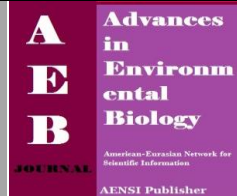




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## Abrasion Processes of Kuibyshev Reservoir as a Factor of Destruction of Archaeological Site Ostolopovo (Tatarstan, Russia)

<sup>1</sup>Iskander Ilgizovich Gaynullin, <sup>2</sup>Ayrat Gabitovich Sitdikov and <sup>3</sup>Bulat Mansurovich Usmanov

<sup>1</sup>Institute of Archaeology of Tatarstan Academy of Sciences, 20, Baumana St., Kazan 420111, Republic of Tatarstan, Russian Federation.

<sup>2</sup>Kazan Federal University, 18, Kremlyovskaya St., Kazan 420008, Republic of Tatarstan, Russian Federation.

<sup>3</sup>Kazan Federal University, 18, Kremlyovskaya St., Kazan 420008, Republic of Tatarstan, Russian Federation.

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### ABSTRACT

Estimation of abrasion on the archaeological sites situated at the Kuibyshev Reservoir, one of the largest in the Volga-Kama cascade is highly important. The bank erosion is a real danger for the cultural heritage, and collection of the data on trends in exogenous geological processes is necessary. Every year the changing water level in the Kuibyshev reservoir causes erosion of around 800 archaeological sites. Remote sensing data (aerial photography and space digital images) were used, as well as topographic maps 1:50000 for abrasion intensity monitoring at archaeological site Ostolopovo. It makes possible to estimate abrasion intensity during recent 40-50 years, and to create a prognostic model of sites destruction.

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## INTRODUCTION

The problem of historical and cultural objects destruction in the zone of large reservoirs negative impact is now one of the most pressing problems in the preservation of historical heritage on the territory of Russian Federation, as for the European part of the country, so for the Trans-Urals and Siberia. Approximately 36% of the reservoir banks of Russia are being actively destroyed, which leads to permanent withdrawal of large areas from the land use of valuable coastal areas [1]. The coast damaging processes, along with floods, falls, mudslides and earthquakes are among the most common and dangerous natural processes in Russia. Two major reservoirs, Kuibyshevskoye and Nizhnekamskoye are located on the territory of the Republic of Tatarstan.

Kuibyshevskoye reservoir, the largest one in the Volga-Kama cascade system and the third large reservoir of the world (50.7 % of its waters are within the territory of the Republic of Tatarstan) stands out by almost all indicators on with the highest values of bank processing.

The location of ancient settlements near water bodies causes their exposure to geodynamic and hydrological processes, both during and after its existence. One of the factors which changes ancient settlements appearance and condition of ancient settlements most intensively is the coastline movement [2,3]. The development of the reservoir changed the whole landscape shape of the valley bottom in the Middle Volga fundamentally. When the reservoir was developed except for Volga riverbed the Kama floodplain and low floodplain terrace below its mouth were under water, and it a considerable amount of historical and cultural objects, including archaeological sites was destroyed and sunk. Due to the fluctuations of the Kuibyshevskoye and Nizhnelamskoye reservoirs on the territory of the Republic of Tatarstan about 800 archeological monuments are destroyed annually. So the monitoring and gathering of information about the status and trends of this and other exogenous processes, posing a real threat, is an urgent task [4].

### Methods:

During the investigation of archaeological site destruction of a multidisciplinary research approach is recommended, especially with the reference to the earth sciences, archeology and history. In our study we used modern methods geologic archeology aimed at natural physical process study that affect archaeological sites [5,6,7]. The use of mapping, geographic information systems and digital relief models and modern methodological approaches for erosion process study [8, 9] in conjunction with the humanities allowed to assess the destruction of archaeological monuments in the area of large plain reservoir impact.

The work includes the following steps:

**Corresponding Author:** Iskander Ilgizovich Gaynullin, Institute of Archaeology of Tatarstan Academy of Sciences, 20, Baumana St., Kazan 420111, Republic of Tatarstan, Russian Federation.

1. The selection of priority areas most prone to destruction;
2. Gathering of information (literary, cartographic sources, archive data, aerial and satellite photographs, etc.). The study of remote sensing data concerning explored area, the selection of key areas;
3. Field stage, the main task of which is to study the coast evolution in order to identify common regularities of reshaping, the determination of quantitative values concerning various factors influence on the size, shape and speed of bank processing and the specification of short-term forecasts and coast damage prediction methods;
4. Office processing (mapping), multi-temporal image decoding (coastline, exogenous processes) in order to identify the danger of monument destruction;

*Main part:*

The main measure of coastal erosion hazard is its destructive force which adequately characterizes the intensity of the process established in the form of mean annual linear, areal and volumetric coast destruction rates per time unit (m/year, ha/year, m<sup>3</sup>/m · year, etc. ) taking into account the overall coastline damage. In this case, the coast is both the carrier (the source) and the object of danger. Therefore, the annual physical (material) losses of coastal areas determined by the velocity of coast destruction are a measure of process hazard and physical loss risk from its negative manifestations [10].

The linear speed of coastline retreat rate is the most visible characteristic of sea coast and reservoir processing intensity. The aerial photographs of the flight performed in 1958 were used with the scale of 1:17 000 and the topographic map was used with the scale of 1:50 000, as well as space digital snapshot of ultrahigh resolution made in 2005 obtained from "Google.Earth" geological service. Thus, we consider the time period of 47 years. During the initial work stage the grid tie of five aerial photographs covering the study area was performed, while a digital satellite image obtained from "Google" service was taken as the work basis. The comparison of images from different years revealed the fiducial objects, such as a church, residential buildings, quarterly grid of settlements for which spatial coordinates were taken from a digital image. The processing of aerial photographs allowed the obtaining of transformed geocoded aerial photographs collected into a single image.

Then the decryption of coastline was performed with the simultaneous creation of coast line electronic layers at different time intervals. The values of coast line retreat to quantify its dynamics were determined at the next stage.

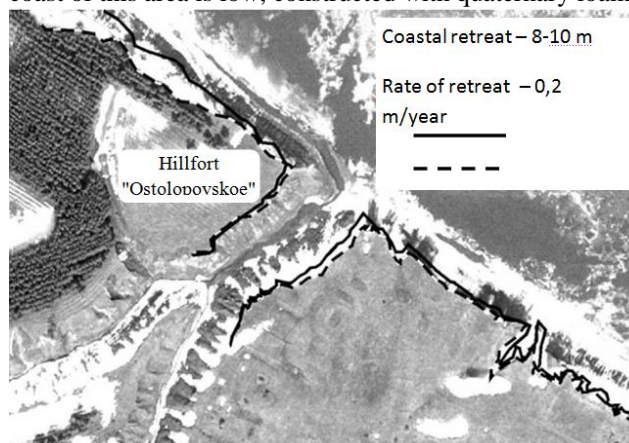
*Conclusion:*

To estimate the intensity of the archaeological sites destruction the authors of this publication selected the fragment of Kuibyshevskoye reservoir coastline from Rechnoye village to the mouth of Shentala river from Alekseevsky District of Tatarstan Republic. Ostolopovskoe settlement, Ostolopovsky Villages I and II are located within the explored area.

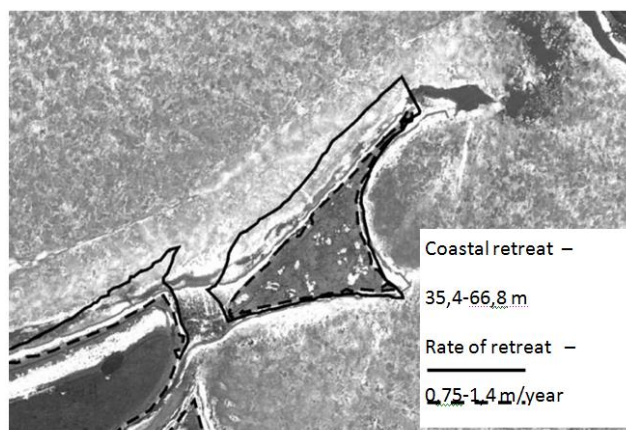
Section 1. Ostolopovskoe mound (Fig. 1) dates back to the Middle Ages of X-XI centuries [11]. It is situated to the north-west of Rechnoye settlement, on a promontory formed by high terrace and a ravine with steep slopes. Arc rampart and ditch limit the mound from the west. The coast line shifts are insignificant here and make 8-10 m. on the average. The reshaping speed makes 0.2 m. per year. The ravine is also quite stable. Most likely, it turns into a beam.

Section 2. Here is an intense destruction of a unique archeological monument - Ostolopovsky village, occupying the peninsula near the Shantaly river mouth (Fig. 2). The long-term studies of this object provided rich data arrays and allowed the dating of this settlement as X-XIII centuries [12].

The coast destruction is influenced by a number of factors, first of all by wind fluctuation, reservoir level fluctuation; moreover, the coast of this area is low, constructed with quaternary loams instable to washing.



**Fig. 1:** Coastline near Rechnoye village. Hillfort "Ostolopovskoe".



**Fig. 2:** Coastline near Rechnoe village. Ostolopovskoe settlement I.

The maximum value of retreat makes 66.8 m, the minimum corresponding value makes 35.4 m. Accordingly, the speed varies from 0.75 to 1.4 m/year. According to our calculations, the area of the island was 52 710 m<sup>2</sup> in 1958, whereas in 2005 it made only 25 310 m<sup>2</sup>, i.e. the area of 27,400 m<sup>2</sup> was destroyed during these decades. It should be assumed that if no measures are taken to strengthen the coast, this archaeological site will disappear in about 45 years.

#### Conclusions:

1. The work carried out by the team that included the use of modern GIS technologies and remote sensing data showed considerably high intensity of coastal processes in the zone of investigated monuments location.
2. Archaeological GIS allows the implementation of data systematization concerning the monument states in the areas of intense coast formation processes.
3. The use of materials concerning noncontemporaneous aerial photoshooting significantly facilitates the work of quantitative and qualitative assessment concerning the development of coastal processes and the assessment of archaeological monuments. The availability of aerial photographs from different years allowed for continuous coastline survey at selected sites and thereby obtain information about bank reshaping intensity prior to the works performed since 2002 concerning the examination of the Kuibyshevskoye Reservoir coastline.
4. The monitoring studies of registered cultural heritage objects allow the estimation of damage intensity and caused destruction of archaeological monuments by analyzing the rate of coast destruction. The result of our study is the optimization of archaeological works, developing a unified information system of archeological monuments state and the formation of justified unified system of archaeological investigation.

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