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Bank Protection on Storage Reservoirs for Municipal Coastal Areas

Nikolay Arefiev, Vladimir Badenko, Aleksandr Nikonorov*, Vitaly Terleev, Yulia Volkova

St. Petersburg State Polytechnical University, Polytechnicheskaya, 29, Saint Petersburg, 195251, Russia

Abstract

The shores of the seas and storage reservoirs are in the same property of the state, as its subsoil, forests, water resources. The urgency of coastal protection against the abrasion especially increased in recent decades (in connection with the construction of new ports, coastal cities, energetic and chemical objects, and rapid development of the resort construction). The protection of the municipal coastal areas is more important, safety of human habitation is often dependent on this. Thus, measures against abrasion are no less important than the protection of land from erosion, and storage reservoirs and rivers from pollution. The paper is based on a research of the negative factors associated with abrasion, and selection of bank protection structure type of the storage reservoirs. Selected structure should allow to provide the necessary protection of reservoir's banks from the wave destruction, both urban conglomerate parcels and agricultural, for example on the Kuibyshev reservoir.

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Keywords: municipal hydraulic engineering work; municipal area bank protection; Volga-Kama cascade; reservoir; abrasion; evaporation; gabion retaining wall; coastal municipal development.

1. Introduction

The paper is based on a research of the negative factors associated with abrasion, and selection of bank protection structure type of the storage reservoirs. Selected structure should allow to provide the necessary protection of reservoir's banks from the wave destruction, both urban conglomerate parcels and agricultural, for example on the Kuibyshev reservoir.

* Corresponding author. Tel.: +7-921-385-2180; fax: +7 (812) 535-25-09
E-mail address: coolhabit@yandex.ru

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Abrasion is a process of destruction and demolition of the land of the water bodies [1]. This is an urgent global problem for large lakes and reservoirs, which directly reflected on municipal coastal areas' conditions. Waves continuously eroding shores, all the protrusions and irregularities are smoothed out. Underwater wave-cut terrace produced in this way. As the sea penetrates, the width of the terraces increases and the living force of the waves diminishes due to the friction of the surface. If the water bodies level rises relative to the adjacent coast, the destructive work of waves penetrate further inland, and abrasion terrace width increases (sometimes up to 10-20 km) [2].

Abrasion is very strong on reservoirs whose shores geomorphologically young and almost never become mature, equilibrium, because it requires more time than would the reservoir be.

Among the causes of abrasive phenomena identified the following:

- wave conditions of the reservoir;
- ice impact;
- mode of sediment movement;
- decrease of the strength properties of soils [3-7].
- The main consequences of the destruction of the coasts are:
- removing of large areas of agricultural and forest land from the land tenure;
- development of landslide hazard in built up areas [8].

All of the aforementioned facts show the significance of the abrasion problem, both global for country as a whole, and local for municipal authorities.

Volga-Kama cascade is reviewed as example of abrasion influence.

2. State of the problem

Volga-Kama cascade (VKC) cascade of storage reservoirs and water-power plants in the Volga river basin. About 800 reservoirs with a total useful capacity of about 100 cubic kilometers allowing adjusting the 40% average annual flow of the river (254 km³) was built in the basin till 2010s [9]. Among some important problems of the VKC are the following:

bank scraping (abrasion);

flooding;

evaporation from the reservoir basin.

According to the researched sources Kuibyshev reservoir is the most affected by abrasion [10]. The basin of the Kuibyshev reservoir has been allocated with the SAS.Planet free tool [11]. Corresponding boundary was processed in AutoCAD. The reservoir shape was determined by the available data of the bank scraping speed per year (5900 km2). The reservoir shape was obtained, taking into account the increase of the area per year. As a result, the annual increase in reservoir surface area was obtained. It was determined that each year an area of Kuibyshev reservoir increased by 0.035% of its current area.

For 10 years the increase in the surface area of the reservoir will be:

$$5900 \cdot (1 + 0.035/100)10 = 5920.68\,\text{km}^2;\ 5920.68 - 5900 = 20.68\,\text{km}^2$$

That is why we should pay particular attention to the strengthening of reservoir banks.

Flooding is one of the most widespread manifestations of the adverse impacts of water, characterized by a significant spread, duration and scope of caused economic losses. Flooding develops as a complex natural process under the influence of a combination of factors; the main ones are the affluent of groundwater [12, 13]. Flooding area is about 27% of the area of the Volga basin. The third important issue is the evaporation from the reservoir's surface [14]. According to the published data, the estimated average annual loss of water to additional evaporation is also maximized at the Kuibyshev reservoir (3.33 km3 per year) [8, 10].