Actual condition and hypsometry of the south-western coast of the Kremenchuk reservoir

S.P. Lashko, A.S. Dryga *(Kremenchuk Mykhailo Ostrohradsky National University)*

SUMMARY

The territory of the south-western coast of the Kremenchuk reservoir (100.1 km long) is under the administrative subordination of the Velykoandrusivska territorial community of the Svitlovodsk district of the Kirovohrad region (Ukraine). This part of the reservoir is characterized by a marine type of regime, with large waves and storms causing destructive effects on the coast. The research included field observations and analysis of interactive Google Earth Pro maps with GPS navigation support. It is established that the width of zone of the coastal wave surf varies from 0 m (steep shores) to 36 m. In places, bluffs with a slope of up to 90 degrees were formed. A hypsometric profile was laid along the coast of the reservoir with a length of 4.62 km – along the route of the upper edge of the coast, which limits the strip of degraded shores. With the available water level in the 77 m reservoir, the elevations of the upper edge of the coast vary from 79 m to 112 m. At the same time, the steepness of the relief along the route of the route in some places reaches 20–26% and even 35.8%. It is recommended to resume systematic monitoring of the banks of the Kremenchuk reservoir at the state and local levels, using remote sensing technologies and geographic information systems.

Introduction

The Kremenchuk reservoir is the main regulator of the Dnieper cascade of reservoirs. The area of the Kremenchuk reservoir at a normal supported water level of 81.0 m is 2090 km^2 (*Vyshnevskyi et al., 2017*), the total capacity of the reservoir – 13.52 km^3, and useful (working) capacity – 8.97 km^3 (*Lashko and Dryga, 2019*). The length of the reservoir along the axis is 149 km, the maximum width is up to 28.0 km, and the average is 15.1 km. The length of the coastline is 800 km. The average depth of the reservoir is 6.0 m, and the maximum is 21.0 m.

According to different estimates, at the present stage, 213–219 km of the reservoir coast remain unfortified and are subject to degradation. More accurate data are not available, primarily due to the termination of observations of the degradation of coast of the Kremenchuk reservoir by the State Service of Geology and Subsoil of Ukraine after 2012. The researchers give the main attention to the water regime, quality indicators of water, parametric characteristics and fish resources of the Kremenchuk reservoir. Remote research methods of this territory are developed by V.I. Vyshnevskyi, S.A. Shevchuk, A.E. Bondar, I.A. Shevchenko, I.M. Shelkovska.

Method

This work is based on the results of our own observations and researches of the authors in the south-western coastal part of the Kremenchuk reservoir, as well as literature data. Some of the information was obtained by calculation, and some – from interactive Google Earth Pro maps with support for GPS navigation.

Results

According to the configuration, morphometric features and hydrological regime, the Kremenchuk reservoir into three parts are conventionally divided (*Vladimirova et al., 1979*): the upper part – narrowest and shoal-water (lake-river type, up to 51 km long); the medium part – medium width and depth (lake type, up to 55 km long); and the lower part – widest and deepest (sea type, up to 43 km long).

The coasts of the Kremenchuk reservoir are formed by the slopes of the second (pine forest), third and fourth above-floodplain terraces of the Dnieper, the first above-floodplain terrace of Sula, as well as the flat of the fundamental plateau. They are compound mainly by loess and loamy rocks, which are easily destroyed during severe storms. Particularly intensive coastal processing occurs in the lower part of the reservoir, which is more prone to storms due to its parametric (width and depth) characteristics. The speed of water flow in the reservoir undergoes daily fluctuations and depends on the regime of water discharge by hydroelectric power plants.

Strong wave phenomena and the shock force of waves cause the collapse of unstable (loess and loamy) coastal slopes, the formation of abrasion-accumulative shoals in shallow water, siltation by products of destruction of the reservoir bed, as well as the retreat of the coastline with the loss of territories. Squall winds from the western and north-western directions often contribute to the occurrence of waves up to 3.5 m high.

In the middle and lower parts of the Kremenchuk reservoir, the coasts are predominantly high and steep. The height of the right bank in the area of Cherkasy – Svitlovodsk is 30–40 m above the normal supported water level; the coastline is winding.

The right bank of the reservoir is characterized by a large number of sandy islands and shoals. The islands stretch along the coast in several ridges. A particularly large accumulation of islands is observed in the south-western part of the reservoir, in the area between the villages of Adamivka – Velyka Andrusivka.

The rate of development of abrasion processes is influenced by the relief and rocks composing the coast. All other things being equal, a steep coast is destroyed by waves faster than a gentle coast, and sedimentary rock strata are destroyed faster than a crystalline basement. The right bank of the Kremenchuk reservoir is predominantly higher and steeper than the left bank; the rate of its reformation significantly exceeds the design and calculated indicators. The increased rate of degradation of the right bank of the Kremenchuk reservoir in its south-western part is also predetermined by the location of the hydroelectric dam (with all elements of water discharge) near the right bank of the reservoir. It is here, during periods of intense water discharge from the upstream to the downstream, that conditions are created for an increased speed of water flow and, as a consequence, for the formation of the highest waves in the reservoir.
The most indented coastline is characteristic of the section of the right bank of the Kremenchuk reservoir in the area of the Kalantaiv – Velyka Andrusivka – Nagirne villages, adjacent to the dam of the Kremenchuk hydroelectric power station. Administratively, this territory is part of the Svitlovodsk district of the Kirovograd region.

The length of the coastline of the Kremenchuk reservoir within the Svitlovodsk district is 100.1 km, of which 35.02 km are unprotected abrasion coasts (*Rehionalna, 2019*). The average long-term erosion rate of these coasts is 1–3 m/year, in some years – 7–8 m/year.
The coast of the south-western part of the Kremenchuk reservoir is under the jurisdiction of the Velykoandrusivska country united territorial community, formed by the merger of the two largest village councils here (Velykoandrusivska and Podorozhnenska), which had access to the water area of the reservoir. The total area of this community is 55662.77 hectares, including 38324.98 hectares (or 68.85%) of the water area of the Kremenchuk reservoir and 17337.79 hectares (or 31.15%) of dry land (Pasport).

In the structure of the dry land of the Velykoandrusivska territorial community (without the water area of the reservoir), agricultural land and forest-covered (trees and shrubs) areas prevail – 57.4% and 37.5% of this territory, respectively; open lands without vegetation – 0.34%; lands under water – 0.33%; swamps – 0.18%; built-up land – 3.0%; other lands – 1.25%. Forests of anti-erosion function prevail here, as well as in general on the right bank of the Dnieper, which is referred (*Lashko, 2009*) to the South-Ukrainian anti-erosion-forestry protection province. For comparison, let us note that water protection forests prevail on the left bank of the Kremenchuk reservoir.

Due to the strong indented relief and considerable forest cover, farmland areas are located here in small areas – mainly on elevations (hillocks), surrounded by forest lands. 75.2% of farmland is plowed up, including in the coastal zone of the Kremenchuk reservoir.

In recent years, on the territory of the Svitlovodsk district and the Velykoandrusivska territorial community in particular, there has been a tendency towards a general decrease in the area of farmland against the background of an increase in the area of arable land (Lashko, 2019). The area of forest lands is expanding at a steady pace – an additional 250 hectares (+ 4.0%) over the past 10 years.
The monitoring of the south-western coast of the Kremenchuk reservoir (within the peninsula Moscow Mountain) was carried out using the Google Earth Pro software equipped with GPS navigation and scale. A peculiarity of this coast is the intensive development of abrasion processes with the formation of steep, up to 90 degrees, bluffs (Figure 1).

In some places (Figure 1) the width of the degraded coast is minimal and depends solely on the angle of stability of the disturbed slope. In less sloping areas, the degraded coast is much wider. In particular, in the area of point F the width of the degraded coast reaches 22–23 m, in the area of point A – 26.5 m, and between observation points B and C – 36 m.
According to a study of Google Earth images, the coast of the peninsula Moscow Mountain is characterized by hypsometry variability. The total length of the hypsometric route (on the upper edge of the coast – the limits of the existing degradation of the shores) was 4.62 km (Figure 2). With an

average hypsometric level of the upper edge of the coast of 92 m and a water level in the reservoir of 77 m, the elevation marks of the upper edge of the coast vary from 79 m (point D) to 112 m (along the route before point E). The maximum elevation in this area (central part of the peninsula) is 138.8 m. The difference of hypsometric marks along the route of the upper edge of the south-western coast of the Kremenchuk reservoir reaches 33 m, and the difference between the water level in the reservoir and the upper edge of the coast varies from 2 m to 35 m.

Figure 1 *Panorama of the northern protrusion of the peninsula Moscow Mountain (view from the Kremenchuk reservoir): author's montage; in the foreground – abrasion bluff; in the background – the city of Svitlovodsk*

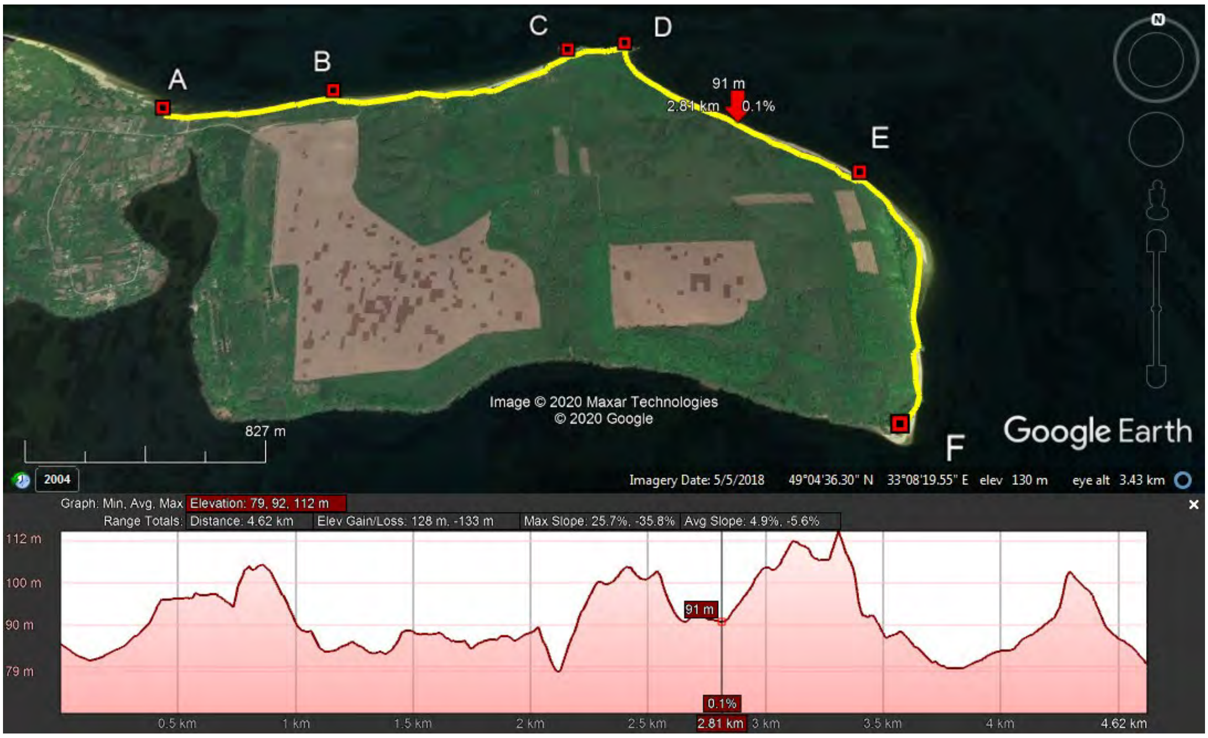

Figure 2 *Hypsometry of coast of the Kremenchuk reservoir within the peninsula Moscow Mountain (Google Earth Pro image): yellow line – hypsometry route; A, B, C, D, E, F – points of the route; horizontal and vertical scales – on the left side of the image; image orientation – to the north*

The steepness of the relief along the route reaches up to 25.7% on the northern coast of the peninsula Moscow Mountain (between observation points A and D), and up to 35.8% on the eastern coast (between observation points D and F). Actually, the maximum value of the steepness of the terrain is fixed at point E of the route.

Google Earth imagery gives a clear indication of the position of the coastline. However, a certain dissonance is introduced by the shrub vegetation that covers the degraded areas of the coast. In this case it is necessary to be guided by spreading of the sandy sites serving as a sign of the previous phases of abrasive and accumulative activity of the Kremenchuk reservoir.

Conclusions

The south-western coast of the Kremenchuk reservoir is characterized by a winding and hypsometrically uneven coastline. The height marks of the upper edge of the coast vary from 79 m to 112 m. The shores are systematically destroyed by waves, with the formation of steep, up to 90 degrees, bluffs. The width of the coastal strip of wave surf in some places reaches 36 m.

The entire territory of the south-western coast of the Kremenchuk reservoir (which is 100 km) belongs to one territorial community. At least 35 km of these shores need protection from the abrasive action of the reservoir.

In connection with the continuous advance of the Kremenchuk reservoir to the coast, it is desirable to resume systematic monitoring of the condition of the banks of this reservoir at the state and local level – by the State Service of Geology and Subsoil of Ukraine, inter-district departments of the State Geocadastre and local geodetic services.

Field observations (monitoring) of coastal reshaping should be accompanied by modern research methods – the use of Earth remote sensing technologies and geographic information systems.

For local monitoring purposes, publicly available Google Earth Pro maps with GPS navigation and scale can be used.

References

Lashko, S.P. [2009]. Strukturno-terytorialni priorytety optymalnoi lisystosti v Ukraini. *Visnyk Kremenchutskoho derzhavnoho politekhnichnoho universytetu imeni Mykhaila Ostrohradskoho,* **2(55),** 1. 101–104. [in Ukrainian].

Lashko, S.P. [2019]. Zminy struktury silskohospodarskykh vyrobnykiv Svitlovodskoho raionu Kirovohradskoi oblasti za 2006 – 2016 roky. *Perspektyvy instytutsionalnoho rozvytku zemelnykh vidnosyn v Ukraini: Materialy Vseukrainskoi naukovo-praktychnoi konferentsii, Poltava, 21–22 May 2019*. Poltava: PoltNTU, 60–62. [in Ukrainian].

Lashko, S.P. and Dryga, A.S. [2019]. Problemy zemleustroistva pribrezhnoy zony Kremenchugskogo vodokhranilishcha. In: Bogomazov, S.V., Chursin, A.I., Galiullina, A.A. (Eds), *Sovremennye problemy i aktualnye napravleniya razvitiya zemleustroystva i kadastrov: monografiya*. Penza, RIO PGAU, 26–42. [in Russian].

Pasport Velykoandrusivskoi silskoi rady Svitlovodskoho raionu. Velykoandrusivska hromada Svitlovodskoho raionu Kirovohradskoi oblasti: ofitsiinyi sait. [in Ukrainian]. Available from http://velykoandrusivska.gromada.org.ua/

Rehionalna dopovid pro stan navkolyshnoho pryrodnoho seredovyshcha Kirovohradskoi oblasti u 2018 rotsi. Departament ekolohii ta pryrodnykh resursiv Kirovohradskoi oblasnoi derzhavnoi administratsii: ofitsiinyi sait. Kirovohrad, 2019, p. 36. [in Ukrainian]. Available from http://ekolog.kr-admin.gov.ua/

Vladimirova, K.S., Zimbalevskaya, L.N. and Pikush, N.V. [1979]. *Melkovod'ya Kremenchugskogo vodokhranilishcha*. Kiev: Nauk. dumka, 284. [in Russian].

Vyshnevskyi, V.I., Shevchuk, S.A., Bondar, A.E. and Shevchenko, I.A. [2017]. The present area of the dniprovsky reservoirs. *Ukrainskyi zhurnal dystantsiinoho zonduvannia Zemli*, **14**. 4–11. [in Ukrainian].