Soil and Landsite Databases for Sustainable Land Management in Hungary

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1. Abstract

Rational land use and soil management are important elements of sustainable (agricultural) development. Soils represent a considerable part of the natural resources of Hungary. Their rational utilization, conservation and the maintenance of their multipurpose functionality have particular significance in the Hungarian national economy and in environment protection (VÁRALLYAY, 1995a, b). Consequently, the scientifically based planning and realization of sustainable land use, introduction of site-specific, precision technologies for biomass production, for the maintenance of the favorable and desirable multi-functionality of soils, for soil and water conservation and for nature preservation require:

- adequate information on the soil*:* exact, reliable, "detectable" (preferably measurable), accurate and quantitative territorial data on well-defined soil properties with the characterization of their spatial (vertical, horizontal) and temporal variability, soil processes and pedotransfer functions and land characteristics;
- comprehensive knowledge on the existing relationships among natural factors, soil and land characteristics and the soil biota, native vegetation and cultivated crops (plant responses) including the partial and integral impacts of influencing factors and their mechanisms;
- application of existing (verified and validated or "calibrated") simulation models for the prediction of the potential consequences of various human actions and for the selection of the most appropriate alternative measures and most efficient technologies for their realization.

2. Data Sources on Natural Factors

In Hungary a large amount of information is available on the various natural factors as a result of long-term observations, survey and mapping activities (The National Atlas of Hungary, 1989). The most important data bases and monitoring systems are as follows:

- Meteorological data*.* Systematic and regular measurements from 1850. At present the basic meteorological parameters are registered at 160 observation points; 18 stations are equipped for detailed atmospheric-chemistry measurements and 4 EMEP stations for continuous atmospheric monitoring (MÉSZÁROS et al., 1993).
- Hydrological data. Regular records on the quantity and quality of surface waters (rivers, creeks, canals, lakes, ponds, reservoirs) from the first decade of the century.

Data on groundwater conditions (depth of water table; chemical composition of the groundwater) in 600 - 1000 groundwater testing wells are available from 1935, including 50 piezometer installations, measuring of pressure conditions and water chemistry parameters in the various deeper aquifers. On this basis the 1:200,000 scale map of the average depth to the groundwater table, and the 1:100,000-scale map of the groundwater chemistry (total concentration, ion composition) had been prepared and permanently updated. During the seventies 1:1 M scale maps on the actual depth of the groundwater table were edited monthly.

- Geological data. As a result of the 160-year geological survey, the 1:200,000 geological map of Hungary has been prepared, as well as a great number of various thematic geological, hydro-geological, geo-chronological maps in larger scales for different regions of the country.
- *Geo-morphological data.* In addition to the 1:200,000 geomorphological map (geomorphological types, subtypes and varieties) of Hungary a series of regional maps has been prepared indicating the geomorphology pattern of smaller territories in larger scale. In addition to the traditional contour maps the relief characteristics (slope gradient, length, complexity, exposure of the slopes) are indicated on a special "relief map" (1:100,000) prepared during the last years with the application of computerized digital relief models.

3. Soil Information Sources

A large amount of soil information are available in Hungary as a result of long-term observations, various soil survey, analyses and mapping activities on national (1:500,000), regional (1:100,000), farm (1:10,000-1:25,000) and field level (1:5,000-1:10,000) during the last sixty years. Thematic soil maps are available for the whole country in the scale of 1:25,000 and for 70% of the agricultural area in the scale of 1:10,000.

There are at least three reasons why this rich soil database has been developed (VÁRALLYAY, 1993):

- the small size of the country (93,000 km^2);
- the great importance of agriculture and soils in the national economy;
- the historically "soil loving" character of the Hungarian people, and particularly the Hungarian farmers.

3.1 Soil Maps

In Table 1 the most important thematic soil maps in Hungary are summarized, indicating their content, scale, author and date of preparation (Proceedings of the Hungarian-Swedish Seminar on Soil Mapping, 1989; STEFANOVITS & SZÜCS, 1961; VÁRALLYAY, 1989).
As it can be seen from Table 1, the maps can be divided into three main groups:

Table 1. Thematic soil maps in Hungary

No	Map	Scale	Date of preparation	Prepared for	Content	Author(s)	References
1.	Practical soil maps	1:25,000	1935-1955	the whole country per topographical map sheets	m, tm, fd, ld, e	Kreybig and coll.	VÁRALLYAY, 1985, 1989
2.	Large-scale genetic soil maps	1:10,000	1960-1975	60% of agricultural land of Hungary, per farming units	m, tm, fd, ld, e	Coll.	SZABOLCS, 1966
3.	Soil conditions and the possibilities of irrigation	1:25,000	1960-1970	present and potential irrigated regions	6 thematic maps, fd, ld	Coll.	SZABOLCS et al., 1969
4.	Large-scale maps for amelioration projects	1:5,000-1:10,000	1960-	amelioration projects (occasionally)	m, e	Coll.	
5.	Soil factors deter-mining the agro-ecological potential	1:100,000	1978-1980	the whole country per topographical map sheets	m (with an 8-digit code), c	Várallyay, G., Szücs, L., Murányi, A., Rajkai, K.Zilahy, P.	VÁRALLYAY et al., 1979, 1980a
6.	Agro-topographical map	1:100,000	1987-1988	the whole country per topographical map sheets	m (with a 10-digit code), c	Várallyay, G. Molnár, S., Szücs, L.	VÁRALLYAY & MOLNÁR, 1989.
7.	Hydrophysical properties of soils	1:100,000	1978-1980	the whole country per topographical map sheets	m, c	Várallyay, G. Szücs, L., Rajkai, K. Zilahy, P.	VÁRALLYAY et al., 1980b
8.	Limiting factors of soil fertiltiy	1:500,000	1976	the whole country	m	Szabolcs, I. Várallyay, G.	SZABOLCS & VÁRALLYAY, 1978
9.	Main types of moisture regime	1:500,000	1983	the whole country	m, c	Várallyay, G. Zilahy, P., Murányi, A.	VÁRALLYAY, 1985
10.	Main types of substance regime	1:500,000	1983	the whole country	m, c	Várallyay, G. Szücs, L., Molnár, E.	VÁRALLYAY, 1985
11.	Soil erosion	1:500,000	1960-1964	the whole country	m, tm, e	Stefanovits, P. Duck, T.	STEFANOVITS, 1964
12.	Salt affected soils	1:500,000	1970-1974	the whole country	m, e	Szabolcs, I., Várallyay, G. Mélyvölgyi, J.	SZABOLCS, 1974.
No.	Map	Scale	Date of preparation	Prepared for	Content	Author(s)	References
13.	Susceptibility of soils to acidification	1:100,000 1:500,000	1985-1988	the whole country	m, c	Várallyay, G., Rédly, M., Murányi, A.	VÁRALLYAY et al., 1993.
14.	Susceptibility of soils to physical degrada-tion	1:500,000	1985-1988	the whole country	m, c	Várallyay, G. Leszták, M.	VÁRALLYAY & LESZTÁK, 1990.
15.	Soil evaluation	-	1980-1985	soil profiles	fd, ld	Coll.	
		1:10,000 1:25,000	1985-	non-mapped part of agricultural and forest land of Hungary	m, tm, f, ld	Coll.	

Remarks: m: soil map; tm: thematic map; fd: field description; ld: laboratory data; e: explanatory booklet; c: computer storage

Large-scale maps (Nrs. 1.- 4. in Table 1)

- In the "Kreybig - practical soil maps" (KREYBIG, 1937) the soil reaction, carbonate and salinity/alkalinity status are indicated by colours; physical-hydrophysical characteristics and depth of the soil by rasters; the organic matter, total P_2O_5 and K_2O content, depth of the humus horizon and depth of the groundwater table by a code number; and the soil type (according to 'Sigmond's soil classification) with roman numbers.

- On the 1:10,000 scale genetic soil maps (SARKADI et al., 1964; SZABOLCS, 1966) the most important soil properties (soil type, subtype and local variant according to the Hungarian soil classification system; pH and carbonate status; texture; hydrophysical properties; salinity/alkalinity status; organic matter resource; N, P and K status) are indicated on separate thematic maps (cartograms); and recommendations are summarized in additional thematic maps for rational land use and cropping pattern; soil cultivation; rational use of fertilizers; soil moisture control, including water conservation practices, irrigation and drainage; soil conservation practices for water- and wind erosion control; etc.

- The large-scale maps on the possibilities and limitations of irrigation (SZABOLCS et al., 1969) indicate:
  - soil types, subtypes, local variants and parent material;
  - physical-hydrophysical soil characteristics;
  - salinity/alkalinity status of the soil (salt content, ion composition, ESP, pH);
  - groundwater conditions (depth and fluctuation of water table; salt concentration, ion composition and SAR of the groundwater) and on this basis:
  - the "critical depth" of the water table and "critical groundwater regime";
  - recommendations for irrigation practices and groundwater management on separate thematic maps.

- Large scale (1:5,000, 1:10,000) maps for various soil amelioration projects. Large-scale soil maps (and related databases) will have a “renaissance” in the near future because of the following reasons:
  - the new land ownership structure, the rent-a-field system and the developing land market requires more detailed information on land/soil resources than ever in the Hungarian history;
  - the new soil/land evaluation system (which - hopefully - will be completed, and officially introduced and formulated in legal documents in the near future) needs also detailed soil/land information, convertible to existing or planned EU-standards;
  - the site-specific precision agrotechnologies (precise and scientifically-based soil moisture control, water- and nutrient supply, soil and environmental pollution control) necessitates adequately precise data on soil and land characteristics.

    The best example in this respect is the new, fully automated and computerized fertilizer application technology. In the system a large-scale “fertilizer-requirement” map (SARKADI & VÁRALLYAY, 1989; VÁRALLYAY, 1994d) is prepared (based on the forecasted (planned) yield, the nutrient requirement and nutrient uptake dynamics of the given crop, the main characteristics and the plant nutrient status of the given soil) and stored in a tractor deck computer. The actual position of the tractor is registered by GPS; and the required quantity of fertilizer is sprayed accordingly, automatically or semi-automatically (controlled by the tractor driver).

Medium scale maps (Nrs 5-7 in Table 1)

- In 1978, the Hungarian Academy of Sciences initiated a national program for the "Assessment of the agro-ecological potential of Hungary". In this program a 1:100,000 scale map was prepared by the author's team (VÁRALLYAY et al., 1979, 1980a) on the *soil factors determining the agro-ecological potential,* utilizing all available soil information. On the map 7 soil factors were indicated with an 8-digit code number:
  1st and 2nd digit: Soil types (31 categories);
  3rd digit: Parent material (9 categories);
  4th digit: Soil reaction and carbonate status (5 categories);
  5th digit: Soil texture (7 categories);
  6th digit: Hydrophysical properties (9 categories);
  7th digit: Organic matter resource (6 categories);
  8th digit: Depth of the soil (5 categories).

  The map was completed later with two additional code numbers expressing two more soil characteristics:
  9th digit: Clay mineral associations of soil (STEFANOVITS, 1989);
  10th digit: Soil productivity index.

- The contours of these 9 soil characteristics were printed on a 1:100,000 scale basic topographical map with rich information content (relief, surface waters, land use, infrastructure, etc.). Meteorological information are given on the territorial and temporal variability of the main climate elements on each map sheet by "micro-maps" and monthly distribution diagrams, respectively. These *agro-topographical maps* were prepared for the whole country and are available in printed form per topographical sheets (VÁRALLYAY & MOLNÁR, 1989).
  The soil contours of the agro-topographical map were digitized and organized into a GIS-based soil information system (see later).
- The map with categories of the hydrophysical properties of soils were also prepared in the scale of 1:100,000. The 9 main and 17 subcategories indicated were defined by the following soil characteristics: texture, saturation percentage (SP); field capacity (FC), wilting percentage (WP), available moisture range (AMR); infiltration rate (IR), saturated hydraulic conductivity (K), un-saturated capillary conductivity (k, k-Y or k-q), and by the layer-sequence of the soil profile (VÁRALLYAY et al., 1980b).
- Maps on the status of soil erosion have been prepared by STEFANOVITS and his team in the 50's for the agricultural lands of hilly regions in Hungary. On the 1:75,000 scale maps the following categories were indicated: strongly, moderately and slightly eroded lands; areas of sedimentation; territories under the influence of wind erosion. In addition to these erosion characteristics parent material was also indicated on the maps (STEFANOVITS, 1964).

Small scale maps

- 1:500,000 scale generalized thematic soil maps (Nos 8-12 in Table 1)
- 1:500,000 scale HunSOTER (HUNgarian SOil and TERrain digital database) (PÁSZTOR et al., 1995, 1996; SZABÓ et al., 1996; VÁRALLYAY et al., 1994);

- 1:1,000,000 - 1:5,000,000 scale soil maps, prepared for various international programmes, e.g. FAO/UNESCO World Soil Map (1:5 M); FAO Soil Map for Europe (1:1 M); World Map of Salt Affected Soils (1:5 M); GLobal Assessment of SOil Degradation, GLASOD (1:5 M); SOVEUR (SOil Vulnerability against various pollutants in EURope); EUSOPOL (EUropean SOil POLlution); CTB ("Chemical Time Bomb" - time-delayed effect of various pollutants); Long-term Environmental Risks for Soils, Sediments and Ground-waters in the Danube Catchment Area; etc.

3.2 Soil Susceptibility/Vulnerability Maps

In the last years special attention has been paid to the characterization of soils from the viewpoint of their sensitivity/susceptibility/vulnerability against various natural and human-induced stresses.

The following thematic soil susceptibility maps have been prepared during the last years (VÁRALLYAY, 1991):

- Susceptibility of soils to water and wind erosion (1:1 M) (STEFANOVITS, 1964; STEFANOVITS & VÁRALLYAY, 1992);
- Susceptibility of soils to acidification (1:500,000, 1:100,000) (VÁRALLYAY et al., 1993);
- Susceptibility of soils to salinization/alkalization (1:500,000) (SZABOLCS, DARAB & VÁRALLYAY, 1969);
- Susceptibility of soils to physical degradation, such as structure destruction, compaction and surface sealing (1:500,000) (VÁRALLYAY & LESZTÁK, 1990);
- Vulnerability of soils against various pollutants (under preparation).

3.3 Soil Information System

In the last years all existing soil data were organized into a computerized geographic soil information system (HunSIS = *TIR)* (CSILLAG et al., 1988; KUMMERT et al., 1989). TIR consists of two main parts:

- The soil data bank, including 3 different types of information:
  - basic topographic information (geodetic data standards and geographic reference systems);
  - point information (measured, calculated, estimated or coded data on the various characteristics of soil profiles (or borings) or their different layers, diagnostic horizons (at present 30 soil and land characteristics), and
  - territorial information (1:25,000 scale thematic maps on various physico-geographical factors (geomorphology, relief, groundwater conditions) and soil properties.
    The attribute inputs of the Hungarian Soil Information System are summarized in Table 2.
- The information system, including models on moisture and plant nutrient regimes of soils; susceptibility of soils to various soil degradation processes, such as water and wind erosion, acidification, salinization/alkalization, structure destruction and compaction; soil-water-plant relationships; status of soil pollutants and potentially toxic elements; etc.

The digitizer-computer-plotter distributed system, including adequate software is able to search for either location or attributes and display results in digital, tabular, graphical or cartographical form (data, categorized data, results of model calculations, thematic maps, etc.).
Current system development is focused upon the enhancement of local (i.e. workstation) modeling and editing functions, as well as to make this quadtree-based thematic GIS compatible with other gridded data sources.
The simultaneous application of (a) and (b) type inputs opens new output facilities: integrated data; classification and grouping of soil according to various criteria; interpreted results; practical recommendation for sustainable land use and proper soil management.

Table 2. Inputs of the Hungarian Soil Information System

No.	Point information	Territorial (cartographical) information
1.	Soil type (subtype, variety, mapping unit) ⊙	Topographical map *
2.	Relief ⊙	Map of geomorphology *
3.	Depth of the humus horizon Ä	Map of slope categories *
4.	Parent material ⊙	Map of slope exposures *
5.	Concretions ⊙	Map of parent material *
6.	Depth of the groundwater table Ä	Map of soil erosion D
7.	Texture ⊙	Genetic soil map (soil types, subtypes, etc.) D
8.	pH (H_2O) Å	Map of the depth of the humous horizon D
9.	pH (KCl) Å	Map of organic matter content D
10.	Hydrolytic acidity Å	Map of soil reaction and carbonate status D
11.	Exchangeable acidity Å	Map of water-soluble salts and ESP D
12.	Carbonate content Å	Map of soil texture D
13.	Alkalinity against phenolphtalein Å	Map of total water capacity, total porosity (VK_T = pF 0) D
14.	Water-soluble salt content Å	Map of field capacity (FC = pF 2.5) D
15.	Ion composition of the aqueous extract Å	Map of wilting percentage (WP = pF 4.2) D
16.	SP (sticky point according to Arany) Å	Map of available moisture content (AMR = FC - WP) D
17.	Fine fraction % Å	Map of saturated conductivity (K) D
18.	Particle-size distribution Å	Map of unsaturated conductivity (k-Y; k-Q) D •
19.	Organic matter content Å	Map of average depth to the water table *
20.	Humus stability index ”	Map of maximum depth to the water table *
21	Clay mineral composition Å	Map of minimum depth to the water table *
22.	Specific surface Å	Map of concentration of the groundwater * D
23.	CEC Å	Map of ion composition of the groundwater D *
24.	Base saturation (T-S) Å	
25.	Exchangeable cation composition Å	Ä Field-measured values; ⊙ Field-coded categories;
26.	SAR ”	Å Laboratory-measured data; — Calculated values;
27.	Characteristic points of the water retention (pF) curve and the hydrophysical indexes (FC, WP, AMR, etc.) Å	D Categories, defined by limit values; * Maps from other sources
28.	Infiltration rate (IR) Ä	
29.	Saturated hydraulic conductivity (K) Å	
30.	Unsaturated capillary conductivity (k-Y; k-Q) Å ™	

3.4 Soil Monitoring Systems

For the registration of soil changes three systematic monitoring systems were established:

- Soil fertility monitoring system (AIIR).
  In the system the most changeable soil characteristics (pH, $CaCO_3$ and organic matter content; saturation percentage (SP); total salt content; total and "mobile" N content; "available" P, K and Ca content; "soluble" Mg, S, Cu, Zn, Mn content) were measured in the topsoil (0-30 cm soil layer or the ploughed horizon, later in the 30-60 cm layer as well). This was done in about 100,000 agricultural fields covering near to 5 million hectares [the total agricultural area of the 93 thousand sq. km. Hungary is about 6.5 million hectares], in 3-year cycles. The programme started in 1978 (I.: 1978-1981; II. 1982-1985; III.: 1986-1989) and stopped before completing the third cycle (BARANYAI, FEKETE & KOVÁCS, 1987).
  The data were computer-stored per agricultural field (their average size was about 50 hectares at that time), without inner contours of the maximum 12 hectares sampling sites, where mixed samples (composed from 30-30 "sub-samples") were collected in two replicates for laboratory analysis.
  In addition to the "soil properties file", separate files contain detailed information on the land-site characteristics (climate, relief, geology), on the agrotechnical operations (tillage, sowing, nutrient supply, pest control, etc.) and on crop yields, respectively for the registered fields.

- Microelement survey.
  In this system, in addition to the above-mentioned basic soil parameters, the "total" (interpreted as a potential "pool") and "soluble" (interpreted as mobile and plant available /?/) content of 20 elements were determined in the 0-30, 30-60, 60-90 cm soil layers of 6,000 soil profiles, representing about 5 million hectares of agricultural fields.
  The planned cycle was 3 years. The first sampling was in 1987-1988.
  The program stopped during the second cycle (because of financial limitations). The 6,000 "representative" sampling sites were selected by regional soil experts on the basis of available previous soil information and on their long-term local experiences.
  1000 "representative" soil samples have been selected from the above-mentioned sample collection by national soil correlators for laboratory analysis. In the 1st cycle ("starting point") the following 20 elements were determined: Al, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, P, Pb, S, Se, Zn from 5 various extractants (by ICP): 0,1 *N* HNO_3; 0,02 *N* $CaCl_2$; NH_4-lactate-EDTA; $(NH_4)_2SO_4$; LAKERV.
  On the basis of analytical data 1:2,000,000 scale thematic maps were prepared for Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb. On the map the measured data (classified into categories defined by limit values) are indicated with a 6x6 km grid). The sampling site was exactly defined by geographical coordinates and served as the centerpoint of the grid (that is the reason why the grids sometimes overlap each other to a certain extent).

4. Soil Information and Monitoring System (TIM)

The new Soil Information and Monitoring System (TIM) is an independent subsystem of the integrated Environmental Information and Monitoring System (KIM) (TIM 1995; VÁRALLYAY 1994A, 1994C).

Based on physiographical-soil-ecological units, 1237 "representative" observation points were selected (and exactly defined by geographical coordinates using GPS). There were

865 points on agricultural land, 183 points in forests and 189 points in environmentally threatened "hot spot" regions. The latter represented 12 different types of environmental hazards or particularly sensitive areas such as: degraded soils; ameliorated soils; drinking water supply areas; watersheds of important lakes and reservoires; protected areas with particularly sensitive ecosystems; "hot spots" of industrial, agricultural, urban and transport pollution; military fields; areas affected by (surface) mining; waste (water) disposal affected spots.

Regional soil experts selected the "representative" sampling sites on the basis of all available soil information (profile descriptions, results of laboratory analysis, long-term field observations, maps, etc.) and on their local experiences. The forest and the "hot spot" sampling sites were selected in cooperation with regional forest land-site experts, environmentalists and experts of the given environmental hazards.

The sampling date is September 15 - October 15 each year. The first sampling was in 1992. In the monitoring system some soil parameters are measured every year, some others every 3 years or every 6 years, depending on their changeability (stability) (Table 3).

In addition to the existing soil maps and maps on the various physico-geographical factors new techniques (geostatistical analysis, remote sensing, etc.) will be applied to extend point information into territorial ones (if it is necessary, possible and rational).

According to the basic concept, TIM is an independent but integral mosaic (subsystem) of the Environmental Information and Monitoring System (KIM) to be established and operated by the Ministry of Environment and Regional Policy (KTM).

The data-base management and the hardware-software configuration of the system:

- guarantee the compatibility of TIM with the other subsystems of KIM which are under elaboration now (e.g. for the atmosphere; surface- and subsurface water resources; geological deposits and mineral resources; biological resources and biodiversity; landscape; human resources and socio-economic aspects of the environment; etc.);
- establish potential conversative connections to similar international systems for the joint regional, continental and global actions of sustainable development;
- give opportunities for the development of various environment-related user-friendly expert systems for scientific applications and for public uses.

The establishment and operation of TIM was and is financed directly from the national budget. The operational directory of TIM is the Agro-Environmental Division of the Ministry of Agriculture. The professional coordination (concept and scientific basis of the system; permanent up-dating and improvement; international correlation, harmonization and coordination; methodology; quality control; etc. is the task and responsibility of RISSAC with a permanent and some necessary ad-hoc committees. The sampling, field measurements, laboratory analyses and the computer storage of the "primary" data are done by the experts of the accredited regional laboratories of the Plant Health and Soil Conservation Service. The data processing (including quality control, classification and evaluation of hard data and their interpretation for various purposes, central data base management is the responsibility of the Budapest Center for Plant Health and Soil Conservation.

Table 3. Soil characteristics determined in the basic observation points [I, M] of the soil information and monitoring system for environmental control TIM [HUNGARY]

Soil characteristics		at start t_o	yearly	3 yearly	6 yearly	Remarks
Morphological description of the soil profile		+				
Particle-size distribution		+				
Texture (SP)		+				
Hygroscopic moisture content (hy_1)		+				
Total water storage capacity ($WC_T \sim pF_0$)		+				on undis-turbed soil cores
Field capacity (FC ~ pF 2.5)		+				
Wilting percentage (WP ~ pF 4.2)		+				
Available moisture range (AMR = FC-WP) Saturated hydraulic conductivity		+ +				
$CaCO_3$ content	if > 5 %	+			+	
	if 1 - 5 % if < 1 %	+ +	 +	+ 		
$pH(H_2O)$	If $CaCO_3$ > 1 % If $CaCO_3$ < 1 %	+ +	 +	+ 		
pH(KCl)	If $CaCO_3$ > 1 % If $CaCO_3$ < 1 %	+ +	 +	+ 		
Hydr. acidity (y_1) if $CaCO_3$% = 0		+	+			
Exch. acidity (y_2) if $CaCO_3$% = 0		+	+			
Total water-soluble salts (in salt-affected soils (sas))		+	+			
1:5 water extract analysis [pH, EC; $CO3^{2-}$, HCO_3^-, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}, Na^+, K^+] (in sas)		+			+	
Phenolphtalein alkalinity(in sas)		+		+		
Depth of the humus horizon		+			+	profile
Organic matter content		+	+			
CEC (cation exchange capacity)		+			+	
Exchangeable cations (Ca^{2+}, Mg^{2+}, Na^+, K^+)		+			+	
Total N		+		+		
NO_3NO_2		+	+			
"Available" plant nutrients [P, K, Ca, Mg; NO_2-NO_3; Fe, Cu, Zn, S, Mn]		+		+		
Potentially toxic elements [Al, As, B, Cd, Co, Cr, Cu, Hg, Mn, Mo, Ni, Pb, Se, Sn, Sr, Zn]		+		+		
	"total"	+				
	"mobile"	+		+		
Cellulose-test	as indicators of soil "bio-logical" activ-Ity	+		+		
Dehydrogenase activity		+		+		
CO_2 production		+		+		
Natural radioactivity		+		+		
"Average depth to the groundwater table		+	+			
Chemical composition of the groundwater [pH, EC, CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^-, PO_4^{3-}, Ca^{2+}, Mg^{2+}, Na^+, K^+] [micronutrients] [micropollutants]		+	+			

The data of TIM are open for public, with some necessary and rational limitations. Because the primary hard data - in most of the cases - are not directly usable for practical purposes by the public, in the contrary they can be easily misused and misinterpreted, their public use will be officially regulated. According to the future plans both KIM and TIM will be open and usable for the public through the set of local workstations adequately equipped with proper (possibly multimedia) expert system hardware-software configurations operated by well-trained technical experts.

5. SOTER-HUNSOTER

The International Society of Soil Science (ISSS) proposed a worldwide project in 1986 for the establishment a World SOils and TERrain Digital Database at a scale of 1:1 million. The main function of the SOTER database is to provide the necessary data for improved mapping, modeling and monitoring of changes of world soil and terrain resources and presenting a wide range of accurate, timely interpretative analyses for decision- and policy-makers for their development concepts, decision-making, planning and implementation activities.

The methodology of SOTER was elaborated by ISRIC (Wageningen, The Netherlands) within the frame of a UNEP-funded Project, with the cooperation of an international expert group.

For the demonstration of the SOTER concept, the database development and its multipurpose applicability regional SOTER projects ("SOTER windows") were established in various parts of the World, representing different physiography (climate, relief, hydrology and soil cover), economy, land use and environmental problems.

In 1993 a project proposal was elaborated by (RISSAC, Budapest) under the title "Multipurpose applicability of soil and terrain digital database (SOTER) for sustainable land use and soil management (HunSOTER)". The proposal was submitted to and accepted by the United Nations Environment Programme (UNEP) as "Establishment of soils and terrain data-base for sustainable agriculture and environmental protection in Hungary (HunSOTER)" (PÁSZTOR et al., 1995a, 1995b, 1996; SZABÓ et al., 1996; VÁRALLYAY et al. 1994.).

Using all available soil information summarized earlier, the 1:500,000 scale map of SOTER units (altogether 1210) was prepared for the whole country, in cooperation with the experts of the Geographical Research Institute (D. LÓCZY) and the Department of Soil Science and Agrochemistry of the Gödöllõ University of Agricultural Sciences (E. MICHÉLI). Within the 1210 SOTER units about 2000 terrain components and about 5000 soil components have been distinguished. The database contains point data for about 1300 representative soil profiles and for their horizons.

For the wide spectra of potential practical applications of the HUNSOTER database five examples have been demonstrated by comprehensive case studies (PÁSZTOR et al., 1995, 1996; SZABÓ et al., 1996; VÁRALLYAY et al., 1994):

- land (soil and terrain, "land-site") evaluation;
- evaluation of the vulnerability of land and susceptibility of soils to various soil degradation processes as:
  - water erosion;
  - wind erosion;
  - acidification;
  - salinization/alkalization.

6. Multipurpose Applicability of Soil Information

"Soil survey is at a crossroad. Over the last several years pessimistic views have been expressed about its future. Some of the reasons put forward are external to soil survey and strongly influenced by the general economic situation. These "conjunctural" issues include budget restrictions as an effect of the on-going economic recession, decreasing governmental land use planning, and the near-completion of systematic soil map coverage in some countries. Criticism also concerns internal, structural issues related mainly to the surveyor-user interface. Insufficient visibility, inappropriate presentation and the poor accuracy of soil information, together with high survey costs, are often to blame. The rapid dissemination of new information technologies imposes additional constraints on soil survey organizations". This was the initial "argument-statement" of the International Workshop for the heads of national soil survey organizations under the general title "Soil survey: Perspectives and strategies for the 21st century" (ITC, Enschede, The Netherlands, 23-25 November, 1992) (Proceedings, 1993). Based on the discussions on the four main topics (the technologic paradox in soil survey: new methods and techniques of data capture and handling; multipurpose application of soil information; supply and demand of soil survey information: international policies and stimulation programmes; strategies for the development of soil surveys and dissemination of soil information) it was recognized that "soil survey remains a vital activity for gathering data and generating interpreted information on the use, management and conservation of the soil resource. However, traditional demand sources, at national and international levels, are either drying up or changing their requests to more purpose-specific soil information that can be integrated into large projects for sustainable development or environmental management. Soil survey must undergo a modernization process, supported by the implementation of new soil concepts, the use of advanced survey techniques and information technologies, and the development of innovative and diversified applications."

Almost simultaneously, similar problems were raised and similar conclusions were drawn at the International Symposium on Soil Resilience and Sustain-able Land Use (Budapest, Hungary, 28 September - 2 October, 1992). A successful attempt was made to precisely define "soil resilience" and the criteria of "sustainable land use", formulating their "soil information" require-ments (GREENLAND & SZABOLCS, 1993; VÁRALLYAY, 1993).

The multipurpose applicability of soil information was discussed and summarized during the International Workshop on the Harmonization of Soil Conservation Monitoring Systems (Budapest, 14-17 September, 1993), as follows:

- assessment of the state of the environment;
- exact description, quantitative characterization, modeling and forecast of the influence of natural factors and human activities on soils (impact assessment, risk assessment);
- contribution to the assessment of long-term global changes;
- providing information on the state of soils (and related terrestrial and aquatic ecosystems), soil degradation processes, soil toxicity;
- providing data for the control of soil processes; for the prevention of soil and land degradation; for the elaboration of strategies for rural development, sustainable agriculture and rational environment protection, and of technologies for rational land use, agrotechnics and amelioration;
- providing data for predictive models and early warning;

- serving as a scientific basis for economically viable and environmentally sound land use policy and legislation measures for soil protection (enforcement, penalization, stimulation).

The various practical applications can become “wide-spread” and efficient if the information producer/user interface will be improved considerably.

Hungarian soil science, soil survey and soil testing practices have always successfully served agricultural development, planning and organization of crop production and environment control (VÁRALLYAY, 1989, 1993, 1994c).

The main fields of successful applications were as follows:
- rational land use;
- optimization of cropping pattern and crop rotation;
- control of limiting factors of soil fertility and soil degradation processes (water and wind erosion; acidification; salinization/alkalinization; physical degradation of soil as structure destruction, compaction; biological degradation of soil; etc.);
- planning and implementation of various agrotechnical measures (e.g. tillage operatons; irrigation, drainage; etc.) and land improvement practices (e.g. land amelioration, soil reclamation, recultivation of disturbed lands, redemption of polluted sites, etc.);
- control of soil moisture regime;
- control of nutrient regime; rational plant nutrition (organic manure and mineral fertilizer application);
- control of soil and water pollution;
- control of other environmental hazards (e.g. landscape deterioration, etc.), biosphere preservation, including biodiversity, etc.

Particular attention has been paid to the control of plant nutrients’ regime of soil (or the biogeochemical cycles of the biosphere) and to the use of soil information in rational plant nutrition (BARANYAI et al., 1987; SARKADI & VÁRALLYAY, 1989).

The quick technical development and the new technical tools (analytical development, new possibilities for the continuous registration of the quantity and quality (status) of more and more soil components; GIS; remote-sensing; geo-statistical evaluation of measured data; bio-indication procedures; etc.) give sharply increasing opportunities. It enables a more comprehensive and more efficient application of soil and landsite information and a better interpretation and risk-reduced spatial and temporal extension of the registered results of long-term field experiments. This multipurpose use will give a “renewed” high value of the existing long-term field experiments (giving scientific arguments for their continuation), but it requires a new - multidisciplinary - conceptual approach in their management and evaluation.

7. Closing Remarks

In the future soil and landsite databases will have sharply increasing significance in sustainable agricultural production (and its risk-reduction) harmonized with successful environment protection, ensuring pleasant life in a clean and nice environment.

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