COURSE Guide

The Carbon Dilemma – a soil perspective

SOQ-35306

Sequestering 'biochar' in soil, which makes soil darker in colour, is a robust way to store carbon.

Department of Soil Quality

http://www.wageningenur.nl/soq

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The Carbon Dilemma (SOQ-35306)

Language of instruction:	English
Study load/Credit points:	6 ects
Components:	
Classroom lectures	24 contact hours (3 ects)
Tutorials	10 contact hours (1 ects)
Self study	2 ects
Period/time:	period 5 (March – April) morning, every day
Contact person:	prof. dr. T.W. Kuyper (tel. 0317-482352); thom.kuyper@wur.nl)
Lecturers:	Scientific staff from the Department of Soil Quality; invited lecturers
Examiner:	prof. dr. T.W. Kuyper
Examination:	Handed in assignments (40%) Contribution to general discussion (10%) Essay on carbon dilemma topic (40%) Feedback to essay (10%)
Assumed knowledge:	BSc degree in Geoscience (admission to new MSc Earth & Environment) or comparable level. Students with a different background who are interested to take this course should contact the contact person
Continuation courses:	Thesis and / or Internship Soil Quality
Study material:	Scientific papers for assignments per topic. These will be announced through Blackboard. Lists of questions pertaining to assignments. Power point (ppt) presentations of lectures.

Profile of the course:

A few years ago Janzen (Soil Biology & Biochemistry 38: 419-424. 2006) published a provocative paper entitled *The carbon dilemma – hoard it or use it*. The main message was that there is an inevitable tradeoff between using the soil organic carbon (as a source of energy, and simultaneously benefiting from the nutrients that are mineralized and released – but accepting a decline in organic matter) and hoarding the soil organic carbon (sequestering it to mitigate the effects of increasing atmospheric CO_2 levels and prevent climate change, but then simultaneously sequestering nutrients). This tradeoff between different soil ecosystem functions and services provided by carbon involves a choice between maximizing pools (hoard it) or maximizing fluxes (use it), which suggests that soil organic carbon is subject to a zero-sum game. However, several people have suggested that we may be able to transform a zero-sum game into a win-win (or even win-win-win) situation: sequestering soil carbon while also improving soil fertility (and growing energy crops). To transfer the zero-sum game into a win-win situation asks for an answer to the question: how can we balance soil carbon pools and fluxes to optimize processes? Around this question, there are active on-going debates on various issues related to soil biology, soil chemistry and soil fertility management.

This course will deal with the dilemma by looking at current debates about the nature, properties, interactions and transformations of soil organic carbon. Debate around soil organic carbon or soil organic matter is everywhere, as suggested by the recent, equally provocative paper by Lehmann and Kleber entitled *The contentious nature of soil organic matter* (Nature 528: 60-68. 2015).

The course starts with an Introduction to the general theme, followed by two sets of brush up lectures that deal with the soil biological and soil chemical views on carbon. We then assess background knowledge of the students. The course will deal with five (interlinked) scientific controversies that are important for resolving or managing the dilemma:

- What is the nature of humus, more particularly of humic acids?
- What are the transformations of carbon from fresh litter to soil organic matter? How does carbon reactivity change over time? What are the (biological) sources of black carbon?
- How do various carbon fractions interact? Can we manage priming as part of dealing with the carbon dilemma?
- To what extent is the organic carbon pool finite or infinite? What are consequences of the various control mechanisms of carbon storage for global environmental change?
- How is the carbon cycle linked to nutrient cycles? How are the various greenhouse gases (carbon dioxide, methane, nitrous oxide) to be regulated to minimize climatic change?

Underlying each debate are a number of fundamental questions and research topics, related to the C-cycle in soils. As the answers to these questions are often (hotly) debated, we will provide (discussion) papers that help you evaluating contradictory claims. Many of these research questions are subject of research by scientific staff of the Department of Soil Quality or by invited speakers. State-of-the-art knowledge and controversies will therefore be introduced.

Even though many questions on soil organic carbon cannot yet be definitely answered, science still has to list a balanced view of what is known (generally accepted), what is possibly known (but still partly controversial) and what is unknown. The final two weeks will therefore be devoted to writing consensus statements (for Wikipedia pages) on a number of topics related to soil organic carbon. These texts will be subject to peer-review by other students, after which the final text is produced.

The various topics will be introduced by a lecture (2 hours). Afterwards students (individually or in groups of two students, or sometimes in small groups) read one or several key publication(s) that is (are) listed for that specific topic. References to these papers will be made available through Blackboard. Reading exercises will be supported through a list of questions that need to be addressed. There are also assigment to write essays (a text with argumentation in support of or a critical reflection on a specific position). The format of reporting will either be as a written report or as presentation for the whole class. Students need to identify weak and strong points of the paper(s), and need to explain the scientific controversies. Students will also be asked to derive novel research questions from those papers, and to propose research approaches that address them.

The programme for each year will be made available through Blackboard. Considering the nature of the course we intend to regularly change topics, to reflect the dynamic nature of the carbon debate.

Learning outcomes:

After this course you are expected to be able to:

- demonstrate knowledge of the various and sometimes contrary roles that soil carbon plays in the functioning of terrestrial ecosystem;
- evaluate soil ecosystem services of carbon and effects of soil organisms that influence the carbon cycle;
- critically evaluate scientific papers on the carbon dilemma, including deriving novel research questions;
- put scientific knowledge of the carbon dilemma in a societal context that is increasingly critical towards the supposed expert role of scientists;
- write an unbiased consensus text (for Wikipedia) that addresses a major issue of the carbon dilemma.

Activities:

The lectures with associated papers provide students with pertinent knowledge. Additional papers help students to understand the relation of individual research publications to the bigger picture. Discussing controversial issues or papers with competing claims help students to separate the knowns from the unknowns, and fact from controversy to mere opinion. Writing a Wikipedia lemma should help students in contributing to write an unbiased perspective on controversial topics related to soil organic carbon.

Course scheduling:
The detailed course schedule will be handed out. Generally lectures take place on Monday and Wednesday, literature reading and self-study on Tuesday and Thursday (individual activities) and tutorials on Friday (group work). However, depending on availability of individual teachers (and the three free days during the first six weeks) we may occasionally deviate somewhat from this schedule. The course continues in week 7 and 8 (where we will use only the first three days).

Assessment of learning outcomes:

assessor: T.W. Kuyper

Learning outcome	Handed in assignments	General discussion	Writing Wiki lemma	Feedback to lemma
Demonstrate knowledge of the various and sometimes contrary roles that soil carbon plays in the functioning of terrestrial ecosystem	x	x	x	
Quantify and evaluate soil ecosystem functions and services of carbon and effects of soil organisms that influence the carbon cycle	x	x		
Understand the importance of the carbon dilemma for the major drivers of global change	x	x		
Critically evaluate scientific papers on the carbon dilemma, including deriving novel research questions	x	x		
Put scientific knowledge of the carbon dilemma in a societal context			x	x
Write a Wikipedia lemma that addresses a major issue of the carbon dilemma			x	x
Contribution to final mark	**40%**	**10%**	**40%**	**10%**