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Chad Staddon

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Dedicated to the 25th anniversary of
the Petro Mohyla Black Sea National University

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FUNCTIONING OF LANDSCAPE COMPLEXES OF THE SOUTHERN BUH RIVER BASIN

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ABSTRACT

The study of the exchange of matter, energy and information between landscape complexes in the riverbed and floodplain can be carried out in two aspects: as a manifestation of paragenetic relations (if they are common in origin) and as a manifestation of paradynamic (if they are adjacent but different in genesis). In paragenetic landscape complexes, the main role is given to the "central place", in relation to which the direction of mass and energy flows between the components of the system is determined. There is an active connection between channel-floodplain paradynamic landscape complex and the adjacent valley-watershed divide landscapes, which determines the functioning of the basin paragenetic landscape complex. Taking into account the peculiarities of such relationships will enable effective implementation of regional environmental policy in the Southern Buh basin.

***Key words**:* landscape complexes, the Southern Buh river basin, transition zones, water-coastal landscape, geoecotons.

INTRODUCTION

Riverbeds and floodplains hold a specific place in the structure of modern landscapes and human life in any region of the Earth. This is due to the peculiarity of their hydrological and climatic conditions, dynamics of metabolic processes, diversity of flora and fauna, high soil productivity. River exploration is one of the top priorities in modern geographical science. However, the question of river beds and floodplains in terms of landscape is open. Identification and functioning of paradynamic and paragenetic relations, which determine the specifics of the development of channel-floodplain landscape complexes, remain outside the view of modern physio-geographers and landscape scientists and are the basis for the development of measures for their optimization, rational use and protection.

The suggested study is a result of years of detailed exploration of the landscapes of the Southern Buh valley and basin by the authors. The vast majority of issues covered in this paper are new, problematic, and can provoke scientific debate, as there is almost no similar research in contemporary geographical and landscape literature.

RESEARCH METHODS

The unique model region for solving these scientific problems is the Southern Bup valley, whose catch basin is the largest of all, completely located within Ukraine. Over the past centuries, landscapes and floodplains of the Southern Buh have been altered as a result of active and diversified economic development. Construction of ponds, water reservoirs, reclamation and drainage canals, dams, bridges, mills and hydroelectric power stations almost destroyed natural river and floodplain tracts. In this regard, research into the anthropogenic landscapes of the Southern Buh riverbeds and floodplains is relevant and will contribute to the improvement, reproduction and conservation of the river valley as a whole.

RESEARCH AND DISCUSSION RESULTS

Peculiarities of natural channel-floodplain landscape complex functioning. Riverbed and floodplain as a paragenetic landscape complex. River basins are characterized by a natural change of landscape complexes from outer divide line to riverbed. All geo complexes that are located here are connected by a common origin – laying of the river, formation of its valley and basin – form a basin paragenetic system (a kind of paradynamic). This system consists of two subsystems: valley and watershed [15]. The first subsystem includes riverbed, floodplain, terrace above flood-plain and root slopes. Valleys are characterized by transverse and longitudinal paragenetic relations with the prevailing tendency to transport matter and energy from top to bottom – from root slopes to riverbed, from the source to the mouth [15]. The peculiarities of geological structure, relief and vegetation of the drainage ditch in the upper reaches of the river are reflected in costs, chemistry, solid waste, the composition of alluvium floodplain many kilometers below the current [16].

The nucleus (core complex) of the valley-river subsystem is river bed. It is the river channel that serves as the carrier of information about ecological state and landscape features of the entire basin. The specificity of riverbed is determined by its dynamics, fluidity and constant updating of matters. The most elemental river paragenetic complexes are riffles and reaches. Due to longitudinal natural paragenetic relations, these aquatic areas merge into a single inseparable whole along the entire path of the stream (Fig. 1 A). The processes of transferring alluvium of different sizes predominate on riffles. In particular, in the tracts of rapids with high (3–4 m/s) flow velocities, fragile material is transported to a diameter of 5–6 cm. At the same time, the accumulation of alluvium takes place between the outcrops of crystalline rocks, which eventually leads to the formation of islands. Due to the process of active mixing of liquids on the rapids, the water of the Southern Buh is characterized by high oxygen saturation [3]. On the brink of riffles and reaches there is a postponement of large-scale alluvial material and the transport of small and medium-sized particles continues. In the tract with slow (up to 1 m/sec) flow velocities, intensive deposition of the material takes place, aggradation in the coastal partial floodplains and partial transfer of small particles downstream.

Along with the movement of matters and energy from the top downstream (direct relations), there are movements from the bottom up – against the current (reverse realtions), which are manifested in valley winds, moving of fish for spawning, spring and autumn migrations of birds [16].

While riverbed is an active complex in the valley-river subsystem, floodplain plays a passive role here. It arises in the process of channel deformation and is formed under the influence of channel forming mechanisms. The floodplain influences riverbed indirectly (performs the function of its boundaries, determines the velocity and direction of the water flow during the flood). In accordance with the principle of contrast [17; 19] heterogeneity of the environments (water – land) causes an active exchange of matter, energy and information between the stream and the floodplain. This makes it possible to distinguish a complex channel-floodplain natural paragenetic landscape complex (NPGLC) in nature, in which the constituent elements complement each other.

Channel-floodplain NPGLC of the Southern Buh is characterized by spatial and temporal contrast. Spatial contrast (Fig. 1 B) is manifested in the alternation of water tracts with terrestrial, the diversity of mesorelief forms and changes in short distances of one type of vegetation to others (thickets of bushes, meadows, and forests) [16]. The change in aquatic tract by terrestrial is particularly important, since thick wetland plant associations (reed, sedge, bulrush, duckweed) with peculiar to them fauna (grass snake, frogs, beavers, muskrats, numerous species of birds) are formed.

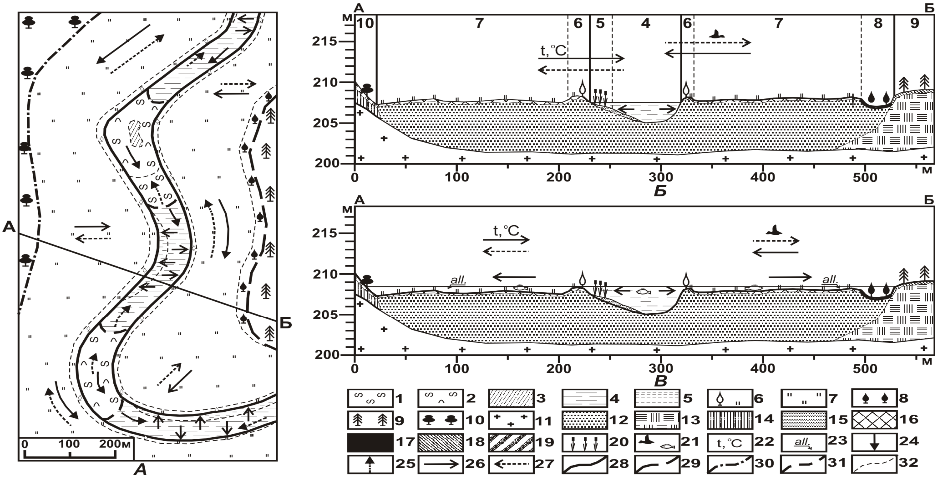

Fig. 1. Generalized charts of paragenetic in the channel-floodplain NPGLC of the plain river

A. Longitudinal and transverse paragenetic relations between riverbed and floodplain.

Б. Spatial and temporal (constant) contrast of NPGLC “riverbed – floodplain”.

B. Temporal (seasonal) contrast of NPGLC “river bed – floodplain”.

Natural landscapes. Channel. Riffles. Tracts: 1 – central channel; 2 – rapids; 3 – natural island. Reaches. Tracts: 4 – central deep water; 5 – coastal shallow waters. Floodplain. Tracts: 6 – natural levees with thickets of willow and meadow-cereal vegetation on meadow sandy soils; 7 – central floodplain with uneven surface and meadow-cereal vegetation on meadow sandy soils; 8 – back marsh with alder stands on wetlands. Supra-floodplain. Tracts: 9 – the first supra-floodplain terrace with a wavy surface and a pine forest on light gray and gray forest sandy soils. Sloping. Tracts: 10 – flat (6–8º) slope with hornbeam-oak forests on gray weakly-formed forest soils.

Landscape profiles: 11 – Precambrian crystalline rocks: granites, gneisses; 12 – sandy floodplain alluvium; 13 – fluvioglacial sands; 14 – loess-like loams; 15 – silty channel alluvium; 16 – meadow soils; 17 – waterlogged soils; 18 – sod-medium and strongly-podzolized soils; 19 – gray weakly-eroded forest soils; 20 – wetland vegetation; 21 – animals; 22 – cold and warm air masses; 23 – alluvium that is transported and sedimented during the flood.

Paragenetic relations: 24 – longitudinal direct relations; 25 – longitudinal feedback; 26 – transverse direct relations; 27 – transverse reverse relations.

Boundaries. Types of terrain. Natural: 28 – channel and floodplain; 29 – floodplain and supra-floodplain; 30 – floodplain and sloping. Aquatic areas: 31 – riffles and reaches. Tracts: 32 – natural.

Temporal contrast determines functioning of transverse PGR between landscape complexes of riverbed and floodplain. It can be constant and seasonal. Constant contrast (Fig. 1 B) is manifested through concaving banks and shore spread (meandering of riverbed in the floodplain); redistribution of heat and moisture day and night; day migrations of animals, etc. Seasonal temporal contrast (Fig. 1 C) is characterized by a change in water regime, in which the floodplain is flooded in the spring for several weeks by water, and by mid-summer it dries. During the flood accumulation of alluvial material occurs on the surface of the floodplain. In short-term flooding, this results in the rapid growth of meadow grasses and the diversification of phytocoenoses, in long-term – inhibition of their growth and the replacement of meadow-grass associations by water-marsh. Each beginning of the flood determines the directed migration of animals in the direction from the channel to the watersheds. Land animals change habitats to the adjacent to the floodplain area, representatives of aquatic fauna carry out pendular movement – from the riverbed to the floodplain and vice versa. After the flood decline, animals return in the opposite direction to their usual habitat. Separate specimens of the fish that have not migrated to the channel may stay in flooded rectangular depressions or old lakes. During the drought season plants that had time to develop on fertile alluvial soils, would be negatively affected by solar radiation. At the same time, the growth of moisture-loving plants is suppressed on elevated sections of the floodplain, and over time – on the middle ones. Gradually they are replaced by dry-resistant species. In modern conditions of regulation of the Southern Buh with ponds and water reservoirs, the Southern Buh riverbed is characterized by constant temporal contrast. The manifestation of seasonal contrast is possible only in the form of partial and not annual flooding floodplain in the lower reaches of hydro systems.

Spatial and temporal contrast are closely interrelated. Due to the contrast of the environments, the boundaries of tracts of the riverbed and floodplain vary from flood to drought season. This is one of the reasons for high productivity of channel-flood biocenoses and the separation of channel-floodplain as the most dynamic complex of valley-river subsystem.

Riverbed and floodplain as a paradynamic landscape complex. Riverbed and floodplain have been formed and function not isolated, but interact with all structural elements of the Southern Buh basin as a paradynamic landscape complex. The combination of channel, floodplain, supra-floodplain, sloping, upland, and interfluvial undrained types of terrain together form a single paradynamic system of the orographic type. The interaction of the channel-floodplain paradynamic landscape complex and the adjacent LC of the river basin is carried out through internal and external paradynamic relations (Fig. 2).

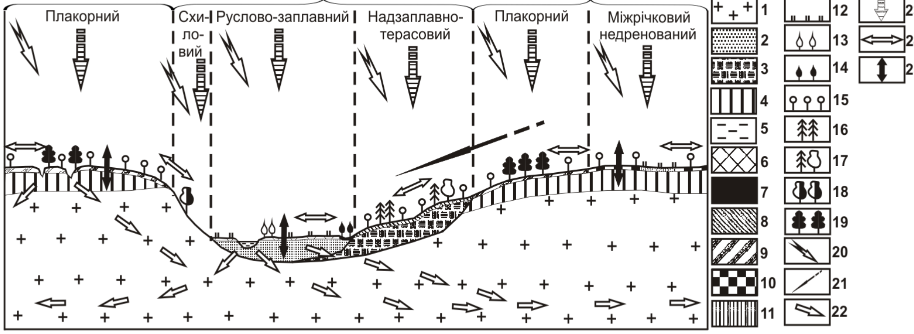

Fig. 2. Generalized chart of interaction in paradynamic system “channel-floodplain NPGLC – adjacent valley-watershed NPGLC”

Landscape profile: 1 – indigenous rocks (granites and gneisses); 2 – modern alluvial deposits; 3 – fluvioglacial sand and sand clay; 4 – loess-like cover and cover loams; 5 – surface waters (river); 6 – floodplain meadow soils; 7 – waterlogged soils and peatlands; 8 – sod-medium and strongly-podzolized soils; 9 – clear gray and gray forest soils; 10 – podzolized chernozems; 11 – over moistened chernozems (mochary); 12 – grass-cereal meadows; 13 – willow stands; 14 - sticky alder forests; 15 - agrophytocenoses; 16 – pine-spruce forests; 17 – pine-broadleaved forests; 18 – ravine forests; 19 – broad-leaved (hornbeam-oak) forests. Paradynamic relations. Outer: 20 – thermal; 21 – mechanical; 22 – water; 23 – social. Inner: 24 – biotic; 25 – biocos.

External PDR include influence of solar radiation on lanscape (thermal), gravitational influence of watersheds on low-lying complexes of the channel and the floodplain (mechanical), the influence of surface and ground waters on chemical composition of water and nutrition of rivers (water), as well as relations caused by economic activity of people (social). The direction of these relations is mostly one-sided, so their reverse effect is negligible and can be neglected. Internal PDR are manifested in the interaction of living and inanimate substances (biokosnye) and between the components of biocenosis (biotic).

Adjacent watershed areas receive a little less heat than low-lying channel-floodplain. During the warm period of the year, the difference in the sum of the temperatures in these areas is 35–50° C [6, p.79]. In the winter, wind blows snow from unforested upland to the floodplain, the wetlands of which are characterized by high humidity and frequent fogs.

Due to the considerable vertical differentiation of the landscapes of the watersheds (340–320 m n.r.m.) and the channel-floodplain PDLC (220–180 m n.r.m.), the development of linear and plane erosion increases. Thus, within Upper Pobuzhzhia, the intensity of the flat-flush on the slopes of the plowed land is from 5 to 20 t/ha, and in some plots – up to 50 t/ha a year [12, p.155]. At the same time, a layer of soil with the in thickness from 1.1 to 3.7 mm/a year is washed [13, p.209]. Sloping and supra-floodplain PDLC play the role of peculiar “transit corridors”, through which the eroded material enters the floodplain, which causes sedimentation of its surface and lowering the water level in the channel.

Modern canalization of the Southern Buh riverbed and its tributaries with ponds and water reservoirs leads to a stable water regime, which significantly reduces mass and energy exchange between channel-floodplain and adjacent basin landscape complexes.

The increasing influence of economic activity on the exchange of matter, energy and information makes social PDR one of the leading factors in the functioning of the paradynamic system “channel-floodplain PDLC adjacent valley-watershed PDLC”. The role of the SPDR will be considered in more detail in the next section.

Biocos relations [22] in landscape complexes of the river basin are manifested through biological matter cycling that covers the soil and representatives of flora and fauna. The combination of processes of photosynthesis, breathing of living organisms, the decomposition of their dead remains and the accumulation of deluvial-alluvial deposits causes accumulation of humus in floodplain soils. Biotical relations are first and foremost traced in trophic feeding chains and animal migration. Thus, during the feeding of the offspring of a white stork (*Ciconia ciconia* L.) can make up to a hundred of flights from the nest which is located on the upland to the riverbed and the floodplain.

Located on different altitudinal levels, the channel-floodplain PDLC and the adjacent valley-watershed paradynamic landscape complexes are characterized by the process of increased matter and energy exchange and information transmission. A complex set of paradynamic relations is formed between them, which together form natural PDLC “Southern Buh basin”.

Due to paragenetic and paradynamic relations, natural channel-floodplain landscape complex is the most sensitive to human activity in the river basin and vulnerable in the case of its ill-considered economic development. The specificity of channel-floodplain nature management is that each specific terrain or tract depends on adjacent (upstream river) complexes and at the same time affects those that are downstream [20].

Transition zones between river-floodplain and adjacent anthropogenic landscape complexes. Relations of water anthropogenic floodplain landscapes with dry land landscapes. After flooding of the floodplain during the construction of water reservoirs and ponds of the Southern Buh, re-formation of interrelations with the landscapes of the dry land was due to increased flow of substances and energy. As a result, water-dry land anthropogenic paradynamic landscape complexes (WDAPLCs) were formed, which include water reservoirs, ponds, their intra-aquatic landscape complexes and adjacent landscapes.

The development and functioning of (WDAPLCs) determine direct and reverse natural PDRs. These relations within the interacting landscape complexes are carried out with the help of moving components that form them: surface and underground waters, solid runoff, snow cover, migration of chemicals, animals, plant seeds, etc. The most active interaction of inner aquatic and transient LCs with landscapes of dry land is due to horizontal flows of substances and energy. Vertical relations are local in nature. Changes in inner aquatic relations and properties of each LC are transmitted as direct relations to adjacent landscapes [28].

The pecualirities of the interaction of the transformed landscapes of the riverbed and the floodplain with the landscapes of the land should be considered in two directions: 1) the impact of anthropogenic reservoirs on the landscape complexes of the land (direct PDR); 2) the impact of landscape dry land complexes on anthropogenic water bodies (reverse PDR) (Fig. 3).

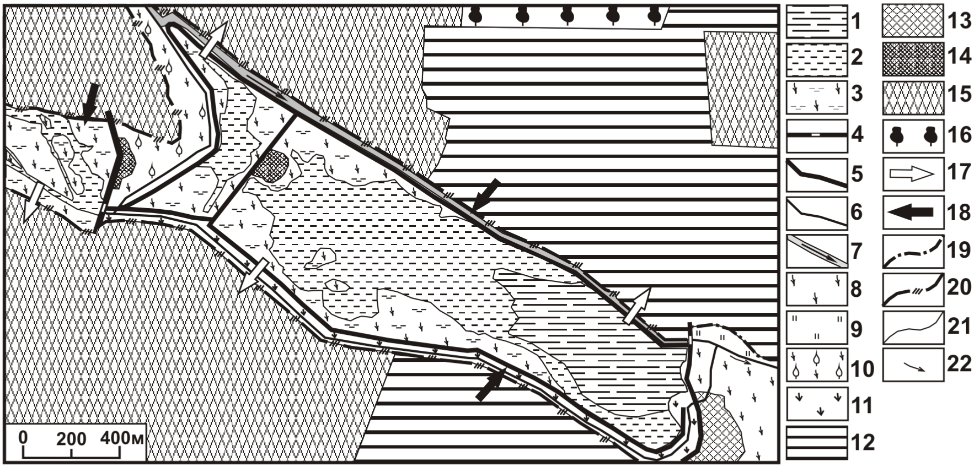

Fig. 3. Relations between landscape complexes of Marianivka water reservoir (the city of Chornyi Ostriv, Khmelnytskyi region) and adjacent territories

Water anthropogenic landscapes. Water reservoir. Floodplain-water reservoir. Tracts: 1 – dam deep water (3–4 m) with concave bottom and silty sediments (0.3–0.4 m), overgrown with small duckweed; 2 – central shallow water (1.5–2.5 m) with flat bottom and silty sediments (0.3–0.8 m), overgrown with small duckweed; 3 – shore shallow water (up to 1 m) with flat bottom and silty sediments (0.5–0.6 m), overgrown with water-marsh vegetation; 4 – stone-earthen dams with the height of up to 3 m, overgrown with grass-cereal vegetation and planted around with aspen and poplar; 5 – earth dams up to 3 m high, overgrown with grass-cereal vegetation; 6 – drainage canals with the depth of 1.5–2 m and the width of 5–7 m; 7 – deep (up to 5 m), 15–30 m wide canal – transformed Southern Buh riverbed.

Agricultural landscapes. Meadow-grazing. Floodplain. Tracts: 8 – flat surfaces with meadow-bog vegetation on meadow-marsh soils under hayfields and grazing; 9 – gently sloping (1–3°) surfaces with meadow-cereal vegetation on meadow-marsh soils under grazing. Floodplain-water reservoir. Tracts: 10 – hilly surfaces with willow stands and meadow-bog vegetation on meadow-marsh soils for grazing; 11 – flat surfaces with meadow-marsh vegetation on meadow-marsh soils for grazing. Field. Sloping. Tracts: 12 – sloping (10–15°) slopes, composed of loess-like loams with gray forest soils under field crop rotations.

Residential landscapes. Town. Floodplain. Tracts: 13 – flat surfaces under low-rise buildings on meadow-marsh soils. Floodplain-water reservoir. Tracts: 14 – bulked stone-earthen surfaces under low-rise buildings on meadow-marsh soils. Sloping. Tracts: 15 – sloping (10–15°) slopes under low-rise buildings, gardens on gray forest soils.

Forest anthropogenic landscapes. Derivatives. Sloping. Tracts: 16 – sloping (10–15°) hills with hornbeam-oar forests on gray forest soils.

Paradynamic relations: 17 – direct PDR of landscapes of water reservoir with landscapes of the land (hydrological and climatic impact); 18 – reverse PDR of landscapes of the land with the landscapes of water reservoir (silting, accumulation, overgrowth).

Boundaries. Types of terrain. Natural: 19 – floodplain and sloping. Anthropogenic: 20 – floodplain-water reservoir. Tracts: 21 – anthropogenic.

Other keys: 22 – direction of the current.

Due to direct NPDR of water reservoirs and ponds on the landscapes of the dryland, zones of hydrological, climatic and hydrogeological influences are formed. The first manifestations of direct paradynamic relations can be traced in the shore zone of water reservoirs and ponds. Two processes prevail here: 1) filtration of water to the shore; 2) support of groundwater in the coastal strip from the side of water objects. The width of the zone of hydrological influence depends on geological and geomorphological conditions of the coast [5, p.36]. Within the zone of climate impact of water reservoirs in autumn, the frost-free period extends from 1 to 5 days, respectively, in the summer – cooling [5]. In summer, the air temperature in the daytime is 0.5–1.5° C lower than outside of the influence of the water reservoir (500m) in the outskirts of Shchedriv water reservoir during daytime breeze movement. The most pronounced climatic influence of water reservoirs is at a distance of 200–250 m, further its borders vary depending on the direction and strength of the wind, features of the relief and the underlying surface. The zone of hydrological influence of water reservoirs forms belt of permanent and periodic flooding, considerable flooding and moderate flooding [21]. LC of the floodplain have undergone radical changes in the area of Ladyzhyn water reservoir in places of considerable flooding. Thus, floodplain meadows with grass-cereal vegetation have turned into aquatic complexes that extend for several kilometers. Unlike water reservoirs, the activity of natural pond densities is much lower, which is due to the small size of these water bodies.

Reverse NPDR are manifested through entrance of liquid and solid waste waters, chemicals, biomass, etc. from the landscape of dry land to water reservoirs. Water reservoirs and ponds of the Southern Buh are powerful accumulators of matters transported from adjacent territories due to erosion processes and coastal abrasion [5]. As a result, anthropogenic water reservoirs are getting intensely muddy, forming wetlands. Such processes are especially intensified due to the action of anthropogenic factor, which is determined by the level of intensity of economic load on adjacent to the water reservoirs of landscapes [28]. Thus, in the spring, during snow melting, migration of dissolved mineral fertilizers and pesticides from fields that are confined to the slopes or supra-floodplains of the valley is intensified. As a result of NPDR, intensive process of overgrowing takes place in shallow waters of anthropogenic water reservoirs. All water anthropogenic LC of the Southern Buh feature groupings of reed, cattail, cane, calamus and sedge of various species. Unlike water reservoirs, ponds become overthrown faster due to their lower parameters and active economic activity in adjacent LC. One of the manifestations of reverse PDR are landslide processes, for example, landslide, which was formed as a result of continuous erosion of the left bank (the floodplain terrace) of Ladyzhyn water reservoir within the village of Stepashky, Vinnytsia region. Vertical movements of matter and energy (evaporation, filtration, ascension and downward displacement of water masses) also affect functioning of WDAPLCs. In arid years, due to evaporation and filtration, water losses increase, hydrodynamic, biochemical and thermal processes are violated, which leads to the transformation of the landscape complex itself.

Relations of road landscapes with landscape complexes of riverbed and floodplain. Laying of roads over the channel and the floodplain of the Southern Buh caused the formation of APDLCs of “bridge – riverbed – floodplain” type. First of all, the interaction of bridges with the riverbed is carried out through direct PDR, which are transmitted from the supports to aquatic landscape complexes. Due to frequent transitions of vehicles through the bridge, there is vibration that scares animals that inhabit the area of the transformed canal. Fixed in the bottom supports divide the river bed into 2–3 or more sleeves, which leads to an accelerated flow of water (up to 0.5 m/s) at short distances. At the sites of the reaches between the bridges, alluvial material is moved more quickly, which sediments 10–20 m below the current. Access embankments of roads and bridge settlements, located on the surface of the floodplain hinder the movement of valley winds and vice versa – in the intervals between the bridge supports air masses flow accelerates, which adds energy to the water flow. V.M. Samoilenko’s research [24] of toxic contamination of the ichthyofauna of surface waters of Ukraine shows that aquatic organisms are active storages of chemical elements that enter water reservoirs. Exhaust gases of cars cause migration of heavy metals in bottom sediments and their accumulation in bodies of representatives of aquatic fauna. Thus, D.V. Lukashev [14] notes the accumulation of Pb in shells and soft tissues of duck mussel (*Anodonta anatina L.*) in the Southern Bug riverbed (the bridge on the 274th kilometer of Kyiv – Odesa highway) and an increase in the concentration of the chemical element by 2.4–2.7 times in specimens below the current. The elevated content of Fe and Mn in molluscan organisms in samples taken near the bridge explains the release of these heavy metals from structural materials of the facility.

Reverse relations of the riverbed LC on the bridges are manifested in the continuous washing of the supports and the destruction of the foundation underneath. In the course of the conducted research it was discovered that there is a washed layer of bottom alluvium 0.5–1 m thick between the supports of the bridge in the village of Voroshylivka, Vinnytsia region. Bulky islands that remained after the construction around the supports of the railway bridge in Pervomaisk, become gradually overgrown with water-marsh vegetation. In the spring period of thawing, the supports of bridges (the upper course of Southern Buh) can prevent the movement of large debris of trees, beds of reeds and sedge, etc.

Relations of mining landscapes with landscape complexes of riverbed and floodplain. Public PDR (Fig. 4), which are conditioned by the need for building materials, and natural PDR in the form of several streams of mineral and nutrient substances: terrestrial (mineral, biogenic and water migration), air and technogenic take part in forming paradynamic relations of mining landscapes with adjacent LC.

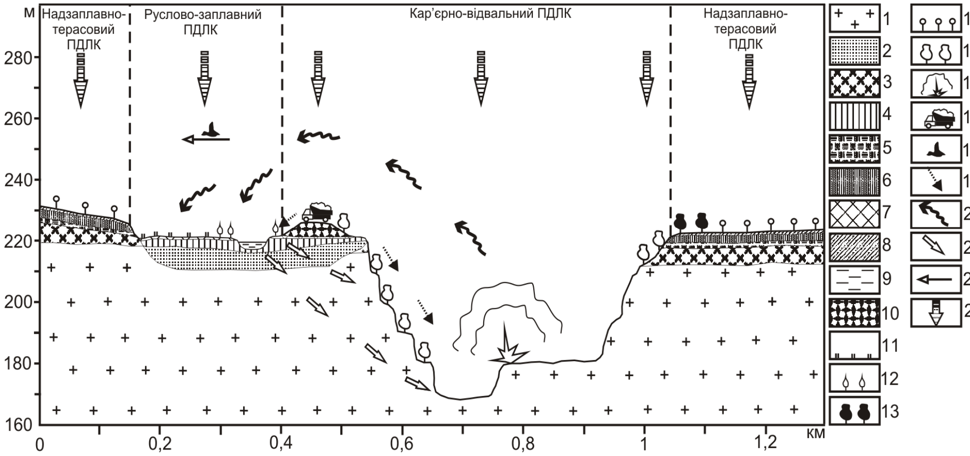

Fig. 4. Relations between channel-floodplain PDLC of the Southern Buh and Hnivan-Vitavsk quarry-stocker PDLC (the outskirts of the city of Hnivan, Vinnytsia region)

Landscape profile: 1 – granites; 2 – alluvial sands of the floodplain; 3 – kaolins; 4 – floodplain loams; 5 – fluvioglacial sands of supra-floodplain; 6 – loess-like loams; 7 – meadow-marsh soils; 8 – gray forest podzolized soils; 9 – waters of the Southern Buh; 10 – dam of granite-loamy rocks; 11 – meadow-cereal vegetation; 12 – thickets of willow stands; 13 – ash-oak plantations; 14 – agricultural crops; 15 – plantations of common birch; 16 – blasting operations; 17 – transport works; 18 – animals. Paradynamic relations: 19 – mechanical (landslides, taluses, creeps, erosion); 20 – aerodynamic (dust transfer, spreading of vibration and sound); 21 – water; 22 – biotic; 23 – social.

The ground flow is manifested in the early unstable stage of the development of the GPL. Migration of mineral matter (mechanical PDR) at this stage actively take place in mining LC, which are confined to sloping and floodplain types of areas. Thus, in 1975, as a result of the erosion and collapse of the freshly-formed part of the dam of Vitovsk deposit of granites in the Southern Buh riverbed, about 1.5 million tons of opening rocks were carried. The island formed by them (length 26 m, width 8 m) divided the channel into two sleeves [4, p.192]. Getting to the riverbed, the products of erosive erosion of opening rocks change its configuration, direction and velocity of the flow, causing silting and shallowing.

An important role in the relations of GPL with the riverbed and the floodplain is played by water migration (water PDR). The developments of peat and granite after the cessation of mining operations during the year are filled with water. Former granite quarry in the outskirts of the village of Myhiia of Mykolaiv region, which was confined to upland and separated from the Southern Buh floodplain by a natural slope, was filled with water to the depth of 15 m in one night. Around the newly formed water complexes of sand and peat quarries, there was waterlogging of the territories in the floodplains of rivers Vovk on the plot between the town of Derazhnia and the village of Haiky and the Southern Buh – between the village of Oleshyn and the city of Chornyi Ostriv [4].

Biogenic migration (biotic PDR) is manifested through the settlement of former mining developments with new plant species. Typically, wetlands are characterized by sedge-reed-cattail associations. Water reservoirs of trench-wetlands in the floodplain of the Southern Buh become gradually overgrown with green and blue-green algae, duckweed, sedge and reed. Here, new habitats of snakes, frogs, beavers, muskrat and waterfowl are formed.

The transfer of air masses (aerial-paradynamic relations) from mining LC to the riverbed leads to the migration of rock particles that rise up during blasting in quarries. According to the production department of Hnivan-Vitavsk granite quarry, in the second quarter of 2010 6.5 tons of dust was released into the air. In this case, the concentration of silicon dioxide of the crystalline (SiO_2), which is part of the granite dust, often exceeds the norm. In the air of the working area of Pervomaisk Quarry “Granite”, which is confined to the right bank slope of Syniukha valley (10.5 km to the Southern Buh), the amount of SiO_2 is 8.1 mg/m^3 (4.1 GDC) [23, p.3]. Part of this material enters the riverbed and, along with the alluvium is transported downstream. Dusts, sedimenting on the surface of the leaves of plants that grow in the floodplain, hamper the processes of photosynthesis and transpiration and inhibit their development. Sound fluctuations from bursts in quarries extend over a considerable distance. Regular harvesting leads to scaring animals, especially birds, whose habitats are floodplain meadows and sloping forests.

Technogenic flow of matter is associated with the process of reclamation, when PDR of mining landscapes with adjacent LC are weakened. However, in case of inappropriate use of re-cultivated territories, negative processes are restored. For Pobuzhzhia region, such processes may include re-flooding and bogging of reclaimed floodplains where peat was previously mined.

Patterns of formation and functioning of anthropogenic landscape complexes of the river basin. Relations in landscape complexes which appeared as a result of the construction of located near a dam HEPS. Due to a significant role of construction of located near a dam HEPS and water reservoirs in the transformation of natural geocomplexes of the riverbed and the floodplain of the Southern Buh, the interaction in paragenetic landscape complexes should be considered on the example of APGLC of the type “located near a dam HEPS – water reservoir – modified landscape complexes of the lower reach” Fig. 5). According to the principles of development and functioning, APGLC “dam – pond – modified landscape complexes of the lower reach” are similar to the mentioned above, but differ only in their parameters and absence of an HEPS building. However, APGLC of the second type are rare (partly in the upper part of the current) and more characteristic of river tributaries.

APGLC of both types are formed and function due to social and natural PDR and PGR. In the first case, the manifestation of SPDR is the need for HEPS, dam and water reservoir for electricity production, in the second – the need for a dam and a pond – for fish breeding or recreation [31]. Natural PDR are manifested through the transfer of matter, energy and information downstream water flow.

In APGLC “dam HEPS – water reservoir – modified landscape complexes of the lowe reach” the “central location” [30] role belongs to LES “dam HEPS”, which forms a peculiar framework, around which the entire landscape complex is formed through the operation of direct and inverse paragenetic bonds. Direct PGR are found in the construction of the HEPS and constant maintenance of its optimal state by man. Reverse PGR are more diverse, their manifestation is due to natural factors in the headrace and the tail bay of water reservoirs.

In the dam part of the upper reaches, transporting capacity of the river flow decreases, which leads to silting of the bottom of the water reservoir. And vice versa – in the lower reach, where the force of transfer of matter increases – the bottom of the riverbed is blurring and deepening, which causes lowering of the longitudinal equilibrium profile.

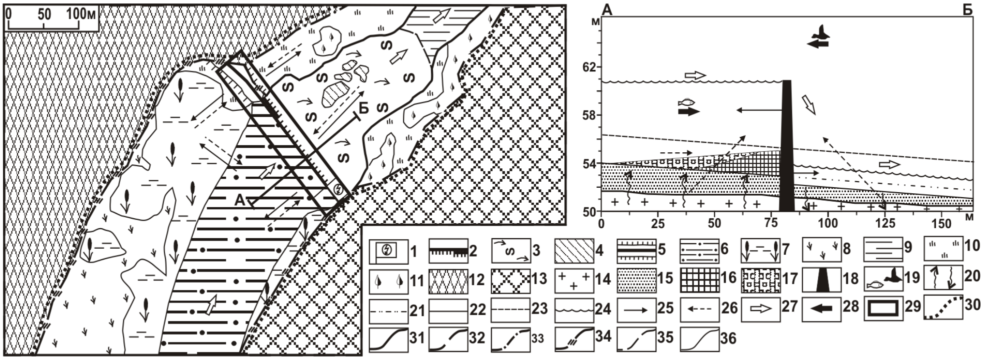

Fig. 5. Relations in APGLC "dam HEPS – water reservoir – modified landscape complexes of the lower reach"(the city of Pervomaisk, Mykolaiv region)

Water anthropogenic landscapes. Water reservoirs. Channel. Tracts: 1 – concrete and brick building of Pervomaisk HEPS; 2 – complex of reinforced concrete dam structures of overflow type; 3 – central stream with the depth of 1–1.5 m and velocity of water flow 2–3 m/s with outcrops of crystalline rocks flooded by waste waters of the water reservoir; 4 – islands with the area of 0.1–0.3 ha with uneven surface, overgrown with willow and sedge on alluvial sediments. Floodplain-water reservoir. Tracts: 5 – water-retaining earth dam of trapezoidal profile (width – 20 m, length – 74 m, height – 7.60 m) with grass-cereal vegetation; 6 – dam deep water (6.7 m) with sandy-silty trough-like bottom and water masses used for the needs of HEPS; 7 – gently sloping (3–5°) loamy surface of the floodplain with reed-sedge associations on marshy meadow soils; 8 – gently sloping (3–5°) loamy surface of the floodplain with over moistened meadows on meadow soils.

Residential landscapes. Urban. Water-recreational. Channel. Tracts of the reaches: 9 – central deep water with the depth of 2–3 m and flow velocity 0.2–0.3 m/s for fishing. Floodplain. Tracts: 10 – flat loamy surface of the floodplain with meso-xerophytic meadow-cereal vegetation on meadow soils under natural beaches; 11 – plantations of crack willow on loamy meadow soils used for recreation. Low-rising. Sloping. Tracts: 12 – sloping (10–12°) loess surfaces under low-rise buildings and gardens on common medium-humus chernozems. Multi-storeyed. Supra-floodplain. Tracts: 13 – true loess surfaces under multi-storeyed buildings on common medium-humus chernozems.

Landscape profile: 14 – Precambrian crystalline rocks: granites, gneisses; 15 – sand channel alluvium; 16 – body of sedimentation of the water reservoir by small sediments; 17 – body of accumulation of the water reservoir with large loads; 18 – concrete dam; 19 – animals; 20 – underground waters; 21 – the previous level of the bottom of the riverbed; 22 – the current level of the bottom of the riverbed; 23 – previous water level; 24 – current water level.

Interrelations: 25 – direct PGR; 26 – reverse PGR; 27 – direct PDR; 28 – reverse PDR.

Boundaries. PGLC: 29 – central site of APGLC; 30 – APGLC "dam HEPS – water reservoir – modified landscape complexes of the lower reach". Types of terrain. Natural: 31 – channel and floodplain; 32 – floodplain and supra-floodplain; 33 – floodplain and sloping. Anthropogenic: 34 – floodplain-water reservoir. Aquatic areas: 35 – riffles and reaches. Tracts: 36 – anthropogenic.

Thus, in the upper reach of Myhiia water reservoir, the thickness of alluvial deposits in front of the overflow dam is 0.9–1.3 m. Due to the fact that water does not spill over the crest for most of the year, and velocity of the current is 0.1–0.2 m/s, in the dam part of the water reservoir the association of coontail and yellow water-lilly have formed. As a result of maintenance of a persistent level of water-retaining horizon, accumulation of various polyutanes that enter the

Southern Buh as polluted waste water of populated areas takes place in the headrace. Studies [29] confirm this by the lowest (64 species) indicators of the phytoplankton species diversity of in the area of Sabarivska HEPS, compared to the sites located upstream near the city bus station (94 species) and outside the city of Vinnytsia (151 species). At the same time, intensive development of blue-green algae (*Microcystis pulverea* (Wood) Forti and *Snowella lacustris* (Chodat) Komárek & Hindák) was observed, which is the result of organic pollution of the river. Thus, Southern Buh water within Vinnytsia region are characterized by the following one-time values of BSKp = 3.4–14.6 mgO_2/dm^3 (maximum limit allowed = 3,..0 mgO_2/dm^3) are characteristic in 47 samples out of 63 selected.

During the interaction of water and soil components of LC, paragenetic relations have a vertical multidirectional character. Saturation of soils of the floodplain with waters of the water reservoir leads to a rise in the groundwater level (up to 1 m and higher), resulting in the development of tracts of wet and moist meadows in the shore part of headrace. In the lower reach, due to lowering of the groundwater level below 2–2.5 m [8; 25], there is dewatering of floodplain meadows and new vegetative groups that were not previously peculiar here develop. In the works of V.S. Zaletaiev [11], H.I. Denysyk [8] it is proved that all the tracts of the lower reaches meadows of the Southern Buh water reservoirs without exception have signs of xerophytization.

In comparison with the upper reaches, geoecological situation is also changing in the lower reaches of the water reservoirs. From 1993–1995, after the beginning of "blowdown" of the water reservoir-cooler of the Southern Ukrainian HEPS to the Southern Buh riverbed, which is a kind of a lower reach of Tashlyk water reservoir, significant concentrations of radioactive elements get it. Thus, according to Yu.A. Tomilin [9; 246], in the area of the area of the discharge of "blowdown" waters in the riverbed and near the village of Buzke, Mykolaiv region, value ^{90}Sr increased to 30–50 mBq/l, and ^{137}Cs – 10–15 mBq/l, during flood, these levels increased by 2–3 times. An increase in the concentration of ^{137}Cs has affected its accumulation in the bottom sediments, seaweed and fish 2-3 times. The activity of ^{3}H in the river water increased 8-10 times. Migration of radioactive elements from the Southern Buh riverbed to the watersheds of the basin continues through the canals of Southern-Buh irrigated massif [10]. As a result of watering soils with contaminated water, active accumulation of ^{90}Sr, ^{137}Cs, ^{3}H in crops takes place [7].

Relations in landscape complexes, which appeared as a result of construction of mills. Construction of the riverbed and the floodplain of the Southern Buh with the mills with drainage canals led to the formation of APGLC of the "mill – canal – island" type. Continuous interaction between the components of APGLC was provided by the control of their condition on the part of man. The cessation of control meant destruction of the mill and disappearance of the whole complex. However, in some cases complexes, left without human control, continued to function due to NPDR. Let us consider the peculiarities of relations on the example of spatial-temporal process of formation of such APGLC in the village of Sokiltsi of Vinnytsia region (Fig. 6).

The construction of Sokilets mill in 1894–1898 was initially conditioned by social PDR, which were manifested in: 1) the need of the local population to process grain for flour and groats; 2) convenient location of the mill buildings on the surface of the left bank floodplain and in the river bed at the site of the riffle; 3) a close delivery of building materials (granites were mined in a quarry confined to the right bank slope of the village of Pechery).

The role of the "central place" in APGLC was played by the mill building with a turbine, where the process of grain processing was coordinated. In relation to the mill, direct PGR with it had a drainage canal and a newly formed island, the state of which was supported by people for the most effective operation of the whole complex. The mill was connected with the Southern Buh riverbed by direct NPDR, which manifested themselves through the canal in the form of downstream flows of matter (water, rock and soil particles, plant seeds, animals), energy and information. Due to the mentioned NPDR, the components of the mill complex were united into a single anthropogenic paragenetic system "mill – dam – canal – island".

Reverse mechanical NPDR were manifested in the processes of watering the banks of the canal and the island.

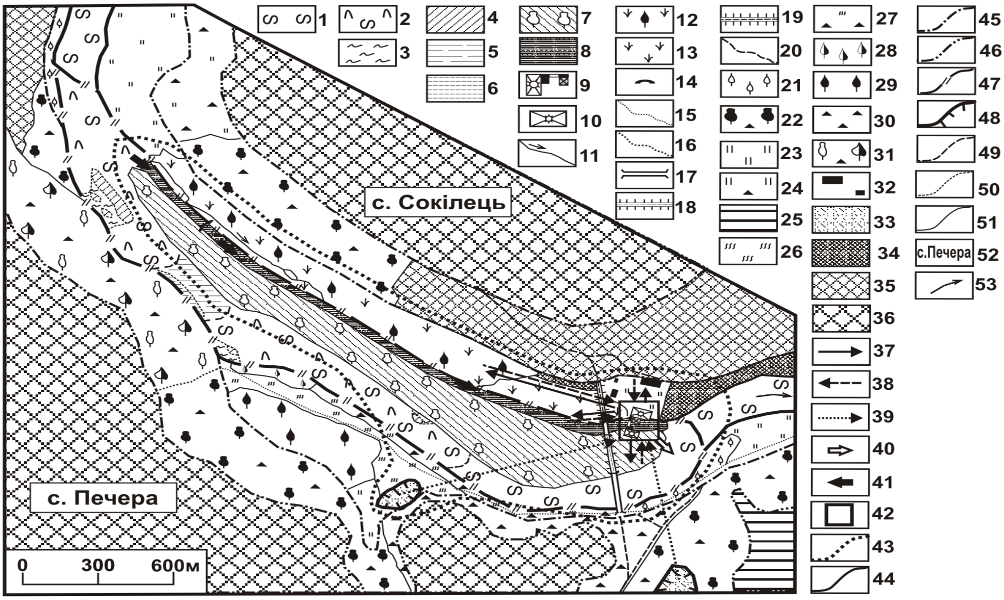

Fig. 6. Relations in APGLC "inactive HEPS – inactive mill – dam – banked earth with a bridge – bottom of a drained water reservoir - island" (the villages of Sokilets and Pechera of Vinnytsia region)

Water natural landscapes. Riffles. Tracts: 1 – central riverbed; 2 – rapids; 3 – shallow water sleeves; 4 – natural islands. Reaches. Tracts: 5 – central deep water; 6 – bank shallow waters.

Water anthropogenic landscapes. Canals. Channel-canal. Tracts: 7 – an island with uneven surface, overgrown with various bush and woody vegetation on floodplain loams; 8 – shallow (1–1.5 m) drainage canal with the width of 11–12 m with "opust"; 9 – granite dam (length – more than 30 m, width–2.5 m, height – 3 m), inactive gristmill and hydroelectric power station. Floodplain. Tracts: 10 – stone building of a former roller mill; 11 – shallow (0.5–1 m) inflow of the canal; 12 – flat surfaces with sticky alder forests and sedge-grassy vegetation on silty sediments; 13 – even surfaces with over moistened meadows with sedge-grassy vegetation on silty sediments.

Road landscapes. Pedestrian. Soil-wood. Channel-canal. Tracts: 14 - a wooden bridge without supports 13 m long. Highway. Soil-gravel Floodplain. Tracts: 15 – low (0.5–1 m) clay-schistose embankments with the width of 2.5–3 m without vegetation. Sloping. Tracts: 16 – field road with the width of 2.5–3 m on sloping (10–12°) loess surfaces with gray forest soils. Asphalt-concrete. Channel-canal. Tracts: 17 – reinforced concrete bridges on 1 and 5 supports (44 and 121 m long, width of the carriageway – 6 and 7 m, load capacity – 30 and 80 t); 18 – high (1.5–2 m) loamy-stone embankment with steep (40–45°)

slopes, planted with box-elder and crack willow, on the surface of the island. Floodplain. Tracts: 19 – high (1.5–2 m) loamy-stone embankment with steep (40–45°) slopes, planted with box-elder and crack willow, on the surface of the floodplain. Sloping. Tracts: 20 – high (1.5–2 m) loamy-stone embankment with steep (40–45°) slopes, planted with box-elder and crack willow, on sloping (10–12 °) surface of the slope.

Forest anthropogenic landscapes. Derivatives. Floodplain. Tracts: 21 – channel alder-willow thickets on loamy meadow soils. Sloping. Tracts: 22 – steep (25–30°) slopes with outcrops of crystalline rocks and oak-hornbeam forests on gray podzolized soils.

Agricultural landscapes. Meadow-pasture. Floodplain. Tracts: 23 – flat loamy surfaces with fresh meadows with meadow-cereal vegetation on meadow soils for grazing. Sloping. Tracts: 24 – steep (25–30°) slopes with outcrops of crystalline rocks and fresh meadows with meadow-cereal vegetation on gray podzolized soils for grazing. Field. Upland. Tracts: 25 – sloping (6–8°) surfaces on eroded gray forest soils under field crop rotations.

Recreational landscapes. Floodplain. Tracts: 26 – flat loamy surfaces with fresh meadows with meadow-cereal vegetation on meadow soils under natural beaches; 27 – situated near the river channel uneven surface of the floodplain with outcrops of crystalline rocks and meadow-grass and wetland vegetation on loamy meadow soils for recreation; 28 – situated near the river channel thickets of willow stands on loamy meadow soils for recreation; 29 – alder plantation on loamy meadow soils for recreation. Sloping. Tracts: 30 – steep (30–45°) slopes with outcrops of granite rocks and meadow-cereal vegetation on washed gray soils for recreation; 31 – park on sloping (10–15°) slopes with the outcrops of crystalline rocks and oak-birch and spruce stands on clear gray soils.

Industrial landscapes. Actual industrial. Floodplain. Tracts: 32 – gently sloping (1–3°) loamy surfaces with additional mill buildings on meadow soils. Mining. Quarry-stocker. Granite variant of the type of terrain “stony badland”. Tracts: 33 – small (up to 0.5 hectares) granite quarries overgrown with ruderal vegetation.

Residential landscapes. Rural. Floodplain. Tracts: 34 – true loamy surfaces under low-rise buildings, gardens on meadow soils. Sloping. Tracts: 35 – sloping (10–12°) surfaces under low-rise buildings, gardens on washed gray forest soils. Upland. Tracts: 36 – sloping (8–9°) surfaces on eroded gray forest soils under low-rise buildings.

Interconnections: 37 – direct immediate PGR; 38 – reverse immediate PGR; 39 – direct intermediated PGR; 40 – direct PDR; 41 – reverse PDR.

Boundaries. PGLC: 42 – central site of APGLC; 43 – APGLC “inactive HEPS – inactive mill – dam – banked earth with a bridge – bottom of a drained water reservoir – island”. Types of terrain. Natural: 44 – channel and floodplain; 45 – floodplain and sloping; 46 – sloping and upland. Anthropogenic: 47 – channel-canal; 48 – types of terrain “stony badland”. Aquatic areas: 49 – riffles and reaches. Tracts: 50 – natural; 51 – anthropogenic.

Other keys: 52 – names of populated areas; 53 – direction of the current.

During the spring floods, water, filling over the canal, blurred the surface of the left bank floodplain, resulting in a shallow channel of river Fosa. The channel is directed in parallel to the drainage canal. The total length of river Fosa is more than 600 m, it is connected with the canal several times, forming three islands in the left bank of the floodplain. The width of the channel is 2–3 m, the depth – 0.5–1 m.

Reverse biological NPDR were manifested in the overgrown of the newly-formed island with wood and bush vegetation. The forested island became a habitat for water-loving animals. In the course of the long-term functioning of APGLC, the projective coverage of the island by the tree-plant increased, which predetermined the emergence of the phenomenon of climatic contrast.

Thus, at the forested surface of the island, the air temperature in the summer is 10–12% lower compared to the shore landscape complexes, the relative humidity of the air increases by 10–40%, and the wind speed decreases by 11 times.

In 1924 a small hydroelectric power station with the capacity of 240 kW was added to the roller mill building. A dynamo machine, whose current illuminated the villages of Pechera and Sokilets, was installed at the station. Direct public PDR, manifested in the provision of settlements with electric power, led to the conditional change of the previous paragenetic landscape complex on APGLC of "HEPS – mill – dam – canal – island" type. Fundamental changes in this complex occurred in 1951, when the HEPS and the dam were reconstructed in order to increase the capacity, and a water reservoir was built for its normal functioning.

The emergence of APGLC of "HEPS – mill – dam – water reservoir – island" type caused reverse water NPDR. As a result of flooding, the surface of the left bank floodplain with wet meadow-cereal biocenoses came under water. Groundwater dam within the water reservoir increased by 1–1.5 m. Water-marsh vegetation belts began to appear in the coastal parts of the water reservoir.

Biological NPDR were manifested in stocking of a new water reservoir with fish populations that migrated from the riverbed. Wild ducks, water hens, muskrat, etc. settled in the coastal thickets. Mechanical PDR in the form of the process of erosion in the coastal part of the island intensified. During one of the floods, the water broke through the mound within the middle part of the island and formed a drop-off. It has a winding character, its depth is 1–1.5 m, its width is 2–2.5 m. The erosional drop-off crosses the island from northwest to southeast and is connected to the riverbed.

In 1964, two reinforced-concrete bridges were built over the Southern Buh riverbed between the cities of Nemyriv and Mohyliv-Podilskyi in order to provide better transport connections (the manifestation of SPDR). The first (121 m long) connects the village of Pechera with the island, the second (44 m long) – the island with the village of Sokilets. Soilets bridge was built in the upper reach of the water reservoir on one support. In order to dampen the level of Sokilets bridge with Pechera bridge, part of the island and of the laeft bank floodplain were elevated by means of embanked earth. Construction of Sokilets bridge led to drainage of the water reservoir, whose waters washed the access embankment and the support, and stopped the operation of the HEPS. As a result, the APGLC of "inactive HEPS – a mill – a dam – banked earth with a bridge – the bottom of a drained water reservoir – an island" type.

In the process of functioning of a new APGLC, water and biotic NPAR played a major role. After the water drainage, the bottom of the former water reservoir, enriched with alluvial sediments, began to be actively overgrown with moisture-loving plants. On the surface of the floodplain, which is located closer to the bridge, a tract of overmoistened meadows was formed, herbs of which are represented by 27–30 species of plants. The grouping is dominated by greater pond sedge, carex acuta, common reed, broad-leaved cattail, narrow-leaved cattail, nettle, snakeweed, throatwort. On the other part of the floodplain the tract of alder-willow thickets develops.

The stop of the mill in 1992 led to "attenuation" of direct public PDR and transformation of landscape complex in APGLC "inactive HEPS – inactive mill – a dam – banked earth with a bridge – the bottom of the drained water reservoir - island", which now continues to operate due to natural PDR.

Water-coastal landscape geoecotons. Paragenetic landscape complexes of the riverbed and the floodplain are physiologically and qualitatively different. In the framework of their contact, due to direct and reverse relations, peculiar transition bands – geoeoctons are formed. Field studies show that water-bank landscape geocotones (WBLG), represented by wetland landscape complexes, are specific transition lanes from the riverbed to the floodplain of the Southern Buh.

According to landscape features, WBLG are radically different from contacting landscape complexes, since they occupy an intermediate position between terrestrial and amphibian variants of landscape sphere [18]. The basis of WBLG is the contact of solids and water, coastal zone and coastal shallow water. Within its limits, the upper component of the cycle of substances, which is directed from land to the water surface, and the lower (underground) in the form of a stream of ground waters, which provides hydromorphy of soils and vegetation in the coastal zone, are well distinguished [1, p.32]. Geocotons are characterized by their own flora and fauna. Due to the principle of contrast (water – soil) here and now, in conditions of anthropogenic loading, relict representatives of flora and fauna can live.

Geoeocontos of anthropogenic origin are of great importance for forming modern river landscapes. WBLG, formed in the conditions of natural hydrological regime of the river, change as a result of the construction of HEPS, dams, ponds and water reservoirs. During the flooding of landscape complexes of the riverbed and the floodplain by water reservoirs, natural WBLG are destroyed and new anthropogenic ones, located on a higher hypsometric level and have larger areas for distribution, appear (Fig. 7).

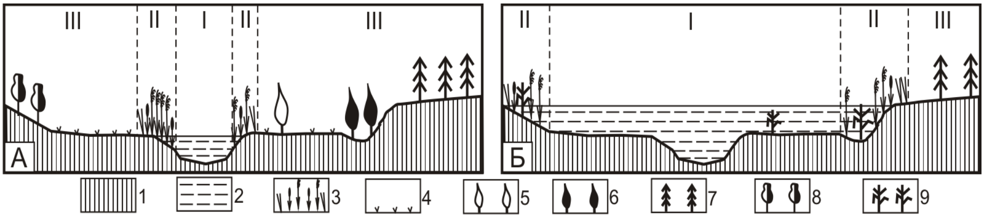

Fig. 7. Generalized charts of the Southern Buh WBLG

A. I – natural riverbed; II – natural water-marsh landscape complex; III – landscape complexes of the dry land.

B. I – riverbed and floodplain, flooded by water reservoir; II – anthropogenic water-marsh landscape complex; III – landscape complexes of the dry land.

Landscape profiles: 1 – indigenous rocks and soils; 2 – water masses; 3 – reed-sedge-cattail associations; 4 – meadow-cereal associations; 5 – willow stands; 6 – sticky alder forests; 7 – pinewoods; 8 – hornbeam-oak forest; 9 – flooded vegetation.

The peculiarity of anthropogenic WBLG is its instability. In its development between the aquatic environment and the land, a process of constant and gradual increase of geoeoconus territory is observed by means of shallowing of ponds and water reservoirs, which promotes the spread of wetland vegetation [27].

Thus, in Marianivka water reservoir (the town of Chornyi Ostriv of Khmelnytsk region) in the period from 2008 to 2011, the width of WBLG increased from 74 to 86 m. The main vegetative groups, due to which its width increased, are small duckweed, common cane, broad-leaved cattail and acute sedge. In the future there is a steady tendency of complete overgrowth of the water reservoir. Already, the entire surface of the water reservoir is 90% covered by a population of small duckweed (Fig. 3).

Now, due to predominance of river landscape-engineering systems in the structure of the Southern Buh valley, natural WBLG are rare. As a rule, they are common in the form of narrow (1–3 m) water-marsh landscape complexes in lower reaches of ponds and water reservoirs.

CONCLUSIONS

The study of the exchange of matter, energy and information between landscape complexes in the riverbed and floodplain can be carried out in two aspects: as a manifestation of paragenetic relations (if they are common in origin) and as a manifestation of paradynamic (if they are adjacent but different in genesis). In paragenetic landscape complexes, the main role is given to the "central place", in relation to which the direction of mass and energy flows between the components of the system is determined. There is an active connection between channel-floodplain paradynamic landscape complex and the adjacent valley-watershed divide landscapes, which determines the functioning of the basin PDLC. Taking into account the peculiarities of such relationships will enable effective implementation of regional environmental policy in the Southern Buh basin. As a result of direct and reverse relations of landscapes of water bodies with dry land, transitional water-marsh stripes, geocotones, appear. As a result of the flooding of the riverbed and floodplain by water resevoirs, anthropogenic geocotones have become widespread, which differ from natural ones by their altitude and latitude location within the valley and constant increase of areas.

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