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10. Сельское, лесное, рыбное и водное хозяйство

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DEVELOPMENT OF CHANNEL PROCESSES AND MUDFLOWS ON MOUNTAIN RIVERS OF THE PRYKARPATTIA

РОЗВИТОК РУСЛОВИХ ПРОЦЕСІВ І СЕЛЕВІ ПОТОКИ НА ГІРСЬКИХ РІЧКАХ ПРИКАРПАТТЯ

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Abstract. *Mudflows are a fairly common phenomenon in Ukraine and other countries of the world. In the Carpathian region of Ukraine, there are three mudslide-hazardous basins, which include the territories of Ivano-Frankivsk, Zakarpattia, Lviv and Chernivtsi regions. The second half of the twentieth century, as well as the twenty-first century, was characterized by a noticeable intensification of dangerous hydrological processes in the mountains of Central Europe. In some countries and regions, they caused large-scale flooding of adjacent territories, loss of life and destruction of transport highways, buildings and other economic infrastructure. With a certain periodicity, powerful mudslides, landslides of rock and subsidence of accumulative landforms cause local damage. The occurrence of floods and inundations in the Carpathians is multifactorial in nature, which often includes factors of not only natural, but also anthropogenic origin. Mudflow processes are characteristic of the Carpathian region, and therefore, high-quality forecasting of their development in space and time, as well as assessment of their impact on infrastructure facilities are extremely necessary. For a detailed assessment of engineering and geological threats to bridge structures, road surfaces, residential buildings and other infrastructure facilities due to the development of mudflow processes, floods, flooding and coastal erosion processes, it is advisable to use an integrated approach.*

Keywords: *mudflows, floods, flooding, landslides, anthropogenic impact.*

Introduction.

On the European continent, 56% of the forest cover has been lost, but the Carpathians have preserved the largest areas of mountain forest in Europe [1, 2]. Over the past centuries, undesirable quantitative and qualitative changes have occurred in

the forests of the Carpathians, which have significantly affected the ecological stability of the natural environment. Changes in the species composition of native stands to less moisture-intensive spruce, the water-regulating properties of which are 7–17 times less than those of primeval beech forests, have led to an increase in the likelihood of dangerous floods and floods. Scientists are greatly concerned about eroded soils, the appearance of which ultimately causes mudflows.

Mudflows are a fairly common phenomenon in Ukraine and other countries of the world. In the Carpathian region of Ukraine, there are three mudflow-hazardous basins, which include the territories of Ivano-Frankivsk, Zakarpattia, Lviv and Chernivtsi regions, where there are 219 large mudflow watercourses and over 400 small ones. In Ivano-Frankivsk region, there are 270 mudflow-hazardous watercourses, covering an area of 606.9 km^2. In Chernivtsi, 70 watercourses were identified, with an area of 255.5 km^2. In the territory of Lviv region, such watercourses are typical for the basins of the Dniester and Stryi rivers, where more than 50 mudflow-hazardous watercourses were recorded, with a total area of 305.5 km^2. And in the Zakarpattia region, there are 278 watercourses with a basin area of 1828.0 km^2 [3].

The main text

The second half of the twentieth century, as well as the twenty-first century, has been characterized by a noticeable intensification of dangerous hydrological processes in the mountains of Central Europe. In some countries and regions, they have caused large-scale flooding of adjacent territories, loss of life and destruction of transport highways, buildings and other economic infrastructure [4]. With a certain periodicity, powerful mudflows, landslides of rock and subsidence of accumulative landforms cause local damage. The root cause of such processes is heavy rains, especially long and intense, as well as the likelihood of causing or intensifying floods by significant snow reserves that quickly melt in the mountains during thaws [2].

The territory of the Carpathians (the basins of the Tysa, Dniester and Prut rivers) is one of the most flood-prone regions in Europe. This is due to the combination of physical and geographical factors, the main of which are hydrometeorological and orographic. The impact of anthropogenic intervention, which may not always meet the

requirements for preventing flood-hazardous processes and restraining their development, is also significant [2, 5]. An important consequence of channel erosion in the rivers of the Carpathian region is not only the development of dangerous hydrological, but also geomorphological processes. They manifest themselves in the form of bank erosion and landslide processes in the valleys along the rivers, as well as mudflows. In the studied region, these phenomena are particularly aggravated by uncontrolled deforestation and residential and economic development of coastal protective strips of mountain rivers. Due to the high risk of erosion spreading upstream to the Stryi River, with a decrease in the area of forest cover, the risk of intensification of mudflows and landslides increases, especially during extreme precipitation and intensive snow melting [6].

Mudflows pose a threat to infrastructure facilities, including roads and bridge crossings. In particular, in July 2020, the village of Lanchyn, as well as in 2021 near the city of Skole in Lviv region, mudflows flooded yards and houses, damaged the road surface (Fig. 1.). It is also worth mentioning the convergence of three mudflows within the Transcarpathian region, which were recorded in 2020 in the basins of the Rika and Teresva rivers of Tyachiv and Mizhhirya districts. Due to the significant spread of mudflows in the Carpathian region and their threat to hydrotechnical and civil construction facilities, as well as infrastructure and safety of life of the population of the region, it is advisable to monitor and predict their development. The main tool used to monitor and model the development of mudflows is geoinformation technologies [3].

In order to reduce damage to the roadbed in the area of influence of the mudflow, bridge structures are used that allow crossing the mudflow avoiding direct blocking of traffic and flooding of roads. Damage to bridges due to mudflows is mainly caused by such manifestations of these phenomena as impact, abrasion, erosion and vibration [3, 7-9].

The impact of a mudflow usually includes the impact of a swamp mass and the impact of large debris. The mudflow carries a lot of sediments, rock fragments, which have an abrasive effect on the bridge supports, and especially on the surface of the

support and the support beam. Therefore, the protective concrete layer of the supporting structure is destroyed, and the steel reinforcement ends up on the surface, which seriously affects the safety of the structure. Erosion causes the exposure of the support foundation, which also negatively affects the stability of the structure. As a result of sufficiently strong vibration of the mudflow, it can cause the formation of cracks in the bridge structure, which reduces its critical stability and increases the probability of damage to such a structure [3, 9].

а)

б)

Fig. 1. Consequences of the descent of a mudslide in the Carpathian region: a) the village of Lanchyn, July 2020; b) the city of Skole, July 2021.

Based on the analysis of the frequency histograms of the characteristics of mudflows and their basins obtained by the author [10], the most characteristic values

of magnitudes of mudflows and centers in the mudflow-hazardous areas of the Ukrainian Carpathians were identified (Fig. 1).

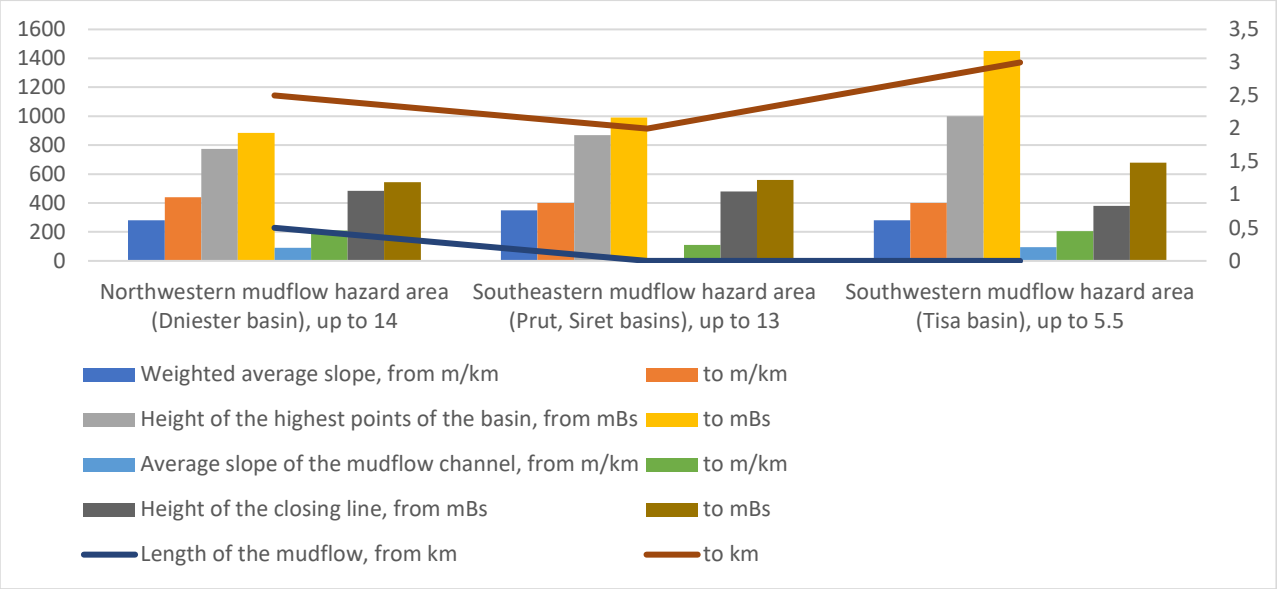

Fig. 2. Comparison of the most typical characteristics of mudflows and their basins for the Ukrainian Carpathians

Conclusion and findings.

Thus, the occurrence of floods and flooding in the Carpathians is multifactorial, often involving factors of not only natural but also anthropogenic origin. The main ones are such indicators of the territory as climate, geological structure, orography and relief, state of vegetation cover, features and nature of settlements, as well as human economic activity in the river basin.

Therefore, mudflow processes are characteristic of the Carpathian region, and therefore high-quality forecasting of their development in space and time, as well as assessment of their impact on infrastructure facilities are extremely necessary. For a detailed assessment of engineering and geological threats to bridge structures, road surfaces, residential buildings and other infrastructure facilities due to the development of mudflow processes, floods, flooding and coastal erosion processes, it is advisable to use an integrated approach. In this case, the tools of geographic information systems and remote sensing data of the Earth should be used.

References:

1. Commarmot, B., Bachofen, H., Bundziak, Y., Bürgi, A., Ramp, B., Shparyk, Y., Sukhariuk, D., Viter, R., Zingg, A. (2005). Structures of virgin and managed beech forests in Uholka (Ukraine) and Sihlwald (Switzerland): A comparative study. For. Snow Landsc. Res. 79, 45–56.

2. Nikolaychuk V.I., Vakerych M.M., Bilkey M.V., Chechuy O.F., Voloshchuk I. (2016). Possible ecologically sound ways of preserving and developing the Ukrainian Carpathians. Bulletin of Dnipropetrovsk University. Biology, Ecology. 24(1), 157–163. https://doi.org/10.15421/011619

3. Chepurna T. B., Kuzmenko E. D., Chepurnyi I. V., Gaydeychuk A. V. (2023). Geoinformation analysis of landslide hazard and assessment of threats to bridge structures within the territory of Zakarpattia. Bulletin of ONU. Ser.: Geographical and geological sciences. Vol. 28, issue 1(42). P.148-161.

4. Douben, K.J. (2006). Characteristics of river floods and flooding: A global overview, 1985–2003. Irrig. Drain. 55(1), 9–21.

5.Schad, I., Schmitter, P., Saint-Macary, C., Neef, A., Lamers, M., Nguyen, L., Hilger, T., Hoffmann, V. (2012). Why do people not learn from flood disasters? Evidence from Vietnam's northwestern mountains. Nat. Hazards 62(2), 221–241.

6. Snitynskyi Volodymyr, Khirivskyi Petro, Hnativ Ihor, Hnativ Roman (2021). The need to protect areas from flooding and shore protection on the rivers of Prykarpattia. Scientific Journal "Theory and building practice" (JTBP). Lviv: LPNU. 2021. Vol. 3, No. 1. P. 72-78. https://doi.org/10.23939/jtbp2021.01.072

7. Yuzhao Liang & Feng Xiong. (2019). Quantification of debris flow vulnerability of typical bridge substructure based on impact force simulation, Geomatics, Natural Hazards and Risk, 10:1, 1839–1862, DOI: 10.1080/19475705.2019.1641564

8. Deng, L., Wang, W., & Yu, Y. *(2016).* State-of-the-art review on the causes and mechanisms of bridge collapse. *Journal of Performance of Constructed Facilities. 30*(2) doi:10.1061/(ASCE)CF.1943–5509.0000731

9. Ivanyuta S.P. (2009). On the safety of functioning of bridges on Ukrainian

highways under conditions of engineering-geological hazards. Geoinformatics. No. 1 (29). pp. 82–90.

10. Surai K.S., Lukyanets O.I. (2017). Main characteristics of mudflow basins of the Ukrainian Carpathians: statistical analysis and features of their territorial distribution. Hydrology, hydrochemistry and hydroecology. Vol. 2(45). pp. 53-60.http://nbuv.gov.ua/UJRN/glghge_2017_2_8

Анотація. *Значне занепокоєння науковців викликають еродовані ґрунти, поява яких у кінцевому результаті спричинює селеві потоки. Для другої половини двадцятого, а також у двадцять першому столітті характерною стала помітна активізація небезпечних гідрологічних процесів у горах Центральної Європи. В деяких країнах і регіонах вони спричинили масштабні затоплення прилеглих територій, загибель людей і руйнування транспортних магістралей, будівель та іншої господарської інфраструктури. З певною періодичністю, завдають локальної шкоди потужні селеві потоки, зсуви гірської породи і просідання акумулятивних форм рельєфу. Першопричиною таких процесів є рясні дощі, особливо тривалі та інтенсивні, а також ймовірність спричинення чи посилення паводків значними сніговими запасами, що швидко тануть в горах під час відлиг.*

Виникнення повеней і паводків у Карпатах має поліфакторний характер, який часто включає чинники не лише природного, а й антропогенного походження. Серед них основними вважаються такі показники території як клімат, геологічна будова, орографія і рельєф, стан рослинного покриву, особливості і характер поселень, а також господарська діяльність людини у річковому басейні.

Тому, селеві процеси є характерними для території Карпат, а отже якісне прогнозування їх розвитку у просторі та часі, а також оцінка їхнього впливу на інфраструктурні об'єкти є вкрай необхідними. Для детальної оцінки інженерно-геологічних загроз для мостових споруд, дорожнього покриття, житлових будівель та інших об'єктів інфраструктури внаслідок розвитку селевих процесів, паводків, повеней і процесів берегової ерозії доцільно використовувати комплексний підхід. При цьому слід використовувати інструментарій геоінформаційних систем та дані дистанційного зондування Землі.

Ключові слова: *селеві потоки, паводки, повені, зсуви, антропогенний вплив.*

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