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INTERACTIONS BETWEEN SOIL STRUCTURE AND EXCESS WATER FORMATION ON CHERNOZEM SOILS

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Introduction

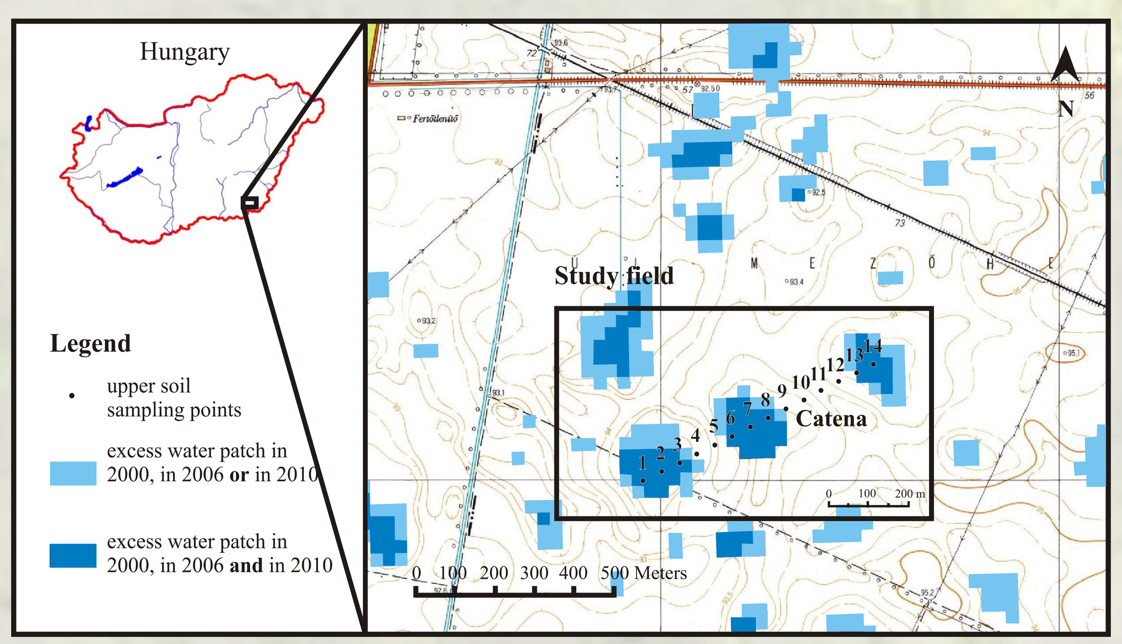
The main natural resource of Hungary is soil therefore its protection is a fundamental obligation for the state and the farmers too. The frequency of the weather extremeties have increased due to the global climate change which takes effect also on the soil properties.
The hungarian agriculture was stricken with drought in the 1990's, whereas inland excess water has caused damages in the previous decade. According to multi-variable correlation tests, pedological parameters influence on the formation of excess water besides hydrometeorological, geological or relief factors. But not only the soil parameters can take effect on the formation of excess water, but also excess water can modify the soil parameters – causing appearance of hydromorfic characteristics or physical degradation (crusts) leading to loss of multifunctionality of soils.
The value of the soil depends how many functions the soil has in the same time. Soil can integrate, accumulate the effects of other natural resources. But due to the inland excess water store function and biosphere function of the soil are limited.

Purposes

- to identify the properties of chernozem soil which influence the formation of inland excess water,
- to estimate the effects of excess water on soil structure.

Materials and methods

With a multitemporal analysis of Landsat TM–ETM images (04/2000, 06/2006 and 07/2010), the study area covered temporarily by inland excess water was defined (located on the South Hungarian Great Plain). In the process of appointing the study field, agrotopographic and Kreybig soilmaps, regional hydraulic regimes by Almási and inland excess water frequency maps by Pálfai were considered (Fig.1).



County:	Békés
Land use:	Ploughland
Soil type:	Calcic Chernozem
Study area:	45 hectares
Catena:	700 m

Figure 1. Study field with inland excess water patches and the appointed catena

In July, 2011 soil samples were collected along a 700 meters long catena at each 50 meters from the depth of 0–5 cm, 10–15 cm and 20–25 cm to compare the partical size distribution and agronomical structure of soils covered temporarily by excess water and without it.

Applied laboratory methods

- Partical size distribution by MSZ-08-0205:1978 2. Hungarian Standard,
- Agronomic structure (aggregate-size distribution) with dry sieving – 9 classes of structural aggregates were separated (>20, 20-10, 10-5, 5-3.15, 3.15-2, 2-1, 1-0.5, 0.5-0.25 and <0.25 mm); mean weight diameter (MWD) was calculated from the mean size of aggregate-fractions according to rate of weight of aggregate-fractions.

Penetration resistance and relative moisture of soil were determined at the depth of 60 cm in definite points (n=117) of a 25x25 m grid on the 45 hectares of study field using 3T System hand penetrometer (Fig. 2) in order to create a multilayer-map from the soil compaction data.

Figures, maps were created with Microsoft Excel, Surfer 8, ArcView 3.2 and ERDAS 8.4 softwares.

Figure 2. 3T System hand penetrometer

Results

Partical size distribution, texture, structure

Partical size distribution of soil samples affected by excess water (3., 6., 9., 14.) shows differences comparing the distribution of samples without water effect (5., 10., 11., 12.) – the ratio of clay fraction is higher in the soil samples covered temporarily by excess water (Fig. 3). Thus, texture of excess water soils is silty clayic loam instead of silty loam. Figure 4 shows the average partical distribution of soils, sampling from 0-5, 10-15 and 20-25 cm depth in a 3D scatter box, created by sand (x), silt (y) and clay (z) axis.

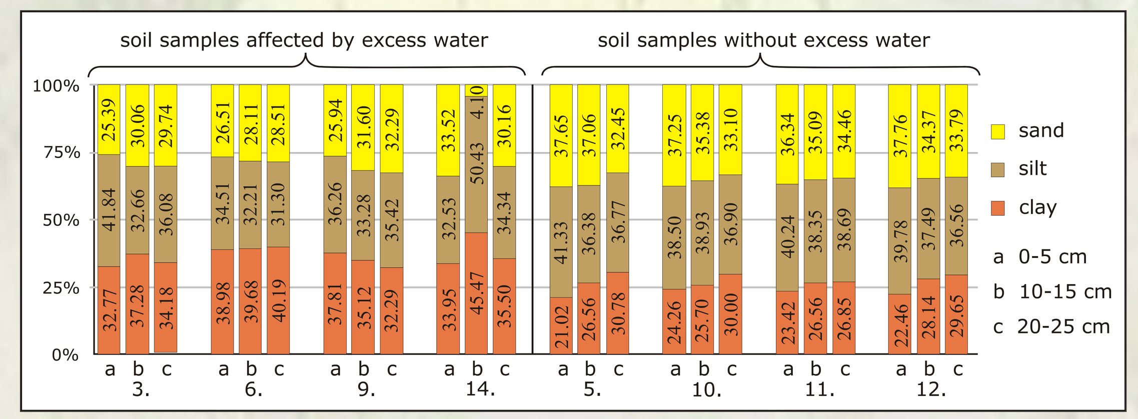


Figure 3. Partical size distribution of upper soil samples

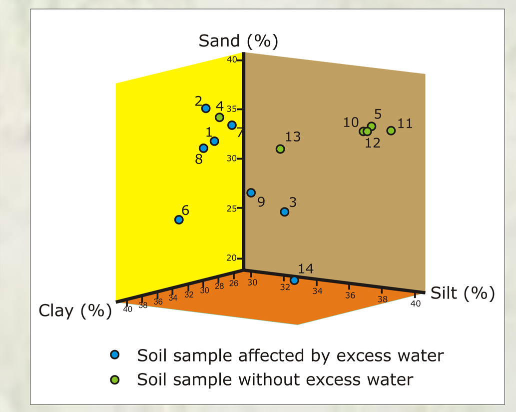


Figure 4. Soil samples in a 3D (sand, silt, clay) scatter box

In clayic soils, swelling is caused by wetting period due to excess water, and during drying period crust forms appear (Fig. 5). Agronomic structure is degradated by crusts – thus, proportion of coarse aggregates is higher in the case of soil samples temporarily covered by excess water (Fig. 6).

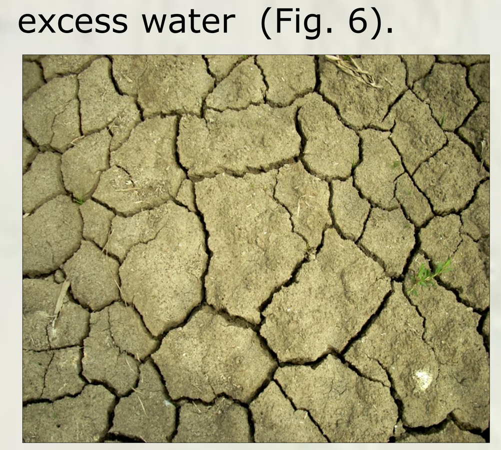


Figure 5. Crusts on clayic soil

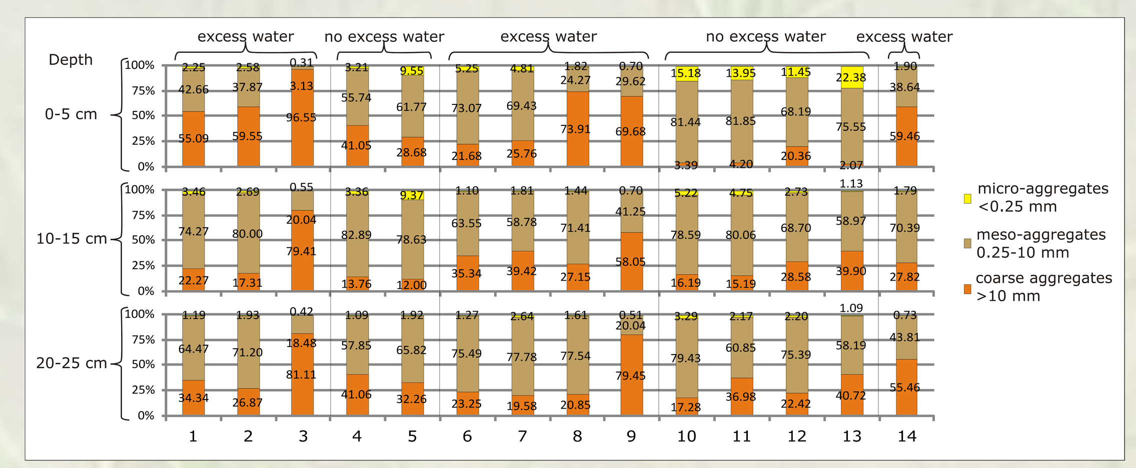


Figure 6. Aggregate-size distribution by dry sieving

In Figure 7 mean weight diameters of some soils samples are presented. MWD indices are higher in the cases of excess water soils because their structure was modified by crusting in the wetting-drying cycles.

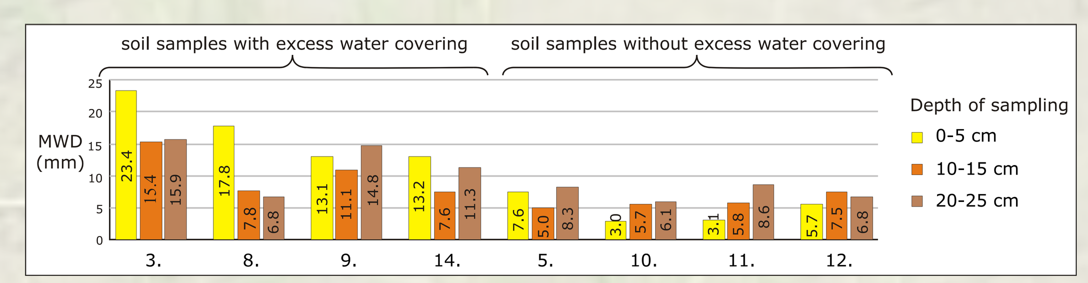


Figure 7. Mean weight diameter of soil aggregates

Compaction analysis using 3T System hand penetrometer

On 45 herctares of the study site, penetration resistance and relative moisture of soil were measured using a hand penetrometer. In 117 points with 3 paralell tests, the compaction was estimated in the upper 60 cm of the soil. In Figure 8 the location of sampling points and the inland excess water pattern are presented.

Penetrometer sampling points were categorized into 3 groups (Fig. 9). Compaction can be observed above 2.5 MPa penetration resistance. All 3 profile types show compaction especially in 36-50 cm deep zone.

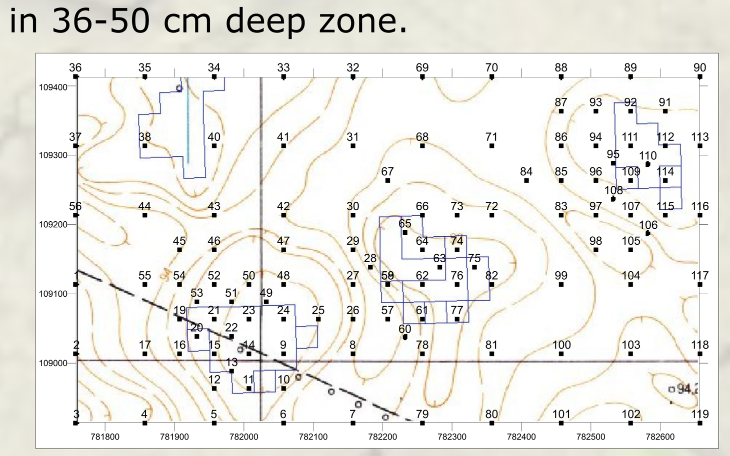


Figure 8. Sampling and excess water pattern

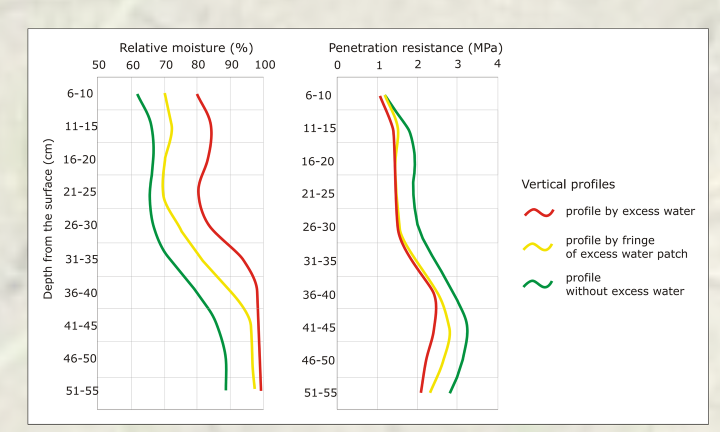


Figure 9. Vertical profiles of soils

In Figure 10 relative moisture data of study area are presented in 6 different depths. The inland excess water pattern defined by remote sensing methods coincides with the areas where the highest relative moisture content was measured by 3T System hand penetrometer.

Relative moisture data in excess water patches are higher than ones of excess water free areas.

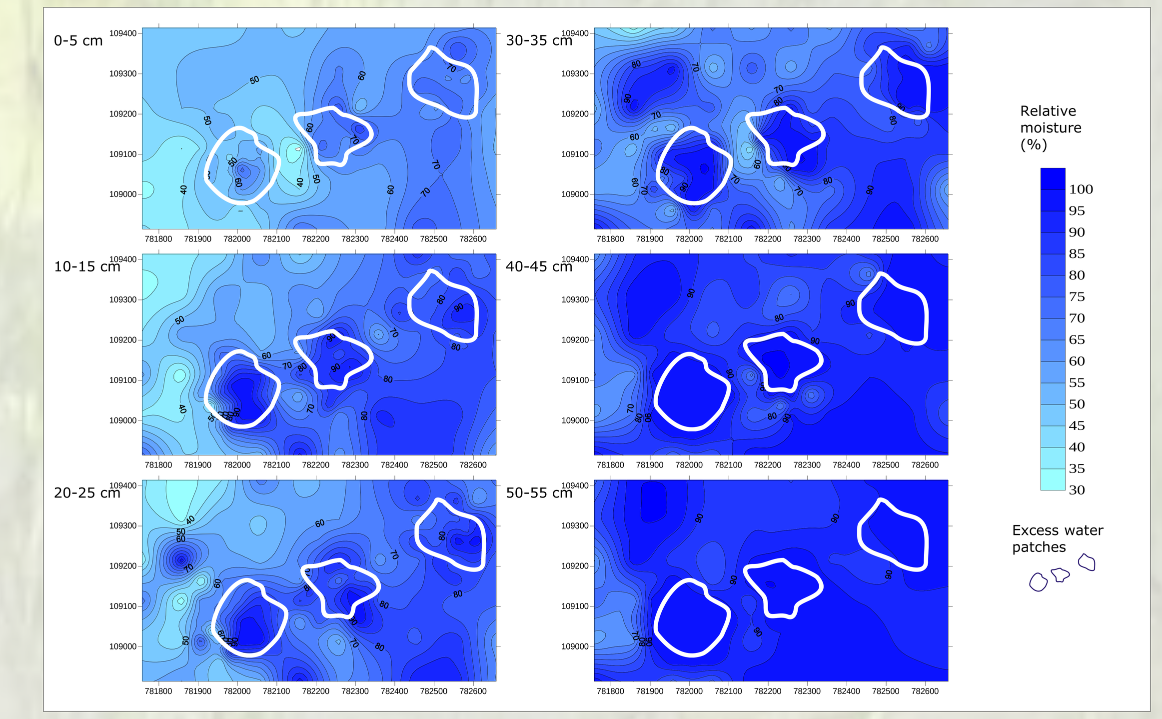


Figure 10. Relative moisture content (%) maps measured by penetrometer in different depths

For the first sight, measured penetration resistance and therefore compaction values of excess water affected areas seem to be lower than ones of excess water free areas. This can be explained by the higher relative moisture content caused by excess water (Fig. 11).

Penetration resistance data of different areas only can be compared if they are normalised into an equivalent state, level of realitive moisture content.

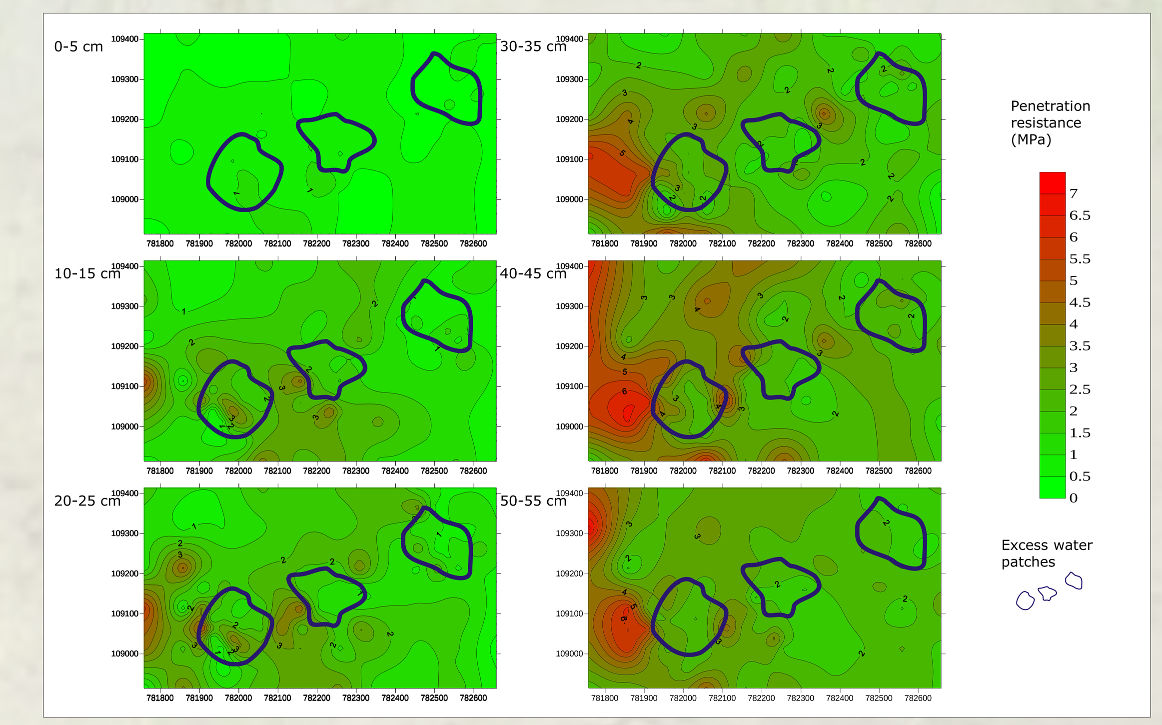


Figure 11. Penetration resistance (MPa) maps measured by penetrometer in different depths

Conclusions

The researches on our study field have proven that partical size distribution and texture are the most influential factors out of the soil parameters taking effect on formation of inland excess water.
The partical size distribution of the examined soil samples affected by excess water can be characterized with high proportion of clay fraction, thus their texture is clayic silty loam.
The inland excess water results in a peculiar dynamics of wetting–drying which might lead to appearance of crusts changing the agronomic structure of soil. Mostly coarse aggregates (>10 mm) are typical of the aggregate size distribution of samples of excess water patches – the MWD indices are above 13 mm which indicate the degradation of soil structure and hereby the loss of multifunctionality.
In our study site, soil compaction is also responsible for formation of inland excess water. Both on the area covered and not covered by excess water soil compaction was measured by 3T System hand penetrometer in a depth of 35–45 cm.
In our further research, relatitions and functionality between soil relative moisture content, penetration resistance and bulk density will be carried out – to compare the penetration resistance values of areas with different relative moisture content.

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