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The problem of greenhouse gas emissions from peatlands

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CONTENT

1. Description of the theoretical part

1.1 The problem of greenhouse gas emissions from peatlands

Undisturbed peatlands (mires) are unique natural ecosystems. It has high values for biological diversity, climate regulation and human well-being [1].
Mires make interchangeable and irreplaceable biological functions. One of the important functions is the gas control function. The essence of this function is the mire phytocenoses in the process of photosynthesis remove carbon dioxide from the atmosphere, link it to an organic matter. The organic matter transforms into peat after the death of plants. So the bogs can remove carbon dioxide from the atmosphere [2].
Peatlands affect content of three greenhouse gases (hereafter - GHG) in the atmosphere: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). These gases pass sunlight to the ground, but they delay the heat radiation from the earth. It leads to general warming of the climate or to the greenhouse effect [3].
Peatlands only covering 3% of the land surface, they hold 30% of the total terrestrial carbon. Within thousands of years the vegetation of peatlands has assimilated CO_2, incorporated carbon in its plants tissues, and sequestered it in the peat after plants died off (Joosten, Clarke 2002) [4].
The processes involve in C gas exchange (CO_2, CH_4) decide whether peat accumulates or whether peat decomposition prevails. Carbon balances based on gas flux measurements provide a fast and precise estimate as to whether a peatland is a carbon sink or a carbon source [5].
The most relevant factors controlling annual gas exchange rates and the climate impact of peatland sites are the mean water table, the vegetation type, the type and intensity of land use [5].
On a global scale 500,000 km^2 of degraded oxidation 1.3 Gt of CO^2 through microbial peat oxidation. This figure does not include emissions from peatland fires, nor the ex situ emissions from extracted peat. Including these sources, the total emissions of emissions from peatlands are estimated at around 2 Gt [6].
The area of peatlands in the Republic of Belarus is 2381,7 thousand ha. It is 11, 5% of the total area [7]. The Republic of Belarus ranks the eighth place in annual CO_2 emissions from peatlands and is 41 Mt. In terms of total emissions per unit land area, Belarus ends up third with 1.99 t per ha (Hans Joosten, 2011) [6].
According to Strategy for the Conservation and Wise (Sustainable) Use of Peatlands and Outline of the Distribution of Peatlands per Type of Use until 2030 of the Republic of Belarus, the emission of GHG from drained peatlands is the main problem [8, 9].
Considering the fact that peatlands are the main sources of GHG, Belarus investigates for improving the methodology for estimating greenhouse gas emissions.

1.2 Description of methods of measuring GHG emission from peatlands

For measurement of the complete balance of GHG from peatlands methods are needed which allow considering precise and continuous monitoring of GHG (carbon dioxide, nitrogen oxide and methane) during the long-lived period. Methods of measurement have to work under various weather conditions. Today two methods are widely used: chamber method and eddy-covariance method [10].
When the chamber method are used, the gas exchange is accounted as functionality of gas concentration changes in time in closed air volume. Closed chambers cover a small part of the soil (usually less than 1 sq. m) and take into account of estimation of variability of GHG sources [10].
The eddy-covariance method allows to determine the GHG exchange level by measurement of gas flux in the lower boundary atmosphere layer: air goes near of sampling points where the speed and the direction of wind, concentration of gas is analyzed [10].

1.3 GEST-approach in estimating of GHG emission from peatlands

Rewetting of drained peatlands can lead to the considerable reductions of a GHG emission in the atmosphere. As well as the obligatory market and voluntary market demands that reductions of emissions were defined quantitatively [11].
GEST-approach is based on comparison of the description of the territories that are presented in literature about greenhouse gases, vegetation to each site where flux was measured. GEST definition is based on a ground water level and types of vegetation, availability of nutrients, pH and land use [11].
The GEST is a rude, but good tool that can be improved and expanded. Currently, the GEST-approach allows estimating GHG flux in more detail. Using of the GEST-approach allows estimating emissions and reductions (in case of rewetting) for the baseline and projecting scenarios quickly and relatively accurately [11].

2 Description of practical part

2.1 Participation in measurements in the WETSCAPES project

The WETSCAPES project investigates Mecklenburg-West Pomerania territory.
WETSCAPES purpose is developing scientific principles for sustainable and gradual development of degraded and rewetted sites. WETSCAPES creates a basis for research and development that concerns metabolic processes, transport of matter, gas exchange and peat formation on peatlands.
Within WETSCAPES, the production and biomass decomposition in temperate peatlands is estimated taking inti account a special focus on root processes. It is key factors of the overall estimation of the carbon budget, because primary production of plants determines the amount of carbon that inputs in peatlands. Particularly important for the formation or degradation of peat is the growth and turnover of root biomass.
The project is funded by the Programme for Excellence in Research Mecklenburg-West Pomerania for a duration of 4 years (2017 to 2020).

Picture 1. Allocation of WETSCAPES research sites

CO_2, CH_4 and N_2O concentrations are measured 2 days a week at intervals of 2 weeks at selected sites.

2.1.1. Preparation of sites for measuring greenhouse gas emissions (CO_2, CH_4, N_2O)

Before measurements, the site is fenced. On areas for measurements round rubber frames with an iron base are installed for the further chambers installation. A wooden bridge is laid for moving that additional release of CH_4 will not provoked.

Picture 2. The site for measuring the GHG concentration in the field

Weather stations are installed for taking into account weather conditions (picture 3).

Picture 3. Weather station

2.1.2. Equipment for measuring CO_2 concentration

For measuring CO_2 concentration transparent chambers are used with ventilator (for air mixing) and temperature sensors, gas analyzer with PC. Chamber and gas analyzer are connect between themselves by tubes. Air goes to gas analyzer through tubes by pumping station.
Chambers are installed very nearly to frame.

Picture 4. Transparent chamber for measuring of CO_2 concentration

2.1.3.Equipment for measuring CH_4concentration

For measuring methane concentration not transparent chambers are used. It connects with gas analyzer by tubes.

Picture 5. Non transparent chamber for measuring CH_4 concentration

2.1.4.Equipment for measuring N_2O concentration

For measuring of nitrogen oxide concentration non transparent chambers are used. Samples are taken by syringes every 30 minutes. Samples are analyzed in laboratory.

Picture 6. Non transparent chamber for measuring N_2O concentration

In addition, height of vegetation and chamber height is measured for future calculation.

Wells are installed at the site for water sampling. Groundwater level, acidity (pH), temperature are measured. Soil temperature sensors are placed at depth of 5 cm and 15 cm. The vegetation is photographed at each sampling site.

2.2. Participation in investigations on REPEAT project

REPEAT aims to clarify the mechanisms of peat formation in fens by linking biogeochemical processes to soil community structure and biodiversity, as well as to plant belowground traits. The central research question is: What are the differences in below-ground production and decomposition, and eventually peat formation, between near-natural, drained and rewetted percolation fens along a climate gradient?

Research sites are near Peene River (Quilow, Gützkow). Sites look like quadrangular square that has 3 m on 8 m size. On plot, vegetation is described, at 3 points the biomass is taken on a 30 cm by 30 cm plot. A well is also installed to measure the level and chemical characteristics of groundwater on the site.

Picture 7. Allocation of REPEAT research sites

2.3. Estimation of GHG emission reduction from peatlands for ecological rehabilitation in Belarus by GEST- approach

John Couwenberg and Franziska Tanneberger estimated reduction of GHG emissions from peatlands for rewetting in Belarus by GEST-approach.

My task in Succow Foundation is estimating of reductions GHG emissions from peatlands for rewetting in Belarus by GEST-approach. For example, I used John Couwenberg and Franziska Tanneberger work report.

Calculation algorithm:

1. For calculation, I needed the list of peatlands for rewetting with vegetation description, class of water level, land use. I got this paper from my leader in Institute for Nature Management of National Academy of Belarus (table 1);
2. For estimating emissions reductions the Scenario of vegetation development in rewetting case (project scenario) and without rewetting (base scenario) were made. Then the vegetation on the site was compared with vegetation that described in literature with values of GHG flux (Franziska Tanneberger , John Couwenberg ,Karl Felix Reichelt);
3. Using this data the current emissions, emissions on baseline scenario, emissions on project scenario and reductions of emissions in rewetting case were calculated for first and future years.

Calculated data are showed in Table 1.

Finalization of this work needs some revision:

- Carbon sequestration in trees;
- Emissions from die-off of trees;
- Correction of flux values.

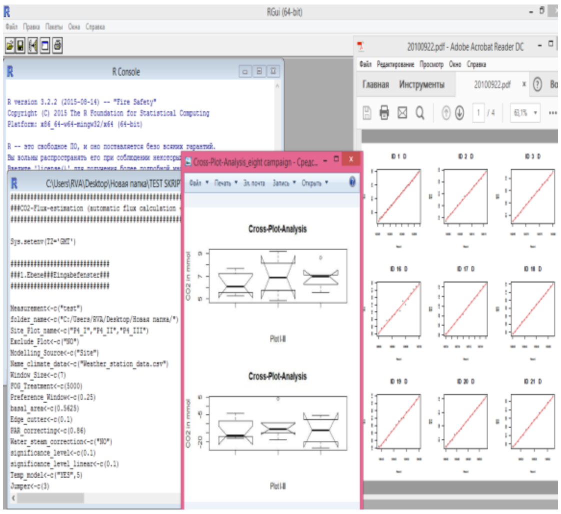
Table 1. Result of calculation of reductions of GHG emissions from peatlands for rewetting in Belarus by GEST-approach

Cadastre number	Name of peatland	Location	Total area, ha	Extracted area, ha	Area for rewetting, ha	Peat type	Current emissions		Baseline scenario		Project scenario		Total reduction potential first years, t CO_2-eq· year-1	Reduction potential first years, t CO_2-eq·ha-1·year-1	Total reduction potential later years, t CO_2-eq· year-1	Reduction potential later years, t CO_2-eq·ha-1·year-1
							Current emission, t CO_2-eq·ha-1·year-1	Total current emissions, t CO_2-eq· year-1	Baseline emissions, t CO_2-eq·ha-1·year-1	Assumed total baseline emissions, t CO_2-eq· year-1	Total emissions after rewetting, t CO_2-eq· year-1	Total emissions after rewetting, t CO_2-eq·ha-1·year-1				
890	Porechsky Moh	Minsk region, Pukhovichi district	4219	0	4219	bog	7,6	32022,2	8,3	34806,8	23204,5	5,5	8817,7	2,1	11602,3	2,8
204*	Zhada	Vitebsk region, Miory and Sharkovshchina districts	3961	159	3961	bog	7,9	31252,3	6,7	26439,7	21785,5	5,5	9466,8	2,4	4654,2	1,2
31*	Berezovik	Minsk region, Vileyka district	4000	394	1756	fen	12,8	22498,8	10,7	18719,0	15804,0	9,0	6694,8	3,8	2915,0	1,7
599	Vecherskoe	Vitebsk region, Gorodok district	671	0	671	bog	6,6	4428,6	8,3	5535,8	3690,5	5,5	738,1	1,1	1845,3	2,8
141H	Ushkov Moh	Vitebsk region, Gorodok district	126	0	126	bog	8,7	1089,9	7,7	970,8	693,0	5,5	396,9	3,2	277,8	2,2
40	Selcy	Grodno region, Smorgon district	727	256	727	bog	11,3	8247,8	11,3	8247,8	3998,5	5,5	4249,3	5,8	4249,3	5,8
Total			**13704**	**809**	**11460**		**9,1**	**99539,6**	**8,8**	**94719,8**	**69176,0**	**6,1**	**30363,6**	**3,1**	**25543,8**	**2,7**

2.4. Courses in the Leibniz Centre for Agricultural Landscape Research (ZALF)

Courses in ZALF were directed on studying of:

- process of formation and emissions of greenhouse gases;
- factors that regulate gas formation and gas exchange;
- equipment for measuring GHG emissions in the field conditions;
- different constructions and design of chambers for measuring of GHG concentrations;
- R-Project software package for data processing that get in the field (picture 7);



Picture 8. R-Project software package

A business trip was organized to stadying operation of automatic chambers for GHG measuring (picture 9).

Picture 9. Automatic chambers for measuring GHG concentration

CONCLUSIONS

During my internship, I received:

1. Base knowledge about problem of greenhouse gas emissions on peat ecosystems;
2. Work experience in measuring of GHG concentration in field conditions by manual chamber method;
3. Knowledge in measuring of GHG concentration by automatic chambers;
4. Skills with data processing in R-Project software package.
5. In addition, I accounted of reductions of GHG emissions from peatlands for rewetting in Belarus by GEST-approach

List of literature & references

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Review

Key words: GREENHOUSE GASES, BALANCE, CARBON DIOXIDE, METHANE, NITROUS OXIDE, PEAT, CHAMBER METHOD, GEST-APPROACH.

Object of research: the problem of greenhouse gases emission from peatlands.
Main goals:
1. Self-studies on greenhouse gas (GHG) emissions from peatlands (literature, expert consultancy);
2. Study of methods and equipment for measuring GHG emissions;
3. Training in field work;
4. Study of methods for data processing and modelling;
5. Applying the improved GEST-approach to assess GHG emissions scenarios for Belarussian peatlands that were chosen for rewetting.

List of figures & illustrations

PHOTOS

TABLES