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# CHANGES IN THE HYDRO-GEOCHEMICAL FUNCTIONS OF THE PEAT SOILS OF THE POLISYA UNDER DRAINAGE AND AGRICULTURAL USAGE

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A b s t r a c t. The parameters of changes in the hydro-geochemical functions of peat bogs after their drainage and under agricultural use were set. On the basis of subsidence size and the wear of draining peat bogs and their depositing capacity in different periods of use, the worsening of peat soil functions is shown. This worsening can be partially compensated with the help of the modernization of agricultural systems and artificial water-regulation.

K e y w o r d s: peat soils; ecological functions; drainage; exploitation; degradation; worsening

## INTRODUCTION

Peat formations in the Ukrainian forest zone (Polisya) are widespread in the flood-lands of small and medium rivers and are chiefly referred to as a depressed (low-placed) type. At present almost all peat lands are drained and put into agricultural use, with the exception of peat bogs within the limits of protected territories and lands of the Goslesfond (State Wood fund). After draining and under agricultural use, the peat soil essentially changes its morphological structure, composition and characteristics. In conjunction with changes to their inner structure, their ecological functions are also changing, in particular the functions of regulation and the geochemical regimes of the territories to which they spreading.

This work deals with the problem of the preservation and restoration of the ecological functions of drained peat-land in the Ukrainian Western Forest Zone (West Polisya) on the basis of the static investigation of land changes under different kinds of agricultural use.

## MATERIALS AND METHODS

The subjects of the investigations are the drained peat soils of the flood-lands of the Rivers Tsyr and Verhniy Pripiat in the Volyn region of the Ukraine. These peat lands are of the lowland type. In their virgin state, the soils had about the same ash content (9-12 % m/m), total carbon (48.2-51.4%), nitrogen (2.81-3.12%) and actual acidity ($pH_{H2O}$ 5.6-5.8). The botanical composition in the upper layers (0-30 cm) – was *Hypnaceae* and sedge; in thelower layers – mostly the remains of arboreal plants. In their virgin state the peat soils had a low grade of decomposition (on the Post` scale). Packing density along the profile of peat soils varied between 0.160 and 0.176 g $cm^{-3}$.

Static investigations were carried out on three plots: perennial cereal grass, lea and field and root crop rotations.

The peat soils were probed periodically with a peat coring tube constructed by the Peat Institute (Moscow) together with a soil stratigraphy discription taken down every 50 cm. The abrupt change from peat layer to underlying sand made it possible to determine the total thickness of the peat layer with great precision (1.5 cm). Repeated probings were made at precisely fixed points on the landscape (0.15 m). Together with the probing, the peat blocks of undisturbed structure were taken in order to determine the water capacity categories (maximum and field limiting water capacity, wilting moisture content etc.) and peat packing density, layer by layer. The accuracy of the last measurements has an effect on all subsequent calculations.

Zaidelman's method [1] turned out to be the most precise; according to it, a special small coring tube is used, made up of a cylindrical cogged-edged cup with a volume of 300 $cm^3$.

The measuring of separate ingredient leaching was carried out through stationary lysimeter investigations on Shelova lysimeters [2].

On the basis of the probing data, changes in the solid and liquid phase store of the drained peat soils for the duration of agricultural use, regular patterns emerge in the worsening of the lands ecologocal functions.

## RESULTS

Long stationary investigation in the "peated districts" of the Rivers Tsyr and Verhniy Pripiat in the Volyn region showed that after draining, cultural and technical work was carried out, a precise regularity in the direction of their evolution began to take place depending on the correlation of creative and degrading proc-

esses. In the first years after drainage, especially in the root rotation of crops processes, intensive subsidence and wear of the peat mass take place, causing a reduction in the thickness of the peat deposit and the total loss of the solid phase of the peat bog. So, for example, if in the first 3-7 years after drainage 1964-1967-1971 in the peat bog of flood-lands of the River Tsyr the annual reduction of thickness of the peat deposit was: under the layer of perennial grass 2.5-3.0 under the root crop 5.0-6.0 cm, and in the last 7 years (1992-1999) the change of the thickness was insignificant: accordingly 0.14-0.18 cm and 0.5-0.6 cm per year (Table 1). The same regularity is seen in the rates of peat wear: if in the first period of development the loss of dry peat-mass was 3.0-7.0 t $ha^{-1}$ on average annually, on the plot of perennial grass and 20.5-32.0 t $ha^{-1}$ $yr^{-1}$ per year on the plot of root crop, and in the period of 22-28-year of agricultural usage (1985-1992) these losses reduced essentially and were 0.5-1.5 t $ha^{-1}$ and 9-16 t $ha^{-1}$ on average per year (Table 2).

During the use of drained peat lands in lea and field crop rotation, the indices of subsidence and wear occupy the intermediate meaning (see Tables 1 and 2). Using the above mentioned parameter of subsidence and wear of drained peat soil and their water capacity, we have calculated the losses of the water retention capacity of the peat-bogs of the Tsyr and Verhniy Prypyat flood-lands within the 28-year period after their drainage and agricultural utilization. The data, given in Table 3, illustrates that identical with the inner structure and peat-bog composition the hydrological functions of peat flood lands change, in particular with regard to the loss of their water-holding capacity. In the flooding period, great masses of atmospheric precipitation waters descend from the catchment area. At the same time with the lowering of the water-holding capacity, the return of the water to the peat bog, which had lain in the above-mentioned flood-lands, increases (Table 3).

Peat and clay soils which occupy, as a rule, the peripheral plots of flood-lands and separate hollows, in many places are completely worn away, transferring to low-humus sandy lands.

In summer, the low water-level and dry periods, plus the drying out of the river-beds of the Verhniy Prypyat and Tsyr happen due to the absence of gravitational moisture entering from dry peat-bogs, that is, the function of feeding the river with water or river feeding by the peat bogs deteriorates greatly.

Parallel with the increase of water descent in the periods of flooding the high peat bog rate wears away the size of the water-soluble substances and the elements with infiltrated and draining flow increases. The data of observation of drained waters chemical composition allowed us to calculate the size of the leaching with

**Table 1.** Subsidence of the drained peat bog of the River Tsyr flood-land at different periods of its agricultural use, cm on average annually

| No. | Agro-background | Within the periods of its exploitation | | | | |
|---|---|---|---|---|---|---|
| | | 1964-1971 | 1972-1978 | 1979-1985 | 1986-1992 | 1993-1999 |
| 1. | Sheet of perennial grasses | 2.71 | 1.71 | 0.85 | 0.42 | 0.14 |
| 2. | Meadow and field rotation of crops | 3.85 | 1.71 | 0.71 | 0.42 | 0.18 |
| 3. | Root rotation of crops | 5.42 | 1.14 | 0.71 | 0.85 | 0.57 |

**Table 2.** Peat bog wear of the drained Tsyr flood-lands at different periods of its use, t $ha^{-1}$ $yr^{-1}$

| No. | Agro-background | | Periods of exploitation | | |
|---|---|---|---|---|---|
| | | | the first years of development | | within the period since 21 to 28 year of its usage |
| | | | 1964-1967 | 1968-1971 | 1986-1992 |
| 1. | Sheet of perennial grasses | A* | 5.0-7.0 | 4.5-6.5 | 0.8-1.5 |
| 2. | Meadow and field rotation of crops | B | 3.0-4.5 | 2.5-4.0 | 0.5-1.0 |
| | | A | 12.0-18.0 | 11.0-16.0 | 5.5-10.0 |
| | | B | 9.0-11.0 | 8.5-10.5 | 4.5-6.5 |
| 3. | Root rotation of crops | A | 27.0-30.0 | 26.0-32.0 | 10.5-16.0 |
| | | B | 20.5-24.5 | 18.0-21.0 | 9.0-12.0 |

*Here and in Table 4: A – a variant of extensive (without fertilizers); B – a variant of intensive usage ($N_{60}P_{60}K_{120}$ – annually)

infiltrated draining outflow of some main ingredients: organic substance, nitrates, calcium and potassium (Table 4).

Compared with virgin land, drained peat-bogs lose, to a certain degree, their capacity to accumulate and clean sewage from pollution. After drainage they become sources of pollutants which feed waterflows and rivers. The dramatic worsening of the "Dniepers water quality, which is used by more than 65% of the Ukrainian population is connected with this phenomenon.

The results of calculations of the increase in descent of volumes of some chemical ingredients with infiltrated and draining outflow after drainage and in the process of agricultural exploitation of peat-bogs shows the necessity of reconstructing farming methods on all Polesian farmland and farming on draining land, in particular.

Such measures as the use of drained peat bogs only in a hay-making and pasturing regime, the renaturalization of separate plots of draining peat bogs, the con-

**T a b l e 3.** Losses of dry peat mass and water-retention capacities of peat soils under drainage and a 28-year exploitation of the total area of spread

| Object of investigation | Background | Total area of peat soils, thousands hectares | Total stocks of dry peat mass, mln. tons | Stocks of moisture mln. square metres | | Weater-return mln. cubic metres |
|---|---|---|---|---|---|---|
| | | | | total capacity | field capacity | |
| Peated river Tsyr flood-lands | Peated virgin soils | 5.20 | 13.4 | 54.9 | 53.7 | 1.2 |
| | Peated soils after drainage and 28-year agricultural exploitation | 4.90 | 10.2 | 41.8 | 39.7 | 2.1 |
| | Difference | 0.30 | 3.2 | -13.1 | -14.0 | +0.9 |
| Peated river Verhnyaya Prypyat flood-lands | Peated virgin soils | 11.56 | 12.9 | 53.62 | 51.7 | 1.9 |
| | Peated soils after drainage and 28-year agricultural exploitation | 10.98 | 11.4 | 43.5 | 39.5 | 4.0 |
| | Difference | 0.58 | 1.5 | -10.1 | -12.2 | +2.1 |

**Table 4.** Leaching of separate ingredients with infiltrated and draining outflow (1979 1982)

| No. | Agro-background | | Leaching, kg $ha^{-1}yr^{-1}$ on average | | | |
|---|---|---|---|---|---|---|
| | | | Organic substances | $NO_3$ | $K_2O$ | CaO |
| 1 | Sheet of perennial grass | A | 86-112 | 7-11 | 8-14 | 12-16 |
| | | B | 78-92 | 4-9 | 5-16 | 14-20 |
| 2 | Root rotation of crops | A | 177-209 | 24-35 | 7-12 | 15-18 |
| | | B | 132-153 | 18-22 | 11-18 | 16-24 |

struction of reservoirs, which compensate the water losses and flood-gate regulators, the rational fertilizer system, tillage of land and rotation of crops in the surrounding draining peat-land territories considerably improve the ecological situation in the Polisya. Among the perspective elements of Polisian agriculture, which supply the ecological stability and high productivity agro-ecosystems is the so called "comfort zone technology and renewal of the bio-geo-cenotic diversity of draining peat massifs. It presupposes that local zones, favorable for root-system are developed in the subsurface horizon of Polesian soils with the help of organic and mineral fertilizers with complex action. With this, the economy of organic and mineral fertilizers, and chemically amended soil is achieved.

## CONCLUSIONS

1. While winning in the output of vegetable production by means of drainage and the involvement of peat-bogs in agricultural production, we simultaneously do considerable ecological damage to woodland landscapes due to the dramatic breach and worsening of the biospheric meaningful function of these unique natural objects.

2. The principal causes of the worsening of the drained peat lands ecological functions are the irreversible processes of settling and wear and also losses in the soils accumulating capacity.

3. The optimum hydro-geochemical functioning of drained peat lands may be preserved and restored through modernization of agriculture and water-regulating systems.

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## ZMIANY FUNKCJI HYDROGEOCHEMICZNYCH GLEB TOFOWYCH POLESIA POD WPŁYWEM DRENAŻU I UŻYTKOWANIA ROLNICZEGO

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S t r e s z c z e n i e. Określono parametry zmian hydrogeochemicznych funkcji gleb torfowych po ich osuszeniu i w procesie rolniczego wykorzystywania. Na podstawie wielkości osiadania i wybrania osuszonych torfowisk oraz ich zdolności do akumulowania wody w różnym okresie wykorzystania, pokazano znaczenie gleb torfowych dla regulacji stosunków hydrologicznych i geochemicznych na terytoriach ich występowania. Mają miejsce straty zdolności do ekoregulacji osuszonych torfowisk, które częściowo mogą być kompensowane za pomocą modernizacji systemów rolniczych i sztucznych regulacji wodnych.

S ł o w a k l u c z o w e: gleby torfowe, funkcje ekologiczne, drenaż, eksploatacja, degradacja