Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe (SOVEUR Project)

Proceedings of an international workshop
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Edited by
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TABLE OF CONTENTS

PREFACE

These proceedings contain the report and papers given at an international workshop on *Mapping of Soil and Terrain Vulnerability in Eastern and Central Europe* (SOVEUR). The SOVEUR project calls for the development of an environmental information system for central and eastern Europe in close collaboration with soil survey institutes in Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, the Russian Federation, Slovak Republic and the Ukraine. Using this system and auxiliary information on climate, land use and the type of soil pollution, the status of human-induced soil degradation and the areas considered vulnerable to defined pollution scenarios will be mapped (scale 1:2.5 million). The central focus of the workshop was to reach agreement on proposed methodological procedures with a view to arriving at project implementation in the 13 participating countries.

The target beneficiaries of SOVEUR include Ministries, planning bodies and scientists in the collaborating countries who can use the final databases and derived maps for policy formulation at the regional and national level, for instance by identifying areas considered most at risk from land degradation. In addition, the project will contribute to strengthening cooperation between national "environmental" organizations throughout Europe.

The current workshop is the first of two to be organized in the framework of the Cooperative Programme of the Food and Agriculture Organization of the United Nations (FAO) and the Government of the Netherlands (GCP/RER/007/NET).

During the editing, minor changes have been made to the papers to conform with the editorial policy. This has been done without interfering with the views of the authors or the professional aspects of the documents.

Following Part 1, with the workshop report and recommendations, the introductory talks (Part 2) and written contributions to the workshop (Part 3) are presented. For practical reasons, national contributions have been presented in alphabetical order of the country of origin. The list of workshop participants concludes these proceedings.

In preparation for the workshop, participants compiled an inventory of data availability in relation to the SOVEUR project objectives; these returns have been stored in the ISRIC library for further use.

It is believed the current proceedings are of interest to scientists and policy makers who are concerned with the problems of soil and environmental pollution, either at the national, European or global level.

We gratefully acknowledge the constructive inputs and comments from the workshop participants, as well as their great enthusiasm for the project objectives. Special thanks are given to the following ISRIC staff for their technical and logistical support during the workshop: Wouter Bomer (cartographic designer); Jan Brussen (financial administration); Koos Dijkshoorn (SOTER); Yolanda Karpes (secretarial support); Jacqueline Resink (GIS programme analyst); Piet Tempel (software programmer); Otto Spaargaren (ISRIC exposition) and Siebe Vriend (general support).

PART 1

WORKSHOP REPORT

EXECUTIVE SUMMARY OF SOVEUR WORKSHOP

N.H. Batjes and E.M. Bridges

Introduction

Environmental policies regarding air and water quality were well developed before soil protection became an important issue, possibly because effects of soil pollution are far less conspicuous. In Europe, the need to protect the soil against pollution was first proclaimed in 1972 in the European Soil Charter. Present concern about adverse effects of point-source and dispersed pollution is related to negative effects on crop quality and quantity, and ultimately on human health and biodiversity. The problems include pollution associated with the excessive application of nutrients, the heavy metal content of fertilizers and manure, human-induced acidification, loss of organic matter, decrease in soil biological diversity, physical degradation, and erosion by water and wind (Barth and L'Hermite, 1987; Stanners and Bourdeau, 1995).

Estimates of areas of land affected by specific types of human-induced soil degradation in Europe have been presented by Oldeman *et al.* (1991) and revised by Van Lynden (1995). Ter Meulen-Smidt (1995) reviewed regional differences in inputs and distribution of contaminants in Europe, describing broad regional trends in chemical loads. Csikos (1994) reviewed important "hot-spots" of pollution in selected Central and Eastern European countries. These studies show that regional and continental estimates of the actual extent of degraded and polluted land, and of areas at risk, remain open to improvement as well as the need to harmonize procedures of measurement and threshold levels used.

Some countries in Europe have started systematic recording, monitoring and clean-up programmes of contaminated sites based on established reclamation methodologies, the implementation of which is often constrained by financial, legal and technical factors. Improved data on the extent of soil degradation and pollution, and establishment of monitoring networks to assess the effectiveness of measures that have been put in place, are seen as a pre-requisite to any further coordinated approach to soil protection in the whole of Europe. It is in this overall context that the project on Mapping of Soil and Terrain Vulnerability in Central and Eastern Europe (SOVEUR),was implemented within the Framework of the FAO/Netherlands Government Cooperative Programme. In view of the specific nature of the services to be rendered, the project activities were implemented under a Contractual Service Agreement with the International Soil Reference and Information Centre (ISRIC), which includes Letters of Agreement with National Collaborators within the frame of their National Institutes representing their countries in the project (13 participatory countries).

The current SOVEUR project is a sequel to: (1) initial discussions during a workshop organized by ISRIC in the framework of the Chemical Time Bombs (CTB) project (Batjes and Bridges, 1993), and (2) the overall objective of the Food and Agriculture Organization (FAO) of the United Nations, International Society of Soil Science (ISSS), International Soil Reference and Information Centre (ISRIC) and United Nations Environment Programme (UNEP) to up-date the information on world soil resources in a uniform digital database (Oldeman and Van Engelen, 1993).

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

Project objectives

The SOVEUR project calls for the compilation of an environmental information system for 13 countries in Central and Eastern Europe, in close collaboration with specialist institutes in Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Moldova, Poland, Romania, Russia (west of the Urals), Slovak Republic and the Ukraine. Basically, there are three main activities in the SOVEUR project:

1) Development of a soils and terrain digital database, at 1:2.5 million scale for the 13 countries under consideration. The proposed, uniform methodology for this part of the work is one which ISRIC, FAO, UNEP and ISSS developed for the Global Soil and Terrain Database (Van Engelen and Wen, 1995), SOTER, with modifications necessary to accommodate for the 1:2.5 million scale (Batjes and Van Engelen, 1997).

2) The SOTER map, with its unique delineations of terrain units - consisting of uniform areas in terms of landform, surficial lithology and soils - is to be used as a geographic basis for an assessment of the status of soil degradation, with special focus on pollution (Van Lynden, 1997).

3) In the third activity, the full SOTER database is to provide the soil geographic and attribute data for an assessment of the vulnerability of soils to selected categories of pollutants. The ultimate aim of this part of the project is the identification of broad areas of soils considered at risk from re-mobilization of specific contaminants subsequent to environmental changes (Batjes, 1997), a phenomenon that has been referred to by the metaphor of "Chemical Time Bombs" (Stigliani, 1988, 1993).

In order to realize the SOVEUR project goals, methodologies for the three project activities enumerated above were prepared for discussion during an international workshop held at ISRIC from October 1-3, 1997. During the workshop, aspects of data availability, accessibility and comparability were discussed in relation to the stated project objectives and methodologies proposed for the various tasks. A central focus in the discussions was to arrive at a consensus on workplans for project implementation by country, through memoranda of understanding, under overall coordination by ISRIC.

Structure of workshop

The study of soil degradation and estimation of pollutant accumulation and migration under changing environmental and socio-economic conditions, which are key objectives of the SOVEUR project, is complex irrespective of scale. Relevant information at the continental or regional level will include data about climatic conditions, soil and terrain types, hydrology, contaminant loading in relation to human activity, and modifications in contaminant behaviour in relation to changing environmental conditions.

Confirming the existence and location of the various data, and identifying their content, is one of the first steps in accessing, processing and analyzing the data. Consequently, the focus during the first part of the workshop was on the presentation of "country-reports", in which the participants provided information on many of the above inter-related issues (see Part 3, this volume). In addition, representatives of the European Soil Bureau (ESB) and the French Institut National de la Recherche Agronomique (INRA) provided information on complementary soil database development activities in Europe, notably with respect to the PHARE countries.

During the second part of the workshop, the focus of the presentations and discussions was on the methodologies proposed for the three main project activities. A leading theme in the three presentations was the need for uniform and explicit methodologies, based on clearly defined criteria, for subsequent application by the respective countries. Besides these largely technical issues, consideration was given in the discussions to the potential end-users, both at a national and regional level, and on increasing national and regional awareness about the SOVEUR project activities.

Subsequently, working groups determined realistic goals for the project implementation phase, and this notably in terms of methodological approaches and feasible outputs in relation to overall data availability. Upon reaching a consensus on methodological issues, workplans for the implementation phase were developed. Parallel to this activity, a SOTER software demonstration was given and the draft physiographic (SOTER) base map for the region was presented with a view that participants refine, where necessary, the preliminary boundaries drawn.

Workshop discussions and recommendations

Discussions

From the start, the workshop organizers clearly specified that in order to implement the SOVEUR project successfully 3 subsequent steps would have to be undertaken: (1) creation of a SOTER database, (2) documenting the soil degradation/pollution status, and subsequently (3) mapping the vulnerability of soils with respect to Chemical Time Bombs.

During the discussions participants were asked to discuss availability and accessibility of data, which are needed for use in the project, by country. Prior to the workshop, a proforma was completed by participants listing the background materials such as physiographic maps, soil maps, soil correlation tables, information on the main types of soil degradation and point sources of pollution, maps of contaminant loadings and criteria in use for pollution assessment. To assist with the subsequent assessment for vulnerability, participants were requested to supply details of any relevant historical land use or statistics, the net accumulated loading of soils from 1950 to the present day, fertilizer use and contaminant composition, and any information about contaminants removed from soils by crops. Information on maps of accumulated contaminant loads was collected also.

Following the plenary sessions where each country presented its information, discussion groups explored the main issues of soil degradation and pollution of regional concern which were mappable at the scale of 1:2.5 million. The availability, accessibility and comparability of the primary and secondary data required were explored with a view to the possibility of model development and the preparation of soil vulnerability maps. Discussion also took place about the potential users of the information and the means whereby awareness of the project could be increased, especially in policy and administrative circles.

Recommendations

Each discussion group returned to the final plenary session with a short report on its findings. These may be summarised as follows:

1) Sufficient information is available and accessible for all participating countries on physiography, pedological data and soil degradation status necessary for project activities (1) and (2) at the scale of 1:2.5 million. At the moment a 1:500,000 SOTER database exists for Hungary. Other countries in the region have enough georeferenced information to develop a 1:2.5 million SOTER shortly. Soil data according the FAO Legend (ESB Soil Map of Europe, respectively correlation work carried out at Dokuchaev Institute for SOVEUR project) is already available and the background information needed on surficial lithology and soil profiles necessary to subdivide SOTER units into terrain component and soil components is easily accessible and as such can be compiled in the required format (see Batjes and Van Engelen, 1997).

2) The proposed SOTER methodology is adequate to handle the necessary soil geographic and attribute data. The SOTER system will be used to store the relevant information and participants indicated they were willing and able to enter the data into the system for their individual countries.

3) Careful boundary correlation will be necessary for the soil geographical data and the interpretation of current status of soil degradation, also because some of the standards may differ within countries and across the region.

4) Most analytical methods are broadly similar within the region and participants agreed they can be brought to a common system using expert knowledge. However, certain physical determinations on soils are made using fundamentally different criteria. Where these variations occur (as with determinations for particle-size class in former Soviet Union countries) these differences must be recorded in the database, as has been done in the European Soil Database, and data comparison may prove difficult. In this context, it would be useful for ISRIC, ESB and the participating countries to initiate joint comparative studies of commonly used soil analytical procedures. In addition there is a lack of measured data on soil physical parameters, such as bulk density, moisture retention and hydraulic conductivity for the region.

5) It has been agreed that maps demonstrating soil degradation status are needed prior to further development of soil vulnerability maps.

6) The group discussions stressed the need for consideration of as wide a group of contaminants as possible in the assessment of soil degradation status, consistent with the adopted 1:2.5 million scale of mapping, available time and finance. As it is often difficult to distinguish between natural and human-induced soil degradation, this distinction is not considered critical by the workshop. However, in cases where this distinction is possible, human causative factors should be documented according to criteria to be defined in revised guidelines. The participants noted there will be regional differences in precision of information about different types of soil degradation, e.g. water erosion versus contamination by radionuclides.

7) Clear definitions are necessary for "slight", "medium" and "strong" degradation as perceptions of these terms may vary between countries; in the absence of such uniform criteria the interpretation of "severe" degradation by water erosion may not be the same in different countries, complicating boundary correlation between countries.

8) The workshop pointed out that criteria have not been given by Van Lynden (1997) for nitrates and phosphates and recommended that figures be given as "maximum permissible levels" rather than "pollution". Permissible levels are to be proposed, based on available literature data. Also, there seems to be no place (yet) for some inorganic pollutants in the guidelines.

9) It is not always possible to give the exact extent of soil pollution, even when the source of pollution is exactly known. In such cases, georeferenced information on point-source pollution should be included in the pollution section of the "soil degradation status" database, specifying the main source and type of pollutants.

10) The workshop agreed that the vulnerability assessment, in first instance, should focus on one degradation factor (i.e. contaminant) and trigger mechanism. It has been proposed that the vulnerability of soils to cadmium mobilization, as induced by acidification should be the first vulnerability mapping exercise in the SOVEUR project.

11) Rating systems and models for specific soil vulnerability studies should be developed and refined by small groups of experts, by pollution scenario, once the necessary input databases have been created or accessed.

12) Initial project results in terms of the SOTER database and the database of soil degradation status in central and eastern Europe will be presented and discussed during an international workshop to be held (tentatively) in early 1999; participants were invited to suggest possible venues for this workshop. This second SOVEUR workshop may also serve to form the expert-groups needed to refine and test the procedures for assessment of soil vulnerability to delayed pollution.

13) As a general conclusion it was observed that working at the scale of 1:2.5 million is an excellent exercise for integrating data and expertise from a range of countries. However, for the future more detailed systems need to be developed, especially for the smaller countries.

14) Copies of the integrated-databases, developed for the SOVEUR project, will be made available to all participating organisations.

15) In first instance, the products derived from the project would be of interest to planners and policy-makers and civil servants of the Governments of the participating countries, as well as international organizations such as FAO, UNEP and the European Union. In addition, there is an important role in education as currently the soil is not seen as deserving protection from degradation and pollution by many authorities.

16) The group expressed a need for more information for example on reference literature on trigger systems and delayed pollution in relation to main capacity controlling properties of the soil; a practical solution could not be presented on increasing this availability.

17) There is a need to improve communication between different groups working on similar topics. Thus, awareness on SOVEUR project activities should be increased through newsletters, publications and enhanced communication, both within and outside the SOVEUR group.

18) It would be useful to develop a meta-database on available data/information about soil degradation and pollution by country, in conjunction with a glossary of terms.

19) As more than one authority or institute in each participating country is concerned and has related information, data or maps, special institutional arrangements may be made to allow effective cooperation at country level. It is up to the country to decide on formation of such arrangements which may be the establishment of a coordination committee to ensure up-to-date information and data.

Project implementation

Following agreement on the feasibility of developing a SOTER database and database of soil degradation status for the region, draft workplans and sub-contracts for the implementation phase were discussed and agreed upon, on behalf of the relevant institutes. It has been agreed that these two "outputs" would be completed before April 30, 1998, after which date ISRIC would merge the respective national contributions into a central database. The preliminary results of the "soil degradation status" mapping exercise will be presented and discussed during a workshop, tentatively planned for June 1998. All participating national institutes have been invited to propose a suitable venue in their respective countries. An important theme of the second workshop will be to refine further the methodological approach for soil vulnerability mapping, with emphasis on selected soil pollution issues.

Conclusions

The workshop concluded with the acknowledgement that:

1) Participants agreed that in order to rapidly achieve the project goals, full collaboration of all parties concerned with respect to the sharing of data and information will be essential. However, some data may be in the process of being collected and delays therefore may occur in collation, which in turn may affect the tight schedule of implementation tasks for the SOVEUR project.

2) Specialist institutes from the 13 participating countries will proceed with the compilation of a soil and terrain (SOTER) database.

3) This will be followed by a survey (database) of soil degradation and pollution status by country at a scale of 1:2.5 million.

4) Upon their completion, the national contributions for items 1 and 2 will be merged into one central database at ISRIC (April 1998). Possible data gaps and border correlation problems recognized at this stage, will be re-solved by the institutes concerned in close consultation with ISRIC staff.

5) Staff at ISRIC will proceed with the development of simple models for assessment of the vulnerability of soils to selected pollution scenarios, in association with small groups of experts, which are to be identified during the second SOVEUR workshop (June 1998).

6) The SOVEUR project can play a significant role in enhancing scientific cooperation between European countries on issues of soil degradation and pollution.

7) The ultimate aims of the SOVEUR project are to strengthen regional awareness of the significant role soils play in protecting food and water supplies, and to demonstrate the need for environmental protection by the generation of land degradation and soil vulnerability maps.

Acknowledgements

The editors gratefully acknowledge the inputs from members of the SOVEUR workshop held at ISRIC, Wageningen (October 1997).

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PART 2

INTRODUCTORY PAPERS

HISTORICAL BACKGROUND TO SOVEUR PROJECT

L.R. Oldeman
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This workshop on the "Mapping of Soil and Terrain Vulnerability in Central and Eastern Europe" (SOVEUR) has been convened to develop and implement a course of action which will lead to a successful conclusion of a project originally proposed several years ago. On this occasion, thirteen countries are represented and have accepted the challenge to create the means to make an overall assessment of soil degradation and pollution status in Central and Eastern Europe at a scale of 1:2.5 million. The workshop is supported in its endeavours by the presence of representatives of the European Soil Bureau and the Food and Agriculture Organisation (FAO) of the United Nations.

The history of SOVEUR can be traced back several years during which the development of systems for data handling have been developed by ISRIC staff, enabling the Institute to co-ordinate the work currently proposed. Firstly, at the instigation of the International Society of Soil Science (ISSS) and in association with the United Nations Environment Programme (UNEP), development of a computerised system for handling soil and terrain data (SOTER) for the whole world at a scale of 1:5 million began in 1986. The system was tested in different parts of the world and with the experience gained, its procedures were refined. A full account of the system and its development is given by Oldeman and van Engelen (1993). The SOTER methodology (van Engelen and Wen, 1995) is now fully operational and available for use in Europe after successful implementation in South America and the Caribbean at a scale of 1:5 million. Other SOTER activities have taken place at more detailed scales of 1:500,000 in Hungary (Varallyay *et al.*, 1994) and 1:1 million scale in Kenya which have demonstrated its flexibility for different purposes including the current SOVEUR project.

A second theme at ISRIC has been an interest in degraded, contaminated and polluted soils (Bridges, 1989; Oldeman *et al.*, 1991) and in 1991 ISRIC staff organized a conference "To Consider the Feasibility and Desirability of Initiating a Project on the Mapping of Soil and Terrain Vulnerability to Specified Chemical Compounds in Europe at a Scale of 1:5 Million" (Batjes and Bridges, 1991). This conference, which took place with the support of the International Institute of Applied Systems Analysis (IIASA) and the Dutch Ministry of Housing, Physical Planning and Environment (VROM), was part of a "Chemical Time Bombs" Project of the Netherlands Foundation for Ecodevelopment "Mondiaal Alternatief". It was attended by delegates from 17 European countries who strongly supported the ideas proposed. The executive summary of this 1991 conference stressed "the large amount of scientific interest and enthusiasm from all delegates, with scientists from many national research institutes willing to co-operate in the production of soil vulnerability maps at continental and national levels. This interest should be capitalised upon immediately while it is freely available, as it will greatly reduce the overall cost of a European-wide initiative". Unfortunately, at that stage no finance was forthcoming to support the project.

In 1993, ISRIC was asked by the Dutch Ministry of Agriculture about the feasibility of a project on the pollution of soils in Central and Eastern Europe following the precipitate changes in government in that region. The outcome was a proposal "Assessment of the Status of Human-induced Soil Pollution in Europe" (EUSOPOL). This proposal was submitted to the Netherlands Assistance Programme for Central and Eastern Europe in a joint programme of the Ministries of Agriculture, Environment and Economics. Re-organisation within the Ministry of Economic Affairs resulted in any decisions being postponed indefinitely.

Eventually in 1995, the Ministry of Economic Affairs renewed their interest in the SOVEUR project. However, it could only be commissioned through an international organisation. A project proposal was drafted in collaboration with FAO and the present project was given permission to go ahead in December, 1996.

In the spring of 1997, ISRIC technical staff prepared three booklets, introducing the SOTER database, a methodological framework for soil data collection, and guidelines for the assessment of human-induced soil degradation and soil vulnerability in Central and Eastern Europe for discussion (Batjes, 1997; Batjes and Van Engelen, 1997; Van Lynden, 1997). The administrative staff have planned the domestic side of the workshop to care for the comfort and well-being of participants.

SOVEUR is an important project which cannot be implemented successfully without the enthusiastic support and commitment of all participants. A recent publication stated that countries of Eastern Europe need to spend $130 billion to clean-up the environment in order to meet minimum environmental standards. This proposal for the mapping and assessment of soil and terrain vulnerability in Central and Eastern Europe will help National Governments set priorities for action. It also has great potential for education at all levels and for raising awareness of the dangers of soil pollution.

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PROJECTED USES AND USERS OF SOVEUR DATABASES

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The Netherlands Ministry of Housing, Physical Planning and Environment (VROM), recognizing the need for sustainable use of the environment, sponsored, in a joint venture with the International Institute for Applied System Analysis (IIASA), as series of workshops and conceptual studies relating to what they call Chemical Time Bombs (CTB) in the European Environment. In March 1991, the International Soil Reference and Information Centre (ISRIC) organized an international workshop on this subject to ascertain the feasibility and desirability of initiating a mapping project on soil and terrain vulnerability to specified categories of chemical compounds in Europe at an average scale of 1:5 million. FAO participated in the workshop and endorsed the project activity. In the framework of the Netherlands Assistance Programme for Central and Eastern Europe Multilateral Projects, a project resumé was drawn up in September 1993 for: "Mapping of soil and terrain vulnerability in Central and Eastern Europe". Finally, FAO reformulated the project document based on the project resumé and it was approved and declared operational in October 1996.

The objectives of the project are the establishment of a geographic database and production of associated maps at a scale of 1:2.5 million on human-induced soil degradation and soil vulnerability for Central and Eastern Europe as a tool for targeting appropriate corrective actions as well as strengthening public awareness of the significant role soils play in protecting food and water supplies and environmental protection. The expected outputs are:

1) Compilation of a soil and terrain (SOTER) database for Central and Eastern Europe, at the scale of 1:2.5 million.

2) Based on above, and in combination with existing data sources, mapping the current status of human-induced soil degradation with emphasis on soil pollution status in Central and Eastern Europe.

3) Soil vulnerability maps for Central and Eastern Europe showing areas vulnerable to defined pollution scenarios (categories of pollutants).

Target beneficiaries of the project will depend on the mapping scale of these outputs and associated information and database. In other words, the key issue in preparation of the mentioned maps is the level of detail or scale (resolution) and the information available or that which is required by the expected user identified at an earlier stage. However, to simplify the information available and remain realistic the adopted scale of mapping is accepted to be 1:2.5 million.

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

Concentrating on the present workshop for Central and Eastern Europe (SOVEUR) and based on the project objectives, expected outputs and the decided level of detailed information or mapping scale, the following users can be projected:

1) The immediate beneficiaries will be the Ministries in the participating countries which will utilize the produced geographic database maps in their decision-making process. This will also result in their increased awareness of the significant role of soil in protecting the food and water supplies.

2) The Ministries of Planning and Development in the participating countries will also benefit from the produced databases and maps for policy and strategy formulation at the regional, as well as at national level. For example, by identifying areas considered most at risk and to decide on corrective action at national or regional level.

3) In the case of point-sources pollution or degradation processes from other countries sharing borders, inter-governmental decisions for corrective measures can be undertaken to protect any negative effects on crop quality and quantity and ultimately on human health and biodiversity.

4) The project also contributes to strengthening of the capabilities of national environmental organizations in Central and Eastern Europe. The project will generate maps and databases which can serve to increase general awareness of soil vulnerability to specific types of pollution of public health concern, allowing problem areas to be identified for subsequent environmental protection studies and measures to be undertaken.

5) International organizations and societies like FAO, UNEP, ISSS, ISRIC etc., will benefit from the outputs of the project to decide on priorities, corrective action, future programmes or projects in specific countries or areas. For example, there is a technical Cooperation Programme (TCP) project proposal on "Rehabilitation of Polluted Soils in Romania". The objectives of that project are to establish demonstration pilot farms for environmentally-safe and contamination-free agricultural production. Selection of these areas for these pilot farms should be based on such database/maps produced by the SOVEUR project.

6) Soil degradation and soil quality are related to the use of the land. Land use has a profound influence on "dynamics", soil characteristics such as pH and redox conditions. Therefore, the project when assessing the soil system's vulnerability considers distinguishing between types of land use as an important parameter in producing relevant maps. However, the status of land degradation, particularly pollution, should be considered as the base for appropriate land use decisions. Land users in areas where improvements are accompanied by appropriate land use, particularly where soils are polluted, are indirect beneficiaries.

7) These database/maps can be considered as a national resource information system and base to find a timely, lasting solution and integrated, management technological package appropriate to the problem of environmental degradation, to stop degradation processes and to increase productivity of such degraded soil and environmentally accepted safe standards for the production of goods for human consumption. Availability of such database/maps will assist in defining the additional fundamental research which should be executed to arrive at better remediation technologies.

8) The project also contributes to strengthening of the capabilities of national research institutes and in general soil science communities. Based on methodologies and guidelines developed to compile a soil and terrain digital database and assess land degradation and soil vulnerability, many other research fields can be developed for different research institutes according to their field of interest, for example, producing maps of potential land capability, land suitability, nutrient movement and groundwater interaction.

9) Based on methodologies and guidelines developed by the project, larger scale and more detailed maps can be produced for other purposes such as legislation, land evaluation and pricing, taxation, etc.

10) The types of maps produced by the SOVEUR project could be an introduction for papers, lectures in workshops related to soil degradation, pollution, etc. to discuss methodologies, severity and extent of the problem.

After visits to eight of the 13 participating countries in the project and following discussions with scientists from different national institutes in Bulgaria, Czech Republic, Hungary, Lithuania, Poland, Romania, Russia and the Slovak Republic, the following concluding comments may be suggested:

1) As more than one authority or institute in each participating country is concerned and has related information, data or maps, special institutional arrangements may be made to allow effective cooperation at country level. It is up to the country to decide on formation of such arrangements which may be the establishment of a coordination committee to ensure up-to-date information and data.

2) Since various soils surveys were carried out for the preparation of original maps in different countries (different values may be obtained by different entities, analytical methodologies and equipment depending on sectorial interests, motivation and availability of specific equipment), it is suggested that base materials such as source maps and analytical methods used should be documented to make the data traceable and to permit subsequent comparison of different analytical data sets.

3) The participating countries are of very different sizes, so in future smaller countries may wish to prepare large scale, maps for more detailed information, particularly soil profile references, hot spots (point source pollution) or areas considered at risk from re-

mobilization of specific contaminants. These larger scale maps may be prepared using the same standard methodology.

4) According to the rules for coding SOTER units, there should not be more than 6 constituents in each SOTER unit, each of which covering at least 15% of the unit. However, in some cases small areas could have specific features of interest in the country (economically, production, land use, etc.) and this needs to be specified on the map. Therefore, it is recommended to relax these rules in such specific cases.

ACTIVITIES OF THE EUROPEAN SOIL BUREAU AND STATE OF PROGRESS OF THE EUROPEAN SOIL INFORMATION SYSTEM

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Introduction

Numerous activities to collate knowledge about soil resources have been made in Europe in past years, but without any real harmonisation. Many activities have been supported by the European Commission, but they have been insufficiently co-ordinated. Recently, a European Soil Bureau has been created to effectively co-ordinate European activities on soils.

This paper will present briefly the organisation of the projects within the European Soil Bureau and then describe the state of progress of one of the projects resulting from an important and fruitful collaborative effort: the European Soil Information System.

The European Soil Bureau

The European Soil Bureau (ESB) was created in 1996 as a new body within the European Commission. It is located at the Joint Research Centre (JRC), Ispra, Italy, and is part of the Agricultural Information Systems Unit of the Space Applications Institute. Its aim is to carry out scientific and technical duties involved with the collection and harmonisation of soil information relevant to Community policies, to the relevant General Directorates (DG's), to the European Environment Agency and to concerned Institutions of the EU Member States.

The activities of the ESB are essentially driven by the demands for soil information from the EU Member States and the European Commission. The needs of these two large user-communities are dealt with by two committees, the Advisory Committee and the Inter-DG Co-ordination Group on Soil Information.

The Advisory Committee is formed by official delegates from the 15 EU Member States and from the EFTA countries. Observers with no voting rights are also admitted from the major international organisations (FAO, UNEP, etc.) and from the EU neighbouring countries. The committee ensures the necessary link between the activities of the ESB and the relevant policies and activities concerning soil in the single EU Member States.

The Inter-DG Co-ordination Group on Soil Information is an inter-service working group with participants of all the relevant services of the European Commission involved in directly or indirectly with soil related issues. DG VI (Agriculture) and DG XI (Environment) are heavily involved in soil related policies. Recently a surge of interest in soil information has been observed also by other Commission services: DG XVI (Regional policy) in relation to the European Spatial Planning Perspective, DG I (External relations) and DG VIII (Development) in relation to soil information in non-EU countries. Indeed, the extension of the European soil databases to non-EU countries has been stimulated by the needs of these General Directorates. Recently, the United Nations Convention to Combat Desertification came into being, and the European Union, as one of the parties to the Convention, will have to strengthen its support to obtain adequate soil information from the affected regions.

The needs identified by the Advisory Committee and the inter-DG Group are collected by the Secretariat of the ESB and transmitted to the Scientific Committee. The Scientific Committee is in charge of implementing the necessary activities in response to the needs for soil information. It is formed by relevant European experts in soil science and operates through small *ad hoc* working groups in charge of performing the individual tasks requested by the soil information users. Currently there are four working groups active within the ESB:

- The *1:1 million scale European Soil Database Working Group* has been operating for many years, well before the creation of the ESB. It has been the driving force of a joint European effort by many soil scientists from different countries. The chairman of the group is Dr M. Jamagne (INRA - SESCPF). It is expected that development of this soil information system will continue well beyond 1998 with the extension of its coverage to the Commonwealth of Independent States and to the Mediterranean countries.

- The *Information Access Working Group* (IAWG) turned out to be one of the most important within the ESB, as it is in charge of the development of a European policy for the access to soil databases. The general aim of the group has been to develop guidelines that insure the maximum protection of the data ownership together with regulated access for all the potential data users, with conformity to the EU policy regarding the access to relevant environmental information in Europe. Chairman of the IAWG is Dr R.J.A. Jones (Silsoe College, Cranfield University).

  The IAWG developed the guidelines that are a major breakthrough in European data access policy. The key statement is that data ownership and copyright remain with the Contributor. This means that the data supplied to the ESB by the Contributors for the creation of the European soil database are owned by the Contributors and not by the Commission. On the other hand, the principle of regulated access to the data by everybody is reinforced. The combination of these two statements produces a data access policy that maximises database access and use, and safeguards the intellectual property by the Contributors. The European Commission through its European Soil Bureau becomes the focal point for data licensing and distribution.

  Data are leased for a limited time and not sold. Charging is according to a price matrix. The adopted price matrix differentiates the cost of lease of data according to the use. Minimum charge (cost of handling) is applied to Contributors and non-profit organisations for internal use. Charging is required in the case of external use by these organisations. Maximum charges are applied to full commercial use by private organisations.

- The *1:250,000-scale Working Group* represents the future of the ESB. It works on the design and construction of the new European soil database at scale 1:250,000. Chairman of the group is Dr P. Finke (SC-DLO, Wageningen).

  The 1:250,000 Georeferenced Soil database of Europe project started after a feasibility study by the Directorate General XI (Environment) in 1993 prepared by R. Dudal, A. Bregt and P. Finke. This study was commissioned to meet the still growing demand for soil parameters in an environmental context - for which assessments on regional or watershed levels seems most appropriate - and to support the databases already developed by CORINE, e.g. on land cover and biotopes at scale 1:100,000. Direct contact to national soil surveys and land research centres of the former 12 EU Member States demonstrated that the national coverage of soil mapping at scale appropriate for a more detailed soil map ranged from 10% to 100%. However, in all countries some areas had sufficient coverage to enable generalisation into a 1:250,000-scale soil map, when complemented with some additional fieldwork. Special attention was paid to soil and terrain attributes which need to be recorded in support of environmental protection.

  Given the low availability of soil data suitable for preparing a more detailed soil map of Europe, it was determined that “a wall to wall soil map” or soil database could be accomplished only in the long term. However, a recommendation was made to carry out studies in small pilot areas having an extensive data coverage, with the aim to develop a methodology, a common legend and a common database useful for the final database at scale 1:250,000. This principle was endorsed by the European Environment Agency (Scoping study on establishing a European topic centre for soil, DGGU Service Report No. 47, 1995). In order to start the project, a working group was created within the ESB. It is charged with the preparation of the Manual of Procedures, the delineation of the pilot areas and the overall scientific supervision of the project. From an operational point of view the database will be created in selected pilot areas by regional co-ordinators for territorial correlation of each project. The selection of the first pilot area, covering the North-Italian Quaternary plains has already taken place under the project leader, R. Rasio (ERSAL-Lombardia).

- The *Soil Hydraulic Parameters Working Group* has been established independently of the ESB, financed through a Human Capital and Mobility Network, but during its second year of work it applied for being included in the activities of the ESB. It is concerned with a soil hydraulic parameters database linked to the 1:1 million scale soil database of Europe. The database has the acronym HYPRES which stands for Hydraulic Properties of European Soils. It will be distributed in its final version through the ESB according to the same data access procedures. Chairman of the group is Dr H. Wösten (SC-DLO, Wageningen).

The European Soil Information System (EUSIS)

This system is being developed in the framework of the European Soil Bureau, as described previously in the framework of the 1:1 million scale European Soil Database Working Group. Before presenting the state of progress of EUSIS, the different stages which led to its present status will be described briefly.

History

Two wide-ranging programmes have been included for many years in the work of the European Communities Commission on soil knowledge and management. These are:

- in the domain of agricultural production (DG VI), through the Soil Map of the European Communities (EC) at scale 1:1 million.

- in the domain of the environment (DG XI), through the CORINE programme.

Action of FAO and EU General Directorate VI (Agriculture)

From 1952, studies were made of the different soil classification systems in Europe, with a view to eventual harmonisation for common activities. The first result was the publication of the FAO Soil Map of Europe at scale 1:2.5 million in 1965. During the seventies, work continued under the auspices of FAO on the Soil Map of Europe at scale 1:1 million. The legend was designed at the same time as that of the Soil Map of the World at scale 1:5 million, which was published in 1974. The work was stopped by FAO because of financial problems, and the map was never published. In 1978, the European Commission decided, with agreement of FAO, to revive it for the countries of the European Communities (EC). The final Soil Map of EC was published at scale 1:1 million in 1985. In 1986, Austria and Switzerland were added to the map through the initiative of UNESCO and the International Society of Soil Science.

During this time, agronomic research was organised by DG VI in different Programme Committees with precise objectives, co-ordinated by the Permanent Committee of Agronomic Research (PCAR). The Programme Committee for Soil Science first was called "Land Use" and later became "Land and Water Use and Management". Between 1972 and 1985, it worked successively on the following points: 1) inquiries in EC countries to define the main problems affecting land management ; 2) drafting of the EC Soil Map at scale 1:1 million; 3) organisation of "Workshops" where soil conservation took an increasingly important place ; 4) introduction of computerisation in data processing ; 5) research into land evaluation, land degradation and conservation.

The publication of the 1:1 million scale EC Soil Map was certainly the most powerful stimulus but it must be kept in mind that it was the outcome of more than 30 years work by regional and national soil survey staffs.

Action of EU General Directorate XI (Environment)

The main objective of the CORINE programme (DG XI) was the creation of a Co-ordinated Information System on the state of the Environment and Natural Resources of the European Communities. This implied setting up a homogeneous framework for collecting, storage, presentation and interpretation of environmental data on the EC countries.

The CORINE programme resulted in the computerisation of the EC Soil Map in 1986, resulting in the first spatial soil database (version 1.0). This consisted of digitising contours and indicating, for each polygon, the number of the corresponding soil association and the nature of the possible phases. No more data were used than those which were shown on the map. The database was created as part of research into, and the storage and handling of soil parameters relevant to both agricultural production and land protection. This first version of the database was rapidly applied to two major problems that required the use of multi-parameter combinations: a map of the buffering capacity and a zoning of the southern part of EC in terms of susceptibility of soil to erosion, associated with land quality. Other uses for this information were investigated but were not published and the number of studies were limited.

Structure of the present European Soil Information System

The soil information system has presently four parts: (1) the meta-database, (2) the soil geographical database at scale 1:1 million, (3) the soil profile database, and (4) the knowledge database.

- The *Meta-Database* is chronologically the last stage and it is still being compiled. The objective is to gather information about pedological studies in Europe. The expected meta-database should provide a catalogue of references from which users could find more information than shown on detailed national maps. An earlier programme was carried out but no update has been made for ten years.

- The 1:1 million scale *Soil Geographical Database* is the heart of the system. It includes the list of the Soil Typological Units (STU) i.e. all soil types within the European Union which were identified with the FAO-UNESCO legend (1974), revised by the CEC (1985). STUs are described by attributes with a harmonised coding: FAO soil name, parental material, slope, phase, topsoil and subsoil texture classes, subsoil texture depth, depth to an obstacle to roots, presence of an impermeable layer, water regime, water management. STUs generally are too small to be drawn on a map at scale 1:1 million. They are clustered in Soil Mapping Units (SMU) which are defined by contour lines and polygons. The "object SMU" is clearly related to the concept of soil association.

- The *Soil Profile Database* contains soil profiles with physical and chemical analyses. For each dominant STU, a representative soil profile was collected with main analytical data. Standard formats were developed for harmonising the various analytical methods in European countries.

  The difficulties experienced in harmonising the various analytical methods led to the adoption of two data formats. The first contains measured data which come directly from real georeferenced profiles. A code enables storage of the analytical methods used and missing values are accepted. The second format stores estimated data. The analytical methods are fixed for comparison of the values throughout the various countries of Europe. In this second format, the attributes must be fully completed by using "guesstimation". About 500 soil profiles are available, but more are expected in the near future.

- The aim of the *Knowledge Database* is to provide interpreted variables for agricultural or environmental purposes, for helping non-expert users, or to provide analytical parameters for modelling. The interpretation is done using pedotransfer rules, elaborated by experts, for estimating the parameters needed through logical relationships. The way of building the rules tries to formalize how the soil expert interprets the soil data stored in the Geographical Data Base. The rules can also use data from other sources e.g. climatic, land use or elevation data.

State of progress

Figure 1 shows the state of progress of the different databases over Europe. For the European Union of the twelve countries, the geographical database version 3.2 has been compiled. A knowledge database and an analytical database are being updated. For Central European countries, the geographical database is almost complete and an analytical database is being developed. For the new countries, the geographical database is in course of development. Inclusion of other countries is not foreseen at the moment.

In the PHARE countries, the actual state shows that work first must take place on border harmonisation with the help of Prof. G. Varallyay from Hungary. Correlation and harmonisation will take place in "buffer zones" of 50 km around each country where the FAO soil name and the other attributes must agree. For the profile database, 140 profiles from Bulgaria, Czech Republic, Romania and Slovakia are being obtained. A new standard format has been developed under Excel 5, with a data dictionary to facilitate their introduction in a harmonised manner. Direct contacts with Slovenia and Croatia will enable old data to be updated from the archives, and work with Albania is progressing well. ESB also has contacts for the region around Kaliningrad.

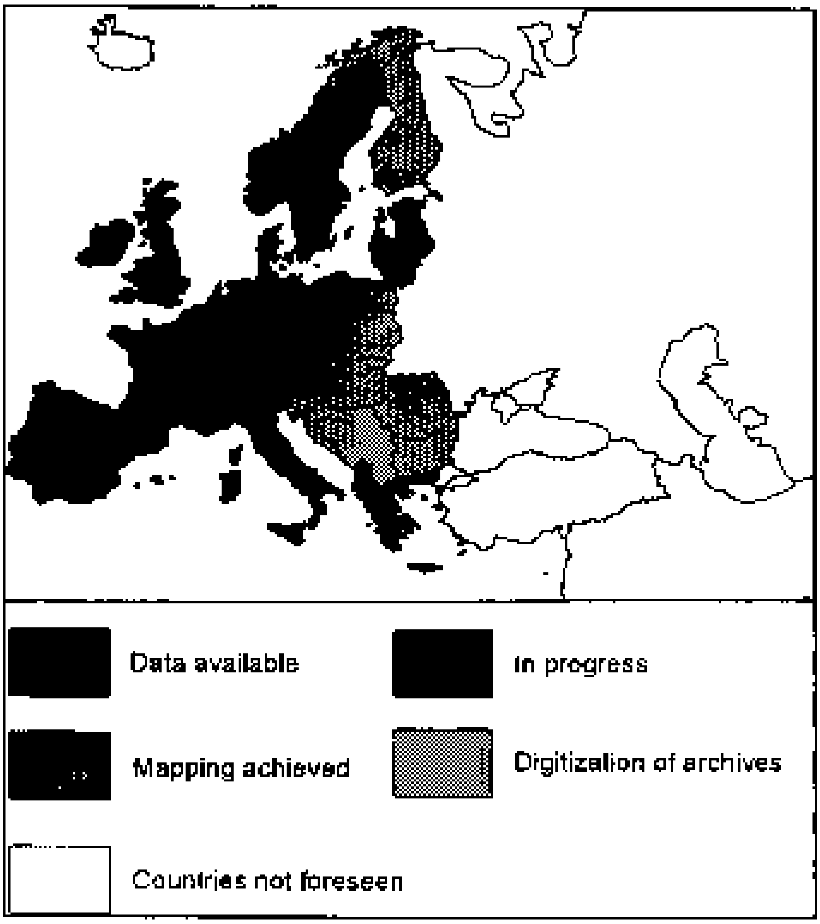

Figure 1. State of progress of the 1:1 million scale Soil Geographical Database of Europe (September 1997)

Conclusion

A usable Soil Geographical Database at scale 1:1 million is available at the EU level and several projects are asking for it. Information in such a database is regularly updated by new knowledge or the addition of new territories. Management of this information is by the European Soil Bureau which should ensure quality control of the updates and should license users.

The 1:1 million scale Soil Map, and the several versions of the 1:1 million scale Geographical Database allow the use of harmonised data for diverse European projects, such as study of erosion risks, monitoring of agricultural production or mapping of water holding capacity. When considering the increasingly precise demands of users, quantitative information at more detailed scales is needed. One of the priorities is to elaborate a 1:250,000-scale soil database. This project is not really an improvement of the 1:1 million scale database but it should use new methods to develop a more flexible and reliable source of information. Moreover it is necessary to use basic information to develop indicators for sustainable management of rural areas and resource protection (water, air, landscape). Methodological research on the indicators is thus an important objective: data combinations, remote sensing use, development of models to formalise the processes, combinations with monitoring networks require development.

PART 3

COUNTRY PAPERS

DEGRADATION STATUS OF BULGARIAN SOILS: OVERVIEW OF AVAILABLE INFORMATION

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Introduction

According to an internationally accepted definition (EE, 1978) soil degradation means "a process which decreases the moment and potential capacity of soil for production (qualitative and quantitative) or management".

Arable lands supply about 88% of food for the world population, 10% is produced from meadows and pastures and only about 2% is obtained from the oceans (Onchev, 1989). Soil is a complex environmental component providing sources of power, food, raw materials and it is necessary for a healthy environment for human beings. The practical possibilities for increasing the arable land area are very limited. That is why an ecological-friendly land use strategy, sustainable soil fertility maintenance and protection of the soil resources from degradation is the main challenge to modern agriculture.

Bulgarian soil and land resources

Bulgaria is not a large country (11.1×10^6 ha), but as a result of climate conditions, geology, hydrogeology, relief and vegetation, it has a great variety of soils. The various soil units differ significantly according to their genesis, structure, morphology, chemical, physical and physico-chemical properties. Agricultural land amounts to 6.85 million ha (61%), woodland to 3.85 million ha (34.7%), and the remaining 0.4 million ha (3.7%) is used for infrastructure and communal purposes. The Statistical Yearbooks (1989-1996) show that there have been no significant changes in the type of land use in the country after adopting changes in the laws of ownership and land use in March 1991. For example, total area of arable land in 1989 amounts to 3.85 million ha and in 1995, 4.00 million ha respectively. Nevertheless some changes in the area under different cultivated crops exist. The total area of cereals in 1989 was 3.37 million ha and 3.35 million ha in 1995, respectively. The same tendency exists for fodder crops, pulses and the area of rice production. Over the same period, the total area of industrial crops increased from 0.25 million ha (1989) to 0.60 million ha in 1995. Land use changes in the last seven years did not significantly affect soil degradation status. Because of lack of funds, a drastic decrease in the use of fertilizers and pesticides has led to a lowering of crop yields and allowed increased weed infestation in the arable land. As an illustration, the mean application rate for nitrogen for all arable lands in 1989 was 93.6 kg ha^{-1} which decreased to 34.1 kg ha^{-1} in 1995. For the same period, pesticides applied per hectare of cultivated land have decreased from 4.22 to 0.2 kg ha^{-1}. It must be concluded that presently the anthropogenic loading of soils and other environment components is lower than in the previous two decades.

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

Available Soil Information

Soil resources

Soil survey in Bulgaria is connected closely with the scientific work of N. Poushkarov, the patron of the Soil Science and Agroecology Institute. This work includes basic soil maps at scales of 1:500,000 to 1:2.5 million and other information for a National SOTER database compilation is available. In addition, there are:

- Soil maps of some Bulgarian districts at a scale of 1:100,000, which have been prepared by generalisation from soil survey data at scale 1:25,000.

- Mapping schemes of the agricultural lands in Bulgaria at a scale of 1:25,000. These schemes concern concentrations of the main plant nutrients and soil acidity. They are based on 20 years monitoring (1972-1993) by the N. Poushkarov Institute of Soil Science and Agroecology.

- Since 1977, soil surveys have taken place at a scale of 1:10,000. At the beginning of the land restitution reform (1991), more than 75% of agricultural lands were covered by this survey.

As a result of these soil surveys, an enormous amount of information about the soil resource of Bulgaria is available. A process of estimation and systematisation in the National GIS is now proceeding. In connection with this work nearly all soil maps, at scale 1:10,000, are checked, boundaries agreed with adjacent sheets, digitised and geometrically corrected (Koulikov, 1993).

It is important to mention that as a result of the preparation of the soil map and geographic database for EU countries, the soil map of Bulgaria at a scale of 1:1 million was created. This map comprises 23 soil mapping units and 33 soil typological units. Profiles of the dominant soil units in Bulgaria are described and necessary analytical information is presented elsewhere (Kolchakov, 1994).

Soil erosion status

The natural physio-geographic conditions (landscape, climate and soils) and the land use established in Bulgaria after the end of the World War II permit conditions in which water and wind erosion are widespread (Rousseva *et al.*, 1992). According to the latest studies (Rousseva *et al.*, 1992; Rousseva and Lazarov, 1997) water erosion is the most important soil degradation process that effects about 64% of the country's territory. A high potential risk of water erosion exists for 79.2% of agricultural lands. It is calculated that average annual soil losses from the area of arable land amounts to 135.9 Mt. These losses are distributed as follows: crop land 68.1%; pastures 16.3%; vineyards and orchards 14.1%, and other agricultural land 1.5%

respectively. Forest land covers 33% of the Bulgarian territory and 19.5% of it is affected by water erosion (Rousseva and Lazarov, 1997).

Wind erosion was not a typical degradation process for the country's soils before land collectivisation at the beginning of the 1950s. According to the National Long-term Erosion Control Programme 1.758 million ha or 38.9% of arable land are potentially exposed to risk of wind erosion (Ministry of Agriculture, 1980). A special study exists concerning an evaluation of wind direction, velocity and frequency of the winds causing soil erosion. A map has been made of the extent and degree of wind erosion for the whole country (Djodjov *et al.*, 1997).

Soil acidity

The analyses of the soil survey data (Stoichev and Kolchakov, 1996) show that total area of the soils with pH < 7.0 occupies about 6.5 million ha, i.e. almost 60% of Bulgaria. A significant part (4.3 millions ha) of these lands are covered with soils with high vulnerability to acidification (pH < 5.0). Half of these soils are affected by acidity, but only 0.45 million ha are in the area of arable lands (Ganev, 1992a,b; Anon., 1987).

There is enough information showing that a long-term acid fertilizer applications lead to a significant decrease of soil pH values (Ganev, 1992a; Stoichev, 1986; Stoichev and Stoicheva, 1986; Stoichev and Kolchakov, 1996; Totev, 1982). As a result of over-fertilization with ammonium nitrate in the period 1965-1985, the area of the acid soils in some regions of Bulgaria has been significantly increased (Ganev, 1992a; Anon., 1987). Some assessments show that about 2.7 million ha of acid soils in Bulgaria have to be limed. About 1.5 million ha of these are arable lands in the plains and semi-mountainous regions and another 1.3 million ha occur in the mountains (Anon., 1987).

Industrial soil pollution

Intensive industrialisation of our country started in 1960-1965, i.e. rather later than most other European countries. Nevertheless we could not avoid soil pollution with heavy metals, arsenic, oils, nuclides, etc. There are many scientific publications, concerning all types of human-induced soil pollution (Faitondjiev and Raikov, 1983; Naidenov and Staneva, 1988; Raikov, 1978; Raikov et *al.*, 1982, 1983, 1985; Stoichev *et al.*, 1990), the main results of which were are reviewed in a special issue (Raikov , 1984). Later a wide description of pollution status of all component of the environmental have been presented in National Report for Environment and Development of Republic Bulgaria (Anon., 1992). Soil pollution by heavy metals exceeds the standard permissible level in over 47,400 ha of the country's arable land. About 61.3% of this land is located in the regions around industrial enterprises and could be classified as hot spots. The greatest soil loading is coming from air emissions of lead, zinc and copper factories. Agricultural lands and forest surrounding these enterprises are affected by solid and liquid precipitation from the atmosphere containing lead, zinc, copper, arsenic, cadmium, selenium, antimony and other elements.

The Ministry of Environment and Ministry of Agriculture funded a large scale survey of all hot spots and most of the arable lands. As a result, soil maps showing pollution by heavy metals, arsenic and radionuclides are available at a scale of 1:5,000, as well as maps of saline soils at the same scale.

A list of studied places, extent of the affected soils, type of pollutant and sources of polluting emissions is published in Government Decree No. 50 (Anon., 1993).

According to this source, the total area of agricultural land polluted by heavy metals is 19,358 ha. The area of land contaminated by radioactive elements as a result of uranium mining is 1,913 ha, of which 1,387 ha is arable land. Oil pollution occurs only in small areas, as a result of accidents, at a Bulgarian oil refinery and along oil transport pipe lines.

Conclusion

A large amount of information exists concerning the degradation status of soils in Bulgaria. It is available in various research and government institutions, but until now it has not been systematically organised and mapped.

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STATUS OF SOIL MAPS, INFORMATION ABOUT HUMAN-INDUCED LAND DEGRADATION AND APPROACHES TO SOIL VULNERABILITY ASSESSMENT IN THE CZECH REPUBLIC

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Systematic soil survey has been completed in the Czech Republic on agricultural lands and in forests at a scale 1:10,000. The compilation of digitized soil maps at scales of 1:1 million, 1:500,000 and 1:200,000 is based on the detailed large-scale material.

The map of soil associations at a scale of 1:1 million, with tables of attributes of SMUs and statistically processed profile characteristics of dominant STUs goes back to the FAO Soil Map of the World prepared in 1974. It is a result of the cooperative MARS – CORINE project, coordinated by Professor M. Jamagne of the French Institut National de la Recherche Agronomique (INRA).

Subsequently, a set of soil and environmental maps has been digitized at a scale of 1:500,000. This set of GIS layers includes maps of soil associations, parent materials, humus (Ap horizons), base saturation (B horizons) and some layers of geomorphological and climatic information. This set of GIS layers will serve to create a synthetic soil – environmental layer and a map in accordance with SOTER methodology, which in its first stage emphasises geomorphological and lithologic features of the landscape. This geometric database will be linked with a database comprising two levels of information: - soil profiles with a broad set of analytical data (200-220 profiles), - selected profiles (2200-2500) from the systematic soil survey. Profile analytical data of forest soils also will be used. A digitized soil map at scale 1:200,000 will be linked to the same pedon database, which has recently been prepared (Kozák *et al.*, 1996).

The studies of human-induced land degradation in the Czech Republic focused on erosion, pollution, acidification, de-humification and pedo-compaction. Erosion maps have been compiled at a scale of 1:25,000 for some areas, and at small scale for the whole country. They represent vulnerability to erosion, evaluated on the basis of climate, soil (factor K), slope and land use parameters of the Universal Soil Loss Equation (USLE). Attempts have been made to map erosion and accumulation features reflected in soil profiles, as shown on soil maps of 1:10,000. The causes of acidification in dying forests on Dystric Cambisols and Podzols are still unclear, the pH data characterizing acidification are not convincing and the determination of Al species has been attempted only recently. In arable soils, liming has not changed the base saturation of the B horizons, so that this feature can be used in general soil taxonomy.

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

Soil de-humification and pollution trends have been investigated by means of retrospective monitoring. It has been found that de-humification took place during the last 30-35 years only in regions of Dystric Cambisols (liming, erosion) and in drained Gleysols. No significant non-point increase of hazardous trace elements (HTEs) was found in the course of this period, even in the most affected regions. On sites where an increased content of HTEs were found, this status was already reached 30-35 years ago, through long-term emissions (Podlešáková and Nìmecek, 1995).

In recent years increasing attention has been paid to soil contamination and pollution. Results of a systematic inventory of Cd, Pb, Cr (in cold 2 *M* HNO_3) and Hg, conducted by the Central Institute for Supervising and Testing in Agriculture (CISTA) are presented in a cartographic form. On selected sites 10 HTEs and some pesticides are monitored and in some of them also atmospheric depositions. The Research Institute for Soil and Water Conservation (RISWC) compiled an inventory of the most severely affected regions, compared with emission-free areas. These regions are characterized by total contents of 12 HTEs and principal groups of contaminants in the Dutch list. Dispersed anthropogenic contamination in the Czech Republic mainly reflects inputs of airborne contaminants, especially in the three most affected areas (North, North-West Bohemia, North Moravia) and in larger cities. The most severe contamination occurs in some Fluvisols, and excluding severely polluted sites in cities, there are three localities, characterized by a complicated combination of HTE point sources, pollutant dispersion and geogenic loads (Poíbram Raškovice, Kutná Hora). Concerning inputs from agriculture, even in the period when Togo-phosphates were imported, the Cd inputs into soils were in the range of 2-3 kg ha^{-1} yr^{-1}. Use of DDT in the past can be detected (along with metabolites) especially in soils of the former state farms (Nìmecek and Podlešáková, 1995).

A three-level set of reference values has been developed by the RISWC. The first level, a contamination limit, reflects the upper boundary of variability of natural and/or anthropogenic diffuse background concentrations (Podlešáková and Nìmecek, 1994). These limits are exceeded on the whole area of the Czech Republic for Cd, Cr, Hg and Pb in 6.9, 2.4, 0.8 and 2.1% of samples respectively. For As and Cd (Be), in the most severely affected regions, the first level is exceeded in no more than 15% samples. Differentiation between anthropogenic and geogenic loads of HTEs are being made, based on profile trace element distribution and geochemical maps. RISWC has developed a new system at the second level of reference values, which reflects critical loads of HTEs in the food chain and for crop productivity protection. They will rest upon the results of studies on trace element mobilities and their uptake by plants, leading to establishment of critical contents in crops (Podlešáková and Nìmecek, 1997). Maximum permissible limits officially used for agricultural soils (Ministry of Environment, 1994) have been exceeded for Cd, Cr, Mg and Pb in 1.3, 0.5, 0.2 and 0.6% of samples respectively. The third level of reference values are action or intervention values for soil sanitation needs. They have been proposed (Ministry of Environment, 1996) for playgrounds, residential and industrial areas.

The principal problem faced in the SOVEUR workshop and for future cooperation is the unification of the soil vulnerability concept and of ways to assess it. In our opinion soil vulnerability is a natural buffering potential of some kind which limits the impact of pollution (degradation). Vulnerability of agricultural soils to HTE pollution, in our opinion, reflects the capability of soil to reduce the bio-availability and/or mobility to groundwater for a long period and the feasibility of regulating the controlling processes.

In order to predict soil vulnerability, the threat of groundwater pollution, the adverse effects on plant uptake and on soil organisms by mobile and non-persistent pollutants, we need models. We present here our approach to the creation of a pesticide model (Kozák and Vacek, 1996). It is based on matching of the properties of individual pesticides with soil properties and regimes.

Another approach has been proposed for persistent pollutants, especially HTEs. Some years ago, six soil groupings with different responses to artificial loads of HTEs (with Cd, Zn, Ni and Cu after regulation of pH on 6.5) on plant uptakes were proposed. They served to differentiate maximum permissible limits. In our present opinion, they can be interpreted as soil vulnerability groups. Reaction of soils to pollutants should become a measurable criterion for vulnerability assessment. In this respect RISWC has available: sequential analyses (Zeilen –Brümmer) for Ap horizons, also after artificial pollution, simplified fractionation data, accompanied by data about crop uptake. The soil set involves current pollution of agricultural soils and the extremes of their anthropogenic and geogenic loads. Based on these data we tried to set up groups of soil-lithologic units, that reflect element-specific differences in vulnerability of soils to Cd (very high pH–dependent mobility) and Pb (low mobility) and to display them on maps (Podlešáková and Nìmecek, 1996).

This approach can be replaced by an analytical procedure. Blume and Brümmer (1987, 1991) have proposed systems, which come into the category of vulnerability assessments. They have been developed for HTEs, pesticides and industrial contaminants. The evaluation is made in points and their sum reflects the potential of pollutant transfer into plants and/or transport to groundwater. Both procedures require support from experimental data. The SOVEUR workshop should be a contribution to the definition of the general concept of soil vulnerability, and especially stimulate further development of the methodology for soil vulnerability assessment.

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SHORT REPORT ON SOVEUR STATUS IN ESTONIA

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The soil cover of Estonia has been mapped completely at the scale of 1:10,000. On the basis of this detailed survey, generalized medium-scale maps (1:50,000) for counties have been compiled. Soil maps of Estonia (1:200,000; 1:500,000; 1:1,500,000) represent the product of step-by-step generalization of large-scale maps. The latest document to be produced was a "Soil Map of Estonia, 1:1 million" compiled on topographic base with FAO–1990 nomenclature used in the Legend. To incorporate this map in the soil map of the European Union, all materials (soil map, legend, attributes) were sent to the INRA Coordination Centre. A reduction of this map will be used as the soil basis (1:2.5 million) for the SOVEUR Project.

Erosion is reflected on soil maps of all scales, whereas erosion-endangered areas with an inclination of terrain greater than 3° make up 10% of arable land. Eroded soils on terrain with a slope of more than 10°, overlying diluvial formations, occur on an area of more than 4,000 ha. In Estonia 542,900 ha of land are at risk from wind erosion. The great majority of the territory is level and soil texture is loamy, so water and wind erosion are not natural hazards.

The use of heavy machinery has resulted in the compaction of arable soils. The degree of soil compaction depends on the carrying capacity of the soil. A total of more than 800,000 ha of arable land have a carrying capacity less than 140 kPa in regions with known soil types (associations). Stagnic and Gleyic Luvisols, Planosols, drained Gleysols are most sensitive to compaction. There are also new data on the decrease of soil compaction as a result of land privatization and changes in the type of tractors in use today. Up to now, 66% of cropland has been drained, but neglected drainage systems have led to the continuation of gleying and waterlogging of formerly drained areas. This kind of physical degradation tends to occur even in the neighbouring forested and arable lands. We have detailed data on the soil degradation induced by oil-shale and phosphorite mining both by chamber-and-pillar, and open-pit-quarry methods.

A geochemical atlas has been compiled for humus horizons of soils in Northeastern (Industrial) Estonia. The maps (1:400,000) are based on the data of about 7,000 samples from an area of 5,900 km^2 (about 14% of the Republic), and represent the territorial distribution and numerical values of As, B, Bi, Cd, Co, Cr, Cu, F, Hg, Mn, Mo, Nb, Ni, P, Pb, Rb, S, Sr, Th, U, V, Y, Zr and Zn. This gives the possibility of a highly detailed characterization of the soil chemical situation in the Northeastern Region. A geochemical atlas of a similar quality for the whole of Estonia is in the final stage of compilation and will be published shortly. The

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

elements B, Ba, Be, Ca, Cd, Co, Cr, Cu, F, Fe, Hg, K, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Rb, Sc, Sn, Sr, Th, U, V, Y, Zn, Zr and OM are characterized territorially and their association with soil types on 31 maps. AAS, RFA and spectral analysis methods have been used. The total content of elements has been determined everywhere and selective determinations made of compounds soluble in *aqua regia*, 1 *M* and 0.03 *M* HNO_3, and 1 *M* and 0.03 *M* NH_4Cl. Soil parent materials as well as natural and technogenic anomalies and the intensity and distribution of contamination via atmospheric deposition are presented. All these data (in Estonian and in English) will be available for the solution of SOVEUR Project. The atlas also contains data on the relationships between leaching and accumulation, leaching and atmospheric deposition, parent materials and soils, soils and plants, etc.

A Bulletin of Geochemical Monitoring of Estonian Soils has been completed, and its publication could take place within the year, depending on the availability of finance. Despite its delayed publication, monitoring data (two series from 19 and 25 areas) on the content, dynamics, deposition and distribution of heavy metals, OM, Ca, Mg, N, S, etc. are available for use in the SOVEUR Project. The characterization, turnover and removal with production of heavy metals in plants (crops) is unsatisfactory as systematic analyses are lacking. Probably additional analytical work on plant material it will be necessary for the project, but this could be compromised by shortage of funds.

The Annual Environmental Issues published by the Ministry of Environment contains a rich database on point-pollution sources (industry, mining, municipal, etc.), contaminant loadings, acid and alkaline deposition. Their tables, maps, etc. are available and compatible with SOVEUR topics. It was impossible in the time available for this report to incorporate the contributions of experts outside soil and geological institutions.

Besides the well-known acid deposition, alkaline deposition via atmosphere is characteristic of Estonia in the region of oil-shale industry. Neutralization of acid contaminants is largely achieved because Rendzic Leptosols, Calcaric Regosols, Calcaric Cambisol–Luvisol complexes and Gleysols on calcareous deposits form about 50% of the soil cover. About 75% of soil parent materials and 50% of bedrock are calcareous. Alkaline dust deposition in the industrial areas leads to changes in the coniferous forest soil system, but also it decreases the buffer capacity of soils on calcareous rocks. Data on alkaline contamination are available and it is desirable to include them in the SOVEUR project.

Special problems connected with soil pollution from fuels and other oil products, as well as with local nuclear residues, occur in some former military and military-industrial areas. Respective tabular and map data are available in the Annual Environmental Issues.

Information about the contemporary changes in the structure of land use and crop rotation influencing on the formation of soil chemical, physical and humus relationships is still fragmentary, but is sufficient to characterize the situation. A decrease in the use of fertilizers is evident, but an increase in the level of fertilizer use can be predicted in connection with the restoration of agricultural activity. Pesticides have never been a problem in Estonia.

Agricultural chemicals do not all behave as pollutants in soils because nitrates for example cannot be fixed and accumulated, but others, phosphates and heavy metals, are able to form relatively stable complexes in the soil. Their potential behaviour as chemical time bombs is well known. Soil compaction promotes reduction processes, encouraging ferrous phosphates to contribute to water contamination. Similarly, with an excess of nitrogen fertilizers, extensive use of slurry and/or intensive clear cutting of deciduous forests, nitrates are leached into the groundwater. The main source of phosphorus contamination in Estonia is sewage.

Inadequacy of agro-technology and the poor utilization of nutrients from manure and fertilizers cannot induce chemical degradation and/or pollution of soils, but it does give rise to the contamination of soil water and natural water bodies with nitrogen.

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SOIL VULNERABILITY ASSESSMENTS IN HUNGARY

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Soil processes and their control

The ability of soil to fulfil its functions ("soil value") is determined by the integrated impacts of various soil properties, which are the results of soil processes. They include mass and energy regimes, abiotic and biotic transport and transformation and their interactions. Any soil-related human activity influences the soil through these processes, consequently their control is the main task of soil science and soil management.

The scientifically-based planning and implementation of sustainable land use and rational soil management to ensure normal soil functions requires adequate information on the soil: exact, reliable, "detectable" (preferably measurable) and accurate, quantitative territorial data on well-defined soil and land properties with the characterization of their spatial (vertical, horizontal) and temporal variability and pedotransfer functions.

Data sources

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:

- *Meteorological data*. Systematic and regular measurements from 1850. Currently, the basic meteorological parameters are recorded at 160 observation points; 18 stations are equipped for detailed atmospheric-chemical measurements and 4 EMEP stations for continuous atmospheric monitoring.

- *Hydrological data*. Regular records are held on the quantity and quality of surface waters (rivers, creeks, canals, lakes, ponds, reservoirs) from the first decade of the century. Observation of groundwater conditions (depth of water table; chemical composition of the groundwater) in 600 to 1000 groundwater testing wells 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) have been prepared and updated; and the actual depth of water table indicated on a 1:1 million scale map at monthly intervals.

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

- *Geological data*. As a result of 160 years of geological survey in Hungary, a 1:200,000 map is available for the whole country and at larger scales for various geologically significant regions.

- *Geomorphological data*. A 1:200,000 geomorphological map showing relief characteristics (slope gradient, length, complexity, exposure of the slopes) indicated on contour maps with digital relief models has been prepared in recent years.

Soil information sources

During the last five decades a considerable amount of soil and terrain (land site) information has been accumulated in Hungary. This was the result of various national, regional and local programmes related to the inventory, mapping, monitoring and evaluation of environmental factors including: meteorological, geological, topographical, hydrological, vegetation and soil conditions and land use in order to help solve environmental problems.

A great number of thematic soil maps were prepared at various scales and with various content and accuracies, of which the most important are summarized in Table 1.

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

- *Soil fertility control system* (AIIR), for measuring the most variable soil characteristics in the top soil (ploughed horizon) of 5 million ha of agricultural fields in 3-year cycles.

- *Micro-element survey*, for measuring the total and soluble microelement content, including micro-nutrients and (potentially) toxic pollutants, in horizons of soils in 6,000 agricultural fields.

- *Soil information and monitoring system* (TIM), contains 1200 representative observation points: 800 points on agricultural land; 200 points in forests and 200 points in environmentally threatened "hot spots", where all the important soil parameters are measured regularly: in 1-, 3- or 6-year cycles - depending on their changeability.

Integrated GIS data

In the last few years the various soil data existing for Hungary were organized into a computerized geographic soil information system by the GIS Laboratory at RISSAC:

- *Agro-topographical System (AGROTOPO)*

  A regional scale computerized information system was developed at a scale of 1:100,000 for Hungary to provide many users with useful information on soils, land use and environmental protection problems.

Table 1. Overview of thematic maps for Hungary

Map	Scale	Date of preparation	Prepared for	Content	Author(s)
Practical soil maps	1:25,000	1935-1955	whole country per topographical map sheets	thematic soil maps, field- and labour data	Kreybig *et al*.
Large-scale genetic soil maps	1:10,000	1960-1975	60% of the agricultural land of Hungary, per farming units	thematic soil maps, field- and labour data	Coll.
Large-scale maps for amelioration projects	1:5,000-1:10,000	1960-	amelioration projects (occasionally)	thematic soil maps, field- and labour data	Coll.
Large-scale maps for land evaluation	1:10,000	1980-1990	approx. 20% of the country per topographic map sheets	thematic soil maps, field- and labour data	Coll.
Soil erosion	1:75,000	1960-1964	whole country per topographical map sheets	soil map	Stefanovits and Duck
Soil factors determining the agro-ecological potential	1:100,000	1978-1980	whole country per topographical map sheets	thematic soil maps	Várallyay *et al*.
Agro-topographical map	1:100,000	1987-1988	whole country per topographical map sheets	thematic soil maps	Várallyay and Szücs
Susceptibility of soils to acidification		1985-1988	whole country	soil map	Várallyay *et al*.
Hydrophysical properties of soils	1:100,000	1978-1980	whole country per topographical map sheets	soil map	Várallyay *et al*.
Limiting factors of soil fertility	1:500,000	1976	whole country	soil map	Szabolcs and Várallyay
Susceptibility of soils to physical degradation	1:500,000	1985-1988	whole country	soil map	Várallyay and Leszták

- *Establishment of a soils and terrain database for sustainable agriculture and environmental protection in Hungary (HunSOTER)*

  HunSOTER provides an orderly arrangement of natural resource data through the creation of a computerised database containing available attributes on physiography, soils, vegetation, land use and climate. This database is linked to a geographic information system which contains the digitised map units. The Hungarian version of SOTER has been built up with various modifications to accommodate the methodology to Hungarian conditions.

- *Environmental Conflict Maps*

  The following is a brief summary of RISSAC's work relating to ECMs, for example land degradation mapping and environmental vulnerability. A Land Degradation Mapping sub-project was implemented by RISSAC team with the assistance of FÖMI RSC between 1995-1996. The aim of the PHARE-MERA sub-project was to provide satellite-based land cover maps and digital databases at regional scale showing the extent of land degradation [soil erosion by water and wind; development of extreme soil reaction; physical soil degradation; biological degradation; decrease in the buffering capacity of soil (soil pollution, toxicity)] in Hungary, and identifying those areas at risk of land degradation.

An integrated GIS was developed according to the MERA Land Degradation Mapping methodology and guidelines based on existing soil, topographic, climate, hydrologic, etc. data.

Identification and delineation of the country’s major land degradation risk regions has been completed based on the existing maps of main limitations of soil fertility in Hungary (coarse texture, heavy texture, acidity, salinity/alkalinity, waterlogging, erosion and shallow depth of soils). Detailed descriptions of the land degradation regions and the delineated degradation units are provided.

Case studies were implemented for a demonstration of the applicability of Land Degradation GIS data for evaluation of the vulnerability of land and susceptibility of soils to various degradation processes in Hungary at 1:100,000 scale for:
- soil erosion by water;
- soil erosion by wind;
- soil acidification;
- soil salinization/alkalization;
- physical degradation (compaction, structure destruction, surface sealing).

Control of Soil Pollution

The transport and transformation of various elements in the soil are controlled by abiotic and biotic soil processes. Most of the elements occurring on Earth can be found in the soil, but their quantity, quality, solubility, mobility, availability for microorganisms, plants, animals and human-beings show an extremely wide spectra. Many of these elements are essential for living organisms, but over a certain "threshold concentration" the same elements can be harmful, or even "toxic" for the same organisms.

The presence of these elements in the soil can be due to natural sources:
- air (N, etc.);
- water (B, Na, N, etc.);
- soil and geological deposits as a result of local weathering (P, K, Ca, Mg, Na, Fe, Al, Mn, As, Co, Cu, Ni, Se, Zn, etc.), and can be due to various human activities (irrigation water, organic manure, liquid manure, mineral fertilizers, amendments for soil reclamation; sewage waters, sewage sludges, solid wastes; pollution by transport, industry, etc.).

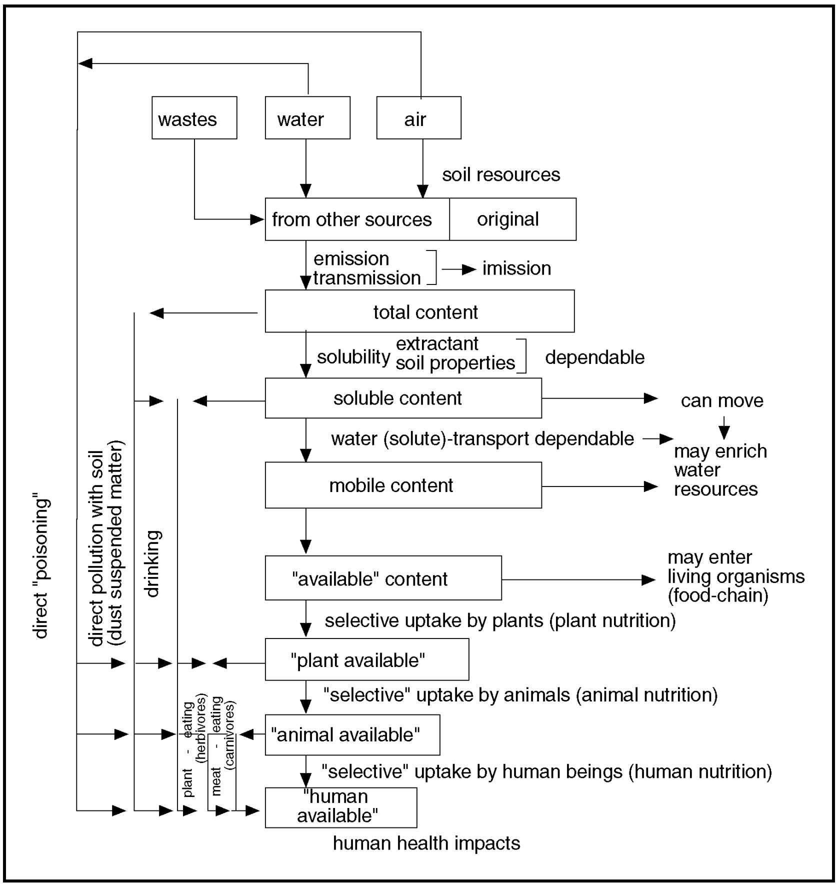

Figure 1. Sources and pathways of soil pollution

The evaluation of the content, state, regime and ecological impact of these elements necessitates the determination, evaluation and interpretation of the following criteria, as diagrammatically shown in Figures 1 and 2:

- "Total content" (interpreted as a potential "pool").

- "Soluble content". This quantity is highly solute specific. The "soluble content" depends on the characteristics of the given compound (e.g. solubility, electro-negativity, polarizability rate of oxidation, ability of complex formation) and on the soil properties (e.g. soils reaction and carbonate status, texture, clay content, clay mineral association, organic matter content and quality, absorption capacity, base saturation, exchangeable cation composition, moisture content, redox potential, microbial activity, etc.). The *in situ* soluble content depends to a great extent on plant-root activities.

  Insoluble compounds are immobile, unavailable for plants and consequently cannot be toxic (through the food chain) for plants, animals or human beings.

  The "Chemical Time Bomb" effect means that the concentration of a particular element may exceed a permissible (tolerable) concentration in soil and may become "toxic" without any additional loading of this element in the soil, as a consequence of changing soil properties. For example, increasing acidity helps the mobilization of numerous "potentially toxic" elements (most of the heavy metals, etc.), consequently the previously insoluble immobile non-toxic element can become soluble, mobile and toxic through acidification.

  The "toxic element mobilization hazard" of soil acidification can be predicted and prevented by using appropriate neutralization measures (e.g. liming, etc.).

- "Mobile content". Only the mobile fraction of elements or compounds can be transported and translocated to other places in the soil (by leaching, accumulation, migration), and may reach plant root surfaces or underground water resources.

- "Plant available content". In addition to the total, soluble and mobile content of a certain element in the soil, its availability for a certain plant depends on its selective ion-uptake, which is a plant-dependent characteristic (species, sort, variety, type). Only the available fraction of a given element can be phytotoxic for the plants, resulting harmful (or even lethal) changes in their metabolisms.

Consequently, the term "toxic element" is imprecise and not specific enough. A given element over its critical concentration can be toxic for certain soils (or more exactly for their biota), for certain plants, for certain animals, and for certain people. The identification of these relationships is a challenging task for future multidisciplinary research. The final result can be an imaginative "super-matrix" showing the potential "toxicity-pathways" under given circumstances (from the total content, through solubility and mobility, up to the availability for various plants, animals and human beings), indicating the potential features of bio-deterioration, their symptoms and further consequences.

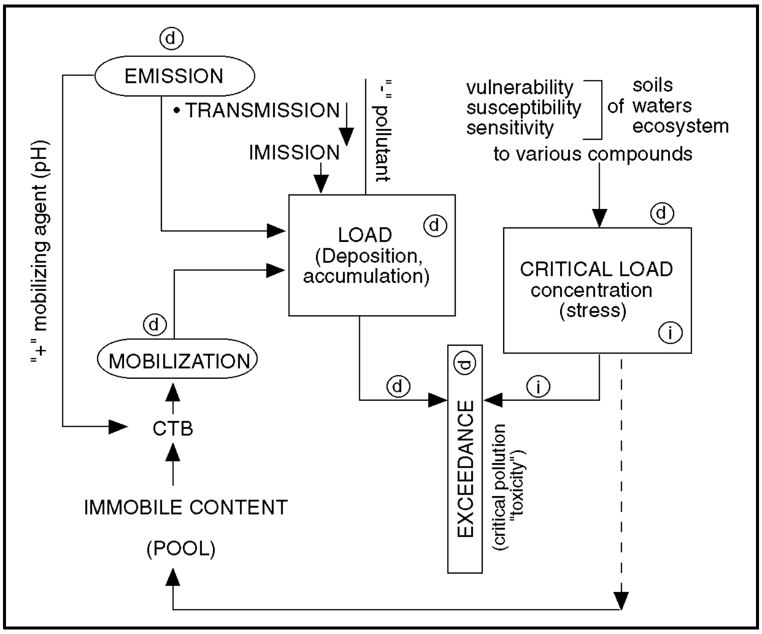

Figure 2. Strategy for pollution control (i: increase; d: decrease)

According to this concept and the available soil database, a series of maps are under preparation on the vulnerability of soils and groundwaters to various potentially harmful chemical pollutants such as nitrates, phosphates, heavy metals, other metals and other inorganic elements. GIS will be used for a territorial comparison of these vulnerability maps with the actual emission/imission and actual load maps exceedance. This will provide a good scientific basis for assessing the hazard of pollution and for its prevention or control.

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SOIL DEGRADATION STATUS AND DATA AVAILABILITY IN LATVIA

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Introduction

The land area of Latvia covers 6,459 × 10^3 ha, including 2,541 × 10^3 ha of agricultural land (of which 1,713 × 10^3 ha is arable), 2,881.2 × 10^3 ha of forests and woodland, 1,029 × 10^3 ha in urban and industrial areas, transport and other non-agricultural land, and 7,7 × 10^3 ha of water bodies. The inventory and assessment of land resources are considered important for management of the natural resources, economic planning and environmental protection in Latvia.

Soil surveys

Soil maps of all the agricultural land have been prepared at the scale of 1:10,000, showing differences in soil type, textural class, water retention, land use type and their suitability for specified uses. Currently, a 1:1 million scale map is being compiled for Latvia, in accordance with the guidelines of the European Soil Database and Soil Profile Analytical Database. This will be the first product in which our soil resources are characterized according to an internationally accepted methodology and nomenclature.

Besides the national soil survey, several other soil programmes are ongoing in Latvia. Between 1959 and 1991, soil fertility tests were carried out on agricultural land. Five cycles of analyses were performed during this period in order to study changes in soil pH, organic matter content, plant available P and S, as well as exchangeable Ca, Mg and K, and micronutrient content. This program is now operating on a "customer ask and pay" basis.

The National Agricultural Land Monitoring programme, which started in 1992, includes long-term observations regarding the anthropogenic impact on agricultural land, data acquisition, processing, analysis, storage, as well as prognosis (Vucans *et al.*, 1996). Several other projects are devoted to studying the distribution of heavy metals (Pb, Cd, Ni, Cr, Cu, Zn, Mn) in soils, plants and agricultural products. They are also aimed at determining natural background levels, emissions, depositions and pollution levels (Nikodemus and Brumelis, 1994; Filipovics and Pinke, 1996). Periodically, this information is reported by several national survey organisations (Environmental Consulting and Monitoring Centre, 1996; State Hydrometeorlogical Centre, 1997; Cadastre of the State Land Service, 1996).

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Soil degradation and pollution studies

The main type of soil degradation in Latvia is erosion. Inland areas with sandy and organic (peatland) soils, which are used for field crop production, and regions bordering on Baltic Sea are at risk from wind erosion. As many natural and human-induced factors influence the process and rate of wind erosion, detailed statistics and estimates of the impact of wind erosion are not yet available. Another important process of soil degradation is erosion by water, since a substantial part of Latvia has hilly morainic landforms. In the past, four classes of water erosion were distinguished using the criteria given in Table 1.

Table 1. Classes of water erosion

Class name	Slope (degrees)	Characteristic pattern
No erosion	0 - 5°	No significant movement of topsoil by water action.
Slight to medium	6 - 10°	Some loss of A horizon; part of the B horizon is mixed by ploughing.
Medium to strong	11 - 18°	Loss of A and part of B horizon; the C horizon is partly mixed by ploughing.
Strong	< 18°	All genetic soil horizons are lost; the C horizon is exposed.

The proportion of water-eroded soils is estimated at 17.3% of total agricultural land, of which 12.5% falls into the slightly eroded class, and 4.8% into the medium or strong erosion classes. There are significant variations in the extent water-eroded soils in the different administrative regions of Latvia, ranging from 0% in Jelgava up to 45% in Kraslava.

Besides water erosion, several other soil degradation factors can adversely affect soil productivity in Latvia. About 63% of the agricultural land potentially has a reaction (pH) which is too low for most major crops. This land should be limed periodically to reduce further acidification. Currently, 42% of the agricultural land should be limed, of which 19% needs basic liming and 23% requires maintenance liming. There is a general decrease in soil organic matter content in Latvia and soil compaction occurs locally.

A survey of heavy metal content in the soil currently covers only 20% of agricultural land, but this programme is ongoing. In general, the content of heavy metals (Cu, Zn, Pb, Cd, Ni, Cr) in the soil does not exceed the concentration in the soil parent materials. Therefore, they could be assumed to be at natural background levels which are significantly less than maximum concentrations allowed for EU countries. Some relative increases from the background levels were found along highways, close to urban areas and in some alluvial soils.

Nikodemus and Brumelis (1994) showed that the pattern of deposition of pollutants in the Baltic countries is determined by meteorological conditions, local point sources, and long range transport. Much of the region receives precipitation with neutral pH, caused by the presence of numerous cement and building-material industries, and basic fly-ash from fuel combustion. Major point sources of pollution which influence Latvia are the Narva oil-shale burning region (Estonia), the steel industry in Liepaja (Latvia), and the Mazeikiai oil refinery (Lithuania), as well as large thermal-electrical power facilities that utilize fossil fuel.

Conclusions

Significant changes within the last decade to the economy, social situation, production profile and attitudes to the environment in Latvia, reveal some activities which should be given further consideration. The main factors that are likely to affect soil productivity and soil vulnerability to pollution in the long run include:

- A significant decrease in the use of manure, commercial fertilizers, agricultural lime and pesticides in the period 1988 - 1997. These have led to reduced plant nutrient inputs into the soil and lowered the potential pollution risk. At the same time, however, they have resulted in depletion of soil fertility and increased acidification.

- The decrease in animal husbandry activities helps to solve the pollution risk from farm wastes, but at the same time reduction of soil organic matter occurs because of the very limited manure application and the dominance of crop rotations without perennial grasses and other fodder crops.

- Water management systems are not maintained properly. The associated decrease in drainage enhances soil reduction, which may increase the mobility of some compounds and thereby their leaching potential.

- The reduction of industrial activities, decrease of coal use in energy supply, reconstruction of waste treatment facilities, more strict regulations and their control have led to the substantial decrease of pollutant loads in Latvia.

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LANDSCAPE AND GROUNDWATER VULNERABILITY MAPPING EXPERIENCE IN LITHUANIA

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Background

Land and terrain vulnerability mapping in Lithuania started in the early eighties and since then several methodologies have been prepared. The most effective methodology was developed for mapping the vulnerability of soils with respect to water and wind erosion. Soil texture, slope class, agricultural intensity and other parameters were considered in order to assess soil vulnerability at the local, regional and national level. Special attention was given to protection measures, special development and planning policies were developed for protective actions against erosion, such as reforestation of agricultural land and converting ploughed land into grasslands. Maps used for spatial planning are on scale 1:300,000 to 1:50,000; these concern mainly land use and land management plans. Soil maps, at the scale of 1:10,000, are available for the whole country. A national soil database, which includes over 4000 soil profile descriptions, is under development.

Principles for landscape vulnerability mapping

A methodology for landscape vulnerability mapping has been developed. Data on land forms and flow structures are used for the delineation of areas with vulnerable zones. The association between gravity and the surface geometry, the importance to carry out mathematical operations over topographical surfaces, the definition of the border between divergence and convergence areas (called zero horizontal morpho-isograph), the mental separation of the topographic surface and the polluting substance area considered in the methodology. This approach allows for the delineation of zones considered of particular importance with respect to landscape functions, migration of pollutants and other materials in the landscape.

Principles for ground-water vulnerability mapping

Groundwater in Lithuania is contained within underground strata (aquifers) of various types. Abstractions from these aquifers provide water for domestic water supplies and varied industrial uses. Some aquifers are highly productive and important on a regional basis, while lower yielding aquifers may also be important on a more local basis. Groundwater provides a proportion of the baseflow for many rivers and watercourses and constitutes over 90% of Lithuania’s drinking water.

Groundwater is naturally of high quality and should require little treatment prior to use. It is, however, vulnerable to contamination from both diffuse and point source pollutants, from both direct discharges into groundwater and indirect discharges into or onto land. Aquifer remediation is difficult, prolonged and expensive and therefore the prevention of pollution is important.

Three 1:50,000 scale pilot maps have been prepared to assess the feasibility of transferring the UK groundwater vulnerability methodology to Lithuania. To assess the vulnerability of groundwater to contamination, consideration must be given to the distribution of aquifers, to the physico-chemical properties of overlying soils and to the characteristics of strata in the unsaturated zone. An assessment of the physical and chemical properties of the soil (see soil classification) is overlain, where appropriate, onto permeability characteristics of geological strata (see geological classification), to produce 10 groundwater vulnerability classes.

The production of these three maps should form the basis of future groundwater vulnerability work in Lithuania which will be an important tool in the protection of groundwaters.

Geological classification (scale 1:50,000)

Geological strata which contain groundwater in exploitable quantities are termed aquifers, whereas rocks which are largely impermeable and do not readily transmit water are termed non-aquifers. The very thick sequence of glacial deposits across the whole of Lithuania makes the soil/geological approach to vulnerability assessment inappropriate for the deeply buried Pre-Quaternary rocks. A four category classification of Quaternary materials has therefore been devised based on the permeability of the uppermost deposit. The categories at pilot areas comprise (Table 1):

- Type A: Extremely permeable.
  These allow the very rapid downward movement of water and offer little opportunity for the attenuation of pollutants. Where these deposits are extensive, both laterally and vertically, they have the potential to be highly productive. They include alluvial sands and gravels, glacio-lacustrine and fluvio-glacial gravels, and other sands and gravels.

- Type B: Highly permeable
  Water and soluble pollutants will move rapidly through these materials by intergranular flow. They may be highly productive where extensive. They include fluvial, lacustrine, glacio-lacustrine and fluvio-glacial fine grained sands and undifferentiated sands. Type A Aquifers may occur below Type B Aquifers.

- Type C: Moderately permeable
  These are unconsolidated deposits of varying permeability. Although they will seldom produce large quantities of water for abstraction they are important for local supplies and in supplying baseflow to rivers. They include lacustrine, glacio-lacustrine and alluvial silt,

sand and silty sand, and glacial till and peat. Type A and B aquifers my occur below Type C Aquifers.

- Type D: Low permeability
  These are formations which are generally regarded as containing insignificant quantities of groundwater. However, groundwater flow through such rocks, although imperceptible, needs to be considered in assessing the risk associated with persistent pollutants. Some Type D aquifers can yield water in sufficient quantities for domestic use and provide baseflow to rivers. In this district they include glacio-lacustrine clay, silt and clay. Type A, B and C Aquifers may occur below Type D aquifers.

Only the uppermost drift deposits are classified and there is no attempt to show the thickness of geological strata.

Table 1. Aquifer vulnerability classes

Geological classes (permeability)	**Soil classes** (leaching potential)
Type A Aquifer (Extreme)	**High**: H1, H2, H3, HU* **Intermediate**: I1, I2 **Low**: L
Type B Aquifer (High)	**High**: H1, H2, H3, HU* **Intermediate**: I1, I2 **Low**: L
Type C Aquifer (Moderate)	**High**: H1, H2, H3, HU* **Intermediate**: I1, I2 **Low**: L
Type D Aquifer (Low)	

* Soil information for urban areas and restored mineral works is based on fewer observations than elsewhere. A worst case vulnerability classification (H) is therefore assumed for these areas. All are given a designation HU until proved otherwise.

All maps involve a compromise between the representation of natural complexity and ease of interpretation of the map. Such compromises place limitations on the resolution and precision of map information. In this case, the variety of soils, geological strata and potential contaminants that have to be covered is wide, and the classification used is, of necessity, generalised. Individual sites and circumstances will always require further and more detailed assessments to determine the specific impact on groundwater resources. In addition, the maps only represent conditions at the surface and therefore, where the soil and/or underlying formations have been disturbed or removed, the vulnerability class may have been changed. Hence where there is evidence of disturbance there will be a need to determine groundwater vulnerability using site-specific data.

Soil classification

This classification groups the different soils of Lithuania into three soil vulnerability classes and six subclasses. Each grouping is based on the soil physical and chemical properties which affect the downward passage of water and contaminants. These include: texture, structure, soil water regime and the presence of distinctive layers such as raw peaty topsoil and gravel at shallow depth. The classification scheme is not applied to soils above Type D Aquifers.

- H: High Soil Leaching Potential

  This category is divided into 4 subclasses with soils in the H1 subclass having a greater leaching potential than H2 soils, and H2 soils a greater potential than H3 ones. Soils in this category show little ability to attenuate diffuse pollutants. Non-adsorbed diffuse pollutants and liquid discharges have the potential to move rapidly to underlying shallow groundwater.

  H1 Soils with groundwater at shallow depth throughout the year. Soils with gravel at shallow depth. Undrained peat soils with permanently wet topsoils.

  H2 Sandy or sandy over gravel soils with a low topsoil organic matter content.

  H3 Loamy soils with gravel at relatively shallow depth within the soil profile.

  HU Soils in urban areas, designated development or resort land and areas of past, or present mineral workings.

- I: Intermediate Soil Leaching Potential

  This category is divided into 2 subclasses; mineral soils are placed in subclass I1 and peat soils in I2. The soils in this category have a moderate ability to attenuate diffuse source pollutants. It is possible that some non-adsorbed diffuse source pollutants and liquid discharges could penetrate the soil layer.

  I1 Deep loamy and clayey soils unaffected by marked seasonal waterlogging, with a topsoil of low or moderate organic matter content.

  I2 Peat or peaty soils which have been drained for agricultural use.

- L: Low Soil Leaching Potential

  There is no subdivision for this category. Pollutants are unlikely to penetrate the soil layer because either water movement is largely horizontal, or they have the ability to attenuate diffuse pollutants. Lateral flow from these soils may contribute to groundwater recharge elsewhere in the catchment.

  L Soils with a clay rich subsoil which severely restricts downward water movement.

Conclusions

- National maps on land use, soil, geology, pollution and forestry are available in Lithuania.
- A new vulnerability map could be developed for Central and Eastern Europe, but the scale should be more detailed for smaller countries.
- The mapping methodology should be improved and developed during the project for bigger scale maps on national and local level.
- Single maps for different types of pollutants should be prepared because of great variety of pollutants and their varying impact on the environment.
- Lithuanian experience and methodology could be used for soil and terrain mapping in Central and Eastern European countries.

THE DEGRADED SOILS OF MOLDOVA: STATE AND ASSESSMENT

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[Compiled by E.M. Bridges based on the oral presentation by Dr V.G. Ungurean]

Introduction

The Republic of Moldova lies in south-eastern Europe. It has borders with Romania to the west and Ukraine to the east and south. It has a land area of 3,384 x 10^3 ha. Lying mainly between the Prut and Dneistr rivers, the elevation of the interfluves is everywhere less than 500 m. The landscape is dissected by the many tributaries of the main rivers to give a hilly relief. The plains alongside the rivers lie at about 147 m. The country may be divided into two natural zones formerly characterised by steppe and a forest-steppe vegetation.

Available maps

Maps are available at scales from 1:200,000 to 1:2.5 million covering relief, soils, climate, hydrology, biodiversity etc.

As a result of studies of Moldovan soils, it has been established that the most extensive soils are Chernozems (74%) Greyzems (10%) and Fluvisols (8%). Smaller areas of Gleysols (3.4%), Cambisols (0.7%) are present and locally Solonchak and Solonetz occur. Twenty per cent of the land surface has slopes of less than 1°, but a further 60% has slopes of between 1 and 5°. Landslipping is a feature of certain areas.

Agriculture occupies 2,557,300 ha, or 75.6% of the territory, and non-arable uses 364,600 ha. Vineyards and orchards both have an area in excess of 20,000 ha, and together cover approximately 12% of the cultivated lands. Information is available which enables the presentation of land degraded to some degree by erosion, amounting to about 20.8% of the territory.

Causes of soil degradation

Hilly terrain and torrential summer rains, combined with a lack of conservation measures have left the Moldovan soils susceptible to erosion. Moreover, there are no incentives for farm managers to conserve soil resources. Although a national agricultural extension service exists, it is purely technically oriented and offers little practical advice for a newly emerging group of private farmers. Unfortunately, the government has no resources to implement a national soil conservation plan. Figures which indicate the impact of soil erosion on the productivity are presented in Table 1. As a result of cultivation and low return of organic matter to the soil the humus content of numerous soils has declined.

Table 1. Impact of erosion on soil productivity in Moldova

Degree of erosion	Corn		Wheat		Sunflower	
	ton/ha	%	ton/ha	%	ton/ha	%
None	3.9	100.0	2.61	100.0	2.1	100.0
Slight	3.3	85.7	2.20	84.0	1.8	84.5
Moderate	2.6	67.5	1.55	59.3	1.3	61.0
High	1.6	41.6	1.15	44.1	0.9	42.2

Chemical contamination of the land in Moldova arises from the use of pesticides in agriculture and the activity of metallurgical and other industrial works. The potential sources of contamination from pesticides and fertilizers has greatly diminished over the past five years as pesticide and fertilizer use has decreased (Figure 1). Although the detection rate of pesticide in foodstuffs has increased since the 1980s, it is expected that this increase will not be sustained unless a return to high pesticide use occurs. Heavy metal contaminants in mineral fertilizers have contributed some toxic metals but the concentrations are not critical for reasons of health. Sources of point pollution are metallurgical factories, power stations, construction activities, wastes from food and wine production and domestic activities.

Actions required

It is necessary to develop and implement urgently a policy for soil conservation in Moldova. This can be done using the basic soil information held at present. It will be necessary to continue national surveys of agricultural chemical use and to keep under review the extent and rate of soil degradation. From this information a strategy must be developed for care of the soils.

Conclusions

Soil erosion and degradation are occurring at a high rate and the total area of eroded land has increased by 45% during the last 20 years, and now stand at 70,000 ha. Thirty per cent of the humus-rich topsoil has been lost in the last 100 years, at the average rate of 2.1 mm yr^{-1}. In total, this amounts to more than 20 million tons per year or 30 tons ha^{-1} yr^{-1}.

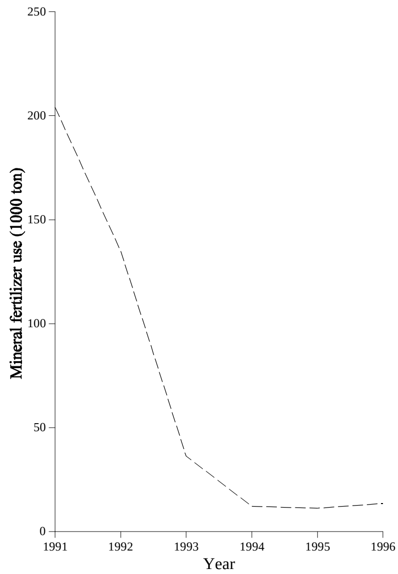

Figure 1. Changes in use of mineral fertilizers in Moldova (10^3 ton)

Table 2. Estimated annual social costs of environmental pollution and degradation in Moldova

Topic	US $ × 10^6
Social cost of health impacts from water pollution:	
- chemical	66-127
- microbiological	na
Social cost of health impacts from air pollution:	
- particulates	17-30
- lead	1.3-3.0
- sulphur dioxide	na
Productivity losses associated with erosion of agricultural lands	45-55
Impairment of water reservoir capacity	1
Economic impact of degraded forest ecosystems	na
Ecological impact of watershed degradation	na
Amenity and recreational values of natural resources	na
Biodiversity	na
Economic and health costs of municipal and hazardous waste management	na
Toxic discharges from industrial sources	na
Total order of magnitude	130-216

na: not quantified or available.

The soil which is being lost contains about 495,000 tons of humus, 78,000 tons of nitrogen, more than 18,000 tons of phosphate and 316,000 tons of potassium. The area of eroded land is increasing at an annual rate of 10,000 ha or 1.5%.

The steady extension of soil erosion and degradation has substantial implications for the long term sustainability of the land resources in Moldova. The regenerative capacity of the soils on slopes is very low, indicating that some of the soil resources of the country should be treated as "non-renewable resources". In addition to land losses through soil erosion, urban encroachment is responsible for the loss of productive arable land at an average rate of 1,500 to 2,000 ha yr^{-1}.

The impact of soil loss and pollution of the environment is not simple to quantify and in many cases figures are not available which will enable a calculation to be made. However, the figures provided in Table 2 suggest that agricultural losses in production amount to between 45 and 55 million US dollars, and that social costs from water pollution by chemical could be between 66 and 127 million dollars.

THE STATUS OF INFORMATIONAL RESOURCES ON SOILS IN POLAND

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Introduction

In Europe during the past ten years there has been improved communication enhancing the interest in implementing pollution prevention programmes at regional and even continental levels. However, developing a strategy for such activities requires a careful evaluation of natural resources. It is obvious that work at the regional or European level must be based on data in a compatible format. As far as soil and other related databases are concerned, the main difficulty arises from different evaluation/classification criteria used in national soil survey programmes. Evaluation of studies done within the framework of some European initiatives by UNEP and ISRIC provides evidence that accommodating the country-specific content and format of available information to the format of commonly accepted and uniform attributes is a challenge.

This report will characterize the databases on soil resources and environmental quality available in Poland with a special reference to the SOVEUR project objectives.

Soil maps and databases

In Poland during the last 50 years there have been a number of projects generating soil maps at different scales and content. The initial approach was based on genetic criteria and a 1:300,000 map reflecting the spatial distribution of major soil types was issued, according to Polish Genetic Classification (Musierowicz, 1960). The quality of this map is difficult to assess since the morphology of soil profiles was used as the main criterion to delineate areas of different soil types (polygons). The supporting analytical work was limited and no analytical data associated with that work are available today.

In the 1960's an extensive soil survey programme was started, resulting in the full coverage of soil maps at a scale of 1:25,000, containing information on soil types and soil suitability units (complexes) as associations suitable for growing different crops or groups of crops. This map was then generalized to produce 1:100,000 and 1:500,000 maps of which the later has been digitized and might be of particular interest for multipurpose GIS analyses (Koter and Oczos, 1973). Soil suitability units (complexes), forests, waters, hypsometry has been vectorized. A layer of physiographic units corresponding more or less to SOTER land forms is to be developed shortly. Both the map and the database need certain refinements and will become available by the end of 1997.

A map at a scale of 1:1,500,000 characterizing soil types according to FAO/UNESCO legend was generated, using the comparison table correlating the Polish classification system and that of FAO (Bialousz, 1994). As previously stated, the actual survey work conducted in the past was not designed to consider any particular aspect of the FAO system. Thus, the match between soil types distinguished and FAO units is quite loose. This map is available in a digital form.

In the soil survey programme, 5700 soil profiles representative of particular areas were described and analyzed for the following properties: texture, pH, organic matter, exchangeable acidity and aluminum, CEC, exchangeable Ca, Mg, K, Na, $CaCO_3$, and plant available P, K, Mg. The database is being maintained by the Institute of Soil Science and Plant Cultivation (IUNG). Each profile is characterized by its location, local geomorphology, morphology of horizons, category of water availability, texture, stoniness and chemical properties listed above. The extent of analytical work does not match the full list of mandatory properties used in FAO classification and SOTER approach. Therefore, it is not possible, using the existing profile analytical data to distinguish diagnostic horizons precisely. Some form of correlation and transfer functions will be necessary to derive the required information; however, assigning soils classified according to the Polish classification to corresponding FAO units will still be a matter of professional expertise (Marcinek, 1997). The most critical gaps in the soil profile database are the lack of bulk density data, colour according to Munsell scale, and the inconsistency between criteria for texture and structure types used in Poland and FAO system. However, these limitations could be ignored for the purpose of developing small scale maps. These profiles could become a valuable source of information on Polish soils. Although their coordinates are unknown at the moment, the georeferences can be established since all profiles are marked on the 1:25,000 topographic map. (Note: these maps did not have coordinates because of the ”security” constraints typical for the previous system of government).

There are at least three other resources relevant for environmental assessment and modelling available: a 1:50,000 geological map in a digital form with the comprehensive database, the IUNG database containing characteristics of 200 georeferenced profiles used for the state monitoring system (Terelak *et al.*, 1994), and 1000 georeferenced profiles established by the Institute of Agrophysics (Glinski *et al.*, 1991). Soil samples from these 1200 profiles are stored and can be analyzed according to FAO and SOTER requirements. It can be assumed that the spatial distribution of these profiles gives a good representation of the soil cover for Poland.

Information on land degradation status - contaminants and assessment criteria

In 1992, the country-wide monitoring programme was initiated collecting a total of 45,000 georeferenced soil samples from A horizons (0-20 cm) to measure the content of Cd, Zn, Pb, Cu, Ni, Cr and $S\text{-}SO_4$. Simultaneously, about 20,000 plant samples from main crops were analyzed for the content of metals. Properties important for mobilization/immobilization of metals such as pH, organic matter and clay content were characterized (Terelak *et al.*, 1994). The data used for further spatial analyses are loaded into the database using the DBF format. The original system for the assessment of soil pollution with metals, sulphur, and PAH's was proposed by Kabata-Pendias *et al*. (1993, 1996). The assessment is for a single metal, but when several metals contribute to the pollution, the evaluation is expressed as a synthetic index. Maps demonstrating soil pollution with metals and sulphur were developed in a digital form using a 1:500,000 scale (Terelak *et al.*, 1994, 1995). A digital map of soil degradation through acidification and a map demonstrating soil vulnerability to water erosion will be completed shortly. The vulnerability to water erosion is expressed as an index combining slopes, susceptibility of a given soil to erosion processes, and land use (Jozefaciuk and Jozefaciuk, 1992). Another aspect of fertility degradation demonstrated on digital maps is manganese reduction as a function of pH and temperature (Stepniewska *et al.*, 1996).

The information on the overall emission of metals, dust, SO_x, NO_x and some organic compounds is published annually for the major administrative units "wojewodztwo" by the Main Bureau of Statistics (GUS, 1996a). However, detailed information on emissions from a particular plant is not widely disseminated, and the respective databases are maintained by control and enforcement organisations. Maps of contaminant loading rates were developed for regions with a possible greater pollution impact (e.g. Silesia), but the data for most administrative units are available as hard copy tables only.

Land use digital maps at the scale of 1:500,000 and 1:3 million were developed by the Institute of Geodesy and Cartography based on the satellite images at scale of 1:100,000, collected for the CORINE project in 1992 (Ciokosz and Baranowski, 1996). The Yearbook published annually for the last 50 years, by the Main Bureau of Statistics, contains the data on the types of land uses for the administrative units (GUS, 1996b).

Soil vulnerability assessment

Most of the data needed for calculating the net accumulation of pollutants already exist. However, it is difficult to assess the movement of metals, and other contaminants associated with the use of sewage sludge (no data are available on application rates and spatial distribution), erosion by water and wind, and leaching.

The present and historic data on land use for all administrative units are accessible in tabular form. Data on N, P, K, fertilizers application are also available. However, the structure by land use and fertilizer type is unknown. This means that while the total amount of phosphorus fertilizers used in a particular region is known the data on the relative share of superphosphate, for example, are missing.

The survey for contaminants in fertilizers was conducted for P fertilizers to characterize the content of cadmium (Gorlach and Gambus, 1997). Analytical data for cadmium, and lead content of agricultural lime exist, however no systematic database has been established. It is worth emphasizing that the load of contaminants from fertilizers can be neglected, since according to available data, the metal thresholds for NPK carriers are not exceeded and their input levels are extremely low.

Other available data relevant for environmental studies and modelling are historical and present data on precipitation, air and soil temperature, humidity, wind speed and direction. There are also algorithms proposed that compute normal temperature and precipitation for any period, for 70,000 georeferenced points distributed regularly throughout Poland. An ArcInfo application was developed to visualize the output data.

Conclusions

The volume of available data characterizing soil and other elements of the environment is considerable, however, the inconsistency of methodologies and criteria used for data collection will be a true challenge to any attempt to work at the European level. Fortunately, adjusting the data to required common formats is possible for the purpose of establishing small-scale multi-layer maps and associated databases.

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REVIEW OF SOIL AND TERRAIN DATA, HUMAN-INDUCED SOIL DEGRADATION AND SOIL VULNERABILITY ASSESSMENT IN ROMANIA

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Introduction

One of the main concerns of the soil science community in Romania is how to best use, ameliorate and protect the soil and terrain resources against human-induced degradation. Public interest for these issues is high. Many of the post-revolutionary laws, for example the Land Reform Law (1990) and Cadaster Law (1996), contain explicit articles for the prevention of soil and terrain degradation. The current status of the soil and terrain resources in Romania is by far unsatisfactory and we expect it to become worse due a lack of clear policies on agriculture and rural development, environment protection, and the misuse of the soil and land resources.

This paper gives an overview the information, available in Romania, which can be used to reach the SOVEUR project objectives of compiling a set of generalized maps at scale 1:2,500,000 on soil and terrain, soil degradation and soil vulnerability in Central and Eastern Europe.

Compilation of a national soil and terrain (SOTER) database

In Romania, the SOTER methodology has been adopted since 1995 when we started to develop an enlarged nation-wide soil and terrain database at a scale of 1:200,000, known as ROMSOTER-200 (Munteanu *et al.*, 1996). Therefore, the information for a generalized 1:2.5 million SOTER database is fully available: physiographic and geological maps, 1:1 million; soils, 1:500,000 - 1:1 million; hydrology, 1:1 million; topography 1:200,000; eco-regions at 1:1 million scale.

The total number of soil profiles (by main soil types FAO/UNESCO, 1989) is 60 for measured data, and 28 for estimated ones. The correlation of national system of classification and FAO/UNESCO Legend is also available. The national profile database comprises more than 6000 profiles.

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

Compilation of map of status of human-induced land degradation

In Romania, the main national concern in terms of soil degradation and land pollution pertains to erosion, waterlogging, organic matter depletion, salinity, crusting and sealing, and compaction. Soil pollution although very severe, affects smaller areas, located around point sources, for example open mining, fertilisers industry, quarries, fuel industry, timber and paper plants, metallurgical plants, power stations, industrial cattle-breeding (pigs, cows, poultry). For most part of the main types of soil degradation, maps and statistical data are available (Table 1).

Existing criteria for assessment of pollution include comparison with: (1) the normal load or with maximum allowed limits (Kloke); (2) the class limits of the A-B-C types (Dutch system); (3) classes of heavy metals content, oil waste residues and biocides (HCH, DDT) residues, according to the loading/pollution index.

Table 1. Present-day status of soil degradation in Romania

Type of soil degradation	Area (10^3 ha)	Country (%)	Agric. land (%)
Water erosion and landslides	7002	29.3	47.3
Wind erosion	378	1.6	2.5
Temporary waterlogging	3781[1)]	11.7	25.5
Soil salinity	614[2)]	2.6	4.1
Soil compaction	6500	27.3	43.9
Crusting	2300	9.7	15.5
Organic matter depletion	7178	30.0	48.5
Acidification	3352	14.0	22.6
Sodication	228[3)]	0.9	1.5
Macronutrients (NPK) exhaustion	6246	26.2	42.2
Trace elements deficiency	1500	6.3	10.1
Chemical pollution	900	3.8	6.1

1) 1/4 human-induced; 2) 1/3 human-induced; 3) 1/2 human-induced

Compilation of soil vulnerability maps

In Romania we have already done some exercises of making nation-wide maps at a scale of 1:3 million with soil vulnerability to the different types of chemical contaminant, for example acidification and heavy metals (Rauta *et al.*, 1992). The premise was that each kind of soil is characterised by a specific vulnerability. In order to map soil vulnerability to chemical pollution, soil sorption (storage capacity) and buffering capacity were the two main qualities used, together with the ease of leaching (migration), biodegradation capacity, soluble salt concentration as complementary qualities. Each quality has been assessed on the base of a specific set of common soil characteristics selected from: texture, organic matter content, soil depth, soil reaction, type of predominant clay mineral, carbonate status, soil compaction degree, presence of an impervious layer, air-water conditions (redox potential), ground-water depth, climatic and relief (geomorphological) conditions.

Using this approach several maps have been compiled, including heavy metals and storage capacity, vulnerability to acidification, and ease of leaching/migration of chemicals through the soil. In all cases a range of these properties was employed, for example: very low/very slight, low/slight, moderate, high/strong and very high/very strong.

However, for making this new approach of soil vulnerability, according to the ISRIC recommendations/criteria, some difficulties arose. They refer mainly to data availability on fertilizer (contamination) composition, maps of (exceedance of) critical loads for acid deposition, nitrogen addition and data on amounts of contaminants removed with produce. This last type of data exist for some crops only at experimental plot level and generalization is difficult taking into account the high variability of soil and climate condition and the wide range of cultivars used. Information is scarce and scattered in different institutes organizations are also the other ones. However, georeferenced statistics are available since 1950/55 in National Yearbooks. Also climate and hydrology as well as land cover maps and statistics can be easy provided at country level (climate recording started since 1890).

Future trends of human-induced soil degradation in Romania

On the short and medium term it is expected that human-induced soil degradation will increase in Romania:

! water erosion is increasing in some hilly and dissected table-land regions, largely due to the poor orientation of peasants plots (i.e. at right angles to the contours) following private land tenure restoration. Many erosion control works have been destroyed. However, afforestation of the most severe degraded arable lands (at least 1.5×10^6 ha) is foreseen.

! increased risk of soil organic matter and macronutrients depletion caused by the drastically diminishing of use of fertilisers, both chemical and organic (manures);

! increased risk of soil salinization in embanked areas from flood plains (mostly from Danube flood plain) due high cost of maintaining the drainage network;

! increased risk of soil degradation (structure deterioration, compaction, salinization) in irrigated areas caused by mismanagement and high cost of rehabilitation of irrigation/drainage systems;

! as concerns soil pollution no scenario can be assessed. However, it is assumed that industrial pollution will decrease as the number of industries diminishes (e.g. mining).

What do we expect from the follow-up SOVEUR

Some ideas on how to continue and strengthen cooperation between countries participating in the SOVEUR project are given below:

! First of all, it is necessary to establish a list of priority problems.

! Develop a glossary of terms with a view to standardizing the technical language.

! Promote trans-border projects which would interest and hence obtain the support from several national governments. For example, a project on "Appropriate use and protection of soils of the Chernozem area" which might be undertaken by Russia, Ukraine, Moldova, Romania, Bulgaria, Hungary and Slovakia. Joint projects may embrace also large river basins, such as the Lower Danube River Basin.

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PROSPECT FOR MAPPING SOIL AND TERRAIN VULNERABILITY IN RUSSIA

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Background

The first attempt to combine soil degradation data collected by different ministries and institutes of Russia was undertaken by the Dokuchaev Soil Institute in 1988-89 in the framework of the project on Global Assessment of Soil Degradation (GLASOD), (Oldeman *et al.*, 1990). Since then numerous publications concerning negative human impacts on soil have appeared in scientific and public journals describing types of degradation, their nature, severity, rate of change, extent, consequences, etc. The basic data were collected and published in Government (national) reports on the status and use of land in Russia.

The GLASOD assessment for the Russian territory was based on data of varying quality, ranging from well-documented sources (i.e., on soil erosion) to assessments based on expert opinion (i.e., acidification). Degradation attributes were linked to soil polygons. A draft soil map of the former USSR at scale 1:8 million was used as a basis for this work.

The aims of present project are:

- to compile a new digital database on soil degradation of the European part of Russia with emphasis on the impact of soil pollution;

- to integrate soil degradation database with digital soil and terrain database at scale 1:2.5 million;

- to assess soil vulnerability to different pollutants for well defined soil pollution scenarios.

Materials

Officially the Former USSR did not have widespread ecological problems, so soil degradation was not widely discussed during the communist period. In spite of the fact that numerous official sources of information are currently available, a unified system to monitor soil pollution in Russia has not yet been established. It will be a major task to collect data on soil pollution for this huge area.

The basic sources of information recommended are:

1. A government report "Environment status of the Russian Federation in 1996", containing data on atmosphere, hydrosphere and soil pollution, including pesticides, agro-chemicals, pollutants of industrial origin (heavy metals, oil and oil products, polycyclic and aromatic hydrocarbons).

2. Government (National) reports on the status and use of land in the Russian Federation, with the maps at observational scale:
   - degree of heavy metals pollution;
   - vulnerability to polycyclic and aromatic hydrocarbon pollution;
   - vulnerability to pesticides pollution;
   - radionuclides pollution.

3. Observations on the background environmental conditions in the Russian Federation in 1996, provides information on soil pollution in the surroundings of 400 of the biggest cities of the country with some additional detail for administrative units "oblasts" on pesticides, heavy metals and fluorides.

Approach

Observations and sampling to determine the extent of soil degradation in Russia have not been on a very dense network because the polygons where soil pollution were mapped are very large. Therefore linking pollution attributes with the smaller polygons of a 2.5 million soil map is not practical. Thus the geographical part of the database will be taken from the physiography layer of the soil and terrain digital database. This database was developed jointly by the Food and Agriculture Organization (FAO) of the United Nations, the International Institute for Applied Systems Analysis (IIASA) and Dokuchaev Institute (Stolbovoy *et al.*, 1997).

Table 1. Application of fertilizers and pesticides in Russia

Compounds	1986	1987	1988	1990	1993	1994
Mineral ($10^9 \times$ kg)	11.1	11.3	11.3	9.9	4.3	2.1
Organic ($10^9 \times$ kg)	458.1	451.4	444.0	389.5	241.2	164.2
Pesticide ($10^6 \times$ kg)	-	-	-	136.5	-	45.5

Source: National Report (1995)

There is no officially acceptable assessment of soil vulnerability to different pollutants in Russia. Nevertheless, several scientific proposals based on a landscape geochemistry approach could be considered (e.g., Perel'man, 1972; Glazovskaya, 1979, 1981, 1990). Net element accumulation could be calculated by deducting the background (Clark) concentration from the currently measured values (see Clarke, 1924). It seems questionable to apply a mass balance method to an observational scale of research. In this context, the lack of historical data on fertilizer application and land-use change across the territory has to be acknowledged. Table 1 lists recent trends in application of fertilizers and pesticides in Russia.

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SOIL DATA AVAILABILITY IN SLOVAK REPUBLIC

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A systematic and detailed soil survey of all agricultural lands of Slovakia has been made and a partial, comprehensive database on Slovakian soils has been created since the Second World War.

In the first stage (1960-1970), the detailed soil survey was carried out. During this stage soil scientists described about 174,700 soil profiles in soil pits, from which about 400,000 soil samples were taken and analyzed. Average pit density was 1 pit per 16.6 ha. The result was, that for each community "terrier" and/or agricultural plan (of which there are more than 3,000) soil survey reports have been elaborated and three kinds of maps produced at a scale of 1:10,000:

- Soil map (soil unit, parent materials, etc.);
- Map of soil texture, gravel and waterlogging;
- Map of suggestions and arrangements for increasing soil fertility.

In addition, for each district of Slovakia (37 of them) reports and maps at a scale of 1:50,000 have been made for:

- Soils
- Soil texture, gravel and waterlogging
- Parent materials.

In district soil survey reports an appendix map at a scale of 1:200,000 depicts various characteristics including district soil resources (soil units, texture, parent material, climate and physiographic regions, humus content, base saturation, pH, lime requirement, P and K contents, etc.). The second stage concerns an evaluation of soil fertility which took place between 1972 and 1977. The most important results of this survey are:

- Map of pedo-ecological units (1:5,000)
- Map of pedo-ecological units (1:50,000).

Secondly, pedo-ecological maps were generalized at a scale of 1:200,000 and 1:500,000, and in particular, many kinds of applied maps of Slovakia produced at various scales, including maps of soil suitability for different crops and irrigation demand.

In the third stage, after finishing the detailed soil survey and the pedo-ecological units evaluation survey, the following maps were published independently or in the atlases:

- Soil map of Slovakia 1:1 million (for FAO project Soil Map of Europe, 1971, 1975);
- Agricultural Soils of Slovakia at scale 1:200,000;

Implementation of a Soil Degradation and Vulnerability Database for Central and Eastern Europe. Proceedings of an international workshop (Wageningen, 1-3 October 1997).

- Set of soil maps in Atlas of the S.S.R. (soil types: 1:500,000; soil texture and waterlogging: 1:500,000; potassium content: 1:500,000; phosphorus content: 1:1,500,000; humus content: 1:1,500,000; soil reaction and content of carbonates: 1:1,500,000; cation exchange capacity and base saturation: 1:1,500,000; soil geographical regions: 1:1,500,000; land evaluation: 1:1.5 million; contamination of soils: 1:2 million).
- Soil map of Czechoslovakia (1:500,000), agricultural and forest soils (in cooperation with Czech Republic).

The fourth stage is a period of new soil survey creating innovative soil maps of basic and applied soil characters. A morphogenetic soil classification system of Czecho-Slovakia was issued in 1987, and a revised edition in 1991. Since completing this work, the following soil maps have been elaborated using the new system, specifically:
- A synthetic soil map of Slovakia (1:200,000) - west Slovakia, with five criteria: soil units, soil texture, parent material, land gradient and climatic regions;
- A soil map of Slovakia 1:400,000 (with bilingual legend: Slovak M.S.C.S., FAO, 1993).
- Regional soil maps of Slovakia 1:50,000 (7 regions, 13,000 km^2, showing both forest and agricultural soils).

Also produced were maps showing:
- The nitrogen content (% N_t) in CSSR agricultural soils at the scale of 1:500,000
- Soil pollution in Slovakia (1:500,000)
- Soil resistance to acidification in Slovakia (1:500,000)
- Soil pollution (update) at the scale of 1:500,000.

The fifth stage represents a period during which soil maps have been digitized and databases have been compiled (Topol, Design CAD software and the latest ARC-INFO). Soil maps (basic and applied) already digitized are:
- Soil maps of pedo-ecological units of Slovakia (1:10,000);
- Synthetic soil map of Slovakia - map sheet Bratislava (1:200,000);
- Soil maps of Danube Catchment (3 maps at scale 1:50,000);
- Soil maps of model territories.

On the basis of the digitized maps and collected data about Slovakian soils the Geographical Information System of Slovakian Soils was built using data from 18,700 soil profiles (1 profile per 14 ha). The following data are available from this information system: soil units (types, subtypes), humus content, texture (fractions), pH, carbonate contents, sorption capacity, P and K contents, yield potential and other derived characteristics. A map (1:500,000) of nitrate potentials in Slovakian agricultural soils was derived from the database, and at the same scale a map of soil yield potentials. Maps of water and wind erosion of Slovakian soils (1:500,000) also were produced by GIS.

A special information system was built on Soil Parameters Monitoring concerning 228 monitored agroecological sites throughout Slovakia. Many physical and chemical parameters are available with possibilities for many special interpretations. The newest map of soil pollution (1:500,000) was created with help of this kind of information system.

The geochemical survey of Slovakia is finalized now with density 1 profile per 10 km^2 (containing analyses of 5,170 agricultural and forest soil profiles). The following elements were determined in the soils sampled: Al, As, B, Ba, Be, Bi, Ca, Ce, Co, Cd, Cr, Cs, Cu, F, Fe, Ga, Hg, K, La, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, Sb, Se, Su, Sr, V, W, Y, Zn (total contents). The results were entered into a database. Single-element and associated geochemical maps are being created.

More detailed information about soil databases and maps in Slovakia can be obtained from the Soil Fertility Research Institute in Bratislava.

THE POSSIBILITY OF THE UKRAINE PARTICIPATION IN THE SOVEUR PROJECT

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Introduction

Soil research in the Ukraine has long-standing traditions connected with the names of V.V. Dokuchaev, N.M. Sibirtsev, K.K. Gedroits, A.N. Sokolovsky and many other scientists. Pedology as a branch of science and the basis of agronomic practices in the Ukraine has been developed over the past hundred years in close connection first with the Russian and later with Soviet school of pedology. Ukraine had certain advantages, because it was able to utilize the achievements of the Russian school, but disadvantages were experienced as contacts with the external world were diminished. The SOVEUR project will provide valuable contacts with soil scientists of neighbouring countries.

Available analytical and cartographic data for the project

To execute the SOVEUR project, the following soil maps of the Ukraine, together with additional analytical data, could be used:

- A map presenting 78 soil subtypes (joined into types) differentiated by parent material, humus content, humus layer thickness. Data on acidification, salinization, granulometric composition are shown with out-of-scale conventional symbols. Complexity of the topsoil is shown with the contours of soil complexes. The scale of the map is 1:750,000.

- Two maps with similar legends including 40 soil subtypes differentiated by parent material. The scale of the maps is 1:1,500,000 and 1:2.5 million. If any adjustment will be necessary, soil map of the Ukraine of the 1:200,000 scale could be used. The map is based on the Gaussian projection in the coordinate system of 1942 using international conventions. The 169 sheets of the map have a trapeziform shape and cover 1° in longitude and 40' in latitude. The map is made on the basis of information contained on local soil maps. It includes 198 soil subtypes and parameters are depicted with conventional symbols including: degree of soil erosion, granulometric composition, soil parent material, kinds and degree of gleying, details of soil complexes and type of salinization.

Besides these maps, all land users of the country have soil maps of 1:10,000 or 1:25,000 scale with detailed mapping of the topsoil and analytical materials in the form of soil sketches.

Local maps at the scale of 1:25,000 and 1:50,000 also exist, showing topography and soils are differentiated by parent material, degree of erosion, granulometric composition, salinization and gleying. Land use maps of 25 regions of the Ukraine are available at the Institute for Soil Science and Agrochemistry Research together with their accompanying analytical data.

In the years after the soil maps have been made (1957-1961), our understanding of both soil genesis and soil transformation caused by intensive land use has been revised considerably. Therefore, existing information on the soil resources and their status is not fully appropriate for the present situation. Nowadays, efforts are being made to update maps and databases. Soil classification and diagnostic methods are being improved, and enhanced versions of topographic maps are available in the form of photo-charts. Many additional maps of geomorphology, geology, hydro-geology, plants and climate are published at different scales.

From 1961 to the present day, the main efforts of soil scientists have been directed towards investigation of the changes occurring in the soil under agricultural use (Table 1). The following subjects were studied extensively: organic matter dynamics, soil nutritive regime, some physical parameters (particularly, soil bulk density and moisture regime), physico-chemical and microbiological properties and soil pollution. Together, all of these properties give an indication of the level and intensity of the degradation process.

Table 1. Changes in soil and agro-chemical indices in the Ukraine (period 1961-1991)

Zones	Annual loss of plant available nutrients (mg / 100 g)			Humus (10^6 kg ha^{-1} yr^{-1})	Soil loss by (10^6 kg ha^{-1} yr^{-1})	
	N	P_2O_5	K_2O		water erosion	deflation
Wooded district	−0.04	+0.15	+0.04	−0.07	3.5	1.2
Forest steppe	−0.09	+0.10	−0.11	−0.07	12.8	0
Steppe	−0.08	+0.08	−0.23	−0.10	23.9	1.5
Ukraine	−0.08	+0.10	−0.15	−0.10	19.1	1.0

As a result of these investigations the following materials are known to be available:

- a schematic map of the humus content in the soils of the Ukraine;
- rates of annual humus losses for each administrative region during the past 100 years;
- agro-chemical maps describing level of soil phosphorous and potassium and the dynamics of their variation during the last 25 years (5 agro-chemical examinations were carried out);
- similar maps for pH;
- maps of soil erosion (for arable land and for agricultural land separately) for each administrative region;

- maps of the assessment of the effective soil fertility (assessment scheme of 13 degrees arranged in 5 quality classes);
- schematic maps of the danger of soil compaction;
- schematic maps of the danger of soil pollution by heavy metals in the land neighbouring industrial enterprises;
- schematic maps of the agro-ecological condition of irrigated lands (by the indices of ground-water table, mineralization, degree of salinization in the layer of 1 m, degree of alkalinization in the layer of 0 - 30 cm);
- a schematic map of the agro-ecological condition of drained lands (by the indices of secondary swamping, siltation, secondary acidification and aluminization, ferritization and carbonate enrichment, salinization and alkalinization);
- different synthetic maps of the soil zoning for the purposes of the topsoil rational use and conservation.

In recent years, great attention has been given to the problem of soil pollution by radioactive components, heavy metals and pesticides residues. Information was collected upon all sources of pollution, fertilizer applications, yield of agricultural crops and content of pollutants in agricultural crops. Also, data on the content of pollutants in the atmosphere, surface and ground-waters are available. Criteria for estimation of soil pollution are determined, however, detailed maps of soil pollution and the balance of certain pollutants have not yet been developed. The data on pollution of soil and agricultural products are incomplete.

Conclusions

The availability in the Ukraine of cartographic and analytical material on soils allows the country to contribute to the SOVEUR Project. The main difficulties anticipated are:

- correlation of the national soil classification with FAO classification;
- transformation of the available cartographic and analytical material taking into account methodological requirements of the SOVEUR Project;
- collection of missing data available in the archives of different institutions (particularly, data on soil and agricultural production pollution, etc.).

Taking into account substantial amount of the preliminary operations and considerable time necessary for the works carrying out, I hope, that participation of research group from the Ukraine will be supported financially. As Director of the Institute for Soil Science and Agrochemistry Research, I will do all my best for to ensure successful implementation of the investigations.

Further reading

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