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NEW DELTAIC LANDSCAPES FORMATION IN LARGE WATER RESERVOIRS: GLOBAL ASPECT

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Abstract. *The formation of new deltaic landscape at the places where rivers flowing into the large reservoir is considered as an important and major scientific and economic problem. This process is estimated to be universal having a global character. New landscapes, which are formed by delta type, are vary considerably depending on climatic conditions. So here the processes of deltas formation in the temperate climate of Ukraine and in arid and semiarid climate of Central Asia are discussed in more detail. Schematic observations are made in other regions of the world as well. Problem analysis was carried out using remote sensing data (Landsat satellite imagery) and ground-based observations. Using satellite images made it possible to trace the process in time and space over a long period. Deciphering of satellite images with the help of specialized software gave a possibility to determine the area of the newly formed landscapes and approximately to diagnose soil and vegetation objects that were specified by ground monitoring in the reservoirs.*

Keywords: *delta, reservoir, satellite image, deciphering, landscape, soil, vegetation*

State of the problem. Creation of new large reservoirs for the development of hydropower, irrigation, water supply, transport and other sectors of the economy is actively continued worldwide**.** Most of the major rivers are regulated by reservoirs, in varying degrees [1, 2, 7, 13, 15], despite the opposition of the environmentalists and the public to this process. The impact of such large water bodies on the environment, including vegetation and soil cover, on the coast flooding and destruction, and even on the climate was studied comprehensively [2, 3, 15]. However, one important aspect of the interaction of water reservoirs and rivers on which they are made was completely insufficiently researched and evaluated. This is -— the formation of new deltas-like landscapes at the confluence of the river into the reservoir. This process is especially characteristic for rivers with large sediment load, which is often observed in arid, subarid and in sub-humid regions [13]. Previously, researchers have considered this process mainly from the standpoint of the silting of reservoirs and reduce of their useful capacity. But in fact it turned out to be much more substantial and varied. In many reservoirs of the world for many decades of their existence actually new deltas with rich hydromorphic landscapes and unique vegetation and soil cover were formed. This is the process we are witnessing in many reservoirs in Ukraine, Central Asia, Kazakhstan, North and South America, eastern and southern Europe [4-14].

Initially, the formation of new deltas in large reservoirs we observed during field hydrological and morphological, botanical, and soil studies. The essential information is also provided by updated topographic maps and cartographic service Google Earth. But the real breakthrough in the study of this problem was made possible with the advent of medium-sized and detailed satellite images that allow us to evaluate this process in time and space. In particular, the huge role was played by the opening of access to the NASA archives. It has made possible to use the Landsat imagery for more than 40-year period for remote monitoring of this important scientific, environmental and economic problems.

Objects and methods of research. Detailed field studies of deltas formed in large reservoirs, as well as the analysis of remote sensing data held in Ukraine on a cascade of six reservoirs on the Dnieper River (Figure 1) and on the Kapchagay reservoir in the Ili River . To monitor the dynamics of the hydromorphic landscapes area in these water bodies space Landsat imagery obtained from NASA's public archives, as well as topographic and electronic Google Earth maps were used. However, at the earliest images of Landsat-2 outlines the boundaries of the water surface and hydromorphic landscapes are insufficiently clear. More reliable results could be obtained from satellite images Landsat 4-5 and 8.

Fig.1. Cascade of reservoirs on the Dnieper River (Ukraine)

The ISODATA algorithm, channel combinations "true color", 7-5-3 (Landsat 4-5) and 7-6-3 (Landsat 8) were used for the decoding of satellite images. Field routes, which since 2010 are held with accurate geo-referenced GPS-receiver allows specifying the nature and characteristics of the delta landscape formation in reservoirs.

Results of research and discussion. The formation of new deltas in the cascade of reservoirs on the Dnieper River, which are extending within a few natural zones, has, in our opinion, very essential environmental, social and economic importance. For 50-60 years of the existence of these reservoirs hydromorphic landscapes with delta features over an area of 40,000 hectares, and taking into account the water surface within these landscapes - about 80,000 hectares, are formed in them. At the same time the growth rate of deltaic landscapes has achieved in recent years in the whole cascade about 2,000 hectares per year.

This rapid development of new landscapes in the Dnieper reservoirs is related not only to the accumulation of river sediment and activation of delta-litho-morphogenesis, but also to the rapid spread of hygrophytic and hydrophytic vegetation, including the "Red Book" species of vegetation - water chestnut (Trapa natans). As a result, the unique natural-technogenic landscapes were formed that promote enrichment of biodiversity in the region, as well as serving the recreational base for many megacities. At the same time, the "blooming" of water and rotting of the great mass of higher plants and algae leads to intense oxygen consumption and deterioration of the living conditions of the entire biota of water bodies. Qquality of river water for municipal and industrial water supply as well as for irrigation is sharply deteriorating. Significant difficulties arose to water transport, energy production, fisheries and other sectors of the economy as well.

The topmost reservoir (Kiev) in the cascade on the Dnieper River (Fig.1) was created in 1964-1965. It accumulates in its upper part a solid runoff (sediments) of the Dnieper and Pripyat, as well as coastal erosion materials and nutrients. Therefore, the processes of hydromorphic delta-like landscapes formation here are the fastest. New riverine shafts and islands with a cellular topography (respectively - and new land resources) the most actively form in the very upper part of the reservoir, that is, in the "spurs" of the Dnieper and Pripyat. That is why we have called this area the Pripyat-Dnieper Delta [4, 6, 14]. Downstream the water area is heavily overgrown with coastal-aquatic vegetation (Phragmites australis, Typha angustifolia, and Scirpus lacustris). But in last years thickets of aquatic plants with floating leaves (Nymphaea alba, Nuphar lutea, Trapa natans) spread rapidly here. On the already formed islands tree-shrub vegetation, which is characteristic for floodplain forests, is developing. The expansion of the new vegetation was so large that it exceeded our forecasts. Therefore we had to significantly increase the area of the territory in which the monitoring is carried out, with 16,547.8 to 25,842.2 hectares (Tabl.1). The annual increase in the area of hydromorphic landscapes in the Kiev reservoir for the period up to 2005 was 100-200 ha. But in the last decade, this value in the hottest years exceeded 1,000 hectares per year, creating significant problems even for navigation [4, 6, 11, 12, 14]. At the same time, recreational use of the territory outside the Chernobyl zone improved; the biodiversity of the region significantly enriched.

During the research we found that the materials of remote sensing make it possible to quantify the formation of the Pripyat-Dnieper delta (Table 1 and Figure 2), and even to predict it in the near future. Nevertheless, the environmental and economic value of the new landscape can be reliably assessed only after the determination of their structure and the state based on detailed terrestrial surveys at least in key areas.

1. Dynamics of hydromorphic landscapes formation in the Pripyat-Dnieper delta (upper part of Kiev reservoir)

Year	Area of wetlands, ha	Water area, ha	Increase of wetlands, ha	Rates of growth, ha/year	Area of plot, ha
1985	6996,0	18846,2	-	-	25842,2
1999	9708,1	16134,1	2712,1	193,7	25842,2
2005	10415,8	15426,4	707,7	117,9	25842,2
2009	15437,5	10404,7	5021,7	1255,4	25842,2
2011	17090,6	8751,6	1653,1	826,6	25842,2
2015	16759	9534	-332,6	558,6	25842,2

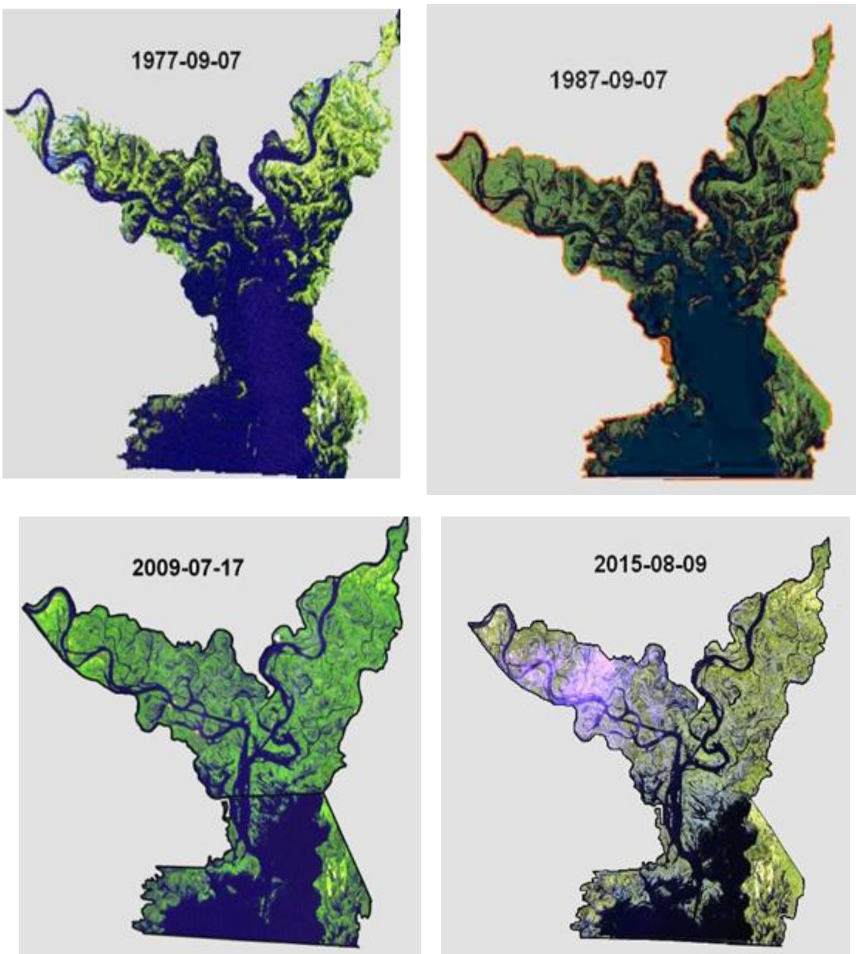

Fig.2. Dynamics of the Pripyat-Dnieper Delta formation in the Kiev reservoir according to satellite images Landsat

With this purpose since 2010 we are holding ground (water) routes with the use of the GPS-receiver to determine the exact geographical coordinates of the investigated areas. Routes were carried out on newly formed islands, riverine shafts and coastal areas outside the Chtrnobyl exclusion zone. First of all on the ground we allocated terrestrial ecosystems with bog-meadow, meadow-bog and bog soils under the sparse trees and shrubs with meadow grasses. Then we studied coastal-aquatic ecosystems under continuous thickets of reeds (Phragmites australis) and cattail (Typha angustifolia), thickets of aquatic vegetation with floating leaves (Nymphaea alba, Nuphar lutea, Trapa natans). It was more difficult to explore areas of submerged aquatic vegetation. In inaccessible to us the Chernobyl exclusion zone, we allocated similar ecosystems on the detailed cartographic servise Google Earth, drawn up on the basis of Spot and Quick Bird satellite images. This experience has shown that the use of these cartographic materials is appropriate for the approximate analysis of emerging hydromorphic landscape structure, in particular, to determine the area of new land resources and wetlands. Only areas of sparse aquatic vegetation, including more recently "Red Book" water chestnut, and submerged aquatic vegetation are not clearly defined.

To objectively confirm the structure of the new deltaic landscape, we proposed an analysis of their seasonal dynamics on satellite images. However, the launch in 2013 the Landsat 8 satellite with a new sensor OLI, which is slightly different diagnoses landscape and water surface, created some difficulties for research as a long-term and seasonal dynamics of the delta. However, the high quality of the images still allows us to investigate the seasonal dynamics of landscapes and their structure. It was possible to estimate the approximate structure of the delta landscape, having isolated terrestrial ecosystems (mainly trees and shrubs), coastal-aquatic ecosystems with a predominance of reeds and cattails as well as areals of aquatic plants with floating leaves [6]. We can not yet diagnose areas of submerged aquatic vegetation which occupy large areas here.

2. Seasonal changes in the landscape area of the Pripyat-Dnieper Delta in the Kiev reservoir, ha

Classes	2014.07.31	2014.09.10	2014.10.14	2014.12.31	2015.04.29
	Area, ha				
Water area	9393	11098	13289	13807	15818
Coastal-aquatic and aquatic vegetation	9982	8803	6716	5626	2329
Terrestrial ecosystems+ alluvium	6918	6392	6288	6860	8148
Total	26293	26293	26293	26293	26293

In the first half of the growing season hydro-morphological processes and vegetation development depend on the power of the passage of spring floods and ice drift. In the second half of the growing season landscapes change depends on the temperature regime of water and air. Maximum development of coastal-aquatic and aquatic vegetation reaches at the end of July - the first half of August (Figure 3, image of the July 31, 2014). In September an extinction of aquatic vegetation starts. In October - November, coastal aquatic vegetation dies, and than it is partly destroyed by the spring ice drift. A study of the seasonal dynamics of the delta landscapes (Table 2) allows estimating approximately the structure of the landscape and evaluating objectively enough in the future the long-term trend both the total area of the new delta and its components.

In general, the formation of the Pripyat-Dnieper Delta in the Kiev reservoir has both positive and negative consequences. The positive effects include: 1) enrichment of biodiversity in new terrestrial ecosystems and wetlands; 2) the possibility of establishing new protected areas; 3) prospects for recreational development in the region outside the Chernobyl exclusion zone; 4) burial dropped to the bottom of the reservoir after the Chernobyl accident radioactive deposits with new mineral and organic sediments; 5) expansion of fish spawning areas, etc.

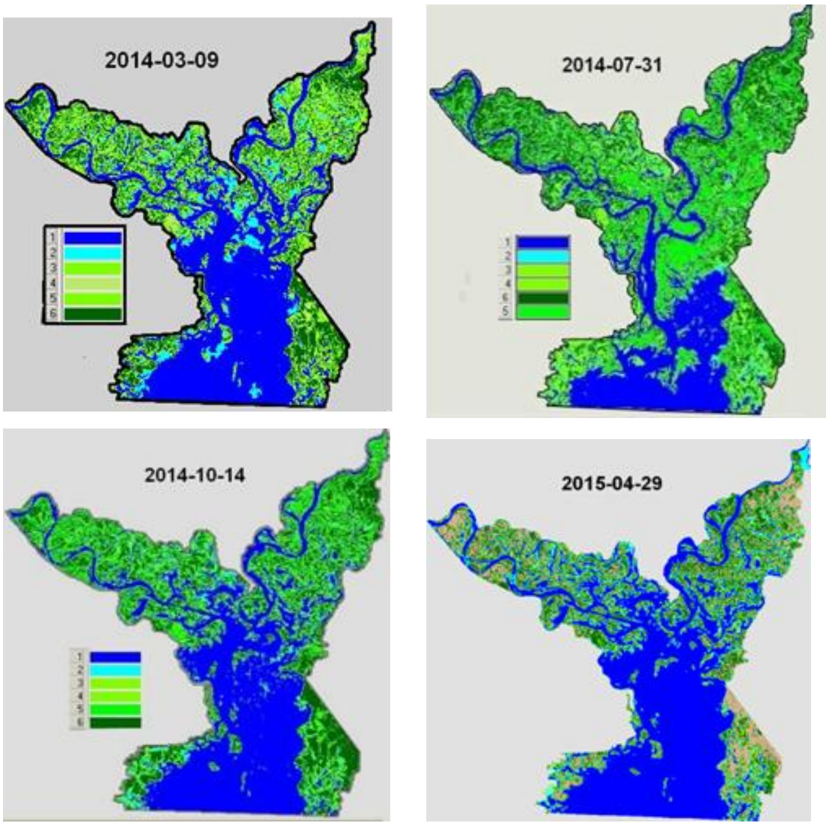

Fig. 3. Seasonal dynamics of the landscape of the Pripyat-Dnieper Delta in the Kiev reservoir

The most important adverse effects include: 1) water quality deterioration due to the decomposition of higher plants organic matter and algae"bloom"; 2) a significant deterioration in conditions for water transport due to the overgrowth of the reservoir water area; 3) reduction of the volume of water in the reservoir, which is used for hydropower generation and water supply; 4) activation of erosion and accumulation in the beds of the Dnieper and Pripyat above the reservoir, followed by a horizontal and vertical changes in the channel that leads to the destruction of beaches and flooding of lands; 5) deterioration of conditions for the passage of powerful floods through the Kiev reservoir.

A limited size of this chapter does not allow us to give a detailed description of the formation of the delta landscape in all the reservoirs created downstream of the Dnieper River. We note only that close by the nature the processes of new deltaic landscapes formation occur in large Kremenchug (third in the Dnieper cascade) and Kakhovka (the sixth in the cascade) reservoirs (Fig. 4 and 5).

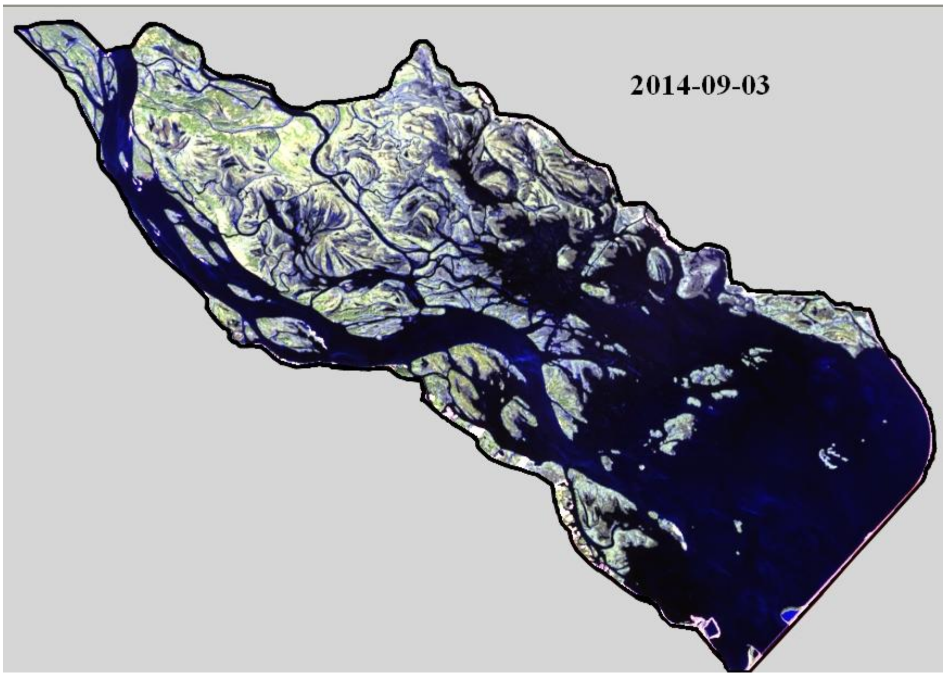

Fig. 4. The Kremenchug delta of the Dnieper on the satellite image Landsat-8

Kremenchug reservoir for many-year flow regulation was filled in 1960-1961. In the upper part of this water body the hydromorphic landscape area fairly quickly increases. By 2010 it was about 7 thousand hectares; an increase for 10 years amounted more than 3 thousand hectares, while the growth rate reached 231 ha / year [7, 12]. In contrast to the Kiev reservoir, the area of aquatic and coastal-aquatic vegetation increases here with the highest rates. However the formation of new islands and shoals, which will soon become the land, there is also quite active.

In the largest Kakhovka reservoir (the sixth reservoir in the cascade, but the first one according to the time of creation on the Dnieper River) ever since it’s filling in 50-ies of the last century almost all solid runoff (sediments) of the Dnieper River have accumulated. In those years the coast with fertile chernozemic (black) soil intensively destroyed there, the area of shallow water increased, new islands appeared. In fact, these processes have been the beginning of the new

(Kakhovka) delta formation, that is, the formation of a unique landscape, which was not there before. Later deposits of the Dnieper River began to accumulate since 1960 in Kremenchug, and since 1964 - in the Kiev reservoir. However, an increase of new deltaic area continued there due to overgrowth with coastal-aquatic, aquatic vegetation and trees and shrubs, and due to the accumulation of organic sediments. An accumulation of mineral deposits formed by coastal erosion and processes inside the water body has continued with slower speed. According to preliminary data, automorphic and hydromorphic soils in the Kakhovka delta occupy 15-20%, bog and subaqueous soil under the reeds, cattails and other hygrophytes - 40-50%, and the ranges of hydrophytes, including water chestnut with floating leaves - 30-40%. Only in the years 2000-2010 the Kakhovka delta area has increased by 1.5 thousand hectares, while the growth rate was about 150 ha / year [9, 10].

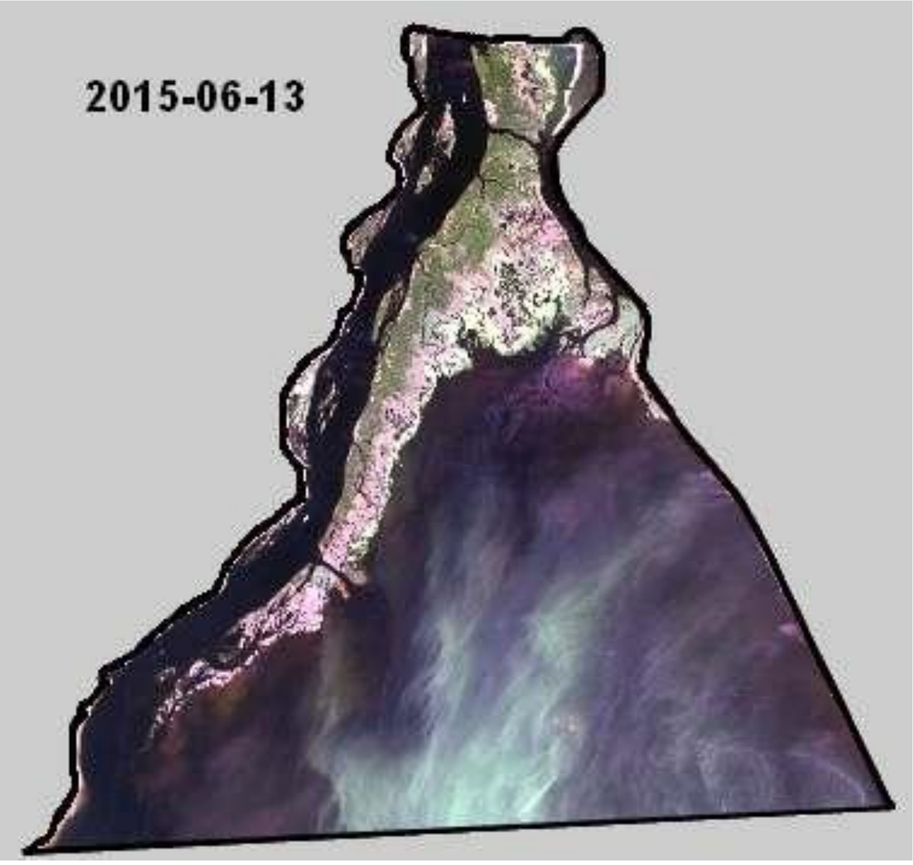

Fig. 5. The Kakhovka delta of the Dnieper on the satellite image Landsat-8

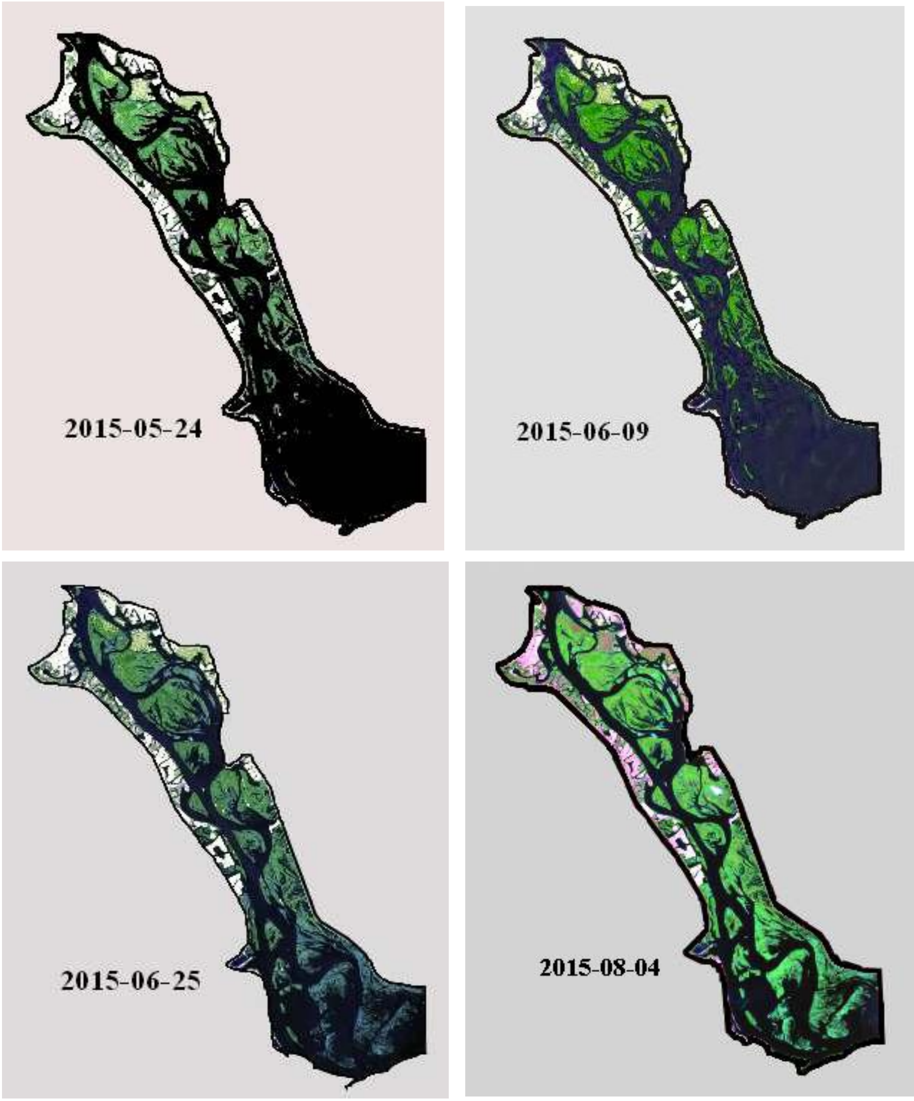

Fig. 6. Fragments of new delta in the Kaniv reservoir. Seasonal dynamics.in 2015

The formation of delta-like landscapes in two long and narrow reservoirs – the Kanev (second in cascade) and the Dneprodzerzhinsk (fourth in the cascade) is less clear (Fig. 6 and 7). Here, the increase in the areas of hydromorphic landscapes occurs mainly around the remaining islands and along the coast. New islands due to the accumulation of mineral and organic sediments are formed as well. In the Kanev reservoir natural processes of hydromorphic landscapes formation at the upper part are complemented by a massive inwash of new lands by dredgers in the water area and the subsequent a “dacha” construction there, as it can be seen even on satellite images. Determination of areas on such images showed that in the period 1992-2005 it was inwashed only within the territory that we studied more than 800 hectares of new land in the reservoir water area. Total area of hydromorphic landscapes in upper part of reservoir exceeded 3 thousand hectares, and the rate of their increase amounted 66 ha/year [5, 14]. The specific feature of this reservoir is a strong "bloom" of water due to the high concentration of nutrients in it. In the upper part of the Dneprodzerzhinsk reservoir (forth in the cascade) delta-like landscapes are forming as islands as well. Total area of such lanscapes amounts about 6 thousand hectares, the rate of its increase is about 100 ha/year [12, 13]. In the most deep and narrow Dneprovskoye reservoir, which flow in rock bed, delta-like landscapes were not formed.

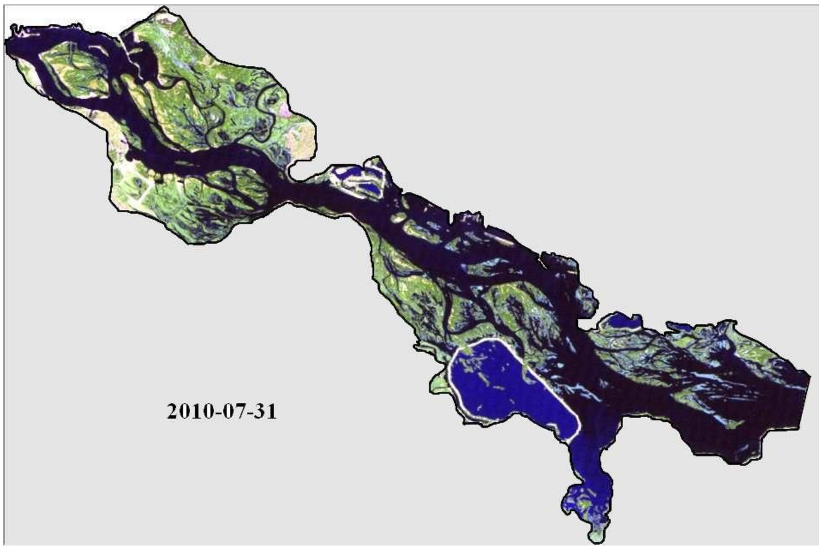

Fig.7 Fragments of new delta in the upper part of Dniprodzerzhinsk reservoir

In semiarid and arid regions one of the most illustrative processes of new deltas forming is the development of a delta in the largest Kapchagay reservoir with capacity of 28.1 km^3 in the south-east Kazakhstan. It was created on the Ili (Ily) river for power generation and the development of irrigation in the lower part of the basin (Fig. 8). Its filling began in 1970 and lasted for a long time, mainly in the wet years. Due to the Ili flow regulation the entire bowl of the reservoir, especially its upper part, accumulated annually about 11 million tons of river sediments [9, 10], as well as a significant amount of the coastal erosion products. Slowing the speed of the water flow at the confluence of the river Ili into the reservoir and the sediment accumulation mainly manifested itself in the early years only in the so-called horizontal erosion of the riverbed (according to Makkaveev N.I.), which extended to the abandoned resort Ayakkalkan. But gradually accumulated deposits began to form islands with peculiar hydromorphic landscapes (Fig. 9, 1975). Enlarging and uniting among themselves, being subject to continuous reformation of the Ili riverbed, especially in the spring and summer, they began to create delta-like area, which we called "the Kapchagay delta" [7, 8, 10]. This process was extremely uneven and it depended on variability of water and solid flow of the river, use of water resources in the Chinese part of the basin, the reservoir level fluctuations and other factors. In the 90s it has become a highly visible (Fig. 9, 1999), and in the first decade of the 21st century it even accelerated sharply. Using Landsat satellite images, we had the opportunity to analyze the formation of the new delta in time and in space (Fig. 9, Table 3) and to assess the rate of increase in the hydromorphic landscapes area within the selected contour. The total delta area (with lakes and streams) in 2009 amounted to 11775.9 hectares, and the area just hydromorphic landscapes (excluding water surface) 8165.8 ha. The growth rate of the area of these landscapes is shown in Table 3.

3. Increase of the Kapchagay delta area in 1979 – 2012 [8]

Data of satellite images	Area of deltaic landscapes, ha	Increase of delta' area, ha	Rate of delta' increase, ha	Total studied area, ha
1979*	436.1	-	-	11775.9
1999-07-31	2836.1	+2400,0	120,0	11775.9
2005-06-21	5782.9	+2946,8	491,1	11775.9
2009-08-27	6497.3	+714,4	178,6	11775.9
2011-09-05	6867.5	+370.2	185.1	11775.9
2012-09-05	8165.8	+1298.3	227.3	11775.9

Fig. 8. Kapchagay reservoir on the Ili River with new delta

Common features of the landscape formation here is broadly in line with views of the unity of litho-morpho-genesis and soil formation in deltas [1], as well as with changes in deltas under processes of aridization [9, 13]. However, the cellular terrain and riverine elevations ("riverine trees" or “levees) are only formed. So the soil cover in low-lying areas is dominated by, in accordance with our long-term studies of ecological and genetic series of soils changes [9, 10], swamp and meadow-swamp soil under reed (Phragmites australis) and cattail (Typha angustifolia). Large areas in the new delta are occupied with floating aquatic vegetation on the so-called "subaquatic" soils. And only on the islands in the eastern part of the delta, preserved unflooded, common meadow-sierozem and meadow saline soils are spread. In general, reservoir level fluctuations and active the reservoir shores (as the northern and southern coast) reshaping are effect on the "Kapchagai delta" landscape formation as well. At the same time, rising of the delta area because of the sediments accumulation leads to increased flooding and soil salinity in the area of the southern shores of Chilik alluvial fan that is diagnosed very clearly on satellite images. In this situation, the conditions are created here for the formation, according to Plisak R.P., salt-hydrophytic vegetation, including annual halophytes, in particular, seepweed (Suaeda crassifolia, S. prostrata), Climacoptera (Climacoptera brachiata, C. obtusifolia), camphor-fume (Camphorosma brachiata, C. monspeliacum), Aeluropus littoralis and etc.

In general, the new delta formation in the Kapchagai reservoir for a 30-year period with an average rate more than 200 ha per year demonstrates the scope and the universality of the process (Fig. 9). Moreover, such speed of the new delta enlargement exceeded our expectations. That is why we must significantly change the size of investigated area sibce 2014 (Fig. 10).

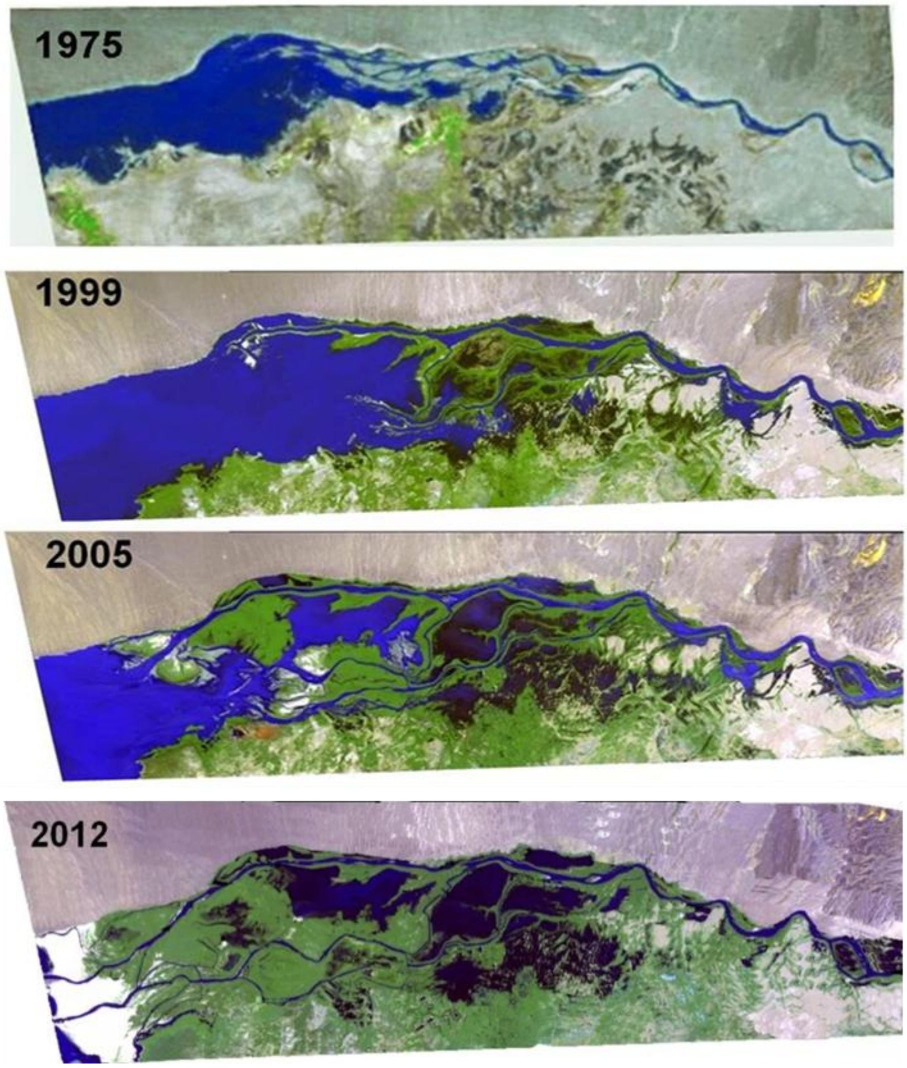

Fig. 9. Dynamics of the new delta in Kapchagay reservoir for 1975-2012

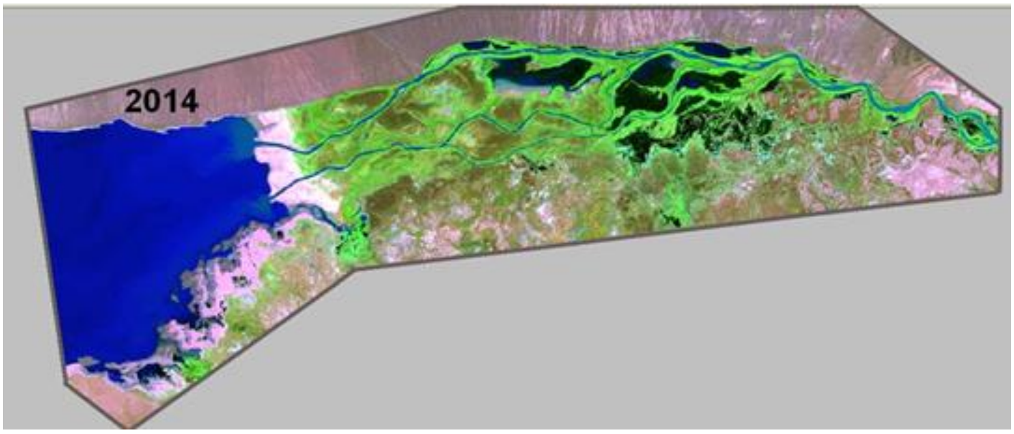

Fig. 10. New configuration of the investigated area in the Kapchagay reservoir

The newly formed landscapes are of great ecological importance as reserves of biodiversity, as well as the recreational facilities and a subject for economic development. Therefore, further remote sensing and ground monitoring of such unique landscapes is an important scientific task in this region. At the same time, of great practical and ecological importance it is a process of banks erosion that manifested upstream from newly formed delta. Development of the river water backing-up causes increased river meandering, coastal erosion, flooding and even the submerging of coastal areas. Such a process is marked at the Ili River in the area between the tributaries of the Chilik and Charyn (Fig. 11).

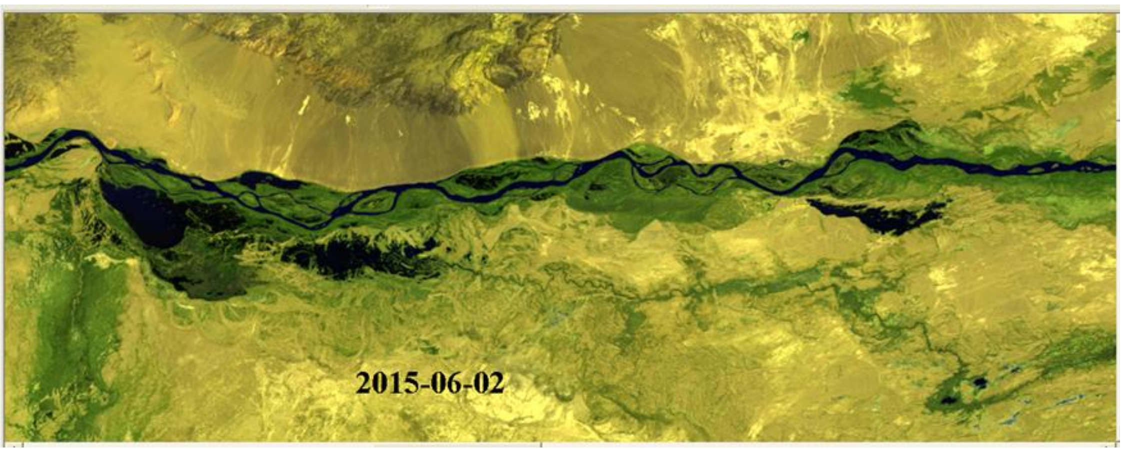

Fig. 11. Banks erosion and the new wetlands formation along the Ili River bed upstream the Kapchagay reservoir

New deltas in irrigation reservoirs, in which every year there are large fluctuations in the level, are forming more complicated. Accumulative processes in the upper part of such water bodies alternate there with coast and bed erosion during the "drawdown" of the reservoir. This is precisely the situation in many reservoirs of Turkmenistan, Uzbekistan, Kazakhstan and other countries. An example of the delta formation at the area more than 3600 hectares in Zeid reservoir on the Karakum channel (Turkmenistan) is shown in Fig.12.

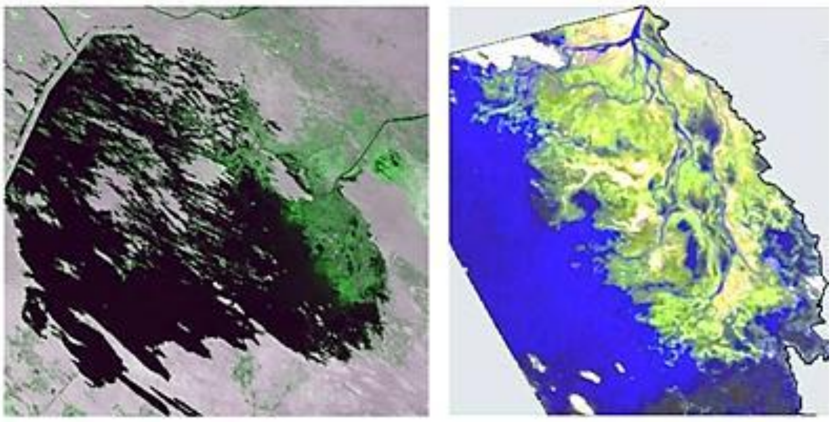

Fig. 12. The new delta formation in the Zeid reservoir: total view (left) and newly formed landscape (right)

Significant differences in the area and the state of the newly forming delta-landscape in reservoirs with large level fluctuations during filling and drawdown are shown on the example of the Chardara reservoir on the Syr Darya River (Fig. 13).

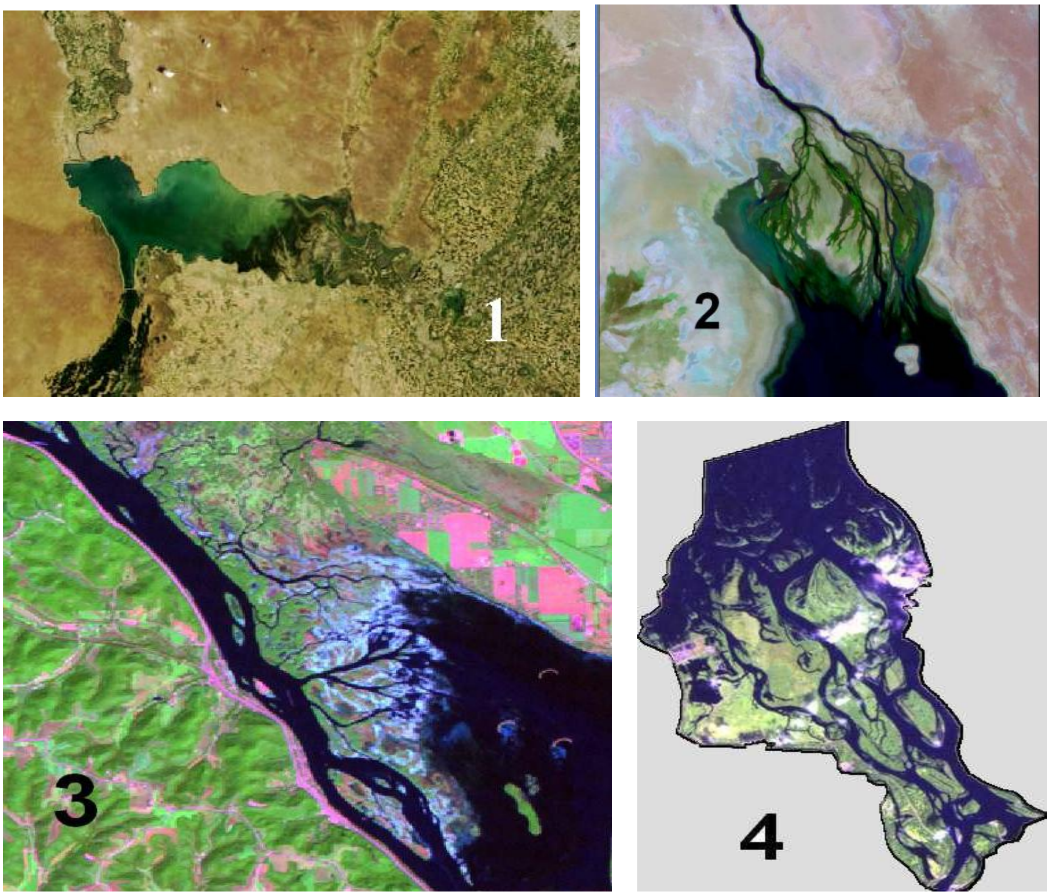

Fig. 13. New deltas formation in the Chardara reservoir on the Syrdarya River (1), in the Mihl reservoir on the Euphrates River (2), in the Onalaska reservoir on the Missuri River (3), in the Krasnoyarsk reservoir on the Yenisey River (4)

The versatility of the new deltas formation processes in the upper part of large reservoirs is confirmed by their presence in reservoirs on the Nile, Volga, Mississippi, Missouri, Euphrates, Colorado, Zambezi, Lena, Yenisey and many other rivers. Even the river Syrdarya had time to form a new small delta at the confluence into the Small Aral Sea, created a decade ago (Fig. 14).

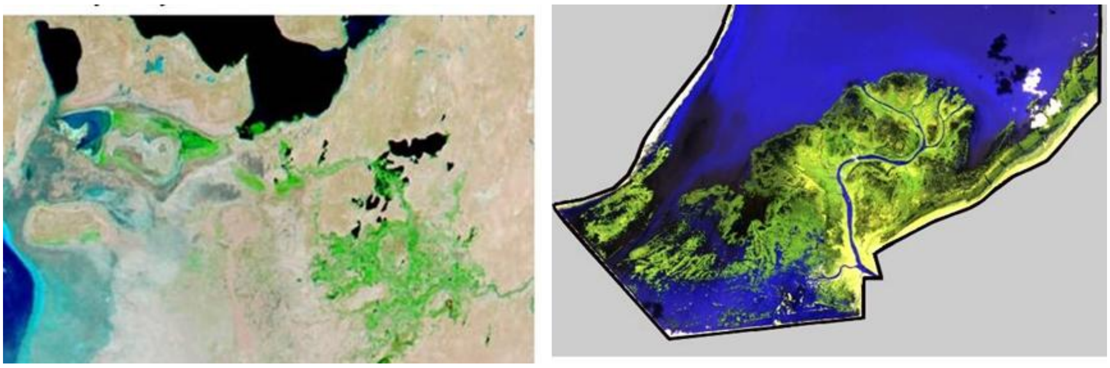

Fig. 14. Old delta of the Syrdarya River (left) and new delta in the Small Aral Sea (right)

Global aspect of new (inland) deltas formation in large water reservoirs we show not only with these figures but also with table 4, where areas of such deltas are calculated. Of course, it is not exhaustive list, but it demonstrates the presence of such process on all continents of the world.

4. Examples of new deltas in large water reservoirs of the world

Continent	River	Reservoir	Investigated area, ha	New landscapes, ha
Europe	Dnieper	All dams	80000	40000
Asia	Euphrates	Keban	2794	1280
	Euphrates	Mihl	7020	2603
	Yenisey	Krasnoyarsk	5193	2736
	Volga	Volgograd	72381	41113
	Amudarya	Zeid	9327	5812
	Syrdarya	New delta in the Aral Sea	12345	4662
Africa	Zambezi	Kahora Basso	14682	2800
North America	Mississipi	Onalaska	9932	6388
	Missuri	Canyon Ferry	2053	1152
South America	Sao Francisco	Sabradinho	81354	41488
	LaPlata		29305	16201

Conclusion. Formation of new deltaic landscape in the upper part of large reservoirs is a universal process, which manifests itself in different ways in different climatic zones, depending on the amount of sediment in the river, flow regulation, geomorphology of reservoir bed, soil and vegetation on coasts, and many other factors. The new elements of relief are formed due to the accumulation of sediment runoff, reshaping coasts, erosion, overgrown of shallow water, an accumulation of organic matter, etc. Here the features of the deltas formation are shown in the cascade reservoirs on the Dnieper River in Ukraine on the territory with temperate climate and plain topography as an example.

Environmental and economic significance of new deltaic landscapes is enormous and ambiguous. Positive consequences of these landscapes are: (1) enrichment of unique biodiversity in such deltas; (2) capability of vast recreational development of these territories, especially near large cities; (3) the possibility of establishing new protected areas; (4) reclamation of new land resources; 5) expansion of fish spawning areas, etc. Negative consequences of new deltas formation are as follows: (1) decomposition of organic matter of higher vegetation and algae "bloom" cause an essential deterioration of water quality that is used for industrial, communal and agricultural use; (2) overgrowing of upper part of reservoirs creates hard problems for a water transport; (3) conditions for fish farming become worse; (4) volume of water in reservoirs for electricity generation gets lesser; (5) new deltas activate regressive erosion in a river course upstream and increase a bank destruction and land waterlogging; (6) threat of spring floods becomes stronger. That is why further remote and terrestrial monitoring of such unique landscapes formation is a very important scientific, economic and environmental task.

Reference

1. Mikhailov V.N. (1998). *Hydrology of river mouths.* Moscow: MGU. (In Russian.).
2. Nilsson C., Reidy C.A., Dynesius V., Revenga C. (2005). Fragmentation and Flow Regulation of the World's River Systems. *Science.* V.308, 405-408.
3. *Reservoirs and their impact on the environment*. (1986). Edited by G.V. Voropaev and A.B. Avakian. Moscow: Nauka. (In Russian).
4. Starodubtsev V.M. (2011). Formation of Pripyat-Dnieper delta in Kiev reservoir. In: *Geography. Economy. Ecology. Tourism: Regional study.* V.5, Nizhyn, 214-221. (In Ukrainian).
5. Starodubtsev V.M. (2012). *Kaniv reservoir: "Ukrainian Venice or environmental threat.* Kyiv: Agrar Media Group. (In Ukrainian).
6. Starodubtsev V.M. (2012). Sesonal dynamics of landscapes in the Pripyat-Dnieper delta of Kiev reservoir. In: *Natural resources of Polessie: estimation, use, protection. Part 2.* Pinsk: Polessriy state university, 78-80. (In Russian).
7. Starodubtsev V.M. (2013). Remote sensing of new deltas formation in a top of large reservoirs. *Problems of desert development,. № 1-2*, 15-21. (In Russian).
8. Starodubtsev V.M. (2017). Formation of new delta-like subject in the Kapchagay reservoir on the Ili River. *Water Resources, № 1.* (in print).
9. Strodubtsev V.M., Bogolyubov V.N., Petrenko L.R. (2004).*Soil desertification in river deltas. Part I.* Alma-Ata: Nauka.
10. Starodubtsev V.M., Bogdanets V.A. (2010). Formation of new delta of the Ili River in the Kapchagay reservoir. *Arid Ecosystems. V. 16. № 4(44)*, 49-53. (In Russian).
11. Starodubtsev V.M., Bogdanets V.A., Yatsenko S.V. et al. (2010). Formation of deltaic landscapes in upper reservoirs of the Dnieper cascade. *Scientific reports of NULES, №5(21).* http://www.nbuv.gov.ua/e-journals/Nd/2010_5/10svmdrc.pdf. (In Ukrainian).
12. Starodubtsev V.M., Bogdanets V.A. (2010). Formation of new deltas in the Dnieper reservoir. *In: Nature management: ecology, economy, technology.* Minsk, 279-282. (In Russian).
13. Starodubtsev V.M., Bogdanets V.A. (2012). New deltas formation in large water reservoirs. In: *Fourth International Conference on Water Resources and Renewable Energy Development in Asia.* Chiang Mai, Thailand, Conference papers, CD.
14. Starodubtsev V.M., Bogdanets V.A. (2012). Dynamics of hydromorphic landscapes formation in upper part of Dnieper river reservoirs. *Water Resources, v.39, #2,* P. 165-168.
15. World Commission on Dams. (2000). *Dams and Development: A new Framework for Decision-making.* Cape Town. www.dams.org.

ФОРМУВАННЯ НОВИХ ДЕЛЬТОВИХ ЛАНДШАФТІВ У ВЕЛИКИХ ВОДОСХОВИЩАХ: ГЛОБАЛЬНИЙ АСПЕКТ

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Анотація. *Формування нового дельтового ландшафту в місцях, де річки впадають у великі водосховища, розглядається як важлива наукова і економічна проблема. Цей процес оцінюється як універсальний, що має глобальний характер. Нові ландшафти, які утворюються за типом дельти, можуть значно відрізнятися в залежності від кліматичних умов. Так що тут процеси формування дельт в помірному кліматі України і в посушливому і напівпосушливому кліматі Центральної Азії обговорюються найбільш детально. А також схематичні спостереження зроблені й в інших регіонах світу. Аналіз проблем проводився з використанням даних дистанційного зондування Землі (супутникових зображень Ландсат) і наземних спостережень. Використання супутникових знімків дало можливість простежити процес у часі і просторі протягом тривалого періоду. Дешифрування космічних знімків за допомогою спеціалізованого програмного забезпечення дало можливість визначити площу новостворених ландшафтів і приблизно діагностувати грунти і рослинні об'єкти, які в подальшому були уточнені наземним моніторингом у водосховищах.*

Ключові слова: *дельта, водосховище, супутникові зображення, дешифрування, ландшафт, грунт, рослинність*

ФОРМИРОВАНИЕ НОВЫХ ДЕЛЬТОВЫХ ЛАНДШАФТОВ В БОЛЬШИХ ВОДОХРАНИЛИЩАХ: ГЛОБАЛЬНЫЙ АСПЕКТ

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Аннотация. *Формирование нового дельтового ландшафта в местах, где реки впадают в крупные водохранилища, рассматривается как важная научная и экономическая проблема. Этот процесс оценивается как универсальный, который имеет глобальный характер. Новые ландшафты, которые образуются по типу дельты, могут значительно отличаться в зависимости от климатических условий. Так что здесь процессы формирования дельт в умеренном климате Украины и в засушливом и полузасушливом климате Центральной Азии обсуждаются наиболее детально. А также схематические наблюдения сделаны и в других регионах мира. Анализ проблем проводился с использованием данных дистанционного зондирования Земли (спутниковых изображений Ландсат) и наземных наблюдений. Использование спутниковых снимков позволило проследить процесс во времени и пространстве в течение длительного периода. Дешифрирование космических снимков с помощью специализированного программного обеспечения позволило определить площадь новообразованных ландшафтов и примерно диагностировать почвы и растительные объекты, которые в дальнейшем были уточнены наземным мониторингом в водохранилищах.*

Ключевые слова: *дельта, водохранилище, спутниковые изображения, дешифрирование, ландшафт, почва, растительность*