. The percentage decrease in the ability of activated carbon as adsorbent media highest in hours and hours to 1 to 2 by lowering the percentage at 70.63%. To decline to the lowest for the clock 23 with a percentage decrease of 42.3%. Results percentage decreased levels of CO gas in room air recovery tool to determine a decrease in the ability of activated carbon as adsorbent media are shown in Figure 2.

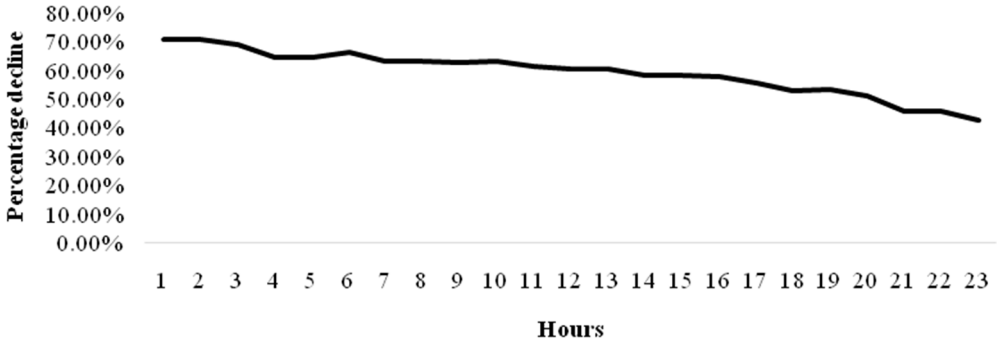

Figure 2. Percentage decrease ability activated carbon

Figure 2 shows that the percentage decrease in the levels of CO gas in room air recovery tool experiencing declining graph, which then rose again on the hour to 5. Movement fluktual in decline and increase the ability of activated carbon which is not significantly visible on the hour up to 6 hours to 13. decline occurred again up to 18 hours and a rebound in the 19th hour, but not significant improvement. Activated carbon has decreased up to 23 hours.

To determine the ability of air recovery tool this room to room that becomes a test, then the test results will be delivered through a replica of a room with a volume of 1 liter. This room is also a replica of the test chamber to determine the size of the levels of CO gas that comes from cigarette smoke. Results detention time detention time CO gas from the vacuum inlet to the outlet vacuum recovery tool room air in a room with a replica of a volume of 1 liter is shown in Table 3.

Table 3. Detention time gas CO from vacuum inlet to vacuum outlet

No. Test	Detention time of vacuum inlet to the vacuum outlet	Detention time of vacuum inlet to the vacuum outlet with CO gas concentration is stable at room replica outlet
1.	31 seconds	3 minutes 45 seconds
2.	59 seconds	4 minutes 36 seconds
3.	57 seconds	4 minutes 2 seconds
4.	36 seconds	3 minutes 58 seconds
5.	42 seconds	3 minutes 46 seconds
6.	45 seconds	3 minutes 56 seconds
7.	39 seconds	3 minutes 38 seconds
8.	34 seconds	3 minutes 36 seconds
9.	40 seconds	3 minutes 49 seconds
10.	38 seconds	3 minutes 31 seconds
Average	42,1 seconds	3 minutes 51 seconds

Table 3 shows that the detention time of the flow of air by CO gas from the vacuum inlet (pre) until the vacuum outlet (post) that exist on the appliance recovery room air volume test chamber for 1 liter of achieving the fastest time is 29 seconds in test 1 and time the longest is 57 seconds on the test to 2. The average detention time of the flow of air by CO gas from the vacuum inlet (pre) until the vacuum outlet (post) through the room air recovery tool to test space volume of 1 liter is 39.6 seconds. While the detention time of the flow of air by CO gas from the vacuum inlet (pre) until the vacuum outlet (post) which by means of restructuring the room air in the test chamber for 1 liter with state levels of CO gas in a replica of the room the test section outlet (post) became stable at the time the fastest is 3 minutes 31 seconds and the longest time is 4 minutes 36 seconds. The average detention time of the flow of air by CO gas from the vacuum inlet (pre) until the vacuum outlet (post) through the room air recovery tool to steady state levels of CO gas in the test room replica outlet section (post) is 3 minutes 51 seconds.

4.2. Discusion

4.2.1. Activated carbon as adsorbent media

The use of activated carbon in this study are as adsorbent media to reduce levels of CO gas. Activated carbon is one of the most commonly used adsorbent in the adsorption process, this is because the activated carbon has a higher adsorption capacity and surface area are better compared to other adsorbent (Pujiyanto 2010 in Qibthiyah, 20 128). Activated carbon can adsorb gases and chemical compounds specific or selective adsorption properties, depending on the size or the pore volume and surface area. Activated carbon absorption capacity is very large, ie 25-100% of the weight of activated carbon (Sembiring and Sinaga 2003 in Somad, 2009).

Activated carbon used comes from coconut shell. According to Basuki et al. (2008) states that termpurung coconut charcoal is charcoal produces carbon with more open pores. Coconut shell charcoal has a large surface and hollow with a layered structure. Pores coconut shell charcoal has the shape and size are varied and irregular.

These pores can capture and adsorb particles very fine particles (molecules). Coconut shell charcoal is used to adsorb gas molecules are porous microstructures. Therefore, the use of activated carbon derived from coconut shell charcoal.

Grain size (mesh) activated carbon used as the adsorbent media, homogenized whole. The size of the activated carbon granules used is the size of 125 um or less. The smaller the grain size, the greater the adsorption power that works on the active carbon. According Maryanto et al. (2009), an activated carbon adsorbent has pores very small diameter which can absorb the gas, so that the CO gas that will pass through the bound and experience the attractive forces with the pores of activated carbon. Sukir (2008), that the higher the size of the mesh, the finer the particle size so that the surface area of activated carbon is getting larger, so the more the number of available active part causes more adsorbate particles that can be absorbed.

Activated carbon that already meet the standard size will be an adsorbent to reduce levels of CO gas is washed to remove the ash attached to the carbon and will cover the pores of activated carbon. Meisrilestari (2013), that the existence of ash greatly affect the quality of activated charcoal. Excessive ash will cause pore blockage activated charcoal so that the active surface area is reduced. In Table 2 have shown that the composition of the ash in the activated carbon made from coconut shell by 15%, so the need to remove the ash in the activated carbon is indispensable. After washing to remove the ash, activated carbon is heated using an oven to vaporize water molecules attached to the activated carbon post-leaching able to cover the pores of activated carbon. The temperature of the oven is used to heat the activated carbon is 120°C. Basuki et al. (2008) that the activated carbon derived from coconut shell charcoal containing metal ions and water molecules. Under normal circumstances the interlayer space in the coconut shell charcoal is filled by free water molecules located around cations. When the coconut shell charcoal is heated to a temperature of 100°C, the water molecules will evaporate (out) so that the coconut shell charcoal can serve as a gas absorber. But if the coconut shell charcoal is heated to temperatures above 150°C, the structure of coconut shell charcoal will be damaged by heat.

Activated carbon weight measurements before and after treatment (washed and roasted) who where in Table 1 is known that the weight before treatment equated it all with a weight of 10 grams and done 3 times and then test each test is calculated active carbon reduction. From 3 times the test has been performed, obtained an average weight of 0.73 grams, or 7.3% of initial weight every 20 grams. The decline came from reduced activated carbon composition that is the ash that has been leached by water, of which 15% (Table 2) decreased 7.3% to 7.7%. In addition, according Meisrilestari (2013), that the mass change is caused in the process of activation (heating) a process of formation and preparation of the charcoal, so that the pores will become larger resulting in heavy charcoal is reduced because the pores are no meetings as before the activation process. Texture of the original carbon-intensive and hard to become more brittle and shiny. The pores are more and more will facilitate the process of entrapment of a large number of impurities are to be removed.

4.2.2. Gas content analysis CO

To analyze the content of CO gas after recovery tool room air through this, it is necessary in terms of Tables 1 and 2 which provide all the measurement results before and after the restructuring by means of the room air. Average results of measurements of the levels of CO gas before going through restructuring tool measurement with the treatment room air for 5 seconds after the administration of cigarette smoke in the amount of 250.1 ppm. As for the average measurement result after restructuring tool room air through the measurement of treatment to see the value in the Gas Alert Micro Clip XT to be stable in the amount of 64.6 ppm. So that the average difference in reduction occurred after the room air through the device is restructuring in the amount of 185.3 ppm with a percentage decrease of 74.27%.

Decreased levels of CO gas after recovery tool room air can occur due adsorpi process occurs in three reactors containing activated carbon. The adsorption process is a process in which a particle attaches to a surface due to the difference in charge between two objects is weak, so that eventually will form a thin layer of fine particles on the surface (Reynolds, 1982 in Basuki et al., 2008). The adsorption process can occur by activated carbon because of the pores in activated carbon are capable mengadsorp CO gas. According Meilita (2003) in Dunggio (2012) explains that the activated carbon material is in the form of free carbon or charcoal that has been made and processed exclusively through the activation process, so that the pores open and thus has great absorption capacity for the gas phase. In addition, the absorption is also determined by the surface area of the particles, where these abilities become higher if done activation by heating at high temperatures (Sembiring and Sinaga 2003 in Somad, 2009). In the normal state of the interlayer space on activated carbon (coconut shell charcoal) filled by free water molecules located around cations. When the coconut shell charcoal is heated to a temperature of 100°C, the water molecules will evaporate (out) so that akit carbon (coconut shell charcoal) can function as a gas absorber. But if the coconut shell charcoal is heated to temperatures above 150°C, the structure of coconut shell charcoal will be damaged because it does not heat resistant (Basuki et al., 2008). Thus, it can be seen that the reduction of the levels of CO gas by activated carbon which has been treated (heating).

Table 3 also can be seen that the value of the measured levels of CO gas is not stable, increasing and lowering the test 1 to test to 10. This can occur because of differences in the ability of granular activated carbon

to adsorb CO gas that reacts to each reactor in the tool , Contaminants gas that has passed through the adsorption section has a concentration of zero, but because of the factor of equilibrium and kinetic factors, some gas with low concentrations of contaminants will pass in the effluent (Basuki et al., 2008).

4.2.3. The contact time between when the CO gas through the room air recovery tool

According Maryanto et al. (2009), adsorption on activated charcoal occurs physically, adsorption occurs because the properties owned as an absorbent activated charcoal, molecular sieves, catalysts and ion exchangers. Activated charcoal is an adsorbent having pore diameters are very small that it can absorb the gas, so that the CO gas that will pass through the bound and experience the attractive forces with activated charcoal pores, so there is a long contact time for this reaction occurs. Adsorbent capacity will be saturated with increasing time since had many adsorbat attached to the adsorbent (Basuki et al., 2008). According to the theory of adsorption, adsorbate particles will approach the pores. Supposedly Langmuir during contact between the adsorbate and adsorbent particles will occur, namely a two-way process of adsorption and desorption. At the time of equilibrium, the adsorption rate equal to the rate of desorption so that the concentration of the adsorbate in the solvent remains. The time required from start of contact adsorbate with adsorbent until a balance is called the equilibrium time. At the time of equilibrium, it is considered that all the parts on the surface of the adsorbent has been occupied by the adsorbate particles (Sukir, 2008). So that when the time equilibrium occurs, the CO gas (adsorbate) will only pass through this reactor without experiencing a reaction. So that the contact time will be faster.

4.2.4. Coconut shell activated carbon in lowering gas CO

Activated carbon used in the study came from the coconut shell charcoal previously given treatment. As adsorbent media are made from organic materials, activated carbon has saturated the later period when it occurs in activated carbon is then the function is no longer the adsorbent media. Basuki et al. (2008), in the process of adsorption on adsorbent reactor, coconut shell charcoal media will continuously contact with the contaminant concentration of gas that is relatively constant contact. Solids adsorbent will adsorb contaminants to achieve equilibrium conditions. According Agusta (2012) that more and more mass adosrben used, will make the number of particles in contact with CO gas the more so the more particles are teradsorp CO gas. According Sukir (2008), the time required from the start of contact adsorbate with adsorbent until a balance is called the equilibrium time. At the time of equilibrium, it is considered that all the parts on the surface of the adsorbent has been occupied by the adsorbate particles. However, studies to determine the ability (balance) activated carbon can not run up because of time constraints and use the measuring instrument CO gas, so that researchers can only carry out related research capabilities (equilibrium) activated carbon during 23 hours in 8 days (interval).

Table 3 shows the ability of activated carbon to decrease in line with the length of exposure to CO gas is given.. However, a decrease in the activity of the activated carbon's ability does not run continuously, because there is also an increase. Figure 3, seen lowering occur up to 4 hours but there was an increase in the hours to 5. Movement fluktual (increases and decreases) the ability of activated carbon which is not significantly visible on the hour up to 6 hours to 13. The decline occurred again until hours 18 and again increase in hours to 19 but not significant improvement. Activated carbon has decreased up to 23 hours with a final percentage of 42.3%. The existence of movement in fluktual is because contaminant gases that have passed through the adsorption section has a concentration of zero, but because of the factor of equilibrium and kinetic factors, some gas with low concentrations of contaminants will pass in the effluent (Basuki et al., 2008).

5. Conclusion

Based on the above results it can be concluded that the decreased levels of CO gas with the percentage decline of 74.27% with a decrease of 185.3 difference criteria ppm.dan on Paired t test showed that there are significant differences in decline, this is due to adsorption on activated carbon manufactured and processed exclusively through the activation process (heating), so that the pores open and has a great absorption capacity for the gas phase CO, resulting in decreased levels.

Suggestions from this study is there needs to be an examination of the characteristics of the activated carbon as media adsorbent more features, such as surface area, density, moisture, porosity and composition of the constituent active carbon, the existence of other innovations in the use of activated carbon in addition to using coconut shell charcoal as a medium adsorbent, such as activated carbon from coal, rice husk, bagasse, and zeolites, as well as testing performed longer, until found levels of CO gas in the effluent is safe for humans in accordance with applicable regulations

References

Agusta, D. (2012). Uji adsorpsi gas CO pada asap kebakaran dengan menggunakan karbon aktif dari arang tempurung kelapa yang terimpregnasi TiO_2. Depok. Program Studi Teknik Kimia, FT-UI.

Atkinson, R. W., Cohen, A., Mehta, S., & Anderson, H. R. (2012). Systematic review and metaanalysis of epidemiological time-series studies on outdoor air pollution and health in Asia. *Air Quality, Atmosphere & Health*, 5(4), 383-391.

Atmoko, R. (2012). Pemanfaatan karbon aktif batubara termodifikasi TiO_2 pada proses reduksi gas karbonmonoksida (CO) dan penjernihan asap kebakaran. Depok. Departemen Teknik Kimia. FT-UI.

Bansode, R. R., Losso, J. N., Marshall, W. E., Rao, R. M., & Portier, R. J. (2003). Adsorption of metal ions by pecan shell-based granular activated carbons. *Bioresource Technology*, 89(2), 115-119.

Basuki, T.K., Setiawan, B., & Nurimaniwathy. (2008). Penurunan konsentrasi CO dan NO_2 pada emisi gas buang menggunakan arang tempurung kelapa yang disisipi TiO_2. Sekolah Tinggi Teknologi Nuklir-BATAN, Yogyakarta.

Beelen R, Raaschou-Nielsen, O., Stafoggia, M., Andersen, Z.J., & Weinmayr, G. (2013) Effects of long-term exposure to air pollution on natural-cause mortality: an analysis of 22 European cohorts within the multicentre ESCAPE project. *Lancet* 383(9919), 785-795.

Belhachemi, M., Jeguirim, M., Limousy, L., & Addoun, F. (2014). Comparison of NO 2 removal using date pits activated carbon and modified commercialized activated carbon via different preparation methods: Effect of porosity and surface chemistry. *Chemical Engineering Journal*, 253, 121-129.

Chen, Z., Deng, S., Wei, H., Wang, B., Huang, J., & Yu, G. (2013). Activated carbons and amine-modified materials for carbon dioxide capture—a review. *Frontiers of Environmental Science & Engineering*, 7(3), 326-340.

Chengwen, S., Shuaihua, W., Murong C., Ping, T., Mihua, S., & Guangrui, G. (2014). Adsorption studies of coconut shell carbons prepared by KOH activation for removal of lead (II) from aqueous solutions. *Sustainability*, 6: 86-98.

Depkes, (2002).Tentang parameter pencemar udara dan dampaknya terhadap kesehatan. Departemen Kesehatan Republik Indonesia.

Dunggio, Y.M. (2012). Adsorpsi gas karbonmonoksida (CO) dan penjernihan asap kebakaran menggunakan karbon aktif dari tempurung kelapa termodifikasi TiO_2. Depok. Program Studi Teknik Kimia. FT-UI.

Ello, A.S., de Souza, L.K., Trokourey, A., & Jaroniec, M. (2013). Coconut shell-based microporous carbons for CO 2 capture. *Microporous and Mesoporous Materials*, 180, 280-283.

Etim, I.I.N., Okafor, P.C., Etiuma, R.A., & Obadimu, C.O. (2015). Solar photocatalytic degradation of phenol using cocos nucifera (coconut) shells as adsorbent. *Journal of Chemistry*, 3(1), 35-45.

Figueroa, J.D., Fout, T., Plasynski, S., McIlvried, H., & Srivastava, R.D. (2008). Advances in CO2 capture technology-The U.S. Department of Energy's Carbon Sequestration Program. *International Journal of Greenhouse Gas Control*, 2 (1), 9-20.

Fitria et al. (2008). Kualitas udara dalam ruang perpustakaan universitas "X" ditinjau dari kualitas biologi, fisik dan kimiawi., *Jurnal Kesehatan*, 12 (2), 77-83.

Foo, K.Y., & Hameed, B.H. (2009). An overview of landfill leachate treatment via activated carbon adsorption process. *Journal of Hazardous Materials*, 171(1), 54-60.

Glinianaia, S.V., Rankin, J., Bell, R., Pless-Mulloli, T. & Howel, D. (2004). Particulate air pollution and fetal health: a systematic review of the epidemiologic evidence. *Epidemiology,* 15, 36–45.

González, Juan, F., Encinar, José, M., González-García, Carmen, M., Sabio, E., Ramiro, A., Canito, José.L., & Gañán, J. (2006). Preparation of activated carbons from used tyres by gasification with steam and carbon dioxide. *Applied Surface Science,* 252, 5999–6004.

Guritno, A. (2012). Sintesis dan uji kinerja katalis komposit Ag/TiO_2 - zeolit alam lampung – karbon aktif serta rekayasa alat untuk purifikasi udara ruang. Departemen Teknik Mesin. FT-UI. Depok.

Hajat, A., Allison, M., Diez-Roux, A. V., Jenny, N. S., Jorgensen, N. W., Szpiro, A. A., Sverre, V., & Kaufman, J. D. (2015). Long-Term Exposure to Air Pollution and Markers of inflammation, Coagulation, and Endothelial Activation: A Repeat-Measures Analysis in the Multi-Ethnic Study of Atherosclerosis (MESA). *Epidemiology*, 26(3), 310-320.

Hoek, G., Krishnan, R. M., Beelen, R., Peters, A., Ostro, B., Brunekreef, B., & Kaufman, J. D. (2013). Long-term air pollution exposure and cardio-respiratory mortality: a review. *Environmental Health*, 12(1), 43.

Huang, P.H., & Wen, J.T. (2014). Study on thorny bamboo activated carbon for capturing heavy metals in groundwater. *Applied Mechanics and Materials*, 535, 427-431.

Huang, P.H., Cheng, H.H., & Lin, S.H. (2015). Adsorption of carbon dioxide onto activated carbon prepared from coconut shells. *Journal of Chemistry*.

Huang, P.H., Hung, S.C., & Huang, M.Y. (2014). Molecular dynamics investigations of liquid–vapor interaction and adsorption of formaldehyde, oxocarbons, and water in graphitic slit pores. *Physical Chemistry Chemical Physics*, 16(29), 15289-15298.

Ioannidou, O. & Zabaniotou, A., (2007). Agricultural residues as precursors for activated carbon production-A review. *Renewable and Sustainable Energy Reviews*, 11, 1966.

Kampa, M. & Castanas, E. 2008. Human health effects of air pollution. *Environmental Pollution*, 151, 362–367

Kastiyowati, I. (2011). Dampak dan upaya penanggulangan pencemaran udara., Staf Puslitbang Tek Balitbang Dephan. Jakarta.

Lacasana, M., Esplugues, A., & Ballester, F. (2005). Exposure to ambient air pollution and prenatal and early childhood health effects. *European Journal Epidemiology*, 20, 183–199.

Li, W., Yang, K., Peng, J., Zhang, L., Guo, S., & Xia, H. (2008). Effects of carbonization temperatures on characteristics of porosity in coconut shell chars and activated carbons derived from carbonized coconut shell chars. *Industrial Crops and Products*, 28(2), 190-198.

Maryanto, D., Mulasari, A.S., & Suryani, D. (2009). Penurunan kadar emisi gas buang karbonmonoksida (CO) dengan penambahan arang aktif pada kendaraan bermotor di Yogyakarta. *Jurnal KES MAS*, 3(3), 162-232.

Meisrilestari, Y. (2013). Pembuatan arang aktif dari cangkang kelapa sawit dengan aktivasi secara fisika, kimia dan fisika-kimia. *Konversi*, 2, 1

Murray, C.J., Ezzati, M., Flaxman, A.D., Lim, S., Lozano, R., Michaud, C., Naghavi, M., Salomon, J., Shibuya, K., Vos, T., Wikler, D., & Lopez, A.D. (2013). GBD 2010: design, definitions, and metrics. *The Lancet,* 380(9859), 2063-2066.

Nowicki, P., Wachowska, H., & Pietrzak, R. (2010). Active carbons prepared by chemical activation of plum stones and their application in removal of NO 2. *Journal of Hazardous Materials*, 181(1), 1088-1094.

Nurbiantara, S. (2010). Pengaruh polusi udara terhadap fungsi paru pada polisi lalu lintas di Surakarta", FK-UNS, Surakarta.

O'Neill, M.S., Kinney, P.L., & Cohen, A.J. (2008). Environmental equity in air quality management: local and international implications for human health and climate change. *Journal Toxicology Environmental Health,* 71, 570–577.

Peraturan Menteri Kesehatan Republik Indonesia Nomor 1077 Tahun 2011 Tentang Pedoman Penyehatan Udara Dalam Ruang Rumah.

Peraturan Pemerintah Republik Indonesia Nomor 41 Tahun 1999 Tentang Pengendalian Pencemaran Udara.

Pirozzi, C., Sturrock, A., Carey, P., Whipple, S., Haymond, H., Baker, J., Weng, H-Y., Greene, T., Scholand, M.B., & Paine III, R. (2015). Respiratory effects of particulate air pollution episodes in former smokers with and without chronic obstructive pulmonary disease: a panel study. *COPD Research and Practice*, 1(1), 1-10.

Pope III, C.A., Brook, R.D., Burnett, R.T., & Dockery, D.W. (2011). How is cardiovascular disease mortality risk affected by duration and intensity of fine particulate matter exposure? An integration of the epidemiologic evidence. *Air Quality, Atmosphere & Health*, 4(1), 5-14.

Qibthiyah, M. (2012). Uji performa TiO_2 -karbon aktif berbahan dasar tempurung kelapa sawit sebagai adsorben gas karbonmonoksida dari asap kebakaran. Departemen Teknik Kimia, FT-UI. Depok.

Rajput, M.S., Sharma, A.K., Sharma, S., & Verma, S. (2015). Removal of lead (II) from aqueous solution using low cost abundantly available adsorbents: A. *IJCS*, 3(1), 09-14.

Saragih, W. (2011). Degradasi polutan udara ruangan menggunakan lampu hias dengan penutup berlapis katalis TiO_2 termodifikasi. Departemen Kimia, FT-UI, Depok.

Sarnat, J.A., Brown, K.W., Schwartz, J., Coull, B.A., & Koutrakis, P. (2005). Ambient gas concentrations and personal particulate matter exposures–implications for studying the health effects of particles. *Epidemiology*, 16, 385-395.

Slama, R., Darrow, L., Parker, J., Woodruff, T.J., Strickland, M., Nieuwenhuijsen, M., Glinianaia, S., Hoggatt, K., Kannan, S., Hurley, F., & Ritz, B. (2008). Meeting report: atmospheric pollution and human reproduction. *Environmental Health Perspectives*, 116(6), 791–798.

Somad, R. (2009).Arang aktif. http://radensomad.blogspot.com/2009/02/arang-aktif.html, Online 16 Januari 2014

Song, C., Wu, S., Cheng, M., Tao, P., Shao, M., & Gao, G. (2013). Adsorption studies of coconut shell carbons prepared by KOH activation for removal of Lead (II) from aqueous solutions. *Sustainability*, 6(1), 86-98.

Šram, R. J., Binková, B., Dejmek, J., & Bobak, M. (2005). Ambient air pollution and pregnancy outcomes: a review of the literature. *Environmental Health Perspectives*, 375-382.

Sukir, (2008). Pembuatan dan karakterisasi karbon aktif dari sekam padi. Departemen Kimia. FT-UI. Depok.

Wardhana, W. (2001). Dampak pencemaran lingkungan. Andi. Yogyakarta.

Yang, G., Wang, Y., Zeng, Y., Gao, G. F., Liang, X., Zhou, M.,Wan, X. Yu, S., Jiang, Y., Naghavi, M., Vos, T., Wang, H., Lopez, A.D., & Murray, C. J. (2013). Rapid health transition in China, 1990–2010: findings from the Global Burden of Disease Study 2010. *The lancet*, 381(9882), 1987-2015.

Yang, H., Xu, Z., Fan, M., Gupta, R., Slimane, R. B., Bland, A. E., & Wright, I. (2008). Progress in carbon dioxide separation and capture: A review. *Journal of Environmental Sciences*, 20(1), 14-27.

Zulfa, A. (2011). Uji adsorpsi gas karbonmonoksida (CO) menggunakan zeolit alam malang dan lampung. Program Studi Teknik Kimia. FT-UI. Depok.