Фізична географія та геоморфологія (2022) 45, 1–6 (111–116), 39-48
https://doi.org/10.17721/phgg.2022.1-6.05

ORIGINAL ARTICLE

Особливості структури вибраних ділянок русла річки Чорної Тиси

Анастасія Дерій

Ягеллонський університет, вул. Інгардена, 6, Краків, Польща

Реферат

Метою статті є характеристика окремих ділянок русла, представлення результатів картування методою Krzemień (2012) та розгляд руслоформуючих чинників річки Чорна Тиса. Картування було проведене в днях 23.07.2020-28.07.2020. Під час типологічної класифікації річки виділено 34 базові відрізки. При класифікації прийнято до уваги різні фактори, в тім: перепад висот на кілометр бігу русла, наявність руслових форм, площа форм, висота берегів, берегова глибина врізання русла, літологічно-тектонічні фактори, а також фактори, що свідчать про антропогенний вплив на русло. Загалом зіставлено 16 факторів. За всіма параметрами були створені графіки, і на підставі аналізу меж відрізків при зміні тенденції параметрів до збільшення або зменшення на кінці відрізка визначалася межа. Місця, у яких збігалась значна кількість меж параметрів, були виділені як межі вищого рангу- типи русла, так і межі нижчого рангу – підтипи русла. За превалюючими процесами було виділено 7 типологічних ділянок. Від злиття Чорної Тиси з Апшинцем і до гирла потоку Плецького (12 км бігу річки) виділено русло акумуляційно ерозійне. До 24 км бігу річки русло було виділене як ерозійне (з домінуючою денною ерозією). До 29 км- з інтенсивною латеральною ерозією. До 34 км – виділено відрізок транспортаційний. До гирла потоку Тростянець (41 км) виділено відрізок з інтенсивною денною ерозією. До гирла потоку Сітний (45 км бігу) виділено відрізок з латеральною ерозією і депозицією. Відрізок до злиття з Білою Тисою охарактеризований як інтенсивної денної ерозії. Русло Чорної Тиси від злиття з Апшинцем до злиття з Білою Тисою має загальну тенденцію до глибинної ерозії (6 з 8 виділенних типологічних відразків), з локальними впливами інших домінуючих процесів, що залежить від багатьох чинників. Так, на відрізках, розташованих в Ясинянській улоговині, іншим процесом є акумуляція. На деяких відрізках відзначається сильний вплив діяльності людини (видобуток матеріалу з берегів та островів, укріплення (стабілазація) берегів, будівництво штучних порогів). Через ліквідацію природних руслових форм тут неможливо визначити натуральний домінуючий процес (транспортаційні та антропогенічно змінені типологічні відрізки, котрих виділено 4). Дослідження проведене в цій статті має як наукове, так і практичне значення, оскільки може стати підставою для планування протипаводкових заходів та змін в локальному плані забудови. Також подібні дослідження є важливими для освітянської діяльності в місцевостях до котрих відносяться ці праці.

Ключові слова

Типологія русел, флювіальні процеси, гірські річки, паводок

Надійшла до редакції: 24 вересня 2022 / Прийнята: 18 листопада 2022 / Опублікована онлайн: 30 грудня 2022

Features of the structure of selected segments of the Chorna Tisza river

Anastasiia Derii

Jagiellonian University, 6, Ingardena St., Kraków, Poland

Abstract

The paper presents an analysis of the structure of the Chorna Tisza river based on the fieldwork done in the summer of 2020. In this paper, the results of the riverbed classification by Krzemień (2012) are presented. During the typological classification of the river, 34 segments were identified, which were grouped into 7 typological segments according to processes prevailing in each. The classification takes a variety of factors into account, including: the difference in elevation per kilometer of channel run, the presence of channel forms, the area of the forms, the height of the banks, the bank depth of channel incision, the lithological and tectonic factors as well as factors indicating anthropogenic influence on the channel. A total of 16 factors were identified. It was revealed that Chorna Tisza's riverbed has a tendency to bed erosion mostly in all typological plots, which may be a problem for residents in the future. An attempt was made to predict the evolution of the riverbed based on the collected data and assessment of the human impact on the structure of the riverbed.

Keywords

River channel typology, fluvial processes, mountainous rivers, flood

Received: 24 September 2022 / Accepted: 18 November 2022 / Published online: 30 December 2022

1. Вступ

The Chorna Tisza river belongs to the upper part of the Tisza basin in the Inner Eastern Carpathians and is 50 km long. As stated in the geographic regionalization of Rudenko (2008), the Chorna Tisza catchment is located across three regions: Torun-Lopushansky, Yasinya and Svydovets-Chernohirsky. According to geomorphological

---

Corresponding author:
Anastasiia Derii, Jagiellonian University, 6, Ingardena St., Kraków, Poland
Email: asja.derii@doctoral.uj.edu.pl

classifications, this region consists of low and medium mountains (Troll, 1972).

The Chorna Tisza catchment itself covers an area of 567 km2 (https://buvrtysa.gov.ua). 69% of the catchment area are forests, 26% – meadows, 4% – fields and 1% – buildings (the author's calculations based on aerial images) (Fig. 1).

Since the Tisza river basin is one of the most flood-prone areas of Ukraine, the study of the riverbed development trends may be important for the identification of the most dangerous river sections. It is also important to demonstrate the human impact on the channel-forming processes and the results of economic activity in the vicinity of the channel.

The purpose of the article is to determine the morphological features of individual sections of the Chorna Tisza riverbed, the main channel-forming processes and the features of their changes under the influence of natural and anthropogenic factors.

2. Study of the problem

In the middle of the 20th century, the basic principles of fluvial geomorphology were created. The works that are considered to be fundamental include: the method of series analysis by Horton (1945) and Strahler (1952), the analysis of river slope by Hack (1957) and the work of Leopold and Wolmann (1957). The problems of river structure and channel typology were touched upon in the works of Kaszowski and Krzemień (1977), Chalov (1980), Rosgen (1996), Montgomery and Buffington (1997), Thorne (1998).

For the territory of the Ukrainian Carpathians, typology of river channels has been carried out quite rarely. Some examples are Wierzbicki (2010) for the Kuźmieniec Wielki stream according to Kamykowska et al.'s (1999) method and Yu. Obodovskyi (2018) according to Chalov's (1980) method.

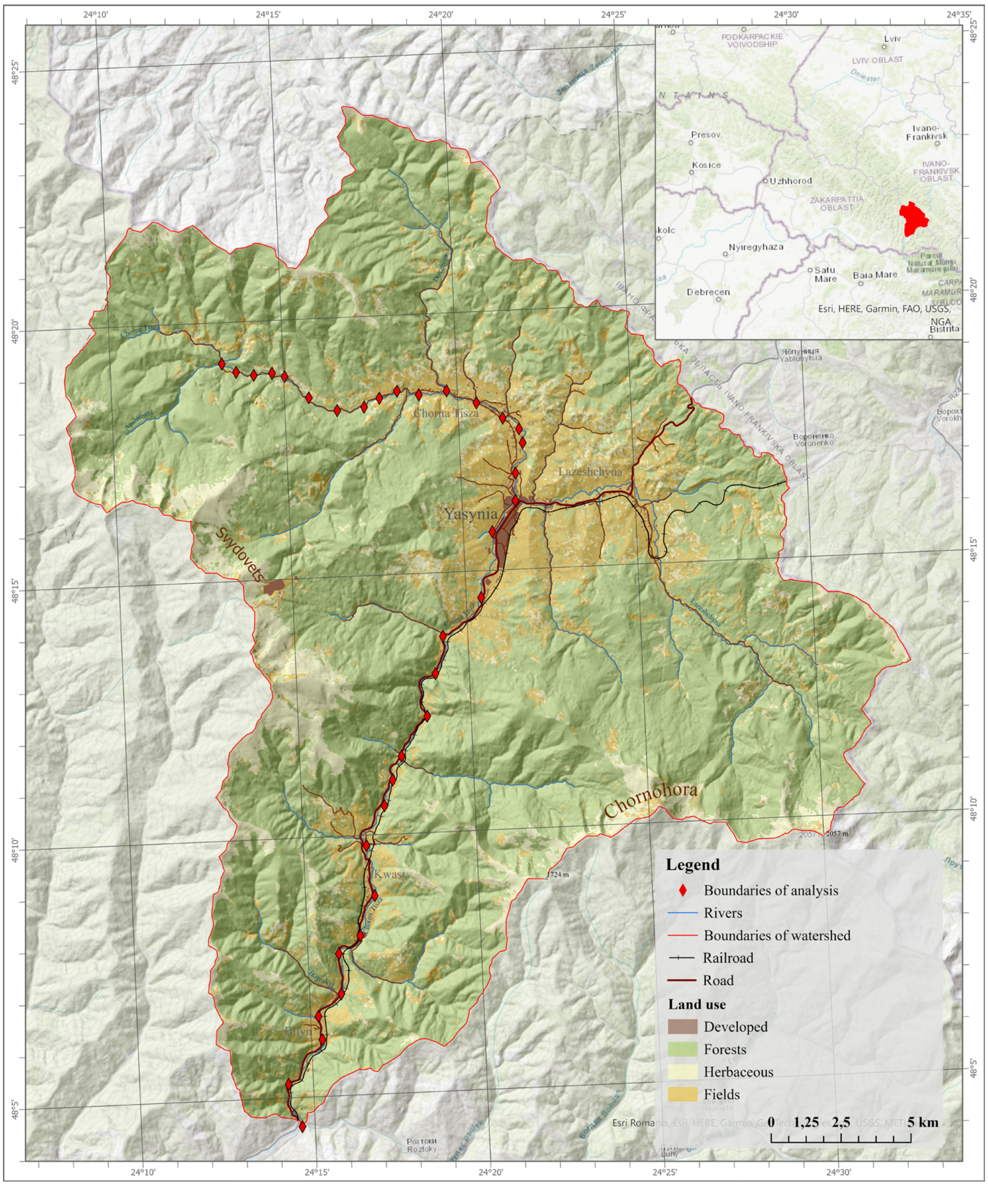

Fig. 1. Map of the Chorna Tisza catchment area with boundaries of mapped segments

Despite the low usage of typological river mapping techniques, the Chorna Tisza catchment is quite well studied. There are many geological and geomorphological works that refer to the elements of this catchment. Staszic (1815) is the first work pertaining to the Chorna Tisza catchment. At the beginning of the 20th century many works devoted to glacial themes were published: Gąsiorowski (1906), Pawłowski (1915), Romer (1904, 1906). The tectonics of the Krosno zone was described by Bogdanov and Pusharovskij (1950). There are comprehensive works on tectonics and stratigraphy for the territory of the entire Ukrainian Carpathians such as Bondarchuk (1959), V. Hlushko (1968), I. Gofstein (1995) and others. In the 21st century, many articles have been published on the geomorphology of the Svydovets massif (Krawczuk 2008, Kłapyta et al. 2020) and Chornohora (Melnyk 2018). O. Obodowski (2005) and Yu. Obodowski et al. (2018) describe the hydrometeorological features of this area. Botanical overviews of the region can be found in Biliak et al. (2013), Felbaba-Kluhina (2015), and Ustimenko (2015).

3. Materials and methods

The mapping was based on the morphometric segmentation methodology (boundary number methodology) (Kaszowski and Krzemień, 1986) developed at the Institute of Geography and Spatial Planning of the Jagiellonian University in Krakow (Kamykowska et. al. 1999, Krzemień 2006, 2012). This methodology consists in dividing the riverbed into homogeneous segments (in the case of Chorna Tisza there were 34 segments (Fig.1)). According to the typological classification of rivers (Kamykowska et. al. 1999, Krzemień 2006, 2012), homogeneous river sections are those where the same processes dominate. Each section was described separately during the fieldwork using the forms given in Krzemień (2012). During the fieldwork, information was collected on the channel parameters (width, depth, height and slope of the banks, etc.), the presence of features (rapids, shoals, sidewalls, rock outcrops and landslides associated with the channel formation processes), and the fraction of material in the channel is measured. Anthropogenic changes of the channel are also taken into account. The fieldwork was carried out by the author in the period 23.07.2020–28.07.2020.

To divide the channel into relatively homogeneous sections, cartographic materials (map at a scale of 1:100000, sheet M-35-133) and satellite images (Landsat, Sentinel) were used. To analyze the trends of changes in the riverbed, a comparative characterization of historical maps was carried out (mapire.eu.). A digital terrain model (Alos DEM) was used to calculate some parameters.

The following parameters were used to analyze the factors' complexity and their changes in the channel (Fig.2.):

Elevation difference per kilometer of the channel run. This parameter was calculated on the basis of the height above sea level of the segment boundaries and the length of these segments. This information was obtained from the digital elevation model (Alos DEM).

Channel depth / channel width. This parameter is calculated based on the water depth measurements near the shore and the channel width. Both parameters were measured during the field surveys and the channel width was additionally verified using satellite imagery (Google Earth).

Bank height / channel width. The parameter is set on the basis of measurements during field surveys. The channel width was additionally checked on the basis of satellite images (in Google Earth).

Amount of rapids. The parameter was established during field surveys.

Amount of rock outcrops. The parameter was calculated during field surveys.

Amount of point bars and island. The parameter was calculated during field research. This parameter was not verified on the basis of satellite imagery, because it was changed during the flood in June 2020.

The area of point bars and islands per kilometer of the channel run. During the field surveys, the maximum length and maximum width of all the point bars and islands were measured. It turned out, however, that the area calculated on the basis of the author's own data and the true area are slightly different. For this reason, the decision was made to calculate the index of the difference between the area of the forms along the maximum axes and the true area. To do this, 21 sidewalls (from different parts of the channel) were selected in ArcGis Pro (based on Landsat satellite images), and for each shape the area based on the maximum axes and the true area were calculated. The index was calculated for each shape (dividing the true area by the area based on the maximum axes), and then its average value was determined. For the Chorna Tisza riverbed this index was 0.71. Further, according to the data collected during the field studies, the arithmetic mean of the area of the sides and islands (along the maximum axes) was calculated, and then these data was multiplied by the index 0.71.

'Wildness' of the channel. The number of islands per length of the segment.

Lithological and tectonic boundaries. The data was obtained from a geological map at the scale of 1:200 000 (geoinf.kiev.ua).

Average maximum fraction of material from the channel. The data was obtained during field research. For this parameter, the 10 largest boulders (which were transported by the water flow) were measured, and the arithmetic mean was calculated from these measurements.

Length of bank reinforcement. To calculate this parameter, the length of the development on each side of the banks was outlined. Wood stabilization, concrete walls and gabions were taken into account.

Anthropogenic thresholds. Amount was calculated during field surveys.

Graphs were created for all parameters based on the analysis of the segment boundaries. The boundary was determined when the tendency of the parameters' changes (increase or decrease). The places where a significant number of parameter boundaries coincided were identified as higher rank boundaries - types of the channel, and lower rank boundaries - subtypes of the channel.

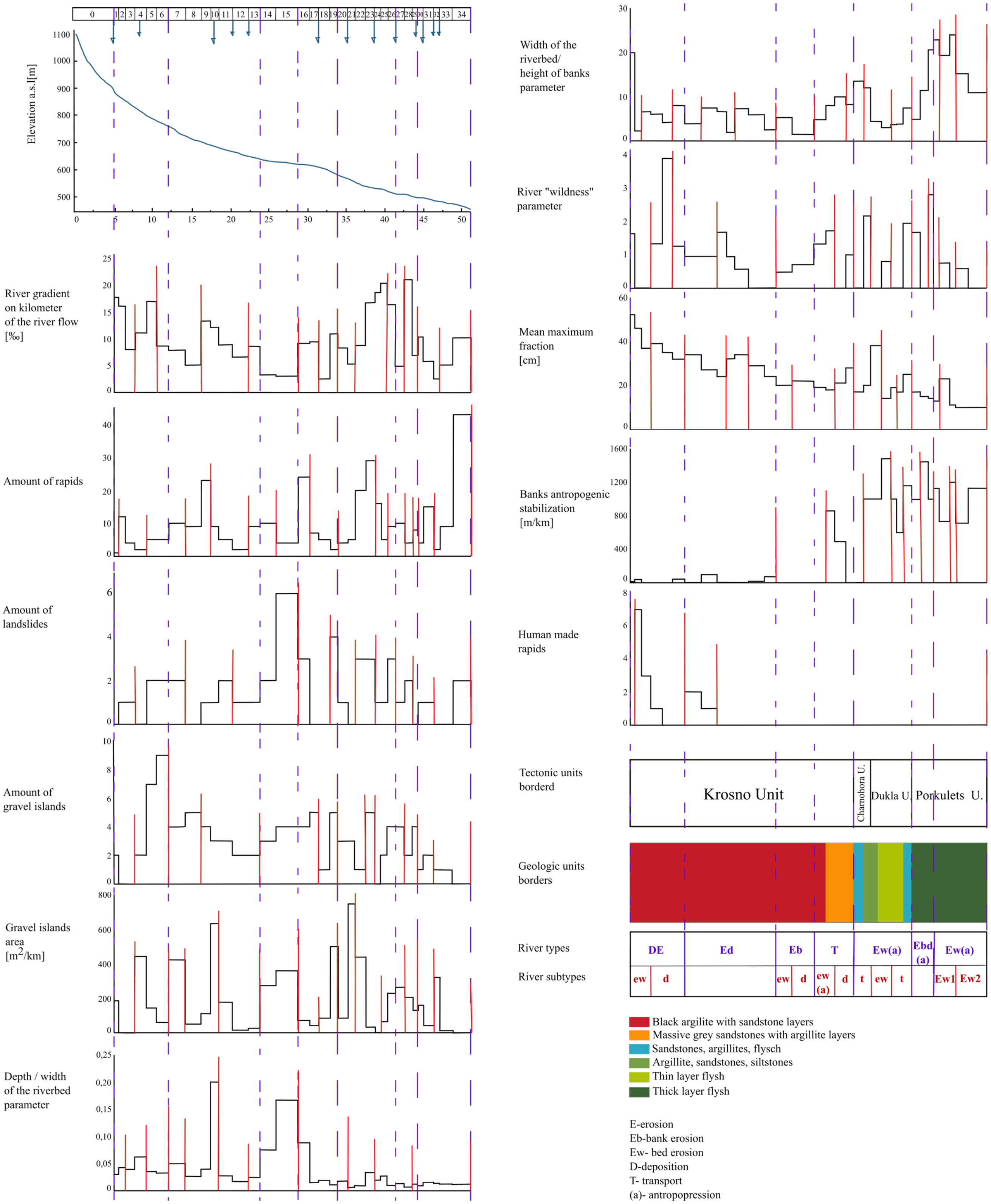

Fig. 2. Graphs illustrating parameter change

4. Discussion

The method of segment boundaries was tested in different regions of the world but it was most often used for mapping rivers in the Western Carpathians. The following studies exemplify the method: the mapping of the Raba River (Poland) (Gorczyca 2016, 2020), the Konin Stream (Poland) (Krzemień 1976) and the mapping of the Feshie River (Scotland) (Chełmicki and Krzemień 1999). Among the works related to the Eastern Carpathians, the article by Wierzbicki (2010), in which a comparative characterization of the structure of the Hulski stream and the Kuźmieniec Wielki stream was carried out, is of particular importance.

5. The results of the study

Since the mapping of the Chorna Tisza was carried out not from the source, but from its confluence with Apshynets, the so-called section 0 was introduced (Photo 1). This section was designated as exclusively erosive, with the dominance of bed erosion (Ew) (Fig.3.). This modification made it possible to interpret the material delivery to section 1.

DE - channel of deposition and erosion. It was highlighted in segments 1-6. This type is characterized by variable erosion and accumulation. This segment was modified by human activity only to a low extent: the bank was stabilized using wood in the vicinity of bridges and at meanders. A total of 11 wooden rapids were mapped in these segments.

Photo 1. The channel in the 0 section

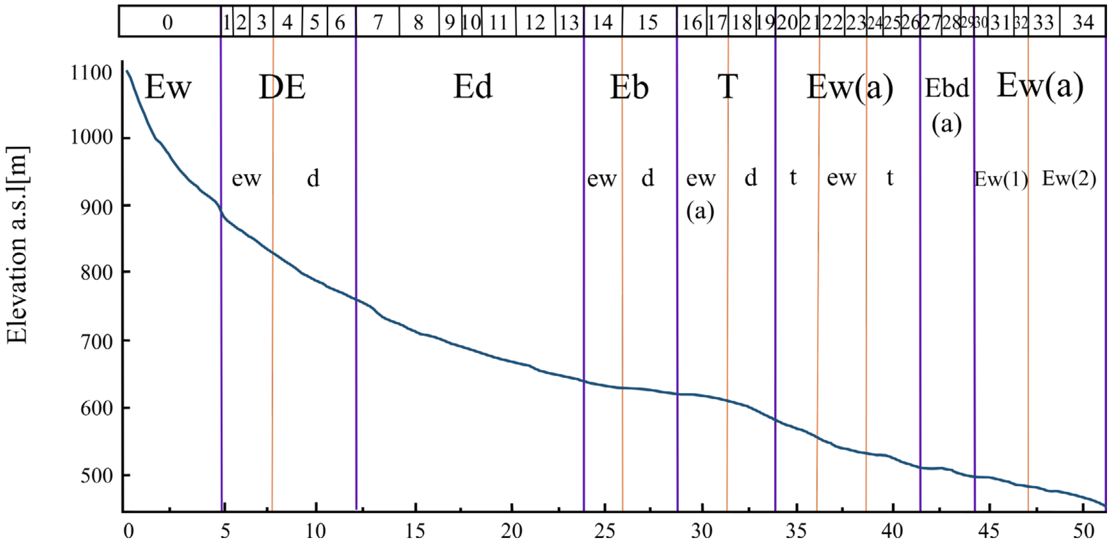

Fig. 3. The longitudinal profile of the Chorna Tisza with typological boundaries

However, the most intensive deforestation is observed in the vicinity of DE segment. To better characterize the channel along its entire length, the DE type was divided into two more subtypes. Thus, segments 1-3 were combined into the subtype *DEew* (dominated by deep erosion). The first segment is characterized by increased accumulation due to the presence of a splash dam in this place in the past. Segments 2-3 are characterized by a tendency to deep erosion, which was additionally intensified by the activity of splash dam (Photo 2.).

The *DEd* subtype was identified as accumulative on reaches 4-6 (Photo 3). The reason for such a characteristic is the presence of a large number of deposition forms such as point bars and islands of significant size. Locally, signs of erosion (sills and outcrops) can be found in this subtype, but accumulative forms prevail.

Photo 2. The channel on the section 2

Photo 3. Channel at segment 4

Type Ed was identified as erosive with local deposition. It was identified in sections 7-13. This type is relatively homogeneous and therefore no sub-types were highlighted. In this type, a series of rapids up to 4 m high were mapped. They are mutually interspersed with segments of sidewalls and islands. Segment 10 is indicative (Photo 4), as high values of Depth/width parameter (indication of bed erosion) are compared with high values of Area of sides and islands parameter.

Type Eb (lateral erosion) was identified in segments 14-15. High banks with the left bank exceeding the right bank are noted on these segments. In this type, bed erosion is noted, but lateral erosion is more pronounced in channel forms (a large number of outcrops (Photo 5). Segment 15 is also characterized by high channel sinuosity and the presence of large islands, which is why the subtype Ebd (lateral erosion with deposition) was also identified in this segment.

Photo 4. The channel on the section 10

Photo 5. Outcrop in section 15

Type T (transport) was allocated for segments 16-19. The reason behind this decision was the insufficient number of channel forms which did not allow to determine the main channel-forming processes (Photo 6). Human activity is an additional distorting factor. The extraction of gravel from the channel, stabilization structures, etc. cause destruction of channel forms. These segments were also divided into subtypes: *Tew(a)* - transport with a tendency to bed erosion and anthropopression, and *Td* transport with a tendency to deposition. The boundary between these subtypes is quite clearly visible on the longitudinal profile of the Chorna Tisza. At the confluence of the Lazeshchyna and the Chorna Tisza there is a profile flattening, which is most likely caused by sediment transport by the Lazeshchyna River. However, there are no channel forms that could more likely confirm this thesis in this section. The data on outcrops are also anthropogenically altered due to the banks' stabilization with concrete walls. The only parameter that may not have been changed to such a great extent is the elevation difference per kilometer of the river, and this parameter, in fact, decreases in section 18 relative to the neighboring sections. In section 19 there is already a tendency to deposition, which translates to the increase of all deposition parameters in the graphs.

Type Ew(a) – deep erosion with the influence of anthropopression, was highlighted in segments 20-26. 3 subtypes were identified in this type. In segments 20-21, the subtype *Ewt* was identified – *deep erosion with a tendency to transport*. The reason for the highlighting of this subtype is the structure of new bank stabilization, which does not allow to identify channel-forming processes. The *Ewew* subtype (*strong dominance of bed erosion*) was identified in segments 22-23. In these segments, traces of intensive erosion can be identified on the old bank stabilization (Photo 7). Moreover, the channel is anthropogenically narrowed in these segments, which increases the intensity of erosion processes. Segments 24-26 were identified as subtype *Ewt - bed erosion with a tendency to transport.* In these segments, the parameter of elevation difference per kilometer of river run increases in comparison with the neighboring segments, and the values for the area and number of point bars are increased as well, but the reason for this is the artificial point bars created during the construction of stabilization.

Photo 6. The channel on the section 17

Photo 7. The channel on the section 22

Type Ebd(a) – anthropogenic with lateral erosion and local deposition, was identified at segments 27-29 (Photo 8). This type is relatively homogeneous, so it was not divided into subtypes. Destruction of bank stabilization due to the intensification of lateral erosion was identified in all segments of this type, and outcrops of left bank terraces were localized in some places. In this type, the parameters of the number of laterals and the 'wildness' of the channel stand out against the background of the neighboring segments.

Photo 8. The channel on the section 27

Type Ew(a) – anthropogenic with the dominance of bed erosion, highlighted for segments 30-34. Segments 30-32 are combined into subtype Ew1 - a lower degree of bed erosion intensity (Photo 9), and segments 33-34 - into subtype Ew2 - a higher degree of bed erosion intensity. This division was used to bring attention to the intensification of erosion and cutting of the channel into the local erosion base. As a confirmation of this thesis, it is possible to present an increase in the number of rapids in the last segments.

Photo 9. The channel on the section 32

6. Influence of various factors on channel formation

Long-term channel forming trends can often be altered by catastrophic floods. Since the mapping took place between 23-28 July 2020, I was able to determine the impact of the June 2020 flood on channel changes. In general, several patterns can be identified: during floods, point bars and islands are extremely prone to pattern change due to erosion. The islands with dense vegetation cover are quite stable, so they are prone to surface reduction only in the coastal zones, where the vegetation is mostly herbaceous (Picture 3). Smaller point bars may be completely eroded and will be restored only in the event of a strong local tendency to deposition (e.g. at the confluences of rivers with a large longitudinal decline). On anthropogenically modified stretches, where the number of point bars is too small to expend all the energy of the water jet, erosion intensifies. This is best seen in the sections of type Ew(a), where during the flood the stabilization on a large section of the road was destroyed (Picture 7). Information on the intensity of deep erosion during floods for stream gauges was found in the works of O.Obodovskij (2006, 2018). Thus, for the gauge in Yasinya, a deepening of 84 cm was measured for 1968-2012, the gauge in Rakhiv shows a maximum deepening of 114 cm. However, according to the Bilyn gauge, the accumulation is within 14 cm, which can be explained by the local nature of the segment. During the author's own fieldwork, the intensity of deep erosion was determined on the basis of traces of deepening on infrastructure (bridge pillars, concrete stabilization of the railway). In the point of the channel which was anthropogenically narrowed to the greatest extent (section 23) it was noted that since 1894 (the year of the railway construction) the channel could have deepened even up to 1 m.

Intensive deforestation in the catchment area causes an increase in the delivery of material to the channel through surface washout and landslides. From our own calculations, it was determined that only in the period 2015-2019 forest cover of the catchment decreased by 18 km2. Such rates of deforestation cause an increase in the mass of material transported to the channel and tendency of temporary deposition of material in Chorna Tisza riverbed and later transport to Tisza bed during flood events.

7. Conclusions

To sum up, the channel of the Chorna Tisza from the confluence with the Apshynets to the confluence with the Bila Tisza has a general tendency to bed erosion (6 out of 8 highlighted typological segments), with local changes in other dominant processes. Thus, on the segments located in the Yasynia Basin, another process is deposition (typological segments DE and Ed). In some segments there is a strong influence of human activity (extraction of material from the point bars, stabilization of the banks, construction of artificial rapids). Due to the elimination of natural channel forms, it is impossible to determine the dominant natural process here (transport and anthropogenically altered typological segments). The research conducted in this article has both scientific and practical importance, as it can serve as the basis for planning flood control measures and changes in the local development plan. Such studies are also important for educational activities in the areas to which these works refer.

ORCID iD

Anastasiia Derii https://orcid.org/0000-0001-9287-9267

References

Biliak B. (2013). The features of vegetation cover of the oligotrophic sphagnum swamp Chorne Bahno in the territory of NNP «Zacharovanij kraj», *Nature Reserve in Ukraine,* 19 (1), 32–34. [Біляк Б. (2013). Особливості рослинного покриву оліготрофного болота "Чорне багно" на території НПП «Зачарований край». Том 19 Випуск 1, 32.]

Bogdanov A., Pusharovskij J. (1950). Osnovnye cherty tektoniki Centralnoj sinklinalnoj zony Vostochnych Karpat//*Izw. AN USSR. Seria geologicheskaja,* №. 2, 45-64. [Богданов А., Пущаровский Ю., 1950, Основные черты тектоники Центральной синклинальной зоны Восточных Карпат //*Изв. АН СССР. Серия геологическая*, №. 2, 45-64.]

Bondarchuk V. (1959). Tektonika teritorii URSR ta MRSR, *Pojasniuwalna zapyska do tektonichnoi karty URSR i MRSR mashtabu 1:750000,* Kyiv, Wyd. AN URSR, 219. [Бондарчук В. (1959). Тектоніка території УССР та МРСР, *Пояснювальна записка до тектонічної карти УРСР і МРСР масштабу 1:750000.* Київ: Вид-во АН УРСР, 219.]

Chalov R. (1980). O klasifikaciji rechnych rusel, *Geomorfologia* №1, 3-16. [Чалов Р. (1980). О классификации речных русел, *Геоморфология* №1, 3-16.]

Chełmicki W., Krzemień K. (1999). Chanel typology for the river Feshie in the Cairngorm mts., Scotland, *Prace Geograficzne,* 104, 57-68.

Felbaba-Kluhina L. (2015). Wetlands and ponds of upper Tisza river (Ukrainian Carpathians): prospects to give them the status of Ramsar sites. *Biological systems,* 7, Vol. 1, 76-81. [Фельбаба-Клушина Л. (2015). Болота і водойми верхів'я р. Тиса (Українські Карпати), перспективні для надання їм статусу Рамсарських угідь, *Біологічні системи* №. 7, Вип. 1., 76-81.]

Gąsiorowski H. (1906). Ślady glacyalne na Czarnohorze. *Kosmos* 31: 148-168, Lwów.

Gofstein I. (1995). *Geomorfologicheskij otcherk Ukrainskich Karpat,* Naukova Dumka, Kyiv, 84. [Гофштейн, И. (1995) *Геоморфологический очерк Украинских Карпат.* Киев: Наук. думка, 85.]

Gorczyca E. (2016). *Rozwój górskich żwirodennych koryt rzecznych w warunkach antropopresji.* Kraków: Instytut Geografii i Gospodarki Przestrzennej UJ, 240.

Gorczyca E., Krzemień K., Jarzyna K. (2020). The evolution of gravel-bed rivers during the post-regulation period in the Polish Carpathians. *Water,* 12(1), 254.

Hack J. T. (1957). Studies of longitudinal profiles in Virginia and Maryland. *U.S. Geological Survey Professional Paper* 294-B, Washington DC.

Hluszko V. (1968) *Tektonika i neftegazonosnost Karpat s prilegajushich progibov.* M.Nedra, 240. [Глушко В. (1968). *Тектоника и нефтегазоносность Карпат и прилегающих прогибов.* М.:Недра, с.240]

Horton R. E. (1945). Erosional Development of Streams and their Drainage Basins: Hydrophysical Approach to Quantitative Morphology. *Geological Society of America Bulletin,* v. 56, n. 3, p. 275-370.

Kamykowska M., Kaszowski L., Krzemień K. (1999). River channel mapping instruction. Key to the river bed description. *Prace geograficzne*, 104, 9-25.

Kaszowski L., Krzemień K. (1986). Metody typologii koryt rzecznych. Zeszyty Naukowe UJ, *Prace Geograficzne,* 67, 7-23.

Kaszowski L., Krzemień K. (1977). Structure of mountain channel systems as exemplified by chosen Carpathian streams, *Studia Geomorphologica Carpatho - Balcanica.,* 11, 21-32.

Kłapyta P., Krzemień K., Gorczyca E., Krąż P., Dubis L. (2020). Geomorphologic effects of human impact across the Svydovets Massif in the Eastern Carpathians in Ukraine. *Studia Geomorphologica Carpatho-Balcanica,* 53, 85-111.

Kravchuk J. (2008). Struktural and geomorphological analysis of Polonynsko-Chornogyrsky Carpathians, *Lviv University publishing, geomorphology series,* 35, 186-201. [Кравчук Я. (2008). Структурно-геоморфологічний аналіз Полонинсько-Чорногірських Карпат, *Вісник Львівського університету. Серія географічна,* №. 35, 186-201]

Krzemień K. (1976). Współczesna dynamika koryta potoku Konina w Gorcach, *Folia Geografica,* X, 88-122.

Krzemień, K. (2006). Badania struktury i dynamiki koryt rzek Karpackich. *Infrastruktura i ekologia terenów wiejskich,* (4/1), 131-142.

Krzemień, K. (2012). *Struktura koryt rzek i potoków:(studium metodyczne.* Kraków: Instytut Geografii i Gospodarki Przestrzennej UJ, 143.

Leopold, L.B. and Wolman, M.G. (1957). River Channel Patterns, Braided, Meandering and Straight. *U.S. Geol. Surv. Paper.* 282-B.

Melnyk A., Karabiniuk M. (2018). Alpian and subalpian highlands of the Chornohora landscape: kritereas, distribution and usage, *Matherials of the III international scientific seminar Natural sources of the region problems of protection, revitalization and usage,* 222-227. [Мельник А., Карабінюк М. (2018). Субальпійське і альпійське високогір'я ландшафту Чорногора: критерії виділення, поширення, використання, *Матеріали III міжнародного наукового семінару,Природні ресурси регіону: проблеми використання ревіталізації та охорони,* 222-227.]

Montgomery D., Buffington J. (1997). Channel-reach morphology in mountain drainage basins. *Geological Society of America Bulletin*, 109(5), 596-611.

Obodovskij O. (red.) (2006). *Hydrometeorological conditions of Czorna Cisa basin*, Kyiv National University, Kyiv, 172. [Obodovskij O. (ред.) (2006). Hydrometeorological conditions of Czorna Cisa basin, Kyiv National University, Kyiv, 172.]

Obodovskyi Yu., Khilchevskyi V., Obodovskyi O. (2018). *Hydromorphoecological assessment of the river bed processes of rivers in the upper Tisha river basin (within Ukraine),* Kyiv, 193. [Obodovskyi Yu., Khilchevskyi V., Obodovskyi O. (2018). *Hydromorphoecological assessment of the river bed processes of rivers in the upper Tisha river basin (within Ukraine)*, Kyiv, 193]

Pawłowski S. (1915). Ze studiów nad zlodowaceniem Czarnohory. *Prace Towarzystwa Naukowego Warszawskiego* 3(10): 1-60.

Romer E. (1906). Epoka lodowa na Świdowcu. *Rozpr. Akad. Um. Wydz. Mat.*- Przyr., A.XLVI.

Romer E. (1909). Próba morfometrycznej analizy grzbietów Karpat Wschodnich. *Kosmos* 34 (7-9): 22-27.

Rosgen D., (1996). *Applied River Morphology, Wildland Hydrology, Pagosa Springs,* Colorado:1–390.

Rudenko (red.) (2008). *Natsionalnyj Atlas Ukrainy,* 440. [Руденко (ред.) (2008). *Національний Атлас України,* 440.]

Staszic S. (1815). *O ziemiorodztwie Karpatów i innych gór i równin* Polski. Warszawa, 397.

Strahler A. N. (1952) Hypsometric (Area-Altitude) — Analysis of Erosional Topography. *Geological Society of America Bulletin,* v. 63, n. 10, p. 1117-1142.

Thorne C., 1997, Channel types and morphological classification [in:] C. Thorne, R. Hey, M. Newson [ed.], *Applied fluwial geomorphology for river engineering and management.*John Wiley and Sons Ltd.

Troll C. (1972) Geoecology and the world-wide differentiation of high-mountain ecosystems [in:] C. Troll (ed.), Geoecology of the high-mountain regions of Eurasia, *Proceeding of the symposium of the International Geographical Union Comission on High-Altitude Geoecology,* November, 20-22, 1969 at Mainz, Franz Steiner Wiesbaden p. 1-16.

Ustymenko P., Dubyna D., Felbaba-Klushyna L. (2015). *Vegetation of the Upper Tisa Valley (Transcarpathian region): current state, phytocoenodiversity, anthropogenic transformation, protection,* Uzhorod, 126. [Устименко, П., Дубина Д., Фельбаба-Клушина Л. (2015) *"Рослинність верхів'я долини Тиси (Закарпатська область): сучасний стан, фітоценорізноманітність, антропогенна трансформація, охорона,* 126.]

Wierzbicki G. (2010). Geomorfologiczne kartowanie koryta jako element przyrodniczej waloryzacji potoków górskich na przykładzie Karpat Wschodnich. *Infrastruktura i Ekologia Terenów Wiejskich,* 9, 5-15.