Spatial distribution of bottom sediments of the near-dam ples of Kuibyshev Reservoir

T V Turutina¹, A V Rakhuba² and M V Shmakova³

¹State Hydrology Institute, SPb, Russia
²Institute of Ecology of the Volga River Basin RAS - Branch of the Federal State Budgetary Institution of Science Samara Federal Research Scientific Center of RAS, ul. Komzina, 10, Togliatti, 445003, Russia
³Institute of Limnology RAS, ul. Sevastyanova, 9, SPb, 196105, Russia

rahavum@mail.ru, m-shmakova@yandex.ru*

Abstract. The composition of bottom sediments and the patterns of their spatial distribution are determined by external (type of underlying surface of the catchment area, anthropogenic development, intensity of soil erosion) and internal (water regime, intensity of water exchange, morphometry of the basin) factors. The analysis of the granulometric composition of the bottom sediments of the near-dam ples of the Kuibyshev Reservoir showed the relative uniformity of the ples soil in terms of size. At the same time, depending on the location of the sampling points, certain patterns of distribution of the size of bottom sediments in space are traced.

1. Introduction

Underlaying types diversity of water collection, different water exchange intensity and non-uniform basin morphometry pre-define particulars of spatial distribution of Kuibyshev Reservoir’s bottom sediments as regards to particle size and mineral-to-organic parts ratio. Two-phase mass transfer in Kuibyshev Reservoir is featured by wide spatiotemporal variability, which is governed by reservoir operating regime, shores configuration, alternating dub expansions and channel narrowing with big depth gradients. Particular water collection of Kuibyshev Reservoir (91,085 km²), non-uniform in its composition, in queue, pre-defines particulars of granulometry for soil erosion products within bottom sediments. In queue, large number of still water areas within reservoir makes contribution in organic sediments content in bottom soil.

Large work on evaluation of bottom sediments in Volzhsky Reservoirs cascade is conducted for a long time by Papanin Institute of the Biology of Inland Waters, Russian Academy of Sciences [1-8]. Following the results of these studies, qualitative and quantitative dynamics of bottom sediments for long period of Kuibyshev Reservoir existence was acquired based on geoinformation analysis of soil system structure and dynamics [2], as well as particulars of mud deposits [1] formation, distribution and accumulation were analysed. Hydrodynamics and morphometry impact onto formation of dam bottom sediments composition – the deepest part of Kuibyshev Reservoir – represents certain scientific interest and is a purpose of this study.
2. Object of study

Soil maps of particular water collection of Kuybyshev Reservoir [9] dam dub were taken as the basis for underlaying types analysis. According to [9], soils of left- and right-shore (in upper and middle courses) parts of particular water collection relate to black soils (approx. 74 %), which mechanical composition is represented by easily movable clay loams. Right-shore part of particular water collection in lower course of dam dub, represented by Zhigulyovsk Reserve area in its basic part is featured both by soils typical for forest-steppe zone (grey and podzolic black soils), and loamy alluvial soils, limestones and dolomites [9].

According to schematic of particular water collection of Kuybyshev Reservoir with indicated different underlaying types, represented in [10], the basic part of particular water collection of dam dub falls to forestry and agricultural lands. The latter, together with enough gradient orography and easily movable soils, governs enough intensity of soil erosion in water collection. Therefore, loamy fractions (with particle size less than 0.005 mm) shall be observed in coastal areas featured by slow water exchange.

Following the results of field research by Institute of Volga Basin Ecology, RAS, in 2020, bottom sediments samples were taken in 21 points of dam dub in 10-cm layer. Sampling points are indicated in bathymetry diagram of this location, as represented in figure 1. Location of sampling points considers dub morphometric non-uniformity and particulars of water exchange and is representative for the next analysis.

![Figure 1. Bathymetric diagram of the near-dam ples with marked sampling points.](image)

Taken samples were treated by combined ‘pipette – fraction meter’ method in sediments and erosion laboratory of Monitoring and Field Research Department, State Hydrological Institute, pursuant to [11]. Following the results of granulometric analysis for sediments samples, qualitative soil characteristic was analysed by its median value, quantiles of 25 %, 50 % and 75 % occurrence and intra-quantile swing.

For further particle size analysis of spatial bottom sediments distribution, the following maps of Kuybyshev Reservoir appurtenance were taken as the basis. Figure 2 a) and b) provides area currents plan with detected areas of water masses circulation. These maps are acquired as a result of simulation using Volna 2D-hydrodynamic model [12] for low-water period for 2015, average from water content viewpoint, for stationary calculation regime and in the case of wind impact to water area (southern wind of dominating directions with wind velocity of 5 m/s).
3. Results

Results of conducted particle size analysis harmonize well with the research data [2], as regards to qualitative characterization of bottom sediments. Totally, more than 85% fall to fine-grained sediments in dam dub that also harmonizes with the research results [2].

It should be noted that size distribution of bottom sediments within dam dub is enough uniform and differences in particle size of bottom soil fall within uncertainty range of particle size test and directly depend on sampling location and depth.

Distribution analysis of different bottom sediments properties for dam dub of Kuibyshev Reservoir, as conducted in line with basin bathymetry and water mass circulation behaviour, has demonstrated the following. Sampling points located closer to the right shore, are featured by lesser particle size of bottom sediments, than those at the left shore. This is due to fine-grained erosion products of water collection part from Zhigulevsk mountains side, represented by limestones and dolomites (points 4, 5, 14 and 34). Left-shore part of the water collection is featured by agricultural lands that leads to intense soil erosion (points 9, 17, 18). This also pre-defines relative growth in size of bottom soil particles at the left shore. At the same time, conspicuous circulation area at the left shore, which cover points 2, 6, 7, 39 and caused by southern winds dominating in summer period, pre-defines re-sedimentation processes of the most movable silt particles in this area.

Bottom sediments of Usa River estuary and distribution area of its waters (points 8 and 12) are represented by sandy and silty fractions.

Elevation distance curve of dam dub, represented by points 19, 3, 11, 14 and 16, is featured by relatively uniform particle size of bottom sediments, predominantly, of silty and sandy fractions, also. Soil diversity in particle size terms in the sample is expressed by intra-quantile swing value. The most uniform soil in terms of particle size is observed along the right shore: fine-grained erosion products of right-shore limestones and dolomites. The greater intra-quantile swing distinguished the samples taken along elevation distance of the dub. The latter can be clarified by the fact that bottom sediments in this area include both sands within fluvial sediments and silty particles because of organic sedimentation process in water area. Significant intra-quantile swing is also observed in sampling points 1, 10, 13, 15 and 17 at the left shore in shallow-water area. In this part of water area, genetically formed by sands and mineral silts, intense organic sedimentation processes occur because of favourable temperature regime and particulars of water masses circulation.

4. Conclusion

In 2020, following the results of field research by Institute of Volga Basin Ecology, RA, bottom sediments samples were taken in 21 points of Kuibyshev Reservoir dam dub. Conducted particle size
analysis has shown relative uniformity of bottom sediments size. At the same time, depending on the location of the sampling points, certain patterns of distribution of the size of bottom sediments in space are observed.

Fine-grained fractions with the least swing of particle size curve fall to the samples taken from the right shore. Water collection area of the right shore provides adjacent water area with erosion products of limestones and dolomites forming Zhigulevsk mountains. Soil erosion of left-shore water collection area, represented by agricultural lands, pre-defines fine- and middle-grained fraction within bottom sediments. The biggest particle size swing falls to elevation distance curve of the dub. This is justified by the fact that bottom soil includes sand drifts depositing in front of the dam, as well as silts and organic sedimentation products.

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