Soil Survey and available Soil Data in Lithuania

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Introduction

The Republic of Lithuania is mainly flat (51%), separated by highlands (21%) and plateaus (29%). Lithuania is situated in the middle of Europe, with an area of 65,305km^2, 58,794km^2 of which is covered by soils (Eidukevicene, 2000). According to data of the State Land Cadastre for January 1999 the total agricultural land in Lithuania is 3,496,761.27ha. These data include all areas used for agriculture. About 1,605,689ha are in private ownership.

Soils are the main natural resource of Lithuania and, because of this, agriculture is a very significant contributor to the GNP. Lithuania has 99km of Baltic Sea coastline, and borders Latvia (610km) in the north, Byelorussia (724km) and Poland (110km) in the east and south, and the Kaliningrad Region of the Russian Federation (303km) in the southwest. Currently the country is divided into 10 counties, 44 districts and 12 municipalities. The total number of inhabitants is 3,704,800 (1998), of which the rural population is 32% and the urban population 62%. The population density is 56.7 people per square km. The capital of Lithuania is Vilnius, with 578,600 inhabitants. Other major cities are Kaunas with 415,800 inhabitants, Klaipeda - 202,300, Siauliai - 147,100 and Panevezys - 133,600. Average life expectancy for men is 65 years and for women 76 years.

The first development in soil science and plant nutrition research in Lithuania started in the 16th century, related to valakas land reform in the Grand Duchy of Lithuania (Eidukeviciene, Eitminavicius, Eitminaviciute at al., 2000). Within these developments there are the elements of applied knowledge about the earth and some additional knowledge about its quality. Professor Michel Oczapowski (1788-1854), at Department of Agriculture of the Vilnius University, made the first classification of local soils with emphasis on their physical properties. These activities were related to agro-geology as was the case in western universities. In 1832 after Vilnius University closed, the activities of the Department of Agriculture were also stopped. Almost a century later in 1922, in an independent Lithuania, agricultural studies were renewed at Kaunas University, and in 1924 at the Stephen Bathory University in Vilnius, which at that time was occupied by Poland.

The research on applied soil science and plant nutrition was started at the beginning of institutionalisation of these sciences - at the Academy of Agriculture (the institution of higher education, 1924) and at the Agricultural Investigation Office (1938). Prof. Viktoras Ruokis (1885-1971) founded the Lithuanian school of pedology. Prof. Juozas Tonkunas (1894-1968) laid the foundations for field trial methods. Various experimental stations both at the Academy at the Institute of Agricultural Research and in the places with different soil cover of Lithuania, have been established.

After World War II, the fundamental and applied soil science and plant nutrition research started in Lithuania. They were, and still are, developed at the Lithuanian University of Agriculture (Prof. Bronius Baginskas, 1903-1991), the Lithuanian Institute of Forestry, the Lithuanian Institute of Agriculture, the Institute of Ecology (Dr. Habil. Ona Atlavinyte, 1916-1991) and the State Land Survey Institute (Vaicys, 2000).

Soil Mapping in Lithuania

Maps of Quaternary deposits and geomorphology of different scale were compiled and recently updated at the Institute of Geology and Geological Survey of Lithuania. The agro-climatic data for the whole area of Lithuania have been collected and stored in the Lithuanian Survey of Meteorology.

This information can be used for the application of Lithuanian Soil Database (LTdDB) by special agreement.

Soil maps of Lithuania are mainly based on the results of large-scale field drilling, profile description, sampling and laboratory analysis mainly at the State Land Survey Institute (VZI). The activities of the Department of Soil Science of VZI, amongst others, include field soil survey at various scales and land evaluation for land reform now going on in the country. The VZI and other institutions hold very large soil research and land use data sets, covering more than 3 million ha and experimental data of plant nutrition and fertiliser application of different arable soils, collected during the last 40 years of soil survey and scientific research activities.

This information is stored in the form of maps, tables and published papers in archives. However, none of these institutions has a database to store and manage this valuable information, and a comprehensive computerized soil information system is now needed. This would enable a proper inventory of data quality to be set up and timely application of soil data to the pressing environmental and land use problems that confronts Lithuania today.

The Agrochemical Research Centre (ATC) of the Lithuanian Institute of Agriculture (LZI) holds the data and general maps of pH_{KCl}, liming requirements, contents of available P, K (4 periods of investigation), Mg, microelements and organic matter. LZI, as well as the Department of Soil Science and Agrochemistry of Lithuanian University of Agriculture (LZUU), has agricultural crop yield data from experimental plots of plant nutrition with different amount of fertiliser applications.

The Department of Soil Science and Agrochemistry of LZUU also deals with the new Classification of the Soils of Lithuania LTDK-99, that conforms with soil cartography methods, the systematisation of the soil cover structure and with the legend of FAO-UNESCO World Soil Map (1990, 1997) and World Reference Base for Soil Resources (WRB, 1998). The Lithuanian Forest Research Institute (LMI) and the Lithuanian Forest Inventory and Management Institute have some data sets of research and investigation into soils under the forests.

The VZI, LZI, LMI and LZUU hold very large soil and land use data sets, covering more than 3 million ha together with experimental data relating to application of fertilisers on arable land with different soils, collected during 40 years of soil survey and research.

In 1992-1995, an active scientific Research Programme on ‘Soil Cover Systems of Lithuania to Adopt FAO-Unesco Soil Classification’ has been set up at LZUU. In 1993, the attribute database of Fertiliser Experiments (plant nutrition) (TBDB version 1.0) of ATC was set up. Version 1.1 of TBDB was finished in 1995. Also in 1995, the main part of the attribute Lithuanian Soil Profile Analytical Database (LTdpaDB) was set up. The main problems still are that almost all data are not geo-referenced and not standardised in terms of description and analyses.

Land Reform is under way in Lithuania, and emphasis on rural development and particularly on environmental pollution is also ongoing. However, none of the institutions mentioned above has a DBMS/GIS to store and manage fully developed attribute TBDB and LTdpaDB databases and other environmental information on soils. To store and manage this valuable information, a comprehensive computerised Lithuanian Soil Database (LTdDB) is now needed. This would enable the proper inventory of data quality and timely application of quantitative soil data to the pressing environmental and land use problems that confront Lithuania today.

There is a need to have a soil information system accessed through a user-friendly menu-driven query and retrieval system, which is operated as an on-line service to extension offices of the Ministry of Environment of the Republic of Lithuania and the Ministry of Agriculture of the Republic of Lithuania. The scientists and technical specialists could use such a database to gain information about specific points and areas as well as other soil attribute data.

Data Type and Volume

The LZUU, VZI, LZI and LMI in Lithuania have been and still are the principal centres for soil and crop science and for the investigation of the agricultural environment of Lithuania. At these institutions there are now about 75 soil scientists, of whom 6 are professor doctor habilitates, 21 are associate professors, 25 doctors of sciences, and 23 are soil scientists. At the Soil Department of VZI, the Agrochemical Research Centre, the Voke and Vezaiciai Branches of LZI, the Soil Science Department of LMI and the Department of Soil Science and Agrochemistry of LZUU with some support have ongoing research on:

- Properties of soils, evaluation of productive space as a basis for regional distribution of crop production;
- Hazards of erosion and industrial pollution soil environment and factors affecting crop and agriculture plant yields and their regional distribution;
- Environmental factors affecting the effectiveness of fertilisation;
- Nutrient balance in plants and soils;
- New varieties of cereal and fodder plants and their yield potentials;
- Land evaluation;
- Research on soil cover structure systematisation and soil cartography methods for formalisation of soil mapping;
- New Classification of the Soils of Lithuania LTDK-99 to adopt the World Reference Base for Soil Resources (WRB, 1998).

Scientific research and the information based on collected data in VZI, LZI, LMI, LZUU and in some other institutions involved in agricultural, environmental and soil research in Lithuania has been published nationally and internationally. Soil data for Lithuania under VZI, LZI, and LZUU control is stored in the form of manuscript-maps, tables, diagrams and some in published papers in archives. This information has been used as a basis for the production of soil maps for Lithuania at different scales (1:10,000, 1:50,000 and 1:300,000). In wider use are the manuscripts of:

- Soil (type and variety) maps at various scales (1:10,000-about 10,000 maps for each former farm up to 1991; 1:50,000 - 44 maps, for each region; 1:300,000 - 1 map for the whole country (Juodis, Kasperaitis *et al*, 1985);
- The maps of soils of the forest area of Lithuania at scale 1:10,000 (under the control of LMI and other forest research institutions);
- The Map of the Relief of Lithuania at scale 1:300,000 - 1 map covering the whole country;
- The Morphoisographic Map of the Land-Surface of Lithuania at scale 1:250,000;
- The Map of Organic Matter Content in Soils of Lithuania at scale 1:300,000 - 1 map for the whole country and some areas mapped at a scale of 1:10,000.

In addition to the above (basically soil maps based on the genetic soil classification used in Lithuania until 1996) there are also:

- Soil-agricultural maps at 1:10,000 scale - about 10,000 sheets, with soil texture, wetness and stoniness;
- Land evaluation maps at scale 1:10,000 defining the quality of the soils in terms of agricultural usefulness;
- General maps of pH and lime requirements, and contents of available P, K, at the scale of 1:10,000 for former farms until 1991, and (for some areas) Mg and trace elements.

Point Soil Data

The analytical data for 7,000 soil profiles as well as detailed soil profile descriptions are representative of the major agricultural and forest soils covering about 4 million ha of arable and forest land in Lithuania. These data contain the main soil properties:

- Soil texture (STX, N. Kacinsky method);
- Humus content;
- pH_{KCl}, exchangeable and potential acidity;
- Content of mobile Al;
- Base cation contents, contents of available P, K, and Mg (major plant nutrients);
- Calcium carbonate content.

They include also:
- Point data of physical properties (mainly bulk density) of soils at 100 points;
- Point data of chemical composition of soils at 200 points;
- Point data of total chemical composition of the clay fraction at 100 points;
- Point data of heavy metals and trace elements As, Cd, Cr, Ni, Pb, Se, V, Co, Cu, Mn, B, Mo and Zn, also S content in soils;
- Point data from experimental plots.

Data of the yield of different agricultural crops and plants are from 2,000 experimental sites with different applications of fertilisers in all prevailing soils throughout Lithuania. All these data come from over 1,000,000 points located throughout all Lithuania. The greatest sampling density was in experimental stations and vegetable and fruit growing farms.

There are also point data of the yield of different agricultural crops and plants from 2,000 experimental sites with different fertiliser application rates on representative soils throughout Lithuania. Now, there are some positive changes - more institutions (Geological Survey of Lithuania, Institute of Geology and Geography and others) are involved in some research on soil science also.

GIS-based Soil Maps

As mentioned already, over the past decades in our country research has been conducted into soil properties. The programme for developing a Land Resources Information System of Lithuania (LTlrIS) has been started with the support of FAO. VZI has successfully carried out pilot studies in two administrative regions. It was also used to introduce the new Classification of the Soils of Lithuania LTDK-99 (Buivydaite, Vaicys, Juodis, 1996, 2001) and the creation of the first Soil Database of Lithuania (LTdDB) based on Geographic Information Systems (GIS) – see Figures 1 and 2).

The proper study of the terrestrial environment, of which the soil is the central component, requires the ability to integrate and manipulate a large amount of data from various points of landscape, i.e. spatial data. This is in recognition of the fact that much of the relevant data needs to be captured in computer compatible format, and this task will take a long time to complete. For Lithuania, about 1,100 soil map sheets (at 1:5,000, 1:10,000, 1:50,000 scale) needed to be digitised or scanned and vectored. In the view of the very large initial costs of collecting the information, it is highly desirable that all relevant already collected data should be stored in a computerised database. There is need to continue with the creation of a comprehensive LTLIS and an integrated part of it – LTdDB. After completing it for the whole country, the establishment and use of LTLIS would facilitate the best strategy for use and proper management of arable land and better protection of the environment in Lithuania.

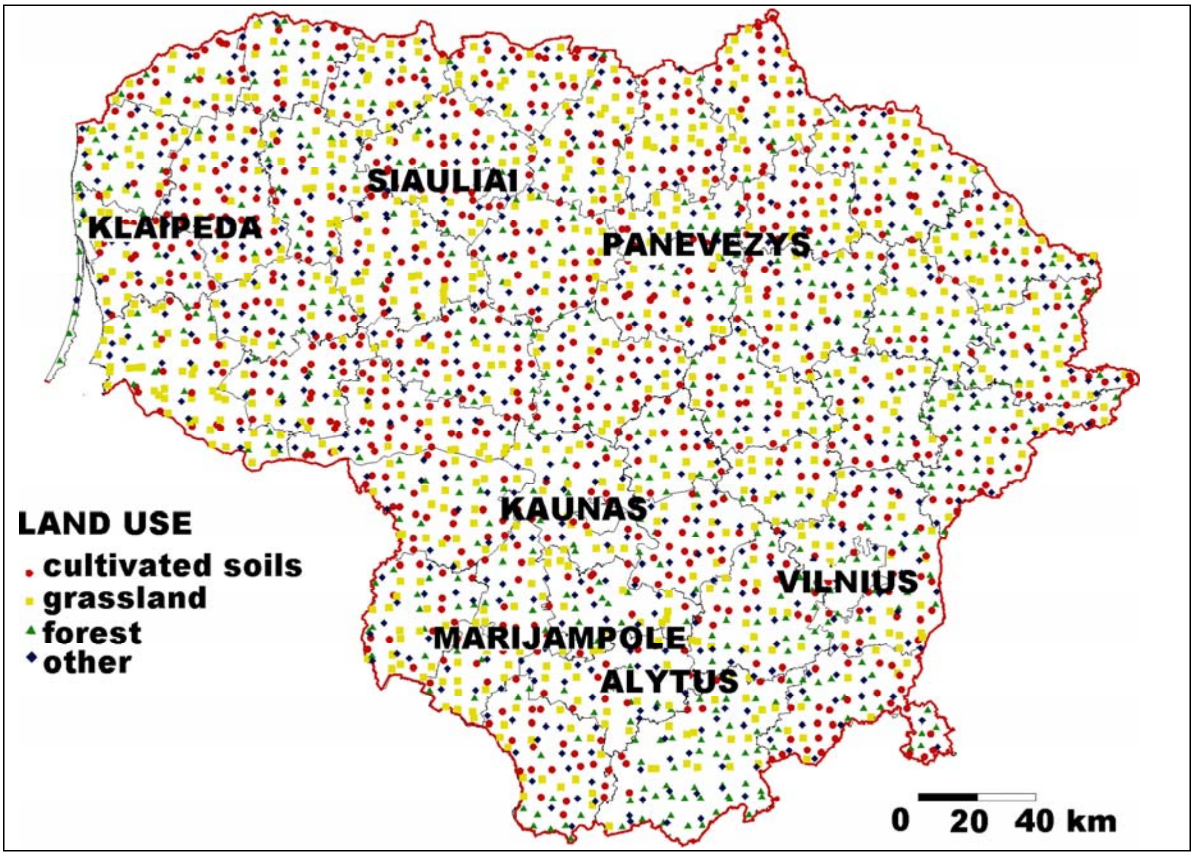

Figure 1: Land use at the sampling sites

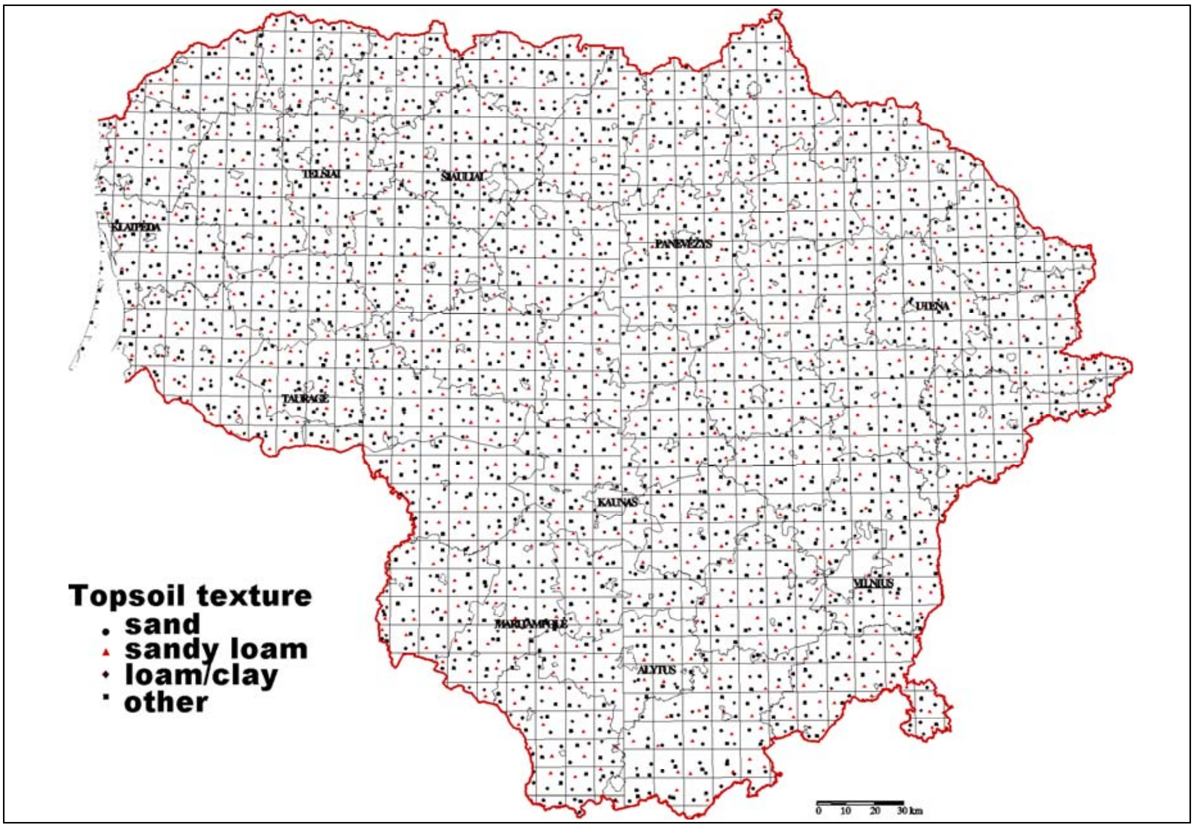

Figure 2: Topsoil sampling sites

LTLIS also would be beneficial for agricultural productivity and food quality through the improvement of the institutions involved in consulting and advisory activities. As a system, LTLIS is needed for land management to ensure sustainable land use not only for agriculture, but also for safe application of waste materials, land consolidation, soil erosion and estimation of other types of soil degradation. Specific needs would centre on the protection of land from degradation, whilst maintaining productivity, and minimising pollution. The ready use of LTdDB would allow the best strategy for use and proper management of arable land and better protection of the environment in Lithuania.

New Classification of soils

A soil classification system is not a natural thing that can be devised for particular uses. In Lithuania several different systems have been used. Sometimes it has been the goal of soil scientists dealing with soils, with different understandings, how to determine the nature of the soils of the country. One of the main approaches has been presented in the Systematic List of Soils of the Baltic States, published in 1953 in Pocvovedenije. This system, with corrections in 1965, 1979, 1992 and updates in 1996, has been used until now and is currently used as General Systematic List of Soil Typological Units (STU) of Lithuania TDV-96. Now, the new Classification of the Soils of Lithuania LTDK-99 based on FAO-Unesco Soil Map of the World revised legend (1990, 1997) and WRB (1998) has been developed.

The New Classification of the Soils of Lithuania has resulted from the research carried out at the Soil Science and Agrochemistry Department of Lithuanian University of Agriculture since 1992 (V.V. Buivydaite), since 1994 in the Department of Forest Soils, Typology and Hydrology of Lithuanian Forest Research Institute (M. Vaicys), and since 1996 in the Soil Department of the State Land Survey Institute (J. Juodis). The work has been done with the support of the members of scientific working group - R. Sleinys (Voke Branch of the Lithuanian Institute of Agriculture), M. Eidukeviciene (Klaipeda University), J. Jasinskas, J. Grybauskas, A. Juozokas, K. Gustaitis (State Land Survey Institute), J. Mazvila (Agrochemical Research Centre of the Lithuanian Institute of Agriculture) and B. Jankauskas (Kaltinenai Experimental Station of the Lithuanian Institute of Agriculture).

During the development, specific questions on Lithuanian terminology of soils has been discussed and worked out with A. Motuzas (Soil Science and Agrochemistry Department of Lithuanian University of Agriculture).

The efforts and success of the Lithuanian Soil Science Society in organising field expeditions for the soil scientists of Lithuania with the participation of leading soil scientists from Latvia, Estonia, USDA, UK, FAO, France and the European Soil Bureau have been important. With the support of the M. Vasiliauskiene (Department of Agriculture and Forest of Lithuanian Academy of Science) several scientific conferences on soil classification has been organised.

The genetic soil classification of Lithuania used in agriculture and forestry since 1953 has been newly revised and correlated following the creation of the Lithuanian Soil Database in 1996 and the setting up of the General Systematic List of Soil Typological Units (STU) of Lithuania TDV-96. It has 98 STU and been used as a background for the new comprehensive classification of soils of Lithuania. During the work on the first version of the soil classification, major soil groups and subgroups have been included with FAO-UNESCO Soil Map of the World, 1990, and later on, with the latest version of the Classification of the Soils Lithuania DKL-99 - with Soil Map of the World Revised Legend with corrections and updates, 1997. As a basis for third and lower level soil typological units, the World Reference Base for Soil Resources (WRB 1998) has been used. WRB has been developed to help encourage all scientists and agriculturists to use the same soil nomenclature; to use the same basic system, and third level soil typological units for more detailed work is proposed. It is intended to ensure that soil information is easily available and can be interpreted for use by land users (farmers), planners and scientists.

The usefulness of a set of soil names depends on a common understanding among the users. It is a fact that some soil properties irrelevant to one user may be important to another. Each significantly different group of users is therefore likely to need a special classification system. Economists, engineers, and pedologists may also classify soils but in very different manner.

In Lithuania, there are probably no two soils that are identical in all respects. The name of the soil in LTDK-99 means only that specified soil properties are within stated limits. In WRB, enough variation is allowed for a name to be given to extensive soil areas in spite of differences in some properties. A particular Lithuanian soil name means that the soil has certain specified properties.

In the new publications the soils of the country (Lithuanian Soils, 2000, 2001) are described also on the basis of the WRB explanation of diagnostic and other horizons, diagnostic and some other properties, diagnostic and other soil materials. Other characteristics in relation to the soil name, soil colour and clay content might be among the differentiating characteristics for a particular soil.

On the basis of these characteristics and organic-matter content there are also explanations of the soil master horizons and/or layers. There are 12 major groups of soils in Lithuania - level I of the classification: Regosols (RG); Leptosols (LP); Cambisols (CM); Luvisols (LV); Planosols (PL); Albeluvisols (AB); Arenosols (AR); Podzols (PZ); Gleysoils (GL); Histosols (HS); Fluvisols (FL); Anthroposols (AT).

There are given explanations of the formative elements of soil typological units of the 46 soil subgroups - level II of the classification. Additional characteristics are associated with 188 soil typological units of level III, 12 units of level IV and 43 differentiations at soil phase level. For the particular group of soils, the soil phase would apply to a soil having differentiating characteristics, and it is in the soil definition.

During the last decades of soil investigations a great deal of information has been gathered about each soil of the country - descriptions of the physical and chemical properties, of its various uses, of its response to management. The New Classification of the Soils of Lithuania is designed to simplify this mass of information and make it manageable. Although on different levels it has 235 STU, the system is organised in such way that the above-mentioned knowledge and research material on soils is arranged in a meaningful way. It emphasises important points and ignores irrelevant details.

It was not easy to combine the taxons of genetic classification with the World Soil Map Legend and WRB, because the old classification of soils of Lithuania in some cases was too detailed, in other cases too coarse. Also there was much discussion on differentiation of the Cambisols and how to place them as the one of the prevailing soil groups.

The New Classification of the Soils of Lithuania LTDK-99 is based on soil investigations in the field, the fundamental and applied sciences expected to be the important reference guide for soil survey and evaluation of land resources for sustainable land use in the country, until in future the soil classification will again be changed to a new system. As knowledge increases, kinds of classification will be developed in the next century by using fuzzy maths, fractals and perhaps chaos theory.

In this research, soil micro-organisms will be included, because the measurement of specific respiration and other techniques has greatly increased knowledge of differences in soil micro fauna and flora in recent years. The use of precision farming will avoid excessive pollution. Flexible soil classification will help to name rapidly changing soil features and the important thing is to be ready to adopt and change as new soil science information becomes available.

Soils of Lithuania

The parent materials of soils in Lithuania vary in the age and genesis, the most common being Quaternary deposits. The thickness of these deposits varies from less than 10m in northern Lithuania to 200-300m in the Zemaiciai and Baltija Heights, with many being 80-120m thick. Glacial deposits are: morainic, glaciofluvial and limnoglacial, and, in some places, there are alluvial, Eolian and organic deposits. These deposits support a great variety of soils and a complicated soil cover in Lithuania.

Gleyic Albeluvisols and some Dystric soils which are formed on materials low in carbonate and deeply leached loamy deposits, predominate in Western Lithuania. In Eastern Lithuania, Albeluvisols predominate on soil parent materials of light texture and here distinct erosion processes are prevalent. In Central Lithuania, the soil parent material and the soil surface layers contain more carbonate and are less leached; here Calcaric Cambisols are common. Calcaric Luvisols, Gleyic Luvisols, and in some places Eutric Gleysols, on loam, clay loam and clay are widely distributed.

Preliminary estimates show that Albeluvisols occupy 30% of the country, Luvisols 27%, Cambisols (13%), Arenosols (12%), Podzols (11%), mainly in forest areas, and Gleysols and Histosols (5.3%) in the depressions.

Soil Degradation

Major production constraints in the country are physiography, acidification and low fertility. Other types of soil degradation taking place in Lithuania include: acidification, erosion and contamination by heavy metals and organic pollutants. These are described in the following sections, but estimated one third of agricultural land is in hilly regions, some of which are not suitable for cultivation.

Soil acidification

A significant danger for soils and the natural environment is caused by the gradual intensification of the acidification process resulting from a decline in the application of lime and the effect of acid rain. This process in Lithuania has been heightened during the past 10 years when the area of liming has declined. It is now time to establish monitoring plots in areas prone to acidification, and to apply lime where required. According to the State Environmental report of 1998, in the previous last 5 years there was a 3.1% increase in acid soils.

Table 1: Soil acidity in Lithuania

pH_{KCl}	Area (ha)	Area (%)
<4.5	23.5	0.9
4.6-5.0	113.9	4.3
5.1-5.5	286.8	10.9
5.6-6.0	453.2	17.2
6.1-6.5	535.6	20.4
>6.6	1,217.8	46.3
All	2,630.8	
Acid soils		
<5.5	424.2	16.1

(source: Lithuania, MoE 1996)

The data in Table 1 indicate that 46.3% of the soils in Lithuania are either very close to neutral (pH_{KCl} =6,6-6,9) or neutral (pH_{KCl} =7.0) but more than 16% of soils are acid and, if under agriculture, must be limed.

Soil erosion

The major cropping rotation is barley + under sowing, perennial grasses of the first year, perennial grasses of the second year, winter crops and potatoes, vegetables or sugar beet. Comparatively rarely, the monoculture system is adopted but in small plots.

The largest areas of slightly eroded soils are in the regions of the moraine highlands - from 12.4% of the area in the Svencionys-Narocius highlands up to 21.8% in the Suduva highlands. Slightly eroded soils are quite extensive (16.6%) in the sandy South-eastern plain.

In some areas of the Baltic highlands, from 19.6% up to 29.8% of soils in agricultural use are moderately eroded. In the Central Zemaiciu highlands and Eastern Lithuanian plateaux eroded soils constitute about 5.7-7.2% of the area. (Soils of Lithuana, 2000).

Severely eroded soils occur more frequently in the plateaux and highlands of Eastern Lithuania (1.6-7.7%).

Contaminated sites

In Europe, during recent years, significant damage has been caused to the environment in some areas. There are sites contaminated with a range of different materials. One of the priorities in many countries is to estimate the danger to the environment from these sites, to identify the polluting materials, and to develop measures to decontaminate the sites.

The international project on Mapping of Soil and Terrain Vulnerability in the Central and Eastern Europe (SOVEUR Project) helped to evaluate the natural geochemical patterns and changes caused by anthropogenic and technogenic activities in Lithuania. In the future there is need to show even small polluted sites of Lithuania using, for example, the SOTER Database (Batjes, Van Engelen, 1997) and methodology of the SOVEUR Project (Van Lynden, 1997).

Monitoring and treatment of contaminated soils is an urgent issue, and one that is very costly to manage.

Pollution by heavy metals

The degree of soil contamination with heavy metals of some areas of forest soils and topsoils of agricultural and other landscapes in Lithuania has been investigated and determined by M. Vaicys (1975), Pauliukevicius (1988), R. Sleinys and P. Rimselis (1993), J. Lubyte *et al*. (1994). But very little attention has been paid to the whole spectrum of trace elements, although they are important for plants, animals, human beings as nutrients or, on the other hand, potentially poisonous in high or even very low concentrations (Kadunas *et al*., 1999).

Table 2: Soil contamination by heavy metals (mg · kg)

Heavy metals	0-20cm	20-40cm	40-60cm
Cr	1.6-38.8	2.2-36.4	1.6-33.6
Cd	0.2-1.0	0.2-1.0	0.2-1.0
Pb	4.4-23.0	4.0-18.0	2.6-17.0
Ni	1.8-32.6	2.4-31.0	2.4-31.6
Cu	0.8-56.0	2.4-31.0	2.4-31.6
Zn	6.6-58.8	6.6-56.8	6.6-60.2

(source: Lithuania, MoE 1996)

According to state monitoring data of 1993-1997, the average amount of heavy metals in topsoils 0-20cm (Table 2) are: chromium 10,7 mg/kg of soil, cadmium - 0.46, lead - 11.9, nickel - 9.9, copper - 6.9, zinc - 28.5, iron – 8,209 mg/kg of soil.

Pollution by organic pollutants

According to data of the State Plant Protection Agency, 1,566.9t of pesticides were used in Lithuanian agriculture in 1998. Most were herbicides - 1,136,002t (72.5%), fungicides - 12.5%, insecticides - 1.9% and other types of chemicals. In the last decade, the use of pesticides has fluctuated. According to the State environmental monitoring data, only in one soil sample were herbicides found to be over the limit. Data shows that only at very few points is there high pollution by pesticides, such as simazine. Only in a very small number of soil samples were significant amounts of insecticides like DDT and other pollutants found. In some samples there were only traces of such materials found.

Use of Fertilisers

Recently, the quantity of fertilisers and chemicals used in agriculture (Table 3) has been reduced but there is potential for it to increase again in the future.

Table 3: Mineral fertilisers consumed in 1996 (kg/ha of crop area, 100% active)

Crops	In private farms	In agricultural companies
Winter crops	58	66
Summer crops	54	79
Flax	67	91
Sugar beet	89	318
Rape	66	144
Potatoes	74	134
Vegetables	103	247
Fodder crops	49	31

(source: Agriculture of Lithuania 1996. Department of Statistics. Vilnius 1997)

The principal measure for reducing the environmental impact of pesticides should be through the development of a control system for hazardous materials and products. The framework for a control system for these materials in Lithuania should encourage not only control of the use of chemicals but also more efficient use of fertilisers and development of low-impact application techniques, as well as a search for more fertiliser efficiency.

Anthropogenic Influence on Soils

The western and eastern parts of Lithuania are characterised by a low amount of available phosphorus, whereas the central part of Lithuania is enriched with phosphorus. The anthropogenic impact and especially diverse reclamation activities such as cultivation of Terric Histosols, drainage of Gleysols or other gleyic soils, liming, application of mineral fertilisers have been and in some places now are among the most active soil forming factors changing the properties and functions of natural soils. Histosols are particularly sensitive to this impact. The amount of phosphorus and potassium in the soil now depends on its application. In the investigated areas the concentrations of these substances are very variable.

In previous years, another problem in agriculture has been caused by intensive cattle breeding, particularly wastes from major breeding complexes. The Ministry of Agriculture has encouraged the regulation and reconstruction of these complexes to include collection of animal wastes, discharge or land spreading of these wastes, and technologies for their use.

Estimation of soil degradation and pollution in Lithuania

The recent data from the geochemical mapping of all administrative districts of Lithuania has been collected between 1994 and 1997 by the Geological Survey of Lithuania (Kadunas *et al*., 1999). Soil samples (total 2700) were collected in the fields of Lithuania (the country has been divided into 10x10km squares, 696 in number) during the summers of 1995 and 1996 from the topsoil. The topsoil samples collected were transported to the laboratory where their pH_{H2O} value was measured with a J-200 ionometer. The samples were then dried at room temperature and sieved through a 1mm sieve. Analyses were conducted at the laboratory of the Geological Institute. The following analytical methods were used: DC-Arc Emission Spectrometry, using the DFS-13 spectrograph, MD-1,000 microdensitometer (Co, Cr, Cu, Mo, Ni, Pb, Sn and Zn concentrations); XRF using ARF-6 X-ray-spectrophotometer (As concentrations).

Concentrations of metals in topsoils

Basic research on topsoils of Lithuania shows that the concentrations of metals in places reasonably distant from the bigger towns, for example, does not reach the B-value of the original standards adopted in the Netherlands for soil contaminants (Moen and Brugman, 1997). Geochemical mapping data has been used for estimation of soil degradation, contamination and pollution for the SOVEUR Project (1997-1999). It is very important to know the location of soils with measured metal concentrations in relation to the EU recommended maximum permissible levels, now set as (in mg/kg of dry matter) 3,300, and 300 for Cd, Pb, and Zn, respectively.

As data for topsoils of Lithuania show, the average concentrations of metals are greater in loamy and clayey soils than in sandy soils (Tables 4, 5). Other research on the soils in Lithuania has shown that in the humus layer (0-20cm) there are the following average quantities of heavy metals: chromium - 10.7, cadmium - 0.46, lead - 11.9, copper - 6.9, zinc - 28.5, manganese - 253, iron 8,209 mg/kg (Soils of Lithuania, 2001).

Table 4: The values of metals in topsoil of Lithuania (average in ppm)

Soil texture	Cr	Co	Ni	Cu	Zn	As	Mo	Sn	Pb
Sand	25.1	3.5	9.4	6.5	22.2	2.1	0.61	2.0	15.5
Sandy loam	35.7	5.0	13.8	9.6	28.9	2.9	0.67	2.2	14.9
Loam-clay	44.0	6.4	18.0	11.4	35.7	3.6	0.71	2.3	15.3
Peat	21.2	3.6	12.1	10.6	39.9	1.9	0.88	1.6	36.2
All groups	31.7	4.7	13.3	9.5	31.5	2.6	0.72	2.0	16.6

Source: V. Kadunas, R. Budavicius, V. Gregorauskiene, V. Katinas, E. Kliaugiene, A. Radzevicius, R. Taraskevicius. Geochemical Atlas of Lithuania. Geological Survey of Lithuania, Geological Institute. Vilnius 1999

Table 5. Median values of metals in topsoils on parent material of different genesis, ppm

Soil texture	Genetic type of soil parent material	Cr	Co	Ni	Cu	Zn	As	Mo	Sn	Pb
Sand	Limnoglacial sediments	23.4	3.2	8.7	23.4	20.0	1.4	0.60	1.9	16.2
	Glaciofluvial sediments	20.7	2.9	7.5	20.7	17.3	1.5	0.60	2.0	14.5
	Eolian sediments	18.3	2.5	7.0	4.9	17.4	1.7	0.58	1.7	14.5
	Glaciofluvial sediments of Nemunas glacier marginal forms	20.8	2.9	8.2	6.8	17.2	1.6	0.58	1.9	15.7
	Glacigenic sediments of Medininkai glacier	23.1	3.4	8.6	6.8	18.9	2.1	0.62	2.1	15.0
Sandy loam	Limnoglacial sediments	41.4	5.2	14.5	10.3	29.1	2.8	0.67	2.2	14.5
	Basal moraine of North Lithuanian phase	37.4	5.6	15.0	9.7	28.4	3.8	0.70	2.4	16.0
	Basal moraine of Middle Lithuanian phase	35.9	4.9	13.5	8.5	27.2	2.9	0.68	2.1	14.0
	Basal moraine of South Lithuanian phase	36.1	4.9	14.4	10.5	29.4	3.2	0.70	2.2	14.5
	Glacigenic sediments of Medininkai glacier	26.2	4.5	8.5	7.7	28.3	2.8	0.63	2.0	14.4
Loam – clay	Limnoglacial sediments	50.5	6.4	18.1	12.1	35.1	4.0	0.69	2.3	15.3
	Basal moraine of north Lithuanian phase	41.6	5.5	16.5	9.4	29.4	3.7	0.66	2.2	14.2
	Basal moraine of Middle Lithuanian phase	44.1	5.7	17.0	11.6	32.5	3.3	0.69	2.3	14.3
	Basal moraine of South Lithuanian phase	38.4	5.4	15.4	9.5	29.5	3.6	0.69	2.1	14.1
	Glacigenic sediments of Medininkai glacier	32.6	4.6	10.7	8.6	32.2	3.5	0.66	1.95	14.6

Source: V. Kadunas, R. Budavicius, V. Gregorauskiene, V. Katinas, E. Kliaugiene, A. Radzevicius, R. Taraskevicius. Geochemical Atlas of Lithuania. Geological Survey of Lithuania, Geological Institute. Vilnius 1999

The Need for Collaboration and Corporate Policy

Lithuania is progressing towards integration into the European Union's political and economic structures. One of the conditions of EU membership will be need to harmonise the country environmental policies and legislation with those of the EU. Many of the Lithuanian environmental standards set by the Ministry of Environment already meet some of the EU requirements and in several cases are even higher than those set by the EU. Specific environmental goals or objectives to address environmental problems currently facing Lithuania are identified for the short and medium term in environmental Action Programmes. Lithuania participates in the conventions which play important roles in shaping environmental policy – Convention on Transboundary Air Pollution, Convention on Climate Change, Convention on Biological Diversity, Combat Desertification Convention and others. A seven-year strategy for the development of sustainable agriculture in the environmentally sensitive gypsum karst region in Northern Lithuania was adopted by the Government in 1993 and commenced the same year.

In Lithuania as well as in other countries following the World Commission on Environment Development (1983), Agenda 21 of the Earth Summit, World Soil Charter and other conventions, European Commission directives and European Soil Bureau recommendations, there is need to have ready access to good information on soils. In its absence, it is difficult to answer the questions raised by the Climate Change Convention. Only those countries that have 1:250,000 or larger scale soil maps based on good standard soil profile description and laboratory data are able to do that well. A good example for Lithuania was the collaboration on the Soil Geographical Data Base of Europe (1998, 1999). The needs of collaboration comply strongly with Lithuanian corporate policy, the main objectives of which are:

- To continue to review available soil data;
- To continue to develop methodology for geo-referencing data;
- To continue to develop routines for database development and data validation;
- To test data capture and preliminary modelling capabilities;
- To test the range and validity of suitability and risk assessment models;
- To test the operation and quality of system outputs;
- To identify polluted areas over the country;
- To test the design of the LTdDB with a view to the further development of LTLIS;
- To train the staff to operate the system.

The proper study of the terrestrial environment, of which the soil is the principal component, requires the ability to integrate and manipulate a large amount of data from various points of landscape, i.e. spatial data. In view of very large initial costs of collecting the soil information needed for the Lithuanian Land Resources Information System (LTlrIS) interactive with the Geographical Information System (GIS) and operating suitable databases, it is highly desirable that all relevant soil data already collected in the country should be stored in a computerised database. All this may include the following components:

- To maintain soil survey field work and set up one National organisation, which would be responsible for surveying, documenting, and researching the agricultural land and all soils of Lithuania;
- To contribute to the State Environmental Monitoring, responsible for monitoring of soils and agricultural products;
- To seek to establish a reference base for the assessment of land quality that would provide a scientific basis for soil protection and contribute to identifying and solve existing problems of soil degradation in Lithuania;
- To contribute a scientific base to secure adequate food, timber and other soil based needs while ensuring sustainable land use in harmony with the environment and causing minimum damage to it;
- To strengthen links with policy makers and legislators in Lithuania, European Union and elsewhere, to assist in policy development in our country and ensure that policies and legislation are supported by the best available scientific information;
- That results would be freely available and published in Lithuanian and international journals. Reports would also be published and made available to Lithuanian agriculturists, planners, policy makers etc. and the EU. Some of these reports would take the form of progress reports for meetings, some would be documentation for the LTdDB-LTLIS;
- Providing a scientific basis for the most suitable and sustainable land use in the future;
- Establishment of an objective basis for the management of soil pollution by administrators, policy makers, and those responsible for agricultural development;
- Establishment of a monitoring and research programme for agro-ecosystems, which can be extrapolated to other parts of Lithuania;
- Narrowing the gap between scientists, managers of agriculture, farmers, and policy makers, and the supply of necessary information to assist decision makers.

Soil is an ever-changing system. The need for new methods of soil research, for new information to be integrated, and the need to be socially responsible for sustainable development of our country make not only theoretical but also practical sense. In Lithuania, there are areas where from point to point in accordance with conditions of drainage, erosion and parent material, soils vary very much. In such areas it is not enough to use geographic methods of soil cartography. There is need to adopt updated soil cartography methods and terrain modelling. Such a perspective allows a systematic appraisal of soil cover and division of the land surface into integral territorial units (systems) for investigation.

There is a need for participation in international projects and consultations with soil scientists from the countries with soil research centres that have been mapping soils and are experienced in the systematic collection and storage of information on soils and sites (including descriptive and analytical information). It is important to meet the needs of national policies and the obligations arising from participation in international projects on soil research and mapping of soil vulnerability for soil degradation. It is also important to set up Lithuanian standards adapted to the requirements of EU countries.

Conclusions

In recent years, the International Union of Soil Science, FAO, and other international bodies, have been stressing that it is important to develop information about conditions of degradation of chemical and physical properties of soils, roles of soils in global climatic change, better utilisation of information on soils, the needs for protection of underground and surface water against pollution, as well as for wider consideration of the properties of soils for the needs of sustainable management of particular areas. Besides presentation of the map of the soil cover it is also important to interpret the acquired data.

Already existing information on soils of Lithuania may be sufficient for some needs, but additional investigations are required to support the needs of the other areas. Because over the past two decades, responsibility for the organisation of soil survey has passed from central government organisations to independent institutes, universities and private sector consultancies, there is a grave danger of a lack of uniformity of methodology, use of different classification systems, and a general lack of coordination between the mapping groups. Bringing together the information from these different sources into an integrated system will prove increasingly difficult as more and more information is collected. Therefore, it is necessary to create a geocoded or georeferenced soil information system of Lithuania that would use contemporary information technology.

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