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SOIL DATABASES OF BULGARIA, MOLDOVA, ROMANIA AND UKRAINE, AND THEIR PARTICIPATION IN THE EUROPEAN SOIL INFORMATION CONTINUUM

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This paper presents national approaches to design soil databases in four countries of Southeast Europe. Ways of data collecting are exposed and the basic sources of the soil information are listed. Numerous references of publications provide evidence of the opportunities to use the soil databases in each country for research, as well as their applicability to data harmonization and integration.

***Key words**: database; soil; classification; properties; map.*

Introduction

Having announced the 2015 a "Year of Soil", FAO inspired the world's soil scientists to focus their efforts to promotion of knowledge on soil cover features and soil properties. The paramount importance of soil as a source of life on Earth makes all of us feel committed to reflect this idea in our proceedings and publications. Establishing soil databases is one of present-day ways to increase the efficiency of multi-purpose applications of knowledge on soil properties. National databases can further be integrated into larger harmonized databases (DBs) (such as, for example, those related to river basins or the whole continent).

Information on national features of soil databases is collected in this article, including their similarities and distinctions, regarding four European countries: Bulgaria, Moldova, Romania and Ukraine.

The national soil databases were created by the following leading Soil Science Centers:

- N. Poushkarov Institute of Soil Science, Agrotechnology and Plant Protection (*www.issapp.org*) in Bulgaria;
– "Nicolae Dimo" Institute of Pedology, Agrochemistry and Soil Protection (*www.ipaps.md*) in Moldova;
– National Research and Development Institute for Soil Science, Agrochemistry and Environment (ICPA Bucharest) (*http://www.icpa.ro/*) in Romania;
– National Scientific Center "Institute for Soil Science and Agrochemistry Research named after O. N. Sokolovsky" (NSC ISSAR) (*http://issar.com.ua*) in Ukraine.

Nowadays, laborers and scholars of Soil Institutes use to employ successfully relevant source of soil information collected in DBs, to be valorized in research, as well as within international projects devoted to further integration of national databases. These activities join together efforts of soil scientists from different countries to establish a Universal Soil Information Continuum resource.

1. Bulgaria

1.1. Soil survey and soil mapping

The structure of the soil cover of Bulgaria is a result of the evolution of the natural processes from the Pliocene to today's Sub Atlantic, actual neotectonic and anthropogenic influence. Five types of pedo-climate regimes can be distinguished in the country: cryo-udic, meso-udic, meso-ustic, meso-xeric and thermo-xeric [1]. For the last 100 years, collecting, preserving, updating and using soil information have been the main aim of intense investigations involving soil survey, diagnostics, classification and mapping.

The organized systematic study of Bulgarian soils, commissioned by the Ministry of Agriculture, started under the guidance of Nikola Poushkarov in 1911. In 1913 Poushkarov presented the first soil map of the region of Sofia at a scale of 1:126,000. The first soil map of Bulgaria was prepared at a scale of 1:500,000 in 1931. This map showed the geographic distribution of the main soil units. The soil map of Bulgaria at a scale of 1:200,000, which was prepared by Koynov and Tanov [2], gave evidence for a significantly larger number of soil units, compared to those identified in the map from 1931. The monograph "Soils of Bulgaria" [3] collected all the available data of morphological, physical, chemical and physico-chemical characteristics of the main soil units. Systematic large-scale soil survey started in 1956.

Soil map of Bulgaria at a scale of 1:400,000 was published in 1968 [4]. That map was based on the information obtained from the soil survey at a scale of 1:25,000 on over 65 % of the country's territory. The map identified 67 soil units at the levels of group and subgroup, soil texture class and degree of erosion. After generalization of the map at 1:400,000 scale, a soil map at a scale of 1:1,000,000 was compiled and published in the geographic atlas of Bulgaria [5]. It distinguished between 45 soil units. The geographic atlas of Bulgaria included also maps of the geographical distribution of the soils according to their texture [6] and soil reaction [7], both at 1:3,000,000 scales, and maps at 1:2,000,000 scales of the soil geographical regions [8], soil erosion regions [9], and the distribution of the soil resources within the administrative districts of the country [10]. The soil map at a scale of 1:400,000 [4] was digitalized [11] and the spatial distribution of the area distribution of the 67 soil-mapping units was assessed.

Soil survey at a scale of 1:10,000 started in 1971. By 1988 the soil cover of the entire territory of Bulgaria was mapped at 1:25,000 scale and the soil survey at a scale of 1:10,000 was in a progress. Currently, soil maps at a scale of 1:10,000 cover almost the entire territory of Bulgaria. In addition, soil survey and maps at scales from 1:5,000 to 1:1,000 cover territories with particular problems, such as salinization and pollution with heavy metals, arsenic, oil products or radionuclides. By 1988 the soils of Bulgaria had been mapped at 1:25,000 scale and the soil survey at a scale of 1:10,000 was in a progress. Currently, soil maps at a scale of 1:10,000 cover almost the entire territory of Bulgaria. In addition, soil survey and maps at scales from 1:5,000 to 1:1,000 cover land with particular problems, such as salinization and pollution with heavy metals, arsenic, oil products or radionuclides. In 1994, the soil map of Bulgaria at a scale of 1:1,000,000 was completed based on the 1990 FAO revised legend. This map was prepared for incorporation in the soil geographical database of Europe at 1:1,000,000 scale [12].

1.2. Soil information, databases and monitoring

According to the extended systematic list of the soils in Bulgaria, 200 soil units have been defined, each of them carrying coded information about the profile depth, the degree of erosion, classes of soil texture and stoniness, parent material, slope and land evaluation. The formula for coding the soil units is expressed as:

$$N^a \frac{L_{1,2,3,...}}{N_{1,2,3,...}} N^b \quad , \qquad (1)$$

where: N^a is the land category, according to the Bulgarian land evaluation system; $L_{1,2,3,...}$ are codes for soil description; N^b is the field index and $N_{1,2,3,...}$ are the codes for texture classes, stoniness, parent materials, etc. The defined soil units are characterized by profile morphological description, particle-size distribution, pH and the amounts of total carbon, nitrogen, phosphorus and calcium carbonates, based on the data from 50,000 main soil profiles. In addition, the information for about 250 soil profiles, representing the main soil varieties, is expanded by analytical data on the humus content, soil-hydrological properties, chemical composition, Fe and Al status, CEC, base saturation, etc.

Archives maintained at administrative level have been created from the basic documents such as soil survey records, remote sensing information, laboratory data forms, climatic parameters, etc. All the relevant information is preserved in Soil Survey Reports in the form of text, tables and maps. The information about the soil resources was summarized, digitalised and systematized in a Geographic Soil Information System by the National Soil Survey Service between 1992 and 2012. The database structure is presented schematically in Fig.1. All paper and electronic records are deposited at the Institute of Soil Science Agrotechnology and Plant Protection “N. Poushkarov”, the Ministry of Agriculture and Food and other government and non-government institutions. The soil maps at scales 1: 200,000 and 1:400,000 have been also digitalised.

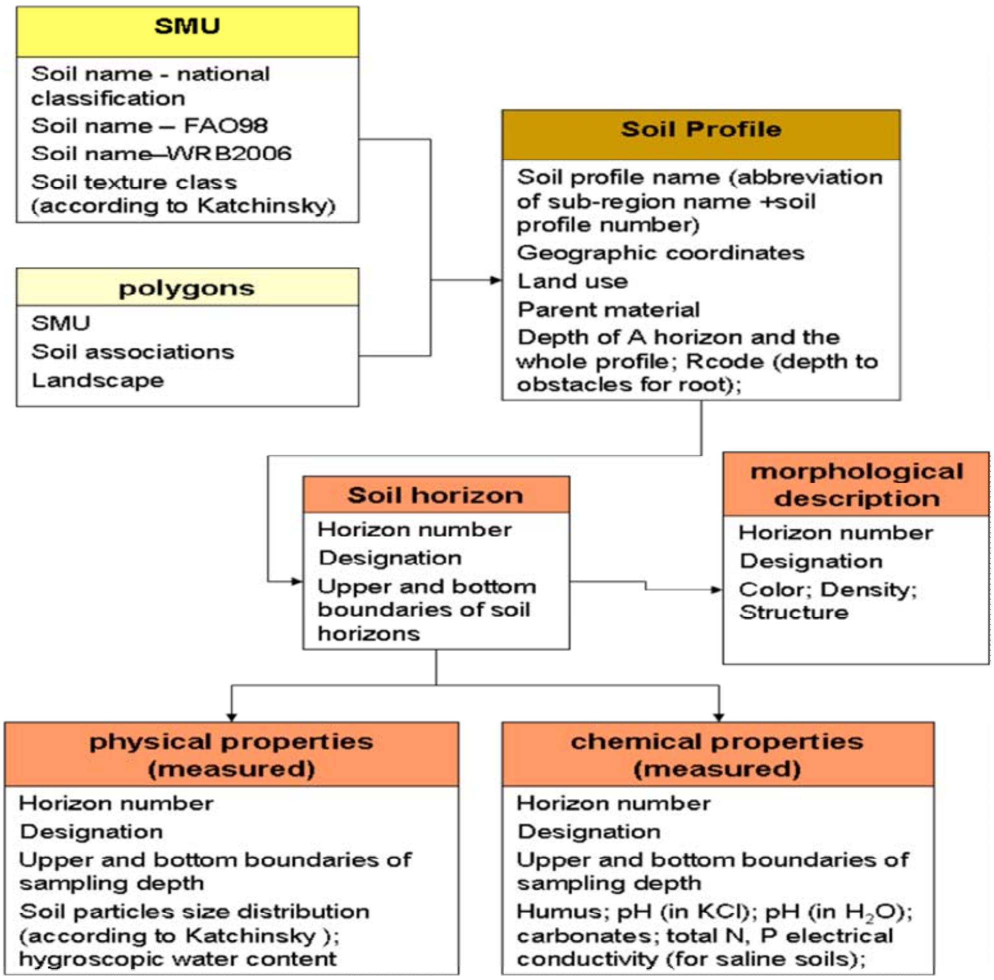

Figure 1. *Database structure related to soil map of Bulgaria at scale M 1:200000, following Kercheva et al. [17]*

The Ministry of Environment and Water is responsible for protection of the land as a natural resource. There are well-developed procedures for preventive protection of soils from pollution and working Executive Environmental Agency (EEA) responsible for monitoring of the state of lands [13]. The EEA monitoring guarantees control and protection of lands from (i) pollution with heavy metals and metalloids – 318 monitoring stations located by source of pollution, such as industry, chemicals, irrigation and road network; (ii) pollution with persistent organic pollutants – 20 monitoring stations of PAH and PCB and 48 stations for monitoring of pesticides; (iii) acidification – 70 polygons; (iv) salinization – 15 polygons; (v) erosion – GIS for soil erosion risk assessments have been developed [14,15,16].

1.3. Soil classification correlations

Boyadjiev [18, 19] proposed correlations of the national soil classification with Soil Taxonomy and the World Reference Base for soil resources (ISSS-ISRIC-FAO, 1994), which recognized respectively 22 and 19 soil groups. The soil map of Bulgaria at 1:1,000,000 scale [5] was actualised further in 1994, considering the revised legend of the soil map of the world FAO-UNESCO [20], at the level of soil sub-group. This map was prepared for the purposes of the soil geographical database of Europe at 1:1,000,000 scale [12]. Correlations of Bulgarian soil taxonomic classification with WRB are described by Teoharov [21, 22] and Shishkov [23].

2. Moldova

2.1. Geoinformation system for soil quality in Moldova

The Soil Quality Geoinformation System of Republic of Moldova has been developed since 2011. The database system includes digital graphic materials placed in the layer "*SoluriRM*" (“*Soils RM*”) and analytical data managed in the layer "*ProfilSol*" („*Soil Profiles”*). The information archives at the scale 1: 50000 of the Institute of Soil Science, Agrochemistry and Soil Protection "Nicolae Dimo" served as a cartographic basis for the elaboration of the digital map of the soil cover structure. The materials from information archives have been developed based on the soil mapping files of I-st and II-nd cycles and performed by the agricultural field’s maps at the scale 1:10000. The materials have been connected to the *MoldRef-99* national coordinated system using MapInfo and ArcGIS programs. The digital layer "*SoluriRM*" was also transformed in raster format (called "*SolRastRM*").

2.2. Soil classification

At the basis of the GIS structure and development of the soil cover digital layer "*SoluriRM"* are the classical principles of soil classification and diagnosis [24, 25]. Soil classification based on the main soil properties - joined in groups according to their origin and productivity particularities - served as background for the layer "*SoluriRM*". The principles of classification are based on a taxonomic system of subordinate units. [26, 27, 28]. This system includes the systematic list of soils, their nomenclature and different indices by which the soils of each unit can be distinguished in the areas with soil associations.

The digital layer structure of "*SoluriRM*" contains 31 fields (181 indicators). The layer includes 25 main fields which characterize soil properties distributed in 7 soils taxonomic classification groups (class, type, subtype, genus, species, variety and rank).These groups are needed to assess and analyze soils by quantitative and qualitative indicators, to determine their natural potential for different use, to prevent and combat soil degradation processes (erosion, humus loss, salinization, alkalization, etc) and to establish soil suitability for irrigation. Other six fields contain a general characterization of the soil area (such as soil code, surface, etc). A synthetic parameter is stored in the field "*Bonit*" (land evaluation) which reflects soil productivity at a soils subtype level. A Real Land evaluation mark calculation - depending on soil properties - is determined by using some correction coefficients and gets placed in the "*BonitCalc*" (Land Evaluation Mark) [29].

The attributive base structure of the layer "*SoluriRM*" can be supplemented with other indicators or parameters. Attributive information is introduced for each soil delineation. This attributive information characterizes soil proprieties at different quantitative and qualitative levels (values). The graphical database consists of 70,473 soil areas with specific characteristics for each soil delineation according to estimates made using GIS functions. The area occupied by soils in Moldova is 3,109,214 ha out of 3,385,287 ha total area of the country [30, 31].

2.3. Profile data

To maintain the analytical database of Moldavian soils properties, the digital layer "*ProfilSol"* was developed to characterize soil profiles. As analytical materials are used current archive data from the Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", pedological files and investigation results from the State Planning Institute for Land Management, as well as some materials from the "ACVAPROIECT" Institute. At present, in the database are introduced data of over 500 soil profiles. Data entry is performed in parallel with the soil survey studies.

The digital layer "*ProfilSol"* structure is made up of several components, such as: general characterization of the territory; field characterization of the profile; characterization of genetic horizons; data on hydro-physical, hydro-geological, hydro-chemical, chemical, physical, physicochemical and physico-mechanical analytical properties, as well as calculated parameters. This layer includes 220 individual fields.

The general characteristic of the territory compartment includes administrative location data of the soil profile (district, village); land use; relief characterization (slope exposition, slope inclination, etc.). The profile field characterization contains the name of the organization, the name of the scientist or soil surveyor who carried out the work in the field, and the soil sampling date; profile geo-referencing (coordinates X, Y, Z); profile number; morphometric features of the profile; soil name etc. In the section titled soil genetic horizons characterization are included horizon serial number, upper and lower horizon boundary, etc. The first three general sections - where soil profile is characterized - contains 31 fields.

2.4. Horizon data

In each genetic horizon database, qualitative and quantitative indices are introduced. This section includes 191 fields, divided by analyzes and type of properties:

- Hydro-physical properties (hygroscopic water content, field water capacity, wilting coefficient, soil wett-ability, the terminal velocity of water infiltration, etc.) – 6 fields;
- Hydro-chemical properties (groundwater analysis) – 27 fields;
- Physical properties (particle size distribution, size distribution of microaggregates, soil structure, soil particle density, bulk density) – 42 fields;
- Chemical properties (total and active calcium carbonate contents, total and mobile NPK macroelements content, total and mobile forms of microelements content, including heavy metals, pesticides and herbicides content etc.) – 67 fields;
- Physico-chemical properties (total carbon content, humus content, soil reaction, exchangeable cations content, soils aqueous extracts composition) – 47 fields;
- Physico-mechanical properties (swelling degree and penetration resistance) – 2 fields.

In addition, the database structure contains indices obtained by calculation.

The Soil Quality Geoinformation System of Moldova enables precise spatial visualization of areas, facilitating the identification in the field. Introduced attributive characterization allows updating and assessment of soil evolution tendencies. This system also allows the elaboration of complex thematic digital maps at different scales [32-36].

3. Romania

3.1. Soil resources

Romania covers more than 29 % of the Danube Region, being entirely included in this Region of European relevance. The surface of the country is 238,391 km^2 from which about 31 % represent mountains, 36 % represent hills and plateaus, and 33 % are plains and the Danube Delta.

The soil resources of the Romanian agricultural lands are managed at national level by the Research and Development Institute for Soil Science, Agrochemistry and Environment (ICPA - Bucharest), and at county or regional level by local Offices of Soil Survey and Soil Testing. The Research and Development Institute for Forestry and Forest Management is in charge with the forest soils.

The soil survey methodology in force is described thoroughly in three volumes published in 1986: I - Soil Data Collection and Synthesis, II - Interpreting soil surveys for different purposes, and III - Ecopedological Indicators [37]. A revised guide was released in 2009 for the description of soil profiles in the field, together with the environment conditions [38].

3.2. Soil classification and taxonomy

Soils are classified according to a national system. The first dates back to 1979 and is called the „*Romanian Soil Classification System – RSCS*" [39].The second system, called the „*Romanian System of Soil Taxonomy – RSST*", is in force since 2003, with major updates published in 2012 [40]. To a certain extent, RSST preserves the heritage of Romanian school of thought. In addition, it reflects by new terms those that are defined in well-recognized classification schemes at international level, with the goal to correlate RSST with other systems, and primarily with the soil classification system of FAO (i.e., with the "Word Reference Base", or WRB). On the other hand, over the last years, it emerged that a meticulous work is necessary for the correlation between the two Romanian systems (RSCS and RSST), therefore a dedicated book was published in 2014 [41] [5]. At the same time, the soil mapping units of the „1:200,000 Soil Map of Romania" [42] [6] were redefined by using an extended terminology of the WRB System [43], namely the 475 soil mapping units that had originally been defined according to RSCS.

The „1:200,000 Soil Map of Romania" consists of 50 tiles published from 1963 to 1993 [44]. It represented the basis for the development of the „Geographic Information System of the Soil Resources of Romania – SIGSTAR-200" [45], which manages more than 80,000 soil delineations. Each soil polygon has four attributes collected from the paper map (i.e., the mapping unit, topsoil texture, skeleton, and landslide risk) and six attributes inferred by expert rules (i.e., risk for water & wind erosion, gleyzation, pseudogleyzation, salinisation, and alkalisation). Besides information on soils, each tile contains other relevant information: (i) maps at the scale 1:500,000 of the landforms and surface lithology, as well as geobotanical and climatic data, and (ii) cross-sections with relationships among the soil cover, landform, surface lithology, and the groundwater depth.

According to [46], this Soil Map at 1:200,000 scale „provides an almost complete pedological information base for the 1:250,000 Geo-referenced Soil Database of Europe planned by the European Soil Bureau".

The digital soil map SIGSTAR-200 has two versions, being geo-referenced in the national coordinate reference system, which is the "Stereographic 1970" projection on S-42 datum and Krasovsky-1940 ellipsoid, and in the coordinate reference system required by the European INSPIRE Directive. This is – for medium scales – the Lambert Azimuthal Equal Area projection on ETRS 1989 datum and GRS-80 ellipsoid.

3.3. Information resources for soil database

Point information about soil properties for the whole national territory is mainly available due to the "Soil Quality Monitoring in Romania" [47, 48]. This project provides local information about plots belonging to a transborder grid of 16km x 16 km, that was established under the auspices of the United Nations Economic Commission for Europe. The physicochemical laboratory methods, as well as the coordinate reference system used to geo-reference the plots, are according to national standards.

The following properties are measured for all samples [48]:

(i) on disturbed soil samples:

- for the whole soil profile: particle-size distribution and soil reaction (pH);
- for 0-50 cm depth: hygroscopic coefficient, water stable aggregates, humus content, total nitrogen content, available phosphorus content, and extractable potassium content;

(ii) on undisturbed soil samples:

- for the whole soil profile: instantaneous water content, bulk density, saturated hydraulic conductivity, water retention at pF 0, total porosity, and air-filled porosity;
- for 0-50 cm depth: degree of compaction;

Specific analyses are also carried out [48]:

(i) unsaturated soils by base cations:

- for 0-50 cm depth: sum of the exchangeable cations, hydrolytic acidity and the total acidity at pH = 8.3, exchangeable aluminium (for samples with pH < 5.8), cation exchange capacity, and percent base saturation (V);

(ii) saturated soils by base cations (V = 100 %, pH=7.4-8.5) with soil alkaline-earth carbonates without soluble salts:

- for the whole profile: total content of carbonates;
- for 0-50 cm depth: cation exchange capacity;

(iii) soils with soluble salts frequently containing alkaline-earth carbonates and/or gypsum (V = 100 %):

- for the whole profile: conductometric residue;
- alkalic samples: exchangeable sodium, cationic exchangeable capacity, percent base saturation, and salt composition;

(iv) polluted soils:

- for 0-20 cm depth: heavy metal contents (soil total Cu, Zn, Pb, Co, Ni, Mn, Cr, and Cd), soluble sulphur content, soluble fluorine content, organochlorine insecticides content (total HCH and DDT), number of bacteria, number of fungi, and dehydrogenase activity;

According to the results, as compared to the normal values, the soil layer thickness for sampling and analyzing may increase.

In the recent years, the grid for the soil quality monitoring changed to ensure a higher density of points, from 16km x 16 km to 8km x 8 km [49]. The results are not available yet for the national territory.

Another source of systematic spatiotemporal point information is the LUCAS topsoil survey, organized by EUROSTAT and the European Soil Data Centre. The first survey in Romania took place in 2012 when more than 1300 topsoil samples were collected following the LUCAS stratified systematic sampling grid. The following physico-chemical properties were measured according to ISO standards: coarse fragments, particle-size distribution, pH in H_2O, pH in $CaCl_2$, organic carbon content, carbonate content, soluble phosphorus content, total nitrogen content, extractable potassium content, and the cation exchange capacity. The licence agreement to use the “LUCAS soil” data requires that these data can be communicated only after a proper aggregation to prevent identification of the point locations. The first findings are in press regarding the general tendencies of the main topsoil properties at the level of NUTS 2 statistical regions of Romania resulted from the „2012 LUCAS” survey [50].

Other relevant sources of information, which are according to the national soil survey methodology [37], are the following two databases:

(i) The “*PROFISOL*” data base of the legacy soil profiles (about 1650, dating from the period 1960 to 1990) that contains: general information about the profile (51 items), general information about the genetic (sub horizons (13 items), morphological information (24 items) and land conditions (38 items) about the profile, morphologic properties (110 items) about the genetic (sub) horizons, physical properties (46+41 items); particle size distribution is according to both Atterberg and USDA systems, and chemical properties (64+34 items for soil and 26 items for groundwater), Maximum 10 (sub)horizons were considered. A detailed presentation of

PROFISOL is provided in Romanian [51], and in English [55] & [46] (all publications are available online);

(ii) The "*BDUST*" database aims at managing the information characterizing the agricultural soil and land of Romania at a large-scale. The data are organized on soil survey works, NUTS3 (counties) and NUTS 5 ("communes") levels. The concept underlying the BDUST development took into consideration the data requirements of the most frequently used models dedicated to land suitability and land capability evaluation, simulation of soil processes and estimation of crop yields. The elementary spatial object in BDUST is the "land mapping unit" (UT) defined as the result of the superposition of three spatial objects: soil unit, ecologically homogeneous territory, and climatically homogeneous area. Many types of reports are provided to the users, such as land evaluations at the UT level (land rating marks, quality/suitability/capability classes, requirements of land improvement and agro-pedo-ameliorative works), descriptive formulae of soil units and capability units, decoding of formulae, and a set of synthetic data of land evaluation and characterization at the NUTS 5 administrative level. A detailed description of BDUST is given in [53] in English (available online). At present, BDUST manages data for approximately 30 % of the agricultural land of Romania, but the maps are not digitised because of lack of funding.

A last type of achievement reported in the present article refers to pedotransfer functions and rules, the most frequently used being developed by Canarache for estimating soil resistance to penetration [54] and other key physical properties of the soil, limiting factors, degradation processes, soil workability and soil trafficability [55], and by Simota for predicting soil water retention curve [56].

4. Ukraine

4.1. History of database creation

The "Ukrainian Soil Properties" Data Base (UkrSPDB) is created on materials of research from expedition field surveys on agricultural land, accomplished by scientists of the O.N. Sokolowsky Institute for Soil Science (now NSC ISSAR), and on available stock of scientific reports published by soil researchers from associated entities anywhere (totally 73 sources).

The first generalization process of the expeditionary research- results (about 300 soil profiles collected) was completed in mid-80-ies, and its outcomes published as a "Reference Handbook on Physical Soil Properties in the Steppe Zone of Ukraine" [57]. Materials of large-scale soil inspection of the agricultural land of Ukraine (1958-1963) were a basis of this book, which became the beginning of the present- day database.

Nowadays, the database includes minimum 2075 described soil profiles (whereby their quantity input is ever continuing) being duly collected from every part all over the territory of Ukraine, and all this is complemented with explicit characteristics of soil-formation factors and relevant environmental features.

To- date, this is digital multi-purpose soil- database of attributive information with Relational Data Base Management System (DBMS). As the tool for creation of DBMS it is taken an objective focused visually programmed language Visual FoxPro of Microsoft with rushmore-technology for inquiries optimization [58].

4.2. The database structure and features of design

All attributive data are connected with such spatial levels:

- Units of administrative division of the country (region, district, village);
- Spatial units of Nature-agriculture zoning (NAZ) (zone, province, okrug, district);
- Soil polygons on small- (1:1500000) and mid- (1:750000; 1:200000) scale- maps;
- Genetic horizon in profile;
- Sampling layer within the horizon.

Taxonomy units of Ukrainian Soil Classification (type, subtype, genus, kind, parent material, texture) are used in procedures of recording the information on a profile [59]. All the data are spread throughout nine bi-dimensional tables. Each table includes a thematically selected group of parameters.

T.1. Address and geographic coordinates for the soil profile location. Total 21 fields with the information about administrative region, area, latitude, longitude, altitude, a place in Nature-agriculture zoning (zone, province, okrug, district) etc.

T.2. Nature-agriculture zoning (NAZ) and climate. In 55 fields the basic data on a climate characteristics, a relief and a soil cover within each spatial unit of NAZ (as well as the list of meteorological stations), of Ukraine are included. Also, the table contains data almost about all basic criteria used as well in SOTER methodology [60, 61]. (concerning climate, parent material, relief, vegetation and soil cover);

T.3. Soil classification and general characteristic of soils and soil-forming factors. 25 digital fields with classification attribute to determine a place of soil (profile) in Ukrainian Soil Classification (1977) and description of the basic soil-forming factors – soil surface conditions, vegetation, position of profile concerning a relief element (slope), type and depth of parent material, depth and mineralization of subsoil waters and other.

T.4. Economic and technological characteristic of plot. 10 fields with differ agricultural information about yield of main crops and soil estimation (bonitet).

T.5. The profile data. Soil properties in the genetic horizons. There is accumulated in 112 fields of the table the information on parameters of soil properties within each genetic horizon and each layer of sampling or *in-situ* measurement. Within the top genetic horizon measurements are executed, as a rule, in 2-3 layers (depths).

The following soil properties and characteristics are subjected to measurements for the whole soil profile, on the most inquired points:

- Index of soil horizon, serial numbers and upper and lower boundaries of soil horizon and sampling layer;
- General physical properties (*bulk density; specific density; total porosity* and other);
- Water-physical properties (*field water capacity, permanent wilting point, available water, soil permeability* and other*);*
- Particle size distribution (PSD) – by Kachinsky method and particle size class of the fine earth, derived from Soil Service Division Staff;
- Size distribution of micro aggregates;
- Structure composition (*percent of macro aggregates of the* next sizes*: >10, 10-7,7-5, 5-3, 3-2, 2-1, 1-0.5, 0.5-0.25 mm)*;
- Aggregate stability in water (*percent of water stable aggregates of the* next sizes*: >7, 7-5, 5-3, 3-2, 2-1, 1-05, 0.5-0.25 mm*);
- Physical-chemical properties (*pH, exchange acidity, exchangeable cations, organic carbon, humus*);
- The content of nutritious elements (total and extractable);
- Toxicological characteristics (*the content of heavy metals mobile forms*).

T.6. Soil properties in the soil surface or in top layer. 10 fields with data concerning water permeability, stoniness and other are included.

T.7. Agricultural group of soils. Some average characteristics of agricultural group of soils, to which the profile is related within the NAZ map unit (deep of profile, deep of humus horizon, humus content in top layer, occupied area inside NAZ province and other).

T.8. References and analytical methods. The table includes data about a source of relevant information on soil profiles: locus of publication, designation of a Publishing house, originators (name of origin author), as well as methods of measuring each soil property and references on the manual for analysis.

T.9. Calculated parameters.The table is intended as a storage resource of before calculated parameters, including received ones with use of pedotransfer models.

Data are entered in tables either in an absolute kind (the measured parameters) or in the form of codes and classes according to system of designations in the Ukrainian Soil

Classification. For coding data there are 38 special directories. Records are made in Russian, but names of tables, fields and symbols in directories are duplicated in English. Profiles are connected with soil maps of different scales (1:1500000; 1:750000 and 1:200000), that provides many opportunities for the detailed and integrated estimations of a soil cover quality.

4.3. DB for national and international research activity

The DB is used in the NSC ISSAR scientific researches which directed on search of laws in spatial distribution of soil with various properties for their monitoring [62], forecasting of the soil processes evolution and estimation of agronomical serviceability of arable lands [63]. Data are included in the integrated databases built by aid and means of the international initiatives, such as: The Project of Mapping the Soil and Terrain Vulnerability in Central and Eastern Europe (SOVEUR) [64]; INCO-Copernicus Concerted Action on Subsoil Compaction [65]; European Hydro- Pedological Data Inventory (EU-HYDI) [66]; Integrated database of soil resources of Russia, Ukraine and Belarus'[67].

The pedotransfer models for calculation of various physical properties were created by means of the collected data. A typical example is, in particular, the permanent wilting point for chernozems being determined in view of textural fractions' contents (e.g., 0.01−0.005; 0.005−0.001 and <0.001 mm) [68].

The spatially focused parameters of physical soil properties are used to define an optimum set of agricultural soil-tillage equipment, of limited weight and specific vehicle chassis' pressure upon the soil surface. Legends of map schemes that characterize serviceability of Ukrainian soils to being cultivated by a proper method, at a definite depth of tillage and using certain types of agri- machines, were constructed for the territory of Ukraine with use of DB also. Eventually, these map schemes became a keystone of the "Soil-Technological Subdivision of Ukrainian Agricultural Land" [69].

Application of such a capacious data file concerning soil- texture aspects allowed us to carry out research and to prove the real feasibility of transit from analytical proceedings (par Kachinsky method) to USDA/FAO texture- classes. Factors of physical soil parameters' variability in samples of close textural classes, in both above- said classifications (as well as correlation between contents of key fractions and physical soil properties), are of similar nature [70].

The UkrSPDB is a valuable source of the information for determining of soil quality in various regions of the country. The major component of soil quality is its physical properties - physical soil quality. Soil Geoecophysic Laboratory has suggested to employ the DB for search of a reference index of physical soil quality (for certain soil types and textures) [71]. Comparison of any soil with its reference muster may serve as a tool for an objective estimation of soil agronomical utility in regions. A set of innovative approaches to soil estimation (via calculations for soil bonitet), in view of soil properties, specific features of terrain and character of climate, with use of a multifunctional soil DB, are also implemented [72].

On the basis of the soil map of Ukraine (M 1:1500000), a series of thematic maps - incorporated in the electronic atlas of maps - is constructed concerning soil qualities [73].

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БАЗИ ДАНИХ ГРУНТІВ БОЛГАРІЇ, МОЛДОВИ, РУМУНІЇ ТА УКРАЇНИ І ЇХ РОЛЬ У ЄВРОПЕЙСЬКОМУ ГРУНТОВОМУ ІНФОРМАЦІЙНОМУ ПРОСТОРІ

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У статті представлено національні підходи до структури грунтових баз даних у чотирьох країнах Південно-східної Європи – Болгарії, Молдові, Румунії і Україні. Показано способи збирання і систематизування даних та перелічено основні джерела інформації. Продемонстровано можливості і приклади застосування даних у наукових дослідженнях та оцінюванні стану грунтових і земельних ресурсів. Особливої уваги надано аналізу прийнятності національних баз даних для інтегрування та гармонізації їх у міжнародному інформаційному просторі.

***Ключові слова**: база даних; грунт; класифікація грунтів; властивості; карта.*

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НАУКОВЕ ОБҐРУНТУВАННЯ АЛГОРИТМУ ЗАСТОСУВАННЯ КАМЕРНОГО СТАТИЧНОГО МЕТОДУ ВИЗНАЧЕННЯ ІНТЕНСИВНОСТІ ЕМІСІЇ ПАРНИКОВИХ ГАЗІВ ІЗ ҐРУНТУ

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Проаналізовано методичні особливості застосування найбільш відомих модифікацій камерного статичного методу вимірювання інтенсивності емісії парникових газів з ґрунту (на прикладі CO_2). Удосконалено алгоритм виконання вимірювань і розроблено методику обрахунку величини емісії парникових газів із ґрунту та значень найбільш істотних похибок, залежно від випадків їх