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Anthropogenic Influence on River Basins and Water Resource Management

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Abstract

The paper examines the impact of anthropogenic transformations on the water regime of rivers. The organization of land use territory is proposed as the main stabilizing measure for the conservation of water resources. The impact of the components of land use territory organization on the river regime is considered using the example of the catchment area of the small Golovesnya River. In general, the study area shows an increase in precipitation and air temperature, as well as throughout Ukraine. However, in the fluctuations of water and sediment runoff since the late 80s and early 90s of the last centuries, a decrease in their values is noted, which is associated with a decrease in the area of arable land and an increase in the forestation of the catchment area. The conducted experiments show the existence of a significant response of the river catchment to agricultural activity, and highlight the ways of ensuring regulatory influences on river catchments, in which the organization of land use territory is of significant importance.

Keywords: Catchment Area, Water Resources, Sediment Runoff, Organization of Land Use Territory, Composition of Crop Areas.

Introduction

Water bodies, including rivers and the hydrographic network, are an element of the landscape. Man in the course of his life adapts to the surrounding landscape and adapts it to his needs. This often leads to negative consequences, but as a rule, the purpose of these adjustments is to ensure the livelihood of the population. There are two main components in the landscape - inanimate nature and living nature, it is the latter that reacts painfully to all kinds of adjustments. In addition to humans, external factors that do not depend on humans also affect landscapes - these are cosmic influences, namely solar cycles, periodic effects of the planets of the solar system, etc., as a result, we have climate fluctuations and changes. Climate changes are not always favorable for the existence of both humans and the surrounding biological component of the environment. Therefore, climate changes, on a global scale, affect the existence of both humans and other living organisms. Since a person cannot do without another living component of the landscape, adaptation to climate change must be carried out comprehensively - while preserving the living environment around him. And man and living nature cannot do without water in their arrangement. A person must, first of all, provide himself and the surrounding living environment with water [1, 2]. That is, the transformation of the landscape, which is already underway under the influence of the global climate, must be directed taking into account the factors affecting the preservation and provision of water resources. And it is not about preserving the rivers in the form they are now - it is about providing water. Humanity has already accumulated a significant amount of knowledge about the development of the hydrographic network and rivers, the factors affecting their development and hydrological regime, and which is now necessary to apply for the preservation of humanity as a component of the nature of the Earth (many river basins in different parts of the world are experiencing historical minimum water flow) [3]. In the 60s and 70s of the 20th century, many scientists worked on projects to divert river flows to expand irrigation areas and develop new unpopulated areas [4]. These were very ambitious plans, moreover, similar plans arose even before the October Revolution of 1917, it was they that strengthened the development of hydrological science, which showed the significant risks of manipulating water between large basins, and the danger of leaving already inhabited areas without water and with a different climate. It should be noted that similar projects arose all over the world (Canada, USA, China, etc.). Even in the world there are proven positive attempts to transform large basins (China, India, USA). In our country, there is more than 100 years of experience in transforming a territory cut by ravines into a steppe (on a part of the Derkul river catchment)

into a forested area, which also preserves already rare species of flora and fauna for this territory [5]. We are talking about the Yunitsky reserve, which is a continuation of the experiments started by V.V. Dokuchaev at the end of the 19th century to stop erosion processes in the weedy steppe. These experiments included attempts to afforest the catchments of streams and ravines, which was achieved thanks to the construction of water retaining structures in the upper parts of streams and ravines. These structures retain water from melting snow and rain and transfer it to the soil, thereby providing an opportunity for the growth of forest crops. We also have experience in creating anti-erosion complexes with structures of various designs [6-8]. As a rule, earthen anti-erosion structures are built on the basis of a 10% provision for delaying the runoff, in case of extreme runoff, it is recommended to discharge it through tinned hollows, or it is recommended to delay the runoff of a smaller volume, with the creation of an insulating effect with transverse bridges and safe discharge of excess runoff along borders, there are also projects of more capital structures on the rigging network with bottom water outlets at critical water flows to prevent overflow through the structure and its destruction, etc [9, 10].

All this shows that in order to preserve water resources and the living component of the landscape, it is necessary to arrange river basins. This arrangement should begin with small water catchments (sluice, beam, that is, from the upper links of the hydrographic network) by means of anti-erosion organization of the territory and agro-forestry reclamation.

However, there is still a negative attitude towards dams and dams in the world, so nature protection organizations (World Wildlife Fund WWF, National Ecological Center NEC, etc.) have been trying to demolish dams in Ukraine for more than one year in a row, relying on the experience of European countries and USA. There is even a world day of action against dams (March 14) initiated by the US. Yes, there are different aspects of the impact of dams on the environment and living creatures living in the water. But there are also facts about the disappearance of rivers in general. About 10,000 small rivers on which there were no dams have disappeared in Ukraine, most of the rivers (especially in the south) that have dams have more or less flooded channels to the dams and very small streams that are overgrown beyond them. Europe is currently experiencing a severe drought, which is considered to be the worst in the last 500 years, which is causing problems in many economic sectors related to the use of rivers (hydropower, transport, irrigation, etc.) [3]. The low level of water in rivers, the increase in air and water temperature contribute to overgrowth of rivers, which slows down the movement of water in them, contributes to stagnation of water and insufficient saturation of water with oxygen, which in turn affects aquatic organisms (fish, molluscs, etc.). This affects not only economic sectors, but also biodiversity. Now we already have very tragic examples of the removal of dams during military operations (Kakhov Reservoir, Oskil Reservoir) and the triggering of the levels of the Dniester Reservoir. All this had a very painful impact on human well-being and on the living nature around. Attempts to demolish a number of dams for the free movement of fish along the riverbeds leads to the shallowing of that part of the rivers that was supported by the dams and the existence of a water flow, at best, in a narrow root channel, and the environment for the vital activity of most species of aquatic organisms is sharply reduced.

The issue of preserving rivers and providing water resources cannot be solved in isolation from the arrangement of river catchments. The well-being of the population and the preservation of soils, living nature and its biodiversity, etc., depend on its solution.

Changes in land use and human economic activity in the watershed can significantly transform the structure of the water balance of the hydrological cycle and the spatial-temporal characteristics of the water resources of the territory, which confirms the need for a thorough analysis of the possibility of changing hydrological characteristics in various types of economic activity in the watersheds for the use of water resources [11]. Changing only the structure of forest areas can have an impact on the water balance of the territories [12].

In the study of erosion processes on slopes, the influence of the composition of seeded areas on the resistance to water movement and the erosion of the surfaces of small watersheds has long been noticed [13]. M.I. Lvovich and others [14, 15]. drew attention to the reduction of runoff during the agricultural use of catchments. The effect of land reclamation on the annual flow of rivers is manifested when the drainage area is more than 3% of the total catchment area [16].

Currently, the composition of seed plots is used in the modeling of hydrological processes (water runoff, sediments, hydrochemical parameters), as well as land productivity, in environmental problems. They are part of the CREAMS, SWAT, SWAP, WEPP, and other models [17-19]. Modeling is carried out both for large rivers and for small catchments. However, depending on the nature of the tasks, the availability of this information turns out to be small, and more often their influence is considered in the models by reverse calculation (introduction of corrections) [20]. The study of the direct influence of the catchment's land use structure on runoff and other hydrological processes is, for the time being, limited to the period of joint observations of the entire variety of studied factors.

The experience of predecessors shows that reliable empirical dependences between anthropogenic changes in the water balance and the characteristics of transformed catchments can be obtained only with a sufficiently wide range of these changes [11].

The objective of the research was to trace the influence of anthropogenic impact on the components of the hydrological regime of a small river.

Materials and Methods

The catchment of the Holovesnya River, which is the right tributary of the Desna River, with an area of 29.5 km^2 (Table 1, Figure 1), located in the zone of mixed forests, was chosen as the subject of the study. A complex of hydro-meteorological, agro-meteorological, water balance, etc. observations related to the list of works of the Prydesnianska Water Balance Station of the State Hydrometeorological Service of Ukraine. The beginning of observations at the Prydesnian water balance station dates back to 1929. For almost 95 years, the composition and subjects of research have changed somewhat, the most stable and uniform observations since 1954 are distinguished. In Figure 2. the change in the composition of land in the catchment area of the Holovesnya River over time is presented.

Table 1. Main Characteristics of the Holovesnya River Catchment.

Characteristic	Catchment area, km^2	River length, km	The width of the watershed is average, km	The height of the catchment is average, m	The slope of the watershed is average, ‰
Golovesnya - Pokoshychi	29,5	12,6	2,88	182	6,1

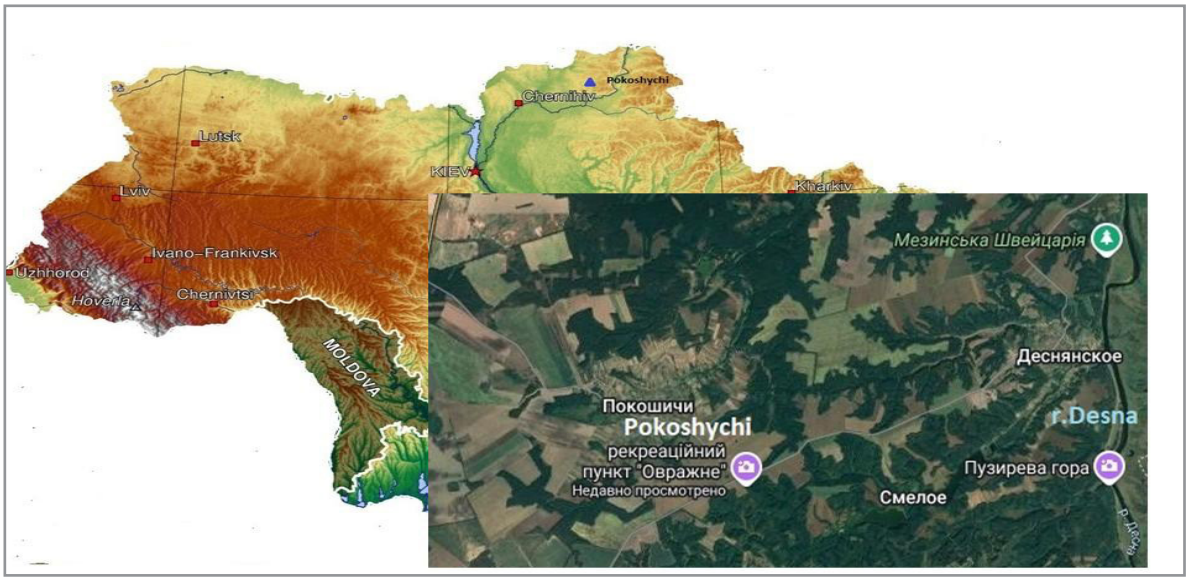

Figure 1: Map-scheme of the location of the Golovesnya River catchment (- ▲ location of the post Golovesnya- Pokoshychi). (Internet resources)

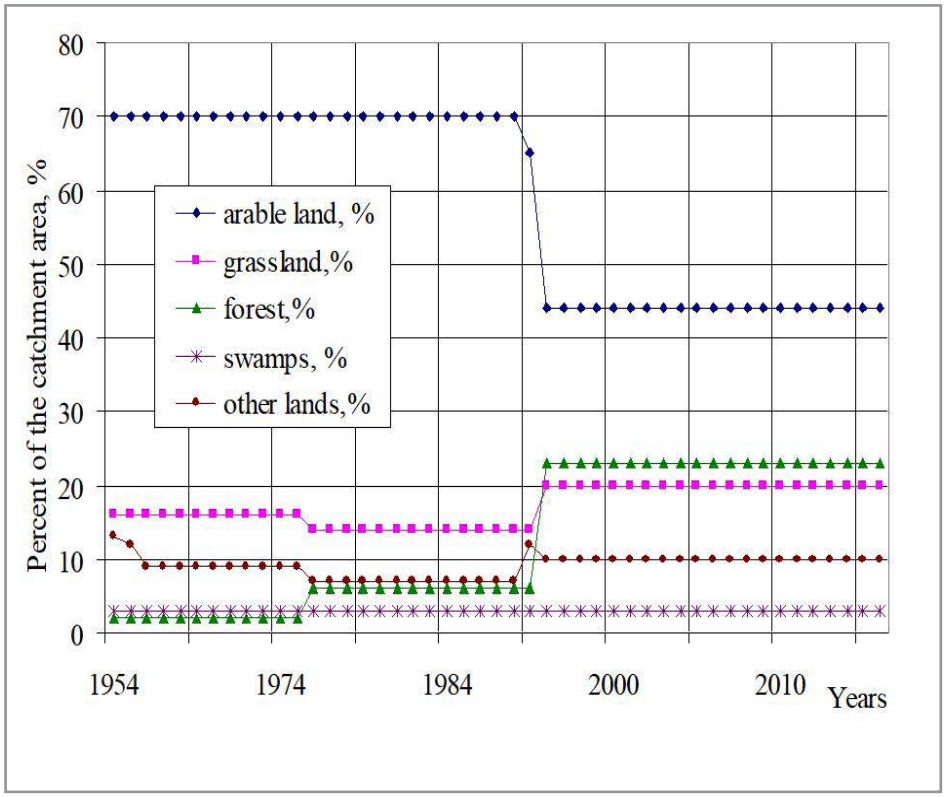

Figure 2: Changes in the composition of land plots on the catchment of the Holovesnya River - post Pokoshychi over a multi-year period.

Results

The organization of the territory of land use is a management measure that ensures the preservation of soil fertility, counteracts soil erosion and deflation, etc [14, 8, 21-24]. The fact that the structure of agricultural land (arable land, forests, meadows, etc.) and the distribution of crops areas (winter, frost, row crops, etc.) affects the runoff and wash-off from the slopes has been known for a long time [7, 8, 14, 24]. There are several dozens of methodical works on the regulation of denudation processes of anthropogenic and natural origin by measures of territory organization [7, 8]. The fact that it also affects the regime of water flow and sedimentation in the basins of small and medium-sized rivers is still in some places open to doubt.

The reaction of small rivers to the use of anti-erosion measures has not been studied separately, but there are studies of changes in the distribution of land composition (forest, arable land, meadows, etc.) and cultivated areas (winter crops, row crops, etc.), and they show the presence of significant sensitivity to of water and sediment runoff [22].

The analysis of observation materials of the Prydesnyanskaya water balance station showed that in the catchment area of the Holovesnya River, there is an increase in the amount of precipitation per year, as well as in the entire territory of Ukraine. However, in the fluctuations of water flow starting from the end of the 80s and the beginning of the 90s of the last centuries, of deph runoff is noted (Figure 3), this is due to a decrease in the area of arable land in the catchment and an increase in afforestation (Figure 4). In those years, a decision was made by the country's leadership to remove all degraded lands from the composition of cultivated areas and transfer them to eco-stabilizing lands (meadows, forests, etc.). Sediment runoff also shows a significant decrease over time (Figure 3) and this also corresponds to a decrease in arable land and an increase in afforestation of the catchment (Figure 5). The influence of the composition of sown areas on sediment runoff can also be traced on the example of the share of areas under winter crops (Figure 6).

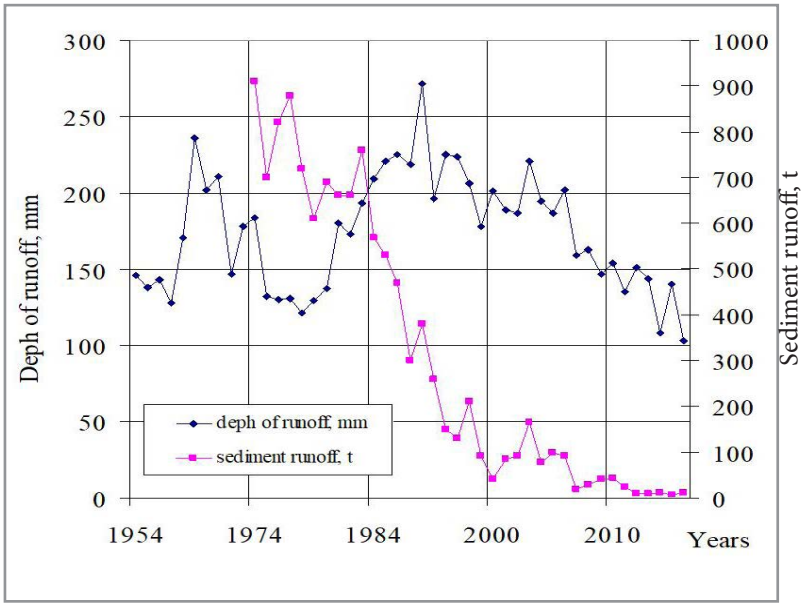

Figure 3: Changes in time of deph runoff and sediment runoff (in tone) for the year of the Holovesnya - Pokoshychi river.

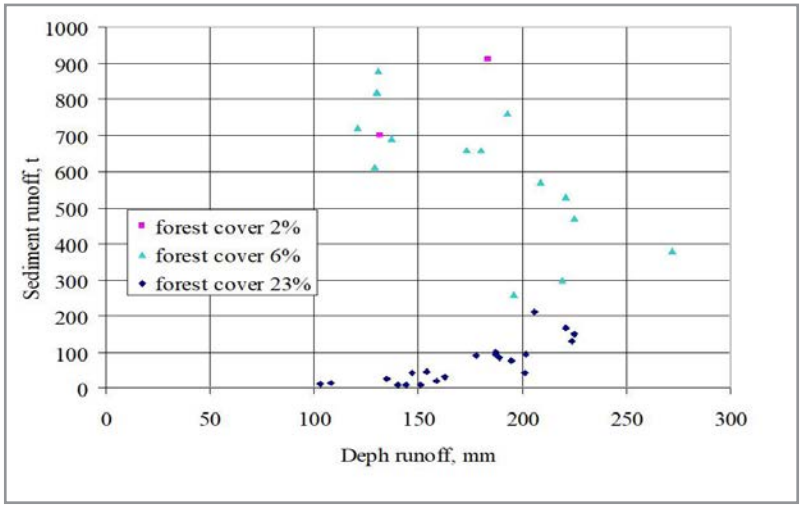

Figure 4: The relationship between deph runoff and sediment runoff in the Holovesnya - Pokoshychi river at different levels of forest cover in the watershed.

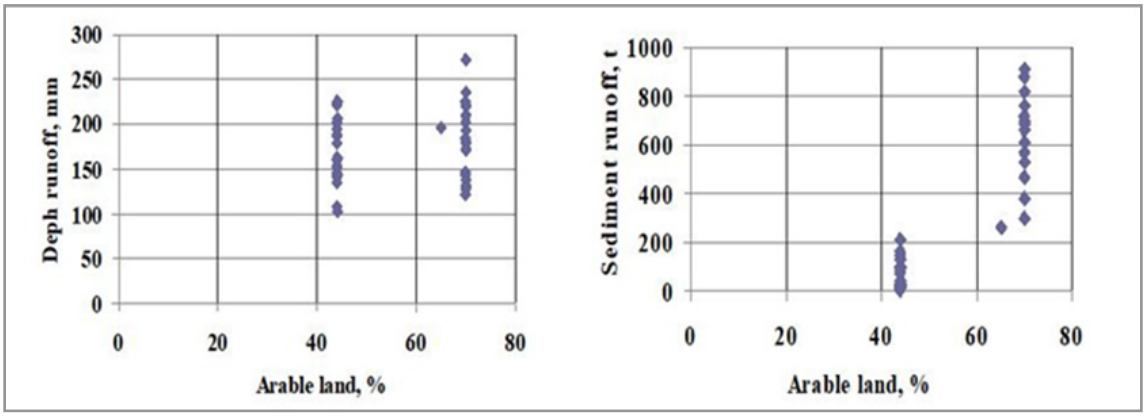

Figure 5: Changes in the deph runoff and sediment runoff during the year of the Holovesnya River for different percentages of arable land.

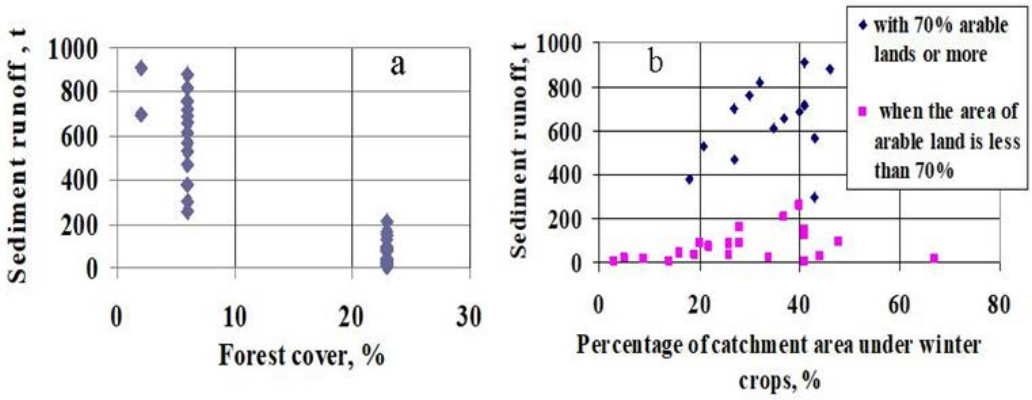

Figure 6: Dependence of sediment runoff per year in the Holovesnya River on: a – the percentage of afforestation of the catchment, b – on the percentage of winter crops in the catchment.

Conclusions

In recent years, slogans regarding river basin management plans to restore, stabilize and ensure the quality of water resources have become increasingly common. However, it is not only water quality that requires improvement. The preservation of water bodies as elements of the landscape becomes an urgent issue. In general, the study area has seen an increase in precipitation and air temperature, as throughout Ukraine. However, fluctuations in water runoff and sediment loads have shown a decrease in their values since the late 1980s and early 1990s, which is due to a decrease in the area of arable land and an increase in forest cover in the catchment area. The conducted experiments show the existence of a significant response of the river catchment to agricultural activity, and highlight the ways of ensuring regulatory influences on river catchments, in which the organization of the land use territory is of significant importance. The analysis of long-term series of observations of many components of the landscape in different physical and geographical conditions will help to reveal reliable dependencies between the components and show the direction of regulation of the components of the catchment system in order to improve the conditions of existence of the living component of the landscape.

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Author Contributions

All the work presented in this paper was conducted by the author.

Conflicts of Interest

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