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THE EFFECTS OF RIVER REGULARIZATION, EMBANKMENT AND DRAINING ON THE ECOLOGY OF MAJOR WATER MEADOWS

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Abstract. The hydraulic works carried for river regularization and floodplain's embankment and draining alter the habitat, both within the river and the floodplain, this having a negative impact on their ecology. The changes of land use are disrupting the distribution of biodiversity: therefore, some species have explosively evolved, becoming dominant species to the detriment of others that will become rare or endangered species. The operation of hydro-ameliorative enclosures may lead to soil salinization phenomena. On rivers, the phenomenon of surge increasing occurs. This paper presents aspects related to environmental changes that may occur within enclosures after the completion and operation of regularization works, embanking and draining.

Introduction

An ecosystem's biodiversity and productivity depend on climatic, trophic and biotic factors and habitat, too, the ecosystem functioning in a dynamic equilibrium. This is the adaptation of living beings to natural or artificial fluctuations of environmental factors.

By means of hydraulic regulation, embankment and draining, several elements change in an artificial way: the habitat, the river's and floodplain's physical structure that brings negative effects on their ecology.

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This paper presents aspects related to the environmental changes that occur in soil, in habitat, wildlife of enclosures, as a result of the completion and operation of river regulation, embankments and draining.

1. The hydraulic works that impact on the embanked floodplain's ecology

The embanking of a river amplifies the flood surges and directly alters the species habitat within the water course and also the wetland habitat of the floodplain under the river natural regime, by disruption of the lateral connectivity of water bodies in relation to the minor and major riverbeds (the river with its flood plain).

Drainages in embanked floodplains are designed to remove surface excess moisture and the moisture from a soil layer of a maximum thickness that equals the channels' depth. Systematic drainages have similar roles for the soil maximum layer thickness corresponding to the burial depth.

Anthropogenic interventions have had serious repercussions on the aquatic environment and biodiversity, due to changes of land use.

Arable land was obtained by grubbing of natural meadows and pastures, by cutting off forests, bushes and hybrid vineyards and also by draining and leveling the low depressions, ponds which are intercepted by drainage collectors, the full draining of water becoming possible. The river's natural levees and abandoned meanders have become dry land or water pools. Wetlands areas have been thus reduced.

2. Ecological changes in embanked floodplains

2.1. Changes in soil

Soils from the embanked floodplain show changes in terms of water regime and salts concentrations. The hydro-amelioration use, carried for agricultural purposes, sought to keep the positive direction of changes that occur and to avoid an unfavorable soil hydro-saline development. There are also situations where unwanted phenomena occur, according to the original natural conditions, sometimes with local character, when the main role belongs to the groundwater's depth and mineralization degree, to climate conditions and land use. All these can lead to a negative evolution of soil's properties, this meaning, frequently, a secondary salting or excessive moisture [6].

In natural conditions, the floodplains' soils were influenced by reversible salt balance processes, because of the regularity of floods, during which salts accumulated in soil at drought periods were removed (i.e. washed) in a natural way. The hydro-saline water regime of soils within the enclosure depended on weather and on the hydro-morphological features of the area (that is, those typical

for a non-embanked floodplain). The soils in the area were in general non-salted or soils with low or moderate salinization.

After embankment works, in the first stage, soil salinization occurs due to the interruption of the natural hydraulic regime (because the area is not flooded). The natural washing process being interrupted, salts concentrations are progressively increasing in soils, this leading eventually to the phenomenon of secondary salinization.

The factors that are influencing the hydro-saline regime are: precipitation (their distribution and intensity), the irrigation systems, the runoff water flows from surrounding higher areas, infiltrations from the terraces and from the river, that is, the consumptions by evaporation and transpiration, the discharges through drainage systems, the surface and underground runoffs (outside the enclosure, taking place under the effect of natural drainage). The hydro-saline regime is influenced by the terrain's morphological features. These features are different in different zones of the enclosure: pre-terrace, central and high areas of the river bank dune. After embankment and surface drainage, the salinization processes depend on the humidity balance within soils, soils which remain dependent on the operation and the effectiveness of the drainage networks and the way water is conveyed and distributed within irrigation systems [5].

2.2. Changes in the hydrological regime

In natural conditions, the floodplain is generally characterized by the existence of permanent ponds, marshes, water meadow forests and agricultural lands (arable, pastures, and meadows) all subject to river flooding and surface slope runoffs. The floodplain depression areas were swampy due to high levels of shore sand banks which were not allowing the water discharge into the river, the excess water varying depending on the magnitude and duration of flood surges.

The floodplains, under natural flow, were functioning as natural reservoirs, being able to mitigate the flood effects. Floods generally occurred in springtime, when ground was still frozen and the water from snow melting, combined with rain, was generating major flood surges.

If the enclosure is embanked, the phenomenon of amplifying surges occurs in the river [2, 7] and the floodplain is not flooded anymore. Thus, even rain waters are collected and removed by the drainage-evacuation systems. Practically, the downward motion of groundwater in the area is interrupted, this becoming mostly an upward movement (by capillarity). Moreover, the evaporation leads to an increasing of salt loads at surface (phenomenon of secondary soil salinization).

2.3. Change of land use

In large and medium floodplains, arable lands were occupying the sand banks areas, that is, partly the central high ground areas and some areas of the pre-terrace area (below the high terrace) where birds had optimal feeding conditions.

Under embankments, the natural ecosystems have been replaced by human-created systems, in general used for agriculture, thus changing the land use, and impacting on the ecosystems biotope specific to floodplains. In the case of embanked enclosures, it is about agricultural land, bush and shrubs and isolated clumps of trees.

The problem is that agro-ecosystems with important areas have replaced the water meadows. These are newly formed ecosystems, with reduced habitat diversity, but supplying birds with a rich and constant trophic source, represented in particular by a wide range of invertebrates, seeds and fruit. The duration of the vegetation period and human interventions (harvesting tools and techniques, chemical treatment of crops) are major negative factors that are impacting on the life of the birds that inhabit these ecosystems.

2.4. The habitat-fauna interdependence under natural and embankment flow regime

The habitat changes that affect the ecosystem (the quality and quantity of food resources, the species nesting and shelter conditions) are a continuous dynamic feature of the floodplain biocoenosis. This refers to its restructuring, in terms of extinction or decreasing in number of species and their replacement with species adapted to the new habitats.

In natural conditions, between the springs and the discharging into the main river, the river basins are in fact large mosaics of habitats. The typical aquatic habitats are the river itself and the lakes within the floodplain, the dead arms, the oxbows, etc. some of the most productive ecosystems in the temperate zone.

In the middle course of rivers, there are submersed and emersion plants, also riverside coppices. In the lower course, there are meadow forests, floodable meadows and reed and bulrush fields. In the middle and lower river course, meanders and riverside ponds appear, with a fluctuating water level.

In this area, bird species diversity is relatively high (aquatic species, forest species, agricultural species, wetland typical species, etc.). These species are in strong correlation with the variety of habitats, the presence of birds being conditioned by the specific vegetation that provides nesting, resting and refuge conditions, and also by the availability of abundant and diverse trophic sources.

Lakes and ponds have a rich submerged vegetation, but also large areas covered by reed and bulrush. On the lake side, willow and poplar coppices appear providing optimal conditions for many groups of birds. Marshes are wetlands with

numerous water pools with usually low levels. This favors their evaporation and drying during summertime. A dense vegetation of various heights is dominant. These ecosystems are providing optimal conditions to birds, especially to semi-aquatic birds, during migration and during breeding seasons. In summertime, despite the fact that the water levels were lower, many wetlands were still remaining. In these areas, there were reed zones, areas with clumps of typical wetland trees and large pasture zones – a wildlife habitat favorable to fauna development.

In depression areas, behind the sand banks, ponds were frequently appearing, which were in fact natural spawning zones for fish. In flood times, the mature fish from the river were entering these stiller areas where brood had optimal development conditions. Thus, floods were in fact the essential phenomenon for fish development.

The fish habitat - which includes the habitat for everyday functions (feeding and resting) and the habitat for critical stages (breeding and refuge) - is therefore directly affected by regularization works.

The European fish species are omnivorous (except for predatory or algivore species). Aquatic invertebrates are the main source of food for fish. The most productive areas for invertebrates are water beds with coarse, stable and permeable layers, which are favoring the reofile fish species.

In slow and deep rivers or stagnant waters, the main characteristic is the presence of pelagic and gregarious (planktophageous) species that feed on the channel bed, in the mobile substrate. The invertebrate development depends on the production of microscopic benthic algae (fixed on support) or planktonic algae (within water), which in turn depend on the water organic material content.

The fish population [3], due to the interruption of cross connectivity, is affected, in terms of spawning and development of larval stages. Also the fish populations are modified, quantitatively and qualitatively: some have an explosive evolution, thus becoming the dominant species, to the detriment of others which will gain the status of rare or endangered species.

The diminishing of floodplain surfaces leads to the extinction of certain fish species or to the decreasing of species numbers.

Extinct fish species: sturgeons have totally disappeared from the Prut River and they are endangered throughout the Danube basin, other species are severely threatened: the mudminnow (*Umbra krameri*) and the crucian carp (*Carassius Carassius*).

Endangered species are: the sterlet (*Acipenser ruthenus*), the ziege (*Pelecus cultratus*), the tench (*Tinca tinca*), the common zingel (*Zingel zingel*), and the streber (*Zingel streber*). Vulnerable species are: the asp (*Aspius aspius*), the barbel (Barbus barbus), the nase (*Chondrostoma nasus*), the common carp (*Cyprinus*

carpio), the ide (*Leuciscus idus*), the burbot (*Lota lota*), the loach (*Misgurnus fossilis*), and the vimba bream (*Vimba vimba*).

Some species of aquatic vulnerable invertebrates have been directly threatened by eutrophication and chemical fertilizers: *Unio Crassus, Astacus astacus, Paramysis ber bispinos, Velia caprai, Aphelocheirus aestivalis, and Cercion linden syn. Coenagrion linden.*

After the arrangements completion, the distribution of birds in embanked enclosures has suffered a severe disturbance. Reed covered areas have been reduced to extinction, which has lead to a decrease of the number of brooding aquatic birds [4]. The size of the areas that offer a suitable habitat for breeding is directly affecting the population of brooding birds within that habitat. For example, the red heron (Ardea purpurea) is nesting in very large reed areas.

The distribution of brooding species is uneven, and divided on the characteristic habitats (forest species, aquatic species, semi-aquatic species) and the presence of some of these species is rare or in regression.

The protective vegetal curtains that were planted (mixed forest species) allowed the appearance of forest prey birds [3].

Dozens of *Passeriformes* species are delimiting their territories, building nests and start brooding. Warblers, grass-warblers, nightingales, the great tits are birds living in the reed covered lands. The river warbler, the thrushes, the chickadees and the true finches prefer the forest ecosystem. The reed *Passeriformes* birds and especially the warblers (*Acrocephalus*) got perfectly adapted to the new conditions created after the completion of hydraulic constructions. All the aquatic ecosystems are dominated by the *Passeriformes* order [1].

On agricultural land, the bird fauna is poorly represented, by birds as *Coturnix xoturnix, Perdix perdix, Alauda arvensisi, Galerida cristata.* The number of these birds is decreasing due to use of herbicides and insecticides, early mowing or mechanical harvesting (the juvenile mortality is high, the chicks failing to take refuge in neighboring areas).

2.5. Impact on soil biological processes

A special aspect of environmental damage inflicted by hydraulic works is the one that occurs in the Ciuc Depression area, where peat soils are present. In this area, due to lowered groundwater table that appeared after river regulation and drainage systems, anaerobic processes in soil were converted into aerobic processes, which by biochemical reactions are releasing heat and flammable gases that favor the peat's auto-ignition (Photo 1). The peat auto-ignition in that area became frequent and the burning released polluting gases, which were contaminating the atmosphere also over the main County City (under the effect of prevailing northern winds)

Photo 1 Peat burning at Ciceu

Conclusions

The regulation of rivers, combined with the embankment and draining of floodplain are inflicting major negative effects on the river's and floodplain's ecology. Human activities are artificially modifying the natural habitat and also the ecosystem's biodiversity and productivity. Given the recognized value of floodplains in the case of natural river flow, the restoring of sideways connectivity between the river and the floodplain may be a useful tool for preserving biodiversity in the rivers' major water meadows.

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