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DETERMINATION OF BOTTOM SEDIMENTS INTENSITY ACCUMULATION IN SAMARA GULF OF DNIEPER RESERVOIRS USING GEOGRAPHIC INFORMATION SYSTEMS (GIS)

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Purpose. Regulation of Dnieper river natural runoff promotes intensive accumulation of sediments within reservoirs. The consequence of this degradation phenomenon is the contraction of Dnieper reservoirs volume and deterioration of surface water. Traditional approaches do not provide objective assessment of reservoirs silting. However, the use of GIS technology can solve this problem. The purpose of work is assessment of indicators of solid flow in the Samara bay of the Dnieper reservoir based on GIS analysis. **Methodology.** The information basis for determining the parameters of accumulation of sediment runoff using GIS are digital models of bottom topography of artificial reservoirs. GIS analysis of bathymetric models in different time will provide receiving quantitative characteristics of the sediment accumulation. **Results and Practical value.** According to the results of GIS - analysis data for different times, in Samara gulf of Dnieper reservoirs intense accumulation of sediment runoff is observed: the rate of the reduction of water mass and intensity of sediments accumulation respectively constitute, on average 1.0%/year and 3.0 cm/year. Use of bathymetric models are also effective in predictive modeling of landscape structure changes of flooded areas in artificial reduction of the normal water level of reservoirs: identification of potential areas land boundaries, riverine lakes and the projected area. *References 7, no tables, figures 1.*

Key words: bottom sediments, the accumulation indicators of solid sediment runoff, digital model of the bottom topography, GIS analysis.

ВИЗНАЧЕННЯ ІНТЕНСИВНОСТІ НАКОПИЧЕННЯ ДОННИХ ВІДКЛАДІВ У САМАРСЬКІЙ ЗАТОЦІ ДНІПРОВСЬКОГО ВОДОСХОВИЩА ЗА ДОПОМОГОЮ ГІС

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Зарегулювання природного стоку р. Дніпро сприяє інтенсивному накопиченню донних відкладів в межах водосховищ. Наслідком цього деградаційного явища є зменшення об'єму дніпровських водосховищ та погіршення якості поверхневих вод. Традиційні підходи не забезпечують об'єктивною оцінкою стан замулення водосховищ. Проте застосування геоінформаційних технологій дозволяє розв'язати дану задачу. Інформаційною основою при визначенні показників акумуляції твердого стоку за допомогою ГІС є цифрові моделі рельєфу дна штучних водойм. За результатами ГІС – аналізу різночасових батиметричних даних встановлено, що в Самарській затоці Дніпровського водосховища спостерігається інтенсивна акумуляція твердого стоку: темпи скорочення об'єму водних мас та інтенсивність накопичення донних відкладів відповідно складають в середньому 1,0 %/рік та 3,0 см/рік. Використання батиметричних моделей також є ефективним при моделюванні прогнозних змін ландшафтної структури затоплених територій при штучному зниженні нормального підпірного рівня водосховищ: визначення меж потенційних ділянок суходолу, прируслових озер та прогнозованої акваторії.

Ключові слова: донні відклади, показники акумуляції твердого стоку, цифрова модель рельєфу дна, геоінформаційний аналіз.

PROBLEM STATEMENT. Unlike river systems where natural mode of operation is preserved, existence of Dnieper cascade water storage exacerbated manifestation of such phenomena as the degradation accumulation of bottom sediments, coast abrasion, intensification of populations of blue-green algae, etc. [1]. The largest environmental damages arise under the influence of accumulation of bottom-put through pollution of the hydrosphere, reduction the areas of commercial fish species, increase of the shallow areas. However, economic losses by reduction the volume of water storage and the need to clear the waterway for shipping are formed.

That shallow depth reduction is one of the main factors increasing areas of hydromorphic landscapes. According to research Starodubtsev V.M only in the Kiev reservoir, extreme acceleration overgrown aquatic vegetation amounted to more than 1,000 hectares per year in the last 5 years. Rates of overgrowing of Kremenchug reservoir are more slowly - 231 ha in 2009, Kanev - 117.5 ha in 2009 [2]. If we consider the dynamics of hydromorphic landscapes areas of Dneprodzerzhinsk reservoirs, then it is possible to observe area overgrowing reservoirs in recent years.

The Area of hydromorphic landscapes in Dnieper reservoirs increases quickly in recent years, reaching in 2009 almost 8 thousand ha, and the growth rate in the last year is 682.16 ha/year [2]. The processes of overgrowing shallow activated not only in all the reservoirs cascade, but also on their tributaries.

The situation with silting of reservoirs is very complicated. On the one hand, we have the uncontrolled flow of solids from the surface runoff from the basin, the main source of income of which is agricultural land

with an area 18 mln ha, in the Ukrainian part of the basin, at extensive farming the share of this contribution will only increase. On the other hand, this intensive processing, undermining, collapse shores form the main contribution to silting. The decisive factor in determining the silting is a process flow product distribution and processing of coast along the bottom of the reservoir. The lack of sophisticated approaches, methods, calculations of sediment runoff and break of coasts, do not allow to do an objective assessment of silting.

According to research of the ecological state of the Dnieper reservoirs, it is established that the use of geographic information analysis methods allow to determine the intensity and spatial differentiation processes of accumulation of solid flow within the cascade reservoirs of Dnieper during retrospective period on the basis of bathymetric data. Using GIS technology it is revealed a significant difference in the intensity of sediments accumulation in different parts of the Dnieper reservoirs - from 0.05% to 1.0% per year [3].

The aim is to evaluate the performance of the sediments runoff in Samara gulf of Dnieper reservoirs with application of GIS spatial data analysis.

On this issue except [3], the experience of digital bathymetric models in determining the rate of decrease of the volume (V) reservoirs due to the accumulation of bottom sediments [4, 5, 6] is also a useful. Thus, according to the geo-analysis it is found a decrease of Volume of reservoir McConaughy (USA) 0.03%/year [4], the reservoir Altinapa Dam (Turkey) - 0.51%/year [5], intensity of accumulation of bottom sediments for Kama Reservoir (RF): 2.5 - 5 cm/year [6].

However, the issue of spatial differentiation of intensity accumulation of sediments and their quantitative assessment for Dnieper reservoirs are studied not enough.

EXPERIMENTAL PART AND RESULTS OBTAINED. Samara gulf in its present form is a result of natural branch flooding of the river Samara due to construction of the Dnieper reservoirs and the corresponding water level rise of about 4.1 m. Gulf area is characterized by a predominance of shallow bays (depth of 2 m 63.95 % of total area) that create conditions for intensive accumulation of sediments.

The balance of Samara gulf sediment runoff is formed with the following parameters:

– solid flow of river Samara, river Kilchen and temporary watercourses small catchment areas;

– moving silts of above-mentioned rivers and water currents;

– abrasion products of coastline;

– solid runoff of rainwater, sewage, domestic and industrial water;

– dust residue on the surface of the gulf;

– the decay products of aquatic and marsh vegetation;

– solid runoff from / in river Dnieper (due to daily fluctuations in the Dnieper reservoir).

The total volume of accumulated sediments can be counted as the sum of the solid runoff values in a given time interval. However, the obtaining of reliable values of most indicators is difficult.

According to our previous researches [3] it is established the possibility of determining the boundaries of shallow sites of Dneprodzerzhinsk reservoir depth of 1 m for satellite images of high resolution (≈ 8 m), It is proved that remote sensing of the Earth also provide some updating hydromorphometric characteristics of reservoirs: area of water table, area of Islands, perimeter and length of the coastline taking into account the islands. However, these data are insufficient for quality assessment of the silting of reservoirs. Therefore, it is necessary to attract cartographic material and the work of soundings in the waters of the study.

Availability of bathymetric data what characters deep-menting characteristics and topography of artificial reservoirs, simplifies solving the problem of estimating the parameters of solid runoff accumulation in the GIS environment.

GIS technology is a modern method of obtaining and analyzing spatial information and it allows to move on a new level of certain ecological parameters assessment. GIS technology are designed to improve management efficiency, conservation and presentation of information, processing and decision support [7].

The information basis for determining the parameters of solid runoff accumulation using GIS is a digital model of the reservoir topography (or bathymetric models) at certain points in time (t_1, t_2, … t_n). The bathymetric model is a digital representation of the topography water object in the form of a regular array of z-values. It is known coordinates and depths mark for nodal points of the model plan.

The main stages of digital elevation modeling of reservoir bottom by cartographic and remote sensing data are reflected in [3]. Bathymetric data can be obtained from the results of hydroacoustic surveys, field observations, remote sensing data (in part) or recreated from topographical maps and navigation.

The presence of bathymetric models in different time will provide the quantitative characteristics of the accumulation of bottom sediments.

Accumulation indicators of solid runoff that may be determined based on digital elevation models in different time bottom water body in GIS environment are:

– power of bottom sediments (maximum, average);

– the volume of sediments;

– the intensity of sediments accumulation;

– reduction of V (volume) of the water object;

– reduce depths marks (maximum, average);

– reduction of water surface S (square);

– increase S (square) of islands;

– increase S (square) of shallow areas and so on.

The main methods of obtaining specified parameters in GIS environment are digital terrain modeling of the reservoir bottom, functional analysis DEM, selective vectoring of raster data, overlay thematic data processing.

Reliability of thematic analysis in GIS substantially depends on the solution of the problem of spatial data georeferencing in different time.

Application of geoinformation analysis method of hydrographic data in different time at research of the waters of Samara gulf allowed to obtain the actual

intensity value of processes of sediments accumulation in the period more than 30 years, namely:

1. The process of sediments accumulation are identified in the area of 3815.8 hectares, which is 84.0% of the overall square of gulf. The average power of sediments is 1.11 m.

2. Volume of bottom accumulated material (excluding the territory of new gulf islands) is 42,35 million m^3. The intensity of accumulation of sediments is approximately 3.0 cm/year.

3. Volume of water masses in the gulf dropped by 38.16%; V rate reduction is approximately 1% per year.

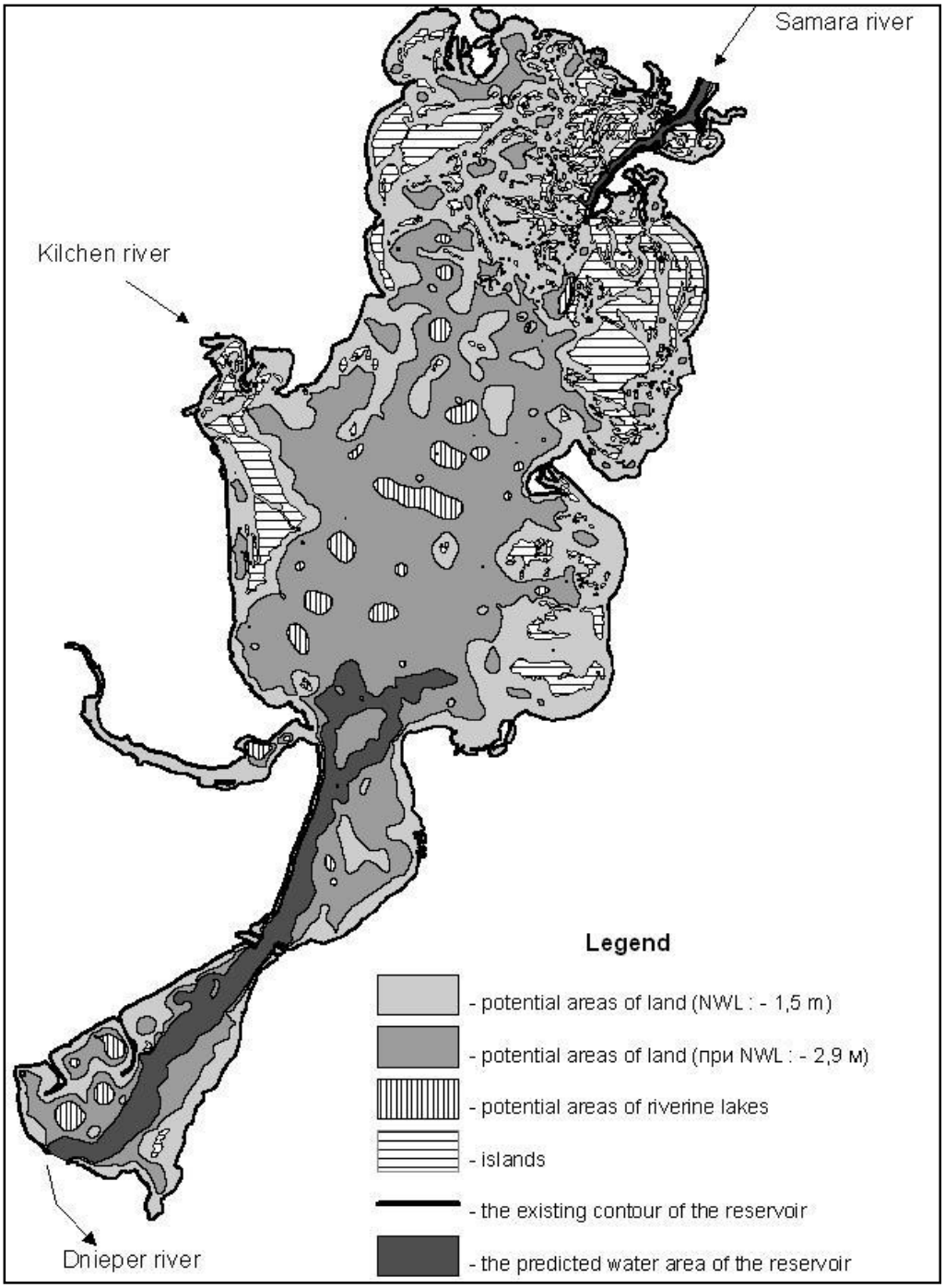

Figure 1 – Geomodeling of potential land areas to the waters of Samara gulf at decrease the NWL to 1.5 m and 2.9 m

4. Dynamics of the underlying characteristics of the gulf has the following laws:

– reducing the average depth of 2.36 m to 1.60 m;

– reducing the maximum depth of 9.20 m to 8.21 m.

5. Significant reduction of square of water surface is characteristic: from 4995.3 ha to 4542.2 ha, which is 9,07% (mainly due to the increase in the area of islands).

6. A significant increase (in 2.19 times) of gulf islands area of 308.0 hectares to 674.2 hectares.

7. The share of shallow areas of the gulf increased from 44.45% to 63.95%.

Also within the waters of Samara gulf we identified areas of washout/dredging of bottom material. This process is common in a limited area - 630.4 hectares, which is 13.9% of the gulf area. In addition, volume of

washout/dredging of bottom material is much smaller than a volume of accumulated sediments - only 2.76 million m^3.

Obviously, that the digital model of the reservoir topography is the basis for geomodelling of forecasting changes of landscape structure flooded areas at artificial lowering of the normal water level of reservoir. Based on the bathymetric model of Samara gulf in GIS environment the contours of potential land areas are defined at reduction of normal water level (NWL) by 1.5 m and 2.9 m (Fig. 1).

With GIS methods we identified the projected limits gulf area and riverine lakes on condition of the NWL decrease by 2.9 m (dead volume of the Dnieper reservoirs). The area of potential land parcels can make according 2140.1 and 4058.6 ha under prescribed conditions.

Zoning waters of the Dnieper reservoirs on the specifics of current velocity threshold part and part near the dam allows to predict differences in the mechanism of sediments accumulation on them. Further research will be directed to the identified area.

CONCLUSIONS.

1. Attracting bathymetric data in different time and further analysis in GIS environment will provide the quantitative characteristics of bottom sediments accumulation within reservoirs.

2. Research the issue of solid runoff accumulation within the waters of Samara gulf revealed the following patterns:

– sedimentation processes prevail over the washout/dredging processes of bottom material by 15.33 times;

– the volume of water masses in the gulf decreases an average of 1% per year;

– the intensity of sediments accumulation is approximately 3.0 cm/year.

3. To ensure mainstreaming of accumulation indicators of solid runoff it should take place hydroacoustic research the topography of the reservoir with interval of 5 - 10 years.

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ОПРЕДЕЛЕНИЕ ИНТЕНСИВНОСТИ НАКОПЛЕНИЯ ДОННЫХ ОТЛОЖЕНИЙ В САМАРСКОМ ЗАЛИВЕ ДНЕПРОВСКОГО ВОДОХРАНИЛИЩА С ПОМОЩЬЮ ГИС

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Зарегулирование природного стока р. Днепр способствует интенсивному накоплению донных отложений в пределах водохранилищ. Следствием этого деградационного явления есть уменьшение объема днепровских водохранилищ и ухудшение качества поверхностных вод. Традиционные подходы не обеспечивают объективной оценкой состояние заиления водохранилищ. Однако применение геоинформационных технологий позволяет решить данную задачу. Информационной основой при определении показателей аккумуляции твердого стока с помощью ГИС являются цифровые модели рельефа дна искусственных водоемов. По результатам ГИС – анализа разновременных батиметрических данных установлено, что в Самарском заливе Днепровского водохранилища наблюдается интенсивная аккумуляция твердого стока: темпы уменьшения объема водных масс и интенсивность накопления донных отложений соответственно составляют в среднем 1,0 %/год и 3,0 см/год. Использование батиметрических моделей также является эффективным при моделировании прогнозных изменений ландшафтной структуры затопленных территорий при искусственном снижении нормального подпорного уровня водохранилищ: определение границ потенциальных участков суши, прирусловых озер и прогнозной акватории.

Ключевые слова: донные отложения, показатели аккумуляции твердого стока, цифровая модель рельефа дна, геоинформационный анализ.