UNIVERSITI PUTRA MALAYSIA

CARBON-SEQUESTERING ABILITIES OF PINEAPPLE LEAF RESIDUE CHARS AND THEIR DECOMPOSITION IN A TROPICAL PEAT

LEE YIT LENG

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By

LEE YIT LENG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

January 2013

Dear Dad, Kok Woon,

Mom, Oi Lien,

Beloved Brothers and Sister, Men Hau,

Men Huan, Yit Qing

Thank you for your love and support

Special Thanks to Wei Han

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

CARBON-SEQUESTERING ABILITIES OF PINEAPPLE LEAF RESIDUE CHARS AND THEIR DECOMPOSITION IN A TROPICAL PEAT

By

LEE YIT LENG

January 2013

Chairman: Ahmad Husni bin Mohd. Hanif, PhD

Faculty: Agriculture

Oxidation of peat in combination with biomass burning on dry surface peat could result in substantial carbon emissions to the atmosphere contributing to climate change processes. Conversion of biomass into biochar is able to reduce CO_2 levels in the atmosphere by sustainably sequestering C. Field burning of pineapple leaf residues (PLR) on peat is a traditional practice to prepare land for cultivation. However, during the open burning not all of the PLR are converted into biochar but ash will also be produced. Biochar produced under controlled combustion is hypothesized to have better yield and quality, thereby better in sequestering C than the biochar produced from the open burning. The study was undertaken to compare the chemical properties and yields of PLR biochar produced by field burning (CF) with that produced by a partial combustion of air-dried PLR in a furnace (CL). Futhermore, the biochar decomposition with and without added fertilizer in the peat were determined.

Biochar produced by the CF and the peat samples were collected from Peninsula Plantation, Johor, Malaysia. The CL biochar was produced by partially combusting the PLR at 340°C for 3 hours in a furnace. Standard procedures were used to determine the chemical properties of biochars produced by CL and CF. The refractory nature of biochar samples were determined by analyzing the lignin content and C/N ratio. The chemical functional groups of PLR and biochar samples were identified using Fourier Transform Infrared Spectrocopy (FTIR). The decomposition of biochars with and without added fertilizer on the tropical peat over 12 months were determined using the litterbag method.

Total C (42.19%), lignin content (55.45%) and yield (5.63%) from CF was found to be significantly lower than CL. Higher total C (53.30%), lignin content (63.34%), and yield (33.71%) from CL as well as the presence of aromatic compounds in the FTIR spectra of the CL biochar suggest that the CL process was better in sequestering C than was the CF process. Although the C/N ratio (20.56) of biochar produced from CL was significantly lower than CF (23.90), the C in the CL biochar was dominated by lignin suggesting that the decomposition of biochar produced from CL would be slow. Decomposition of CL and CF biochars in peat, with and without added fertilizer, fit the three-parameter single exponential decay model.

Fertilizer treatment significantly reduced the weight and lignin remainings in the CL and CF biochars after 12 months. The FTIR spectra showed the changes in the functional groups of both biochars over 12 months were most likely the transformation from aliphatic to aromatic functional groups. Total C remaining in the biochar showed an increase in this order: CF + fertilizer (0.25 Mg/ha) < CF (0.31

Mg/ha) < CL + fertilizer (2.05 Mg/ha) < CL (2.41 Mg/ha). To sequester C by biochar application, the PLR could be partially combusted in a controlled process rather than by burning in the field.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KEUPAYAAN ARANG SISA DAUN NANAS DALAM MENSEKUESTASI KARBON DAN PEREPUTANNYA DI TANAH GAMBUT TROPIKA

By

LEE YIT LENG

Januari 2013

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Pengoksidaan tanah gambut dengan pembakaran sisa tanaman atas permukaan tanah gambut yang kering boleh menyebabkan pelepasan karbon yang tinggi ke atmosfera dan mengakibatkan proses perubahan iklim. Penukaran bentuk sisa tanaman kepada arang boleh mengurangkan kandungan karbon dioksida dalam atmosfera dengan cara mensekuestasi karbon secara mampan. Pembakaran daun nanas secara terbuka biasa diamalkan untuk penyediaan tanah semasa penanaman semula. Walaubagaimanapun, pembakaran sisa daun nanas (PLR) tidak akan membentuk arang sepenuhnya, tetapi kebanyakannya akan menjadi abu. Hipotesis kajian menyatakan bahawa penghasilan arang PLR melalui pembakaran terkawal adalah lebih tinggi hasilnya dan lebih berkualiti dari segi pensekuestasian karbon berbanding dengan arang yang dihasilkan secara pembakaran terbuka. Kajian ini dijalankan untuk menbandingkan sifat-sifat kimia dan jumlah hasil arang PLR yang dihasilkan daripada pembakaran secara terbuka (CF) dan pembakaran terkawal daun nanas dalam relau (CL). Seterusnya,

kajian dijalankan untuk mengenalpasti pereputan pada arang yang diberi rawatan baja dan tanpa rawatan baja di tanah gambut.

Sampel arang yang dihasilkan daripada proses CF dan sampel tanah gambut telah dikumpulkan dari Peninsula Plantation, Johor, Malaysia. Sampel arang yang dihasilkan daripada CL proses diperoleh daripada pembakaran PLR dalam relau pada suhu 340°C selama 3 jam. Prosedur setaraf digunakan untuk menentukan sifat-sifat kimia arang PLR yang dihasilkan daripada proses CL dan CF. Sifat refraktori sampel arang juga ditentukan dengan meggunakan cara menganalisis kandungan lignin dan nisbah C/N. Selain itu, kumpulan berfungsi kimia pada PLR dan sample arang dikenalpasti dengan kaedah Fourier Transform Infrared Spectroscopy (FTIR). Tren pereputan arang PLR di tanah gambut dengan rawatan baja dan tanpa baja ditentukan dengan menggunakan kaedah penanaman beg nilon yang diisi dengan arang.

Kandungan karbon (42.19%), lignin (55.45%) dan hasil arang (5.63%) dalam proses CF adalah didapati lebih rendah daripada proses CL. Kandungan karbon (53.30%), lignin (63.34%) dan hasil arang (33.71%) yang lebih tinggi serta sebatian aromatik yang didapati pada FTIR spektrum dalam proses CL menunjukkan keberkesanan lebih tinggi dalam mensekuestasi karbon berbanding dengan arang yang dihasilkan dalam proses CF. Walaupun arang yang dihasilkan daripada proses CL mempunyai nisbah C/N (20.56) lebih rendah daripada CF (23.90), tetapi kedominasian kandungan karbon oleh lignin menyebabkan proses pereputannya menjadi lebih perlahan berbanding dengan proses pereputan arang hasil daripada proses CF. Pereputan arang yang dihasilkan daripada proses CL dan CF dengan rawatan

mahupun tanpa rawatan baja adalah bersesuaian dengan model pereputan eksponen tunggal tiga-parameter.

Rawatan baja nyata mengurangkan berat dan kandungan lignin dalam arang CL dan CF selepas 12 bulan pereputan. FTIR spektrum bagi kedua-dua proses menunjukkan perubahan dari segi kumpulan berfungsi di mana kumpulan berfungsi alifatik berubah kepada kumpulan berfungsi aromatik dalam jangka masa 12 bulan. Jumlah kandungan karbon dalam arang menunjukkan peningkatan dengan susunan rawatan berikut: CF + baja (0.25 Mg/ha) < CF (0.31 Mg/ha) < CL + baja (2.05 Mg/ha) < CL (2.41 Mg/ha). Justeru, PLR sewajarnya dibakar dalam proses terkawal berbanding dengan proses pembakaran secara terbuka di ladang supaya lebih banyak karbon mampu disekuesterkan dalam aplikasi arang.

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I certify that a Thesis Examination Committee has met on 11 January 2013 to conduct the final examination of Lee Yit Leng on her thesis entitled "Carbon-Sequestering Abilities of Pineapple Leaf Residue Chars and Their Decomposition in a Tropical Peat" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Commitee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not currently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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LEE YIT LENG

Date: 11 January 2013

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