Biosphere and Global Environmental Issues

Basic Information

This is a course, which contributes to MSc award in Biology

Course period	From October 1st till February 1st, 1 semester (16 weeks)
Study credits	3 ECTS credits
Duration	108 hours
Language of instruction	English
Academic requirements	- BSc degree in Biology, Physics, Biophysics, Chemistry, Biochemistry, Environmental Sciences or equivalent (transcript of records), - Good command of English (certificate or other official document)

Course Description

One of the problems in fundamental Biology and Biophysics is the problem of ensuring the stability of the biosphere in the course of the further development of mankind. The biophysical approach to complex systems makes it possible to include in the orbit of biological engineering the biological system of the upper hierarchy level - the biosphere.

The course consists of five parts (modules). In the first module the nature of global ecological problem, its essence and premises are considered. The need to overcome three barriers in the way to sustainable development – scientific, technological and social-economical ones is disscussed.

The second module is devoted to the consideration of the main stages and principles underlying the evolution of the earth's biosphere, which led it to its present state.

The third module acquaints students with the first barrier and scientific objective: evaluating “resilience” of local ecosystems and the biosphere. Possible approaches to overcoming the barrier are discussed.

The fourth module considers the second barrier and scientific-technological objective: providing the lowest environmental impact over lifecycle of goods. This module allows coming to understanding some important aspects of biosphere-technosphere interaction.

The fifth module is devoted to overcoming the third barrier and social-economical objective: designing systems of optimal environmental management and adequate optimality criteria.

Special Features of the Course

The course is based on the consideration of biosphere-technosphere interaction via selecting the contradiction between human and the biosphere due to the dual nature of human being and extending biophysics approach of working with complex systems to the problem of sustainable development.

Course Aims

The existence of unfavorable or even catastrophic trends in the development of the environment has been recently recognized by various experts and leaders of most of the countries and international organizations. Earth's biosphere and its interaction with the technosphere are very difficult to analyze and predict. Within the framework of biophysics, using the methodology of physics, a toolkit for working with complex systems is being developed. *So the primary aim of the course is to apply the contemporary concepts and methodology of biophysics to the problems of sustainable development and biosphere dynamics.*

Course Objectives

The course objectives are:

- to acquaint students with modern ideas about the evolution and principles of the functioning of the biosphere;
- to enable students to experience ways of mathematical description of the biosphere as a system closed in terms of matter turnover;
- to give students an understanding main problems on the way of sustainable development and possible ways to overcome them.

Learning Outcomes of the Course

After completing the course students should be able to:

- understand the key property of the biosphere – the closure of matter turnover, and driving forces and stages of the Earth's biosphere evolution;
- understand the nature of the main contradiction in the relationship between the biosphere and human civilization, and the nature of three barriers in the way to sustainable development – scientific, technological and social-economical ones;
- get an idea of possible biophysical approaches to description and forecasting the biosphere dynamics which is necessary for overcoming the barrier;
- get an idea of possible ways to overcome closely related technological and social-economical barriers.

Lecturers and Tutors, Contact Information

Prof. Sergey Bartsev
e-mail: bartsev@yandex.ru

Course Structure

Learning Activities	Hours
Lectures	8
Practice sessions / Seminars,	16
Self-study Assignments	84
Final Exam (including preparation)	-
Total study hours	**108**

Course Outline

Week	Lectures	Practical work / Assignments	Hours
1-3	Module 1 «Sustainable development and associated problems»		6
	• Lecture “The origins of the problem of sustainable development.” • Lecture “Global dynamics and limits to growth.”	• Seminar “D.Broun’s book “Inferno” – is it a model of the problem solution?”	
4-9	Module 2 «Origin, evolution and current state of the Earth’s biosphere»		
	• Lecture “The origin of the biosphere, main stages and driving forces of its	• Seminar “Biological	

	evolution.” • Lecture “Biosphere closure and Vernadsky-Darwin paradox. ” • Lecture Current state of the biosphere and the main trends in its dynamics.”	Life Support Systems for space missions as models of biosphere: possible environmental lessons.”	8
10-12	Module 3 «Forecasting the dynamics and stability of local ecosystems and biosphere»		
	• Lecture “Difficulties in describing and predicting the dynamics of ecological systems. ” • Lecture “Small-scale models of biosphere and possible scenarios for its development.”	• Seminar “Ecological system management lesson.”	6
13-15	Module 4 «Minimizing the harmful impact of the technosphere on the environment»		
	• Lecture “The closure of biosphere and the contribution of technological processes to the global circulation.” • Lecture “Integrated assessment of the impact of technologies on the environment.”		4
	Module 5 “Optimal environmental management and adequate optimality criteria.”		
	• Lecture “Natural science aspect of the problem of optimal environmental	• Seminar “If I would be a “President of the Earth?”	

	management.” • Lecture “Social and psychological aspects of the problem of optimal environmental management.”		4
16	Final Exam		4

Attendance Policy

Since almost every class contains material, which is not presented in literature in compact form, attendance of all of them is highly desirable.

Web page of the course

The webpage of the course «Problems of Sustainable Development and Biosphere Dynamics» is available through E-learning SibFU web site: www.e.sfu-kras.ru. You must be logged in to access this course. Course Guide and all accompanying materials are also available at the course web-page.

Core reading

Rio (1992) The Rio declaration on environment and development/ http://www.unesco.org/education/pdf/RIO_E.PDF

IPCC (2014) *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Core Writing Team, Pachauri R.K., Meyer L.A. (eds.) IPCC, Geneva, Switzerland, 151 p. *(*https://www.ipcc.ch/report/ar5/syr/synthesis-report/).

Bartsev S.I., Degermendzhi A.G., Sarangova A.B. (2017) Stability of the Biosphere and Sustainable Development: a Challenge to Biospherics *Journal of Siberian Federal University. Biology*, 10(2): 134-152

Bartsev S.I., Degermendzhi A.G., Sarangova A.B. (2019) Closure of Earth’s Biosphere: Evolution and Current State. *Journal of Siberian Federal University. Biology*, 12(3): 337-347.

Barlow C., Volk T. (1990) Open systems living in a closed biosphere: a new paradox for the Gaia debate. *BioSystems*, 23(4): 371–384

Judson O.P. (2017) The energy expansions of evolution. *Nature Ecology & Evolution*, 1(6): UNSP 0138.

Ruiz-Mirazo K. Peretó J., Moreno A. A universal definition of life: autonomy and openended evolution // *Origins of Life and Evol. Biosph*., 2004, 34, 323–346.

Bartsev S.I., Degermendzhi A.G., Sarangova A.B. (2017) Stability of the Biosphere and Sustainable Development: a Challenge to Biospherics *Journal of Siberian Federal University. Biology*, 10(2): 134-152.

Bartsev S.I., Degermendzhi A.G., Erokhin D.V. (2008) Principle of the worst scenario in the modelling past and future of biosphere dynamics. *Ecological Modeling*, 216: 160–171.

Saltykov M.Yu., Bartsev S.I., Lankin Yu.P. (2012) Stability of closed ecology life support systems (CELSS) models as dependent upon the properties of methabolism of the described species. *Adv. Space Res*. 49(2):229-223.

Bartsev S.I., Degermendzhi A.G., Okhonin V.A., Saltykov M.Y. (2012) An integrated approach to the assessment of an ecological impact of industrial products and processes. *Procedia Environmental Science*, 13: 837–846.

Bartsev S.I., Gitelson J.I. (2016). A mathematical model of the global processes of plastic degradation in the World Ocean with account for the surface temperature distribution. *Dokl. Earth Sc.* 466:153–156.

Bartsev S.I., Degermendzhi A.G., Sarangova A.B. (2017) Stability of the Biosphere and Sustainable Development: a Challenge to Biospherics *Journal of Siberian Federal University. Biology,* 10(2): 134-152.

Bartsev S.I. (2013) Optimal Design of Biological Life Support Systems: Criteria and Problems. Current Biotechnology. 2(3): 19 p.

Facilities, Equipment and Software

The program is designed with a strong emphasis on theoretical knowledge. Lectures and seminars take place in rooms equipped with interactive tablets and direct projection boards.