TO THE PROBLEM OF STUDYING THE EFFECTS OF DEGRADATION AND HAZARDOUS NATURAL PROCESSES ON AGRICULTURAL LANDS IN RUSSIA

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Under discussion are the results of systematization and comprehensive analysis of different literature sources containing the information on degradation and dangerous natural processes at the Asian territory of the Russian Federation. The degradation and adverse natural processes are divided into 3 groups according to their hazard extent: (a) processes oriented to destroy the soils and lands, (b) processes changing the soil cover pattern and leading to degradation of soils and decreasing their fertility; (c) processes deteriorating the land productivity. The assessment is given to show the distribution and dangerous occurrence of degradation and adverse natural processes in the Asian part of Russia (gully erosion, destruction of seashores and banks of water bodies, change in river channels and floodplains, underground flood, heavy rainfalls, flooding). The distribution and dangerous manifestation of adverse processes is highly varying at the studied territory in dependence on peculiar natural-climatic conditions. The paper presents the plans to continue such studies at the territory of European Russia in 1916 and their further development at the total country's territory within the framework of the project "Transformation, evolution and degradation of soils due to agrogenesis and global climate changes". The solution of the problem envisaged in this project is of primary importance in order to solve the social-economic tasks and objectives facing the country as well as to strengthen the Institute's position as a leading centre in the given field of soil science.

Keywords: soil map, database, system of scales and criteria, monitoring, thematic maps, GIS-technologies, regionalization, complex of measures.

INTRODUCTION

At present, the problem to combat the soil degradation and dangerous natural processes intensively developing due to anthropogenic effects and global climate changes is facing the agriculture in Russia. The vast areas of agricultural lands are subject to adverse effects of water, wind, gully erosion, excessive moistening, water-logging, salinization, flooding, erosion of river beds, etc. that cause harm to the agricultural production. All the degradation and dangerous natural processes adversely affecting the soil can be divided into three groups: (1) processes causing the total soil degradation, (2) processes changing the soil cover pattern and leading to soil degradation and (3) processes decreasing the land productivity. The processes of the first group causing harm to soils and lands include gully erosion, destroying of seashores, erosion of river beds and floodplains. The second group of processes is represented by degradation phenomena, the manifestation of which is widely spread for a long period of time. They have no direct hazard to soil and biota but can change the soil cover pattern and vital conditions for biota up to its disappearance: water erosion, deflation, excessive moistening, flooding, salinization, desertification, etc. The third group includes the natural processes (phenomena) quickly developing and adversely affecting the land productivity: dust droughts, heavy rainfalls, flooding, etc. In Russia where the climatic conditions are characterized by a great diversity and subject to considerable fluctuations the land loss caused by hydro-meteorological phenomena makes up 80–90%.

The soil degradation happens usually due to the combined effects of natural and anthropogenic factors, and it is rather hard to distinguish them. Not frequently two or more kinds of soil degradation take place simultaneously at the same territory, for instance, the water and wind erosion, the higher soil acidity and excessive moistening, water-logging and the secondary salinity or alkalinity, etc. These kinds of soil degradation can be accompanied by such processes as dehumification, overcompaction and soil depletion The risk to increase the existing hearths of soil degradation and those newly developed at the territory of agricultural lands is highly dependent on the properties and composition of soils (texture, structure, water permeability of soil aggregates, water and air regimes, humus content, etc.), vegetation and its projecting cover, deter-

mining the resistance of the soil cover to adverse natural and anthropogenic phenomena as well as on inappropriate land management and measures required for rational land use and conservation of concrete landscapes.

In the last time the global and local climate changes increased a number of extraordinary phenomena associated with prolonged droughts or heavy rainfalls, thus causing sometimes the total degradation of the soil cover; the increased dependence on climate and weather conditions leads to lowering the land productivity with consequent decline in the quality of crop yield, the growth and development of some agrocenoses on agricultural lands.

The high dynamics of degradation and dangerous natural processes, the proper mechanism responsible for their occurrence and development under conditions of constantly changing the climate at global, regional and local levels, the adverse human intervention into the environment makes it necessary to provide a deeper insight to this problem and to create an efficient system of monitoring over the state of soils and soil cover at the total territory of the country. The study of degradation and dangerous natural processes that not only decrease the land productivity but cause sometimes irreversible changes in the quantitative and qualitative composition of the land resources is a problem of today in the country now.

In many foreign countries the study of such adverse processes started after their catastrophic manifestation, for instance in the USA the Service of Soil Conservation has been organized when 75% of arable lands have been lost due to wind erosion in the 1930s of the XX century. In Mongolia the scientists were compelled to study the degradation processes and undertake the measures for the soil conservation after disastrous wind and water erosion induced by plowing the steppe areas in the 1970s. The own methods and approaches were used to prevent adverse effects of natural and human-induced phenomena, to create forecasting models for the development of these processes but the problem relating to the mechanism responsible for occurrence of such processes, conditions and factors affecting their manifestation and development remained beyond comprehension.

For today, the inventory of soil degradation at huge territories in the world was carried out by using the traditional soil-cartographic methods. The intensive development of computer techniques proved to be applicable for assessment of soil degradation as based upon computer and GIS-technologies. However, the proper method remained unchanged: a soil map is compiled to reflect the soil degradation degree; it is digitized; the attributive database is created to provide the information on the degraded soils. These principles were used to elaborate such standard databases as GLASOD (http://www.fao.org/nr/land/information-resources/glassod/ru), LADA (http://www.fao.org/nr/lada), SOVEUR [19] containing the information on the soil degradation in the world and Eastern Europe respectively. The shortcoming of such approaches is the insufficiently exact geographical localization of the information on degraded soils and the labor-consuming character of renovated database with the view of obtaining the more factual information.

At present, an insignificant attention is paid to fundamental research in the soil degradation and the development of dangerous natural processes under conditions of agrogenesis and global climate changes. Of interest is the applied aspect of this problem but without the knowledge of the regularities in the occurrence and development of adverse processes it is impossible to forecast them and to take measures for their prevention. It is worthy mentioning that such organizations are dealing with the study of land degradation as European Soil Bureau in Italy, ISRIC in the Netherlands. There are systems of satellite monitoring over the sown areas affecting by dangerous meteorological processes permitting to judge about the scope and intensity of degradation and dangerous natural processes. In Europe such monitoring was organized by the Institute of Environment and Sustainable Development at the European Commission (Italy), in China – by the Institute of using the satellite data, in the USA – NASA, in the Ukraine – Institute of Cosmic Research, in Russia – the Institute of Cosmic Investigations of Russian Academy of Sciences.

In Russia the fundamental investigations of soil degradation have being conducted by the V.V. Dokuchaev Soil Science Institute since the time of its foundation in 1927. Much attention to this problem was paid by research institutions of the former Russian Academy of Agricultural Sciences situated in different towns of the country (Kursk, Stavropol,

Ulyanovsk, etc.). A valuable contribution to the study of degradation and dangerous natural processes is made by specialists of the Moscow State University, Voronezh State University, etc.

The available cartographic and attributive information on soils in the country has been obtained 20–30 years ago. Being created in paper it is almost unsuitable for elaborating the present-day projects of land management associated with consolidation and redistribution of lands. Since 1991 the soil survey with the view of assessing the quality of lands came practically to the end. For example, in the Rostov region only 3% of agricultural lands were thoroughly studied [6]. From the beginning of the 1950s to the 1990s of the XX century the study and mapping of degradation and dangerous natural processes have been carrying out by zonal institutes of land management combined into "Roszemproject" under the guidance of the V.V. Dokuchaev Soil Science Institute. Later on the administrative bodies have failed to take proper measures aimed at studying the state of lands and their rational use, the reproduction of the soil fertility and prevention of adverse processes at the territory of agricultural lands. As a result of the land reform in the early XXI century 87 zonal institutes of "Roszemproject" have been liquidated. Such curtailment of studies to assess the land quality led to the absence of the required information in order to identify timely the changes in the land status, to evaluate these changes and to take preventive measures with the view of avoiding the consequences of adverse effects and organizing the State control over the land use and soil conservation. According to the experience gained in this sphere of science the materials should be supplemented by new data about the qualitative state of lands once for 10–15 years.

A comprehensive analysis of the annual information on the state and use of lands in the Russian Federation (State reports, papers, publications) permits to stress that the land quality in the country is becoming increasingly deteriorated, the agricultural lands are subjected to degradation, changes and even disappearance, the soil cover reveals the loss of its stability to destruction and the capacity to reproduce the productivity due to exhaustive and consumption use of lands. Unfortunately, today it is impossible to obtain the comprehensive characteristics of the qualitative state of lands because these data are fragmentary presented or completely absent. For instance, there is no information on the land

quality under forests, industrial lands and those occupied the especially conserved territories of the region. The data about the soil fertility as the most important index for the quality of agricultural lands are absent as well. This is explained by the absence of efficient monitoring over the qualitative state of land resources at federal, regional and local levels. The land policy pursuing in the country is oriented to govern the land as the immovable property, thus ignoring the fact that the land resources are the national property and the most important base for human being. The existing monitoring is aimed only to give the quantitative description of land use, the distribution of lands according to their categories and property forms.

Meanwhile, in Russia a great experience has been gained in the study of degradation and dangerous natural processes and mapping of conditions for their occurrence and development. However, in spite of abundant materials scattered in publications and archives it is rather difficult to obtain the complex information for decision-making to undertake the required measures, because these studies have been carried out in different time without due regard for the clearly formulated criteria to classify them according to the hazard degree by using the united approach for their assessment in different natural-climatic zones.

Of great importance is the identification of reasons, conditions and factors responsible for the development of degradation and dangerous natural processes with the view of increasing the soil fertility and crop yield under conditions of soil-protecting agriculture. By this reason the programs of long-term scientific investigations in soil science must include as priority trends the fundamental investigations of regularities in the occurrence and development of all the soil degradation kinds, their prevention as well as the improvement of methods to reproduce the soil fertility, to develop the adaptive-landscape farming system providing the ecological stability of agrolandscapes. According to the State program "Development of Science and Technologies in the period from 2013 to 2020" approved by the Government of the Russian Federation on April 15, 2014 and the program taken for realization by the Presidium of the Russian Academy of Sciences (№ 10115-54, February 03, 2015) the V.V. Dokuchaev Soil Science Institute intends to conduct the studies

within the framework of the project "Transformation, evolution and degradation of soils under conditions of agrogenesis and global climate changes".

At the first stage of the given studies in 2015 it is foreseen:

to assess the distribution and dangerous manifestation of degradation and hazardous natural processes on agricultural lands in Asian part of Russia (gully erosion, destroying of seashores and water bodies, changes in the river channels and floodplains, underground flood, heavy rainfall, flooding, etc.);

to determine the quantitative and qualitative changes in the land status caused by different kinds of degradation and dangerous natural processes under conditions of agrogenesis and global climate changes at the Asian territory of Russia.

In 2016 the identical investigations will be carried out at the territory of European Russia. For the total country's territory it is planned in the nearest future:

to elaborate a system of scales and criteria for assessing the danger and risk of changes in the soil cover pattern, the degradation degree of the soil fertility and crop yield under the influence of hazardous natural processes and phenomena;

– to create the GIS database of degradation and dangerous natural processes including those taken place in the period from 1991 to 2014 (dust droughts, heavy rains, floods, etc.);

– to make a spatial-temporary analysis of extraordinary situations and to evaluate the territorial peculiarities and ecological-economic consequences of natural catastrophes taken place in the past;

– to compile a set of different-scaled thematic maps on the base of GIS-technologies permitting to assess the distribution and dangerous development of degradation and natural processes and their consequences for the soil cover of the country;

– to carry out the regionalization of agricultural lands according to the danger degree of degradation and hazardous natural processes at the total territory of Russia;

– to elaborate a complex of measures for preventing the degradation and dangerous natural processes in agricultural lands with the view of protecting them and improving their state.

OBJECTS AND METHODS

The huge amount of information was systematized and comprehensively analyzed to show the development of degradation and dangerous natural processes taken place in Asian part of Russia within 1991–2015. Under use were literature sources as well as different reports on the state and conservation of the environment, the ecological situation, the utility of land and water resources in different regions of Asian Russia. Some of them are described below.

RESULTS AND DISCUSSION

The Asian Russia includes the lands of Ural, Siberia and Far East. The vast area extending from the north southwards and from the west to the east is characterized by a great diversity of orographical and geological conditions, the latter being combined with the climate changes serve as evidence of developing the dangerous natural processes of different origin at this territory. The gully erosion causes harm to land use in agriculture at the expense of shortening the area under crops and deteriorating the quality and structure of arable lands. The ever increasing gully erosion changes the landscape to a considerable extent. The gullied lands, the area of which is higher than the proper gullies by 2.5–3 times [8] reveal the low productivity being sometimes transformed into pastures or abandoned lands unsuitable for agricultural purposes. The main indices to show the gullied lands on soil maps are their density. The amount of gullies combined with their length for the area unit allows evaluating the danger of gully erosion [7]. In Asian part of the country the gully erosion is intensively developed in the south of Siberian Federal Territory (Novosibirsk, Altay and Krasnoyarsk regions) as well as in the north of the Ural region (central part of Yamal peninsula, the northern part of Tazov and a part of Gydan peninsula), where the gully formation is connected with the intensive development of the territory within the permafrost zone [1, 2, 3, 9]. In the Far East the gullies are distributed to a lesser extent and mainly in the south of the region [8, 13]. The danger of destructing the seashores and banks of water bodies is the irreversible loss of lands used in agriculture and those occupied by forests and settlements. The linear velocity of the sea recession from the coast-line speaks about the intensity of the seashore destroying. In Russia it makes up 1.2 m/yr being varied from 5 m/yr in great water bodies

to 1.5 m/yr. [10]. At the territory of Asian Russia the land loss due to seashore destruction is widely spread what is conditioned by huge extent of the coast-line and activity of abrasion processes. In the Far East the coast-line of great water bodies and seas is subject to destroying especially the seashores of the Okhotsk, Bering and Japan Seas [4]. In the Ural region the seashore of the Kara Sea including a part of this Sea, Baidarat, Ob', Tazov, Gydan inlets is subject to abrasion processes with the velocity averaged 1–1.2 m/yr. Sometimes it reaches 10 m per year due to thermo-abrasive processes in the area containing the thick underground ice [2]. In Siberia the seashores subjected to destruction are observed only in the north of Krasnoyarsk region (Taimyr). The active destroying is also characteristic of Irkutsk and Novosibirsk regions, in the Republics of Buryatia and Khakasia [3].

The changes in river beds and floodplains are caused by bank washout and silting. As a result of intensive washing the tens thousand hectares of land prove to be destructed almost every year. Some rivers such as the Upper Ob and the Lower Amur display the highest velocity of bank washout and deformation of their bed form [5]. This adverse process is characteristic of small rivers in Western Siberia, Central Yakutia and in the Lower Amur lowland derived from loose Quaternary deposits [4]. In the Far East the most dangerous are such rivers as Lena, Vilyui, Jana, Indigirka, Kolyma, Amguema, Amur and Zea. In the Ural region these processes are most intensive in the middle part of Ob stream, Lower Irtysh and their tributaries Tobol, Demianka, Vakh. The lands of such towns as Salekhard, Urengoi, Nefteyugansk, Surgut, Nizhnevartovsk, Khanty-Mansiisk, Ekaterinburg, Tyumen, Tobolsk, Kurgan, Magnitogorsk are subjected to adverse effects of channel processes [2].

As a rule, the underground flood of lands is an irreversible factor of degradation. The prolonged rise of the groundwater level leads to deteriorating the land quality; up to now there is no real information on manifestation of this dangerous process because the measures are undertaken only when the local extraordinary situations occur. The assessment of effects exerted by this adverse process is quite different in natural zones. In wetter zones the underground flood increases the natural soil moistening and leads to lowering the soil fertility with consequent decline in crop yield; in zones of insufficient moistening the process of underground flood can be even favorable if it is not accompanied by soil

salinization. In Asian Russia the lands are suffering from this process at the territory of Novosibirsk, Krasnoyarsk and Irkutsk regions [2].

The heavy rainfall is also a dangerous process negatively affecting the soil cover and lands under crop. The storm surface runoff can cause harm to agricultural lands. At the territory of Asian Russia the daily maximum rainfall is marked in Petropavlovsk-Kamchatskyi (207 mm) and in the south of the Primorie region (178 mm). In the Far East the air mass enriched with moisture from the Pacific Ocean and its Seas serves as a reason for regular storm rains. Frequently such rains take place in Sverdlovsk, Chelyabinsk, Kurgan regions. In the Urals mountain the daily precipitation make up 130 mm [2,13].

The periodical flooding of lands as a natural-technogenic process plays a significant role in the development of river and floodplain agrolandscapes, thus providing the higher productivity of pasture areas, on the one hand, but causes harm to agricultural crops, orchards, vineyards, etc, on the other hand. In Russia the area of periodically flooded lands is estimated as 350–400 thou km^2 [2]. In the Ural region the lands of about 20 towns and 100 settlements are suffering from the spring flooding, the latter being also intensive in Siberia within the floodplains of Ob, Irtysh, Tobol and Tara streams. Widespread and dangerous is the flooding in the Far East. It is worthy remembering that the flooding taken place in the Republic of Sakha (Yakutia) in 1998 caused a serious hazard to the lands of 198 settlements [1, 11, 12] or the catastrophic flooding in the Far East in 2013.

CONCLUSION

The fundamental scientific problem that will be solved within the framework of the program mentioned above is oriented to identify the distribution and dangerous effects of degradation and hazardous natural processes exerted by them on agricultural lands in Russia. The realization of this project will permit to elaborate a system of efficient monitoring over the state of agricultural lands at the total territory of the country and to improve the measures in order to prevent these dangerous processes and to reproduce the soil productivity in adaptive-landscape farming for decisions regarding an optimal pathway to food security. The scientific novelty of the given studies is beyond double because the complete and objective information will be first obtained to show a set of

degradation and dangerous natural processes adversely affecting the agricultural lands in Russia. These studies carried out by specialists of the V.V. Dokuchaev Soil Science Institute will allow to modify the theory of occurrence and development of different soil degradation kinds and to prepare a scientific basis for monitoring of agricultural lands with the view of preventing the adverse natural processes. At the current stage of this program implementation solving intricate involves the application of an approach, in which a wide range of factors is taken into account. The solution of these tasks is provided by a huge amount of materials accumulated in the Institute since the time of its foundation 88 year ago. In the end, having realized this program the Institute will take the sound position as a leading scientific center in the given sphere of science.

Acknowledgement. The studies are carried out at the financial support of the Presidium of Russian Academy of Sciences, project within the framework of the Program of fundamental scientific investigation for 2013–2020.

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