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ESTABLISHING THE ENVIRONMENTALLY SAFE WIDTH OF PROTECTIVE RIPARIAN ZONE ALONG WATER BODIES

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Aim. Establishing protective riparian zonesalong the riversides of the Shopurka river inside water protection zones at the territory of urban settlement Velykyy Bytchkiv for protecting surface water bodies from polluting and littering, as well as for saving their water content. The aim of the research is determining the safe protective riparian zonesof water bodies taking into account ecological factors. **Methods.** The research methodology consists in using the algorithm of determining the width of the protective riparian zone, which enables providing the science-baseddetermination of the width of the protective riparian zone of the water body depending on the types of sylva, granulometric composition of soils, slope expositionand type of soil treatment. **Results**. The proposed method of determining the optimal width of protective riparian allows justifying the topicality and necessity of its application. For the given river, the width of protective riparian has been determined according to the requirements of Water code of Ukraine and calculated in accordance with formula (1). It will allow the elimination of ambiguity of the determining the width of the protective riparian by the calculations made by the representatives of local water economy with the use of Water code of Ukraine and will facilitate the univocal determining the areas of protective riparian zones. **Scientific topicality**. Realization of the method of determining the width of the protective riparian according to the proposed algorithm and actual legal documents has shown that the aberration of the protective riparian along the river Shopurka is equal to 20 m. The area of the protective riparian according to the Water code equals 1.82 ha, but according to formula (1) is equal to 3.29 ha. Therefore, the total area of the protective riparian zone should be expandedby 1.47 ha. **Practical importance**. Determined area and boundaries of the protective riparian zones along the river Shopurka (Zakarpatsky region) will enable the systematic monitoring of the use of riparian soils to be conducted and facilitate the improvement of ecological and sanitary state of the river.

Key words: water protection zone, protective riparian, water body, water code, land code.

Introduction

Lands belonging to the inventory of water resources play an important role in social, economic, ecological spheres and biosphere as a whole. Overflow lands, being a specific kind of biogeocenosis and integral part of modern landscape, influence other types of ecosystem and biosphere as a whole through the system of energy flows caused by living matter and different natural and antropogenic factors [Yatsyk & Khorieva., 2000; Henssen, 2010].

The major problems of using lands in the vicinity of water resources are [Syvakov, 2007]:

– violation of natural landscapes (slopes, beaches) due to intensive development of riparian lands (site coverage) without taking into account natural processes [Stubkjaer, 2012];

– not establishing the protective riparian zones most territories adjacent to the water resources worsens the environmental conditions of water bodies andof the areas adjacent to a watercourse;

– violation of laws concerning the riparian zones in general and protective riparian zones in particular directly influences the soil condition of the inventory of water resources;

– unfounded site development of river flood lands has intensified the critical situation in river basins;

– ploughing up the areas within protective riparian zones to the waterline [Land Code of Ukraine. 2001];

– deforestation within riparian zones of rivers, lakes, seas or water-storage basins negatively influences the soil conditions of the inventory of water resources [Williamson, 2011].

For solving these problems, the investigations of rational use of the supply of riparian lands within the legal and natural framework are very important for promoting the preservation and restoration of these vulnerable objects.

Aim

Solving the problem of establishing the protective riparian zones of water bodies is topical nowadays. The aim of the investigation is to establish environmentally safe protective

zones for water bodies taking into account the ecological factors.

Methodology

According to the methodology [Methodology of water-protection zones arrangement in the rivers of Ukraine, 2004], the protective riparian zone is a part of a water protection zone of a proper width along the river or other water bodies, where more strict conditions of economic activity are implemented comparing to those on other terrains of the water protection zone.

The internal boundary of the protective riparian zone is a level of a low stage (LS) of a river [Loik & Kostovska, 2009].

The external boundary of the protective riparian zone is a level of the most intense development of unfavourable processes of interplay between a water body and a coast.

Minimum dimensions of the protective riparian zone are established at both river banks and around water bodies along the waterline (in a low stage period) with the width according to Water Code of Ukraine [Water code of Ukraine, 2000]:

– 25 m for small rivers, rivulets and streams (water-shed area up to 2,000 km^2);

– 50 m for middle-size rivers (water-shed area up to 50,000 km^2);

– 100 m for big rivers (water-shed area more than 50,000 km^2).

If slope rate of grade exceeds 3°, the minimum width of protection riparian zone is doubled [Water code of Ukraine, 2000].

Therefore, the protective riparian zone is a part of the water protection zone, they are tightly interconnected, and at changing the width of one the width of another one should be changed [Zhelykh, 2006; Palamarchuk, 2000].

The Tysa and Shopurka rivers with tributaries (the biggest of which is the rivulet Mlynivka) flow through the territory governed by the settlement council.

The water content of the rivers changes significantly over a year. The characteristic feature of the internal water-shed area is the occurrence of floods during the most part of the year, unstable summer-autumn and winter low water and indefinitely pronounced spring floods formed by thaw waterand rain water [Retrieved from https://uk.wikipedia.org/wiki/ Velykyi Bychkiv].

A whole warm period of a year is characterized by frequent precipitation, as a result of which there are annual rain floods on the rivers of the region. In average, 8 to 10 floods can be observed during the year, 1 to 4 of them spreading onto flood plains (lands). Intense water yield of water intake during storm rainfalls as well as significantly broken terrain cause floods with drastic water rise and recession. Therefore, the durability of high water is not very long and, as a rule, does not exceed 4–8 days.

As the rivers of Rakchiv region are considered as mountain ones, the river channel processes in general occur due to the depth erosion.

The river Shopurka is a right tributary of the river Tysa. It is created by the confluence of the rivers Mala Shopurka and Serednia Rika, whose source is located on the southwest slope of mountain ridge Svydovets at an altitude of 1580 m above sea level (Fig. 1).

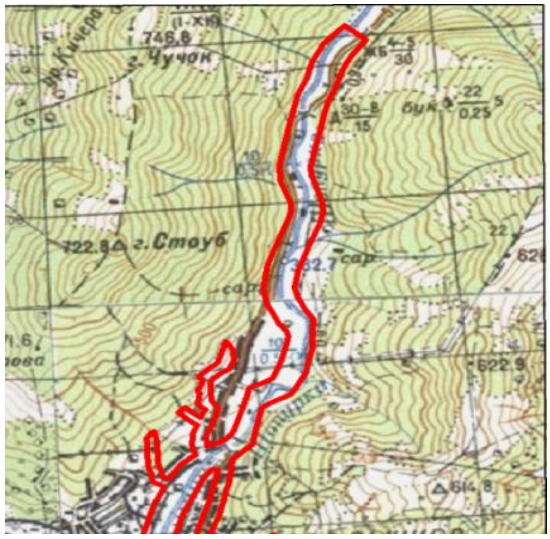

Fig. 1. Diagram of study area

They flow in parallel with Kosivska valley along deep narrow valleys whose slopes are almost completely covered by forest. The length of the river Shopurka is 13 km (or 41 km together with the Small Shopurka), the area of water intake is 283 km2. It is a typical mountain river. The river basin is 8 to 10 km wide, with a steep gradient of 20–40°and channel slope of 26 m/km. Flow velocity is within the range of 2–3 m/s. Volumetric flow rate is 8.9 m^3/s (cumec) [Retrieved from https://uk.wikipedia.org/wiki/ Velykyi Bychkiv].

The aim of this investigation is providing the fulfillment of requirements of Water code of Ukraine during planning and constructing activities at both banks of the river Shopurka. Creating the

protective riparian zone along the river will enable monitoring of land usage within the riparian zone and promoting the improvement of ecological and sanitary state of the river.

Checking the results of the theoretical investigations according to formula (1) has been performed on the river Shopurka in urban settlement Velykyy Bychkiv. For this purpose, the width of protective riparian zone was calculated for this river in accordance with the requirements of Water code of Ukraine and given formula (1).

Itisproposedtocalculatethewidthoftheprotectiveriparianzoneaccordingtothelowwaterlevelinthebodyofwaterbytheformulagiveninthesynopsisofathesis [Sai, 2009]:

$$L_{prz} = L_{req} \cdot K_f \cdot K_s \cdot K_e \cdot K_n \cdot C_v , \qquad (1)$$

where: L_{prz} is the optimal width of the protective riparian zone, m; L_{req} is the width of the protective riparian zone established by the Land code, m; K_f is the coefficient of transition from broadleaf forest to other forest types (Table 1); K_s is the coefficient of the transition from sandy loams to other soil types according to their granulometric composition (Table 2); K_e is the coefficient of transition from north exposure to other exposures (Table 3); K_t is the coefficient of the transition from the category of adjacent area; C_v is a variation coefficient (Table 5).

Coefficients K_f, K_s, K_e, K_t, C_v were determined according to the data presented in [Design, arrangement and exploitation of water protection areas of reservoirs. VBN 33-1993].

Forest directly influences the water regime of slope lands, which manifests itself mainly in absorbing surface flow formed on these terrains.

The biggest infiltration capacity is the feature of soils created under the sylva. Forest soils quickly absorb water due to the cultivation of the soil by the rootage of herbaceous plants. The rate of water absorption by the forest soils depends on the forest type [Panas, 2006].

Forests have great significance for saving soils and water as well as for recreation. More than 35,000 ha of forest located on the water erosion areas perform a protective function [Panas, 2008].

The type of a forest on the territory of urban settlement Velykyy Bytchkiv was determined with the help of the map of Ukrainian forests. As there is no forest along the bank of the river Shopurka, the coefficient of transition from broadleaf forest to other forest types was chosen equal to 2.5 as for the non-forest slope [Map Forest Ukraine].

Water permeability depends on the granulometric composition of the soil, its structure and watering. For example, better water permeability is intrinsic to the soils of light granulometric composition, structural and slightly watered [Panas, 2006].

Let us consider the most characteristic properties of soils according to their granulometric composition.

Sand (size of particles from 1 to 0.5 mm) has high water permeability, does not swell, is not plastic. Sand is structureless, non-cohesive, is crumbly when dry; it consists of separate grains, sometimes with a admixture of smaller particles.

Sandy loam can be very slightly plastic or non-plastic; when dry, this soil is crumbly, but sufficiently cohesive with slight dust formation. It dries out quickly, does not swell and has not stickiness. These soils are steady in dry and wet state, since they unite advantages of sand (high internal friction and quick draining) and clay (cohesion in dry state) particles.

Light clay loams are slightly plastic. They are cohesive with slight permeability. Plasticity, stickiness, swelling and capillarity are quite noticeable, especially with increasing number of clay particles. Medium clay loam (0.01–0.005) is stiff and its characteristic features are rather close to heavy clay loams. They are characterized by higher capillary water rising and the capability of transferring to liquefaction under moistening (at a small number of clay particles).

Heavyclayloams (0.005–0.001) areveryplastic. In dry state they are cohesive and dense, therefore, are difficult to be crushed. They dry out slowly and have poor permeability. Plasticity, stickiness, swelling, moisture and capillarity are strongly pronounced.

Clay (particle size less than 0.01 mm) is highly plastic. Clays are characterized by high density and cohesion. They are practically impermeableand difficult to crush, with high stickiness and swelling. Capillarity of these soils is less than that of clay loams or dusty soils.

Light soils (sand or sand loams) are warmer, that is, they thaw and warm up more quickly than heavy soils (clay loams and clays), which, in turn, contain more nutrients.

Table 1

Coefficient of transition from broadleaf forest to other forest types

Forest type	Broadleaf	Mixed	Needleleaf	Non-forest slope
K_f	1	0.92	0.85	2.5

Table 2

Coefficient of the transition from sandy loams to other soil types according to their granulometric composition

Type of soil	Light (sand, sandy loam, peat)	Medium (light and medium clay loams)	Heavy (heavy clay loam, clay, rocky soil)
K_s	1.0	1.5	2.0

Table 3

Coefficient of transition from north exposure to other exposures

Slope exposure	Northeast and west	North, southeast, northwest	South and southwest
K_e	1.0	0.8	1.2

Table 4

Coefficient of the transition from the category of adjacent area to the lands of inventory of water resources

Roughness conditions	Ploughing across the slope	Ploughing along the slope and perennial fallow lands	Fallow lands used as pasture and virgin lands
K_t	1.6	2.4	2.6

Table 5

Variation coefficient

Notation	Carpathians	Crimea	Polissya	Forest-steppe	Steppe
Cv	0.3 – 0.4	0.7 – 0.4	0.7 – 0.3	0.6 – 0.4	0.8 – 1.5

For determining soils on the territory of urban settlement, the Interactive map of soils of Ukraine was analyzed [Interactive map of soil Ukraine]. According to the data obtained from it, the investigated terrains consist mostly of brown mountainous forest gruss soils and sand loams. On the basis of the above-mentioned analysis, for the given river the coefficient of the transition from sandy loams to other soil types according to their granulometric compositionwas accepted to be equal to 1.

The river Shopurka flows from the northeast towards the west, so the chosen coefficient of the slope exposure is equal to 1.

The agrotechnical system contains the package of measures directed to the regulation of the surface flow (ploughing across the slope or along the contours).

The most available and efficient measure taken for the regulation of the surface flow is ploughing across the slope or along the contours. In this case every furrow and every furrow ridge is the obstacle to the flow of surface water. At this type of tillage the surface flow can be 3 to 10 times less depending on relief, type of soil and meteorological conditions [Lemkivskyi, Padun & Lybid, 2006; Panas, 2008].

For determining the width of protective riparian zone of the river Shopurka, the chosen coefficient of the transition from the category of adjacent area to the lands of inventory of water resources was equal to 2.4, since there are perennial fallow lands along the banks of this river.

The variation coefficient C_v is a relative value, describing the fluctuation (variation) of the features.

It is a ratio of mean square deviation of random quantity to its assembly average [Dubniak, Korobka, Sakevych, & Shevchuk, 1999].

The river Shopurka belongs to the zone "Carpathians", therefore, the chosen variation coefficient is equal to 0.3.

According to paragraph 79 of Water Code of Ukraine, the river Shopurka is a small river concluding from its water-collecting area. The width of the protective riparian zone along the river Shopurka is 25 m (Fig. 2).

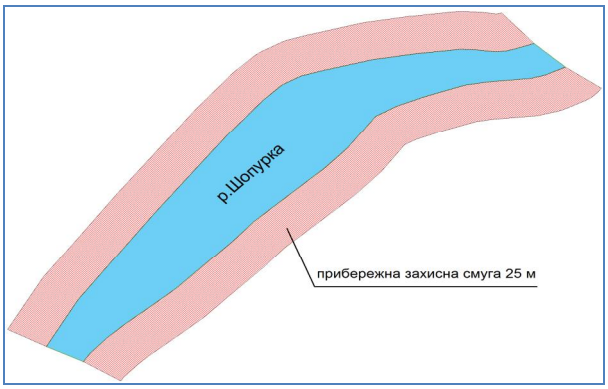

Fig. 2. Diagram of the protective riparian zone along the river Shopurka (part) according to Water Code of Ukraine

For calculating the optimal width of protective riparian zone, formula (1) is interpreted as a functional dependence on coefficients.

K_f is a function of the coefficient of transition from broadleaf forest to other forest types**:**

$$K_f = f_1 (K_{11}; K_{12}; K_{13}; K_{14}) \quad (2)$$

K_s is a function of the coefficient of transition from sandy loams to other soil types according to their granulometric composition**:**

$$K_s = f_2 (K_{21}; K_{22}; K_{23}) \quad (3)$$

K_e is a function of coefficient of transition from north exposure to other exposures**:**

$$K_e = f_3 (K_{31}; K_{32}; K_{33}) \quad (4)$$

K_t is a function of the transition from the category of adjacent area to the lands of inventory of water resources:

$$K_t = f_4 (K_{41}; K_{42}; K_{43}) \quad (5)$$

Since the investigated river is located in the Carpathians, the value of the variation coefficient should be equal to 0.3.

After the transformation, formula (1) is represented as follows:

$$L_{prz} = L_{req} \cdot f_1 (K_{11}; K_{12}; K_{13}; K_{14}) \cdot f_2 (K_{21}; K_{22}; K_{23}) \cdot \cdot f_3 (K_{31}; K_{32}; K_{33}) \cdot f_4 (K_{41}; K_{42}; K_{43}) \cdot 0{,}3 \quad (6)$$

The calculations of the width of riparian zone for the river Shopurka can be determined from the low water level in the water body. The internal boundary of the riparian zone is the level of the water average annual mark 50.5 m, the external boundary is the boundary of the riparian zone according to the Water code of Ukraine and the width of riparian zone is determined by formula (1).

For choosing relevant coefficients, the digital model of relief (DMR) was created with the uniform grid pitch of 50 by 50 m (Fig. 3).

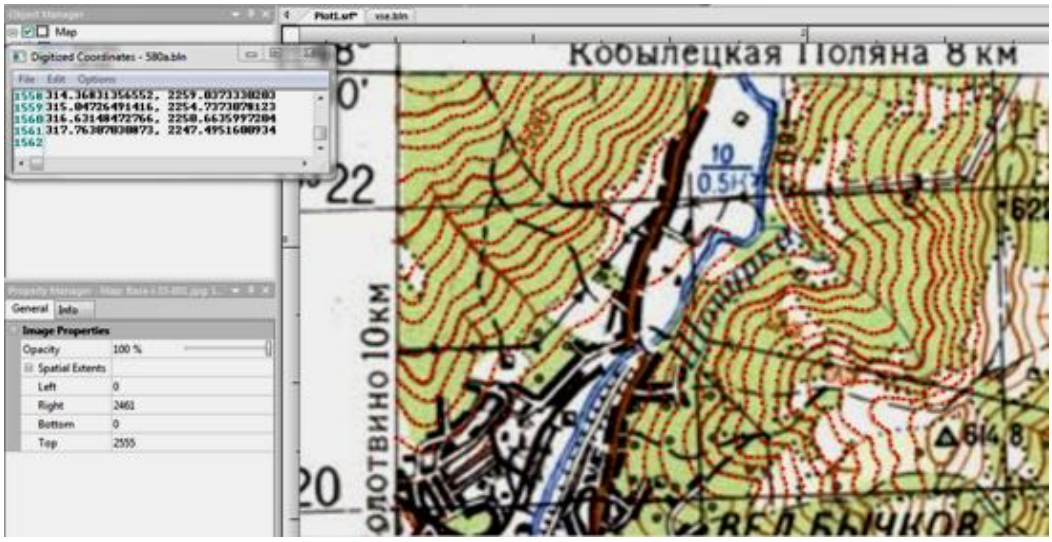

Fig. 3. Surfer software window with vectorized contour lines

The digital model of relief (DMR) is a digital presentation of Earth surface relief created on the basis of the data about relief and with the use of the methods of their spatial interpolation.

The digital model of the relief of the river Shopurka was created with the use of the Golden Software Surfer software for plotting the 3-dimentional map surfaces.

For the visualization of surfaces, Surfer uses the data of the rectangular uniform grid.

The initial map was the General Staff map with the nomenclature L-35-001. Data collecting ia performed through the vectorization of contour lines (3).

Then the uniform grid of levels was created and 3-D model of the relief (3D Surface) was built according to the source data (Fig. 4).

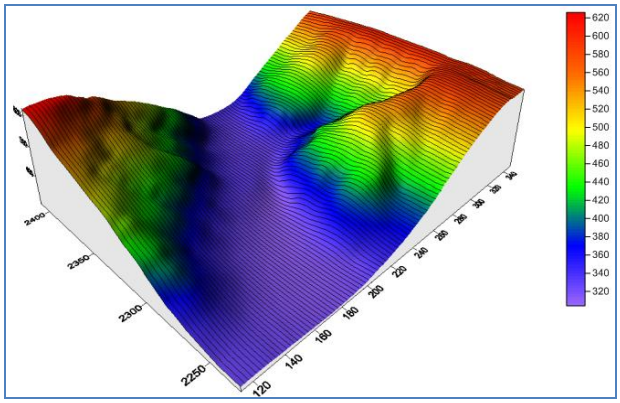

Fig. 4. Part of the digital map obtained by the method of vectorization of the fragment of the map raster image

In the legend to Fig. 4, levels of contour lines in meters are presented which have been vectorized for building and for determining the exposure of the river slope.

The width of protective riparian zone of the river has been determined from the low water stage. Therefore, after performed all necessary calculations by formula (1), the width of the protective riparian zone is equal to 45 m (Fig. 5).

It has been determined that the protective riparian zone calculated by formula (1) is wider than that proposed by the Water Code of Ukraine by 20 m (Fig. 6).

Therefore, proposed methodology of determining the optimal width of the protective riparian zone taking into account the factors reflecting the granulometric composition of soils, percentage of forest land, types of sylva, types of land resources by assuming proper coefficients enables substantiating its topicality and necessity of its implementation. It is proved by the fact that the territory of the protective riparian zone is the terrain with the specific land managing and limited economic activities.

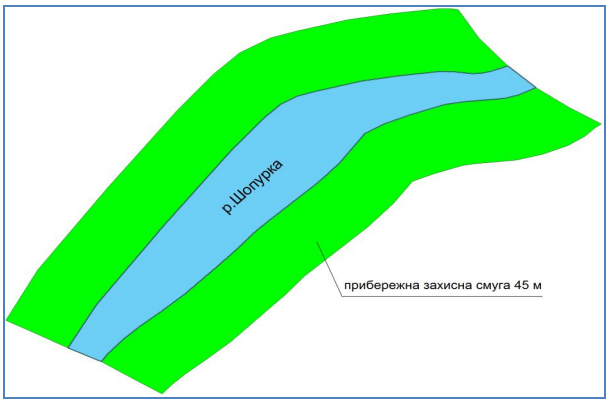

Fig. 5. Diagram of the protective riparian zone along the river Shopurka (part) according to formula (1)

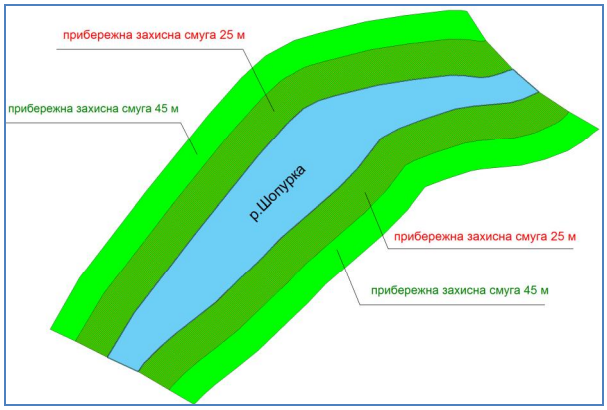

Fig. 6. Joint diagram of protective riparian zones along the r.Shopurka (part)

Practical realization of theoretical research

The boundaries of the protective riparian zone are established at both banks of the river Shopurka on the territory of urban settlement Velykyy Bytchkiv (Zakarpatskyy region) (part) according to the requirements of Land and Water Codes of Ukraine, taking into account the road system, existing buildings, landownership (land use), industrial projects etc.

The width of the protective riparian zone along the river Shopurka is 25 m, but according to above-mentioned formula it should be 45 m. The area of the lands of riparian zone according to the Water Code of Ukraine is 1.82 ha, but according to formula (1) it is 3.29 ha. Therefore, a total area of the riparian zone in accordance to the authors' calculations should be increased by 1.47 ha. These

figures are given for the part of the river, because the diagrams for the whole river are cumbersome and poorly readable.

Topicality

Conducted research has enabled establishing the width of protective riparian zone of the river Shopurka on the basis of above-mentioned algorithm and taking into account the types of sylva, granulometric composition of soils, slope exposition and kinds of land treatment, which is of great practical importance for the optimal determining and using this kind of lands of water resource.

Practical importance

Established dimensions and boundaries of protective riparian zones on the river Shopurka (Zakarpatskyy region) will enable monitoring of the use of riparian lands and promote the improvement of the ecological and sanitary state of the river.

Conclusions

The aim of the research article was to determine the protective riparian zones along the banks of the river Shopurka inside the water protective area on the territory of urban settlement Velykyy Bytchkiv for the protection of surface water objects from polluting and littering as well as saving their water content.

According to the results of theoretical research directed to the determination of the width of protective riparian zone taking into account ecological factors, the practical implementation of the results, namely, the establishment of new riparian zone along the right and the left bank of the river Shopurka was provided.

The realization of the methodology of determining the width of protective riparian zone according to the proposed algorithm and current normative acts has shown that the deviation in the location of the protective riparian zone is equal to 20 m.

REFERENCES

Design, arrangement and exploitation of water protection areas of reservoirs. VBN 33-1993.

Dubniak, S. A, Korobka, A. A., Sakevych, A. M., & Shevchuk, V. Ia. (1999). Recommendations for improving the ecological status of the coastal areas of the Dnieper reservoirs. Design, arrangement and exploitation of water protection areas of reservoirs. (1993). VBN 33-4759129-03-05-92. Kyiv: Derzhvodhosp Ukrainy, Min. pryrody Ukrainy, Kyiv: KSP.

Henssen, J. (2010). Basic Principles of the Main Cadastral Systems in the World. Cadastre and Rural Land Management, of International Federation of Surveyors (F J G), may, 16 Delft, The Netherlands, 171–175.

Interactive map of soil Ukraine. Retrieved from http://geomap.

Land Code of Ukraine. (2001). Lviv: Ukr. Tekhnolohii.

Lemkivskyi, S. S., & Padun M. M. (2006). *Rational use and protection of water resources:* textbook. Kyiv: Lybid.

Loik, H. K., & Kostovska O. V. (2006). Legal provision of conservation of degraded, unproductive and technogenically contaminated land Status and prospects of legal science and education development: international scientific and technical conference.

Map Forest Ukraine. Retrieved from http://stat.nonews.co/ukraine/maps/wood/.

Palamarchuk M. M. (2000). Structural and geographic aspects of water management. Ukraine and Global Processes: Geographic Dimension: Collection of Scientific Papers. Kyiv – Lutsk: Vezha, 128–129.

Panas R. M. (2000, 2006). *Soil science*: textbook. Lviv: Novyi Svit.

Panas R. M. (2008). *Rational use and protection of land*: textbook. Lviv: "Novyi svit- 2000".

Syvakov D. O. (2007) *Water law*: educational and practical guide. Moscow: Yustytsynform.

Sai V. M. (2009). Normativ-lawful and geodesic ensuring the cadaster of water fund`s lands. (Doctoral dissertation). Lviv Polytechnic National University, Lviv.

Stubkjaer E. (2012). Cadastral research – issuer and approaches. Oslo. *Kart of Plan*, 59, 267–278.

Velykyi Bychkiv. Retrieved from https://uk.wikipedia.org/wiki/ Velykyi Bychkiv.

Williamson I. (2011). The Evolution of Modern Cadaster. Paper presented on the Conference on new technology in a new century, FIG Working Week, Seoul, Korea, 6–11, May, 59 p.

Water Code of Ukraine. (2000). Parlament of Ukraine, 21 september 2000, no.1990-III. Kyiv: Parlam. edition.

Yatsyk, A. V., Tomiltseva, A. I., Filimonenko, R. P., Tomiltsev, M. H. (2004). Methodology of water-protection zones arrangement in the rivers of Ukraine. Kyiv: Oriony.

Yatsyk, A. V., & Khorieva, V. M. (2000). *Water management of Ukraine*: textbook. Kyiv: Geneza.

Zhelykh, S. I. (2006). Modern problems of rational use of water resources. *Ridna pryroda*. 3, 52–59.

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ВСТАНОВЛЕННЯ ЕКОЛОГІЧНОЇ БЕЗПЕЧНОЇ ШИРИНИ ПРИБЕРЕЖНОЇ ЗАХИСНОЇ СМУГИ ВЗДОВЖ ВОДНИХ ОБЄКТІВ

Мета. Встановлення прибережних захисних смуг по берегах річки Шопурка в межах водоохоронних зон на території Великобичківської селищної ради з метою охорони поверхневих водних об’єктів від забруднення і засмічення та збереження їх водності. Мета досліджень – визначити безпечні екологічні прибережні захисні смуги водних об’єктів з врахуванням екологічних факторів. **Методика.** Використана методика досліджень полягає у застосуванні алгоритму визначення ширини прибережної захисної смуги, який дозволяє на науковообґрунтованому рівні визначати ширину прибережної захисної смуги водойм залежно від видів лісової рослинності, гранулометричного складу ґрунтів, експозиції схилів та виду обробітку ґрунту. **Результати.** Запропонована методика визначення оптимальної ширини прибережної захисної смуги дозволяє обґрунтувати актуальність і необхідність її застосування. Для цієї річки визначена ширина прибережної захисної смуги відповідно до вимог Водного кодексу України та розрахованої відповідно до формули (1). Це дозволить усунути неоднозначність визначення ширини прибережної захисної смуги за розрахунками водгоспів України та за Водним кодексом України і сприятиме однозначному встановленню площ прибережних захисних смуг. **Наукова новизна**. Реалізація методології формування ширини прибережної захисної смуги відповідно до запропонованого алгоритму та чинних нормативних матеріалів показала, що відхилення в положенні прибережної захисної смуги вздовж р. Шопурка становлять 20 м. Площа земель прибережної захисної смуги згідно з Водним кодексом становить 1,82 га, а згідно з формулою (1) становить 3,29 га. Таким чином, загальна площа прибережної захисної смуги за нашими розрахунками буде збільшена на 1,47 га. **Практична значущість**. Встановлені розміри та межі прибережних захисних смуг на р. Шопурка Закарпатської області дадуть можливість вести контроль за використанням земель прибережної смуги, сприятиме покращенню екологічного та санітарного стану річки.

Ключові слова: водоохоронна зона; прибережна захисна смуга; водний об’єкт; водний кодекс; земельний кодекс.

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