



Air Stripping as an Effective Carbon Monoxide (CO) Adsorption Model on Cigarette Smoke

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Abstract

Carbon Monoxide (CO) produced from smoke by cigarettes has a certain level that accumulates indoors and affects indoor air quality. The purpose of this study was to see how effective the method of air stripping in reducing CO gas concentration by using activated carbon, silica sand, and zeolite media in the experimental room which has a volume of 1000 liters. This research was performed in the laboratory by using pre-experiment random group design. The independent variables of this study include activated carbon, zeolite, and silica sand as adsorbent, while the dependent variable of this study was carbon monoxide concentration. The test was carried out by measuring the accumulation of CO gas from burning cigarette, and subsequent testing with air stripping test treatment by using the varies adsorbent on 30 minutes. From the test results obtained the highest percentage reduction of CO concentration, which was 50.89% by using the activated carbon adsorbent medium, and the lowest percentage of CO reduction was 5.85% by using silica sand adsorbent medium. The difference of CO gas concentration was significant after passing air stripping process by using zeolite media, activated carbon and silica sand with significance level p value = 0.0001. There were significant differences in the ability of zeolite, activated carbon and silica sand to reduce CO concentration, with p value = 0.0001.

Abstrak

Karbon Monoksida (CO) yang dihasilkan dari asap oleh rokok memiliki kadar tertentu yang terakumulasi di dalam ruangan dan mempengaruhi kualitas udara dalam ruangan. Tujuan dari penelitian ini adalah untuk melihat seberapa besar efektivitas metode air stripping dalam menurunkan konsentrasi gas CO dengan menggunakan media karbon aktif, pasir silika dan pasir zeolit di dalam ruangan percobaan yang memiliki volume 1000 liter. Penelitian ini merupakan penelitian yang dilakukan di dalam laboratorium dengan menggunakan pre-eksperimen desain kelompok acak. Variabel bebas dari penelitian ini meliputi karbon aktif, pasir zeolit dan pasir silika sebagai adsorben, sedangkan variabel terikat dari penelitian ini konsentrasi karbon monoksida. Pengujian dilakukan dengan mengukur akumulasi gas CO dari pembakaran rokok, dan pengujian berikutnya dengan perlakuan uji air stripping menggunakan adsorben yang berbeda-beda dengan waktu pengujian selama 30 menit. Dari hasil uji didapatkan persentase penurunan konsentrasi CO tertinggi, yaitu 50,89 % dengan menggunakan media adsorben karbon aktif, dan persentase penurunan CO terendah yaitu 5,85% dengan menggunakan media adsorben pasir silika. Perbedaan konsentrasi gas CO yang signifikan setelah melalui proses air stripping dengan menggunakan media zeolit, karbon aktif dan pasir silika dengan taraf signifikansi nilai $p = 0,0001$. Ada perbedaan nilai yang signifikan terhadap kemampuan media zeolit, karbon aktif dan pasir silika dalam menurunkan konsentrasi CO, dengan nilai $p = 0,0001$.

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INTRODUCTION

Air pollution can be defined as the presence of airborne substances in concentrations that sufficient to cause disturbances in humans, animals, plants or materials. This substance can be either gas, liquid or solid particles. There are five types of air pollutants, particulates with diameters less than 10 μm (PM10), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and lead. In Government Regulation No. 41 of 1999 it is stated that air pollution is the entry or inclusion of substances, energy, and/or other components into the ambient air by human activities, so that ambient air quality drops to a certain level which causes ambient air to not fulfil its function.

One cause of unhealthy indoor air is due to smoking activities. Cigarette itself produces carbon monoxide (CO) and carbon dioxide (CO_2) gas caused by the combustion process. The content of these two gases is different between filtered cigarettes and non-filter cigarettes. The emission factor values generated by non-filter cigarettes for carbon monoxide (CO) parameters of 14-20 mg/cigarette and for CO_2 of 90-116 mg/cigarette (Utami, 2014). The emission factor itself is a representative value to connect the amount of pollutant released into the atmosphere by the release of the pollutant itself. In another study, the results of the gas test found in cigarette smoke showed that carbon monoxide produced from cigarette smoke captured in Cambridge filters was 14-23 mg or 2-5%, this value is the third largest composition after nitrogen of 280-120 mg and carbon dioxide of 45-65 mg and oxygen of 50-70 mg (Tirtosastro, 2010). Cigarette smoke can lead to various health disorders, both for active smokers and passive smokers (Puji, 2017; Agustina, 2015; Mukti, 2014; Tsani, 2014). Based on WHO research results in 2014, smoking was the cause of six million deaths each year and 600 thousand of whom were passive smokers. Passive smoking is shown to have a greater risk than active smokers for the occurrence of cigarette-related disorders such as abnormalities in pregnancy, LBW, growth disorders, sudden death, cancer, heart disease, lung disease, and others (Hanum, 2016; Cao et al, 2015; Naeem, 2015; Hagstad et al, 2012).

Among the methods to solve the problem of indoor cigarette smoke is by natural and mechanical processes. Natural air cleaning using plants could adsorb pollutants including cigarette smoke. And among plants that can adsorb CO in space is *Sansevieria*. The best variant of *S. trifasciata* cultivars in adsorbing CO from cigarette pollutants is *S. trifasciata* "Green Tiger" which was 76% and adsorbs CO_2 from cigarette smoke pollutant of 80.07% (Dewati-

sari, 2015). But the process of absorption by these plants is slow and less effective in a room that has a large volume.

Air Stripping has been widely used in wastewater treatment technology. In general, the Air Stripping method is used to break air particles into smaller grains of contact with the solid to create fine grains of air. Making these fine grains aims to increase the cross-sectional area of the physical contact between air and water, with the increasing number of cross-sectional areas in direct contact with water, the particles in the air will become more easily soluble in the aqueous solution. In this study the liquid used was water. After the particles contained in air dissolved in the air and then dissolve in water, then the duty of activated carbon and zeolite to adsorb the particles in the water. So the air coming out of the filter is expected to have a lower CO level than before it was filtered. Adsorption itself is defined as the process of separating the material from a gas mixture by means of binding the material to the liquid adsorbent surface followed by dissolution. The solubility of the gas to be adsorbed may be caused only by physical forces (on physical adsorption) or in addition to the force also by chemical bonds (on chemical adsorption). While the adsorbent is defined as a substance that can adsorb or attract moist gas and/or liquid into the pores.

In previous research, the CO gas adsorption method used activated carbon from cocoa leather waste. The activated carbon cocoa skin was proven to adsorb 70% CO emission level of four-wheel vehicles from 500 ppm to 150 ppm (Tamarjaya, 2012). Research conducted by Nurulita (2015), the decrease of CO in space by adsorption method by using activated carbon material from coconut shell of 62%, while the biggest decrease was using adsorption material from activated carbon material from durian leather of 70.6%.

The most important factors in Air Stripping include the characteristics of the material to be stripped, the type of material to be used as the contactor and the required number of levels, mass balance analysis of the stripping water building, as well as the physical needs of the dimensions of the water stripping building.

Therefore, in this study would be tested the effectiveness of the use of adsorbent media (zeolite sand, silica sand and activated carbon) in the process of Air Stripping which has been used for wastewater treatment but in this research was used as a air purifier of indoor cigarette smoke. Effective results of this model can be used as one solution to improve air quality of indoor smoky room by reducing the carbon monoxide content inhaled by anyone inside the room, especially passive smokers. It is expected

that this can reduce the risk of respiratory disorders for passive smokers.

METHOD

This research was conducted in public health laboratory of Semarang State University by using measuring instrument of carbon monoxide parameter. Testing was performed in the airtight box of 100 cm x 100 cm from acrylic which in the box would be given a source of carbon monoxide in the form of cigarettes. The research focus included the differences in the effectiveness of zeolites, activated carbon and silica sand as carbon monoxide adsorption medium in the air combined with the air stripping method as an air purifier in reducing the carbon monoxide concentration of indoor cigarette smoke.

Data analysis was performed based on mathematical calculation from each treatment during experiment and supported from secondary data in the form of previous research with similar method of Air Stripping used.

In experimental research required replication/repetition on each adsorbent media. Based on calculations to minimize errors in replication or repetition of experiments, the following formula was used: $(t-1) \times (r-1) \geq 15$

"t" is the number of treatments, while "r" is the number of replication. Based on the formula, it is required 3 treatments and 9 replications for each research group.

RESULTS AND DISCUSSION

From the calculation, the average air CO content in the experimental room after being contacted with the adsorbent media obtained varied values. The lowest value of the activated carbon was 314 ppm with a standard deviation of 6.09. The highest value of silica sand was 610 ppm with a standard deviation of 13.09. This showed that activated carbon was able to adsorb carbon monoxide better than zeolite and silica sand. To explain the levels of carbon monoxide in various types of adsorbent media can be seen in Figure 2.

The minimum value of CO concentration decrease was 16 ppm on silica sand media and the maximum value of decrease CO concentration was 345 ppm on activated carbon media. The highest average decrease in CO concentration can be seen in the medium of activated carbon was 339.4 ppm. This indicated that the activated carbon had a better CO adsorption capacity than either the zeolite or silica sand.

The percentage of CO decrease by air stripping method by using various media can be seen in Table 1.

The highest mean percentage in CO concentration decrease was found in the activated carbon media of 50.89%. The decrease of CO concentration by Air stripping method in various media can be seen in Table 2.

The requirement to perform ANOVA test is that the data has the same variance (homogeneous). How to read it is to compare the level of significance on Sig. with significance value used (level of signifi-

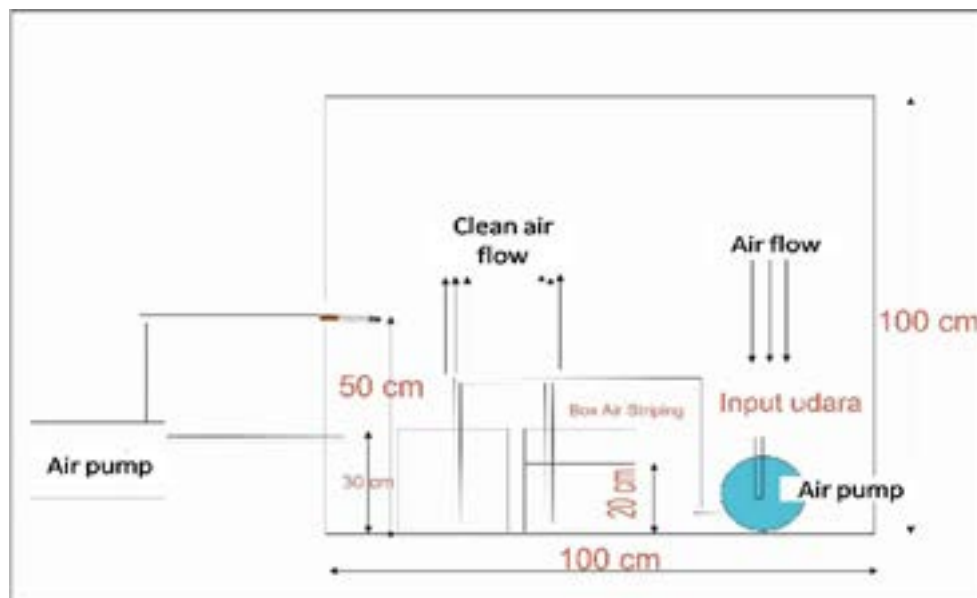


Figure 1 Schematic of test equipment and experimental room

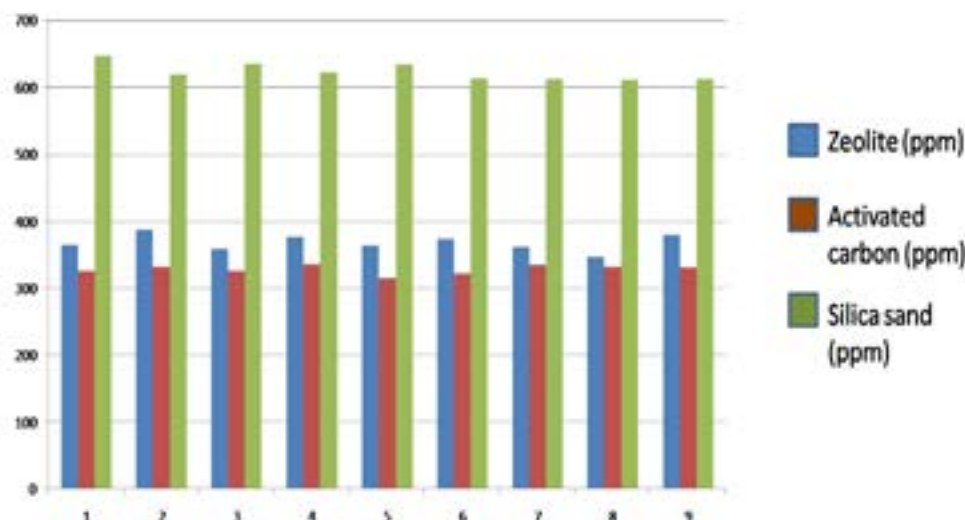


Figure 2. Carbon monoxide levels after the treatment

cance used was 0.05). The criteria used was if Sig. > 0.05 then the data had the same variance, otherwise if Sig. < 0.05 then the data had different variance.

From the statistical test data obtained Sig. = 0.107 > 0.005, so it can be concluded that the data had the same variance (homogeneous). After the homogeneity of variants was tested then followed by Post Hoc Test which was used to determine which variables had significant differences. The way to analyze is to see whether or not there is a mark (*) in the Mean Difference column. The sign (*) indicates a significant mean difference. From statistical data showed that the mean with zeolite adsorbent media was significantly different with the mean of activated carbon media and silica sand. The mean of activated carbon media was significantly different from the mean of zeolite and silica sand. And the mean silica sand media was significantly different from the mean of zeolite and activated carbon. LSD and Bon

Ferroni rows showed similar results in significance differences.

Based on the probability value (p-value) listed in the Sig column. If the probability is > 0.05 then H_0 is accepted, otherwise if probability < 0.05 then H_0 is rejected. From the above data obtained the probability of 0.0001, because $0.0001 < 0.05$ then H_0 is rejected. So, the research hypothesis that there was a difference in mean decrease in carbon monoxide concentration with the use of zeolite media, activated carbon and silica sand in the air stripping process was provable. Activated carbon is a carbon compound that has enhanced its adsorption power by activation process. In the process of activation occurs the removal of hydrogen, water, gases from the carbon surface so that there are physical changes on the surface. In the activation process also formed new pores due to the erosion of carbon atoms through oxidation/heating. This new pore makes

Table 1. Percentage of CO decrease with various adsorbent medium

| Replication | Zeolite (%) | Activated Carbon (%) | Silica Sand (%) |
|-------------|-------------|----------------------|-----------------|
| 1 | 44.53 | 51.49 | 2.413 |
| 2 | 42.5 | 50.82 | 5.927 |
| 3 | 44.67 | 50.76 | 5.646 |
| 4 | 43.96 | 50.07 | 5.479 |
| 5 | 44.5 | 52.28 | 5.514 |
| 6 | 43.48 | 51.21 | 6.269 |
| 7 | 44.72 | 50.3 | 7.273 |
| 8 | 47.42 | 50.3 | 7.855 |
| 9 | 42.6 | 50.75 | 6.279 |
| Mean | 44.26 | 50.89 | 5.851 |

Table2. CO concentration decrease with various adsorbent medium

| Replication | Zeolite | | |
|-------------|---------|------------------------|-------------------|
| | (ppm) | Activated Carbon (ppm) | Silica Sand (ppm) |
| 1 | 365 | 325 | 647 |
| 2 | 387 | 331 | 619 |
| 3 | 358 | 326 | 635 |
| 4 | 376 | 335 | 621 |
| 5 | 363 | 314 | 634 |
| 6 | 373 | 322 | 613 |
| 7 | 361 | 334 | 612 |
| 8 | 346 | 332 | 610 |
| 9 | 380 | 330 | 612 |
| Minimal | 346 | 314 | 610 |
| Maximal | 387 | 335 | 647 |
| Mean | 367.7 | 327.7 | 622.6 |
| SD | 12.55 | 6.69 | 13.09 |

the activated carbon has a broad and hollow surface with a layered structure.

The carbon monoxide gas exposed to the experiment box would accumulate on the surface of the adsorbent. Through the air stripping method, the surface of activated carbon would expand, as the air mixed with the CO was directly contacted to the adsorbent medium by using a blower, which resulted in more area that adsorbed CO in the media. Then the CO gas that was contacted with the adsorbent was adsorbing, and the air which released back into the experimental room was the air with the smaller CO concentration. While on the medium of zeolite and silica sand, the surface of the media in contact with carbon monoxide was not as wide as the surface of the activated carbon medium, thus affecting the decrease of CO concentration in the experimental room (Abdullahi et al, 2014).

When compared with two other adsorbent materials, activated carbon has the ability to reduce CO levels in the air. One of the reasons obtained at the time of the study was the density of the adsorbent material. Although it uses the same 30 kg of material and resides in a container of equal dimensions, the density of activated carbon is most appropriate. In the adsorbent of silica sand which has the smallest particle diameter size, the air that is sprayed will be very difficult to pass through every layer and gap between the silica sand grains. So the air will seek its own outflow and formed the flow of collected air. This results in the physical contact volume and the cross-sectional area of contact is reduced (Utami et al, 2014; Yuliusman, 2014; Ulfa, 2015).

In the adsorbent using zeolite sand, a slightly different adsorption was obtained when compared

to the activated carbon adsorbent. In observation during the study, this was due to the size of the zeolite particle diameter which larger than the activated carbon. This causes the cross-sectional area of physical contact to be smaller when compared to the activated carbon. Although on the use of zeolites and activated carbon airflow can be split and physical contact can occur thoroughly (Maleiva et al, 2015; Ghoreyshi et al, 2014).

CONCLUSION

Based on the results and analysis of research data obtained that the highest percentage decrease in CO concentration of 50.89% by using activated carbon adsorbent medium, and the lowest percentage of CO decrease of 5.85% by using silica sand adsorbent medium on the process before and after air stripping was performed. It shows that each of the adsorbent used in this study has different ability and characteristics of the material (shape, pore, and cross-sectional area of adsorbent) in adsorbing carbon monoxide.

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