METHODOLOGY AND CATEGORIES OF STUDYING DEPOSITARY, BIOGEOCENOTIC, ECOLOGICAL AND SERVICE FUNCTIONS OF SOILS

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The methodology, structure and major categories of fundamental studies are considered to be carried out within the framework of the Program adopted by the Presidium of Russian Academy of Sciences in accordance with the priority trend in "Depositary functions, technology of indicating the state and risks of soil degradation in the system of planning and rational environment conservation in Russia". These studies are foreseen to be realized according to 5 projects including digital remote sensing inventory and monitoring of arable lands; transformation, evolution and degradation of soils due to agrogenesis and global climate changes; depositary and ecological functions of soils in agrolandscapes; optimal use of the soil resources; analysis of the soil microbiome index in processes associated with the soil formation, the organic matter transformation and fine regulation of the vegetative process. Theoretically the above program is based upon the available typology and the system of agro-ecological valuation of lands, methodology and projecting of adaptive-landscape systems in agriculture; the development of the theory of creating and functioning of plant-microbial associations; methods of taxonomic identification of more than 100 soil microbiomes and the theory of soil ecological functions. The methodology under consideration differs from existing approaches by the fact, that the study of soil functions (function groups) is carried out as based upon the statistic and dynamic description of the energy-mass exchange processes at global biosphere levels and services rendered by the soil at the current stage of the human society's development. A block-scheme of studies and methods has been elaborated. The empiric analysis, physical modeling, imitation of the state in space are used at the depositary level. Biocenotic functions are described on the basis of studying the cycles of transformation, monitoring, metagenome indication, digital inventory and the other up-to-date technologies. The objects, categories, basic trends in transformation, evolution

and degradation of soils have been taken into complete account; the adaptation, management and regulation practices have been also determined; the results of scientific and applied studies are expected to be successfully obtained.

Keywords: digital inventory, monitoring, arable lands, soil degradation, climate change, agrolandscape, soil resources, microbiome, organic matter.

The framework of this paper is the program of fundamental investigations, drown up by specialists of the V.V. Dokuchaev Soil Science Institute and Russian Research Institute of Agricultural Microbiology. It has been approved by the Presidium of Russian Academy of Sciences and included into a set of programs oriented to priority trends in the different spheres of science (decision No. 10115-54, on February 03, 2015). The program answers the purposes of "Forecasting the scientific-technical development of the Russian Federation up to 2030" and deals with the necessity to develop new approaches to ecological monitoring over the environmental conditions, to assess the state and dynamics of agrolandscape resources, to give model description of biogeochemical flows, energy-and mass transfer, the possibility for additional mobilization of the soil fertility potential, to increase the application coefficient of industrial fertilizers and the bioproductivity as well as to prevent the soil degradation including its latent manifestations.

In Russia the study of soils from the viewpoint of assessing their depositary, agroecological and service functions, conservation, rational use and optimal pathway to food security is the most important problem, the solution of which requires interdisciplinary intellectual efforts. Today the ecologic-economic unity in the land use stipulates an efficient plant metabolism governed by mineral, water and air regimes in soils as well as the complex and operative forecasting and express-analysis of climatic and soil indices, physiological and agroecological requirements of crops to the bioproductivity of agrolandscapes at an optimal level. These investigations are of significant value for solving a great number of tasks relating to the organization of ecological monitoring, diagnostics of the state of natural and anthropogenic systems, the increase of agroecological level in agriculture and the biosphere environment conservation.

During the last ten years the attempts were made by research institutions combined in the Department of agricultural sciences in Russian Academy of Sciences (earlier in Russian Academy of Agricultural Sciences) to elaborate and coordinate the program of scientific investigations concerning the adaptive-landscape farming systems. Under study were the typology and a system of agroecological assessment of lands, the methods for projecting of adaptive-landscape farming systems. The appropriate methodical guides and innovative projects of adaptive-landscape farming and agricultural technologies have been prepared for many agricultural enterprises and regions of the country. As a result, there are the required scientific prerequisites and priorities for the further development of this trend in science. The native and international priorities are beyond question being completely corresponded to the world tends of the biosphere environment conservation.

In the last time the research in soil metagenome has being carried out as well. To analyze the soil microbiome, there is a collection of samples taken in different soil types of varying destruction degree and utility in agriculture and it is constantly replenishing now. Under use is an original method for obtaining the high-purified DNA from the soil as well as the methods to construct an optimal set of multi-complex fusion-primers permitting to analyze simultaneously 20 soil samples with 3-3.5 thousand nucleotide sequences for every sample, the soil microbiota by means of polymerized reaction, detection in real time and taxonomic analysis of complicated microbial communities.

For today, there are the data about the taxonomic structure of more than 100 soil microbiomes, for the first time the information on the soil microbiota as an indicator of the state of the country's soils and their functions has been obtained. The results of studies in the field of soil metagenome serve as evidence that they can be used as an integral index for the quality of soils and their functioning being promising for further development of approaches to the adaptive-landscape farming and landscape planning on the whole.

The competent classical schools of soil science, the tens of stationary experiments and a great diversity of soils in different agroecological status should be considered as prerequisites for these studies in Russia. The obtained results of this project will be able to enrich the

world science by qualitatively new achievements and innovative practical decisions, the latter being unique can be used in different branches of national economy.

The specific of the proposed approach is the study of soil functions (function groups) with respect to statistical valuation, description of their dynamics at micro-process (energy-and mass transfer) and biosphere level and soil services instead of traditional understanding of the function. The latter trend in the world science on soils being pragmatically expressed and differently successful is intensively developing now [8, 6, 9]. Meanwhile, the native scientific school of soil science [1, 5, 2] and theoretical positions in farming [4, 7, 3] allow solving this problem adaptively to the present-day social-economic conditions and natural-climatic changes to be widely used in applied sciences.

The program includes five independent projects which are the following:

- digital remote inventory and monitoring of arable soils in Russia;
- transformation, evolution and degradation of soils under conditions of agrogenesis and global climate changes;
- depositary and ecological functions of soils in agrolandscapes;
- optimization of the soil resources use;
- analysis of indices for the soil microbiome in processes associated with the soil formation, transformation of the organic matter and fine regulation of the vegetation process.

In the nearest future it is foreseen to create an intellectual expert system, the database of depositary functions of soils, agrolandscapes and soil microbiome. It is important to use the up-to-date bioinfomation means, the physical-technical basis and program pockets for describing the functions and processes, the structural-functional organization of the soil coenosis, assessment of the agroecological state of soils, the elaboration of the system of indicators for ecological stability of agrolandscapes taking into complete account the microbiological and genetic reserves of soil microbiome to determine the standard permissible loads and to provide the efficiency of expenditures.

The elaboration of methods for projecting of agrolandscapes and their infrastructure is foreseen as based upon the principles of functional

polyrization and formation of the ecological territorial frame with account of the experience gained in the adaptive-landscape land use in Russia. These studies will be conducted in the following trends:
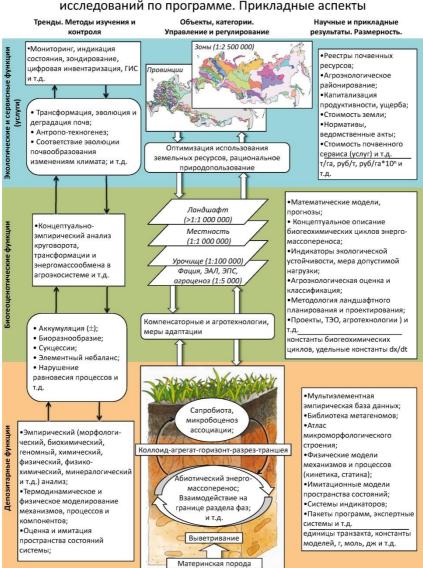
– depositary and ecological functions of soils in agrolandscapes: static and dynamics (evaluation of effects exerted by human activities and global climate changes on the soil status; elementary soil processes and regulation of agrobiochemical cycles of elements including P and N in ecosystems; migration of microelements, the carbon balance as a criterion for assessing the state of agroecosystems; the qualitative composition of the organic matter of soil and microbial community as an index of the soil fertility and ecosystem wealth);

– Russian chernozem – the main prosperity of Russia – the state and forecast of its changes caused by natural and anthropogenic factors;

– rational use of the soil cover (agroecological assessment of the soil cover state; adaptive-landscape farming systems as a technology capable to prevent the soil degradation, to reproduce the soil fertility and to provide the food security in Russia; modeling of degradation risk, efficient monitoring of agricultural lands).

The practical utilization of the proposed theoretical and methodological principles and approaches as well as empiric generalization of the expected experimental results will be conducive to possible elimination of many contradictions between the ecologization and intensification of the agricultural production in the course of providing the food securityin the country, creating a scientific base for the major trends in ecological-agricultural policy and rational use of agricultural lands in Russia, modernization of the system for preventing the soil degradation as a component of adaptive-landscape farming systems and agricultural technologies. It will help to increase the productivity of agricultural lands and promote the elimination of the country's dependence on deliveries of import agricultural produce, the normalization of ecological and safe conditions for the country's population. The introduction of new technologies will provide the possible reconstruction in planning of land use for purposes of agriculture.

The methodology of investigations within the framework of the given program is presented in a conceptual block-scheme (Fig.).

Методология, структура и категории фундаментальных исследований по программе. Прикладные аспекты

Based upon the studies carried out by G.V. Dobrovolsky and E.D. Nikitin and published in 1990 the biogeocenotic and global functions of soils (pedosphere) are divided into the groups including depositary, biogeocenotic, ecological and service ones. Bearing in mind the above understanding of soil functions, the most important are the functions of the first and last groups. The identified objects of research make it possible to detect their scale, size and methods of practical regulation: from compensatory and agrotechnologies, adaptation measures to the intensification level and natural-climatic metamorphoses to optimal use of land resources of agrolandscapes and rational environment conservation in general. The taxonomic hierarchy is also taken into consideration.

According to the above groups of soil functions the methods of studies and control are ranked in the following way. At the depositary level are used:

 –empiric (morphological, biochemical, genomic, chemical, physical, physico-chemical, mineralogical, etc) analyses;

– thermodynamic and physical modeling of mechanisms, processes and components;

–assessment and imitation of the system spatial state.

For characterizing the biocenotic functions the conceptual-empiric analysis of turnovers, transformation, energy-and mass transfer in agrosystem as well as the description of ecological and service functions, monitoring, indication of the state, sounding, digital inventory, GIS-technologies, etc. are required.

The studied trends are also different. At the first level these trends are accumulation, biodiversity and succession, elementary unbalance, destruction of the equilibrium, etc. At a higher level of this hierarchy – transformation, evolution and degradation of soils, anthropotechnogenesis, correspondence between the evolution of soil formation and the climate changes, etc.

The scientific and applied interpretation is a matter of principle as well.

The program is interdisciplinary by nature. Apart from the V.V. Dokuchaev Soil Science Institute and Russian research institute of agricultural microbiology the creative collectives of scientists from Agrophysical institute, Institute of Agriculture in Central-Chernozem zone,

Institutions in Belgorod and Kursk, a newly organized laboratory of estimation of soil economic degradation at the Moscow State University will take part in realizing this program.

The materials presented on Internet-site of the V.V. Dokuchaev Soil Science Institute (http://esoil.ru) are available and open to discussion. It will be used as a priority in plans of scientific investigations in the foreseeable future.

REFERENCES

1. Vernadskii V.I. *Biogeochemical Essays*, Moscow, 1940, 250 p.
2. Dobrovol'skii G.V., Nikitin E.D. *The functions of soils in the biosphere and Ecostems*, Moscow, 1990. 262 p.
3. Ivanov A.L., Sychev V.G., Derzhavin L.M. et al. *Agrobiogeohimichesky phosphorus cycle*, Moscow, 2012, 513 p.
4. Kiryushin V.I. *he theory of adaptive-landscape agriculture and projection-tirovanie agricultural landscapes*, Moscow, 2011, 445 p.
5. Kovda V.A. *Biochemical cycles in nature and their violation chelove com*, Moscow, 1975, 73 p.
6. Larkher V. *Plant ecology*, Moscow, 1978, 185 p.
7. Tikhonovich I.A. The theoretical basis and practical possibilities of the greening of agricultural production on the basis of vegetation-but-microbial interactionsб *Problems of intensification and environmentaltion of agriculture in Russia*, Moscow, 2006, pp. 55–77.
8. Odum E.P. *Fundamentals of ecology*, 2 Ayfl. Sounders Comp, Philadelphia–London, 1959.
9. Groot R.S. *Function of nature*, Wolters–Noordhoff, 1992, 316 p.