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AGRO-ECOLOGICAL PROBLEMS OF SOIL FLOODING AND UNDERFLOODING IN UKRAINE

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A b s t r a c t. Problems related to soil flooding in Ukraine are discussed. Directions of soil processes and changes in the soil properties under the influence of flooding are reviewed on the basis of an example of a chernozem-meadow soil located close to the Kremenchung water reservoir.

K e y w o r d s: soil flooding, soil properties, agroecology.

INTRODUCTION

Considerable areas of Ukraine are exposed to temporary and continuous flooding and overflooding that result in excessive soil moisture.

The main reason for the apparent soil overmoistening are: excessive atmospheric precipitation and floods, while constant overmoistening results from, among others, construction of water reservoirs, high level of ground waters, incorrect water balance, disturbances in the natural drainage system and surface/underground water regime, etc. At present the total area of permanently flooded and overflooded soils amounts to 800.000 ha of arable lands, in that 200.000 ha in the irrigated regions.

Construction of large water reservoir cascades in the area of the Dniepr lowland caused an enormous rise in the water level and formation of large areas of shallow water (<0.5 m). These shallow areas are without water surface in the summer time as water supply decreases then, but are not agriculturally utilized.

Moreover, broken down drainage system and numerous mistakes in the design of the system resulted in flooding of South Ukraine during the time of abundant rainfalls in 1997 (the region of Zaporjie, Kherson, Dniepropetrovsk, Crimea Republic). Flooding often occurred in the northern-west part of Ukraine (Prypiat, Polesie) and also in the valleys of the mountain rivers in the regions of the Carpathian Mountains.

Flooding causes great damages to agriculture and environment. It is also the cause of ecological catastrophes and social disasters. The problem of flooding and underflooding with its social and economic consequences has not been sufficiently investigated so-far even though there is an urgent need to find suitable solution to it.

In the period from 1980 till nowadays, the Institute of Soil Science and Agrochemistry UAAS, have carried out experiments to study the influence of flooding on soil properties and fertility. The most important results of this research work has been presented in this paper.

MATERIALS AND METHODS

The main object of the present investigation were shallow soils of the Kremenchug water reservoir (Fig. 1). The results presented in this paper were collected for chernozem-meadow sandy loam from the Domantovo-Korobov shallow land area. This land area is the largest in the region (14.000 ha). It is formed on the left shore of the Dniepr as a result of flooding of the river bed and the central part of the flooded plain. The distance of the shallow area from the bank to the fairway is nearly 7 km.

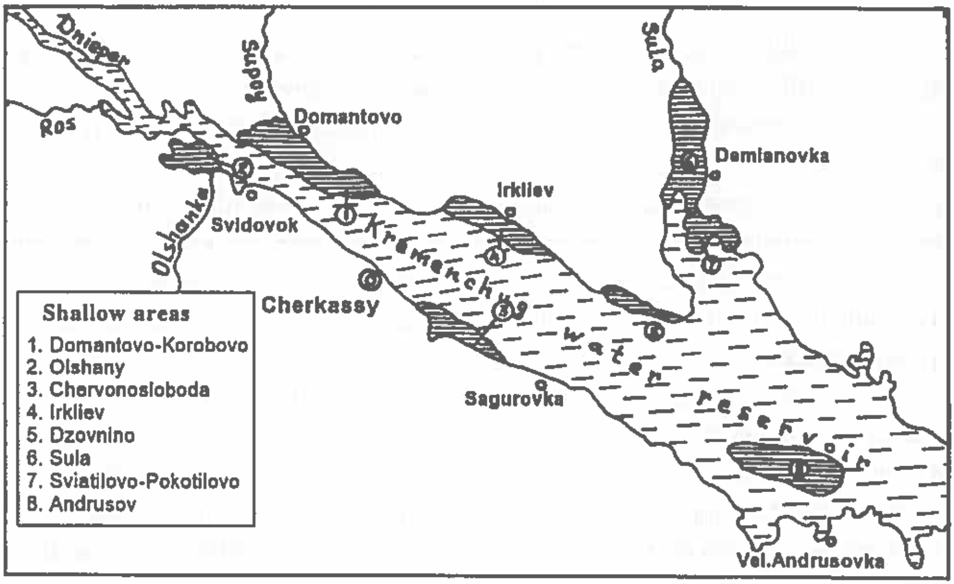

Fig. 1. The approximate scheme of shallow areas distribution in the location of Kremenchug water reservoir (by R. Truskavetsky).

Terrain relief of this shallow area had been very varied before the flooding which is also reflected in the specific features of this shallow area. The degree of overgrowing is as high as 68% of the total area.

The shallow area of the Kremenchug water reservoir is classified as protected area. The soil there are formed at the bases of water reservoirs and can be defined as separate half-closed lakes between the non-flooded heights in the terrain relief which protect these shallow areas from wind and waves. Stagnation regime is characteristic of such conditions and is manifested in intensive plankton development, high content of water plants and algae.

A comparative method together with statistical evaluation of results was applied to study soil properties in this region. Eighteen profiles were chosen as representing the flooded and non-flooded chernozem-meadow soils of the Domantovo-Korobovsky area. The above amount proved to be sufficient to obtain a reliable assessment of changes in the soil properties during the last 25 years of flooding. The relative error for the averaged values was not higher than 5% (with variation coefficients not higher than 10%, and the probability level of 0.95).

Laboratory determinations included examination of such parameters as: soil texture and aggregate composition according to Kachinsky, total carbon content according to the Turin's method as modified by Simakov, humus composition according to Kononova-Belchikova, content of mobile iron forms in fresh soil samples according to the method by Kazarinova-Oknina as modified by Kopteva, total oxides content according to Arinushkina, content of available phosphorus according to Chirikov-Shkonde, content of exchangeable potassium according to Brovkina, soil density by the pycnometric method, soil water permeability according to the method by Williams-Pustowoitova.

RESULTS AND DISCUSSION

As can be seen from the description of the soil profiles in the flooded and non-flooded plots of chernozem-meadow and meadow soils, texture has significantly changed. These changes are manifested in the following way:

- clay depositions with high content of organic carbon and detritus of a depth of 12-24 cm are formed on the surface of the flooded soils
- gleyization degree increases in the flooded soil profile which is manifested in colour changes into light grey with blue tints. The tints are barely visible in the humus but it is possible to see glossiness and increasing amounts of iron-manganese compounds.

In the lower part of the flooded soil profile, gleyization is well manifested alongside lowered humus content. In the non-flooded soils these manifestations are hardly present.

Flooding of chernozem-meadow soils results in an increase in the total carbon and clay particles content (<0.001 mm) (Table 1). Moreover, in the whole profile of the flooded soil there is a considerable increase in the content of fulvic humus and decrease in the content of calcium-humus compounds, especially in the deeper horizons (Fig. 2).

A significant difference between the flooded and non-flooded soils can be observed in the total content of iron oxides and available iron oxides (Table 2). Under the influence of flooding, the following phenomena can be observed: a considerable accumulation of protoxidic iron forms, increase of soil bulk density, decrease of total porosity, decrease of the coefficients of absorption and filtration.

Thus flooding of chernozem-meadow soils promotes gleyization processes, hinders mineralization of organic matter, intensifies accumulation of fulvates. These last processes are aggressive for the alumino-silicate parts of the flooded soils. As the result of interactions between fulvates and alumino-silicates, metal oxides are released and available phosphates are bound making them inaccessible for plants.

When the soil flooding is over, it is necessary to provide deep aeration (by soil loosening) to neutralize soil acidity and to restore agronomically valuable soil status.

The results of investigations carried out in the conditions of contemporary soil flooding in various regions in Ukraine show significant changes in the basic soil characteristics. These changes depend on such factors as time-period and regime of the flooding, genesis and properties of the flooded soils and soil cover. When soil buffers against deoxidisation are poor, even a short-term flooding results in damage to agricultural plants and degradation of soil fertility. According to Savych *et al.* [4], dangerous levels of redox potential (<200 mV) can be observed after 20 days when soil redox buffer abilities are high, and when these abilities are low, after 5 days from the onset of flooding.

Gleyization rate under flooding when the soil texture is heavy, is quicker than in the case of a soil with light texture [1,2,5]. At the same time, when a light soil is flooded, there is always evidence of leaching of the nutrients applied as mineral fertilizers [3,5].

In the regions of temporary flooding, it is not possible to store agrochemical substances, fuel or other materials that are aggressive to environment since flooding

T a b l e 1. Main agrophysical properties of natural and flooded chernozemic-meadow soils

Soil	Horizons	Depth (cm)	Particle content (%)		Soil density	Soil bulk density	Total porosity	Water permeability (%)		Aggregate content (5-0.25)	Total carbon content
			<0.01 (mm)	<0.001 (mm)	(Mg m^{-3})		(%)	Sinking coefficient	Filtration coefficient	(%)	(%)
Natural	A	0-20	16.4	11.6	2.65	1.33	49.8	1.21	1.02	37.9	1.67
	AB	30-40	17.2	13.5	2.68	1.52	43.3	0.23	0.14	40.2	1.53
	BC	60-70	16.6	13.7	2.70	1.65	38.9	0.17	0.09	-	0.96
Flooded	Clay deposition	0-15	37.2	29.3	2.44	1.18	51.6	0.45	0.36	8.2	3.44
	Agl	20-30	17.7	14.9	2.58	1.41	45.3	0.21	0.17	15.0	1.93
	ABgl	50-60	18.0	15.7	2.70	1.60	40.7	0.18	0.09	19.1	1.24
	BCgl	80-90	16.9	15.6	2.73	1.71	37.4	0.13	0.07	-	1.05

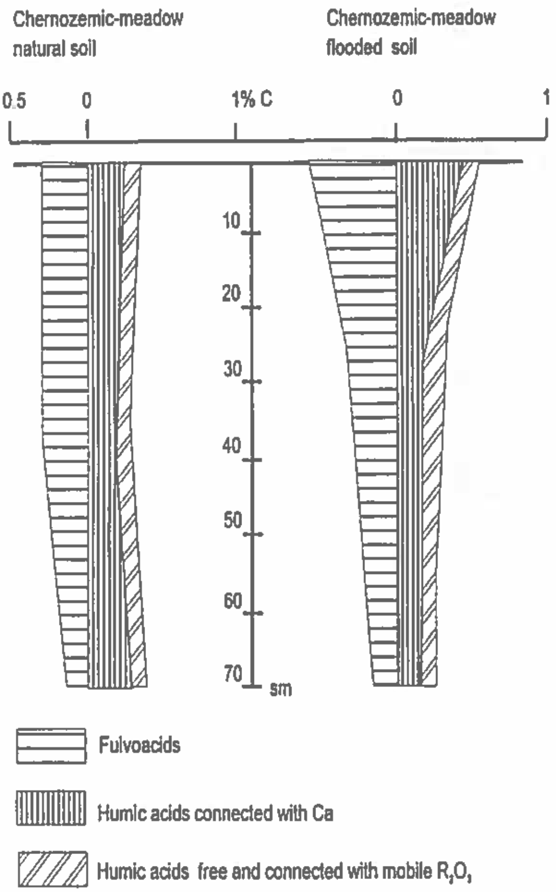

Fig. 2. Distribution of humic acids in the soil profile of chernozem-meadow (acc. to Altman).

can cause chemical pollution [3,5]. Moreover, in the flooded soils there is always a great danger of an extensive radioactive pollution.

Thus, flooding can cause rapid and significant changes in the value of agroecological soil cover. Cost involved in recultivation and restoration of the flooded soils and their fertility can thus increase significantly.

CONCLUSIONS

1. Soil macro-morphology changed under the influence of long-term flooding. In the process of subaqual soil formation, there are clear indications of gleyization especially visible in the lower part of the soil profile.

2. Soil flooding results in an increase in the content of organic matter. The qualitative composition of humus shifts to fulvatization due to an increase in the nonhydrolized organic matter content.

3. Under the influence of soil flooding, an increase in the content of clay fractions is observed. Destruction of clay is intensified alongside accumulation of non-silicate iron compounds. Activation of mobile iron (mostly protected) is quite significant.

4. Negative changes in the soil agrophysical properties are observed under the influence of flooding, namely: breaking up the structure, decrease of total porosity and filtration.

5. Changes taking place in the chernozem-meadow soils under the influence of flooding require recultivation measures and integration of the affected areas into agricultural lands.

Table 2. Content of some chemical components in the clay fraction of chernozemic-meadow soils

Soil	Horizons	Depth (cm)	Oxides, % per calcinated mass					Mobile forms, mg per 100 g of dry soil			
			CaO	MgO	MnO	Fe_2O_3	K_2O	Fe^{3+}	Fe^{2+}	P_2O_5	K_2O
Natural	A	0-20	0.70	0.33	0.04	1.41	2.81	3.3	Traces	6.0	7.2
	AB	30-40	0.65	0.34	0.05	1.64	2.83	3.4	Traces	2.0	3.7
	BC	60-70	0.66	0.35	0.06	1.67	2.75	3.4	Traces	Traces	2.5
	Cglk	90-100	5.52	0.92	0.05	1.78	2.43	Traces	3.1	-	-
Flooded	Clay deposition	0-15	0.80	0.25	0.04	1.70	1.73	33.0	81.7	4.0	14.0
	Agl	20-30	0.86	0.34	0.04	2.29	1.09	20.8	153.6	0.5	7.0
	ABgl	50-60	0.64	0.36	0.08	2.69	0.93	11.3	198.0	Traces	7.4
	BCgl	70-90	0.59	0.34	0.12	2.62	1.19	3.0	26.2	Traces	6.2
	Cgl	110-120	0.92	0.35	0.16	3.32	1.61	14.4	0.4	-	-

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