Anthropogenic complex development in modern cropping systems in central Volga region based on agrolandscape land management

Mikhail Mikhailovich Geraskin[1], Vasily Ivanovich Kargin[2], Ivan Fedorovich Kargin[2]

[1]State University of Land Management, Kazakova str., 15, 64, Moscow, 105064, Russia
[2]Mordovian N. P. Ogarev State University, Bolshevist str., 68, Saransk, 430000, Russia
e-mail: karginvi@yandex.ru

Abstract. It has been found out that one of the reasons of anthropogenic complex low production is degradation processes development, which manifests in the deterioration of the balance of humus, nitrogen, phosphorus and potassium in the agriculture of Mordovia Republic. Increased tension of humus balance occurs due to the sharp decrease in the number of organic fertilizers applied. It has been studied that the design of modern farming systems should be based on uniform allocation of natural complexes allowing to solve the problem of environmental improvement with minimal costs. Agricultural areas planning should take into account the structure of land, industry accommodation, recreation areas and to ensure the prevention of environmental risks.
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Introduction

Anthropogenic systems development in cropping systems is determined by the balance of production and cultural soil-forming process. By increasing the intensity of the biogeochemical cycle, both improvement and the deterioration of soil fertility can occur [1–6]. Under favorable conditions, a change in the components of natural systems in a positive way is occurred. One of the reasons for the low productivity of anthropogenic systems is their degradation, reducing the complexity of energy potential. Thus there are a lot of degradative changes in soil cover [7].

The design of modern farming systems with the help of agrolandscape is based on the idea of selection of natural homogeneous complexes, which allows to solve the problem of producing high quality products and environmental improvement with minimal cost. Anthropogenic complexes have been formed on farmland, which differ in the way of functioning, physical-chemical, biological and ecological criteria, which immediately requires the introduction of farming systems based on agrolandscape management.

In the late twentieth century and the first half of the twenty-first century anthropogenic complexes with unpredictable elements were formed, failures were observed in the genetic information of living systems. In this connection the role of land management increases significantly, the essence of which at the present stage is to create a flexible territorial organization of agricultural production, which has environmentally, economically and technologically foundation, ensuring production of a certain number of products, taking into account the bioclimatic potential of farmland, soil fertility improvement, creation of environmentally sustainable agricultural landscapes based on stable territorial units (areas). Allocation of stable primary sites in agricultural enterprises and farms organization according to its natural features provides more efficient use of microclimates and soil conditions, creates a flexible system of farm units and conditions for detailed economic, environmental and technological justification to adopt land management decisions, facilitates the selection of the most economical and catch crops, and creation of environmentally sustainable areas, fields, arrays, crop rotations.

Determination of anthropogenic complexes based on typing its territory according to the macro- and mesolevels is the basis of information support system for design and project surveying soil management actions to form sustainable production and territorial structure of agricultural landscapes and to organize such a territory. Land management enables to justify the composition and value of farmland, recommendation for crops cultivation, adaptive system of crop rotation, agro-technical, environmental and anti-erosion measures to improve the formation of sustainable agricultural landscapes against anthropogenic loads. In particular, there is a special interest for selection of permanent plots for corn and potatoes growing near livestock farms, which will allow more efficient use of organic fertilizers and will reduce transport costs for both manure and crop production.

Projects of farm boundary in agricultural production cooperatives (APC) “Rassvet”[8] in Ardatov district and APC “Alovsky” ”[9] in Atyashevo district of Mordovia Republic, developed by the scientist of State University of Land Management, prove the effectiveness of agrolandscape approach to land use and determine its feasibility in other agricultural enterprises and farms to create a territorial basis for the design and development of modern anthropogenic biosphere complexes. To organize territorial agricultural production, agrolandscape approach affects all components and elements of the project farm boundary taking into account the indicators characterizing the natural properties of the territory. Under market economy it promotes the development of a highly productive, profitable agricultural production adapted to agrolandscape terrain conditions. As a result of development activities provided for land management in the APC "Alovsky" in 5-year term (2005-2009), cereal yield was 3.31 t/ha, sugar beet yield was 31.3 t/ha. An increase compared to the start of the project (1998), was respectively 2.2 and 7.5 t/ha. In 2011 the yield of grain and sugar beets were, respectively, 3.23 and 45.18 t/ha, that more compared to the republic average index of these crops yields, respectively 0.96 and 5.87 t/ha.

There is a paradoxical situation in modern agriculture, when a systematic decrease in the balance of major nutrients and humus occurs (Table 1). Application of only the fertilizer does not provide a positive balance of humus. The need for solid manure of deficit-free humus balance in Mordovia Republic is from 5.9 to 9.7 t/ha, and it application in 1996-2012 was from 0.8 to 0.5 t/ha.

The number and quality of incoming plant residues in the soil is determined by the structure of crop rotation and the level of crops productivity [10]. Maximum number of plant residues with a favorable ratio of carbon and nitrogen enters the soil when perennial legumes are cultivated.

Humus balance decreasing is due to a significant reduction of organic matter input. During 2008-2012 there accumulated 72.3% of the total produced manure in republic livestock farms. Even a simple calculation shows what huge losses are in agricultural economics. If for 1 ton of humus it is required 12.5 tons of manure, not removed from the farm manure (6794, 7 thousand tons) allows to increase the humus content to 543.6 thousand tons, energy cost of which is 12,502 thousand gigajoules, which is equal to 312.5 thousand tons of diesel. This amount of manure contains 42.46 tons of nitrogen, 26.53 tons of phosphorus and 24.58 tons of potassium. This amount of nutrients in terms of mineral fertilizers is equivalent to 183,482.7 tons of NPK (N:P:K – 13:19:19; cost of 1 ton on the 01.05.2013 is 15300 rubles.) which costs 2.807,3 million rubles. Moreover residual manure leads to increasing of groundwater pollution. According to the State Agrochemical Service center "Mordovsky" in October district of Saransk (bench marked section 7) in 2012 nitrate concentration reached 188 mg/l and on the bench marked section 13 in 2009-2011 it was 58,7-90,8 mg/l which is significantly higher than the permissible limits (9 mg/l).

Table 1. Balance of humus and nutrients in Mordovia Republic agriculture (according to FGBI State Agrochemical Service center "Mordovsky")

Years	Humus losses, t/ha	Humus accumulation, t/ha	Humus balance, ±	Balance, kg/ha ±		
				N	P_2O_5	K_2O
1992	1,0	0,53	-0,47	+6,0	+24,0	-3,0
1993	1,0	0,51	-0,49	-0,7	+5,7	-31,5
1994	1,02	0,51	-0,51	-22,8	-9,4	-26,7
1995	1,0	0,39	-0,61	-19,6	-8,6	-50,8
1996	1,0	0,32	-0,68	-14,7	-3,2	-33,0
1997	0,97	0,31	-0,66	-19,4	-7,9	-38,5
1998	1,07	0,30	-0,77	-3,0	-1,5	-27,6
1999	1,05	0,27	-0,78	-10,5	-4,4	-31,6
2000	1,08	0,46	-0,62	-11,3	-5,2	-19,6
2001	0,93	0,42	-0,51	-13,8	-7,2	-22,8
2002	0,91	0,45	-0,46	-12,5	-4,8	-21,9
2003	1,04	0,35	-0,69	-12,2	-2,9	-20,3
2004	0,87	0,45	-0,42	-22,9	-7,1	-31,0
2005	0,94	0,45	-0,49	-20,0	-6,3	-27,6
2006	0,97	0,49	-0,48	-29,9	-4,8	-27,9
2007	0,98	0,49	-0,49	-18,2	-4,5	-28,3
2008	0,98	0,54	-0,44	-25,0	-9,4	-35,9
2009	0,97	0,57	-0,40	-35,5	-13,5	-44,3
2010	0,67	0,39	-0,28	+13,0	+2,7	-6,9
2011	0,99	0,59	-0,40	-25,4	-12,1	-42,4
2012	0,92	0,48	-0,44	-12,0	-6,2	-29,7

In our opinion, in order to improve soil fertility, and take into account high ecological importance and effectiveness of early use of organic fertilizers, large labour-intensiveness and expensive for their dressing, it is advisable to subsidize part of the costs of this type of work by payments for land rent.

The placement of building of large holdings and accumulating of large stocks of organic fertilizer next to breeding farms one have to take into account its placement, funds to develop the territory and building of manure storage, allowing to collect and store of complete manure produced.

Farmland planning should be of biosphere nature that takes into account the structure of farmland, location of industries and recreation areas and prevents environmental risks.

Currently, the scientific literature extensively discusses long-term development scenarios of anthropogenic systems. Based on their analysis, there are two scenarios: innovation (optimistic) and inertial (pessimistic). The first one involves paradigm changing of agricultural production in combining of the technosphere and the noosphere. It is based on ecological and landscape

approach, which allows to take into account the potential role of each crop and land of territorial anthropogenic system to create stable, high productivity agrolandscape for sustainable development highly productive agricultural enterprises.

Corresponding Author:
Dr.Geraskin Mikhail Mikhailovich
State University of Land Management
Kazakova str., 15, 64, Moscow, 105 064, Russia
e-mail: karginvi@yandex.ru

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