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Optimizing Application of *Melaleuca Cajuputi* Biochar on Removing H_2S Odour from Poultry Manure

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ABSTRACT

The chicken sector has grown quickly, which has resulted in the creation of a lot of manure, which produces gases like hydrogen sulfide (H_2S) and contribute to odour pollution. H_2S is a very unwanted gas component and must be removed from the environment. First, the current study focused on preparing the *Melaleuca Cajuputi* biochar at three temperatures: 300 °C, 400 °C, and 500 °C. The synthesized biochars were confirmed by FT-IR analysis. The effect of the biochar on H_2S absorption were studied. The biochar that was prepared at 500 °C showed the most effective material in absorbing the odour gas after two days.

1. Introduction

The development of large-scale livestock-breeding operations, such as concentrated animal feeding operation systems, can lower the operating costs of raising livestock and poultry, but these facilities can also release particulate matter, ammonia, hydrogen sulfide, volatile organic compounds, and greenhouse gases (like carbon dioxide, methane, and nitrous oxide) [1,2]. These outside influences have a direct impact on the development of multifactorial diseases in both animals and humans. Worker duties on livestock farms include handling manure for slurry removal, caring for animals, cleaning animal enclosures, and maintaining breeding facilities. Particularly during manure-handling procedures such as agitation and mixing, smells, ammonia, and hydrogen sulfide can be released extremely quickly [3,4].

Environmental factors and specific farming circumstances both have a significant role in the production of dangerous gases [5]. Recent studies of gas emissions from manure-handling facilities have been conducted to estimate the emissions based on inputs of actual measurement data and influential parameters, including farm operation or management factors (e.g., storage type, duration

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of manure storage), environmental factors (e.g., air temperature, humidity), and physicochemical characteristics (e.g., manure pH, chemical reactions) [6].

Most continuous emission monitoring studies have been conducted in specific workplaces, including inside an animal house throughout predetermined times, even though researchers have evaluated exposure to harmful chemicals at livestock farms. The evaluation of livestock facilities and the short-term fluctuations of potentially harmful emissions lacks appropriate data [7]. With a focus on short-term exposure at commercial swine and poultry farms, this study measured the concentrations of ammonia and hydrogen sulfide released during manure agitation for slurry removal at the manure-handling facilities and determined the effects of environmental factors, such as temperature, humidity, and breeding environment, on the concentrations.

Current research is focusing on synthesizing the *Melaleuca Cajuputi* biochar by pyrolysis method at different temperatures. The effectiveness of this biochar in absorbing the H_2S gas was monitored.

2. Methodology

Melaleuca Cajuputi leaves were washed using tap water and were dried in the oven at 75 °C. It was grounded and sieved with 5 mm in size. Furthermore, the *Melaleuca Cajuputi* powder was placed in the oven for pyrolysis at temperatures of 300 ºC, 400 ºC and 500 ºC for 2 hrs as shown in Figure 1. The produced sample was weighed to determine the solid yield of *Melaleuca Cajuputi* biochar (MCB). Fourier-Transform Infrared Spectroscopy (FTIR) was utilized to determine the MCB functional group. The KBr disc was prepared with each containing 1.5 mg of sample and 200 mg of KBr with IR range of 4000–400 cm^{-1}.

Poultry manure was bought from a local poultry farm and placed in a sealed container to maintain its condition before the experiment. For aerobic composting, a batch reactor system with laboratory size was used. Four batch reactor systems using the poultry manure (500 g) and MCB were employed with varying % of MCB addition. Four variables of 0%, 5%, 10% and 20% on MCB wet weight basis were applied. The H_2S gas strength that gives the odour was measured by using Odour Meter, MSA Model Altair-4X. Sample results were taken every day until the fifth day.

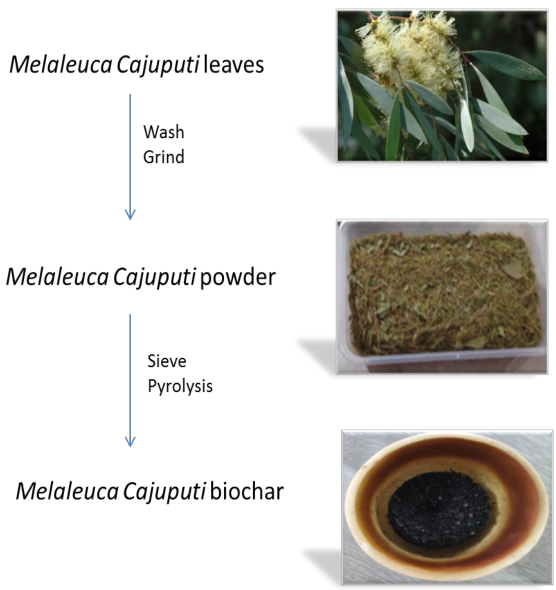

Fig. 1. Schematic route of MCB preparation

3. Results

3.1 FTIR Analysis

The functional group present in MCB was determined by Fourier Transform Infrared Spectroscopy (FTIR) analysis. Surface functional groups on biochar's are one of the key features which determine biochar properties and their potential applications. Figure 2 shows the FTIR spectra for *Melaleuca Cajuputi* after the pyrolysis process, thereby revealing the function of the groups' presence.

Based on the FTIR spectrum, carboxyl group presence in three different temperatures of MCB with the wavenumber of 1205–1124 cm^{-1} (C–O). Carboxyl functional groups are known to be effective in adsorbing/stabilizing several contaminants, such as heavy metals [8], pharmaceuticals and others [9].

There is a sharp intensity absorption in the absorption areas at the wave number of 3700–3584 cm^{-1} (O–H) will allow the compound to contain oxygen-related groups, such as alcohol or phenol. The alcohol presence decreased when the pyrolysis temperature was increased due to the thermal destruction of cellulose, hydroxyl group and aliphatic groups.

A functional group for carboxylic acid also has been found at the wavenumbers of 1440–1395 cm^{-1} (–COOH). Carboxylic acids can functionalize the biochar surface [10,11]. Moreover, apart from adsorption, biochar with the copious presence of carboxylic groups on the surface can be effectively used for various other applications including catalysis, biochar-supported nanostructures, and energy storage, among others [12]. Stretching vibration of O=C=O (CO_2) with wavelength 2400–2300 cm^{-1} was observed.

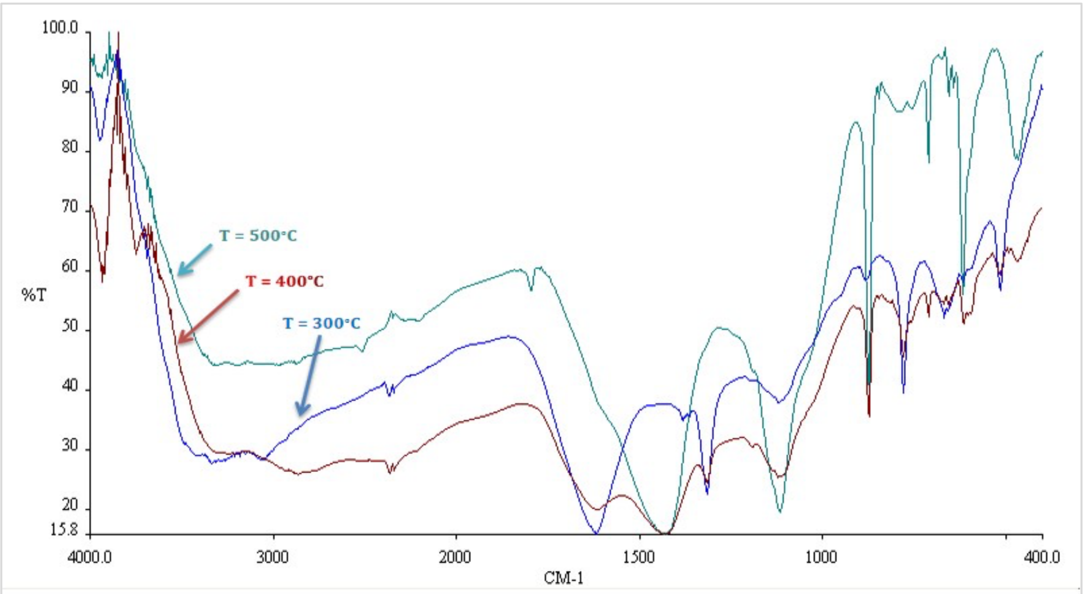

Fig. 2. FT-IR spectra of *Melaleuca Cajuputi* biochar synthesized at different temperatures

3.2 Odour Detection

The experiment to determine the concentration of H_2S gas was successfully done for 5 days. The initial concentration of poultry manure was 0.4 ppm. Without exposing the poultry manure to MCB biochar (MCB 0%), after 5 days, the H_2S gas declined to 0.30 ppm. The details of the result were tabulated in Figure 3 and Figure 4. Based on the recorded result, we can conclude that the temperature of biochar at 400 °C and 500 °C are more efficient temperatures compared to 300° C.

Both 400 °C and 500 °C were able to absorb and reduce the concentration of H_2S gas after 2 days by using MCB 20%. MCB 10% at 500 °C was able to reduce the H_2S after day 3 and day 4 for 400 °C of biochar. This shows that MCB is a good absorbent of H_2S gas. The result also may be affected by the temperature and humidity. There are many factors influencing ammonia and hydrogen sulphide concentrations, such as temperature, humidity, animal density, open type of housing, and manure storage duration. Previous studies have also shown that as temperature and moisture levels increase, ammonia and hydrogen sulphide concentrations rise [7].

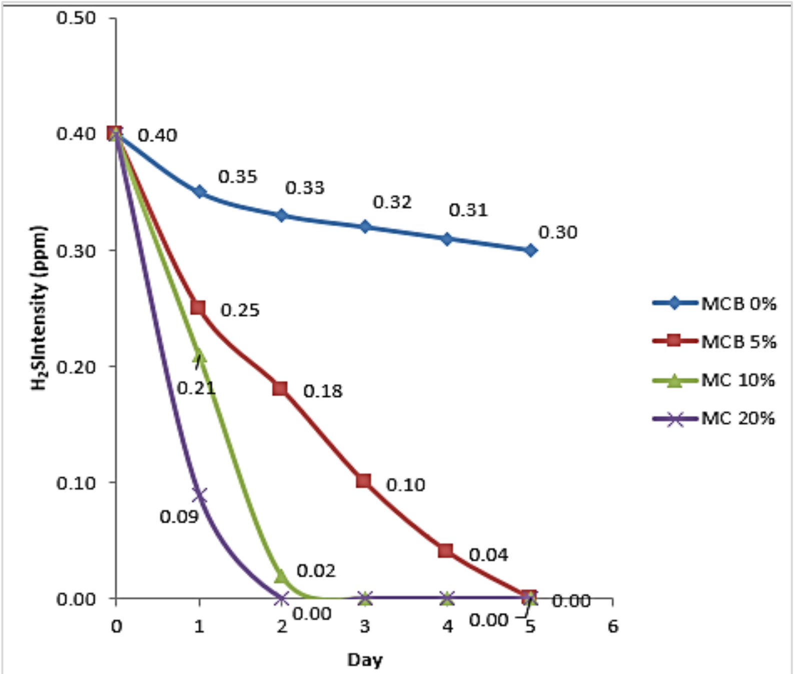

Fig. 3. Odor intensity of poultry manure by using MCB 500°C

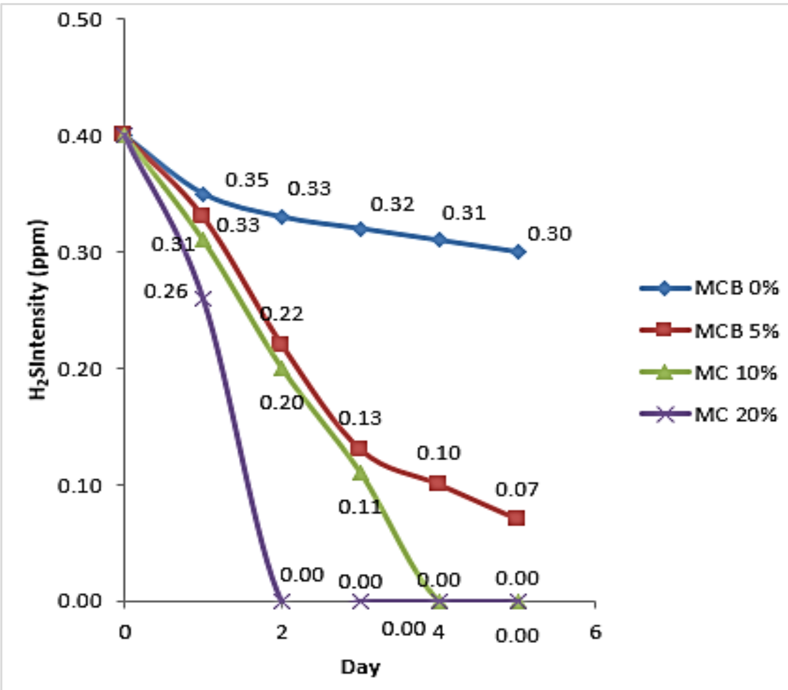

Fig. 4. Odor intensity of poultry manure by using MCB 400°C

MCB at 300 °C is less effective in absorbing the H_2S gas where it was only totally reduced on day 5 for MCB at 10% and MCB at 20% as shown in Figure 5. Previous researchers mentioned that the concentration of H_2S detected from poultry manure was very low and only the ammonia concentration was mainly detected at the poultry farms [13]. Hydrogen sulphide was not detected in broiler hen farms and measured in the range from 0.7 to 3.4 ppm at the farms with laying hens. The exhaust H_2S of manure with sawdust was detected to be below the detectable limit which is 0.1 ppm as measured by Gastech Portable Detector compared to the manure without added sawdust (3-5 ppm). Other researcher also reported a detectable amount of H_2S (0.02 ppm) was found in caged-hen high-rise layer houses [14].

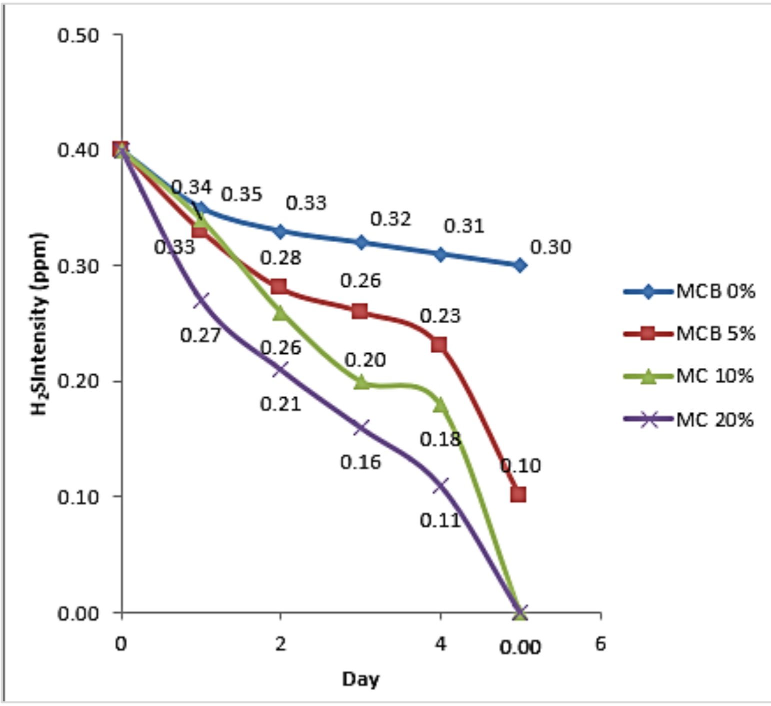

Fig. 5. Odor intensity of poultry manure by using MCB 300°C

Numerous studies have shown that there are wide variations in the NH_3 and H_2S contents and emission rates at swine facilities. They have to do with the design of the building and manure storage, its administration, the age and activity of the animals, their density, outdoor temperature, ventilation, and the time of day, season, and weather. Sulphur levels in the water used for swine production were also connected to H_2S generation and emissions [15]. Swine facilities typically have NH_3 values between 0 and 40 ppm, which is greater than dairy and beef facilities but lower than poultry houses. The completing buildings typically have the highest values. Meanwhile, H_2S emissions from midwestern U.S. dairy lagoons are episodic and seasonal. Emissions were determined using an inverse diffusion model in conjunction with measured upwind and downwind line averaged H_2S concentrations and turbulence [16].

Biochar is a stable solid material with rich carbon content and has demonstrated enormous potential in energy and environmental applications. Synthesizing biochar is affected by the temperature factor. In a previous study, Hashim *et al.,* [17] suggested the temperature of 300 °C in pyrolysis process shown maximum yield of *Melaleuca Cajuputi* biochar compared to temperature of 400 °C and 500 °C. In another study, Potnuri *et al.,* [18] focused on synthesizing the biochar from sawdust using torrefaction at 125 °C, 150 °C and 175 °C followed by pyrolysis. The maximum biochar product yield varied from 24 to 48 wt% and increased with torrefaction factor. Selvarajoo *et al.,* [19] produced biochar via pyrolysis of citrus peel fruit waste. biochar was derived from citrus peels biomass by slow pyrolysis over the temperature range of 300–700 °C. The effect of pyrolysis temperature on the quality of citrus peels-derived biochar was examined based on the physical and chemical properties obtained from various analyses. Pyrolysis is a flexible process, allowing us to obtain optimized product yields by adjusting the process parameters according to the product requirements [20].

4. Conclusions

The *Melaleuca Cajuputi* biochars were successfully prepared by using three temperatures; 300 °C, 400 °C and 500 °C. This study indicates that biochar produced from *Melaleuca Cajuputi* leaves can effectively reduce H_2S gas concentration from poultry manure. MCB that undergoes pyrolysis at 500 °C is the most effective because it only took two days to eliminate H_2S gas concentration from poultry manure. The characterization of biochar by different pyrolysis temperatures was the dominating factor affecting their physiochemical properties.

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