FULL CARBON ACCOUNTING IN BIOENERGY PRODUCTION FROM SUGARCANE

MISS MONTHIRA YUTTITHAM
ID: 47022021

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN ENVIRONMENTAL TECHNOLOGY

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

2ND SEMESTER 2009

FULL CARBON ACCOUNTING IN BIOENERGY PRODUCTION FROM SUGARCANE

MISS MONTHIRA YUTTITHAM
ID: 47922021

A THESIS SUBMITTED AS A PART OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY
IN ENVIRONMENTAL TECHNOLOGY

THE JOINT GRADUATE SCHOOL OF ENERGY AND ENVIRONMENT
AT KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI

2ND SEMESTER 2009

Full Carbon Accounting in Bioenergy Production from Sugarcane

Miss Monthira Yuttitham
ID 47922021

A Thesis Submitted as a Part of the Requirements
for the Degree of Doctor of Philosophy in Environmental Technology

The Joint Graduate School of Energy and Environment
at King Mongkut' s University of Technology Thonburi

2nd Semester 2009

Thesis Committee

(Asst. Prof. Dr. Amnat Chidthaisong)	Chairman
(Assoc. Prof. Dr. Shabbir H. Gheewala)	Member
(Asst. Prof. Dr. Sudarut Tripetchkul)	Member
(Dr. George Andrew Gale)	Member
(Prof. Dr. Kasem Chunkao)	External Examiner

Thesis Title: Full Carbon Accounting in Bioenergy Production from Sugarcane

Student name
Miss Monthira Yuttitham,
The Joint Graduate School of Energy and Environment,
at King Mongkut's University of Technology Thonburi,
Telephone: 02-8704091, 085-4832009
E-mail: monthira_y@yahoo.com

Supervisor' name
Asst. Prof. Dr. Amnat Chidthaisong,
The Joint Graduate School of Energy and Environment,
at King Mongkut's University of Technology Thonburi,
Telephone: 02-4708309 ext. 4119 Fax. 02-8729805
E-mail: amnat_c@jgsee.kmutt.ac.th

Member
Assoc. Prof. Dr. Shabbir H. Gheewala,
The Joint Graduate School of Energy and Environment,
at King Mongkut's University of Technology Thonburi,
Telephone: 02-4708309 ext. 4139 Fax. 02-8729805,
E-mail: shabbir_g@jgsee.kmutt.ac.th

Member
Asst. Prof. Dr. Sudarut Tripetchkul,
Natural Resources Management, School of Bioresources and Technology,
at King Mongkut's University of Technology Thonburi,
Telephone: 02-4707556, Fax. 02-4523455,
E-mail: sudarut.tri@kmutt.ac.th

Member
Dr. George Andrew Gale,
Natural Resources Management, School of Bioresources and Technology,
at King Mongkut's University of Technology Thonburi,
Telephone: 02-4707555, Fax. 02-4523455,
E-mail: george.and@kmutt.ac.th

External Examiner
Prof. Dr. Kasem Chankaew
College of Environment, Kasetsart University,
Telephone: 02-5792116 ext. 105
E-mail: ecksc@ku.ac.th

Topic: Full Carbon Accounting in Bioenergy Production from Sugarcane

Name of student: Ms. Monthira Yuttitham Student ID: 47922021

Name of Supervisor: Asst. Prof. Dr. Amnat Chidthaisong

ABSTRACT

This research study is focused on carbon dynamics and its life cycle inventory during sugarcane production and utilization in Eastern region. Field experiments were conducted to cover the whole sugarcane cropping season to measure soil carbon content, soil carbon fluxes, and sugarcane biomass decomposition. In addition, farm management and fossil fuel uses data were also obtained from the surveys of sugarcane farms and sugar mill factories. During the 2006/07 cropping year, soil surface emissions of CO_2 and CH_4 resulted in a carbon loss of 16.39 ton C/ha/yr. On the other hand, soil carbon gain was mainly through the incorporation of sugarcane biomass and organic fertilizer. In this study, inputs to soil of biomass were as followed 6.68 ton C/ha/yr from above ground biomass, 4.75 ton C/ha/yr from root system and 4.98 ton C/ha/yr from organic fertilizer. Decompositions of most of these biomass (80%) are completed within a year time. However, decomposability of each sugarcane parts did vary; with leaf sheath being the faster (2.67 months) and root the slowest (9.49 months). This left only a small fraction of incorporated biomass remained as part of soil organic carbon and may be one of the reasons why soil organic carbon content in sugar field is relatively low. For farm operations and managements, it was found that compared to surface soil emission, the GHG emissions was (0.56 ton C/ha/yr). Balancing between carbon loss and gain, it was estimated that sugarcane cultivation emitted 0.58 ton C/ha/yr. In the sugar mill factories, use of sugarcane biomass such as bagasse is an important GHG mitigation option. If it is assumed that all electricity consumed is generated from natural gas (baseline), the amount of CO_2 emission would be 5.80 kg CO_2-eq/ton cane. Utilization of bagasse, helps offset this emission to only 0.27 kg CO_2-eq/ton cane.

Keywords: Full carbon cycle inventory, Sugarcane, Soil carbon, Carbon budget, Sugar mill

ACKNOWLEDGEMENTS

I am deeply grateful to my advisor, Asst. Prof. Dr. Amnat Chidthaisong, for his supervision, helpful, advice and guidance during my work on my Ph.D. thesis. I would very much like to thank all those to my committee members, Dr. George Andrew Gale, Asst. Prof. Dr. Sudarut Tripetchkul and Assoc. Prof. Dr. Shabbir H. Gheewala, for their comments and suggestions in this study. In addition I would very much like to thank thesis external examiner: Prof. Dr. Kasem Chunkao for his suggestions and evaluation.

This research cloud not have been completed without to help and data supported of many people and office, especially, Mr. Nikom Saengong for providing access to research site and Mr. Chatri Yuttitham for his helps on field experiments. In addition, Mr. Attapole Malai for his helps for automatic chamber for flux measurement equipment, sugarcane farmers and sugar mill officers in Eastern Thailand for their answer the question for farm management and sugar mill process. Thanks also to Mr. Sataporn Jaiarree and teams at Land development department for their helpful on soil profile and analyzing soil properties at the site, Office of the cane and sugar board for geographic information system data and Thai meteorological department for precipitation data.

This research project was supported by Royal Golden-Jubilee Ph.D. Programme, The Thailand Research Fund and The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi.

I would like to extend thanks to Prof. Dr. Christiane Schmullius at Department of Remote Sensing, Friedrich Schiller University Jena, Germany for remote sensing laboratory supported and helpful. She gave me a very good experience on remote sensing knowledge and cooperation. Thanks also to the whole Geography Department's Remote Sensing group at Friedrich Schiller University Jena, Germany and friends for the friendly and their great help for my living there for a year. A thank you also goes to all friends who gave some diversion and who were always considerate.

Last but not least, I really would like to grateful to express my parents, my sister, my brother and my family who supported me throughout my studied and who gave me willpower and warmth. They always gave me grate care.

CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

LIST OF TABLES

LIST OF TABLES (Cont')

LIST OF TABLES (Cont')

LIST OF TABLES (Cont')

LIST OF FIGURES

LIST OF FIGURES (Cont')

LIST OF FIGURES (Cont')

LIST OF FIGURES (Cont')

List of Abbreviations

Brix: Degree Brix (symbol °Bx)

Bbg: Ban Bueng soil series

Bbg-Sh: Ban Bueng and Sattahip soil series

BOD: Biological Oxygen Demand

Cb: Chon Buri soil series

CDM: Clean Development Mechanism

CFC_s: Chlorofluoro carbons

CH_4: Methane

CO_2: Carbon dioxide

COD: Chemical Oxygen Demand

GHG: Greenhouse gases

GIS: Geographic Information System

ha: hectare

Hg: Hup Kraphong soil series

IPCC: Intergovernmental Panel on Climate Change

Knk: Khlong Nok Krathung soil series

KP: Kyoto protocol

LDD: Land Development Department

Nm: Nong Mot soil series

N_2O: Nitrous oxide

OC: Organic Carbon

Pg: petagram = 10^{15} g

Pga: Phang Nga soil series

Pp: Phon Phisai soil series

ppmv: Parts per million on a volume basis

Ra: Aboveground plant respiration

Rb: Belowground plant respiration

Re: Ecosystem respiration

Rp: Plant respiration

Rm: Microbial respiration

Rs: Root respiration

SF_6: Sulfur hexafluoride

Sh: Sattahip soil series

SOC: Soil Organic Carbon

Suk: Satuek soil series

Tg: Thung Wa soil series

Tg = 10^{12} g C

UNFCCC: United Nations Framework Convention on Climate Change

Walkley's method: Walkley and Black method