LANDSCAPE ECOLOGY AND ENVIRONMENTAL MANAGEMENT

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UDC 91

THE RUNOFF IN WATERSHED LANDSCAPES OF THE ISHIM PLAIN (ACCORDING TO THE RESULTS OF INDEX PLOTS RESEARCH)

SUMMARY. Runoff differentiation depending on morphological structure and properties of the Ishim plain landscapes is established. Hydrological function of landscapes is quantitatively characterized. Spatial differentiation of the runoff is reflected in a series of the maps created by GIS. The obtained results are recommended to use in landscape planning, environmental management optimization and in developing a regional segment of a sustainable development.

KEY WORDS. The Ishim plain, runoff in landscapes, V.M. Kalinin's method, landscape-hydrological analysis.

The landscape-hydrological approach enables to make spatial analysis of water resources formation and to present hydrological characteristics in the form of landscapes functions. The determined consistent patterns can form the basis of landscape transformation and economic activity conducting on the basis of rational water resources management.

The landscape-hydrological analysis discloses the developed water-balance ratios within spatially localized territories — landscape plots, as properties of a landscape define the actual (local) runoff. To calculate runoff rate for every landscape plot (a kind of natural boundary) is possible by allocation of runoff-forming complexes (RFC). By definition of V.M. Kalinin [1; 17], "a runoff-forming complex is the part of a river watershed presented by a set of natural components, characterized by relative uniformity and defining characteristics of a hydrological cycle in this territory". It is easy to notice that RFC according to V.M. Kalinin is very close to classical definition of a landscape complex.

As the instrument of transfer of landscape variety [2-5] into runoff-forming variety V.M. Kalinin's technique [1] has been applied. The application of landscape mapping and creation of GIS maps set have enabled to solve the problem of hydrological interpretation of the Ishim plain watershed landscape structure.

Index plots for the research of the runoff from watershed landscape structure elements have been chosen in various natural zones and subzones — in a sub-boreal forest (the river Barsuk water collection), in a forest-steppe zone (the rivers Kiternya, Karasul and Loktinka water collections).

Landscape structure with the corresponding runoff rated parameters has been defined for each watershed area and sets of GIS maps have been made.

Index plot № 1 (the Barsuk river basin)

On the average the water collection of the river Barsuk basin (Fig. 1) gives 43,1 mm of runoff a year.

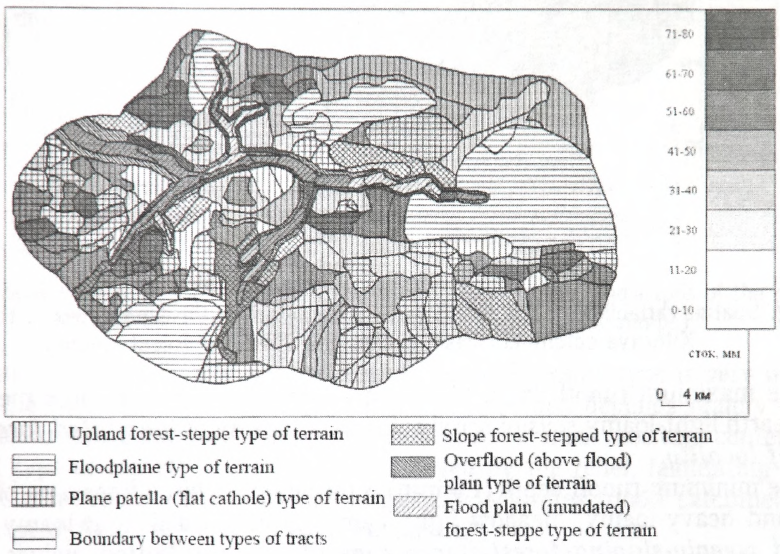

Fig. 1. Spatial variability of the runoff rated parameters in the landscapes of the river Barsuk catchment basin (index plot № 1, sub-boreal forest)

The maximum runoff depth (78,7 mm) comes from meadow natural boundaries on meadow heavy-loamy soils and boggy in flat-bottom steppe microdepressions, and dry meadows on meadow average and heavy-loamy soils of *above-floodplain-bench type of locality*.

The minimum runoff depth (25,8 mm) comes from the low-angle wavy suboptimally humidified and interflat-bottom steppe depression surfaces of flat-bottom steppe and upland types of locality (field natural boundaries with gray wood heavy-loamy soils; birch forests with admixture of aspen; mixed herb-grass meadows on meadow medium-loamy soils).

Forest natural boundaries of all types and subtypes of locality produce runoff close to average for the whole watershed which is explained by a regulatory role of forest vegetation. Ploughed natural boundaries give, as a rule, peak values of runoff. The minimum runoff is characteristic for plough lands with light-loamy soils, and maximum — for ploughed lands with heavy-loamy soils. Close to average values are peculiar for boggy and flat plots of the watershed. Meadow natural boundaries give the absolute maximum.

Index plot №. 2 (the river Kiternya basin)

On the average all the water collection gives 20,5 mm of runoff a year (Fig. 2).

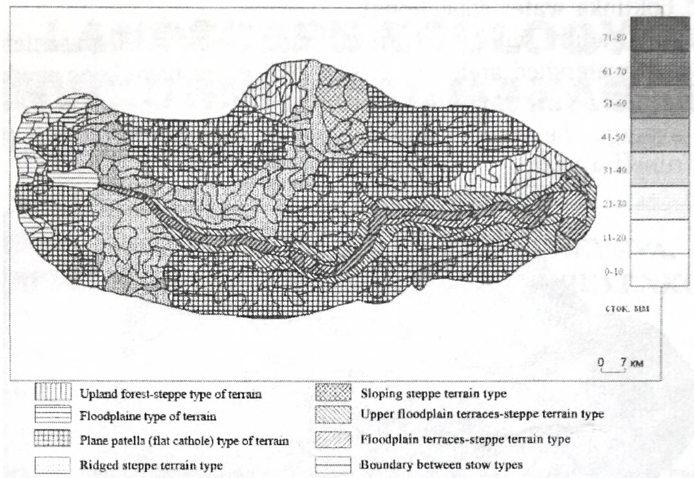

Fig. Spatial variability of the runoff rated parameters in the landscapes of the river Kiternya catchment basin (index plot № 2, the forest-steppe)

The maximum runoff depth (49,4 mm) comes from mixed herbs meadows on black-earth light-loamy soils of scroll subtype of locality of *inundated forest-steppe type of locality*.

The minimum runoff depth (1,5 mm) is formed from birch forests on black-earth light and heavy-loamy, meadow light-loamy, gray wooded light-loamy, solonetz soils of *steeply-sloping forest-steppe type of locality*. Bottom values of runoff depth are also taken from the natural boundaries of birch and aspen mixed herb-grass and the upland mixed-herbs forests on black-earth light and heavy-loamy, meadow and gray wooded light-loamy soils of *flat-bottom steppe type of locality*

From the whole river Kiternya water-shed the minimum (and more regular) runoff is given by forest natural boundaries, boggy natural boundaries (mainly floodplain meadow type of locality) and plough-lands. The greatest runoff depth is given by meadow natural boundaries.

Runoff formation is influenced, first of all, by soils, their mechanical structure, moisture content, freezing capacity, besides, a significant amount of depressions catch runoff, becoming a watershed.

Index plot № 3(the Karasul river basin)

On the average the water collection of the river Karasul basin gives 35,6 mm of runoff a year (Fig. 3). The maximum runoff depth (76,4 mm) comes from ploughed natural boundaries with meadow medium-loamy soils of central inundated subtype of *inundated type of locality*.

The minimum runoff depth (16,3 mm) comes from ploughed natural boundaries with meadow sandy-loam soils of low-relief *ridge subtype of locality* of ridge type of locality and ploughed natural boundaries with meadow sandy-loam soils together with solonets natural boundaries of *above-floodplain forest-steppe type of locality*.

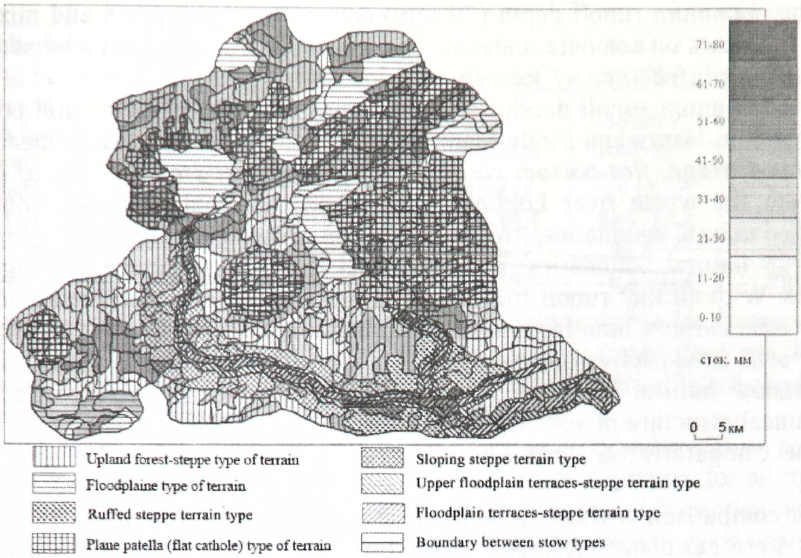

Fig. 3. Spatial variability of the runoff rated parameters in the landscapes of the river Karasul catchment basin (index plot №. 3, the forest-steppe)

The run off distribution in natural boundaries of the same type is very uneven. Possibly, the run off on the river Karasul water collection depends mainly on the mechanical structure and physical properties of the soil, from moisture content. For inundated type of locality a certain role is played by the relief, facilitating runoff increase. Considerable water collection bogginess facilitates runoff catchment.

Index plot № 4(the river Loktinka basin)

On the average all the water collection gives 49,4 mm of runoff a year (Fig. 4).

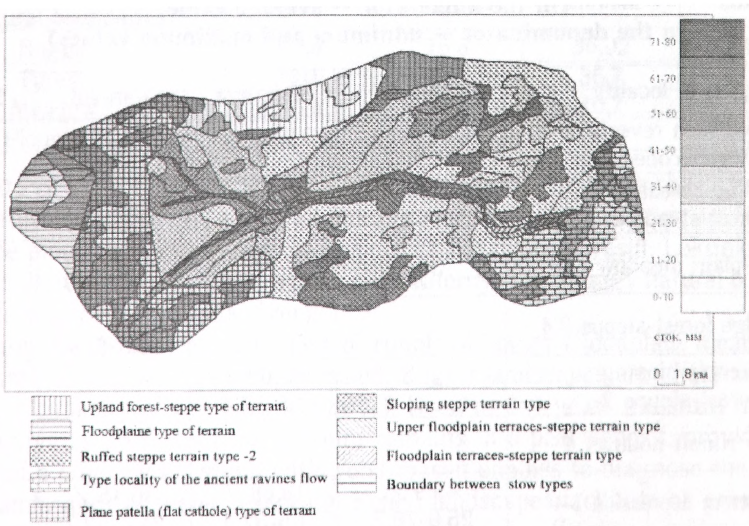

Fig. 4 Spatial variability of the runoff rated parameters in the landscapes of the river Loktinka catchment basin (index plot №. 3, the forest-steppe)

The maximum runoff depth (79 mm) comes from reed-grass and mixed herb-grass meadows on solonetz, meadow and black-earth light-loamy and sandy-loam soils of *inundated type of locality.*

The minimum runoff depth (29 mm) comes from ploughed natural boundaries with medium-loamy and sandy-loam black-earth and medium-loamy meadow soils *of upland, ridge, flat-bottom steppe and slope forest-steppe types of locality.*

From the whole river Loktinka water-shed the smallest runoff comes from ploughed natural boundaries, irrespective of soil and relief types. It is slightly higher in boggy natural boundaries. Forest natural boundaries show quite high runoff indexes. With all that runoff from forest natural boundaries with black-earth light-loamy soils is more than from forest natural boundaries on gray wooded medium-loamy soils (irrespective of type of locality). The highest runoff indexes are given by meadow natural boundaries. Runoff formation is mainly influenced by the mechanical structure of soils and forest vegetation.

The comparative analysis of the runoff in the landscapes of the index plots group.

For comparison of runoff function of the index plots landscapes average runoff values were calculated. Average, minimum and maximum runoff values of each water collection types of locality are specified in table 1. From the table it is clear that the minimum average and absolute runoff indexes have been defined for the Kiternya river water collection. As a whole, rather low runoff indexes are characteristic for this index plot. The maximum average and absolute runoff indexes have been revealed for the Loktinka river catchment basin landscapes. The run off indexes from the Barsuk river water collection are closer to similar indexes of the Loktinka river water collection. The corresponding runoff indexes for the Karasul river water collection are a little lower.

Table 1

Runoff rated parameters of index plots water collections types of locality, mm (in the numerator — average value, in the denominator — minimum and maximum values)

types of locality	Barsuk	Kiternya	Karasul	Loktinka
have been revealed on water collections	1	2	3	4
upland sub-boreal forest 1 / forest-steppe 2-4	42,8 / 25,8-71,1	17,67 / 3,6-28,4	35,72 / 24,7-52,7	48 / 29-71
flood-plain meadow 1-4	30,3	17,25 / 3,6-18,3	37,77 / 27,8-52,7	47,38 / 31-65
low-ridge forest-steppe 3,4			31,95 / 16,3-61,6	47,57 / 29-71
steeply-sloping forest-steppe 2		20,04 / 1,5-37,4		
early runoff hollows 4				49,9 / 31-65
flat-bottom depression 1-4	42,9 / 25,9-78,7	18,88 / 1,5-37,4	36,45 / 24,7-52,7	49 / 29-65

The end of Table 1

valley-sloping 1 / sloping forest-steppe 2-4	40,6 / 25,8-71,1	20,73 / 3,6-28,4	31,44 / 18-52,7	42,11 / 29-55
terrace above flood-plain sub-boreal forest 1 / forest-steppe 2-4	47,99 / 30,2-78,7	22,1 / 3,6-37,4	35,36 / 16,3-52,7	54,11 / 36-71
inundated sub-boreal forest 1 / forest-steppe 2-4	46,7 / 30,2-78,7	32,4 / 3,6-49,4	37,68 / 24,7-76,4	64,14 /36-79
watershed	43,1 / 25,8-78,7	**20,5** / 1,5-49,4	35,6 / 16,3-76,4	**49,4** / 29-79

The comparison of the results of the runoff research from the landscapes of the index plots catchment basins testifies that the climatic factor does not have a considerable influence on runoff rate (having the most drought-afflicted conditions, the Loktinka river watershed gives the highest indexes).

The soil factor (first of all, mechanical structure of soils and moisture content) matters for specific landscape conditions, but the general regularity for all the four index plots has not been revealed. The leading factors for runoff formation from the landscapes of all key water collections are the following: presence of wood vegetation, hyperhumidity and bogginess, economic activity.

The authors consider that it is more logical to analyze average runoff values distribution both in individual and general perspective according to the groups of natural boundaries combined with account of forest vegetation presence, hydromorphic feature degree and economic activity presence. On this basis four groups of natural boundaries — boggy, forest, meadow, ploughed — have been allocated for all index plots. The result of runoff rate averaging is given in Table 2.

Table 2

Average runoff indexes for groups of natural boundaries, mm

Groups of natural boundaries	Barsuk	Kiternya	Karasul	Loktinka
Boggy	***30,3***	18,5	36,02	45,6
Forest	39,01	***6,2***	36,7	53,7
Meadow	54,6	28,9	40,7	55,6
Ploughed	42,04	22,3	***29,9***	30,5

The data of table 2 testify that the highest runoff indexes are characteristic for meadow natural boundaries. The lowest indexes for each water collection are individual. They can be ploughed lands (water collections of the rivers Karasul, Loktinka), forest natural boundaries (water collection of the river Kiternya) and boggy natural boundaries (water collection of the Barsuk river).

High importance for the formation of runoff of boggy (floodplain meadow) and forest natural boundaries has been revealed. Boggy landscapes are characterized by big moisture capacity of peat (up to 680%). Even in dry years moisture from bogs to runoff activates 25%. Its basic amount remains in a peat deposit, providing self-regulation of a bog massif which with good reason enables to diagnose the function of boggy landscapes as water reserving. Forest landscapes facilitate an even spatial-temporal runoff distribution, transition from surface run off into underground.

The connection of the runoff with the Ishim plain landscapes is carried out through climatic runoff indexes in "precipitation-runoff-evaporation" system. Intraregional runoff peculiarities are connected with group properties of locations within types of locality. Detailed (and more accurate) picture of territorial variability of runoff rates can be seen according to the types of natural boundaries.

It is established that to analyze runoff distribution using types of locality and their subtypes as operational units is inexpedient because the values are coarse (averaged). Essential runoff distinctions are shown at the level of types and sorts of natural boundaries that enables to reveal the runoff dependences on physico-geographical and social factors. The indexes of runoff from natural boundaries show the real picture of the runoff differentiation on water collections.

In terms of landscape planning for a sustainable development of the territory it is expedient to carry out on the basis of hydrological interpretation of large-scale landscape maps. Therefore, it is becoming necessary to prepare large-scale maps for objectification of knowledge of runoff spatial organization and landscape and hydrological conditions. Visualization of spatial differentiation of runoff parameters and hydrological landscape function lets the cartographical model become the basis and the tool for landscape planning and control for geochemical (first of all, technogenic) substance streams.

While carrying out landscape planning within the Ishim plain it is necessary to consider:

- the mechanical structure and physical properties of soils at water collection points;
- the maximum runoff of natural boundaries, ploughed with heavy-loamy soils;
- the existence of forest or meadow vegetation;
- the degree of hydromorphism and halogenesis development.

It is necessary to pay special attention to boggy, floodplain meadow natural boundaries as water regulators and natural filters of water, to keep the area of forests and floodplain meadows for providing runoff norms.

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