Design of Environmental Technologies on Agricultural Land

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Abstract—**Annually an area equal to an agricultural enterprise is removed from intensive agricultural use as a result of water and wind erosion. Along with this, the deforestation is increasing and the ploughing of territory is also growing. Therefore the issue of the development of environmental technologies on agricultural lands is extremely relevant. The purpose of the research is to develop a methodological framework for the design of environmental technologies on agricultural land in relation to the conditions of the Voronezh region and the entire Central Black Earth region of the Russian Federation. A model of environmental technologies located on agricultural lands was created by "Druzhba" and "Bogdanovo" agricultural enterprises in Kantemirovsky district of the Voronezh region. In this agricultural enterprise, the crop farming is carried out taking into account ecological principles on a landscape basis, and social and economic conditions of management are also taken into account. There is a tendency to increase soil fertility. Thus in topsoil there was an increase in humus content from 6.07 to 7.14%, the pH of the aqueous solution increased from 7.5 to 7.6 and the amount of Ca + Mg also decreased from 38.5 up to 20.3 m. per 100 g of soil.**

Keywords — land regulation; agricultural lands; soil fertility water and wind erosion

I. INTRODUCTION

Nowadays there is a global concern in terms of the formation of the negative impact of agrarian sector on the quality of soil fertility, flora and fauna, and as a result of public health. In the 20th century, soil fertility of the Voronezh Region was characterized by 10% average content of humus. At the beginning of the 21st century, soil fertility of the Voronezh Region is mainly characterized by a humus content of 4–7% on the average, and soils with a humus content of 2–4% appear. Land degradation is one of the main problems of our region and Central Black Earth region as a whole.

The degradation is mainly represented by water and wind erosion, which annually removes from the intensive turnover of land an area equal to a large agricultural enterprise. In addition, the value of the loss of nutrients washed away from the fields of crop rotation arrays is twice as large as the annual amount of fertilizer applied. Apart from this there is an increase in the ploughness of the territory and deforestation which lead to the aggravation of ecological crisis in the Voronezh region and in the Central Black Earth region in general. Therefore, the design of environmental technologies on agricultural land is an urgent problem of present time.

The land use of the Voronezh region, which make up agricultural land, has its own characteristics, and the main one is the management of agricultural production in sloping territories. The share of arable land of the Voronezh region on slopes with a steepness of up to 3 degrees is 86.5%, from 3-7 degrees the share of arable lands is 13.4% and over 7 degrees is about 0.1%. Thus, 13.5% of the arable land area is an area that requires close study and development of specific actions for the design of agricultural land use agroecosystems. The aim of the work is to develop a methodological framework for the design of nature-like technologies on agricultural land in relation to the conditions of the Voronezh region and the entire Central Black Earth region of the Russian Federation.

The land use of the Voronezh region, which makes up agricultural land, has its own characteristics, and the main one is the management of agricultural production in slope territories. The share of crop land of the Voronezh region on slopes with a steepness of up to 3 degrees is 86.5%, from 3-7 degrees the share of crop lands is 13.4% and over 7 degrees the share is about 0.1%. Thus, 13.5% of the crop land area is an area that requires close study and development of specific actions for the design of the agroecosystems agricultural land use. The purpose of the research is to develop a methodological framework for the design of environmental technologies on agricultural land in relation to the conditions of the Voronezh region and the entire Central Black Earth region of the Russian Federation.

II. METHODS AND MATERIALS

The theoretical and methodological basis is presented by the research work of national and international scientists in the field of land management, environmental management, as well as the fundamental concepts of interaction between nature and society, the rules of formation and structure of landscapes and agricultural landscapes, the principles of organization of environmentally sustainable agricultural production and its territory as well as information technologies of agriculture and sectoral environmental management. In addition, during the course of the research the conceptual provisions are used which provide the possibility of applying a systematic approach to the justification of environmental protection methods from negative anthropogenic impact as the main factor ensuring the planning and organization of environmentally sustainable land use, which are the basis of rural territorial entities.

Developing methodological foundations for the design of environmental technologies on agricultural lands, it is undoubtedly necessary, first of all, to study the experience of the Kamennaya Steppe, the foundations of which were laid by V.V. Dokuchaev, the Great Russian soil scientist. Analyzing the positive aspects of the experience of V.V. Dokuchaev in Kamennaya Steppe, it is necessary to note that the created model of the territory design does not comply with all the conditions of the Voronezh Region and the Central Black Earth Region. It is necessary to take into account that the territory of the Kamennaya steppe is a plain. The territory of the Voronezh region 53.3% of crop land, located on the plain, and the rest of the territory of 46.7% of crop land are on sloping surfaces, often rugged by a dense network of gully-frame complexes, therefore, in order to develop a methodological basis for the design of environmental technologies on agricultural lands in relation to agricultural organizations of the Voronezh region and the entire Central Black Earth region it is necessary to develop a model of organization of the territory, which would satisfy the requirements of the organization on the slopes of the Territory (46.7% of the crop land of the Voronezh area) taking into account the environmental situation, which aggravated significantly in recent decades.

III. RESULTS

A model of environmental technologies on agricultural lands was created by “Druzhba” and “Bogdanovo” agricultural enterprises on the basis of the research work of V.V. Dokuchaev and the experience of the Kamennaya Steppe, adjusted for the specific climatic conditions. In this agricultural enterprise, crop farming is carried out taking into account ecological principles on a landscape basis, as well as social and economic conditions of management.

The essence of the methodological framework for the design of environmental technologies in “Druzhba” and “Bogdanovo” agricultural enterprises is to identify environmentally homogeneous lands, genetically suitable for the cultivation of specific crops, through a reliable device of each crop, to the system of adaptive-differentiated crop rotation, and then to the structure of crop lands and the specialization of agricultural enterprise.

The novelty of the Kantemirovsky model is as follows. On land-use “Druzhba” and “Bogdanovo” agricultural enterprises within the framework of field-type watersheds the agroecosystems were created capable of self-regulation by thermal, nutrient and water regimes. The created forest-agrarian landscape on the territory of the Kantemirovsky model is saturated with strip-field landscapes with differentiated land use. It improved the microclimate, energy exchange on field arrays and raised the overall landscape-ecological immunity of homogeneous areas and fields of crop rotations against harmful factors of production. At the same time, on the crop lands, along with protective forest zones, bush zones are actively used.

Nowadays 16% of eroded and erosion-dangerous plough land is removed from intensive use, and almost 20% of the plough land is transformed into meadow of annual and perennial grasses. This fact reduces the mechanical load on the soil, erosion processes in the slope areas are significantly reduced, the area of gullies overgrown with forest vegetation, heavily washed soil gradually move into medium and poorly washed. There is a tendency to increase soil fertility, so on humus ordinary soil there was the increase in humus content from 6.07 to 7.14%, the pH of the aqueous solution increased from 7.5 to 7.6 and the amount of Ca + Mg also decreased from 38.5 up to 20.3 m. per 100 g of soil. That is, in general, the progress towards sustainable agriculture is observed. Evaluating the economic component, it is necessary to note the increase in crop yields by the example of grain by 5-7 c/ ha. Thus, the ecological and economic effect is observed in all the main components of the formation of environmental technologies on agricultural lands.

The developed methodological foundations for the design of environmental technologies for the conditions of the Central Black Earth region are embodied in the Existing Methodology for the Design of Environmental Technologies and consist of six main components.

The first component is the formation of a balanced structure of territorial units (land use) through the allocation of natural and territorial landscape ecosystems according to the watershed principle, the formation of land with an improved ratio, the formation and placement of fields of crop rotation tracts, ecologically homogeneous areas, the planning of landscape stripes in inter-shrub places on plough land, the placement of the stripe crops in the fields of crop rotation and eco tones on the edges of perennial grasses at protective forest stripes.

The second component of the existing method is the formation of an agroforestry-ameliorative complex by placing protective forest plantations up to 5% on plough land and bush zones in slope areas of 100–120 meters, the forestation of a gully network and provoking succession processes on it, the design of protective forest stripes around ponds and economic centers, the design of silt filters at the tops of the ponds and in the beams carrying out cones, the initiation of erosion-dangerous troughs on plough slopes, as well as regime use and improvement of natural pastures and hayfields.

The third component is the agricultural and technological complex, which includes the improvement of the structure of crop areas for the purpose of biologization of agriculture, expanding the sowing of cropped and green fallow, adjusting the structure of cropped areas and increasing the area under perennial grasses to 17%, designing cultivated non-irrigated pastures on plough land, and introducing differentiated crop rotations, the formation of lanes and mixed crops, landscape heterogeneity and adaptability of crop varieties, plan contouring, beardless soil-protective technologies, the differentiated application of organic and mineral fertilizers in the context of agro-ration and landscape stripes.

The fourth component of the existing method for the construction of environmental technologies is the irrigation and drainage complex consisting of the design of earthen ramparts and dams - bridges on the tops of beams and gullies, forming small ponds on the tops of a gully beam network, intermittent shafts - ditches on gullies together with the design of protective forest strips , ponds, including dry filtering on gullies and beams, the creation of water-retaining nano-relief at protective forest stripes and field roads.

The fifth component characterizes common ecosystem and nature protection measures and consists of the formation of landscape agro-ecosystems, the transformation into meadows and conservation of degraded plough lands, the bringing the forest land up to 17–20% of forest land, the creation of island meadow areas and inter-fields in the fauna fields, the entomological self-regulation through landscape formation systems, the limitation of noise in the habitats of the fauna, the entomological micro-reserves and wild animals, the increase in the number of wild animals and birds and the creation of water protection zones and coastal strips.

The sixth component includes measures to limit and eliminate unfavorable factors of agriculture. These include the limitation of the area of complete fallows, the movement from mold-board ploughing of plough lands to beardless one, the limitation of pesticide use based on landscape and agrotechnical methods, the restriction of the use of heavy tillage machines and the elimination of the burning of stubble, straw and last year grass on pastures.

For adaptive farming, it is necessary to change the properties of natural components for a more rational and effective use of them. The system of measures for the environmental management of agricultural land, in contrast to the agrarian nature management, uses other technologies for changing the components of nature, interferes most expressively in the structure of land and the course of natural processes. Irrational organization and arrangement of land causes negative, irreversible changes in the development and functioning of agroecosystems of agriculture and this is often associated with the expenditure of a large amount of material, energy, labor and financial resources.

Environmental management, first of all, is aimed at reducing and eliminating degradation causes, preserving and reproducing lost agricultural resources. Based on the above mentioned facts, it can be emphasized that environmental issues of environmental management, in particular land use in agricultural sector, are closer to agriculture and agronomic sciences, and environmental management issues of agricultural territories with their land resources are the prerogative of land management and science.

The solution of environmental problems in the agricultural sector of production leaves an imprint on land management of agricultural enterprises. Land management is a system of measures which should become a mechanism for the environmental management of agricultural areas for environmental use.

The process of organization and arrangement of the territory of an agricultural enterprise with an agro-resource potential is carried out within the framework of intra-economic land management. At the same time, a wide range of tasks related to the organization of production is affected in order to ensure the rational use of land resources (the specialization of the enterprise is improved, the structure of land, the structure of cropped areas and the system of crop rotation are refined, the system of linear elements of the territory is being designed, etc.).

All this is aimed at the environmental management of an agricultural enterprise and the formation of a sustainable agricultural landscape design. The main goal of the developed activities is to create optimal conditions for the conduct of adaptive crop farming. If the agrolandscape as a conditional reservoir is stable, then its agroecosystem can be balanced (the reservoir can be filled), otherwise the unstable design will not allow forming the optimal agricultural regimes of farming system. The agrolandscape and agroecosystem are inseparable from each other, and it is impossible to solve separately the tasks of plough land from adapting the farming system.

The stability of the agrolandscape to the manifestation of negative natural processes and anthropogenic load along with the state of balance of farming regimes determine both the economic and ecological efficiency of agricultural use of natural resources.

It is difficult to even imagine, and it is almost impossible to solve the tasks of the organization of rational use of plough land in isolation from the elements of the farming system and also to form a sustainable agricultural landscape without associating it with the farming system. Rational use of plough land is ensured with a balanced nutritional regime of agriculture.

An integrated, landscape-ecological approach in the solution of issues of agrarian nature management will create conditions for overcoming the crisis in agriculture.

The solution of the tasks of environmental management and environmental use in agriculture should take place simultaneously and in combination with the priority of environmental principles; these tasks cannot be solved separately. Under the rational use of natural agricultural resources and in particular plough land they understood such use when the withdrawal of a resource (nutrient elements, humus, etc.) does not exceed the level of their natural reproduction. Schematically, this requirement looks as follows:

$$Ws = S/I, \tag{1}$$

where P – annually spent part of natural resource;

I – annual increase in natural resource.

With equality of ($Ws = 1$), the consumption of a specific resource is relatively balanced, if $Ws > 1$, then this indicates a depletion of the resource consumed, and the need to develop additional measures to improve its condition; if $Ws < 1$, an enhanced reproduction of the resource is observed , which indicates the rational use of natural resources.

This provision primarily concerns the soil fertility of plough land - the unique ability to provide conditions for the growth of agricultural plants at all phases of development with nutrients, moisture and air. The characteristics of the natural soil fertility in different regions are different, but topsoil has the highest fertility. Fertility is the most important property of the soil, able to create certain conditions for the growth of plants.

The diagnostic sign of rational use of plough land is a change in soil fertility. Currently, a number of scientists have noted a significant drop in soil fertility, the rate of decline in fertility is increasing.

Soil fertility is one of the most important producing functions of soil, which consists in its ability to provide plants at all stages of physiological growth and development with elements of mineral nutrition, heat, moisture and air. It is a major factor in the productivity of agricultural land. An important fundamental position of land management is the preservation (maintenance and reproduction) of the land balance, in other words, the formation of the optimal structure and combination of land areas of the agricultural territory: plough land, hayfields, pastures, perennial plants, populated and industrial places, forests, water bodies and disturbed lands.

The ecologization of agriculture is a relevant requirement to ensure the rational use and protection of lands of agricultural organizations, which is solved in the process of environmental management by creating optimal conditions for conducting economically beneficial environmental management. Rational use is directed to the need for the conservation and reproduction of the natural potential of land resources, the organization and arrangement of agrolandscapes that are resistant to adverse natural processes and anthropogenic conditions.

IV. CONCLUSION

The developed methodology for the design of environmental technologies for the conditions of the Central Black Soil Region has been tested in the development of projects for the development of the territory and the production of 110 agricultural enterprises of the Voronezh region.

On the basis of optimally organized and arranged agrolandscapes, the conditions are created for conducting adaptive, cost-effective crop farming. Economically beneficial agricultural production is possible only on the basis of rational use of land resources. The problem of the rational use of land as a natural resource has always had an extremely important role and it is especially acute under the current conditions.

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