UDC 504.4.05+06

RENEWABLE WATER RESOURCES OF NORTHEASTERN MACROSLOPES OF EASTERN CARPATHIANS AND THEIR QUALITY

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Versatile economic activity (deforestation, plowing slopes, etc.) has changed the water regime of the rivers of the Eastern Carpathians. Powerful floods occur more frequently now, and their destructive power has become greater. Significantly deteriorated consumer of surface water quality of Carpathians Northeastern macroslopes by hydrochemical indices. To preserve the renewable resources of natural waters of the Eastern Carpathians, you must stop clear-cutting of forests, to minimize the area of arable land, stop the discharge of untreated sewage into rivers, expand econetwork within the nature reserve fund.

Introduction. Volumes of receipt and consumption of natural water show a decreasing trend in Ukraine since 1990, except for the last few years [8]. However, the importance of renewable natural resources is increasing, as quality of surface waters continues to deteriorate. At the same time 64 new state enterprises were put on a list to use water resources in Lviv region during the four quarters of 2013. 29 of new enterprises users are based in the basin of the Dniester river, 24 – in the basin of the Western Bug, 6 – in the basin of the San, 5 – in the basin of the Dnieper. Ukrainian Carpathian mountains have a dense network of rivers (aver. 0,7 km•km^{-2}, and in some areas – 1,2 km•km^{-2} or more). The rivers of Northeast slope belong to the basin of the Visla, Dniester and the Danube (the major tributaries of the first order Seret and Prut). The majority of them belong to the Black Sea basin. Only in the North-Western part of the mountains a small amount of water flow of the river belongs to the San – tributary of the Visla river (table 1).

Table 1. Basin and main rivers of Ukrainian Carpathians

Basin	Name of river	Where tributary flows and it is right or left	Hydrographic length within the Eastern Carpathian, km	Basin area within the Eastern Carpathian, km^2
Visla	San	Visla (right)	52	2,4
Dniester	Dniester	Black Sea	245	11,6
Danube	Tisa with the Black Tisa	Danube (left)	250	12,8
	Seret from Borsukiv	Danube (left)	123	2,1
	Prut	Danube (left)	274	8,1

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Carpathian main watershed is dividing rivers of Northeast and Western macroslopes Eastern Carpathians. It is connected to the main European watershed near Užocký pass. Water resources of the Northeast slope of the Northeast Carpathians account for 10% of the total in Ukraine. This landscape has a dense river network. Density ratio watercourses are even greater, ranging from 0,94 $km \cdot km^{-2}$ (Prut river basin) to 2,5 $km \cdot km^{-2}$ (White Cheremosh basin) [4-6, 10].

The purpose of the article – to analyze the causes of quality deterioration and sustainability of water resources of the Northeast slope of the Eastern Carpathians in order to find measures to reduce their negative impact.

Material and methods. 40 observation stations are operating on the rivers of the Northeast slope [7]. The upper basins Tismenitsya, Sivka, Dniester, Oper, Slavka, Worona, Chechva, Seret, Prut, Limnytsya and White Cheremosh were an experimental watershed. We investigated the value of the soil and surface waterways content by dissection of the annual runoff hydrograph. We investigated the impact of the balance method for river flow, such as comparing the transformed economic activity with the natural flow [1]. We used the landscape and hydrological principle when assessing whether the transition from a point on the watershed in comparison to the whole of its area [3, 4, 6, 11]. We made a comparative analysis of the flow conditions of the Northeast slope of the Eastern Carpathians based study reporting material for State Hydrometeorology Committee [8].

Research results. Rivers of Western and Northeastern Carpathians makroslope have certain peculiarities. However, their also inherent common features. The origins of all Carpathian rivers are located high in the mountains. They start mostly from springs or swampy areas of mountain slopes. Major leak merges with the growing number of streams and along the flow turns into a flowing river.

The largest share of water resources is concentrated in the upper part of the river basins. There are more than 900 thousand m^3 of water per square kilometer in an average year water content area. Water resources are 2,94 $km^3 \cdot km^{-2}$ in the upper basin of the Dniester (leaked to the observation post Zhuravno, catchment area 9910 km^2). 2,63 $km^3 \cdot km^{-2}$ of water, or 90% of runoff flowing from the mountain catchments of the basin (area 4794 km^2). The volume of river water in the basin of the Prut (leakage to Chernivtsi) is 85,4%.

Rivers are typical mountain slope. They have a shallow channel. Rate of flow of the rivers is 1-2 $m \cdot s^{-1}$ and during floods increases to 5,9 $m \cdot s^{-1}$.

Well-defined flood regime of rapid fluctuations in the volume of runoff is a special feature of the Carpathian rivers. Small rivers turn into turbulent flow during flood in a short time. They destroy banks, roads, surrounding buildings.

Another important feature of weather conditions of the rivers of Ukrainian Carpathians – unstable and short freezing. He often interrupted by large thaws. There are 25–35 peaks raising the water level in the rivers of the Carpathians in an average year. They account for most of the spring and summer. Flooding occurs in the Carpathian rivers in spring (late February – early March in the mountains is late by about 15 days), when the snow melts.

The rivers of the Carpathians are full of water during floods. We observe the maximum levels in the mid and late March. Water raging in the rocky beds of muddy and turbulent flow, wash low-lying coasts. Spring tide supplemented rain floods frequently. High water levels in rivers remain in place until the end of April or early May. The general elevation of the water level reaches 3,4 m or more in that time. Flooding may take a catastrophic power combined with floods

[9]. This is particularly evident where the water at the outlet of the mountains spreads in the lowlands.

Water levels rise even more in the Carpathian rivers during the summer floods, during some last years, prolonged and intense rains. Water levels in rivers often rise again sharply in May as a result of torrential rains. 15–20 or more peaks of rain floods happen during the summer. The highest summer elevation of water levels reach 4,5 meters or more. They are usually in June and August. Floods last an average of 5–15 days to 1 month.

Shallow river late summer, coming during the summer-autumn low water. Then even the largest of them do not flood the shimmering stones that have accumulated in the beds. Limitations generally last from September to November, but it is often disrupted less intense autumn rain floods.

We note the catastrophic flooding in the northeast Ukrainian Carpathians macroslope in the warm season (June-August) 1911, 1927, 1941, 1947, 1948, 1955, 1959, 1964, 1969, 1970, 1974, 1977, 1980, 1982, 1989, 1992, 1993, 1997, 1998, 2001 and 2008 [10]. Floods in the Carpathians are a regular feature of the hydrologic regime, flood large areas, causing nature, economy and population huge losses. They were repeated every 10–15 years earlier. Now floods are repeated three or four years.

Watercourse cut in banks, eroding rocks reveal aquifers, so never dry up. Most of the river flow – 64,5%, is established in the warm season. It is 19,2% in the cold season, and 16,3% – during snowmelt. Water flow mainly formed by internal soil runoff in all seasons. This portion of river flow varies from 44,5% during snowmelt to 61,2% during summer. Share of 38,5% of the flow is formed in the cold season due to underground (basic) income, and only 6% – from surface runoff. However, 41,9% of the water flowing from the surface during snowmelt, and only 13,7% is underground revenues. These figures are 18,8 and 20% during the summer. Daily water levels in rivers are random and unpredictable alternation of floods. The general elevation of water levels in rivers is very fast. The average intensity of raising the water level by intense floods reaches 1,5-3,5 $m \cdot day^{-1}$.

Mostly stream draining the water formed during rainfall in the basins of the rivers on the northeast slope of the mountain areas. Carpathian rivers carry a great job with devastating torrential rains and sustained. Then the formed surface runoff, which river water removal of products of soil erosion in the form of suspended particles. The average annual runoff of suspended particles is 1-2,5 $t \cdot ha^{-1}$, in the mountains of 2,5-5 $t \cdot ha^{-1}$ and more at the foot of the mountains. For example, the Prut river makes a total of 1 million tons of soil and river Dniester – up to 2 million tons per year [2].

Evapotranspiration was greater in continuous primary forest cover of Carpathians than today. Its evaporation component was almost the same in different basins, such as the mountain area of the Lviv region. The situation changed in accordance with the transformation degree of the modern landscape. The amount of evaporation has increased 2,2 times from surface soil and water in a sector of large transformation. Maximum capacity retain water of indigenous forest cover was higher by 30% compared to today. There was a redistribution of power streamflow volumes for his constituents, depending on the degree of landscape transformation. Forest cover, which occupies more than half (63-90%) in the catchments areas of medium and low transformation contributes significantly transferable runoff in the mid ground. With the current situation in the Carpathian overall water balance of basin ecosystems of mountain areas has changed significantly due to the increased proportion of river flow and decrease in evapotranspira-

tion. The loss of water transformation potential of basin ecosystems ranging from 16% to 43%, depending on the proportion of forests in the landscape of the mountain area of the Lviv region.

According to our calculations, the water makes 677,2 tons of soil from the main basin of the northeast slope of the year eastern Carpathians annually. Watercourses washed with 84,4% of the volume of soil in the warmer months. Watercourses render of 0,04 tons (cold season) to 0,54 tons of soil from 1 hectare (warm period) as a result of mechanical work of these catchments (table 2).

Minimum flushing plane predominates in the plains of the rivers of the Northeast slope. Total soil washed away by rain water depends on economic use. Indicators of flushing confirm that the maximum amount of fine soil particles are washed away on arable slopes. The intensity of erosion is greater in 40–110 times in such sites, compared with slopes covered field crops, and 450 times higher compared to slopes covered with grass [3].

Insoluble impurities (suspended particles) that come as a result of soil erosion in the channel, leading to an increase in turbidity streams. This causes the active heating water and reduce the amount of oxygen in it. The average amount of oxygen is about 11 mg•L^{-1} in the rivers of the Eastern Carpathians. However, the average amount of oxygen is 5,8-8,0 mg•L^{-1} in the rivers Dniester and Tysmenytsia. River carries the largest amount of substances in the dissolved state.

The water of the rivers of the northeastern slope of the Eastern Carpathians are a group of fresh and soft sub hydrochemical classification. It is a medium-mineralized (except he Tysmenytsia). The water of the rivers is hydro-dominated by calcium ions and the relations between them. It has a slightly alkaline (pH 7,3–8,1), caused by the predominance of bicarbonates of calcium and magnesium. For this indicator, the water is not different from most of the rivers of Europe.

Northeast slope water is classified as contaminated or dirty for chemical parameters in most rivers of the northeast slope of the Eastern Carpathians. Analysis of surveillance data shows that the level of good quality water is lost [1]. The natural background level or amount of dissolved mineral compounds is 190 mg•L^{-1} of nitrate nitrogen – 0,2-0,4 mg•L^{-1}, 0,1-0,2 mg•L^{-1} ammonia , phosphorus – 0,013–0,031 mg•L^{-1}. The current concentration of chemicals in drains exceeds the background during the year. In particular, excess nitrate nitrogen is 2-3, ammonia – 4–6, phosphorus – 3–5. Total mineralization in these conditions in 1,5–2,5 times higher than natural in the recent past (table 3). Northeast slope water has a low mineral content (up to 150 mg•L^{-1}) in the basins of major natural forestation and soil washing mode. The number of mineral nutrient elements is low. One liter of water contains 1800 mg•L^{-1} of dissolved mineral substances in deforestation plain landscape (eg, river Tysmenytsia).

Table 2. Total washout and removal of suspended particles from the watershed year of major northeastern slope of the Eastern Carpathians (catchment area 10 661 km²)

Year period	River flow		Total washout		Removal of suspended particles	
	$м^3 \times 10^6$	%	т	%	$т \times га^{-1}$	%
Cool	929	19,2	43300	6,4	0,04	6,4
Melting snow	789	16,3	62200	9,2	0,06	9,2
Warm	3122	64,5	571700	84,4	0,54	84,4
Drain year	4840	100	677200	100	0,64	100

Table 3. Removal of chemicals major rivers of the northeast slope of the Eastern Carpathians in different periods of the year (over the line – tons of watershed areas, below the line – kg · ha^{-1}).

Year period	The amount of ions ×10^3	Nitrogen			Phosphorus	Petroleum compounds	Other common organic compounds	Metals
		ammonium	nitrite	nitrate				
Cool	996,8	1226	33	2118	127	334	287	581
	0,9	1,2	0,03	2,0	0,1	0,3	0,3	0,5
Melting snow	796,9	989	24	1541	79	490	353	452
	0,7	0,9	0,02	1,4	0,1	0,5	0,3	0,4
Warm	3110,6	6581	130	7517	409	1132	1241	7208
	2,9	6,2	0,10	7,1	0,4	1,0	1,2	6,8
For the year	4904,3	8796	187	11176	615	1956	1881	8241
	4,6	8,3	0,15	10,5	0,6	1,8	1,8	7,7

Therefore, we explored the close dependence of hydrochemical conditions of the rivers on the depth economic activity at watersheds. In addition, in some areas, communal and technological effluents pass by cleaning systems and natural barriers fall into bed and rapidly increase the salinity of the river water.

We have found that there is a close dependence of chemical runoff of water during different periods of the hydrological regime of the rivers of the Northeast slope. The value of the ion flow reaches 3110 kg•ha-1 in the warm season (table 3). It declines to 997 kg•ha-1 during the cold period to 797 kg•ha, as snow melts. This trend is the same in relation to the removal of other substances.

The use of water from the river is the main source of water supply in regions and cities of the Northeastern slope of the Eastern Carpathians. Share of 57%, or about 21 million m3 of total water intake is taken from surface waters each year. 23% of water is used for production needs of the total intake.

The volume of industrial, municipal and domestic wastewater in the slope is 12,8 million m3. They dumped directly into the rivers. Only 44% of the water dropped corresponds to the category of regulatory net. Volume of 0,1 million m^3 (0,8%) contaminated wastewater enters the water bodies without treatment.

Conclusion. In the basins of the Northeast slope of Eastern Carpathians sometimes happens unsatisfactory treatment of industrial and municipal wastewater. The area of natural areas continues to reduce, causing destruction of forest vegetation. Applied inappropriate agricultural practices, such as plowing of agricultural land. They cause considerable flushing water to pesticides, fertilizers and so on. All these factors lead to a significant deterioration in the quality of river water. They also led to significant changes in the balance of quantitative parameters of surface runoff Northeastern slope of the Eastern Carpathians.

The current situation in the natural environment of the Eastern Carpathians makes it necessary to reproduce the natural forest cover of the mountains, to increase the share of natural landscapes and protected areas, limited arable farmland. Local self-government should pay special attention to prevent uncontrolled discharge of untreated municipal and industrial effluents into the rivers of the Eastern Carpathians.

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АНОТАЦІЯ

П. С. Гнатів, Н. Я. Лопотич. *Відновні водні ресурси північно-східного макросхилу Східних Карпат та їх якість // Биоресурсы и природопользование. – 2014. – **6**, №5–6. – С. 127–132.*

В Україні від 1990 року водозабір і споживання природної води демонструють тренд до зменшення, за виключенням кількох останніх років. Проте важливість збереження цього відновного природного ресурсу зростає, адже якість поверхневих вод продовжує погіршуватися. Ріки північно-східного макросхилу Карпат є типовими гірськими. На них добре виражений паводковий режим зі стрімким коливаннями об'єму стоку. Повені у поєднанні з паводком можуть набувати катастрофічної сили.

Неврегульована господарська активність (вирубка лісу, оранка схилів тощо) змінила водний режим Східних Карпат. Потужні паводки виникають тепер частіше, а їх руйнівна сила стала більшою. Споживча якість поверхневих вод північно-східного макросхилу Карпат за гідрохімічними показниками суттєво погіршилася. Для збереження відновних ресурсів природних вод Східних Карпат необхідно зупинити суцільне вирубування лісів, зменшити до мінімуму площі орних земель, припинити скидання неочищених стоків у річки, розширити екологічну мережу в рамках природно-заповідного фонду.

АННОТАЦИЯ

П. С. Гнатив, Н. Я. Лопотич. *Возобновляемые ресурсы вод северо-восточного макросклона Восточных Карпат и их качество // Biological Resources and Nature Managment.– 2014. – **6**, №5–6. – P. 127–132.*

В Украине с 1990 года водозабор и потребление природной воды демонстрируют тренд к уменьшению, за исключением нескольких последних лет. Однако важность сохранения этого возобновляемого природного ресурса растет, ведь качество поверхностных вод продолжает ухудшаться. Реки северо-восточного макросклона Карпат типичные горные. На них хорошо выражен паводковый режим со стремительными колебаниями объема стока. Наводнения в сочетании с паводком могут приобретать катастрофическую силу. Реки мелеют позднего лета, вступая в период летне-осенней межени.

Неурегулированная хозяйственная активность (вырубка леса, распашка склонов и т.п.) изменила водный режим рек Восточных Карпат. Мощные наводнения возникают теперь чаще, а их разрушительная сила стала больше. Потребительские качества поверхностных вод северо-восточного макросклона Карпат по гидрохимическим показателям существенно ухудшились. Для сохранения возобновляемых ресурсов природных вод Восточных Карпат необходимо остановить сплошную вырубку лесов, уменьшить до минимума площади пахотных земель, прекратить сброс неочищенных стоков в реки, расширить экологическую сеть в рамках природно-заповедного фонда.