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Research paper

Characteristic of Husk Charcoal, Bokashi Compost, and Wood Charcoal as Biofilter Filler on Application of Ammonia 5 Percent

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Abstract

Bio-filter has been widely used as one of methods to remove odorous gas, because of inexpensive, easy, and can remove the odour perfectly. This research has been conducted in order to determine the best physical of characteristic of bokashi compost, husk charcoal, and wood charcoal toward the adsorption of ammonia and compositions of such materials. 5% of Ammonia solution has been used to the physical characteristic of packing material. Some methods which use was water content and density, porosity, pressure drops, Water Holding Capacity (WHC), Pollutant Holding Capacity (PHC). Data were analyzed by ANOVA statistic test with error value 5% and continued with Duncan Test. From the physical experiment, by performance ranking shows husk charcoal is better than wood charcoal, and compost. Husk carbon shows the highest porosity, availability in hold water and air, PHC, and pressure drops. Husk carbon can adsorb 1.18x10-3 g-N/g bk of ammonia. Treatment of material composition with a ratio of (K212) shows that it is the best composition in ammonia absorption. This is evident from the water content of K212, lower pressure drops, PHC of 1.8x10-4 g-N / g bk. The conclusions are husk charcoal can be used as an alternative material absorbent of ammonia pollutant which is good enough seen from its physical character and the addition of wood charcoal as a filler composition can improve the physical character of the material as a filler on the mixture of compost material bokashi and charcoal husk.

Keywords: *Ammonia; Bio-filter; Charcoal; Compost; Husk.*

1. Introduction

Ammonia gas is one of the main contributors of air pollution which leads to deterioration of the atmospheric environment [1]. Ammonia has low odour threshold of 4 ppmv and easily detected by human olfactory [1] [2]. Ammonia has been widely used as a chemical for industrial activities. The rubber industry produces large amounts of ammonia which is about 1-600 ppmv [3]. Ammonia gives a bad influence on the body, inhaled in certain levels.

The most common biological treatment used to pollutants is a biofilter [4]. If biofilter compares with bio trickling filters, the biofilter has several advantages including: simple operation, low capital and operating cost, and can reduce the smell of pollution [5]. An odorous gas stream passes through a layer of a filter followed by biodegradation of the adsorbed pollutant [6] [7] [8]. A study ever utilizes the biofilter as an alternative solution to degrade organic matter contained in household waste water as well as increase the economic value (the cultivation of silk worms) [9].

A biofilter that using granular activated carbon with immobilized Paracoccus sp. applies to eliminate of 10-250 ppm of trimethylamine (TMA), dimethylamine (DMA), and methylamine (MA) [10]. The results indicate that the system effectively treated MA (>93%), DMA (>90%), and TMA (>85%) under high loading conditions [10]. The research was used Activated Carbon Fibre (ACF) as the carrier for the removal of ammonia gas. The ACF biofilter seeded with night soil sludge was performed the removal ratio at an average of 90% [11].

Treatment with biofilter uses bio-phosphate filter and gypsum rock to determine the impact on waste purification by analyzing EC, TDS, Cation (Mg+2, Na+, K+) and anion parameters ($HCO3^-$ and Cl^-). D results showed a significant reduction in EC values, TDS Cations (Mg+2, Na+, K+) and anions ($HCO3^-$ and Cl^-) concentrations for bio-phosphate filters compared with gypsum bio-filters [12].

Before applying materials as biofilter media, we need to know the characteristics of materials both physical, chemical, and biological. Biofilter materials most commonly used are granulated activated charcoal [13], bio media [14] and rockwool [15], pine nuggets dan lava rock [16]. In addition, organic media, [17] has used synthetic media or inorganic as biofilter medium.

Bokashi compost is produced from the fermentation of organic material with EM4 technology (Effective Microorganisms 4) [18]. Composts are widely used as filter media due to their excellent properties such as high surface area, high fluid permeability, high water holding capacity, high microbial population, neutral pH, nutrient content, and low cost [19]. The pressure drop of compost is higher than of peat soil, this is because compost has been compacted first. For this reason, compost is usually mixed with bulking agents (e.g., wood chips, saw dust, bark, and sand) to improve waste stream flow [20].

Wood charcoal comes from wood waste which is burned completely, it is containing carbon, solid, porous, has a low adsorption capacity, and the adsorption capacity can be enlarged by activating charcoal using steam or chemicals [21]. Furthermore, from this study is expected to obtain the physical characteristic of bokashi

compost, husk and wood charcoal as media to absorb smell of ammonia that can be applied in a bio-filter.

2. Research methodology

2.1. Tools and Materials

Material packing that used in this study are compost bokashi, husk and wood charcoal and the materials were composed into 4 treatments (K222, K122, K212, and K221). Gas contaminants used are ammonia (NH3) solution with a concentration of 5%, 0,2% boric acid (H3BO3) as ammonia adsorbent, aquades, 0.1 N HCl, and phenol phthalein (pp) indicator.
The tools used in this study are air flow meter, pump (capacity of 50 litres / minute), plastic hose with diameter of 0.5 cm, Parallon pipe as a column with a diameter of 2 inches.

2.2. Method

Material density is measured by measuring the dry weight of the materials. The total porosity test is done by adding up the pore size holding the water and the air. Material mixture is given water, so that all material surfaces absorb water. The amount of water that can be absorbed shows the ability of water holding materials.
Water Holding Capacity is done by calculating the weight loss of the material after adding water with the weight of dry matter. The amount of water which can be absorbed shows the ability of water holding material.
Column pressure is measured by flowing air using an air pump and U pipe manometer. The material is put into a parallon pipe where the edges are connected to the inlet and outlet hose as Fig 1. The inlet hose is connected to the air pump and the outlet hose to a tube containing water. The end of the inlet and outlet are connected to the manometer. When the air is flowed on a manometer containing water there will be a difference in height [22].

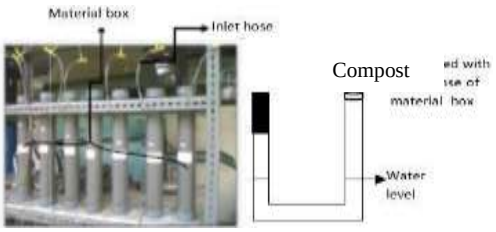

Fig. 1: Absorbing column design

PHC is done by saturating the material into a closed container containing 5% Ammonia solution as Fig 2. Measurement of the weight of ammonia gas held in the material is carried out until the material is saturated. The differences of final weight compared to initial weight is the amount of ammonia that can be absorbed by material.

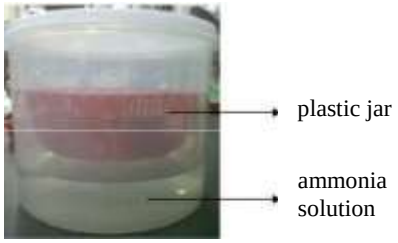

Fig. 2: Saturation process

3. Results and Discussion

3.1. Water Content and Density

Material Compost has the highest water content and density and the lowest is husk charcoal.

Table 1: Material water content and density

Materials	Moisture Content (%)	Density (Kg/m3)
Compost	55.78	399
Husk C.	6.85	136
Wood C	13.17	347
K222	25.28	255
K122	19.32	220
K212	27.58	260
K221	26.11	247

The addition of compost can affect the water content of the filler. Water content in biofilter fillers is very important to be considered, it is as a media for transporting the nutrients and minerals needed for the survival of microorganisms [5] [20] and biofililizing media by microbes that will degrade the ammonia gas pollutant into the biofilter [22]. K212 is the best composition that has the higher water content.
The using of husk charcoal gives a larger column volume. This can be seen from the composition of the filler which use of husk charcoal in large quantities resulting lower density. Rice husk charcoal has porous properties so it can pass water well and retain moisture It can be seen by the picture (Figure 3). Husk charcoal has porous properties than compost and wood charcoal is tighter.

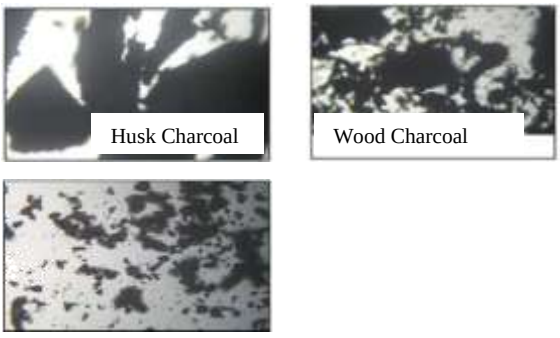

Fig. 3: Microscopic photo of materials

Based on ANOVA test with 95% confidence interval, density parameter gives significant effect on ammonia absorption at 5% concentration. With Duncan's advanced test, it was found that the treatment of K212 to K122; K222 to K122; K221 to K122 shows a significant difference.

3.2. Porosity

Water which is capable of being held by the material will affect the amount of pollutants which can be absorbed by material. Porosity of the filler (Figure 4). Husk charcoal has the greatest porosity compared to other materials. The lower density of the soil mass will result in the availability of pore space for water and air which means higher soil porosity [23].
Husk charcoal is capable of holding the air in smaller quantities than bokashi compost and wood charcoal.

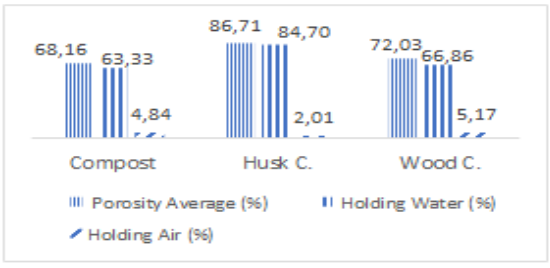

Fig. 4: Material Porosity

Husk charcoal has the higher absorption water and the air because of larger pores which can absorb them and stored in the pores. Throughout the observation, bokashi compost can receive water in

large quantities, but also able to release water in quick time [24]. The more amount of water that can be retained by the material, the smaller cavity holds the air. Water released by the material will allow the air to enter the cavity, so that the water filled cavity will make the material hold air in small amounts (Figure 5).

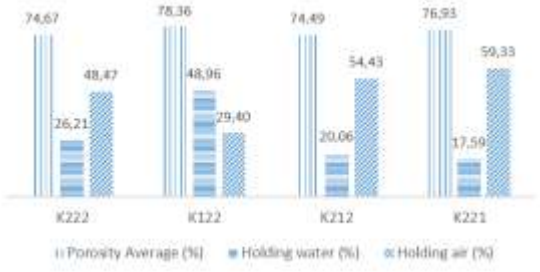

Fig. 5: Material Composition Porosity

The composition of materials which using large amounts of bokashi compost tend to be capable of holding large amounts of air and if compared to the composition that using of large amount of husk charcoal. This is indicated by K212 and K221 which is appear to be dry faster because releases the largest water.
Based on ANOVA test with 95% confidence interval, porosity parameter shows no significant effect on absorption of ammonia in 5% concentration. Followed by a Duncan test with 5% error value, it was found that the K122 treatment showed significant differences in the ability of materials water holding for 24 hours.

3.3 Pressure Drops

Pressure drops is an important factor in biofilter operations because it is directly related to operational costs. It was influenced by several factors such as particle size, composition of the filler, material density, water content, biofilter configuration and exhaust gas flow [20].
In this study, the pressure drop is performed by using a manometer on the U pipe. The airflow given was 1 litre / min. The changes of material pressure and composition are presented in Table 2.

Table 2: Material Pressure Drops

Material	P end (Pa)	ΔP (Pa)
B. Compost	68.6	656.6
Husk C.	191.1	534.1
Wood C.	164.2	561.1
Treatment	P end (Pa)	ΔP (Pa)
K222	83.3	641.9
K122	80.9	644.4
K212	112.7	612.5
K221	98.0	627.2
* P initial = 725.2	Pascal	

The result shows that compost has the greatest decrease compared with other materials, husk charcoal has decreased the smallest. Greater pressure drops occur in materials with higher water content [25]. Media with more compost (less wood chips) will result a higher pressure drops but only slightly higher efficiencies [26].
Pressure drops indicates the life of the filler. The greater of pressure drop of the material is not feasible as a biofilter filler as it will clog the outlet hose. Biofilter requires a material that has a small pressure reduction capability throughout its use. If the outlet hose is filled with filler, it will disrupt biofilter performance [6].
ANOVA test result with 95% of confidence interval stated that pressure drops parameter is not significantly affect the absorption of ammonia with 5% concentration. A study has found no clear relationship between the ammonia load and the pressure drop [22].

3.4 Water Holding Capacity (WHC)

WHC is the ability of materials to retain the water. The filler has maximum binding strength to the water, this is influenced by the size of pore diameter and the porosity of material, thereby affecting the pollution removal capacity [17]. Observation is done every 3 hours for 24 hours see Figure 6.

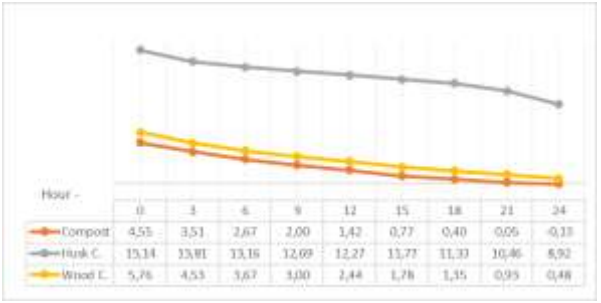

Fig. 6: Material water holding capacity

The observation shows that water that can be retained by the material has decreased. Husk charcoal looks better in holding water than wood charcoal and bokashi compost. This is presumably because the compost has low of porosity and density in the column compared with other materials, so that just a little gas can be restrained with a short time [27].
From the observations, the filler composition is releases water so that the amount of water retained by the material decreases (Figure 7). Compost releases water faster. Husk charcoal holds water and does not absorb the water given, so it is difficult to release water.

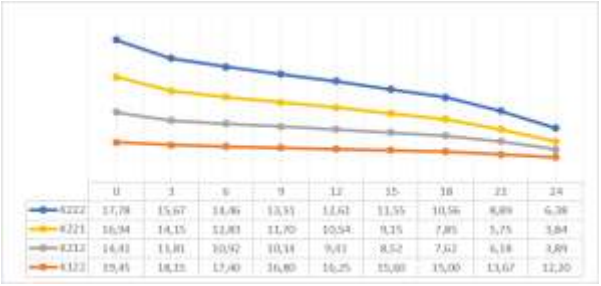

Fig. 7: WHC material composition

The ANOVA test with 95% confidence interval shows that WHC parameter significantly affected the absorption of ammonia gas. From the results of further tests Duncan with $\alpha = 0.05$ showed a significant difference.

3.5 Pollutant Holding Capacity (PHC)

PHC indicates the ability of the material to withstand pollutants. The ammonia captured by material will adsorbed until the material becomes saturated by the pollutant for a certain time. The capacity of each ammonium-containing filler is shown in Figure 8.
The amount of ammonia retained by the material with high density will increase the absorption process efficiency [28]. Figure 8. material adsorb ammonia (g N/g dry weight).

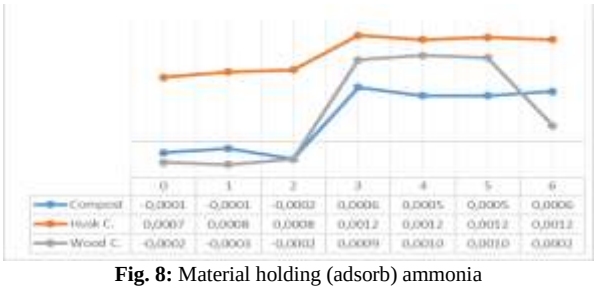

Fig. 8: Material holding (adsorb) ammonia

The ability of the filler composition (Fig. 9) shows a composition of K212 shows a positive result. This composition is better used as a filler in absorbing ammonia gas.

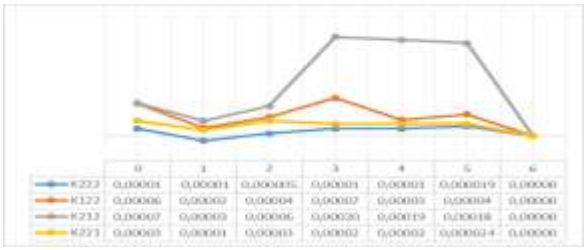

Fig. 9: Material treatment holding (adsorb) ammonia

Based on ANOVA test with 95% confidence interval, PHC parameters did not significantly affect the absorption of ammonia concentration 5%.

3.6 Parameter Comparison by Ranking Method

The parameters for this method consist of all parameters that used as the condition of the filler in the biofilter. Assessment is done by giving weighted. The largest number will be ranked as 1st and the smallest number is ranked as 3rd. From the rankings, husk charcoal is one of the best materials used as a biofilter filler (ranked1st) and treatment K212 is the best material used as a biofilter (ranked 1st).

4. Conclusion

Physically, husk charcoal has good characteristics if used as one of the medias which can absorb the smell of ammonia. The treatment of materials ratio of (K212) indicates good enough if used as filler.

There are several things which can be done related to this research;

1. Husk Charcoal can be used as an alternative material absorbent of ammonia pollutant which is good enough seen from its physical character.
2. The addition of wood charcoal as a filler composition can improve the physical character of the material as a filler on the mixture of compost material bokashi and husk charcoal.
3. Further research on these materials is required to obtain another physical characteristic needed in the selection of biofilter fillers for ammonia gas pollution absorption.

References

[1] Nisola GM, Cho E, Orata JD, Redillas MCFR, Farnazo DMC, Tuuguu E & Chung WJ, "NH3 Gas Absorption and Bio-oxidation in a Single Bioscrubber System," *Process Biochemistry*, vol. 44, no. 2, pp. 161-167, (2009).

[2] Ranau R, Kleeberg KK, Schlegelmilch V, Streese J, Stegmann V & Steinhart V, "Analytical determination of the suitability of different processes for the treatment of odorous waste gas," *Waste Management*, vol. 25, no. 9, pp. 908-916, (2005).

[3] Saputra F, "Penggunaan bahan pengisi tanah, kompos, arang sekam dan serasah dengan teknik biofilter untuk menghilangkan NH3 pada ruang produksi lateks pekat," Institut Pertanian Bogor, Bogor, (2008).

[4] Yani M, Purwoko, Ismayana A, Nurcahyani PR & Pahlevi D, "Teknik biofilter (ammonia removal from leum storage at crumb rubber industry by biofiltration technique)," *Jurnal Ilmu Pertanian Indonesia*, vol. 17, no. 1, pp. 58-64, (2012).

[5] Iranpour R, Cox HH, Deshusses MA & Schroeder ED, "Literature Review of Air Pollution Control Biofilters and Biotrickling Filters for Odor and Volatile Organic Compound Removal," *Environmental Progress*, vol. 24, no. 3, pp. 254-267, (2005).

[6] Nicolai RE & Janni KA, "Biofilter media mixture ratio of wood chips and compost treating swine odors," *Water Science Technology*, vol. 44, pp. 261-267, (2001).

[7] Pagans EL, Font X & Sánchez A, "Biofiltration for Ammonia Removal from Composting Exhaust Gases," *Chemical Engineering Journal*, vol. 113, no. 2, pp. 105-110, (2005).

[8] Chung Y-C, Lin Y-Y & Tseng C-P, "Removal of high concentration of NH3 and coexixtent H2S by biological activated carbon (BAC) biotrickling filter," *Bioresource Technology*, vol. 96, pp. 1812-1820, (2005).

[9] Ain YK, Herwanti TE & Husniyati T, "Pengolahan air limbah rumah tangga (grey water) dengan sistem biofilter untuk ecotech farm," Institut Pertanian Bogor, Bogor, (2010).

[10] Ho KL, Chung YC, Lin YH & Tseng CP, "Biofiltration of Trimethylamine, Dimethylamine, and Methylamine by Immobilized Paracoccus sp. CP2 and Arthrobacter sp. CP1," *Chemosphere*, vol. 72, no. 2, pp. 250-256, (2008).

[11] Yani M, Hiral M & Shoda M, "Ammonia Gas Removal Characteristics using Biofilter with Activated Carbon Fiber as a Carrier," *Environmental Technology*, vol. 19, no. 7, pp. 709-715, (1998).

[12] Mustufa AS, Sulaiman SO & Khudai MY, "Application of Biofilteration Wastewater Treatment Using Iraqi Gypsum and Phosphate Bio-filters," *Journal of Water Resource and Hydraulic Engineering*, vol. 2, no. 4, pp. 149-156, (2013).

[13] Chung Y-C, Lin Y-Y & Tseng C-P, "Waste Gases by Activated Carbon Biofilter," *Journal of the Air & Waste Management Association*, vol. 54, no. 4, pp. 450-458, (2004).

[14] Kim JH, Rene ER & Park HS, "Performance of an Immobilized Cell Biofilter for Ammonia Removal from Contaminated Air Stream," *Chemosphere*, vol. 68, no. 2, pp. 274-280, (2007).

[15] Yasuda T, Kuroda K, Fukumoto Y, Hanajima D & Suzuki K, "Evaluation of Full-Scale Biofilter with Rockwool Mixture Treating Ammonia Gas from Livestock Manure Composting," *Bioresource Technology*, vol. 100, no. 4, pp. 1568-1572, (2009).

[16] Akdeniz N, Janni KA & Salnikov IA, "Biofilter Performance of Pine Nuggets and Lava Rock as Media," *Bioresource Technology*, vol. 102, no. 8, pp. 4974-4980, (2011).

[17] Hirai M, Kamamoto M, Yani M & Shoda M, "Comparison of the Biological NH3 Removal Characteristics among Four Inorganic Packing Materials," *Journal of Bioscience and Bioengineering*, vol. 91, no. 4, pp. 428-430, (2001).

[18] BPTP CK, "Make Compost with EM4 Aktivator," BPTP Central Kalimantan, Central Kalimantan, (2018).

[19] Mudliar S, Giri B, Padoley K, Satpute D, Dixit R, Bhatt P, Pandey R, Juwarkar A & Vaidya A, "Bioreactors for Treatment of VOCs and Odours - A Reviw," *Journal of Environmental Management*, vol. 91, pp. 1039 - 1054, (2010).

[20] Cabrera G, Ramirez M & Cantero D, "Comprehensive Biotechnology, Second Edition," in Biofilter, Spain, University of Cadiz, Cadiz, Spain, (2011), pp. 303-318.

[21] Wahjuni S & Kostradiyanti B, "Decrease of Peroxide Value of Traditional Coconut Oil with Adsorbent of Rice Husked Hydro Ir 64 Which Are Verified with Potassium Hydroxide," *Chemical Journal*, vol. 2, no. 1, pp. 57-60, (2008).

[22] Shahmansoury MR, Taghipour H, Bina B & Movahedia H, "Biological Removal of Ammonia from Contaminated Air Streams Using Biofiltration System," *Iranian J Env Health Sci Eng*, vol. 2, no. 2, pp. 17-25, (2005).

[23] Kumalasari SW, Syamsiyah J & Sumarno, "The Study of Soil Physics and Chemical Character on Various Straightened Composition of Crop on Sub DAS Solo Hulu," *Scientific Journal of Soil Science and Agroklimatologi*, vol. 8, no. 2, pp. 119-124, (2011).

[24] Agustin AD, Riniarti M & Duryat, "Use of sawdust and rice husk as a growthmedia of yellow cempaka (Michelia champaca)," *Sylva Lestari Journal*, vol. 2, no. 3, pp. 49-58, (2014).

[25] Jekayinfa SO, "Effect of Airflow Rate, Moisture Content and Pressure Drop on the Airflow Resistance of Locust Bean Seed," *Agricultural Engineering International: the CIGR Ejournal*, vol. 8, pp. 1-9, (2006).

[26] Nicolai R, "Biofilters", South Dakota State: University David Schmidt, University of Minnesota, 2005.

[27] Yani M, Purwoko & Wahyuni A, "H2S gas removal by biofilter using compost and activated carbon as packing materials," *Agricultural Industry Engineering Journal*, vol. 19, no. 3, pp. 138-144, (2011).

[28] Rahmani AR, Mahvi AH, Mesdaghinia AR & Nasseri S, "Investigation of Ammonia Removal from Polluted Waters by Clinoptilolite Zeolite," *International Journal of Environmental Science & Technology*, vol. 1, no. 2, pp. 125-133, (2004).