UDC 551.4 + 477.86

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FORECASTING OF DISASTER FLOODS IN DNIESTER VALLEY

Summary. *In recent years, two catastrophic floods have occurred in the Carpathian region and in Podillya: one on July 23–28, 2008, and the other on June 20–24, 2020. Both caused enormous damage to the environment and the population, which was widely reported in the media. To be prepared for natural disasters, you need to learn to predict them, that is, to know in what area they occur, what will be the height of the rise of water and when it will happen. From this triad, the first two components have already learned to predict, but the third has not yet. The article considers the possibility of a weather forecast, which was confirmed during the flood of June 20–24, 2020. O.M. Adamenko and D.O. Zorin plotted global climate change over the period of the Earth's history from its birth 4.567 billion years ago to the present. It turned out that the warm and cold periods alternated periodically, from the Galactic Year (225–250 million years), of which there were 19, to the current 11 summer cycles of solar activity. A total of 13 orders of cycles were identified, which interfere in the form of sinusoids, determining the periodicity of geological events. Geotectonic epochs of the 2nd order (50–70 million years) are superimposed on the cyclicity of the 1st order – galactic years – these are Karelian, Baikal, Caledonian, Hercynian, Pacific and Alpine tectonic-magmatic epochs, which are divided into parts of the 3rd (30–40 million years) and 4th (10–15 million) orders. The following cycles – 5 (3–5 million years), 6 (150–140 thousand years) and 7 (10–20 thousand years) are associated with a large Cenozoic cooling, which ended with the Quaternary glaciation. 8 (1–4 thousand years) and 9 (500–600 years) cycles reflect changes in warming and cooling in the quarter. And then the analysis of events is reconstructed on the basis of archaeological and chronicle data: from the beginning of our era to the XII century. Warming of the IX cycle continued – a small climatic optimum and a small ice age (XIII – XVII centuries). Since the XIX century modern warming began with clear 33-year fluctuations of the X cycle. Since 1881, instrumental observations have appeared at meteorological stations and hydro posts. XI (20–15–11 years), XII (5–6 years) and XIII (3–4 years) cycles appeared. Against the background of 33 annual fluctuations in the global climate, 11 annual cycles and catastrophic floods of 1911, 1927, 1941, 1955, 1969, 1980, 1988, 2002, 2008 appeared, and the catastrophic flood of 2020 predicted by O.M. Adamenko and D.O. Zorin. Thus, it is possible to learn to predict the time of the next catastrophic flood.*

Keywords: *floods; river valley; cycles; periods; landfill*

DOI: https://doi.org/10.32347/2411-4049.2022.2.112-120

Introduction

Problem statement in general and connection with important scientific and practical tasks. For many centuries, the population and environment of the Carpathian region and Podillya have suffered from catastrophic floods. Only the penultimate floodplain on July 23–28, 2008 flooded the valley of the Dniester, Prut and their tributaries to a height of 10 m, covering 70% of the territory of Ivano-Frankivsk, Lviv, Chernivtsi, Zakarpathian, Ternopil and Vinnytsia regions. According to the State Committee for Water Management of Ukraine [1], only in Ivano-Frankivsk region 417 settlements, 24 905 houses, 20 600 hectares of agricultural lands were affected, 602,6 km of shores were washed away, 25,445 km of fortifications were destroyed, 10,645 km of protective dams were damaged, 66 were damaged and 4 were damaged. 9 km of roads, 347 bridges, 24 water intakes were destroyed, 19 people died, including 5 children. Losses caused more than UAH 4,2 billion [2].

The catastrophic flood of 2020 occurred in several stages in different areas. Initially, on June 20–24, Ivano-Frankivsk, Lviv and Ternopil regions were flooded. Later, on June 29 – early July, the flood repeated in the Lviv region and "went" to Volyn. July 4–5 – again some regions of Ivano-Frankivsk and Ternopil regions, and July 7–9 – Volyn, Vinnytsia and Odesa.

Selection of previously unsolved parts of the overall problem. Previously studied the state of forests, flora and fauna, and other components of the environment, such as pedosphere, hydrosphere, air, were ignored, which negatively affected the strategic environmental assessment of nature reserves, ignoring the procedures of environmental audit and monitoring, reducing the level environmental safety of these important areas [1, 7, 11].

Thus, the aim of this article is a more complete coverage of all components of the environment and the development of a methodology for ecological assessment of soil and vegetation, water resources, air, and the impact of the technosphere on them.

The study was performed by the Department of Ecology of Ivano-Frankivsk National Technical University of Oil and Gas under the leadership of O.M. Adamenko, with the participation of M.I. Mosyuk, D.O. Zorin, K.O. Radlovska, N.O. Zorina and master's students – future ecologists. Field environmental studies on the monitoring network at 78 observation points [1] were performed from 2012 to 2019, and their analytical and computer processing – in 2015–2019 [1, 11, 16].

From the history of research. Since the northeastern border of the Dniester RLP is the Dniester River, its valley, especially the canyon. researchers have long been attracted. The first cartographic document was the General Map of Podillya at a scale of 1: 800,000, which was presented in 1650 by the French military cartographer W. Boplan under the Polish King Wladyslaw IV [17]. Since 1772, after the transition of Galicia to Austria-Hungary, the future territory of the Dniester RLP was several times "covered" by topographic surveys at scales of 1:28 800, 1:75 000 and 1:25 000. The maps are still stored in the Vienna Military Archives. In 1794–1805, the Slovak cartographer Jan Lipski made a map of Hungary, including Galicia [12].

The first published works belong to Polish geologists V. St. Staszic (1815), whose name is now the Krakow Academy of Mining and Metallurgy, J. Push (I. Push, 1830), E. Eichwald (E. Eichwald, 1846), N.P. Barbot-de-Marne (1867) [3, 15, 16]. Among the geological information of these authors there is a lot of data on the state of soils, waters and vegetation.

Systematic study of the nature of the former Galicia began with the removal of the scale of 1:75 000, which resulted in the publication in 1887–1907 "Geological Atlas of Galicia" [2, 17]. After the First World War, Polish researchers W. Zych (1930) and R. Kozlowski (1929) divided the sediments in the Dniester Valley into tiers and horizons by studying fossil fauna and flora. The study of Transnistria was conducted by the Romanian geologist G. Vascaucanu (1931) and the Russian specialists R.R. Virzhikovsky (1929, 1932) and G.F. Lungershausen (1941) [13]. Yu. Polyansky made a significant contribution to the study of terraces, fossil soils, forests and archeological monuments. His "Podolsk Etudes" has not lost its scientific significance until now [15]. After the annexation of Galicia to the USSR in 1939, work began on generalizing the previously collected material, which was reflected in the book "Geology and Minerals of the Western Regions of the USSR" (1941) edited by N.A. Behovera. After the Second World War, beginning in 1947, in the Western region of Ukraine began large-scale geological surveys, exploration and exploration with large volumes of seismic, magnetometric, electrical and other geophysical works, accompanied by large volumes of drilling with depths from hundreds to thousands of meters. This made it possible to study in detail the Quaternary sediments and geomorphology [5–8].

In 1959–1960, G.P. Shramenko, G.M. Padalko and P.G. Lazarenko performed a comprehensive geological survey at a scale of 1: 200,000 sheets of M-35-XXVI Volyn-Podolsk series, which directly relates to our research area [5–8, 10].

A large amount of natural material was collected by the expedition of the Lion Society, which worked on the Dniester in the 90s of the twentieth century. Its task was to develop a system of land, water and forest use on a landscape basis in the transition to a market economy. The research involved German colleagues (G. Plachter and others) from the Universities of Marburg, Dortmund, Frankfurt, and from the Ukrainian side – Ivano-Frankivsk National University of Oil and Gas, Institute of Ecology of the Carpathians, Lviv National University Ivan Franko, Institute of Environmental Monitoring, etc. (O.M. Adamenko, I.P. Kovalchuk, V.M. Stetsyuk, V.G. Omelchenko, O.M. Zhuravel, D.O. Zorin, etc.) [1, 10, 11, 14, 16].

In recent years, expeditions of the Lviv National University named after Ivan Franko (A.B. Bogutsky, A.M. Yatsyshyn), Maria Curie-Skłodowska University of Lublin, Poland (M. Lanchont), I. Krepyakevych Institute of Ukrainian Studies NASU (O.S. Sytnyk), Geological Institute of the Polish Academy of Sciences (T. Madeyska) [4, 5–12].

The ecological state of the geological environment, geomorphosphere, water resources, atmospheric air, soil and vegetation of the Dniester canyon was studied in the candidate's dissertation of D.O. Zorin, whose materials are partially published in his textbook [11] and ecological-tourist essay "Dniester Canyon". The works of D.O. Zorin we will use in the future, with component-by-component characterization of the natural environment of the Dniester Regional Landscape Park.

The main material

The first part of the triad is the territorial forecast. DILI has an area of 1460 km^2 – which is divided into 72 squares with an area of 20 km^2 on a scale of 1: 10000. The study involved 52 students of future masters, who assessed the ecological situation in each square, took soil samples and others. Thus, the landfill was mapped at a scale of 1: 10000 and maps of Quaternary sediments, geomorphological and landscape. Their joint analysis allowed to distinguish hypsometric levels of low (+ above the water edge in the Dniester and its tributaries), medium (+ 3 m), high (+5 m) floodplain and floodplain (+ 10–12 m) terraces [7, 10]. On this basis the Map of ecological risk of flooding of territories by catastrophic floods is constructed. This allows not only to perform spatial forecasting, i.e. which areas will be covered with water, but also to determine for each settlement, which will be flooded and which will remain "dry", from which it will not be necessary to evacuate the population.

According to geological (stratigraphic, paleontological, lithological, tectonic, radioisotope, and other studies of James Lehr, Douglas Palmer, Clare Peterson, Charles Walcott and Louis Alvarez, developed by the Smithsonian Institution in Washington, DC, New York Museum of History, the Institute of Human Paleontology in Paris [1], in the geological history of the Earth there are several elements of different orders (epochs, periods, cycles) of development [13–17] the path together with the solar system and the Earth around its (galaxy) center. There were 19 such revolutions since the birth of the Earth (4.567 billion years ago).

The cycle is an alternation of tectono-magmatic stages with a length of 50–70 million p., when geosynclinal depressions were transformed into mountain-folded systems, "soldered" by magmatic bodies. There were several such cycles not yet established in the Gadean, Archean, and Proterozoic eons – Karelian, Baltic, Caledonian, Hercynian, Pacific, and Alpine. Phanerozoic tectonic-magmatic stages are divided into III (30–40 million years) and IV (10–15 million years) orders – substages.

IV cycles are complicated by ecological catastrophes – collisions of the Earth with other space bodies (Wertford meteorite in the Proterozoic, Chixulub asteroid at the end of the Pacific tectono-magmatic stage – 65 million p. with a diameter of 300 km near Antarctica and the Permian extinction of biota), etc.

The closer to the present, the more detailed are the periodic cycles of historical and geological events. So, for example, according to archeological and paleontological researches of M.F. Veklych from the Kiev Institute of Geography of NASU, for the period from emergence of our ancestor Homo habilis 2,3 million p. therefore, 16 paleoclimatic changes took place in Kiev Rus (V – 3–1 million p., VI – 130–140 thousand p., VII – 10–20 thousand p.). At the end of each, there were extreme situations with climate change [5, 12] from warm and humid conditions to dry, cold and even glaciation. These are the Aidar, Kryzhaniv, Berezan, Azov, Martan, Sul, Lubny, Tiligul, Zavadov, Dnieper, Kaidak, Tyasmin, Pryluky, Uday, Buz, and Black Sea stages [6]. They were accompanied by extreme catastrophic phenomena.

Climatic optimum from the beginning of the new era until the XII century, when it was replaced by a small ice age (IX cycle) (XIII – XVIII centuries), followed by warming of the XIX – early XX centuries (X cycle). Interesting is the graph of climate change over the last millennium, when against the background of global climate fluctuations appeared 33 summer cycles of 1911, 1921, 1941, 1955, 1969, 1980, 1998, 2002, 2008 and 2020. This is the XI order of cycles with a frequency of 19–15–11 years, which is divided into XII (5–6 years) and XIII (3–4 years) cycles.

The resulting curve of climatic fluctuations throughout the history of the Earth is the superposition of sinusoids of the following order, which make it possible to compare the frequency of catastrophic floods after a certain number of years. Thus, we obtained the date of the flood of 2020 12 years after the previous flood of 2008 with a probability of 30%. This means that we are on the right track in predicting when this will happen, but it is not the main thing. It does not matter when it happens, in 4, 8, 12 or 1 year, the main thing is that it will happen and you need to be ready for the next one.

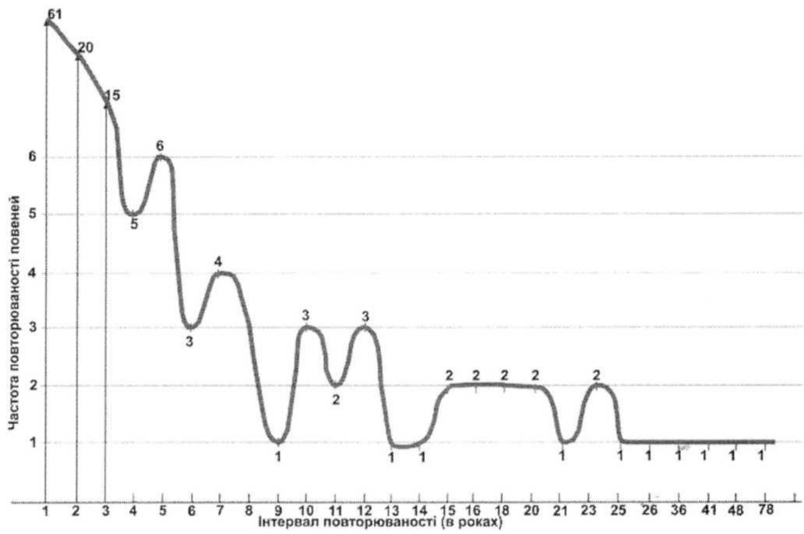

Fig. 1. The climate changes of Earth (4560 bil.y. – 14 thousand years)

What are the causes of catastrophic floods? There is a shift of 200–300 km of latitudinal climatic zones to the north – from temperate continental to Mediterranean. It is necessary to restructure the strategy of agriculture, forestry, water management in the new climatic conditions; unauthorized deforestation, which delayed 10 to 30% of precipitation [8–10, 13] on their way from watersheds to the main valley. It came to the point that the "bald spots" in the Carpathian forests became water reservoirs, from which streams dig their own way to the main valley. It is necessary to make an inventory of all "bald" according to space images and to oblige the relevant forestry's, united territorial communities and districts to afforest what has been cut down; stray selection of sand-gravel mixtures from riverbeds – to prohibit highways should not be built near rivers, but should be removed from the zone of influence of possible catastrophic floods at elevated levels II and higher floodplain terraces or slopes between rivers; in the construction of bridges, pillars should be described to the bedrock so that they do not "hang" in the alluvium, as can be observed now in the Middle Ages.

Thus, the above materials allow us to confidently (75–90%) predict the two parts of the triad – the scale of the future manifestation of floods, i.e. their spatial distribution and intensity of manifestation, or the height of water rise. The third component – when this will happen is still predicted with a low probability (up to 30%).

The recurrence of floods each year is a common occurrence when the snow melts. In 3–4 years there are summer floods, sometimes catastrophic. In 5–6 years they can recur, but reach maximum intensity in 11–15–19 years.

Discussion of the obtained results. The causes of catastrophic floods are natural and anthropogenic (man-made).

The natural ones are:

• western Atlantic cyclones, moving to the east, after crossing the Carpathians as an orographic barrier, "swirl" and fall with heavy rains (up to 3 monthly norms in one day), i.e. excessive rainfall;

• deeply dissected steep terrain promotes rapid descent of rainwater from the interfluves and slopes to the tributaries, and then to the main river, the level of which rises by several meters in a very short period of time;

• high moisture saturation of the soil substrate from previous rains, which reduces the water absorption capacity;

• seismic instability of individual blocks of the lithosphere;

• weak engineering-geological and physical-mechanical properties of bedrock – forests, loess-like loams and sandstones, menilitic argillites and siltstones, which spill quickly, form subsidence, which leads to siltation of tributaries, as well as landslides, mudslides, etc.;

• reduction of the protective capacity of forest vegetation, especially tall trees due to early cessation of vegetation, tree disease, drying of grass leaves in meadows;

• high water power, which causes high flow rates of water and others.

Anthropogenic (technogenic) factors include:

• mismanaged (illiterate) activities;

• planned and poaching deforestation of the Carpathian forests, the emergence of more and more "bald spots", and the forest cover could reduce the intensity of water elements by up to 30%;

• unsystematic plowing of watersheds without anti-erosion measures;

• construction of river floodplains, especially water protection zones and water protection strips;

• unauthorized extraction of sand-gravel-pebble mixtures from riverbeds, which intensifies bottom erosion and "entails" the intensification of force processes – landslides, mudslides, screes, landslides, etc.;

• construction of highways along riverbeds, and they need to be moved to higher levels;

• construction and restoration of bridges destroyed by floods without sufficient deepening of supports (piles) to the bedrock;

• destruction of Polonyn meadows, Polonyn forests and long periods of cattle grazing in the same areas, etc.

Conclusions

To overcome the consequences of the catastrophic floods of 2008 and 2020 and their possible prevention, it is necessary:

1. To instruct the Dniester Basin Department of Water Resources (here in after DBUVR) to develop a "State Program for Protection against Catastrophic Floods and Floods in the Western Region of Ukraine" (here in after SE) with the involvement of SES in Ivano-Frankivsk region, Department of Ecology and Natural Resources of Ivano-Frankivsk Regional State Administration, National Space Agency of Ukraine (NSAU), Space Information Reception Center in Dunaevtsi, Khmelnytsky Region, Ivano-Frankivsk National Technical University of Oil and Gas (IFNTUNG), Kyiv National University T.G. Shevchenko, Lviv National

University I. Franko, NTU of Water Management and Nature Management of Rivne, Institute of Telecommunications and Global Information Space of NASU in Kyiv, Institute of Hydraulic Engineering and Land Reclamation of NAAS and other organizations.

2. To support the initiative of IFNTUNG, which at its own expense created the Center for Forecasting and Prevention of Technogenic and Hydroecological Danger of Prykarpattia (CPPTGNP), approve its Regulations, Strategy for 2021–2023, Business Plan for 2021 and resolve issues of financing CPPG.

3. IFNTUNG to perform Strategic Environmental Assessment (SEA) of economic development in the prepared areas and 2–3 standard, Environmental Impact Assessment (EIA) of individual enterprises in Halych, Tlumach and Horodenka regions.

4. CPPTGNP to continue the development of AVIPS – an automated information and measurement flood control system taking into account similar systems on the Prut River in Chernivtsi, the Tisza River in Transcarpathia and the Danube River in Vienna (Austria).

When developing a SOE, take into account the solution of the following problems:

1. To substantiate the network of observations for constant monitoring of the environment and ecological audit of flooded areas.

2. CPPTGNP perform retrospective analysis of historical-geological, space, geomorphological, paleogeographic, archaeological, chronicle and instrumental methods to create a system of periodicity of extreme processes, in order to predict and prevent catastrophic floods.

3. To propose solutions to alternatives for the protection of the left bank of the Dniester in the Halych district: construction of a protective dam along the left bank of the Dniester from the village of Stary Martyniv to the village of Dubivtsi; construction of a bypass road from Halych through the village of Tustan and Bolshivtsi to the town of Burshtyn; organization of a spare polder between the dam and the road for loading flood water; increasing the height of the road and railway from Halych to Burshtyn.

4. To consider the issue of additional discharge of flood water of the Dniester by building a canal on the left bank between the villages of Nyzhniv and Dibrova.

5. Design the transfer of roads to non-flooding.

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The article was received 14.11.2021 and was accepted after revision 20.04.2022

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ПРОГНОЗУВАННЯ КАТАСТРОФІЧНИХ ПОВЕНЕЙ В ДОЛИНІ ДНІСТРА

За останні роки в Карпатському регіоні та на Поділлі відбулися дві катастрофічні повені: одна – 23–28 липня 2008 р. та друга – 20–24 червня 2020 р. Обидві завдали величезної шкоди довкіллю та населенню, що було широко висвітлено в ЗМІ. Щоб бути готовим до стихійних лих, потрібно навчитися їх передбачати, тобто знати, в якій місцевості вони трапляються, якою буде висота підйому води і коли це станеться. З цієї тріади перші два компоненти вже навчилися передбачати, а третій – ще ні. У статті розглядається можливість прогнозування, яке підтвердилося під час повені 20–24 червня 2020 р. О.М. Адаменко та Д.О. Зорін окреслили глобальні зміни клімату за період історії Землі від її народження 4,567 мільярда років тому до сьогодення. Виявилося, що теплий і холодний періоди періодично чергувалися, від Галактичного року (225–250 млн років), яких було 19, до нинішніх 11-річних циклів сонячної активності. Всього було виділено 13 порядків циклів, які інтерферують у вигляді синусоїд, що визначають періодичність геологічних подій. Геотектонічні епохи 2-го порядку (50–70 млн років) накладаються на циклічність 1-го порядку – галактичних років – це Карельська, Байкальська, Каледонська, Герцинська, Тихоокеанська та Альпійська тектоніко-магматичні епохи, які поділяються на частини 3-го (30–40 млн років) і 4-го (10–15 млн) порядків. Наступні цикли – 5-й (3–5 млн років), 6-й (150–140 тис. років) і 7-й (10–20 тис. років) пов'язані з великим кайнозойським похолоданням, яке завершилося четвертинним зледенінням. 8-й (1–4 тис. років) і 9-й (500–600 років) цикли відображають зміни потепління і похолодання в квартолі. А далі

аналіз подій реконструюється на основі археологічних та літописних даних: від початку нашої ери до XII ст. Тривало потепління IX циклу – малий кліматичний оптимум і малий льодовиковий період (XIII – XVII ст.). З XIX ст. сучасне потепління почалося з чітких 33-річних коливань X циклу. З 1881 з'явилися інструментальні спостереження на метеостанціях і гідропостах. З'явилися XI (20–15–11 років), XII (5–6 років) і XIII (3–4 роки) цикли. На тлі 33-річних коливань глобального клімату виникли 11-річні цикли і катастрофічні повені 1911, 1927, 1941, 1955, 1969, 1980, 1988, 2002, 2008 рр., як і катастрофічна повінь 2020 р., передбачена О.М. Адаменком та Д.О. Зоріним. Отже, є можливим передбачати час наступної катастрофічної повені.

Стаття надійшла до редакції 14.11.2021 і прийнята до друку після рецензування 20.04.2022

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