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Application Of Basin Approach For Soil And Water Protection Geoplanning Of Territory And Environmental Management

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ABSTRACT

The article analyzes existing in the world and Russian practice organizational and management arrangements of rational environmental management principles based on basin principles. As the basis of the assessment and management of land resources, as an example of a river basin (the river Vorsklitsa) in Belgorod region (Russia), we have taken the concept of territory geoplanning with basin organization of natural resources usage. The aim of the work was the assessment of the quality of surface waters of the Vorsklitsa basin based upon hydrochemical indicators (dissolved oxygen, phosphates, oil products, suspended substances, ammonia nitrogen, nitrite nitrogen and nitric nitrogen), class of water quality according to assessment of integral water quality criteria has been identified. The extent of human impact on the environmental sustainability of river basin ecosystem by stabilizing and destabilizing factors has been revealed. The ecological state of the river basin Vorsklitsa within the boundaries of the Belgorod region has been calculated on its basis. The principles of justification of soil and water protection measures and river basin management mechanism are shown. Geoplanning of the basin of the small river has been done. It was done on the basis of a system of water protection measures, allowing to stabilize the environmental situation in the basin. The efficiency of the design solutions has been calculated by means of finding the coefficient of ecological stability of the actual state of the territory and after the introduction of design solutions.

Keywords: river basin, ecological stability of territory, soil and water protection activities, environmental management, Belgorod region.

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INTRODUCTION

Modern research on the scientific and technological justification of geoplanning of areas develop at the intersection of landscape ecology, environmental modeling and geoinformatics [1]. Selection of operating territorial unit is a key issue of geoplanning. In justifying territorial unit of countryside geoplanning different approaches are taken [2]: 1) administrative-territorial division of the territory; 2) landscape regionalization; 3) resource and economic approach; 4) basin approach.

If you want to solve the interrelated problems of rational soil and water use, allowing to evaluate the interaction of water, land and soil and plant components of ecosystems, as well as to carry out comprehensive cartographic work selection of such operating unit of geoplanning as river basin has perspective. [2; 9; Eleven; 23]. The objective need for integrated management of water and land resources, based on the basin principle, can be considered generally recognized [1; 8; 9; 11; 17; 20; 23], but at the same time, there are different approaches. In most countries, water management facilities of major river basins are selected as the main object of economic management [14]: in the United Kingdom there are10 of them [6], in France - 6 [4; 25], in China - 7 [4], in Poland - 7 [5], in Germany - 5 [14], in Spain - 8 [15].

Intergovernmental coordination is on the way of interaction between participants of the water solution complex on the problem of its development within the framework of integral pools. It is noteworthy that the European water policy in recent years has undergone a process of restructuring and adopted in 2000 the EU Water Framework Directive (WFD) becomes an operational tool that provides a perspective of integrated protection of water resources of the basin principle. [26]

MAIN PART

The experience of individual countries in the implementation of environmental protection measures on the basin principle

Currently, a number of countries, depending on the organizational and functional objectives and mechanisms of environmental management adhere to the four basic concepts, based on the river basin approach as a territorial unit management:

- Development and management of watershed as a whole [28];
- Organizational and functional management of water resources [4; 17; 28];
- Integrated Water Resources Management [7];
- Environmental development of the regions [7; 22].

The current state of implementation of soil and water protection activities on basin principles in Russia

In the subjects of the Russian Federation (except the Belgorod region) soil and water protection practical arrangement of the territory, based on the basin principle, is not implemented yet. In the country the principle of basin approach is widely developed only in management of water resources and has legal confirmation in provisions of the Water Code and the Water Strategy of Russia for the period up to 2020.

The main aim of creating a unified system of basin water resources management is to optimize water use, increase use of available water resources in the whole in basin through the use of a single basin approach to water management, combining basin-wide interests with administrative and territorial ones [10; 12; 19].

It should be noted that the existing basin councils carry out development of recommendations only on the use and protection of water bodies located within the river basin district, while the programs for the implementation of environmental protection measures aimed at the conservation and restoration of soil, forest and other resources available on watersheds and directly affecting the status of water bodies, are supervised by different agencies (the Ministry of Agriculture, the Federal Agency for Subsoil Use, the Federal Forestry Agency). At the present time a unified management system based on an integrated approach to the implementation of environmental activities within the boundaries of basin territorial structures has not been created. It shows a significant issue in environmental management impacted by human activity.

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Belgorod region as an example of the implementation of soil and water conservation measures on the basin principle within the whole region

With the adoption in 2006 of the Water Code of Russia on the territory of Belgorod region basin approach realization in the organization of water management facilities was started. River basins of the Belgorod region are subordinate to the Don Basin Water Management. The river network of the region western part belongs to the basin of the Dnieper river (20% of the total area of the Belgorod region), eastern part belongs to the Don (80% of the total area of Belgorod region) (Fig. 1).

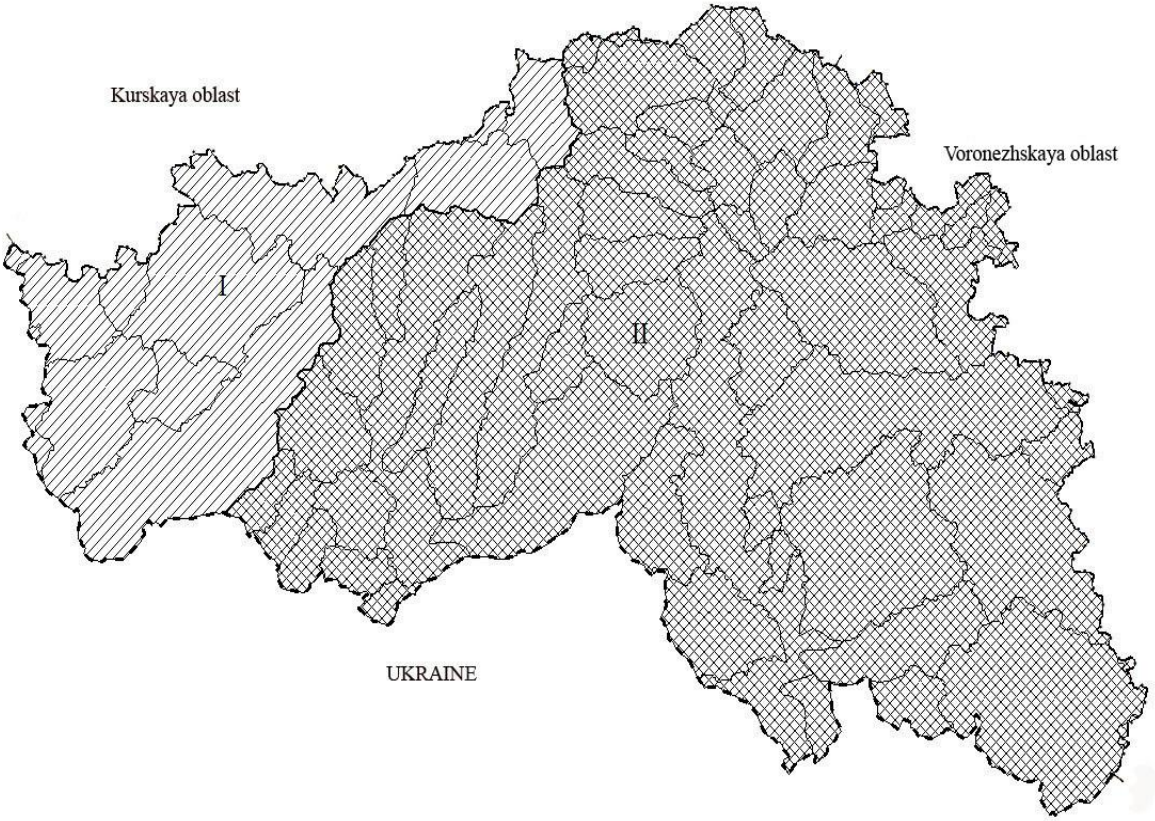

Fig.1. The spatial organization of river basins in Belgorod region, where I – basin of the river Dnieper, II – basin of the river Don

Adopted in Belgorod region landscape greening policy on the basin principle is aimed at improving ecological stability of the territory of watersheds, reduction of anthropogenic load, increase of water content of rivers, improvement of quality of water bodies. To this end, basin-municipal administrative level of environmental management, legislatively stated in the Conception of basin environment usage has been realized in the region since 2011. As part of this concept Belgorod State National Research University developed 140 projects for the basin nature resources usage for 63 river basins in Belgorod region.

METODOLOGY

After analyzing global existing approaches of territorial management of water resources at the basin principle, we are convinced that the most effective in terms of the greening of the river basin is the integrated management of soil and land resources. Water quality in rivers and water bodies (reservoirs, ponds) on the basin territory is the integral indicator of ecologically oriented water usage. To this end, we have carried out assessment of environmental condition of the river Vorsklitsa within the boundaries of Belgorod region following methodology of A. V. Yatsyk with author's comments. The calculation is based on the data of Department of Natural Resources Usage and Environment Protection of Belgorod region. The calculations were performed on the three monitoring points. Each site was estimated by 8 hydrochemical indicators. According to the results of the study classes of water quality were accordingly assigned (Table. 1).

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Table 1. Hydrochemical indicators of surface water quality in basin of the river Vorsklitsa

Indicator, mg/l	Sites of water samples withdrawal					
	I		II		III	
	C	K	C	K	C	K
Dissolved oxygen	II	1	II	1	II	1
Ammoniacal nitrogen	I	3	I	3	III	0
Nitrite nitrogen	IV	-1	VI	-4	IV	-1
Nitrate nitrogen	II	1	II	1	II	1
Phosphates	IV	-1	V	-3	II	1
Oil products	II	1	II	1	II	1
Suspended material (author's addition)	VI	-4	VI	-4	VI	-4
Biological oxygen demand in five days	II	1	III	0	IV	-1
Evaluation of integral test (K)		1		-5		-2

Note: C – grade of water quality (according to A.V. Yatsyk) corresponding to the assessment of water quality criterion (K) -4 or less - "very dirty" -3 - "dirty" -1 - "polluted", 0 - "insufficient purity", 1 - "pure"> 3 - "very clean."

Table 2. The main factors stabilizing and destabilizing the ecological situation in the basin of the Vorsklitsa

Factor name	Factor extent	Factor value	Assessment index	Factor value	Assessment index
		Before the project		After the project	
Factors that form ecological stability (ES)					
soil cover (typical black soil, leached (author additions), ashed, with middle- and heavy granulometric content, not eroded and slightly eroded, with humus content in plow layer 4.5-5.5%	% in comparison with the total area of agricultural land	233,17	0,2	233,17	0,2
Are of land with the inclination of less than 2 degrees		44998,6	0,4	44998,6	0,4
Woodiness		10626,7	0,6	12788,6	0,6
Part of stable agricultural land		1447,6	0,2	1558,95	0,4
Perennial grasses in crop rotation		0		5972,35	
Pastures		0		1591	
Hayfields		0		5671,8	
Wood shrub vegetation		1447,6		1503,8	
Broadleaves, small nature reserves, bee parks (author additions)		0		820	
Hydrographic system		1121,6	0,2	1121,6	0,2
Average geometrical ES			0,29		0,33
Factors that destabilize ecological situation (DF)					
Ploughness	% in comparison with the total area of agricultural land	38807,4	0,2	32109,3	0,2
Location of ecologically dangerous objects	Location on watershed; on slope; in valley or near a water body	on watershed and on slope	0,4	on watershed and on slope	0,4
Concentration of agricultural livestock	Number of items per 100 ha of agricultural land		0,6		0,6
Chemical load on agricultural land	Amount of acting substance, kg per 100 ha of agricultural land a year	330	0,8	212	0,6
Mechanical load on agricultural land	Total weight of mechanisms, tons and distance, passed along a field, km/ha per year	69	0,4	48	0,2
Possibility to create residential areas on the territory including road network with hard surface (author's addition)	% in comparison with total area of agricultural land	5103,7	0,2	5103,7	0,2
Violation of the use of protected water zones, including coastal areas (author's addition)	Distance to the water body, m	15	0,8	40	0,2
Average geometrical (DF)			0,42		0,30
Total ecological assessment (TA)			-0,13		+0,02

As a result of the calculations it was found that the quality of surface water in the basin of the Vorsklitsa can generally be described as "dirty, very dirty." Analysis of the spectrum of pollutants shows that the pollution of the river are due to runoff from agricultural land and livestock farms, as well as residential areas. In order to identify the extent of human impact on the environmental sustainability of river basin ecosystem, we used the technique of V.V. Medvedev [16] with additions supplemented by the author. This method provides for the detailed characteristics of the environmental sustainability of the landscape and the factors that destabilize the ecological situation (Table. 2).

Total environmental assessment (TA) was calculated as the difference between the average geometric ES and average geometric DF [16]. The calculations (ES = 0.13) indicate a critical and even threatening ecological status, which requires urgent measures to improve it.

To solve this problem a draft of basin natural resources usage has been created (Fig. 2).

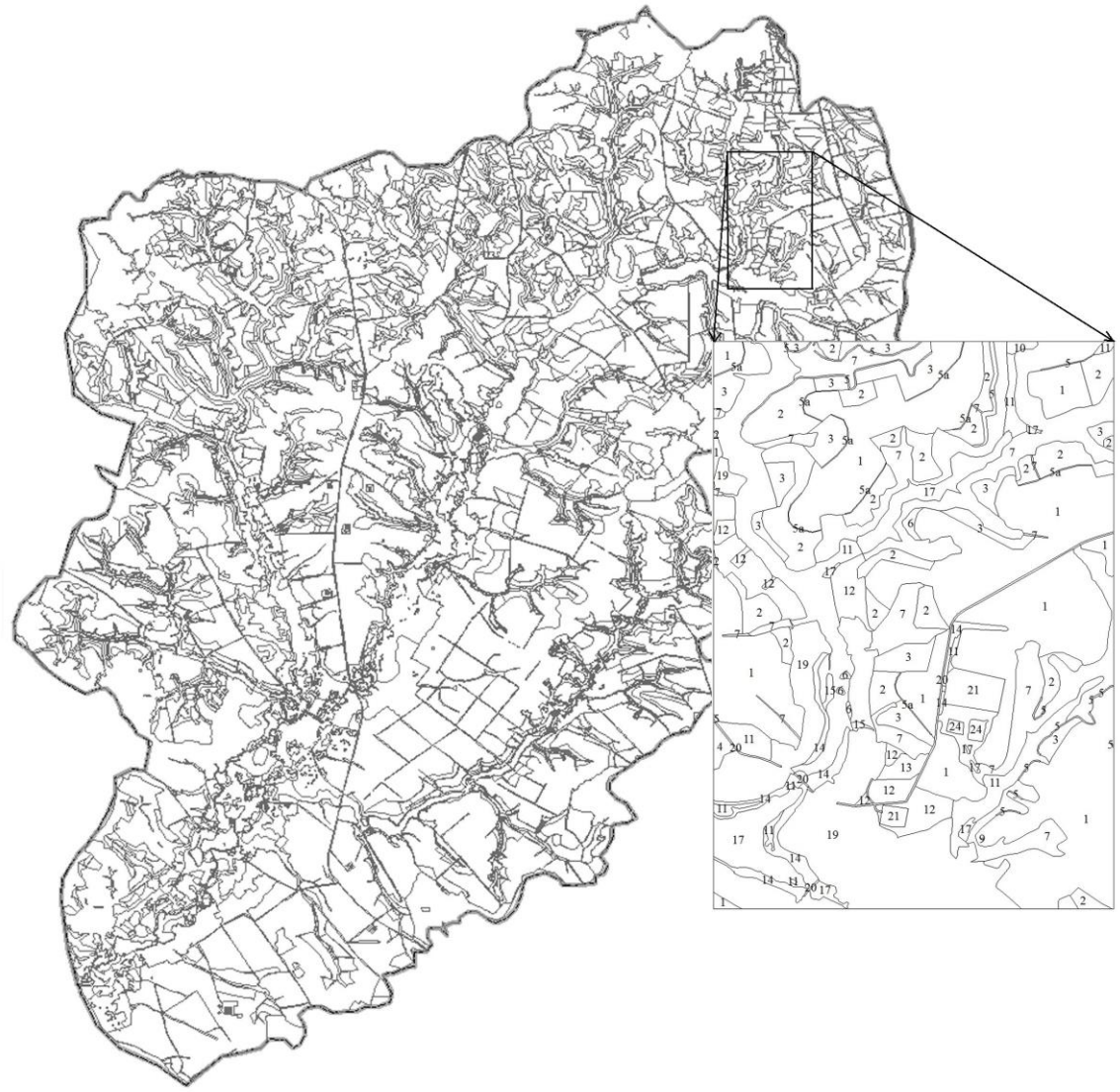

Fig. 2.

Result of territory geo planning with basin organization of nature resources usage (for example, the river Vorsklitsa within the boundaries of Belgorod region) where 1 - field crop rotation, 2 – crops and grasses rotation, 3 - soil protecting crop rotation, 4 – bee parks 5 – existing forest zones 5a - projected forest zones, 6 - lands conservation 7 - tinned spillways, 8 – kitchen gardens, 9 - sites, 10 - micro-reserves, 11 - hayfields, 12 - pastures, 13 - Gardens, 14 - forests, 15 - trees and shrubs, 16 - afforestation, 17 - under water, 18 - swamps, 19 - constructions, 20 - roads 21 - Industry 23 - cemeteries 24 – holding ponds, 25 - animal burials, 26 - silage pits.

Reorganization of the structure of lands and formation of ecological frame by performing the following steps [13]: 1) arable land management based on the basin and position-dynamic principles; 2) afforestation projects; 3) Projects of water protection zones; 4) rational use of forage land; 5) Projects of recreational areas; 6) identification of new nature reserves, served as a basis for geo planning. Perspective structure of land will allow to reduce the anthropogenic load on river basin, and thus balance ecological situation. Table 2 in the column "after the project" shows the results of the Vorsklitsa basin geo planning.

Thus, as a result of design decisions overall environmental assessment will be a value of +0.02, which means permissible level of anthropogenic load on the basin (Table 2). Implementation of systems of water conservation measures will stabilize the environmental situation in the basin. Reduction of arable land in the period from 2012 to 2014 by depressions grassing (203.89 ha), as well as afforestation of erosion-prone areas of the basin (1361.9 ha) showed effectiveness of the project activities that allowed to enhance environmental sustainability of the basin territory by 35%. The degree of increase of ecological stability of the territory (Kkest) is calculated using the formula:

$$\text{Kkest} = \frac{\text{KEST(f)}}{\text{KESL(pr)}} \times 100\%$$

where (according to V.A. Baranov):

KEST (f) - the coefficient of ecological stabilization of landscape before implementation of project activities;

KESL (pr) - the coefficient of ecological stabilization of landscape after implementation of project activities.

SUMMARY

Experience of introduction and implementation of environmental measures at the level of administrative regions (on the example of Belgorod region) showed the need to implement basin-administrative approach in organic (general) management of natural resources of the territory. The management organization for the implementation of tasks within the catchment area, but under the control of local authorities, can achieve high ecological, economic and socio-economic effects. In Belgorod region it is planned and is being implemented practice of redistribution of powers at the regional level, which allows using the existing management structure, to organize the processes of nature usage in the most economically effective and environmentally acceptable manner.

Monitoring the application of environmental decisions based on the basin principle, using GIS technology and remote Earth sounding allows to provide timely updating of information on the status of land use at each stage of implementation of project activities, which serves as an objective basis for control and management of sustainable development of territories.

CONCLUSION

Basin approach is recognized as the most effective mechanism for achieving sustainable, economically efficient and environmentally sound wildlife management in the international and Russian practice. As shown by the analysis of foreign and Russian experience in the management and protection of water resources, the use of the basin approach is reduced at the moment to a narrow framework of water management.

In our opinion, among the existing concepts of public administration in the realm of rational usage, protection and restoration of natural resources within the boundaries of river basins, the most effective is the concept of geo planning and management of environmentally oriented natural resources usage at the basin principle.

Watershed resources management, limited with narrow limits of hydrological and hydro-chemical monitoring of water bodies, gives a subjective assessment of the river basin and sets corresponding vector of

institutional management, limited by water legislation. In organization and management of natural resources following basin principle multilevel monitoring system is practical, which is based on the idea of subordination of hierarchical levels of natural systems, and has already been proposed [24] for control of soil erosion and their monitoring. This also applies to the part of the agro-ecological monitoring, which is responsible for tracking routes of pollutants from agricultural production (crop and livestock) to water sources. Ignoring control of the sources of pollution from agricultural run-off may create environmental risks in the operation of basin territorial structures [3; 18; 21; 27]. In this connection, it is necessary to have a complex design of environmental measures and complex management of basin natural resources usage.

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