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PRACTICAL PROBLEMS OF SOIL STATE ASSESSMENT; EXPERIMENTS IN THE BODROGKÖZ SAMPLE AREA

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Introduction

Information about soils

The information demands about soils, about their state and about the changes in their state, which can be identified on the basis of observations in different dates, have been appreciably increased in the last decades (MERMUT and ESWARAN 2000). The basis of the information are data determined in field or in laboratory from samples (soil profile, drilling, on-site examination, etc) taken on known, localized (geo-referenced) spots or a given classification; regarding of their spatial references they can refer to discrete soil segments, pedons, agricultural plots, agro ecological units. Anyway the main requirements are that they should be available for the whole given territory in definable forms, consequently soil data are most often issued in form of (thematic) maps. The traditional tool of this information extension is the classical soil map using soil mapping units. Crisp soil maps subdivide the region into disjunctive units in a way that within heterogeneity of soil properties is less than for the whole territory (BECKETT and WEBSTER 1971). The model using soil mapping units supposes the mapped soil characteristic is homogenous inside a given plot, consequently it characterizes every single part of the area uniformly and there are changes only along the borders.

Both the initial overview maps and the soil surveys based on systematic soil examinations were established to supply social demands and need for soil information. The current expectation about the information is that it should be widely available in digital forms. As a result, soil databases and spatial soil information systems (SSIS; BURROUGH 2005, LAGACHERIE and MCBRATNEY 2005) and their versions, which are accessible through internet map, servers (ROSSITER 2004) have become the most important soil information carriers. Many soil databases take part into land use, rural development and agro-environmental (BAYLIS et al. 2004) programs; they are used in environmental modeling, surveying of environmental resources (FAO 1976) or in risk prediction (LIM and ENGEL 2003).

The conventional soil examination and soil mapping are time and cost consuming. New conventional mapping works for extended territories cannot be expected in the future. Nowadays fewer and fewer data are collected (NACHTERGALE and VAN RANST 2002, SELVARADJOU et al. 2006) and the number of soil experts has also decreased (HOWELL and SMITH 2006, PÁLMAI 2006). Because of the high costs of new sampling the use of extant information has an increasing role. Nevertheless the data from previous mapping and the currently needed information do not always overlap. The aim of mappings, the work executed and the data from that cannot be necessarily applied in a given situation, when soil information is needed. One reason for that is that conventional soil mappings had mainly agricultural aspects, because soil functions related to biomass production were important.

As a contrast, nowadays soil functions related to environmental quality have become increasingly important (VÁRALLYAY 2002). Society also needs this and sustainable development claims are built on the multifuncionality of the soil (VÁRALLYAY 2001). Because of the lack of new data collections theoretical soil science can bring relevant solutions. Digital, map-based knowledge concerning the environmental parameters gain a significant role, because they can be purchased at lower price and can be used to estimate certain soil characteristics with the help of digital soil-mapping (DOBOS et al. 2000, 2005; MCKENZIE and GALLANT 2005). With the introduction and calibration of adequate pedotransfer functions a significant improvement is expected in multiple application of available soil information (WÖSTEN et al. 1998). On one hand these instruments can facilitate the establishment of reliable and multifunctional soil information systems and on the other hand they cannot miss traditional knowledge about soil (WALTER et al. 2005) and do not work without data which primarily collected in the field (WEBSTER 1997).

According to ROSSITER's (2004) international survey existing spatial soil information systems concerns mainly regional or national scale (corresponding cartographic scale less than 1:200,000; spatial resolution greater than 400 m or 16 ha in territorial units). However many users would need spatially more detailed soil information. The next level is one with a cartographic scale between 1:200.000 and 1:20.000, which is equivalent with the 40-400m and the 0,16-16 ha (LAGACHERIE and MCBRATNEY 2005). Even the highly developed countries are not always able to fulfill the expectations of the worldwide developing spatial data infrastructure (SDI) from soil information point of view, either because the existing soil databases are not exhaustive or precise enough. However European Soil Protection Strategy (CEC 2002) requires adequate spatial information on soils, which should be organised according to INSPIRE principles (CEC 2004) as it was discussed in details by DUSART (2004).

Also in Hungary many areas and important projects need or will need in the future digital, map-based soil information suitable to the INSPIRE principles (PÁSZTOR et al. 2002). In order to have success in agro-environment management programs, the agro-environmental state of the target area and the cognition of the general environmental state and agro-potential and suitability to agricultural production of the area and the vulnerability and regenerating ability of the soils have to be surveyed (NÉMETH et al. 2000, MAGYARI 2005). The function of the agro-environmental management information and monitoring system is out of the question without adequate thematical and spatial map-based basic soil information. During the New Vásárhelyi Plan[1] the characterization of soil water regime, the evaluation of landscape management from the point of view of soil science and the regional description of soil moisture content, as well as the elements

[1] Re consideration of the huge river training project for the flood control carried out in the 19th century in the Great Hungarain Plain.

of the soil moisture balance and the spatial state of the soil resources and the following of temporal changes of soil state are important requirements in the future reservoirs beside the Tisza River (FLACHNER et al. 2004). Many further area requires also detailed and reliable soil information: habitat mapping (MOLNÁR et al. 1999), drought sensitivity mapping (NÉMETH 2004), mapping of inland inundation hazard (PÁLFAI et al. 2004), precision agriculture (TAMÁS 2001), land evaluation (GAÁL et al. 2003) etc.

Soil protection strategy in the EU

In the last decade soil degradation processes have been significantly increased and, according to the predictions, it is almost sure that without adequate arrangements this tendency will continue. In 2006 the Council of The European Union suggested a governing principle for the European Parliament and Council to define the frames of soil protection and modify the 2004/35/EK principle (EU 2006/0086), wherein the chapter named "*Towards a thematical soil protection strategy"* defines the eight most important soil degradation processes in the EU: erosion, organic matter decline, contamination, salinization, compaction, decreasing biodiversity, soil sealing, hydrogeological risks (landslide, flood).

General arrangements to forestall natural and anthropogenic soil degradation processes are named in the first chapter of the principle. Among these arrangements are the followings: decrease of the impact of these processes and restoration of the degraded soils at operability level of the actual and planned usage.

The second chapter is about risk prevention, decrease and restoration of damages. According to the arrangement after the principle takes effect, all member states have to identify on their national territory the area endangered from erosion, from decrease of organic matter content, from compaction, from salinization and from landslide during 5 years. Member states can identify the endangered areas with empirical evidences or modeling. The Soil Frame Directive suggests methods and soil data, which are needed to the spatial regionalization and delineation of the areas, which are endangered with different degradation processes. According to the suggestion for preventing soil functions, member states have to work out arrangement-programs in the second phase, which serves the contentions against erosion, decrease of organic matter content, compaction, salinization and landslides. Arrangement-programs must be worked out in seven years after the adoption, and their implementation must be started in eight years after the mentioned date.

The third chapter of the arrangement is about soil contamination. According to that, to prevent soil functions, member states have to make adequate and proportional arrangements to restrict the dangerous matters that get into the soil willfully or non-willfully (prevention). Furthermore member states identify those areas in their national land where presence of dangerous matters can be detected in such quantity, which can endanger the human health and the environment according to the member states (catalogue of contaminated areas).

Methods of the soil state evaluation

OECD has developed active agents-state-answer model (DSR) for the general evaluation of the environment state (OECD 1993). The further developed variety of this is the Driving force-State-Impact-Answer (DPSIR) model of European Environment Agency (EEA), which determines the evaluation process of the complex systems in a problem-oriented way. This approach can be also well adapted to soil state evaluation as a methodological frame, which mainly means the determination of the rate and the spatial extension of soil degradation processes (local and diffuse contamination, salinization, nutrient concentration or diminution, physical and biological degradation; soil erosion). Important element of the approach is that beside the soil state evaluation the effects causing soil degradation will be also monitored, furthermore arrangement plans helping amelioration of soil state participates in the models as well.

For the objective determination and evaluation of the soil state caused by loading processes it is necessary:

- to determine the spatial and temporal scale of soil processes and soil characteristics;
- to have descriptive data-collecting and observing programs describing soil characteristics: soil mapping, soil surveys, reviewing and evaluating soil monitoring systems;
- to determine models estimating objectively the degradation processes and soil damage;
- to create indicators, which are needed to follow the changes in the quantitative and qualitative parameters of soils.

Anyway the objective survey is difficult because of the following reasons:

- to describe soil condition caused by loading processes and to determine condition changes, an adequate information carrier database is needed whose spatial and thematic resolution fits the scale (national, regional, local) of the evaluation;
- spatial variability of soil characteristics is large;
- the temporal changes of different soil properties are very different;
- methods used for determining soil parameters diverse in time;
- modeling the certain degradation processes is a complex procedure, so their consequences can be hardly quantified.

As a curiosity we mention that the European Soil Bureau Network has also worked out a peculiar methodology (HOUSKOVA and MONTANARELLA 2006) to describe soil condition. Its specialty is that it uses soil properties perceptible by eye as state indicators (VSA: visual soil assessment). In this way soil conditions, adequacy, balances and vulnerability can be evaluated in field circumstances, without on-site and laboratory measurements.

Indicators of soil protection

Simple defined, easily determinable soil parameters can be considered as indicators of soil protection. With their help degradation processes occurring in the complex soil-water-plant system can be reliably followed and further impacts in the system can be indicated both in space and time. However the different processes can be indicated very much differently. TAMÁS and NÉMETH (2005) discusses in details the theory and practice of agro-environmental protective indicators, including the state and load indicators of soils.

Soil degradation processes can be classified into two main groups according to the fact if the human induced environmental load is direct or indirect. Local and diffuse contaminations belong to the first group. In the course of these the concentration of harmful materials is caused directly by human activity during the industrial and agricultural production with the inputs allocated into the soil or with the placing of different polluting matters. Soil condition changes caused by human activity not with direct inputs but with their indirect effects belong to the second group.

Indication of the local and diffuse pollution can be done with the help of easily measurable soil parameters as common sampling methods and different contamination limit values recorded in law. However much deeper expertise is needed to characterize soil condition and detect the changes. Soil conditions are mainly influenced by soil degradation processes, which are deducible from agro-ecological relations and caused by human activity, so characterization should be done connecting with those processes.

In connection with the local and diffuse contamination the following processes must be examined in the soil-soil moisture system:

- Concentration/diminution of nitrate in soil (total N: MSZ-08-0012/10, NH_3, nitrate: MSZ 20135:1999) and in soil moisture.
- Heavy metal contamination in soil (13 toxic heavy metals and total P (MSZ 21470-50:1998, 10/2000. (VI.2) KöM-EüM-FVM-KHVM joint decree).
- Determination of non-volatile carbon-hydrogen (oil) content of ground water samples on the base of regulations of EPA 8270C.

In connection with the condition changes of the Hungarian soils the following processes must be examined: acidification, secondary salinization, diminution of organic matter content, compaction, decrease of biodiversity and erosion. Table 1. shows the indication possibility of these processes.

Material and method

The Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences has developed and tested an experimental methodology in trial plots in the Great Hungarian Plain, which is suitable to describe current soil condition and to detect changes in soil condition. The experimental method is based on spatial and temporal data collection as: digital processing of archive soil survey data, their organization into database, fitting within appropriate spatial data infrastructure as well as the new survey planned on this basis and their overall integration.

For the evaluation of soil developing and soil degradation processes the earlier condition(s) must be known and the changes can be evaluated compared to them. Usually we don't have such monitoring network concerning the given area, which is sufficiently extensive and its operation would be commensurable with the valuable changes from the point of view of soil science. In this case an adequate solution is to lean on information of an earlier mapping as starting condition.

Table 1. Soil protection indicators
1. táblázat Talajvédelmi indikátorok

Degradation process	*Indication of the process*	*Potential occurrence*	*Hazard*	*Sampling*	*Soil examination*
Nitrate leaching	Determination of nitrate profile in the 0–90 cm soil layer	Landuse: arable land	Low groundwater level	Soil layers	NO_2+NO_3,
Heavy metal contamination	Identification of the most dangerous heavy metals is topsoil and subsoil	Not specifiable	Food production dominated agrarian areas	Soil layers	13 toxic heavy metal and overall P
Acidification	Determination of level of acidity	Not specifiable	agrarian areas, soils with low carbonate content	Soil layers	pH, hydrolith /y1/ and exchangeable acidity /y2/
Secondary salinization	Identification of salinization on irrigated lands	Vicinity of salt-affected areas, high ground-water level and salt content, salty irrigation water	agrarian, irrigated areas	Soil layers	Water soluble salt, exchangeable cations Na% and S value
Organic matter decline	Determination of organic matter content in topsoil	Not specifiable	Not specifiable	Humic soil layer	Humus content, depth of humic layer
Compaction	Determination of soil compaction in the 0-60 cm layer	Arable lands with intensive crop production on extended plots	Soil texture: sandy loam	In the 0–60 cm soil layers	Measurement of soil resistance
Decreasing biodiversity	macrofauna and mezofauna abundance	Not specifiable	Not specifiable	In the 0–5 cm soil layers	Laboratory analysis according to ISO 23611-2:2006

Reference soil state

In the case of medium range evaluation (LAU1, landscape scale) the Digital Kreybig Soil Information System (DKSIS; SZABÓ et al. 2007) based on the digital processing of the national, 1:25,000 scale, practical soil mapping project initiated and led by Kreybig (Kreybig survey; KREYBIG 1937, 1938) can be used. The elaboration of DKSIS has primary importance being the spatially most detailed and still nationwide complete, map-based soil database. The soil and land use conditions were shown jointly on the maps. Land use was given in a simplified form, distinguishing: croplands (arable land, orchards, meadow–pasture); temporarily waterlogged areas; forests; lakes, marshes, rivers and settlements. Overall chemical and physical soil properties of the soil root zone featuring soil patches were identified for croplands. Altogether three characteristics were attributed to soil mapping units and displayed on the maps. Further soil properties were determined and measured in soil profiles. One of the important characteristics of the Kreybig method is that, a representative and further, non-representative soil profiles occurring within the patch are attached to the soil units of the maps. These profiles together give information on the heterogeneity of the area. Soil profiles occurring in certain mapping unit are spatially accurately displayed in the surveying, hand-painted and in some of the printed map sheets. Soil profiles, which were typical for the given area and were able to found in spots, were distinguished. Those soil profiles whereby soil samples were taken for laboratory analyses were also distinguished in the surveying and hand-painted profiles. For coding soil profiles within the same map sheet the similarity of soil profiles was exploited and if the newly surveyed soil profile had a similar geographical position and nearly similar soil properties than an earlier described one, then it received the same code. As a consequence more soil profiles occurs with the same code on a map sheet. Data of the surveying and laboratory reports can be found in explanatory booklets enclosed to the map sheets together with the detailed soil and environmental description of the area.

Digital processing of the Kreybig archives started in 1998 integrating the data available at various institutions, in different scale and processing level (SZABÓ et al. 2000, 2005). Scanning of the map sheets as well as their rectification was finished. Vectorization of spatial data (soil units as polygons and soil profiles as points) is carried out by map sheets. The digital processing of the spatial entities and loading of profile database has been progressing independently. At present compilation of the soil spatial pattern is completed for about two-third part of the country. Compilation of profile database module is a bit lagging behind and it confines to databases of discrete experimental sites. For the loading of the field data and laboratory analysis of soil profiles included in the explanatory booklets a data loading and control program was developed (Kreybig Profile Data Manager). Presently the second-generation version of the profile database is used. Because of the increasing of database and the expansions making possible the integration of new surveys, the earlier used Microsoft Access based system was not efficient enough so hereafter the database management is based on SQL Server, which also needed the alteration of the database structure.

With GIS based processing of the original Kreybig data one can get information about soil condition of the years of 1930–1950; about the territory of cultivated lands and the rate of built-in areas and through the soil profile data about the most important physical and chemical properties of the soil layers and their spatial distribution (Kreybig1K data).

Current soil state

Determination of the actual soil conditions means the upgraded delimination of agro-ecological units (soil landscape units), which is carried out on the basis of the data of on-site survey integrated with large scale digital elevation model, remotely sensed data and further spatial thematic datasets (e.g.: CLC-50) of the territory using digital soil mapping processes. During the filed work we revisit and verify the original surveying places of the representative soil profile, which is assigned to the soil spot and determined by the compiler of the archive map for the soil spots. The result is information about soil condition in the moment of the recent survey (Kreybig2K data).

With the comparison of the past and actual soil description we fortify the status of the revisited surveying place as actual spot and with the help of the differing soil description we can interpret the changes caused by soil processes. Combining the data of the archive and actual experimental and laboratory examinations and making database from them as well as spatial extension of the examined soil profile data to the actually delimitated (thematically specified) agro ecological units can help in the identification of changes in soil condition.

The spatial soil information system of the Bodrogköz experimental site is based on data of soil survey conducted by Kreybig (Keybig1K) and on new surveys done in several dates between 2003 and 2006 (Kreybig2K). During the current survey (reambulation) we revisited the representative sites of Kreybig 1K to determine their actual soil condition. We explored the place and made on-site examination of the soil profile and also recorded the description of environment and soil layers in new soil surveying records. We took digital pictures visually recording both the environment and soil profile itself, completing explorations and other soil properties. We collected disturbed and undisturbed soil samples from the soil layers according to the Kreybig 1K stratification and did laboratory measurements. On the basis of the results achieved in 43 surveying plots and 35 laboratory measurement datasets, we determined the physical, chemical and biological characteristics of the typical soil profiles and the genetic soil types occurring in the Bodrogköz experimental site. In addition to the “classical” soil survey we also made soil contamination (in 10 representative spots) and soil biological (in 50 spots) surveys as well as soil hydrological measurements (in 4 representative spots). To deliminate the current soil units, our target was the examination of the possibility of spatial extension, whereby we wanted to certify the thematical identity of survey spots coded by surveyor in the same way during the Keybig1K mapping.

The data originated from on-site soil samplings from different time are: data of on-site examination for the whole soil profile and for the examined layers and results of laboratory analysis and photo documentation of the actual survey. These data are handled by the so-called Kreybig database server, which can be queried from the MS SQL database or from GIS through direct database connection. In this way management of the data of field observations and laboratory analysis is realized in a virtually unified, integrated GIS in internet-based environment, as well as provision of soil map databases, which ensure planning at regional level and map-based databases, which help in orientation (topographical maps, ortophotos, etc) and other complementary knowledge (field photo documentation, tables, graphs; PÁSZTOR et al. 2006).

Results and discussion

Reference soil condition

In the Kreybig1K points the soil texture can be determined on the basis of field tests and the composition can be estimated using laboratory methods. On the basis of the data the area is mostly covered by clay, silty clay and clayey loam. Sandy layers with lighter mechanical compound were found only in 8 profiles and drillings usually under the layer between 0,5-1m, depending on their catena position. The surface layer had light mechanical compound in three cases. After examination of laboratory data of 36 profiles we can state that aside from some exceptions the profiles to 1-meter depth are lime-free and acid. In one third (12 places) of the cases the hydrolith acidity value (y1) doesn't reach 10 in the surface level and in other third of the cases this value is higher than 20 and in some cases it exceeds 40. Directly under the surface layer y1 exceeds 10 only in one forth of the cases. The pH value measured in aqueous media is usually slightly acid or neutral or in some cases slightly alkaline, which is caused in the lime-free profiles by dissolved salts occurring often close to the surface. The pH value is between 4.3 and 5.5 on peaty areas. Near to the soil surface the dynamic effect of groundwater causes iron separations in different forms as flecks and peas. They usually appear in the upper one-meter layer, but they are often strong in the upper 50 cm. The traces of airless states caused by depressed water can be found at the upper part of clayey profiles in the surface depression (pseudogley). 60 percent of the 36 examined points is salt-free in the surface layer. The shape of salt-profiles is different. Salt distribution is homogenous in most profiles; there is no detectable accumulation level. The deepness of accumulation level in characteristically between 1 and 1.5 m in the salt profiles, which can be characterizes with one salt maximum. The accumulation rate exceeds rarely the 0.15% and its highest value is 0.27%. Figure 1. illustrates the reference soil condition for the whole Bodrogköz region on the basis of chemical soil properties.

One fifth of the area is floodplain and 5% is covered by forest. The chemical reaction is neutral on the 20% and slightly acid on the 15% of the territory. Highly acid soils with hard mechanical compound can be found in the highest rate (37%).

Current soil condition

During the field examinations between 2003 and 2006 43 sites were surveyed and laboratory data are available for 35 soil profiles (Figure 2). As for the physical properties no significant change was expected, the newly visited soil profiles had soil layers mainly with clay, slimy clay and clayey loam in accordance with the earlier survey.

The organic matter content of the upper layer is strongly variable, it doesn't reach 1% in two but reaches or exceeds 5% in eight profiles. The most frequent value is between 2% and 3%. This relative high organic matter content is caused by meadow–kind soil

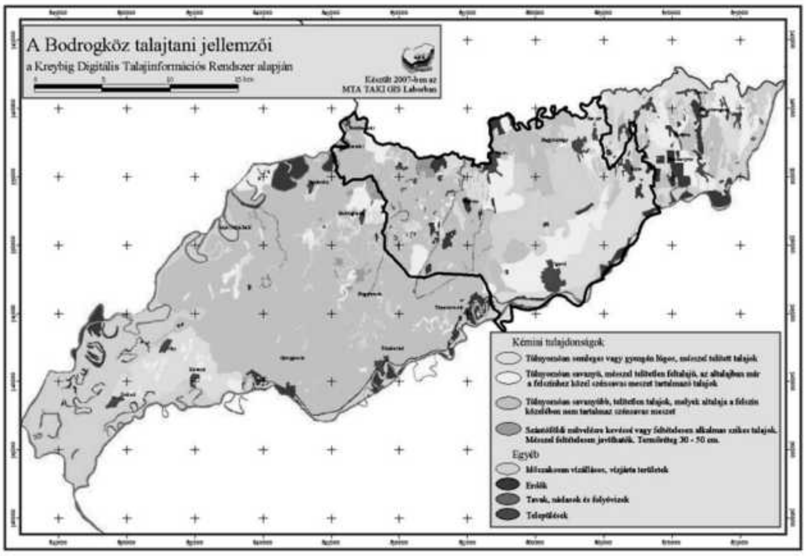

Figure 1. Soil properties of the Bodrogköz according to the original Kreybig survey (Kreybig1K): chemical properties
1. ábra A Bodrogköz talajtulajdonságai az eredeti Kreybig felmérések alapján (Kreybig1K): kémiai tulajdonságok

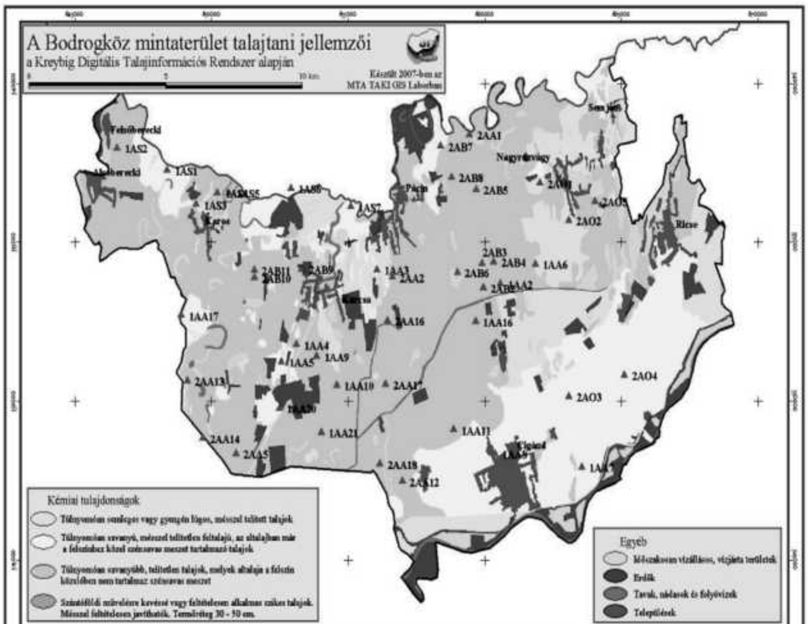

Figure 2. Soil properties of the Bodrogköz pilot area based on the upgraded database (Kreybig2K): chemical properties; the representative soil profiles are also displayed
2. ábra A bodrogközi mintaterület talajtulajdonságai a felújított adatbázis alapján (Kreybig2K): kémiai tulajdonságok; a reprezentatív talajszelvények feltüntetésével

formation, which can be characterized with too high moisture relations. Due to the iron-humate complexes the topsoil is usually dark, often black.

Soil profiles are usually lime-free and acid to the depth of 0.5 meter. In the case of three profiles carbonate content exceeding 1% can be observed in the deeper layers. The pH value of the surface layer doesn't exceed 5 in three cases. The pH value of the surface layer exceeds 6 in 17 cases. The average of measured pH values in the 0-30 cm layer is 5.97 (min: 4.98, max: 7.59) in the 30-60cm layer it is 6.74 (min: 4.86, max: 8.05) in the 1m layer it is 7.56 (min: 7.14, max: 8.25) and under that layer the average is 7.97 (min: 7.57, max: 8.22). In the surface layer the value of hydrolith acidity (y1) exceeds 10 in the 80% of the cases, but it reaches or exceeds 30 in one third of the cases. Its highest measured value is 49. Directly under the surface y1 value exceeds 10 in 50% of the cases. Besides the increasing of y1, the light decreasing of pH value refers to progressing acidity compared to the earlier state.

In most cases salt content (more than 0.01%) can be detected in the surface layer of the examined profiles, but it only reaches 0.05% (means that it occurs in traces) only one fourth of them. Considering all layers, the accumulation reaches or exceeds the 0.1% only in 5 cases and its highest value is 58%.

Identification of the change in soil condition

During the identification of change(s) in the condition of soils the comparison of reference and actual data must be done very circumspectly. The reason for this is that the two datasets to be compared, originate from surveys done with different methodology as well as the laboratory analysis methods have been meanwhile changed (this is vigorously valid for the measurement of humus content). Taking into consideration this fact the changes in chemical reaction (soil acidification) and in salt-profile (salinization) can be reliably followed, because the spatial representativity of the data are the same in case of the evaluation both acidification and salinization data sets.

During the primary evaluation all Kreybig1K and Kreybig2K (originating from the current soil surveys) data were taken into consideration, to study the main trends of possible changes. As it can be seen in Figure 3, according to both indicators (pH and y1), which can be used to characterize soil acidification, this degradation process is present in the Bodrogköz region.

The distribution of data referring to the two dates shows significant difference showing chronologically an obvious drift in the direction of lower pH and higher y1 value ranges.

Detailed description of changes in the area can be carried out by the means of comparative analysis of those point pairs, where both the identity of the location of previous and current sampling plots and their territorial representativity can be presumed. Filtering criteria of the point-pairs selection has been as follows:

- Identifiability in the field: The revisited point in the field is well identifiable, during the samplings the previous Kreybig survey place (Kreybig1K) was approached as precisely as it was possible. (That means that place of point surveyed during the Kreybig mapping can be found, can be sampled, it is not built in or covered or railed off etc).
- Profile structure: Soil profile described in earlier record data are almost the same as the currently surveyed profile, especially no tendencies occurred in texture changes

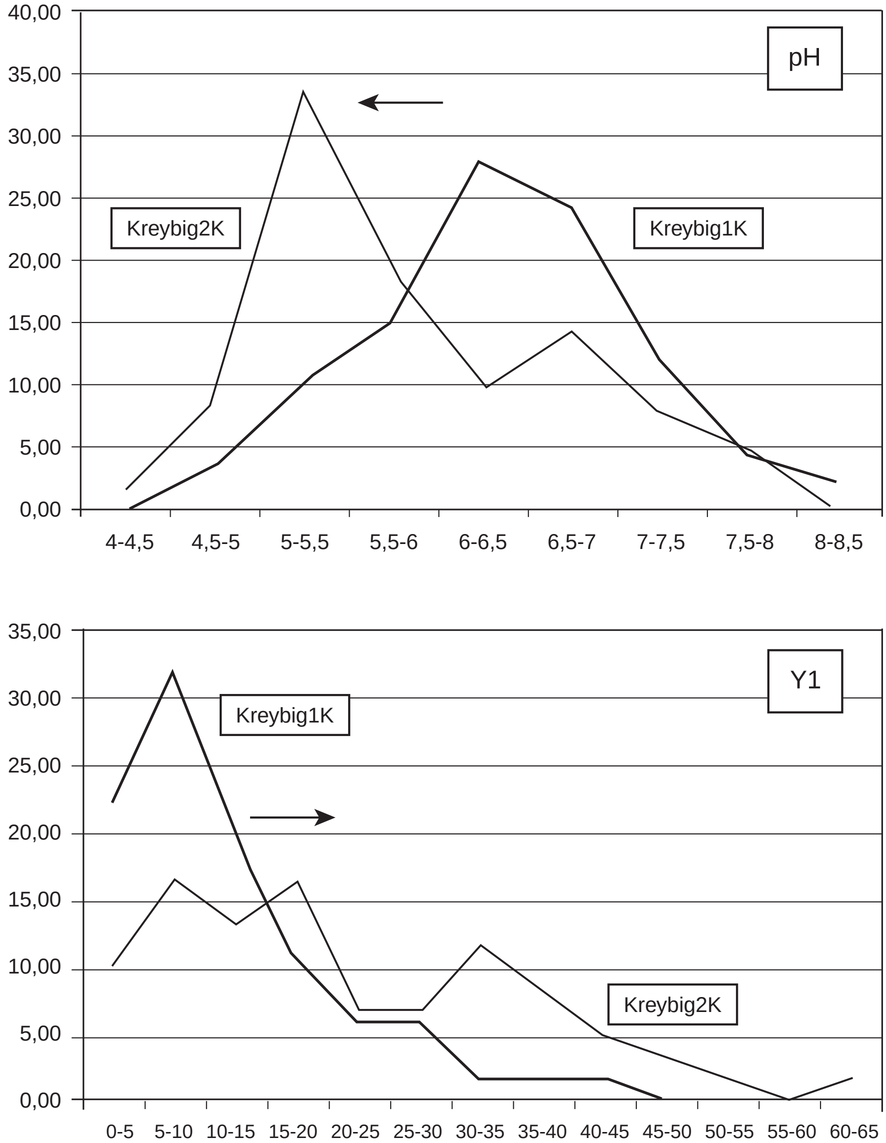

Figure 3. Changes in soil chemical properties in the Bodrogköz as shown by pH and Y1 histograms of Kreybig1K and Kreybig2K data
3. ábra Talajkémiai paraméterek változása a Bodrogközben a Kreybig1K és Kreybig2K adatok alapján készített pH- és Y1-hisztogramok alapján

(content getting finer toward the deeper layers in the profile or inter-settlements with different texture etc).

- Sampling strategy: In the case of the given profile the previous sampling strategy can be considered representative during the description of the current profile (sampling depth can be compared).

- Land use stability: There were no significant land use changes between the Kreybig-mapping and the recent sampling period. (e.g.: forest-plough land change).

With the help of this criterion system we minimized the probability that differences in data can be tracked back to sampling errors, so the changes in chemical reaction, in carbonate-state and in salt content can be evaluated from the point of view of degradation. 36 of the 43 new surveying points have laboratory analysis data from previous surveys. After the pre-screening we chose 17 point-pairs, which were compared by pairs (Figure 4).

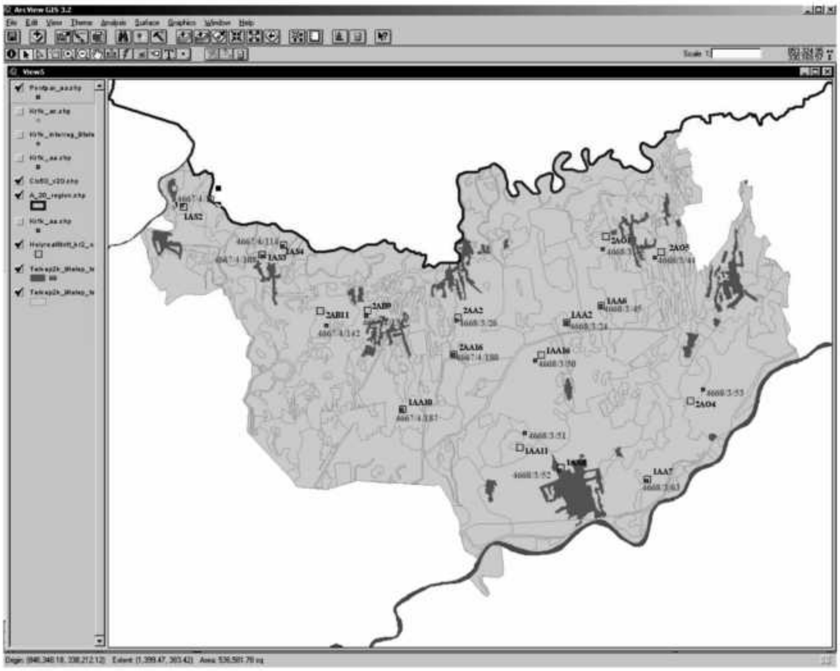

Figure 4. The Kreybig1K and Kreybig2K point pairs
4. ábra A Kreybig1K és Kreybig2K pontpárok

As a result we concluded that the general changing processes of the area are the followings:

- Acidification process becomes lightly stronger and it moves on to deeper soil layers.
- In the surface layers the chemical reaction moves from the neutral-lightly acid range toward the lightly acid-acid range
- In some profiles the water-dissolved salts move toward the surface layer (light salt accumulation, which doesn't have certainly general tendency and can be caused by the season-dynamic in the salt profile, and the result is that soluble salts move toward the surface).

By spatial extension of data referring to soil profiles to their supporting mapping units there is a possibility to compose territorial statistics applying to state characteristics and indicators and processes as well as to illustrate their spatial distribution on maps. Figure 2. shows the map compiled on the basis of results of desktop (primary) and field (secondary) reambulation. It shows as precisely as possible the current state of the topsoil's chemical properties based on the existing data.

On the basis of the newer surveys, one third of the experimental territory are floodplains, almost 5% are forests. 14% of the territory is neutral, 16% is lightly acid in point of the chemical reaction. 50% of the soils are hard acid with heavy mechanical compound. During the new surveys with 13% more territories were found with hard acid soils (50%) than before, although rate of territories with lightly acid soils (16%) hasn't been changed. One part of the previously neutral soils became more acid, instead of the previous 20%, 14% can be found. Hard acid clay soils have the biggest territorial expansion during both surveys; the rate of them was previously 23%, now 30%.

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