โครงการ
การเรียนการสอนเพื่อเสริมประสบการณ์

ชื่อโครงการ **Assessment of soil organic carbon stocks: A comparison between open burning paddy field and organic paddy field**

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ภาควิชา **Environment Science**

ปีการศึกษา **2018**

คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

SENIOR PROJECT

Project Title **Assessment of soil organic carbon stocks: A comparison between open burning paddy field and organic paddy field**

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Department Environment Science
Academic Year 2018

Faculty of Science, Chulalongkorn University

Assessment of soil organic carbon stocks:
A comparison between open burning paddy field and organic paddy field

การประเมินการสะสมคาร์บอนอินทรีย์ในดิน:
การเปรียบเทียบระหว่างพื้นที่นาข้าวที่มีการเผาในที่โล่งและพื้นที่นาข้าวแบบอินทรีย์

Phanupong Wongchan

A Senior Project Submitted in Partial Fulfillment of the Requirement for the Degree of Bachelor of Science Program in Environmental Science, Faculty of Science, Chulalongkorn University, Academic Year 2018

Project Title	**Assessment of soil organic carbon stocks: A comparison between open burning paddy field and organic paddy field**
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Academic year	**2018**

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โดย	**นายภานุพงษ์ วงษ์จันทร์ รหัสประจำตัวนิสิต 583 33365 23**
อาจารย์ที่ปรึกษา	**ผู้ช่วยศาสตราจารย์ ดร.ภศิชา ไชยแก้ว**
ภาควิชา	**วิทยาศาสตร์สิ่งแวดล้อม**
ปีการศึกษา	**2561**

บทคัดย่อ

เกษตรกรส่วนใหญ่ในทวีปเอเชียรวมถึงประเทศไทยเลือกจัดการพื้นที่นาข้าวด้วยวิธีการเผา เนื่องจากเป็นวิธีที่สามารถกำจัดฟางข้าวและสามารถเตรียมพื้นที่ได้พร้อมสำหรับการเพาะปลูกในครั้งถัดไป ซึ่งเป็นวิธีที่ง่ายและสะดวกเมื่อเทียบกับวิธีอื่น สำหรับพื้นที่นาข้าวที่มีการเผาในที่โล่งนั้นได้รับผลกระทบตั้งแต่ในดินจนถึงอากาศ อย่างไรก็ตามยังมีประเด็นที่ถกเถียงกันถึงผลกระทบต่อปริมาณคาร์บอนอินทรีย์ การศึกษาครั้งนี้จึงมีวัตถุประสงค์ 1) เพื่อเปรียบเทียบปริมาณคาร์บอนอินทรีย์ในดินระหว่างพื้นที่นาข้าวที่มีการเผาในที่โล่งและพื้นที่นาข้าวแบบอินทรีย์ 2) เพื่อศึกษาความสัมพันธ์ระหว่างสมบัติดินทางกายภาพและเคมีกับปริมาณคาร์บอนอินทรีย์ในดิน 3) เพื่อประเมินการกระจายตัวเชิงพื้นที่ของปริมาณอินทรีย์คาร์บอนในดินระหว่างพื้นที่นาข้าวที่มีการเผาในที่โล่งและพื้นที่นาข้าวแบบอินทรีย์ โดยการเก็บตัวอย่างดินจำนวน 2 ชุดจากพื้นที่นาข้าวที่มีการเผาในที่โล่งและพื้นที่นาข้าวแบบอินทรีย์ในระยะเวลาอย่างน้อย 5 ปีติดต่อกัน จำนวนทั้งหมด 20 ตัวอย่างจากแต่ละพื้นที่นาข้าวที่ระดับความลึก 30 ซม. การวิเคราะห์คาร์บอนอินทรีย์ใช้วิธี Walkley and Black ซึ่งผลการศึกษาพบว่าค่าเฉลี่ยของปริมาณคาร์บอนอินทรีย์ในดินพื้นที่นาข้าวที่มีการเผาในที่โล่ง ($2.17 \pm 0.38\%$) คิดเป็นปริมาณการกักเก็บคาร์บอนในดินเฉลี่ย 9.96 ± 0.07 กก./ตร.ม. ซึ่งสูงกว่านาข้าวแบบอินทรีย์ ($1.33 \pm 0.15\%$) ที่มีปริมาณการกักเก็บคาร์บอนในดินเฉลี่ย 6.42 ± 0.04 กก./ตร.ม. อย่างมีนัยสำคัญ ($p\text{-value} < 0.05$) และจากการประเมินการกระจายตัวเชิงพื้นที่ของคาร์บอนอินทรีย์ในดินและอัตราส่วนคาร์บอนต่อไนโตรเจนสามารถช่วยให้เกษตรกรมีแนวทางในการปรับปรุงดิน ซึ่งเป็นประโยชน์ต่อเกษตรกรทั้งทางด้านเศรษฐกิจและสิ่งแวดล้อม ดังนั้น ผลจากการศึกษาที่ได้รับแม้จะมีผลในเชิงบวกสำหรับพื้นที่นาข้าวที่มีการเผาในที่โล่งแต่แนวทางการจัดการที่ดีควรได้รับการแนะนำอย่างถูกต้องเพื่อถ่วงดุลผลกระทบด้านลบทางสิ่งแวดล้อมอื่น ๆ และเพื่อสร้างระบบการจัดการที่ดินอย่างยั่งยืน

คำสำคัญ: นาข้าวที่มีการเผาในที่โล่ง นาข้าวแบบอินทรีย์ คาร์บอนอินทรีย์ในดิน

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Department **Environmental Science**

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Abstract

Most farmers in Asia including Thailand select burning methods because it is a conventional way to remove stubbles and prepare for the next crop cycle. Air pollution arising from open burning paddy field is a major concern for public health. However, a controversial issue of its impacts on the amount of soil organic carbon (SOC) still remains. This study aimed to i) compare SOC stock content between open burning paddy field and organic paddy field. ii) determine the relationship between physical-chemical properties of soil and organic carbon stock in soil. iii) spatially assess the soil organic carbon stock distribution between open burning paddy field and organic paddy field. Two sets of soil samples were collected from two paddy fields based on minimum consecutive five-year periods of burning versus non-burning practices. Twenty soil samples were collected from each paddy field at a 30-cm depth, which made up a total of 40 soil samples. Organic carbon was analyzed by the Walkley and Black method. The average of SOC content in burning paddy field (2.17±0.38%) was observed significantly higher than organic paddy field (1.33±0.15%) (p-value < 0.05). The estimated average SOC stocks per unit area were 9.96±0.07 kg C m^{-2} in the open burning paddy field, and 6.42±0.04 kg C m^{-2} in the organic paddy field. Spatial distribution of SOC and C/N allowed farmers to have a rough idea of which location should be prioritized in terms of soil improvement. This way is beneficial to farmers both for economic and environmental aspects. On the basis of results obtained, despite the positive effects found in burning paddy soil, a better management approach should be introduced to counterbalance the negative impacts on other environmental aspects and to create a sustainable land management system.

Keywords: Open burning paddy, Organic paddy, Soil organic carbon

ACKNOWLEDEGMENTS

This project consumed huge amount of work, research and dedication. It would not be possible without kind support and help of many individuals and organizations. Therefore, I would like to extend my sincere gratitude to all of them.

First and foremost, I would like to express my sincere gratitude to my research advisor Asst. Prof. Dr. Pasicha Chaikaew, Department of Environmental Science, Faculty of Sciences, Chulalongkorn University for the continuous support for my senior project. I would like to express my sincere thanks again to my senior project advisor for her invaluable help and constant encouragement throughout the course of this research. I am most grateful for her teaching and advice, not only the research methodologies but also many other methodologies in life. I would not have achieved this far and this research would not have been completed without all the support that I have always received from her. Besides my research adviser, I would like to send my gratitude to my senior project chairman, Asst. Prof. Dr. Sarawut Srithongouthai and my project committee Asst. Prof. Dr. Pantana Tor-ngern and Dr. Chidsanuphong Chart-asa for their encouragement, recommendation and correction.

My thanks go Mrs. Jutamat Thiangtam and Mr. Anan Thethan, the proprietor of the paddy field in the Amphoe Nong Don and Amphoe Phra Phutthabat, Saraburi Province, Thailand for useful paddy field management data and the area to collect soil samples for research.

I am also grateful to Mrs. Ketsaraporn Kankaew and Miss Pansuree Jariyawichit, for laboratory support and useful guidance throughout my laboratory analysis and I would like to thank the Land Development Regional Office 1 that provides support for information and facilitates various aspects.

In addition, I would like to thank the Department of Environmental Sciences, Faculty of Science, Chulalongkorn University and also people in this organization for giving me such an attention and time.

Finally, I most gratefully acknowledge my parents and my friends for all their support throughout the period of this research.

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CHAPTER I
INTRODUCTION

1.1 Statement and significance of the problems

Paddy field coverage in Thailand accounts for 24 million acre (9,600 km^2) in which about 30-32 million tons of paddy rice are produced per year. Of the total rice cultivation, Thai rice consumption is only about 10 million tons per year, implying that Thailand's rice cultivation is mainly for export (Petchseechoung, 2017). Intensive rice growing practices affect land management, in particular, accelerating land preparation for the next rice cultivation. Therefore, removal of rice stubble and rice straw is one of the major problems that all farmers are facing. Several methods have been implemented and the trade-offs are associated with each technique such as chemical application, straw incorporation and open burns. Most farmers in Asia including Thailand select burning methods because it is easy and convenient compared to other methods. For open burning paddy field is effected from soil to air. The heat from the burning will spread over the land surface that lead to a rapid increase in soil temperature. The dramatic change in temperature, affects the physical, chemical and biological components of the soil. When the structure of the soil changes, the loss of organic matter and nutrients in the soil are unavoidable.

The Pollution Control Department (PCD) estimated that Thailand produces about 50-60 million tons of straw annually, which generates carbon dioxide (CO_2) from burning up to 27 million tons of carbon (Pollution Control Department [PCD], 2004). The soil from burned rice straw lost 6.9 kilogram per rai of nitrogen, 0.8 kilogram per rai of phosphorus, and 15.6 kilogram per rai of potassium which accounted for 261 baht of total cost per rai (Department of Agriculture, 2015). It also causes destruction of useful microbes and animals in the soil, loss of soil water, cause of air pollution and poor visibility. These effects are the disadvantages of managing rice fields by burning. On the other hand, there are some advantages from burning. Nitrogen, phosphorus and potassium content increased as compared to bare soil and soil with dried rice straw. The addition of rice straw ash also increases the carbon content of the soil, as the straw contains about 23-27% carbon. When the straw is burned with heat, some carbon is burned and the rest is biochar, which can increase the amount of carbon in the soil. (Smakgahn, 2011) However, both the advantages and disadvantages of burning affect the change of organic carbon in the soil. Organic carbon is one of the most important components of organic matter that affects soil fertility in rice fields. Soil fertility can be determined by the amount of soil organic matter (Leifeld, 2012) and organic matter is a soil quality indicator that reflects the land management system (Grigal and Ohmann, 1992).

Amphoe Nong Don and Amphoe Phra Phutthabat are one of the major rice cultivation areas of Saraburi Province. Amphoe Nong Don has 57,897 rais of agricultural areas, of which 79% (46,005 rais) is paddy field. Amphoe Phra Phutthabat has 101,906 rai for agricultural areas and 29% (29,374 rai) is paddy field (Agricultural Economic Office, 2013). Both districts are suitable areas for studying the changes in organic carbon, as they are managed in both open burning paddy field and organic paddy field without burning rice straw and stubble. In the area of Amphoe Nong Don, the paddy field management was studied by open burning. Amphoe Phra Phutthabat, the study of organic paddy management without burning rice straw and stubble. Therefore, for this study, it is very important to be able to analyze changes of soil organic carbon content in areas with different land management to contribute to improve the quality of the soil as well as to manage the rice fields properly.

1.2 Objectives of research

1.2.1 To compare soil organic carbon stock content between open burning paddy field and organic paddy field.

1.2.2 To determine the relationship between physical-chemical properties of soil and organic carbon stock in soil.

1.2.3 To spatially assess the soil organic carbon stock distribution between open burning paddy field and organic paddy field.

1.3 Scope or delimitation of the study

1.3.1 Study area

The study area is located on an open burning paddy field in Amphoe Nong Don and organic paddy fields in Amphoe Phra Phutthabat, Saraburi Province.

1.3.2 Duration of study

1 March 2018 - 24 May 2019

1.3.3 Sample

Soil samples were collected at a depth of 30 cm. A total of 40 soil samples were collected; 20 samples from burning paddy field and 20 samples from organic paddy field.

1.4 Expected Benefits

1.4.1 It is possible to apply knowledge and analytical methods to determine the amount of organic carbon in the field to be studied.

1.4.2 Soil inputs can be modeled using computer programs to analyze the changes in area utilization that affect the amount of organic carbon.

1.4.3 This research can provide the general public with information on the organic carbon content between the burning paddy field and organic paddy field.

1.4.4 Farmers in the area can reach information and realize the importance of organic carbon in soils that will affect the exuberance of rice fields.

1.5 Definitions

1.5.1 Soil organic carbon (SOC) is the carbon held within soil organic constituents (i.e., products produced as dead plants and animals decompose and the soil microbial biomass). Only SOC in the top 30-cm soil layer was reported in this assessment.

1.5.2 Open burning is the burning of unwanted materials such as paper, trees, brush, leaves, grass, and other debris where smoke and other emissions are released directly into the air. During open burning, air pollutants do not pass through a chimney or stack.

1.5.3 Organic paddy field is produced areas for using free chemical seeds, fertilizers and pesticides.

CHAPTER II
LITERATURE REVIEWS

2.1 Soil organic carbon

Soil organic carbon is a component of soil organic matter, with about 58 % of the mass of organic matter existing as carbon (GRDC, 2013). Because different forms of carbon behave differently, they are often grouped into three distinct pools: labile pool, slow pool and inert pool. Labile carbon includes fresh plant and animal material, and micro-organisms, which are easily decomposed. The slow pool includes well-decomposed organic materials called humus. The inert pool is the soil carbon fraction that is old, resistant to further breakdown and in the last stage of decomposition. Soils differ not only in total soil organic carbon but also in the composition of the different organic carbon pools (Office of Environment and Heritage, 2018).

The nature and quantity of organic carbon in the soil affects a wide range of physical, chemical and biological soil properties as following: 1) soil nutrients; decomposition of organic materials in the soil releases soil nutrients such as nitrogen, phosphorus etc. 2) soil structure; soil organic carbon promotes good soil structure by binding soil particles together in stable aggregates. Improved structure aids aeration, water holding capacity, etc. 3) soil biology; organic matter and organic carbon in the soil are a food source for a range of soil organisms and so enhance soil biodiversity and biological health. A wide range of organisms in the soil also helps release nutrients and create pores and can help protect against crop diseases. 4) soil protection; adequate soil carbon reduces the severity and costs of natural phenomena (e.g. drought, flood, and disease) and can increase farm production. Therefore, soil organic carbon contributes to farm production and increasing soil organic carbon is valuable for a range of soil health, sustainability and production benefits (Office of Environment and Heritage, 2018).

2.2 Soil nitrogen

Soil nitrogen is primarily determined via biological processes, which are influenced by rate limiting factors such as soil pH, tillage, soil moisture and temperature. Ammonium released from organic matter mineralised by soil microbes determines the supply (rate and amount) of inorganic nitrogen. The rate at which nitrogen is immobilised within soil microbes and converted to nitrate is directly proportional to microbial demands for nitrogen (Murphy et al., 2003) and determines the net amount (or surplus) of soil nitrogen that becomes available for plant uptake. While both plants and microorganisms can use ammonium a large proportion of it is converted into nitrate. Once dissolved in solution, nitrate is more readily taken-up by plants, but is also easily leached

There are three major forms or states of nitrogen in soil: organic nitrogen (Org-N), ammonium nitrogen (NH_4^+-N), and nitrate nitrogen (NO_3^--N). Plants cannot use the nitrogen in the organic form. Plants can only use ammonium and nitrate forms of nitrogen. Microbes are constantly metabolizing and recycling nitrogen as they breakdown organic matter. Mineralization occurs when organic nitrogen is broken down to form ammonium nitrogen, which is available for plant use. Nitrification occurs as ammonium is further changed by microorganisms to the nitrate form, also available to plants. The rate at which nitrogen becomes available is determined by the complexity and stability of the organic matter and by microbial activity. It may occur in days or, if the nitrogen is in a very stable form, it may take years (Frate, 2012).

2.3 Soil phosphorous

Soil phosphorous can be divided into three pools, each differing in its availability to plants: 1) Soil organic phosphorus bound to organic compounds. 2) Inorganic compound phosphorus (phosphorus combined with Ca, Mg, Fe, Al or clay minerals). 3) Organic and inorganic phosphorus compounds associated with living cells (GRDC, 2013).

The carbon to phosphorous ratio of organic matter can be used to predict whether phosphorus will be mineralised (released) or immobilised during organic matter decomposition. Net immobilisation of inorganic phosphorus is more likely if residues added to soil have a ratio of more than 300:1 (Brady and Weil, 1996). As the ratio declines, phosphorus is in excess of microbial requirements, resulting in a net release of plant-available phosphorus. Microbial decomposition of crop residues available phosphorus. Microbial decomposition of crop residues with a phosphorus content more than 0.24 per cent results in a net increase of phosphorus mineralisation, while crop residues with a phosphorus content lower than 0.07 per cent result in net phosphorus immobilisation (Iqbal, 2009).

2.4 Carbon to nitrogen (C/N) ratio

The carbon to nitrogen (C/N) ratio indicates the proportion of nitrogen and other nutrients relative to carbon in that material. Organic matter varies widely in its C/N ratio and reflects how readily organic matter decomposes, providing an indication of both the amount and rate of nitrogen release that might be expected to result from decomposition (GRDC, 2013).

To grow and reproduce soil microbes requires a balanced amount of carbon and nitrogen that reflects a relatively low C/N ratio (generally less than 15:1). In plant residues such as wheat stubble, which have a high C/N ratio (120:1) and contain relatively more carbon than nitrogen, soil microbes must find another source of nitrogen to fully digest wheat stubble and this often results in soil nutrient reserves being immobilised and soil becoming nitrogen deficient. Such nitrogen deficiency is often seen in the field where stubble has been incorporated during sowing operations and nitrogen availability decreases in the soil because it becomes tied-up, or immobilised in the microbial biomass. Therefore, residues with a high C/N ratio are considered nutrient poor and can take years to decompose.

To maintain or increase soil stocks of organic carbon long-term, increased amounts of organic matter must be continually added. Any decline in the amount of organic material being returned to soils will result in a decrease in the soil's organic carbon content.

When soil organisms digest organic residues part of the carbon originally in these residues is used for new growth and cell division, with the remainder being emitted as carbon dioxide. As a general rule, less than one-third of the applied carbon in fresh residues remains in the soil after the first few months of decomposition. As the material is decomposed the C/N ratio decreases and the remaining organic material becomes more resistant to further decay (GRDC, 2013).

2.5 Open burning paddy field

Rice straw open-field burning is practiced in many countries and has been proven to be a significant source of emissions during the harvest season. Current approaches to obtain the fraction of rice straw subject to open burning vary significantly, and can lead to incorrectly estimating air pollutant emissions (Chang, Liu and Tseng, 2013). Open burning of rice straw causes release of air pollutants, which contributes to enhance climate change related issues. Burning of rice straw in the field releases pollutants to the atmosphere and contributes to enhance global problems such as climate change. During burning, carbon is released into the air in various forms. Major fractions of carbon released from crop burning consist of CO_2 (1,515±117 g/kg$_{dm}$), CO (92±84 g/kg$_{dm}$), TC (4 g/kg$_{dm}$), and CH_4 (2.7 g/kg$_{dm}$). These air pollutants contribute to enhance climate change. Although biogenic carbon is emitted to the atmosphere as a result of open burning, the CO_2 fraction is reabsorbed via photosynthesis in the next cultivation in the form carbon biomass. However this is not the case for other forms of carbon such as CO, TC or CH_4 (Kanokkanjana and Garivai, 2013).

2.6 Organic rice production system

Organic rice production system means a system of rice production management that enhances the ecosystem, sustainable biodiversity and biological cycles. It emphasises the use of natural materials by opposing the use of synthetic raw materials, transgenic plants, animals or microorganisms or raw materials derived from genetic modification. It also covers the product management, which carefully emphasises on every processing step to maintain the organic integrity and quality of organic rice products (National Bureau of Agricultural Commodity and Food Standards, 2010).

2.7 Review of related literature

Rittl et al. (2017) described the soil organic carbon stock changes in a chronosequence of native forest, pasture and soybean sites established during different periods by the native forest was converted to pasture and later to soybean, the pasture sites were 11, 15 and 26 years old, while the soybean sites were 1 years old of two sites and 3 years old on a farm in Rondônia State. Their study is the soil organic carbon stocks at depth 0 to 0.3 meters of the native forest and the six sites were measured for comparison. The study found that at up to 0.3 meters depth without changes in soil organic carbon on forest converted to pasture. But the soil organic carbon stock rapidly decreased immediately after the pasture was converted to soybean. Therefore, this information have an important for future studies on soil carbon dynamics about the increase (pasture) or immediate decrease (pasture-soybean) of soil organic carbon stocks after conversion from forest to agricultural areas.

Zhou et al. (2018) reported that land use and climate changes effects on soil organic carbon (SOC) in the North and Northeast China is vulnerable. Therefore, to understand of the SOC dynamics and driver factors, their study collected data of the 1980s and 2000s and made the digital soil mapping for spatial variation of SOC for the respective period. Their study is divided into two types: data collected in 1980s (585 samples) and repeated in 2003 and 2004 (1,062 samples) in a 30-km grid for the main land use in the area was cropland, forest and grassland. The random forest was used to forecast the SOC concentration and its temporal change using land use, terrain factors, vegetation index, vis-NIR spectra and climate factors as predictors. According to them, this shows that the average SOC concentration in 1985 was 10.0 g kg^{-1} compared to 12.5 g kg^{-1} in 2004. The SOC variation was similar over the two periods, and levels increased from south to north. The estimated SOC stock was 1.68 Pg in 1985 and 1.66 Pg in 2004, but the SOC changes were different under different land uses. During the period of twenty years, the average temperature increased and the larger forest and grassland areas were converted into different cropping areas. SOC decreased 0.094 Pg (+ 9%) while 0.089 Pg SOC was lost under forest (- 25%) and 0.037 Pg in the soil of grassland (-25%). Thus, the author concludes that land use is a major driver of the change of SOC in this area, while climate change is contributed in different regions. SOC loss is remarkable under land use conversion while cropland has considerable potential to sequester SOC.

Naijia et al. (2017) described the environmental and anthropologenic factors driving changes of SOM in paddy soils of China. Their study uses data as follows: soil, climate, terrain, and agricultural management data from 6 counties selected based on representative soil types and cropping systems in China. Then use that correlation analysis, analysis of variance, and cforest modeling to analyze the drivers of changes in SOM in paddy soils in the Middle and Lower Yangtze River Plain from 1980 to 2011. The purpose of their study were to identify the main factors driving the changes in SOM and to quantitatively evaluate their individual impacts. The study found that the paddy SOM stock in the study area increased by 12.5% at an average rate of 0.023 kg m^{-2} $year^{-1}$ over the 31-year study period. However, results from planting rice in long-term, agricultural management is more important than the properties of the soil, climate and topography. Furthermore, among the major drivers, straw incorporation, the most influential driver, together with fertilization and tillage practices, resulted in a significant increase in SOM accumulation, while significant increases in temperature digestibility of SOM. Therefore, to face the challenge of higher temperatures, it is important to strengthen the positive effects of agricultural management. The reasonable use of fertilizers to stabilize cereal production and crop straw incorporation are potential measures for carbon sequestration in this region.

Falu et al. (2017) describe the results of modeling reporting with uncertainty data that will benefit decision making by reducing the extent to which variance affects selected proportions. For making decisions with greater confidence, the uncertainty period should be as narrow as possible. Here, the change of soil organic carbon in the major paddy subgroup from the four different rice fields of China by located in four different climate, soil and management combinations. Using the format DeNitrification-DeComposition (DNDC), the period from 1980 to 2008. However, the uncertainty intervals associated with the SOC dynamics for these 4 subgroups was assessed by a long-term global sensitivity and uncertainty analysis and their sensitivities to 7 influential factors were quantified using the total effect sensitivity index. Their results show that modeled with high confidence, indicating that in the past 29 years, the paddy fields studied in Xinxing, Yixing and Zhongjiang Districts are carbon sinks (C), while paddy in Helong County is the source of C. The 3 C sinks sequestered 12.2 (5.4, 19.6), 17.1 (8.9, 25.0), and 16.9 (−1.2, 33.6) t C ha^{-1}. Conversely, the C source had a loss of −5.4 (−14.2, 0.06) t C ha^{-1} in the past 29 years. Therefore, the 7 factors that change according to the context of the climate and soil management influences on various parameters of the SOC models. However, for suggest measures that have the potential for preservation or storage of C in the soil, such as inserting residues into the soil and decrease for the rate of use of chemical fertilizers for specific soil depends on the sensitivity analysis results.

Girona-García et al. (2018) described the organic matter in soil aggregation and water repellency are relevant interrelated soil properties, which may have been affected by the fire. The purpose of their study were to analyses the effects of shrub prescribed burning for pasture reclamation on the soil aggregate stability, organic carbon and water repellency of different soil depths and aggregate sizes in a subalpine environment. Soil was collected from the lowest heat-affected area in autumn at the Central Pyrenees (NE-Spain) at depths 0-1, 1-2, 2-3 and 3-5 cm before and approximately 1 hour, 6 months and 12 months after burning. However, the samples were separated into total soil (<10 mm) and 6 sieve fractions, <0.25, 0.25-0.5, 0.5-1, 1-2, 2-4 and 4-10 mm. The results showed that soil organic carbon (SOC) is an aggregate stability (AS) and soil water repellency (SWR). In the unburned samples, SOC and SWR were higher in the <0.25 to 2 mm sieve fractions than the 2 to 10 mm sieve fractions. Serious fire and significant SOC content drop in the whole soil and the <0.25 mm fraction at 0–1 cm depth and in the 0.25–0.5 mm fraction at 0–2 cm depth. SWR was reduced by burning mainly at 0–1 cm depth for the whole soil and the <0.25 to 2 mm sieve fractions. However, the AS aggregates of 0.25-0.5 mm increase after a fire, while the rest of the sieve fractions are still not truly affected. One year after the prescribed burning, SOC slightly increased and SWR recovered in part affected by the fire, while the AS for all aggregate sizes and depth decreased significantly. Their results indicate that the direct effects of burning persist for a year after burning, and that post-fire predicament may increase the risk of soil loss. In addition, their results show that well soil fractions are more likely to be affected by fire than coarse soils fractions and greatly influence the behavior of the soil.

CHAPTER III
RESEARCH METHODOLOGY

3.1 Study area

The study area is located on an open burning paddy field in Amphoe Nong Don and organic paddy fields in Amphoe Phra Phutthabat, Saraburi Province. A total of 40 soil samples were collected; 20 samples from burning paddy field (size of 33,270 m^2) and 20 samples from organic paddy field (size of 10,157 m^2) on 21 April 2018 and 22 April 2018.

Figure 3.1 A total of soil samples from burning paddy field in Amphoe Nong Don, Saraburi Province.

Amphoe Nong Don area is about 88.07 km^2 (55,093.75 rai). Topography is flat low, Pasak - Chai Nat canal irrigation. The climate is generally warm and humid. The average temperature ranges from 23 to 33.20 C°. Rainfall is high during May to September and average rainfall is 1,398 mm per year (Nong Don district office, 2018). Rice fields are rented areas that are older than 10 years old. There are 2 times a year for rice farming according to the irrigation canal transmission system. Rice field management has burned rice straw by samples in paddy fields that have been open burned straw, due to the high postharvest straw and the difficult to biodegradable, it is difficult to remove and the use of chemical fertilizers in the area.

Figure 3.2 A total of soil samples from organic paddy fields in Amphoe Phra Phutthabat, Saraburi Province.

Amphoe Phra Phutthabat area is about 287.065 km^2 (179,415.63 rai). Topography is generally flat with some hills and mostly clay soil suitable for farming, gardening and growing vegetables. The climate is monsoonal with 3 seasons: summer, rainy and winter. Summer season from March to May, rainy season from June to October and winter season from November to February. The average temperature is from 28 to 29 C°, the maximum temperature is 33-34 C° and the minimum temperature is 23 to 24 C° (Phraphutthabat district office, 2018) Samples of organic paddy fields started in 2013. The organic paddy field is managed by using two types of compost, water and dry. The compost derived from fermented fresh plants such as banana trees and animal manure. For compost in paddy fields, use rattan method and embed in soil (compost form a cube by embedding in an area of 1 m^2 per 1 lump). In addition, post-harvest paddy area is managed by the incorporation of stubble and straw, as well as the planting for sunn hemp (*Crotalaria juncea*) to improve the soil in rice fields.

3.2 Sample collection

A systematic sampling design was applied for soil sample locations. At a depth of 30 cm, we collected 20 samples from the burning paddy field and 20 samples from the organic paddy field, which made up a total of 40 soil samples. Samples were placed in a sealed plastic bags with site identities. We collected soil samples on 21 April 2018 and 22 April 2018 after harvesting rice fields.

3.3 Preparing the soil

The soil preparation method was to dry the soil for 5-7 days by avoiding sunlight, dust and rain. After that, separate the gravel and leaves, then grind the soil thoroughly with a grinder or mortar. Finally, sift the soil through a sieve of 2.00 and 0.50 mm to further analyze soil properties in the laboratory.

3.4 Analyses

1. Physical analysis

1.1 Analysis of bulk density

Analysis of bulk density by the core method (USDA-NRCS, 2004). The core method is to use a cylindrical metal drilled into the soil at the desired depth with blows from a drop hammer. The inner cylinder containing an undisturbed soil core is then removed and trimmed to the end with a knife to yield a core whose volume can easily be calculated from its length and diameter.

The weight of this soil core is then determined after drying in an oven at 105°C for about 18-24 hours.

1.2 Analysis of soil color

Soil color was compared with the Munsell color scale for soil taxonomy (USDA-NRCS, 2004). By matching each soil sample with the closest Munsell color chart color chip and compared the color of the corresponding chip with the color of the soil. The Munsell system has three components: hue (a specific color), value (lightness and darkness), and chroma (color intensity) that are arranged in books of color chips. For example, a brown soil may be noted as: hue value/chroma (10YR 5/3).

1.3 Analysis of soil texture

Soil texture was analyzed to determine particle size by hydrometer method (North Central Texas Water Quality, 2005). The experimental methods are as follows: 1) Weighed 50 g soil samples size 2 mm. 2) Added 100 mL Calgon 5% (50 g sodium hexametaphosphate and 8.3 g Sodium carbonate dissolved in 1000 mL of deionized water) and soaked for 24 hours. 3) The prepared samples were spined for 5 minutes in blender machine 4) Mixed the soil solution into hydrometer jar and adjusted the volume to 1000 mL. 5) Used stirring rod to mixing soil solution for 1 minute. 6) Measured temperature and the volume from hydrometer at 40 second and 2 hours to bring to the equation for calculate particle size.

2. Chemical analysis

2.1 Analysis of pH

The experiment was conducted by mixing 20 g of soil sample and 20 mL of deionized water and set it for 30 minutes to measure the pH of the soil sample with a pH meter (Land Development Department, 2010)

2.2 Analysis of nitrogen

The Kjeldahl method (Land Development Department, 2010) was applied for nitrogen analysis. The experimental methods are as follows: 1) The soil samples were prepared by using Freeze-drying method. 2) Transferred a 1-2 g soil sample for particle size 0.5 mm sieve into a digestion tube 3) Added 20 mL 98% H_2SO_4 and 7 g catalyst 4) The digest until the solution is clear and must be open the scrubber at all times 5) Set aside to cool for about 1 hour 6) Added 60 mL the deionized water and the soil solution was separated through a filter paper (Whatman No.2) 7) transferred the soil solution to a distillation apparatus with 80 mL 10 N NaOH 8) Trapped the distilled vapors by 40 mL 32% H_3BO_3 was conducted in the Erlenmeyer flask for underlie the distillation solution and added mixed indicator in H_3BO_3 solution 9) Titrate the distillate with standard 0.1 N H_2SO_4 titrant until indicator turns to pink.

2.3 Analysis of phosphorus

The Bray method (Land Development Department, 2010) was conducted for total phosphorus analysis. The experimental methods are as follows: 1) Weighed 5 g of particle size 2 mm sieve 2) Added 200 g of charcoal powder and 20 mL extracting solution 3) Filtered through a filter paper (Whatman No.2) into a volumetric flask and then adjust the volume with the deionized water 4) Pipette 5 ml from the filtered solution and adjust the volume 5) Added 10 mL Ammonium molybdate solution with H_2SO_4 6) Added 4 mL Mixed reagent (antimony-asscorbic acid) and adjust the volume with the deionized water 7) Waited for a stable color for 10 minutes and measured the absorbance at 840 nm 8) Made a standard curve to compare the phosphorus content in the soil.

2.4 Analysis of organic carbon

The analysis of soil organic carbon was conducted using Walkley-Black method (Land Development Department, 2010). The experimental methods are as follows: 1) Weighed 0.5 g of particle size 0.5 mm sieve into an Erlenmeyer flask and added 10 mL 1N $K_2Cr_2O_7$ 2) Added 20 mL conc. H_2SO_4 and then left to cool by placing on an asbestos for 30 minutes 3) Added 200 mL the deionized water and then filter the samples solution. 4) Added 10 mL 85% H_3PO_4 for eliminate turbidity 5) Added 0.2 g NaF for remove chlorine in deionized water 6) Added Ortho-phenanthroline (Ferroin) indicator and titrated with 0.5 N $Fe(NH_4)_2(SO_4)_2$ to an endpoint.

The SOC stocks were then calculated using a measure of carbon content multiplied by soil bulk density and the thickness of the sampled soil. Simple formulas are as follows:

$SOCstocks_{burning} = \%OC_{burning} \times BD_{burning} \times A \times 10$ ……………………………….....(3.1)

$SOCstocks_{organic} = \%OC_{organic} \times BD_{organic} \times A \times 10$……………………………….....(3.2)

where SOC stocks is the estimated carbon stocks (kg C m^{-2}); %OC is the average organic carbon content in the soil (%); BD is the soil bulk density (g cm^{-3}); A the thickness of the sampled soil layer (0.3 m).

3.5 Data analysis and statistics

Analysis that the compare soil organic carbon stock content between open burning paddy field and organic paddy field using Independent Samples T-Test, the relationship between physical-chemical properties of soil and organic carbon stock in soil using Pearson product-moment correlation coefficient. An interpolation method, inverse distance weighting (IDW), was used to perform the spatial distribution of SOC content using ArcGIS software.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Characteristics of soil properties between open burning paddy field and organic paddy field

4.1.1 Physical properties

Soil bulk density

Analysis of soil bulk density between open burning paddy field (n=5) and organic paddy field (n=5) were 1.53 ± 0.058 g/cm^3 and 1.61 ± 0.14 g/cm^3. The bulk density of the soil was an indicator of soil particle compression. For soil that has bulk density of 2 g/cm^3, it is a soil that compacted so that the roots of the plant cannot easily penetrate, causing the plant to grow incomplete (Boonsaen, 2005). Soil bulk density in both areas suggested no restriction for root growth.

Soil color

The color of the soil in open burning paddy field is Black (10yr 2/1) and organic paddy field is Very dark gray (10yr 3/1) and Black (10yr 2/1) which the soil that is brown to black caused by the influence of two elements: organic matter and dark origin minerals such as volcanic rocks. The process that occurs with very old soil that has been developed for a long time until the decomposition of plant debris and the accumulation of organic matter is humus.The decomposition of organic matter is slow, which causes organic matter to accumulate. In addition, the soil may be a new soil, which is caused by the deposition of clay sediments in the lowlands with waterlogging (Department of Soil Science, 2007).

Soil texture

The average percentages with standard deviation of soil particles in the open burning paddy field were 30.22±2.2% sand, 8.23±1.86% silt, and 61.55±2.02% clay. Soil constituents in organic paddy field contained 29.48 ± 1.28% sand, 13.97±1.42% silt, and 56.55±1.36% clay. The results suggested that soil texture in both areas were classified as clay. Clay is a soil that has the ability to hold organic matter and high exchange plant nutrients (Potjanee and Thaweesak, 2001).

4.1.2 Chemical properties

Soil pH

The pH of the soil in the open burning paddy field and organic paddy field ranged between 7 and 7.6 (p-value > 0.05), indicating neutral to slightly alkaline soils. Alkaline soils can be improved by adding organic matter or planting soil nourishing plants. The soil with pH of about 6.5 is the best soil to grow of plants because it is relatively neutral. An appropriate pH level can help nutrients and organisms in the soil grow well and enhance nutrients for plant use (Department of Soil Science, 2007).

Soil organic matter

The amount of organic matter in open burning paddy field and organic paddy field were significantly different (p-value < 0.05). The average amount of organic matter in open burning paddy field was 3.74 ± 0.65 %, greater than the organic paddy field with values of 2.28±0.26%. The carbon in the form of charcoal contributes to increasing the amount of organic matter in the soil, because the soil organic carbon is an element of organic matter in the soil, about 58% of the organic matter contained in the form of carbon (GRDC, 2013). Charcoal contains the following properties: stable chemical configuration, high carbon content and long-term soil durable potential. Therefore, organic matter accumulates in large amounts of soil and decays slowly, which is different from other organic substances such as plant debris, fertilizers from fresh plants and compost that are often rapidly degraded especially in the tropical region causes carbon emission to form a high rate and fast of carbon dioxide (Steiner, 2007).

Nitrogen

The nitrogen content in open burning paddy field and organic paddy field were significantly different (p-value < 0.05). The nitrogen content for open burning paddy field was greater than the organic paddy field with mean values of 0.69±0.16% and 0.42±0.07%, respectively. High amount of nitrogen in the open burning paddy field can be explained by remaining carbon in the form of charcoal that accumulated in the soil was capable of absorbing nitrogen compounds such as NH_4^+, urea or ammonium bicarbonate (Day et al., 2005). Organic paddy field, degradation of rice straw and rice stubble remain in the area was slow, impacted on transformation process of organic nitrogen into inorganic nitrogen through the mineralization process by the reaction of aminization, ammonification and nitrification. Various forms of nitrogen such as NH_4^+ and NO_3^-, thus, accumulated in the soil (Department of Land Development, 2010). Non-dead rice plants in organic paddy fields are able to absorb nitrogen and some nitrogen in the soil may be pulled by microorganisms to decompose the leftover rice straw (Shindo and Nishio). Therefore, all these reasons contribute to the low level in the amount of nitrogen accumulation in the soil.

Phosphorus

The amount of phosphorus in the open burning and organic paddy soils were significantly different (p-value < 0.05). The average phosphorus content for organic paddy field was 8.46±0.81 mg/kg, the open burning paddy field was 5.91±1.07 mg/kg. The addition of bio-fertilizers in organic paddy field helps to increase phosphorus to the soil. The organic fertilizer has phosphorus in the form that is beneficial to the plant approximately 0.2 to 2.5% (Mala, 2003). On the contrary, fire can be responsible to the loss of phosphorus in soil (Department of Agriculture, 2015). Another factor derived from the amount of organic matter in the soil may reduce the adsorption of phosphorus in the soil because the decomposition process of organic matter can release phosphorus into a useful form that the plant can use (Fox and Kamprath, 1970).

Table 4.1 Descriptive statistics of physical and chemical soil properties in burning paddy field and organic paddy field

Explained statistics	Paddy fields	Bulk density (g/cm^3)	OM (%)	SOC (%)	Nitrogen (%)	Available P (mg/kg)
Max	Burning	1.60	4.59	2.67	1.00	7.32
	Organic	1.80	1.70	1.54	0.59	10.34
Min	Burning	1.43	2.35	1.37	0.41	2.50
	Organic	1.49	2.65	0.99	0.34	7.10
Mean	Burning	1.53	3.74	2.17	0.69	5.91
	Organic	1.61	2.28	1.33	0.42	8.46
SD	Burning	0.06	0.65	0.38	0.16	1.07
	Organic	0.14	0.26	0.15	0.07	0.81
p-value		0.175	0.000*	0.000*	0.000*	0.000*
Suitable range		-	2.0 – 3.0	2.0 – 3.0	0.1 – 0.15	35 – 60

*Mean is significantly different at the 0.05 level ($P < 0.05$)

Ref: Soil management for crop cultivation (p. 6), (Santasap, 2013)

4.2 Soil organic carbon (SOC) stocks and carbon to nitrogen ratios (C/N)

4.2.1 Soil organic carbon stocks

The average SOC content in the open burning paddy field was 2.17±0.38%, and SOC content in the organic paddy field was 1.33±0.15%. Based on the t-test analysis, these two sites were significantly different in the amount of SOC contained in soils (p-value < 0.05). The estimated average SOC stocks per unit area were 9.96±0.07 kg C m^{-2} in the open burning paddy field, and 6.42±0.04 kg C m^{-2} in the organic paddy field. The paddy fields that are managed by open burning contained burnt rice straw and stubble. These stubbles contain organic carbon in a compact and inert form for reaction such as charcoal coal and graphite. Soil organic carbon accumulation obtained by easily decomposing rice straw (Ariyakanon et al., 2013). The rice straw that is burned when accumulated in the soil can stock for the carbon in the soil more than of 40% (Lehmann et al., 2006) and burnt rice straw can retain the carbon in the soil for a long time.

(Suksawang, 2009) Assessment of the remaining rice straw from the harvest of 26.9 million tons per year, total carbon content of 39.2% (Department of Agricultural Extension, 2009). The composition of rice straw with carbon about 23-27% (Smakgahn, 2011). Therefore, when the rice straw is degraded in the area, the carbon in the biomass can be decomposed into various carbon forms in the soil, both in organic carbon and inorganic carbon, which helps to increase soil carbon. A lot of incompletely decomposed rice straw and stubble was found in the organic paddy area. Rice straw is a material that is difficult to degrade due to high C/N. For the decomposition of rice straw and rice stubble with tillage method, it must take at least 14 days and the method of adding bio-fertilizer requires a period of decomposition of rice straw and rice stubble 7 days, compared with the open burning method which is used for 3 days (Department of Agriculture, 2013). Therefore, the carbon stored in the biomass of plants in organic rice fields is slowly decomposed into the soil, resulting in low SOC accumulation in organic paddy field.

Table 4.2 The average of SOC content and SOC stocks in open burning paddy field and organic paddy field

Paddy field	SOC content (%)	SOC stocks (kg C m^{-2})
burning	2.17±0.38	9.96±0.07
organic	1.33±0.15	6.42±0.04

4.2.2 Carbon to nitrogen ratio (C/N ratio)

C/N ratio is used to index Analysis of carbon to nitrogen ratio (Percentage of organic carbon content to percentage of nitrogen content in the forms of organic nitrogen and ammonia) performed similarly in both locations. A mean ± SD C/N was 3.21±0.32 in the open burning paddy field and 3.18±0.49 in the organic paddy field.

Carbon-to-nitrogen ratio in soil between open burning paddy field and organic paddy field of both areas with a C/N ratio of less than 10 (C/N ratio, narrow range less than 10:1) Organic matter has a C/N ratio greater than 10, the rate of decomposition is slow, which microbial extracts nitrogen from the soil, resulting in a decrease in the amount of available nitrogen in the soil.

Organic matter has a C/N ratio of about 10 or less than 10, the decomposition of organic matter by soil microbial activity is fast (Land Development Department, 2010). Therefore, values of C/N, with a ratio less than 10, indicated that both areas of the soil are easily degraded. The C/N ratios in this study were too low when compared to optimal ranges for plant growth and needs microorganisms. The appropriate C/N ratio for the growth of plants should be about 10-12 (Akarathanakul, 2006). The optimum C/N ratio for the needs of microorganisms should lie in the range of 20-30 (Anongrak, 2014). Therefore, an enhancement of carbon materials accumulation is required to improve soil quality in these paddy fields.

4.3 Correlation of soil organic carbon (SOC) and soil properties

SOC was statistically significant associated with nitrogen in a positive direction. A strong relation of $r=0.889$ (p-value < 0.001) was detected in the burning paddy field and moderate relation of $r=0.456$ (p-value < 0.05) was investigated in the organic paddy field. Mostly, nitrogen obtained from organic matter is caused by the mineralization process of organic matter itself. Nitrogen compounds can be changed in two ways at the same time: nitrogen release (N mobilization / mineralization) that the result is ammonium. Another process that occurs in turn is that nitrogen can be immobilized in the form of elements or compounds within the microbial cells (N immobilization) which is immobilized in the form of ammonium and nitrate. (Wolf and Syder, 2003). Therefore, accumulated nitrogen in the soil varied with SOC.

SOC showed a statistically significant correlation coefficient with %Clay ($r = 0.498$, p-value < 0.05) which related in the same direction. Clay particles have the ability to absorb organic carbon more than coarser particles. Soil with high clay particles tends to hold high organic carbon content (Moncharoen and Wongsilp, 2001).

Table 4.3 Pearson's correlation coefficient between soil organic carbon and soil properties in burning paddy field and organic paddy field

	Nitrogen	%Clay
SOC in burning paddy field	0.889**	0.498*
SOC in organic paddy field	0.456*	-0.322

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

4.4 The spatial patterns

4.4.1 Spatial distribution of SOC content

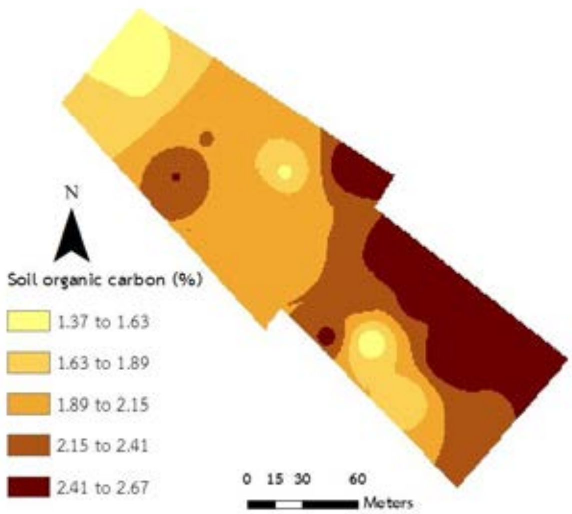

Figure 4.1 Spatial distribution of SOC content in the open burning paddy field derived by inverse distance weighting (IDW) method (n=20)

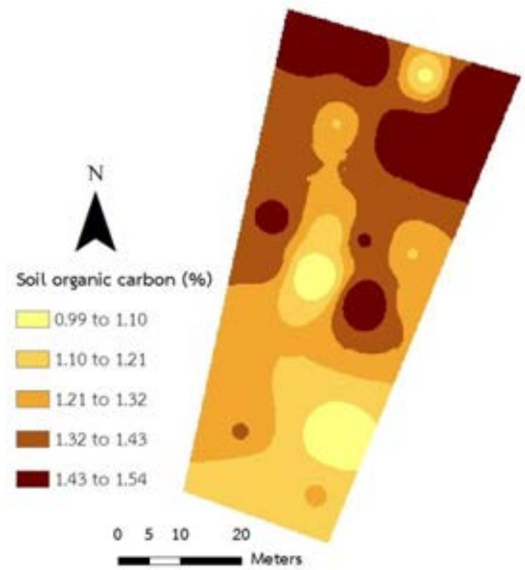

Figure 4.2 Spatial distribution of SOC content in the organic paddy field derived by inverse distance weighting (IDW) method (n=20)

The spatially assess that the soil organic carbon stock distribution between open burning paddy field and organic paddy field, a total of 40 soil samples were collected; 20 samples from burning paddy field (size of 33,270 m^2) and 20 samples from organic paddy field (size of 10,157 m^2). In the open burning paddy field, the spatial distribution of high SOC content was found on the southeast side, and low level on the northwest. In the organic paddy field, there is a spatial distribution of the SOC at a relatively high level on the north side and relatively low on the south side.

In both areas, spatial distribution of SOC has both high and low areas because the decomposition of organic matter in the area determines the amount of SOC which affects the distribution in the area. However, areas with low SOC should be focused by adding organic carbon in the fields in the form of fertilizer or burnt straw, to create a balance of carbon in the area.

4.4.2 Spatial distribution of nitrogen

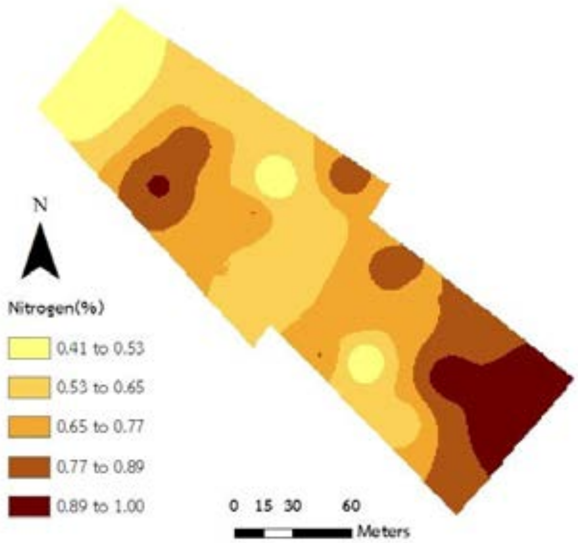

Figure 4.3 Spatial distribution of nitrogen in the open burning paddy field derived by IDW method

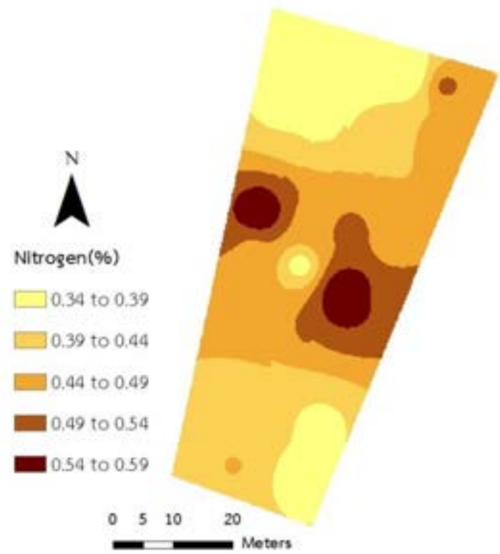

Figure 4.4 Spatial distribution of nitrogen in the organic paddy field derived by IDW method

In the open burning paddy field, the spatial distribution of high nitrogen was found on the southeast side, there were highly concentrated on the northwest where high SOC also distributed and low level on the northwest. The spatial distribution of nitrogen in some areas is related to the amount of SOC, the area with high SOC, nitrogen is also high.

In the organic paddy field, there is a spatial distribution of the nitrogen at a relatively high level on the central and relatively low on the north and south side. Organic paddy field in areas where SOC is high but low nitrogen. This is due to the activity of microbial degradation for organic carbon causing rapid growth of microorganisms and increase the amount of microorganisms, which makes it necessary to use nitrogen to create proteins for component of various tissues and organs. Microorganisms pull nitrogen in the soil to be partially used, reduced nitrogen in the soil, which can lead to nitrogen deficiency in plants. Therefore, the area where nitrogen is low should be filled with fertilizer to balance with the carbon content.

4.4.3 Spatial distribution of C/N ratio

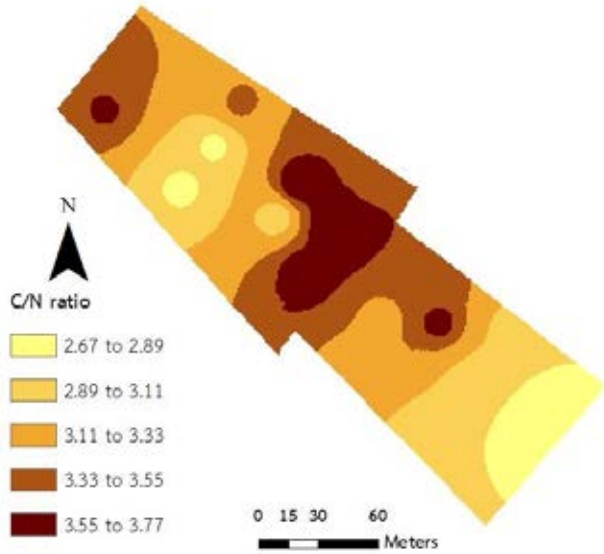

Figure 4.5 Spatial distribution of C/N ratio in the open burning paddy field derived by IDW method

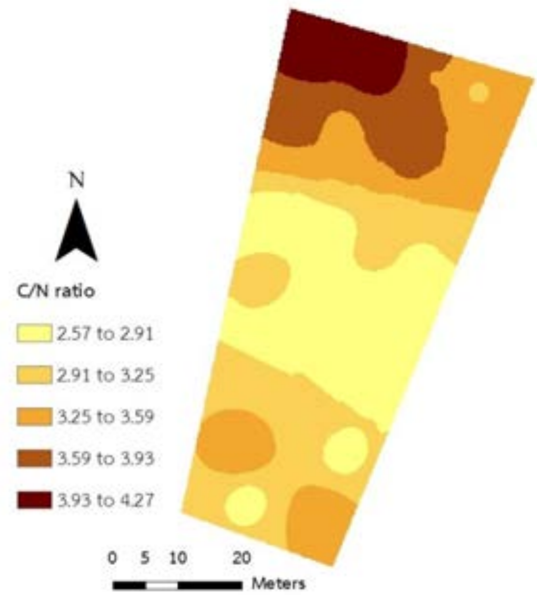

Figure 4.6 Spatial distribution of C/N ratio in the organic paddy field derived by IDW method

In the open burning paddy field, a spatial distribution of the C/N ratio was relatively high on the northwest side and relatively low level on the southeast side. The nitrogen content in the northwest is low in carbon, causing lower SOC than the southeast but has C/N ratio higher than the southeast part. The amount of SOC is very low but the C/N ratio is less because the area has a lot of nitrogen. The northwest side should increase nitrogen balance with SOC and southeast area should increase organic carbon balance with nitrogen by adding bio fertilizer or chemical fertilizer.

In the organic paddy field, a spatial distribution of low C/N ratio occurred across the area and there were highly concentrated on the north where high SOC also distributed. Some areas have high SOC but some performed low C/N ratio because the amount of nitrogen has more than carbon proportion. It is recommended to maintain the balance of nitrogen and carbon in the area.

CHAPTER V

CONCLUSIONS

This study focused on soil organic carbon content and its related properties in the open burning paddy field in Amphoe Nong Don and the organic paddy field in Amphoe Phra Phutthabat, Saraburi Province. The average of soil organic carbon stock content in open burning paddy field was statistically greater than the organic paddy field. Incomplete combustion from any burnt biomass in the burning paddy field generated carbon in a form of organic carbon in a compact and inert form for reaction which can accumulate in soil and organic carbon from decomposing rice straw that can be easily decomposed. This may account for high carbon content. In the organic paddy field, decomposition process of rice straw and stubble was slow, resulted in low organic carbon accumulation. Positive effects can be generated from burning practice in farm including pest reduction, weed control, space clearing, and increase in carbon content and some nutrients; however, the it will not sustain in a long run. Burning residues should not be encouraged because of a number of harmful effects on human health and environments. Management strategies to increase SOC from natural organic matter together with environmental care are required. This study recommended that rice straw and stubble should be properly handled in the area, there should be a closed system for burning these residues. Alternatively, to remove stubble quickly, a cutting machine that is able to cut rice straw into fine particles should be introduced. Therefore, these multiple approaches should be applied in the area to create a sustainable land management system. Spatial distribution of SOC and C/N allowed farmers to have a rough idea of which location should be prioritized in terms of soil improvement. This way is beneficial to farmers both for economic and environmental aspects.

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APPENDIX

Laboratory analysis

1. Analysis of soil texture

Apparatus

1. Electric mixer (stirrer), with baffled stirring cup
2. Settling cylinder
3. Graduated cylinder, 1 L
4. Beaker
5. Erlenmeyer flask 250 mL
6. Hydrometer
7. Thermometer in C°

Reagents

1. Calgon 5%: Dissolve 50 g of Sodium hexametaphosphate, $Na_6O_{18}P_6$ solution (examples of commercial Names: Calgon, Graham's salt, Glassy sodium) and Sodium carbonate 8.3 g in Water and dilute the solution to a volume of 1 L.
2. Amyl alcohol

Procedure

1. Weigh 50 g oven dried fine textured soil into a baffled stirring cup. Fill the cup to its half with distilled water and add 100 mL of Calgon 5% solution.
2. Place the cup on stirrer and stir until soil aggregates are broken down. This usually requires 3-4 minutes for coarse textured soils and 7-8 minutes for fine textured clay.
3. Transfer quantitatively the suspension to the settling cylinder by washing the cup with distilled water. Fill the cylinder to the lower mark with distilled water after placing the hydrometer in the liquid. If 100 g of coarse textured sample was used, fill to the upper mark on the settling cylinder.
4. Remove hydrometer and shake the suspension vigorously in a back and forth manner. Avoid creating circular currents in the liquid, as they will influence the settling rate.
5. Place the cylinder on a table and record the time. After 20 seconds, carefully insert the hydrometer and read the hydrometer at the end of 40 seconds.
6. Repeat step 4 and 5 to obtain hydrometer readings within 0.5 g differences from each other. The hydrometer is calibrated to read grams of soil material in suspension.
7. Record the readings on the Data Sheet for Hydrometer Readings.

8. Measure the temperature of the suspension.

9. Re-shake the suspension and place the cylinder on a table where it will not be disturbed. Take a hydrometer reading exactly two hours later. Correct for temperature as described above.

10. From the percentage of sand, silt and clay as calculated on the Data Sheet, use the diagram for textural triangle to determine the textural class of the soil.

2. Analysis of organic matter

Apparatus

1. Pipette 20 mL
2. Burette 50 mL
3. Beaker 250 mL
4. Erlenmeyer flask 500 mL
5. Control cylinder 500 mL
6. Funnel
7. Weighing machine

Reagents

1. Pitassium dichromate ($K_2Cr_2O_7$) 1 N
2. Conc. Sulfuric acid (conc. H_2SO_4)
3. Conc. Orthophosphoric acid (conc. H_3PO_4)
4. O-phenanthroline-ferrous complex (Ferroin) 0.025 M
5. Ferrous ammonium sulfate $Fe(NH_4)_2(SO_4)_2$ 0.5 N

Procedure

1. Weighed 0.5 g of particle size 0.5 mm sieve into an Erlenmeyer flask and added 10 mL 1 N $K_2Cr_2O_7$.
2. Added 20 mL conc. H_2SO_4 and then left to cool by placing on an asbestos for 30 minutes.
3. Added 200 mL the deionized water and then filter the samples solution.
4. Added 10 mL 85% H_3PO_4 for eliminate turbidity.
5. Added 0.2 g NaF for remove chlorine in deionized water.

6. Added Ortho-phenanthroline (Ferroin) indicator and titrated with 0.5 N $Fe(NH_4)_2(SO_4)_2$ to an endpoint.Calculations.

$$\% \text{ organic carbon} = \frac{(B-T)\times \text{Normalily of } Fe(NH4)2(SO4)2 \times 3 \times 1.14 \times 100}{\text{sample weight (mg)}}$$

% organic matter = % organic carbon $\times 1.72$

B = $Fe(NH_4)_2(SO_4)_2$ solution used to titrate blank (mL)
T = Fe $(NH_4)_2(SO_4)_2$ solution used to titrate sample (mL)

3. Analysis of Total Kjeldahl Nitrogen (TKN)

Apparatus

1. Digestion apparatus
2. BUCHI apparatus for titration (Model K-360, Series No. 1000295106)
3. Digestion tube
4. Weighing machine
5. Pipette
6. Beaker
7. Erlenmeyer flask
8. Control cylinder

Reagents

1. Conc. Sulfuric acid (conc. H_2SO_4)
2. Potassium sulfate (K_2SO_4)
3. Copper sulfate ($CuSO_45H_2O$)
4. Selenium (Se)
5. Sodium hydroxide (NaOH) 10 N
6. 32% H_3BO_3
7. H_2SO_4 0.1 N

Procedure

1. The soil preparation method was to dry the soil for 5-7 days by avoiding sunlight, dust and rain. After that, separate the gravel and leaves, then grind the soil thoroughly with a grinder or mortar. Finally, sift the soil through a sieve of 0.50 mm.
2. We weighed 1 g of the soil samples.

3. The soil samples were transferred to the digestion tube, added 20 ml conc.H_2SO_4 and catalyst of 7 g (K_2SO_4 : $CuSO_45H_2O$: Se, 100:10:1).
4. The tubes were placed in a TKN digestion block at 360°C and held a constant temperature for two hours.
5. The tubes were removed from the block. Water 50 mL was added in the tubes after the temperature dropped to the point.
6. We transferred the soil solution to the BUCHI apparatus with 80 mL 10 N NaOH.
7. We trapped the distilled vapors by 40 mL 32% H_3BO_3 was conducted in the Erlenmeyer flask.
8. Titrate the distillate with standard 0.1 N H_2SO_4 titrant until indicator turns to pink.

Calculations

$$N\ (\%) = \frac{\{(V1-VB)\}\ x\ F\ x\ c\ x\ f\ xM(N)}{m\ x\ 1000} x100$$

V1 = consumption of titrant, sample, (mL)

VB = average consumption of titrant, blank, (mL)

F = molar reaction factor (1= HCI, 2 =H_2SO_4)

C = concentration of titrant (mol /L)

F = Factor of titrant

M(N) = molecular weight of N (14,007 (g/mol))

m = sample weight (g)

1000 = conversion factor (ml in L)

4. Analysis of phosphorus

Apparatus

1. Erlenmeyer flask 250 mL
2. Beaker
3. Pipette
4. Funnel
5. Weighing machine
6. Volumetric Flask 50 mL
7. Control cylinder
8. UV-visible Spectrophotometer

Reagents

1. Extracting solution
2. Ammonium molybdate solution
3. Antimony
4. Ascorbic acid
5. Standard solution of KH_2PO_4

Procedure

1. Weighed 5 g of particle size 2 mm sieve
2. Added 200 g of charcoal powder and 20 mL extracting solution
3. Filtered through a filter paper (Whatman No.2) into a volumetric flask and then adjust the volume with the deionized water
4. Pipette 5 mL from the filtered solution and adjust the volume
5. Added 10 mL Ammonium molybdate solution with H_2SO_4
6. Added 4 mL Mixed reagent (antimony-asscorbic acid) and adjust the volume with the deionized water
7. Waited for a stable color for 10 minutes and measured the absorbance at 840 nm
8. Made a standard curve to compare the phosphorus content in the soil.

Calculations

$$\text{P (mg/kg)} = \frac{\text{The value of standard curve } (\mu\text{g / L}) \text{ x volume of solution (L)}}{\text{soil weight (kg)}}$$

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