

BIOGEOCHEMISTRY OF PERMAFROST LANDSCAPES

Fall semester, 2019-2020

Coordinator	Nina Pakharkova (Siberian Federal University, Russia)
Credits	3 ECTS (optional course), 18 in-class hours
Lecturers	Irina Borisova (Siberian Federal University, Russia)
Level	MS's
Host institution	Siberian Federal University , Institute of Ecology and Geography
Course duration	September 2 – December 23, 2019

Summary

Biogeochemistry as the discipline: general terms, aims and current developments in methods and approaches. Characterization of frozen grounds: general terms and characteristics of permafrost in the sense of geographic extent, types, thickness, ice content and temperature. Development and current state of permafrost: seasonal and perennially frozen ground. Natural controls of permafrost due to climate and landscape effects. Freeze-thaw cycles, active layer and taliks. Permafrost and landscape processes. Pedogenesis in permafrost landscapes and soil types. Biogeochemical characteristics of permafrost landscapes: fluxes of elements within and from landscapes. Permafrost degradation changes to the depth of the permafrost in cryogenic soils (IPCC, 2014). Global warming: general patterns and permafrost degradation. The response of permafrost landscape biogeochemistry to warming.

Target student audiences

Last year MS's students in ecology (majoring in environmental sciences)

Prerequisites

Required courses (or equivalents):

- Good level of Geology,
- Pedology,
- landscape Science,
- Ecology.

Aims and objectives

The aim of the course is to study the specifics of biogeochemical cycles of macro- and microelements of permafrost landscapes; to study the intensity of the processes of mineralization of organic matter, the ratio of biomass and annual productivity; pedogenesis in permafrost landscapes and soil types.

1. To give a comprehensive overview of biogeochemical cycles of forest landscapes and forest permafrost landscapes.

2. To analyze the mechanisms of migration of elements in boreal permafrost zone.
3. To train skills of practical application of methods for studying changes in the degradation of permafrost and their impact on the depth of permafrost in cryogenic soils.

General learning outcomes:

By the end of the course, successful students will:

- To give students sampling skills in the principles and approaches of biogeochemical zoning of geographical areas.
- To study the biogeochemical processes of geographical zones, in particular permafrost landscapes.
- To give information about development and current state of permafrost: seasonal and perennially frozen ground.
- To introduce the response of permafrost landscape biogeochemistry to warming.

Overview of sessions and teaching methods

The course will make most of interactive and self-reflective methods of teaching and learning and, where possible, avoid standing lectures and presentations. During the self-studying according to practical lessons and theoretical part of course students should read and be ready to discuss given topics.

Course workload

The table below summarizes course workload distribution:

Activities	Learning outcomes	Assessment	Estimated workload (hours)
In-class activities			
Lectures	Understanding theories, concepts, methodology and tools	Class participation	4
Practical lessons	Understanding of practical application of methods for studying changes in the degradation of permafrost and their impact on the depth of permafrost in cryogenic soils.	Class participation and preparedness for discussions	12
Moderated in-class discussions	Understanding principles and approaches of biogeochemical zoning of geographical areas.	Class participation and preparedness for assignments	2
Independent work			
Self-studying according to practical lessons and theoretical part of course	Ability to interpret data, to analyze audience, and to use the concepts, tools, and methods	Group assignments and individual presentations	40
Reading and discussion for seminars and preparation for lectures	Familiarity with and ability to critically and creatively discuss key concepts, tools and methods as presented in the	Class participation, creative and	50

	literature	active contribution to discussion	
Total			108

Grading

The students' performance will be based on the following:

At each seminar students make personal class assignments (50% of score), home assignments and current assessment (20% of score). The final examination will be given at the end of the course (30% of score).

Course schedule

Item No	Learning Activities (lecture, seminar, assessments and other)	Topic	Lecturer
1	Lecture	<ul style="list-style-type: none"> Common geochemical composition of the biosphere. Living matter; composition, natural variations of chemical elements concentrations in organisms. Biogeochemistry of geographical zones. Elementary landscapes (elementary ecogeosystem). Cascade landscape-geochemical systems (catens). 	Irina Borisova
2	Lecture	<ul style="list-style-type: none"> Biogeochemistry of permafrost landscapes (arctic, tundra, north-boreal subzone) Biogeochemical specificity of the soils of permafrost boreal landscapes. Soil types. Permafrost degradation changes to the depth of the permafrost in cryogenic soils Economic activity of human society as a factor of natural biogeochemical cycle deformation. Local (impact) antropogenic biogeochemical anomalies of heavy metals in permafrost landscapes 	Irina Borisova
3	Practical lesson	<ul style="list-style-type: none"> Assessment of biological absorption intensity (A_x). Assessment of radial and lateral migration of elements in the profile of cryogenic soils (R-analysis). Self-studying according to topic. 	Irina Borisova
4	Practical lesson	<ul style="list-style-type: none"> The intensity of the biogeochemical cycle (C_x, C_t, C_b); type and property of cryogenic soils; geochemical classification of surface and groundwater; geochemical barriers; weathering rates; resistance to pollutants. Self-studying according to topic. 	Irina Borisova
5	Practical	Morphological, physical and chemical properties of	Irina Borisova

	lesson	cryogenic soils. Soil classification (WRB, 2014). Impact of permafrost on soil, there is a difference between north taiga and middle taiga subzones. Degradation of permafrost can be seen from changes of permafrost-gley horizon and area of melting spots. Self-studying according to topic.	
6	Practical lesson	Intensive forest ground fires as a factor of increasing the depth of the seasonally thawed layer. Influence of permafrost on the accumulation of pollutants in cryogenic soils. Self-studying according to topic.	Irina Borisova

Course assignments

At each seminar students make personal class assignments (50% of score), home assignments and current assessment (20% of score). The final examination will be given at the end of the course (30% of score).

Literature

L.S. Shirokova, O.S. Pokrovsky, S.N. Kirpotin, C. Desmukh Biogeochemistry of organic carbon, CO₂, CH₄, and trace elements in thermokarst water bodies in discontinuous permafrost zones of Western Siberia // Biogeochemistry. 2013. May, 2013. Vol. 113. P. 573-593.
<https://link.springer.com/article>

Likens, G.E. and F.N. Borman. 1995. Biogeochemistry of a Forested Ecosystem. 2nd ed. Springer-Verlag, New York. <http://www.springerlink.com>

Oliva M., Fritz M. Permafrost degradation on a warmer Earth: Challenges and perspectives // ELSEVIER. Vol. 5. October, 2018. P. 14-18. <http://www.sciencedirect.com>

Raudina T.V., Loiko S.V., Lim A., Manasyanova R.M., Shirokova L.S., Istigechev G.I., Kuzmina D.M., Kulizhsky S.P., Vorobyev S.N., Pokrovsky O.S. Permafrost thaw and climate warming may decrease the CO₂, carbon, and metal concentration in peat soil waters of the Western Siberia Lowland // ELSEVIER. Science of the total environment. Vol. 634. September, 2018. P. 1004-1023.
<http://www.sciencedirect.com>

Regional Biogeochemistry. In: Modern Biogeochemistry. Springer, Dordrecht Schlesinger. 2003. DOI https://doi.org/10.1007/0-306-48103-0_6.

Robert MacLean, Mark W. Oswood, John G., Irons I, William H. McDowell. The effect of permafrost on stream biogeochemistry: A case study of two streams in the Alaskan (U.S.A.) taiga // Biogeochemistry. 1999. December, 1999. Vol. 47. P. 239-267.

V.V. Dobrovolsky. 1994. Biogeochemistry of World's land. CRC Press Inc. ISBN 0849375363. Google Scholar <https://scholar.google.com>.

William H. 1997. Biogeochemistry. An analysis of global change. 2nd ed. Academic Press, USA. ISBN 0-12-625155-X. <http://www.springerlink.com>