DURIAN HUSK AS AN ALTERNATIVE PACKING MATERIAL FOR BIOFILTRATION OF AMMONIA POLLUTED GASEOUS STREAMS

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1. Introduction

Biofiltration is a process which utilizes microorganisms immobilized in a biofilm on the surface of the filter material. One advantage with the use of biofilters is that low concentrations of odorous effluent gases can be processed at low operation and maintenance costs. It involves microorganisms immobilized in the form of a biofilm on a porous carrier, such as, peat, soil, compost, synthetic substances or combinations of them. As the polluted air stream passes through the filter bed, pollutants are transferred from the gas stream to the biofilm developing on the organic substrate. The microorganisms metabolize the pollutants (Bohn, 1992; Wani et al., 1997; Morgan-Sagastume et al., 2001). Because these removal processes take place on the carrier in the packed bed, the carrier is an important factor determining the characteristics of odor gas removal. According to Clark and Wnorowski (1991) almost all organic compounds can be used as biofilter carrier. Bohn (1996) listed 13 important physical, chemical and biological characteristics with the most important being (i) large specific surface area, (ii) low density, (iii) (iv) large WHC (v) sufficient nutrients (vi) and a neutral or alkaline pH as well as buffer capacity. Durian, a tropical fruit, is one of the most important fruit commercially in South East Asian countries. The durian cultivars grown are derived from *Durio zibethinus Murray* originating in peninsular Malaysia. Durian is nearly round-shaped with an average size weighing between 2 and 4.5 kg depending on their varieties. The shell which usually weighs more than half of the total fruit weight is green to yellowish brown, thick and semi-woody with sharply pointed pyramidal thorns (S. Hokputsaa et al., 2004) which makes peeling a difficult task for untrained people cause risk to scary injury. Only one-third of durian is suitable for eating, whereas the seeds (20–25%) and the shells are usually thrown away. Due to the high utilization of durians, huge amounts of the shells (as waste products) are disposed, causing a severe problem in the community. In the interest of the environment, we propose to use this agricultural, therefore, the purpose of this study was to examine the characteristic of durian shell (DS), as a low-cost biosorbent for removal of ammonia (NH_3) polluted gaseous streams. In this study, the ability of durian shell in removing ammonia (NH_3) polluted gaseous streams was examined and it were characterized, and investigated as potential carrier material in biofilters.

2. Objective

1) To determine the physical and chemical characteristics of the packing material prepared from
durian shell.
2) To assess the performance of packing material (with and without bacteria) in biofilter for NH_3
gas removal.

3. Research Methodology

3.1 *Research Material*

Untreated durian shell (DS) were obtained from the markets in Serdang, Selangor (Malaysia). Durian shell were undergoing size reduction (30-50mm) by using wood chipper and part of it then directly analyzed for pH and water holding capacity (WHC) in triplicate according to methods of the AOAC (1975). The collected materials were then washed with distilled water for several times to remove all the dirt particles and straight away dried in a hot air oven at 70 ˚C for 48 h. Then, the samples were grinded into smaller size (0.5mm) by using pulverisette machine. Grinded samples were mixed with inert materials ($Ca(OH)_2$) with ratio 5.75g:0.25g respectively for pH balance and make it into pellets form (30mmØ) in large quantity by using hydraulic hand pressure with 5psi pressure. The specific surface area of pellets prepared from durian shell were determined by Micromeritics ASAP 2010 volumetric sorption analyzer with nitrogen flow at temperature -196^{o}C and was calculated using (Brunauer, Emmett and Teller) BET method. The pellets then stored in glass bottle for further use.

3.2 Ultimate analysis

Elementary analysis for C, H, N and S content of the packing material were also performed in an elemental analyzer (LICO – CHNS 932), and the oxygen percentage was estimated by difference.

3.3 Determination of organic functional groups

A Nicolet Magna FT-IR-750 spectroscopy apparatus was employed to determine the presence of bulk functional groups in samples at room temperature.

3.4 Filter with media without bacteria (as a control)

The pellets of durian shell will be pack into the filter. The source of pollutants from NH_3 gas will be introduced into the filter column. At room temperature (30^{o}C), the inlet and outlet gas will be sampled and analyzed for the concentration of NH_3 gas with Portable Handheld VOC monitor (ppbRAE3000) to determine the efficiency of removal by the filter.

3.5. Filter with media with bacteria

In the filter, the pellets will be inoculated with bacteria (*Nitrosomonas europaea).* The bacteria will be feeding with nutrient and oxygen to make sure it is alive. After make sure the bacteria were inoculated on the pellet by SEM *(scanning electron microscope)* analysis, and then the pellets will be placed into the column. NH_3 gas will be introduced into the filter column continuously. At room temperature (30°C), the inlet and outlet gas will be sampled and analyzed the concentration of NH_3 gas with Portable Handheld VOC monitor (ppbRAE3000) to determine the efficiency of removal by the filter. The reading will be take every 30 minutes for 10 hours duration for each parameter to analyze the performance of filter in order to degrade and absorb the NH_3 gas after passes through the filter.

4. Result & Discussion

Parameters in Table 1 are inherent to the material, allowing for comparison of, e.g., specific surface area, material density and CHNSO content with other materials characterized in the literature (E. Ramirez-Lopez et al., 2003; H.L. Bohn, 1996). A high specific surface area ($1.352 \pm 0.123 m^2/g$) of the durian shell, not much different to that of peat (M. Zilli et al., 1996) and coconut fiber Guillermo (Baquerizo et al., 2005) is a favorable characteristic for biofiltration applications. In any case, the low pore size of the material may lead to biomass growth over the surface of the durian shell, thus reducing the specific surface area available for pollutant degradation.

WHC of pellet as presented in table 1 can absorbed up to 11 times its own dry weight and overcome a low dry density. This value higher than the WHC of 2.8 gH_2Og dry material^{-1} reported for peanut shells, a suitable packing material for biofiltration applications (E. Ramirez-Lopez et al., 2003) .In any case, analyses were useful in order to gain knowledge prior to setting up the pilot-biofilter unit and to understand some operating conditions in the full-scale biofilter. Other than that, water holding capacity of carrier is important, especially in gas biofiltration, as the gas passing through the carrier has a large drying potential. So a moistened filter bed of durian shell can lose up to much H_2O before a lack of H_2O will inhibit microbial activity.

Although pH value of durian shell is low, it can be compensated by adding a buffer or a compound with an alkaline pH. In this study, $Ca(OH)_2$ were used during making pellets process to adjust the pH to 7.5-8.5 which is suitable for bacteria (Nitrosomonas europaea) to live. This is similar as reported by (Kennes et al., 1998) where peat is the main carriers used in biofilters although characterized by a low pH (3–4, Dalouche et al., 1989; Hirai et al., 1990) and high water holding capacity (WHC, 85%). Nevertheless, peat is generally found in delicate ecosystems, not always available in large quantities and not costs effectives.

The pellets were prepared like a cylinder shape (length 10 mm and diameter 30 mm) just like reported by (Kazuhiro Shinabe et al., 2000) that the best carrier was cylindrical. It is also similar as commercial carrier as reported (H.L. Bohn, 1996) for the carriers are made of polyethylene which is used in moving bed biofilm process. The basic principle of the process is similar with biofiltration where that the biomass grows on plastic carriers that move in the reactor because of the agitation set up by aeration (in aerobic reactors). Other than that, if the particles are too small, the surface area will be high, which is favorable characteristic but it could generate large pressure drop and clogging in biofilter.

Table 1 Physical and chemical characteristics of pellets prepared from durian shell

Properties	**Pellets of durian shell**
Shape	Cylindrical
WHC	11.27 ± 0.65
Specific surface area (m^2/g)	1.35 ± 0.12
pH	4.88 ± 0.49
Dry density	0.22 ± 0.02

The ultimate analysis of the durian shell is collected in Table 2. The content of carbon is high which is suitable for the microorganism to growth by using it as a source of energy. Higher oxygen content is suitable for microorganism growth in aeration condition.

Table 2 Results of ultimate analysis for durian shell

Raw material	Ultimate analysis (%)				
Durian shell	C	H	N	S	O
	39.3 ± 1.1	5.9 ± 0.2	1.0 ± 0.1	0.06 ± 0.01	53.74

*All values of ultimate analysis are on a dry basis.

Figure 1 show the peak of functional groups presence in durian shell determined by FTIR. Eventhough there is lots of peak, only Alkyl group (C-H stretch-3000-2800 cm^{-1}), amino (N-H bend-1650-1560 cm^{-1}) and hydroxy group (O-H stretch-3525-3200 cm^{-1}) were fulfill the range of wavenumber (cm^{-1}). These functional group structures are almost same to those of soil humic substances, which is normally take place in nitrification cycle naturally. This suggests that maybe NH_3 (remaining NH_4-N) will be trapped in pellets associated with chemical trapping by the functional groups of the durian shell and forming ammonium salts during biofiltration process. Other than that, the removal of NH_3 by pellets prepared from durian shell maybe achieved by the adsorption process with the functional groups of humic substances in the durian shell acting as active centers. This various kinds of functional groups of humic substances have been reported by (Kennes et al., 1998). Trapping schemes of NH_3 with functional groups of the durian shell are proposed as shown in Table 3.

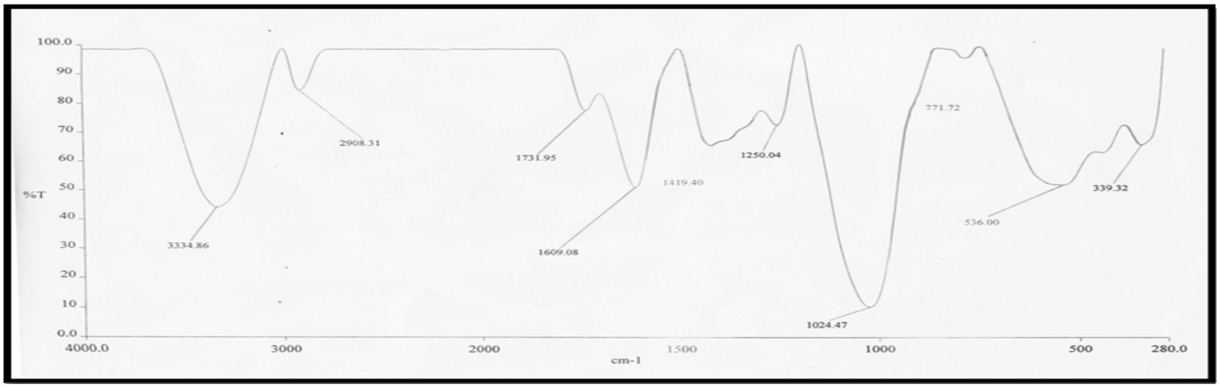
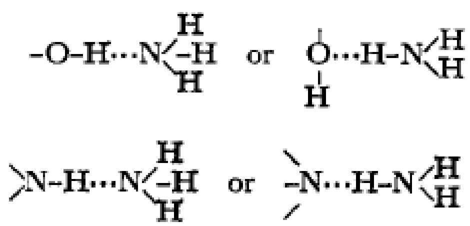


Figure 1 FTIR spectra of durian shell

Table 3 Probability schemes of NH_3 bond's with the functional groups of the durian shell.

Hydrogen bonding trap
i) Hydroxy, OH ii) Amino group, N-H (less contribution) 

5. Conclusion

A comparison of characteristic of pellets prepared from durian shell which is use as a carrier in biofiltration process with those reported in the literature showed that, durian shell is expected to be an effective and cheap alternative of raw material of carrier for biofiltration systems. They have a large specific surface area, a low density, suitable pH, a large WHC, sufficient nutrients for microbial growth and no significant clogging risk.

6. Significance of study

The present study shows that the pellets prepared from durian shells represent a potential alternative of characteristic of carrier which is use in biofiltration applications, especially in regions where peat is not available at a low price and/or in large quantities.

7. References

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