LAND QUALITY AND LANDSCAPE PROCESSES

TAMÁS HERMANN, GERGELY TÓTH, TAMÁS KISMÁNYOKY
AND ATTILA DUNAI (Eds.)

KESZTHELY
2015

LAND QUALITY AND LANDSCAPE PROCESSES

Keszthely
2015

The international conference on ’Land Quality and Landscape Processes was held on 2-4 June 2015
in Keszthely, Hungary.

Organised by the:
University of Pannonia
European Commission Joint Research Centre
European Environmental Agency
Chinese Academy of Sciences Institute of Soil Science

With the support of
International Union of Soil Sciences
Hungarian Soil Science Society
Scientific Network for International Research on Desertification
International Year of Soils
Danube strategy

Cover design:
Tamás Hermann

European Commission
Joint Research Centre
Institute for Environment and Sustainability

Contact information
Tamás Hermann
Address: Joint Research Centre , Via E. Fermi 2749; I-21027 Ispra, Italy
E-mail: tamas.hermann@jrc.ec.europa.eu
Tel.: +390332786243 Fax: +390332786394

JRC Science Hub
https://ec.europa.eu/jrc

JRC 96120
EUR 27249 EN

ISBN 978-92-79-48310-3 (print)
ISBN 978-92-79-48311-0 (PDF)

ISSN 1831-9424 (online)
ISSN 1018-5593 (print)

doi: 10.2788/641226

Luxembourg: Publications Office of the European Union

Printed in Hungary
By Ziegler-nyomda, Keszthely

Abstract
This monograph contains a selection of scientific papers presented on the conference on Land Quality and Landscape Processes, hold in Keszthely, Hungary. It covers topics related to various aspects of land quality including: concepts of assessment; evaluation of biomass productivity; bioindicators of land quality; quality assessment of degraded land; land use related data processing.

Contents

Integrated quality assessment of forest soils from Central Moldavian Plateau (Romania)

***Ligia Acatrinei*[1], *Geanina Bireescu*[1], *Adina Călugăr*[1], *Otilia Ivan*[1]**

Forest Phytocoenosis

Our integrative research was carried out in four natural forests and in four tree plantations from representative sites of the Central Moldavian Plateau (Northeastern Romania). Natural forests (EU's protected areas-Natura 2000) are: 1 (Hârboanca) - *Quercus pubescens* and its hybrids, *Ulmus minor*, *Tilia tomentosa*, 2 (Bălteni) - *Q. robur*, *Acer campestre, Acer platanoides, Tilia tomentosa,* 3 (Micleşti) - *Quercus petraea, Q. petraea* ssp. *dalechampii*, *Fraxinus excelsior*, *Carpinus betulu,* 4 (Dobrina)- *Quercus robur*, *Tilia cordata*, *Carpinus betulus*, *Fagus sylvatica*, *Acer campestre*, as the main representative species. In this area, acacia plantations (*Robinia pseudoacacia* L.) were established in view to prevent soil erosion and degradation, improve soil fertility and fixing nitrogen. The investigated sites 5-8 are forest plantations at different age.

Soil resources. Biological activity

Ecological interpretation of the main soil resources highlighted the qualities, lacks and excesses through ecological size and favourability classes (Bireescu, 2007). Biological Synthetic Indicator (BSI%) (Figure 1) has middle values in the first 20 cm under litter of oak forests. The best values occur in eutric vertic stagnic cambisols (plots 1 and 3) and the lowest ones in the haplic chromic luvisol (plot 4). Biological activity becomes sub-medium below 20 cm depth and then significantly decreases to 60 cm of bioactive zone in all investigated ecosystems. Investigated forest plantations are placed on soil resources belonging to Regosols, being represented by loesssands and bedrocks. The analysis of soil biological activity through the Biological Synthetic Indicator indicates middle values in the first 20 cm of soil profile. Below 20 cm these indicators quickly decrease, characterizing a middle fertility for the plantations, one exception (plot 5) that showed sub-medium fertility on regosol (Figure 1).

Edaphic mites

In forest soils, especially, oribatid mites constitute a key group in the decomposer food web, as the main group of detritophages, beside springtails. Analysis of structural parameters of oribatid communities from natural forest shows values generally higher of average density, and especially of the species number and specific diversity compared to forest plantations in the area.

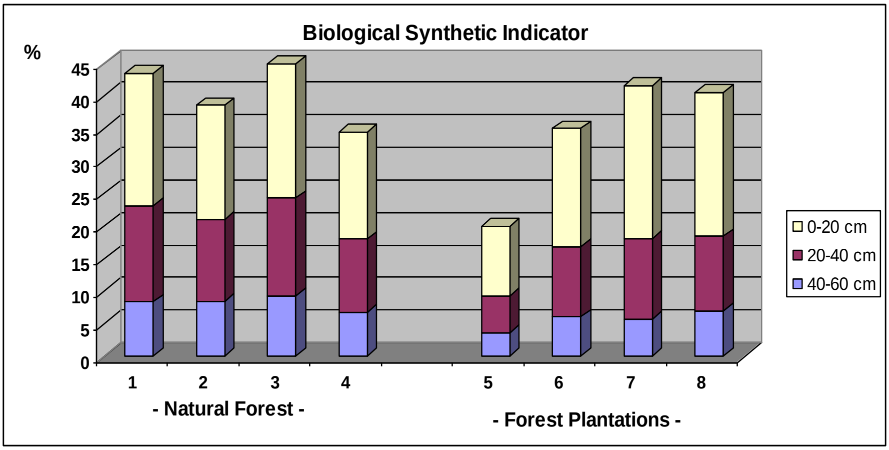


Fig. 1 Variation of Biological Synthetic Indicator (BSI %) on soil depth

Edifying species groups include mainly sylvicolous species or that prefer forest soils, and a smaller number of euryplastic species. Well-balanced trophic and demographic structure and high structural heterogeneity indicate stability and self-regulation capacity of the oribatid coenoses. As regards forest plantations, oribatid communities differ structurally, especially depending on floristic composition that determine quality and quantity of vegetal necromass. In mixed plantations aged 50-60 years the average abundance, number of species and specific diversity have values approaching those reported in natural forests, while in young plantations of acacia these parameters are lower, with significant differences from one stand to another. Noteworthy are important qualitative differences regarding species composition of edifying and influential groups, observing that some sylvicolous elements, characteristic for oak forest of the area missing or are accidental and less abundant; however, some grassland species are frequent and abundant, along some euryplastic forms (Călugăr et Ivan, 2013; Ivan, 2004).

Among Mesostigmata the majority of species are predators. In natural forests the Mesostigmatid mites were represented by lower densities than Oribatida (approximate 3-11 times) and a number of species half of those of Oribatida. In terms of ecological preferences sylvicolous species that prefer a wet environment are the majority. In forest plantations the abundances and the number of species are even lower than that of oribatids (4-26 times, respectively 3-4 times). A comparison natural forest vs. forest plantations showed both lower densities and number of species in forest plantations, as well as qualitative differences – predominance of praticolous and euryplastic species, and poor representation of sylvicolous elements (Calugăr et Ivan, 2013).

Carbohydrates tree metabolism

Comparative analysis on different type of ecosystems showed those insoluble carbohydrates fraction (polysaccharides) is in average 3.3 times higher in plantation than in natural forest (Figure 2). In natural forest, proportion between soluble fraction (7-14 g %) and insoluble ones (5-16 g %) is almost close.

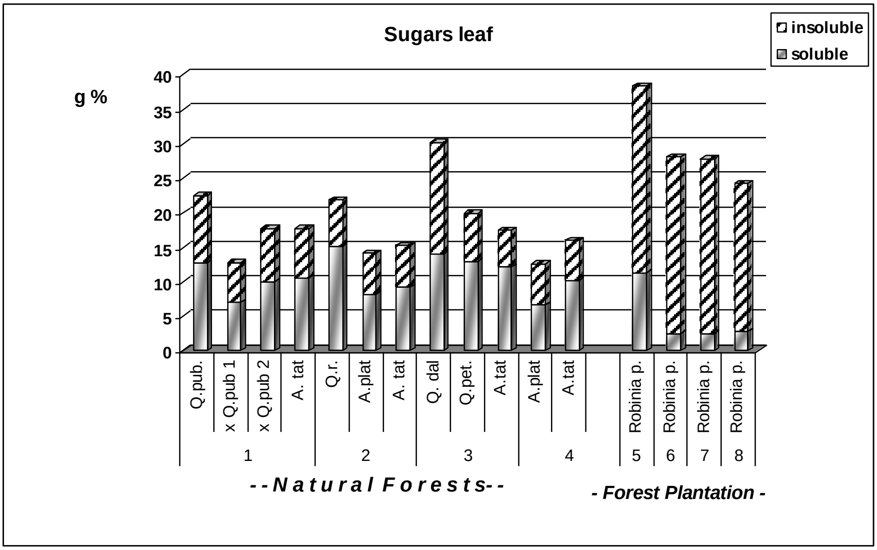


Fig. 2 Variation of sugars leaf in main tree species

Legend: Q. pub - *Quercus pubescens,* x Q. pub.1 - *Q. x budensis,* x Q. pub. 2 - *Q. x corcyrensis,* Q. dal. - *Q. dalechampii,* A. plat - *Acer platanoides,* A. tat.- *Acer tataricum,* Rob. p. - *Robinia pseudoacacia*. x- hybrid, Plots 1-8.

Intense metabolism of plantation trees, revealed by total sugars accumulation (23-38 g %) is higher than those of natural forest trees (15-30 g %); in natural forests, species *Q. dalechampii* register the greater value of total sugars leaf (30 g %) but smaller than that register in *R. pseudoacacia* (37 g %). The age of tree stand is very important issue, the older have an increased soluble fraction (for cellular consumption, tissue maintaining) meanwhile the younger (plantation) register the higher insoluble fraction which is used for rapide growth. The high accumulations of insoluble sugars were observed also in other type of ecosystems (agroecosystems, grasslands) from Central Moldavian Plateau due to the specific type of soil with higher quantity of clay, haplic chernozem, subtype vertic (Acatrinei, 2013).

Research results highlight that a sustainable forest management must take into account above ground - below ground linkages, ecological specificity of each area and conservation of soil resources.

Acknowledgements

This study was conducted within BIODIV research program, funded by the Romanian Ministry of Education and Scientific Research.

References

Acatrinei, L. 2013**.** Variability of some ecophysiological parameters at woody species in certain forest plantations from Central Moldavian Plateau. Scientific Papers, Agronomy series, 56 (2), 69-73.

Bireescu G., Bireescu L., Breabăn I., Teodorescu E. 2007 Ecopedological study over soil resources in forest ecosystems from Moldavian Plain - Scientific Papers, Horticulture series, 50, 863-870.

Călugăr A., Ivan O. 2013. Diversity and distribution of the edaphic mites (*Acari*: *Gamasina*, *Oribatida*) in some forest plantations from the Central Moldavian Plateau. Scientific Papers, Agronomy series, 56 (2), 97-103.

Ivan, O. 2004. Structural peculiarities of the oribatid communities (Acari: Oribatida) in some oak forests from Romania, Annual of Museum Complex of Bucovina - Suceava, fasc. St. nat., XVI – XVI, 89-108.

World Reference Base for Soil Resources. A Framework for International classification, correlation and communication 2006. FAO by BGR, Hanover.

[1]Institute of Biological Research, Iaşi, Romania,

ligia.acatrinei@icbiasi.ro, geanina.bireescu@icbiasi.ro

adina.calugar@icbiasi.ro, otilia.ivan@icbiasi.ro.

Mapping impacts of land cover flows on soil productivity

***Ece Aksoy*[1], *Christoph Schröder*[1], *Mirko Gregor*[2], *Geertrui Louwagie*[3]**

Abstract

Land, and here in particular soil, is a finite and essentially non-renewable resource. EU-wide, land take, i.e. the increase of settlement area over time, consumes more than 1000 km² annually of which half is actually sealed and, hence, lost under impermeable surfaces. Land take and in particular soil sealing has already been identified as one of the major soil threats in the 2006 EC Communication “Towards a Thematic Strategy on Soil Protection” (Soil Thematic Strategy), and has been confirmed as such in the report on the implementation of this strategy.

The aim of this study is to relate the potential of land for a particle use in a given region with the actual land use. This allows evaluating whether land (in particular the soil dimension) is used according to its (theoretical) potential. Therefore, It’s been started to focus on conceptual thinking on how to approach the issue of (mainly negative) anthropogenic impacts on natural resources in the context of economic activities and the related increasing living standards; and the concept of ecological potentials and compared the potential use with the actual use of the resource aiming at analysing potential loss of productive land. To this aim, the impact of a number of land cover flows on soils with a good, average and poor production potential were assessed and mapped by the help of available biomass production and land cover flow data. Thus, the amount and quality (potentials and/or suitability for agricultural production) of agricultural land lost between the years 2000 and 2006 was identified.

Background

The EU has announced its resource efficiency roadmap (EC, 2011) according to which ecosystems and their components (such as land in the sense of space for which different land uses compete) are considered a natural resource. The roadmap sets a milestone of no net land-take in the European Union by the year 2050.

But how can this target be achieved? Is the most efficient use the attempt to get the maximum out of the land/soil resource? Or could resource efficiency also be seen as the way to receive sufficient outputs with a minimum input? What is the relation between the potential use of a defined area and the actual/current use, and which consequences does this have on the quantity and quality of the (remaining) natural resources? In this sense, we are interested in optimising the use of land within the limit of ecological risks; that is, obtaining an acceptable use (output) with a minimum of resources (input).

Material and Method

There exist 9 major land cover flows (LCFs) on level 1 (Land and Ecosystem Accounting, LEAC, 2000-2006) and we are particularly interested in LCF2, LCF3, LCF4, LCF5, LCF6, LCF7 and LCF9 (either the entire flow or sub-flows). Data are available from the EEA Data Service and are based on the CORINE Land Cover (CLC) changes 2000-2006. All input data sets are available on the 1 km EEA reference grid which is the basis for the spatial analysis and used in this study.

Table 1. Land cover flows that wer used in the study

Major Type of Cover Change	Code
Urban Land Management	LCF1
Urban Residential Sprawl	LCF2
Extension of Economic Sites and Infrastructures	LCF3
Agricultural Internal conversions	LCF4
Conversion from Forested and Natural Land to Agriculture	LCF5
Withdrawal of Farming	LCF6
Forests Creation and Management	LCF7
Water Body Creation and Management	LCF8
Changes of Land Cover Due to Natural and Multiple Causes	LCF9

The land productivity maps for arable land, grassland and forest land which have been produced with the spatially explicit Soil Productivity Model for Europe (SoilProd, Toth et al. 2011) by JRC were used in this study (Figure 1). SoilProd understands the biomass production of a given soil as dependent from the geographical location (climate, hydrology, terrain), land use type, land management and the plant cultivated. The soil productivity data provided by JRC, 1 km2 raster data sets have full coverage of Europe but they are only valid for the corresponding land use types. Therefore, the appropriate CLC classes (based on CLC/Corilis 2000) were identified to build the masks for the extraction of the soil/land productivity layers; the land cover data.

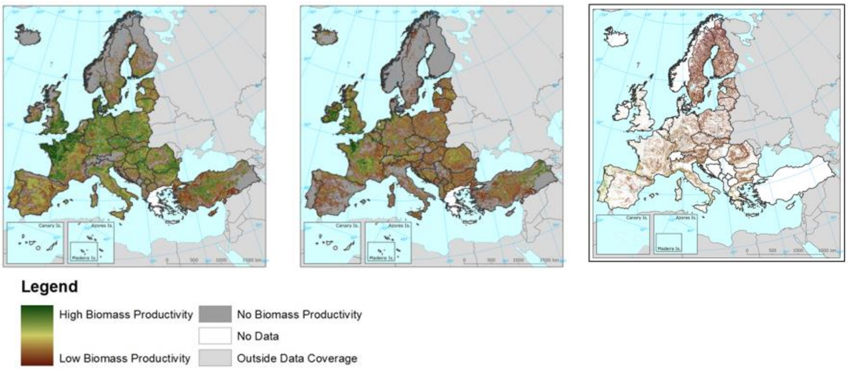


Figure 1. Soil productivity data (Pan-European grid layer) masked on the relevant CLC classes; left: arable. middle: grassland, right: forest productivity

All of the details concerning the method and processing flow chart of the impact of selected LCFs on the agricultural, forest and grassland production potential per NUTS-3 level can be found in the EEA Technical report of Land Resource Efficiency, 2014.

Results

For interpretation purposes the value ranges described regarding their impact (expressed as percentages) on good, average and poor soils/land as follows: small impact (>0-0.001);intermediate impact (>0.001-0.01); relatively high impact (>0.01-0.1); high impact or strongly impacted (>0.1-1), and very high impact or severely impacted(>1), and one of the example of the result maps can be seen in Figure 2. All of other maps and the details of the impacts of land cover flows on soil productivity can be found in the EEA Technical report of Land Resource Efficiency, 2014.

In general, short/mid-term economic benefit of land use (urbanisation, irrigation, forest plantation) seems to outbalance potential biomass productivity. The European picture is, as expected, very heterogeneous. Moreover, European Cohesion Funds seem to be a major driving force for urban development in many countries that lag behind from an economic growth perspective. In highly productive, intensively used agricultural regions (both based on soil and climatic conditions), grasslands are more exposed to changes than arable lands.

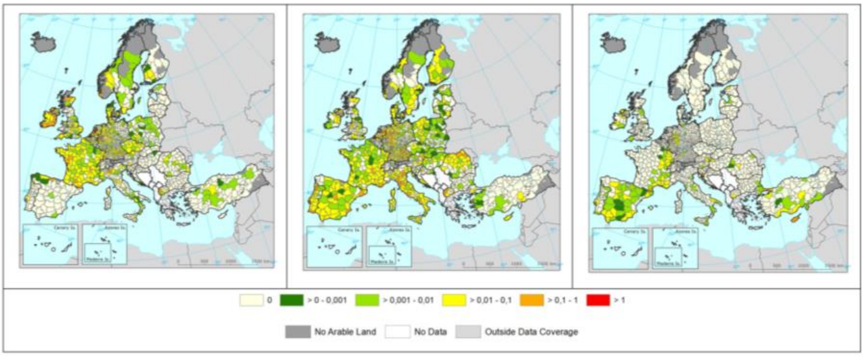


Figure 2. Arable land affected by 'Urban Residential Sprawl' (% at NUTS-3 level, changes 2000-06) for high, average and low productivity potential.

The urban residential expansion activities, is spatially distributed across Europe, with often small to intermediate impact on the biomass productivity of arable land. Higher or very high impacts on good land can mainly be detected in regions in Ireland, France, Germany, Austria and the Benelux countriesWhen taking the GDP of the outstanding regions into account there seems to be no direct relation to the economic situation of a region. Both well developed and less-developed regions experience strong or severe impacts of the urban sprawl related land cover flows on the soil productivity. Expansion at the expense of good and average land is a widespread phenomenon in Europe, and relatively more so for industrial and commercial development and transport networks than for residential purposes.

Addresses of authors:

Ece Aksoy1, Christoph Schröder1, Mirko Gregor2, Geertrui Louwagie3
[1] University of Malaga, European Topic Centre on Urban, Land and Soil Systems (ETC-ULS, UMA), Malaga, Spain, ece.aksoy@uma.es ; christoph.schroder@uma.es
[2] Geoville, European Topic Centre on Urban, Land and Soil Systems (ETC-ULS, Geoville), Luxemburg, gregor@geoville.com
[3]European Environment Agency (EEA), Copenhagen, Denmark, Geertrui.Louwagie@eea.europa.eu

European land quality as a foundation for the sustainable intensification of agriculture

Jasmin Schiefer[1], Georg J. Lair[1,2], Winfried E.H. Blum[1]

[1] Institute of Soil Research, University of Natural Resources and Life Sciences (BOKU) Vienna, Peter-Jordan Straße 82a, 1190 Vienna, Austria

[2] Institute of Ecology, University of Innsbruck, Sternwartestraße 15, 6020 Innsbruck, Austria

Introduction and definition of the aims

By 2050, the world population will reach more than 9 billion according to actual UN projections (Alexandratos and Bruinsma, 2012). Besides the growth of population, higher per- capita income, and increasing demand for meat/ fish and dairy products, the total demand for food will increase (Godfray et al., 2010). The "green revolution" starting in the 1960s allowed an enormous increase of yield in the past 40 years mainly due to greater inputs of fertilizers, irrigation, new crop strains, agricultural machineries and other technologies (Tilman et al., 2002). However, studies show that the increase of yields at the current state would not meet the future demand for food (Ray et al., 2013). To meet the needs of agricultural products by 2050, further intensification of food production will be necessary. It has to be considered, that high input production needs more energy, fertilizer and irrigation. This has adverse effects on soil and environmental quality such as biodiversity, groundwater and surface water quality, and air due to greenhouse gas emissions.

An agricultural production, where "yields are increased without adverse environmental impact and without the cultivation of more land", is defined as "Sustainable intensification" SI (The Royal Society London, 2009). This form of production combines energy flows, nutrient cycling, population-regulating mechanisms, and system resilience to intensify existing arable land without harm to the environment or other economic or social factors (Pretty, 2008) .

As food security is intimately related with soil security and sustainable agriculture (The Royal Society London, 2009), the resilience (the capacity of systems to return to a (new) equilibrium after disturbance) and performance (the capacity of systems to produce over long periods) of soil under intensification must be considered (see also Blum and Eswaran, 2004).

Soils perform environmental, social, and economic functions (Blum, 2005): (1) biomass production for different uses; (2) buffering, filtering, biochemical transformation; (3) gene reservoir; (4) physical basis for human infrastructure; (5) source of raw materials and (6) geogenic and cultural heritage. Sustainable land use has to harmonize the use of these six soil functions in space and time, minimizing irreversible uses like sealing, excavation, sedimentation, acidification, contamination or pollution, and salinization (Blum, 2005).

To define the capacity of soil systems to provide goods and services for a long term, indicators have been chosen which are comprehensive enough to characterize the intrinsic potential of soils to level out or to reduce negative impacts of agricultural intensification. Fertile soils with specific characteristics have a high resilience against physical, chemical and biological disturbances such as erosion, compaction, contamination of air, plants and water, and against loss of biodiversity. They can therefore protect the groundwater against contamination, maintain biodiversity and reduce or minimize erosion and compaction. Soils with these characteristics also show a high performance and can produce a maximum of agricultural commodities if managed accordingly.

The main objective of this work was to identify the most important soil intrinsic parameters (indicators), which determine soil resilience and performance according to the ecological functions of soil.

Material and Methods

The suitability for SI is based on intrinsic soil quality parameters such as 'resilience' against adverse ecological impact and'performance' in the sense of long lasting productivity and was defined with 6 soil parameters (= indicators). The indicators presented in Table 1 were chosen based on available literature and expert knowledge. They were scored according to defined threshold levels in terms of poor (1), medium (2), good (3) and in some cases excellent (4) conditions.

Table 1: Indicators and their threshold levels for evaluating the potential of arable land for sustainable intensification.

	excellent	*good*	*medium*	*poor*	*unit*
SOC %	*≥ 4*	*2-4*	*1-2*	*≤ 1*	*%*
Clay+ Silt	*≥ 50*	*35-50*	*15-35*	*≤ 15*	*%*
pH		*6.5-7.5*	*5.5-6.5; 7.5-8.5*	*≤ 5.5; ≥ 8.5*	*in* H_2O
CEC		*>25*	*10-25*	*≤ 10*	*cmol/kg*
Depth*		*≥ 60*	*30-60*	*≤ 30*	*cm*
Slope**		*≤ 8*	*8-15*	*15-25*	*%*

** Estimated according to WRB 2006 (see Schiefer et al., 2015)*
*** Sites with slopes >25% were excluded from calculations*

Data for these indicators have been taken from the Land Use/Land Cover Area Frame Survey 2009 (LUCAS), i.e. soil organic carbon (SOC) content, clay + silt content, soil pH, and cation exchange capacity (CEC), which was carried out in 25 member states, and the European Soil Data Base (ESDB) 2.0 1:1,000,000 (i.e. slope and depth) provided by IES/JRC European Commission. To exclude sites not under agricultural cropping, a map of arable land from Corine Land Use Cover (CLC 2000) was used. All analysis was carried out with ArcGIS 10.2.

By summing up all the scores, a minimum value of 6 and a maximum value of 20 (4 points for SOC content as well as for clay + silt content and 3 points for pH, CEC, depth and slope, respectively) could be attributed to a land unit. The total score points were separated into four different categories of SI potential.

Land with lowest quality has only a final score between 6 and 10 (category 1). This means that the soil has intrinsic properties which cannot support environmentally friendly intensification and therefore even extensification is suggested. Land in category 2 can show medium or good conditions (score >10), but one or even more indicators are in a "poor" condition (see table 1) and therefore an intensification is only possible with a high risk. A total score of 11 to 15 represents the medium category 3 where a low potential for SI is given, meaning that intensification should only be done with much caution. Land which can be recommended for SI (category 4) presents soils which can compensate environmental impacts show good agricultural production and have a total score from 16 to 20. This land was recommended for intensive agriculture under the precondition that it is managed in a sustainable way.

This classification scheme was also applied at a local scale in Rutzendorf/Marchfeld in the eastern part of Austria (Figure 1). Data were taken from the soil quality index for cropping which was elaborated by the Austrian Soil Taxation using a very detailed raster for soil sampling (40 - 60 meters).

Results

This work is a conceptual approach in order to identify soils with a potential for SI based on existing data. Because of a lack of data, not all arable land could be covered by this study. The results show for an analyzed area of 671.672 km^2 of arable land in Europe, that almost half of it (47%; class 1 + 2) is not suitable for sustainable intensification. Out of this, 4% have such bad intrinsic soil qualities that intensification cannot be considered (class 1). It is recommended to rather de- intensify and a reduce land use intensity in order to avoid environmental. 12% of the area are in medium conditions which means that a sustainable intensification on this land is not possible at the present state. This land should be used with precaution. Intensification without environmental risks can only be implemented at 41% of the analysed land, because this land has a high resilience against negative impacts from intensive agricultural production and showing a high performance at the same time.

The most frequent limiting factor for sustainable intensification is the cation exchange capacity (CEC). Clay content, pH and soil organic carbon (SOC) cause similar constrains in many areas. These soil properties influence each other and are also linked to the CEC.

Portugal, Poland, Greece and Spain are examples for countries with limited soil resources for intensive agriculture. Soils in regions around river basins in general show positive resilience and persistence. It is also found that proportionally seen, agricultural land suitable for SI counts more than 60% in Belgium, Slovak Republic, the United Kingdom, Latvia, the Netherlands and Hungary.

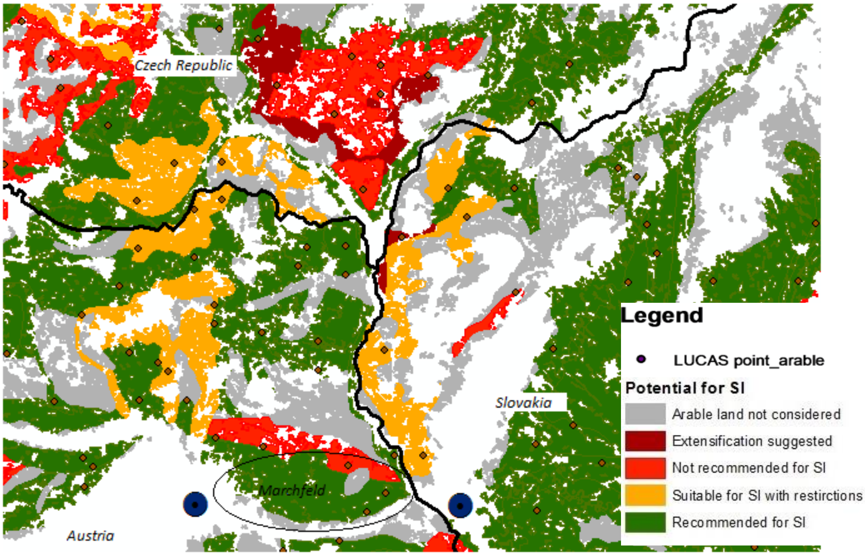


Figure 1: Land suitability for SI in Austria (Marchfeld), Czech Republic and Slovakia

In general, it must be observed that soils are very in-homogenously distributed and any final decision about SI can only be taken at a local scale. This was shown by a local case study in Rutzednorf/Marchfeld (Austria). In this local case study the classification scheme was applied on an area of 1.56 km^2. The SI classification scheme performed on European scale showed that land in this region can be recommended for SI (Figure 1).

However, only two sites were sampled in the LUCAS topsoil survey (2009) in the whole Marchfeld region. According to the land evaluation for SI, almost 63% of the studied area is indicated as land in rather poor conditions (category 2 and 3), where one indicator is out of range. In all cases, low SOC contents according to our classification scheme could cause environmental problems if used intensively.

Applying the SI scheme and indicators on local (Rutzendorf), regional (Germany, see Schiefer et al., 2015), and continental scale (Europe, see RISE, 2014), shows that the indicators and the classification scheme can be used at all scales. Further on it was shown that land recommended for SI is congruent with the best yield potentials. However, soils with only high yield potential cannot always be recommended for SI, because the capacity of "resilience" has to be observed additionally. A spatially expanded LUCAS soil survey also designed for soil mapping purposes could improve the results and would help to analyze more agricultural land.

References

Alexandratos, N. and Bruinsma, J., 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working paper No. 12-03. Rome, FAO.

Blum, W.E.H. and Eswaran, H., 2004. Soils for Sustaining Global Food Production. Journal of Food Science 69-2, 37-42.

Blum, W.E.H., 2005. Functions of Soil for Society and the Environment. Reviews in Environmental Science and Bio/Technology 4, 75-79.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M., Toulmin, C., 2010. Food Security: The Challenge of Feeding 9 Billion People. Science 327, 812–818.

Pretty, J., 2008. Agricultural sustainability: concepts, principles and evidence. Philos. Trans. R. Soc. B Biol. Sci. 363, 447–465.

Ray, D.K., Mueller, N.D., West, P.C., Foley, J.A., 2013. Yield Trends Are Insufficient to Double Global Crop Production by 2050. PLoS ONE 8, e66428.

RISE, 2014. The sustainable intensification of European agriculture, pp. 57-62. The RISE Foundation Brussels, www.risefoundation.eu.

Schiefer, J., Lair G.J., Blum W.E.H., 2015. Indicators for the definition of land quality as a basis for the sustainable intensification of agricultural production. International Soil and Water Conservation Research. http://dx.doi.org/10.1016/j.iswcr.2015.03.003

The Royal Society (London), 2009. Reaping the benefits science and the sustainable intensification of global agriculture. The Royal Society, London.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R., Polasky, S., 2002. Agricultural sustainability and intensive production practices. Nature 418, 671–677.

Anthropogenic impact in some grassland ecosystems in Romanian northern forest steppe

Adina Călugăr[1], Otilia Ivan[1], Ligia Acatrinei[1], Geanina Bireescu[1]

Introduction. Characteristics of the studied area

A fully understand of the vulnerability and auto-regulation capacity of an ecosystem especially if it is under anthropogenic impact must involves multidisciplinary studies. In this respect our researches pursue a holistic interpretation of three important components of an ecosystem: soil parameters - edaphic biodiversity - plant adaptation.

The studied area is located in Moldavian Plain and Central Moldavian Plateau which covers north-eastern and eastern Romania. According to Florea (2005) Moldavian Plain is included in steppe and forest steppe domain in the hillocks and hills. The Central Moldavian Plateau is also characterized by forest steppe vegetation substituted by crops in a great proportion (50%). The climate conditions characterized by high summer temperature and low precipitation amount, together with the vegetation and relief have caused distribution, depending on the altitude, of the main soil types: Luvisols and Chernozems (WRB, 2006).

Soils *vs.* anthropogenic impact

Soil quality reflects how well a soil performs the functions of maintaining biodiversity and productivity, partitioning water and solute flow, nutrient cycling providing support for plants and other structures. The modification of the soilscapes can lead to an increase in soil aggregate breakdown, loss of organic matter, an increase of soil erosion and, eventually desertification (Dazzi *et al*., 2013).

The soil resources in Central Moldavian Plateau belong to Chernozems, Gleysols and Regosols. The natural meadows investigated from Moldavian Plain generally are placed on fertile soils belonging to Haplic Chernozems (Bireescu et al., 2010, WRB, 2006). Both in Central Moldavian Plateau and Moldavian Plain the majority of ecopedological factors and determinants are included at medium and high size of ecological and favourability classes. The analysis of the soil fertility and quality indicators showed relatively low and medium physiological levels in the excessive drought summer season. In Moldavian Plain soil respiration and cellulosolysis showed higher values on the topsoil, these values decreasing on the soil profile, in relation with soil physical and chemical features. Enzymatic activity follows a similar trend, highlighting different levels during the vernal season, depending on physico-chemical soil features and local and zonal ecological specific. Fine soil texture, deficient air-water regime, hard soil consistency in the summer season, low summer precipitations and dry winds represent the main ecopedological factors and determinants restricting by lack or excess that limit the full use of the soil megatrofic potential. In all investigated pasture ecosystems, the anthropogenic impact particularly due to overgrazing has negative effects on the physico-mechanical and biological quality indicators.

Soil bioindicators

Soil biodiversity is one of the most important topics in the context of sustainable management of soil resources, a global priority assumed by European countries in which research, policy and practice are involved alike (Jeffery et al. 2010). Edaphic mesofauna together with microorganisms and other groups of fauna play a major role in mineralisation processes of the nutrients and indirectly to the plants growth (Colle et al., 2006). Nowadays it is well recognized that mites characterized by high species richness and ecological variability are valuable bioindicators. In this work two major groups of soil mites - Oribatida and Mesostigmata (excluding Uropodina) were investigated in a quantitative and a qualitative manner. In the both study areas oribatid mites are remarked as an abundant group in most of the investigated grasslands, holding substantial weight of total mites effectives and/or of entire mesofauna (Table 1). Lower densities and percentages occur in sites where another group of microarthropods was more abundant (e. g. collembolans or prostigmatid mites) (Acatrinei et Călugăr, 2014). Large-scale variation of average abundance and species richness can be noticed in both hayfields and pastures, depending on the site conditions, but especially on management measures and impact of certain factors. Human impact exerted by grazing, agriculture, construction, tourism and others induces changes in structure of the oribatid communities, as higher proportion of euryplastic species, which become edifying elements, a big number of accidental species, reduction of density and specific diversity. In the studied grasslands, Mesostigmata occupy the third place within the mites fauna, after Oribatida and Prostigmata with few exceptions (Acatrinei et Calugar, 2014). Reporting Mesostigmatid mites of total mesofauna indicate close proportions both in pastures and hayfields, from the two geographic units. Average density is higher in pastures compared with hayfields, as well as the weight of total mites; probably the increased intake of nitrogen from manure stimulates especially this group of mites (Table 1), in accordance with other authors (Cole et al., 2005).

Table 1 - Quantitative and qualitative parameters of the representative groups of edaphic mites

Study area/ grassland type **Taxonomic group**		**Central Moldavian Plateau**		**Moldavian Plain**	
		hayfields	pastures	hayfields	pastures
Mesostigmata	Number of species*	5-10	6-15	5-18	10-17
	Average abundance **	220-1560 *846.7*	400-4000 *2160*	600-1860 *1336*	1440-3820 *2220*
	% of total mites	5.8-26.1	9.4-20.4	9.5-14.8	11.2-18.3
	% of total mesofauna	6.2-12.5	6.3-15.6	4.9-15.9	3.8-13.4
O	Number of	8 - 36	5 - 13	8 - 44	10 - 21

	species*				
	Average abundance **	680-8640 *4287*	1780-16240 *8247*	1720-15720 *7213*	2060-15120 *6576*
	% of total mites	50.0-69.1	43.1-74.3	50.3-75.7	11.0-63.0
	% of total mesofauna	32.7-58.2	28.3-63.5	27.4-64.7	7.1-44.4

*number of species/site (minimum – maximum); **minimum – maximum, and *average* values/grassland type, (individuals/m^2)

Plant adjustment

Ecophysiological analysis of plant communities in different meadow was related with biotope influences (type of soil, moisture, nutrients accessibility, irradiation etc.) in order to evaluate the plant responses to the changing habitat (drought, extreme temperature, plant composition, overgrazing etc.). Previous work in a related soil-plant interaction showed that total content of photosynthetic pigments are comparable in hayfields growth on haplic vertic chernozem in Moldavian Plain with Central Moldavian Plateau, due to an adaptation of similar conditions of biotopes resources (slope xerophilous grasslands). The plant of steppe ecosystems from Central Moldavian Plateau on regosol arenic skeletic registered the smallest values of leaf sugars of all studied grasslands (Acatrinei et Calugar, 2014). Variation of investigated physiological parameters (photosynthetic pigments and leaf carbohydrates) in dominant plants of different grassland ecosystems showed smaller values in hayfields (mostly xerophilous) than in pastures (more humid) in both studied regions.

In conclusion, an optimized management of grasslands in the study area should integrate the assessment of anthropogenic impact, maintaining phytocoenosis function, as well as biodiversity and soil conservation.

Acknowledgements

The interdisciplinary study was made within BIODIV Program funded by the Romanian Ministry of Education and Scientific Research.

References

Acatrinei L. and Calugar A. 2014. Anthropic impact evaluation by soil-plant perspective in grasslands ecosystems from Northeastern Romania, Scientific Papers, Agronomy series, 57 (2), 155-162.

Bireescu L., Bireescu G., Constandache C., Sellitto M.V., Dumitru M. 2010. Ecopedological researches for ecological rehabilitation of degraded lands from Eastern Romania. Soil and Water Research, 5, 96-101.

Cole L., Bradford M. A., Shaw P. J., A. Bardgett R. D. 2005. The abundance, richness and functional role of soil meso-and macrofauna in temperate grassland - a case study, Applied Soil Ecology 33, 186-198

Dazzi C., Lo Papa G., Poma I. 2013. Integrating soil survey, land use management and political ecology: A case study in a border area between Peru and Ecuador. Land Use Policy, 35, 302-311

Florea N. 2005. Map of ecological units in Romania. Factors and Pedogenetic Processes under Temperate Zone. 4 S. noua, 109-116 pp. (in Romanian)

Jeffery, S. et al. (eds.). 2010. European Atlas of Soil Biodiversity. European Commission, Publications Office of the European Union, Luxembourg, pp.128

World Reference Base for Soil Resources 2006. A Framework for International classification, correlation and communication. Published by FAO - BGR, Hanover.

[1]Institute of Biological Research, Iasi, Romania,

adina.calugar@icbiasi.ro otilia.ivan@icbiasi.ro.

The changes of farmers' behavior in land use and its impacts on the food production during the process of marginalization of arable land

Liu Chengwu[1], Huang Limin[2]

Introduction

With the acceleration of industrialization and urbanization in the past 30 years, the phenomena of the marginalization of arable land use developed rapidly from east to west in China (Liu and Li, 2006). As an economic person, household peasant usually adjusts his land use behavior according to the change of food market. Some farmers shift a lot of surplus labor to non-agricultural areas and transfer land to other family when they reallocate labor and land resources. Some farmers, in the process of land use, constantly adjust agricultural land use pattern and change agricultural land use system and so on. These changes of farmers' behavior indicate that China's agricultural production is changing quickly during this process of the marginalization of arable land use.

This change is good or bad for China's food production, different scholars have different views. The impact of farmers' behavior change on agricultural land use is a complicated and dynamic process. The current research focused on labor shifting and its effect on agriculture development, and ignored the change of micro farmers' behavior and its impact on land use and food production. Until now, there is not a systematic conclusion about this problem. Some researches show that massive transfer of rural labor can effectively increase farmers' income (MaCarthy，2006；Wouterse，2008), improve agricultural productivity and production technology（Yilma，2008）, optimize the structure of agricultural production, enlarge the area of cash crop production (Taylor, 2003), achieve large-scale agricultural operations and relieve population pressure on arable land (Xu, 2012).However, some scholars believe that massive outflows of young, skilled agricultural labor in rural area weakened the agricultural labor force, resulting in the old and the woman to be the main agricultural labor, leading to excessive labor force and intergenerational labor fault (Xi, 2012). Farmers' diversified employment patterns resulted in farmers tend to operate their arable land in small scale (Yan, 2009), extensively use even abandon the arable land (Cheng,2010).These change caused the declining of multiple cropping index, the shrink of sown area and the degradation of environment. Many researchers believe it will threaten the foundation of agriculture development and national food security (Liu, 2006; li, 2011). There are two main reasons to result in researcher's different finding. The first cause is that many people study this issue just limited in a small area, a village in plains or hills, lack of the comparable analysis in different space. The second one is that they often focus on the study in a short period and lack of the comparable analysis in different time. So, these above research can't bring a whole and clear understanding about the farmer's behavior change on food production, and even cause confusion in the field of setting policy and regulation.

Although these research results are different from each other, they show the farmers' behavior change have important influence on the food production. Will Farmers' behavior change surely effect on Chinese food security? What is the difference of impacts of farmers' behavior change on food production between in plains and hills area?

In order to better understand the farmers' behavior change in land use and its impact on the food production during the process of the marginalization of arable land use, in this paper, based on nearly 30 years of farmer survey data, 1252 farmers' behavior data in land use in Xinaning city(Fig.1), we will comparatively analyze the differences of farmers' behavior change and its impact on food production between in the plains and the hills.

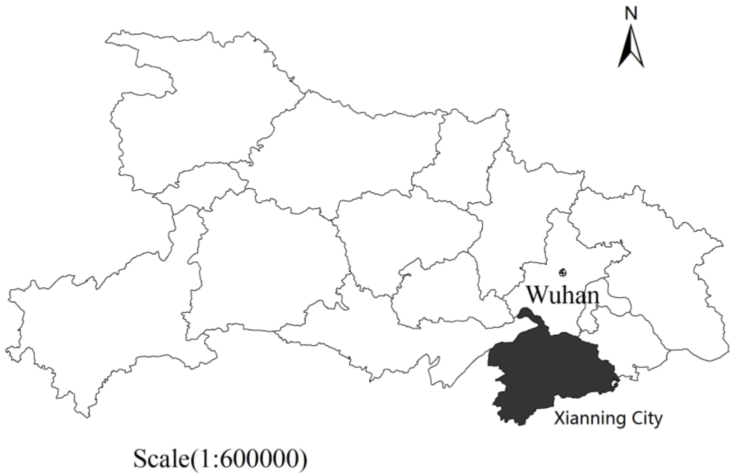


Fig.1 Location of Xianning city in Hubei province

Results

（1）In the process of land use， farm households substantially transfer labor force to non-agricultural areas outside the region，the current main agricultural labor characterized by female，middle-aged and low educational degree labor force，especially in the hills. The labor input per unit of land area dropped significantly. In the adjustment of land use structure，farm households enlarged the operation scale of total land area as well as dryland and reduced the sown area of main food crops (paddy) ，especially in the plains. The patterns of farmers' arable land use such as field plowing，seeding planting，weeding and harvesting changed profoundly，labor forces were replaced by agricultural machinery. As for the other factors of production inputs，farmyard manures were reduced，NPK chemical fertilizers were gradually replaced by compound fertilizers. The consumption of pesticides increased quickly. More and more families used agricultural service in land use，the level of agricultural mechanization was improved significantly.

（2）In the process of farmer behavior changing， the labor productivity，the land productivity and grain commodity rate significantly increased. Food production center of gravity moved emerged sloping phenomenon in space from the plains to the hills and mountains， from the high commercial value land to the low value land. However， the total output of main food crop like paddy had a persistent tendency to decline，the mains food share of average household decreased. Regional food security capacity has been weakened.

（3）In order to response the challenge of decreasing of food production because of the farmer’s behavior change in land use and make sure the security of food production， China government should stable the main food crops’ sown area in the marginalization area， set more positive policy to encourage the circulation of land， enlarge the scale of food production of farm household and improve land productivity of major food crops. Walking the road of “stabling area and increasing output” style is more sustainable than taking the road of “reclaiming wasteland and increasing the cultivated area”.

References

Liu C.W， Li X.B. 2006.Diagnosis on the marginalization of arable land use in China--A case of the average results of three major grain crops production. Geographical Research， 25(5): 895-904.
Li X.B, Zhao Y.L.2011. Forest transition， agricultural land marginalization and ecological restoration. China Population， Resources and Environment， 21(10): 91-95.
Gong P.2011. China needs no foreign help to feed itself. Nature,474(2):7.
Kong X.B.2014. China must protect high-quality arable land. Nature，506(2):7.
Long H.L.2012. China's rural transformation development and land use. Beijing: Science Press
Nancy M.， Calogero C.， Talip K.， et al. 2009. Assessing the Impact of Massive Out-Migration on Albanian Agriculture. European Journal of Development Research. 21: 448-470.

Wouterse F. S.，Taylor J. E.2008. Migration and Income Diversification: Evidence from Burkina Faso. World Development, 36(4):625-640.
Yilma T，Berg E，Berger，T.2008. The agricultural technology-market linkage under liberalization in Ghana: Evidence from micro data. Journal of African Economies, 17(1):62-84.

Addresses of authors:

LIU C.W[1], HUANG L.M[2]

1South-Central University for Nationalities, Research Center of Hubei Ethnic Minority Areas Economic and Social Development, Wuhan, China, liucw@igsnrr.ac.cn
2South-Central University for Nationalities, Research Center of Hubei Ethnic Minority Areas Economic and Social Development Wuhan, China, hlm267@163.com

Acknowledgements
This work was supported by National Social Science Foundation of China (Grant No. (14BGL156), the National Natural Science Foundation of China (Grant No. 41071069) and the Humanities and Social Science Foundation of China's ministry of education (Grant No.11YJAZH038).

Soil carbon stock change under winter wheat cropping systems

Šeremešić S.[1], Ćirić V.[1], Milošev D.[1], Vasin J.[2], Đalović I[2]

Introduction

Soil organic matter (SOM) is most often reported attribute of the long-term experiments and can be observed as the most important indicator of soil quality and agronomic sustainability of the agro-ecosystems (Varvel at al., 2002). Changes in SOM and other soil quality parameters can be accessed and verified only in continuous field trails within defined agro-ecological conditions.

Preservation of soil organic carbon stock is essential for maintaining soil productivity and yield stability. While the influence of individual management practice may be fairly understood, the interaction and aggregate effects of several practices on carbon stock are more difficult to predict. Beside that crop yields are sometimes hard to explain when SOC or C stock is considered. Changes in SOC stock in different cropping system may occur due to changes in carbon (C) input or crop management change. The aim of this study was to access the soil C stock of winter wheat cropping systems in the Chenozem soil.

Materials and methods

The selected winter wheat crop rotation systems from long-term experiments Crop rotation (CR) and IOSDV (Der Internationale Organische Stickstoff- Dauerdüngungsversuch) were investigated. Both experiments are situated at the Rimski Sancevi experimental station of the Institute of Field and Vegetable Crops in Novi Sad within the Chernozem zone of the Pannonian Basin. The crop rotations trial was set up in 1946/1947. The 3-year crop rotation consists of maize, soybean and winter wheat, the 2-year crop rotation consists of wheat and maize and winter wheat was grown in the monoculture. The IOSDV experiment was set up in 1984/1985 and it involves a 4-year crop rotation with sugar beet, winter wheat, maize and spring barley. The methodology of the experiment performance involves:

1) BØ manure 40 t ha^{-1} with no N fertilizer, crop residue removal
2) B2 manure 40 t ha^{-1}+ 100 kg N ha^{-1}, crop residue removal
3) A4 -mineral N 200 kg ha^{-1} crop residue removal.
4) C4 mineral N 200 kg ha^{-1} N crop residue incorporation.
5) N2 Unfertilized 2-year rotation with plowing the crop residues.
6) N3 Unfertilized 3-year rotation with plowing crop residue
7) MO wheat monoculture 100 kg ha^{-1} N with plowing the crops residue
8) D2 fertilized 2-year rotation 100 kg ha^{-1} N with plowing the crops residue
9) D3 fertilized 3-year rotation 100 kg ha^{-1} N with plowing the crops residue
10) C - Natural (virgin) soil – ruderal type of vegetation

The soil samples were taken after wheat harvest in three years sampling campaign sampled from 4 depths (0-20 cm, 20-40 cm 40-60 cm, and 60-100 cm). Grain yields were measured as average of four replicates every year and were adjusted to 13% moisture content.

Soil organic C stock was calculated according to formula:

$$SOCt\ ha^{-1} = \frac{SOC\ g\ kg^{-1}}{1000000}\ x\ depth(cm) x\ BD(Mg\ m^3) x\ 10000\ (m^2 ha^{-1}) x\ 1000\ (kg\ Mg^{-1})$$

The regression analysis was conducted to detect the effect of C stock on winter wheat yield by using the program STATISTICA 8.0 series 608c.

Results and discussion

For 0-20 cm soil depth C stock ranged from 32-49 t C ha^{-1}. Individual values were influenced with the applied manure, mineral N and plowing of crop residues that renewed SOC reserves in the soil. Compared with other plots the significantly lowest SOC stock was found in N2. The highest value of the deposited C (t ha^{-1}) was obtained in the soil layer of control. Similar values were presented in Belić et al. (2012) study. The variation of the accumulated C depends on the cropping technology, and the largest deviation was observed in C4 and MO.

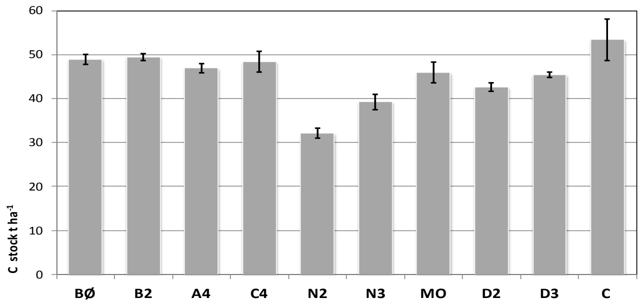


Figure 1. Soil C stock of the 0-20 cm soil depth

As for the value of stored C to a depth of 0-100 cm the bigger differences was found between cropping systems compared with soil layer 0-20 cm (Figure 2). They are partly a consequence of a general reduction in the level of SOM in the soil, but a considerable part comes as a resulted from belowground plant remains of crops in rotation. Significantly higher C stock was observed in the control. Accordingly, comes difference between control and N2 of 90 tC ha^{-1}. In 4-year rotation deposited SOC stock in layer 0 to 100 cm were similar. Interestingly MO with 40-years of winter wheat cropping was able to preserve SOC in deeper soil layers as a result of better moisture preservation and soil cover most of the year. This is in agreement with results presented by Németh et al. (2002) and Filcheva et al. (2002) for Chenozem soil.

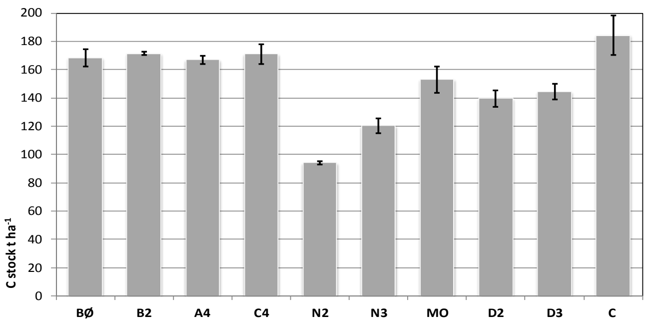


Figure 2. Soil C stock of the 0-100 cm soil depth

Carbon stock of both soil depths has influenced the winter yield. However, C stock for 0-100 cm has best fitted with polynomial regression (r=0,93**) indicating that increase of deposited C has optimal values of about 170 t ha^{-1} (Figure 3). In contrary, regressions for C stock in 0-20 cm depth indicate the existence of a linear dependence between C and yield.

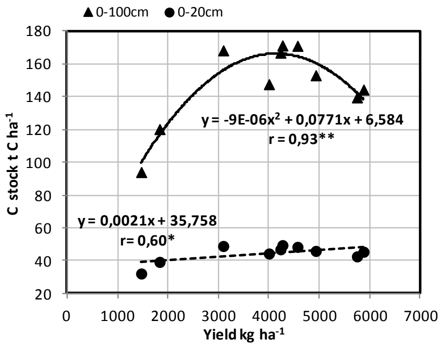


Figure 3. Correlation of C stock and winter wheat yield

Conclusion

Arable soils were lower in C stock compared with the control-natural soil. Differences among winter wheat cropping systems derives from a long-term cropping management and judicious fertilization with crop residue retention plays a crucial role in soil carbon maintenance. Depletion of soil carbon has occurred in both, top soil and subsoil. Obtained results could be valuable for developing a sustainable cropping technology for winter wheat and SOC conservation.

References

Belić, M., Manojlović, M., Nešić, Lj.,Ćirić, V., Vasin., J., Benka, P., Šeremešić, S. (2013): Pedo-ecological Significance of Soil Organic Carbon Stock in South-eastern Pannonian Basin. Carpathian Journal of Earth and Environmental Sciences, Vol. 8, 171-178.

Varvel, G.E., Liebig, M.A, Doran, J.W. 2002. Soil organic matter assesment in a long–term cropping system study. Communication in Soil Science and Plant Analyses, Vol. 33: 2119–2130.

Németh, T., Michéli, E. Pasztor, L. 2002. Carbon Balances in Hungarian Soils. In: Lal R, Kimble JM, Follett RF (eds) Agriculture Practices and Policies for Carbon Sequestration in Soil, CRC Press, pp. 449-459.

Filcheva, E., Rousseva, S.V., Kulikov, A., Nedyalkov, S. Chernogorova, T.Z. 2002. Organic Carbon Stocks in Soils of Bulgaria. In: Lal R, Kimble JM, Follett RF (eds) Agriculture Practices and Policies for Carbon Sequestration in Soil, CRC Press, pp. 471-476.

Addresses of authors:

Šeremešić Srdjan[1], Ćirić Vladimir[1], Milošev Dragiša[1], Vasin Jovica[2], Đalović Ivica[2]

[1]University of Novi Sad, Faculty of Agriculture, Department for Field and Vegetable Crops, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia. srdjan.seremesic@polj.uns.ac.rs

[2]Institute of Field and Vegetable Crops, Maksima Gorkog 30
21000 Novi Sad, Serbia

Features of land with technogenic pollution use (on the example of Pervouralsky-Revdinsky industrial hub)

Firsov I.O., Gusev A.S., Belichev A.A., Vashukevich N.V.

Sverdlovsk region is the largest industrial center of Russia. The historical development in this region of factories of siderurgy and non-ferrous metallurgy with old technologies leads to significant pollution of the environment with gas and dust emissions containing large amounts of toxic compounds.

One of the most dangerous and widespread type of environment pollution is the contamination with heavy metals (HM). In soil heavy metals lead to quite dramatically change of the soil formation processes, break down barriers controlling the entry of excessive amounts of heavy metals through the trophic (food) chains to humans.

An important problem is that different levels of contamination with heavy metals fall on different soils with different properties and, therefore, to identify the effect of singular pollution factor on soil properties, and even to compare properties of contaminated and pure, without technogenic pollution, soils is almost impossible.

To solve the abovementioned problems we have attempted to explore the complex influence on soil of the industrial enterprises in Pervouralsky-Revdinsky industrial hub emissions. The works of scientists of the Ural State Agrarian University were devoted to the study of the characteristics and the possibility of using this land area (Gusev et al., 2014; Gusev, 2000; Firsov, 2014). The basic factories of Pervouralsky-Revdinsky industrial hub are SUMZ – environment polluter by copper, lead, zinc, cadmium and other HM together with oxides of sulfur and nitrogen, hydrogen fluoride and «Chrompick», in which emissions chromium compounds are dominated. Under the influence of these and other factories, vehicles etc the regional soils are contaminated with HM complex at large areas (about 71%) and belong to the soils of areas with ecological emergencies (Zc from 32 to 128), and in some places (up 17.5%) - to soils areas of ecological disaster (Zc ≥128) (Gusev et al., 2014).

At the centers of pollution, levels of HM dozen times or more great than the amount set by clark quantities and levels of MPC. Around the SUMZ (1-2 km) the area of technogenic desert landscape with a highly degraded soils enriched with mobile forms of TM is allocated; it is replaced by the zone of 0.5-2 km wide with degraded soils of varying degrees and oppressed vegetation, after that - a zone of small-changed soils and vegetation also contaminated with HM.

According to the current level of pollution in the survey area, we have proposed restrictions on land use basic categories. It is recommended to minimize the use of land in the contaminated areas in agriculture, the introduction of special water and forest protection procedures, as well as recultivation methods of agricultural land (Table 1).

Table 1. The ways of land use in accordance with their anthropogenic pollution

Land category	**Moderately hazardous pollution**	**Slightly hazardous pollution**
Settlements lands	Exclusion of lands belonging to agricultural use, increase of the recreation zone area	Diagnosis of the air pollution level, limiting the agricultural land use
Water lands	Holding of special protection measures, environmental monitoring of water objects	Periodic monitoring of drinking water and wastewater type

Forest lands	Limit of deforestation, conducting forest monitoring	Retesting forest inventory, conducting forest monitoring
Agricultural lands	Requires removal of land from agricultural use	The use of special measures for recultivation. The introduction of special crop rotation

Special attention to areas with increased anthropogenic level demands to be given to the agricultural lands use because of high pollution levels can significantly degrade the quality of plant products derived from contaminated soils. It is known that certain content of toxic substances in the soil, the plants growing on them accumulate dangerous for human and animal health amounts of harmful substances. The principle of «biological dilution» allows to reduce the concentration of toxic elements during the passage of the trophic chains (plant - animal - people). Therefore, in one case we can replace crops to more stable and increase the food chain, in the other – to reject of food crops and replace them with technical cultures. The processes of pollution prevention and melioration of contaminated lands are improved (purification of contaminated wastewater, using sorbents etc.) (Gusev et al., 2014; Baikin et al, 2001; Buraev et al., 2008). The cost of these activities is not too high, but we consider the appropriate connection procedures as a promotion for developers of these techniques, as well as for those who apply them, by the departments of the Ministries of Natural Resources and Agriculture.

At the present time, the zoning principle of crop production was developed in relation to the location of the inhabited locality. Developers of similar subjects pay attention to the agricultural land condition, which, in our opinion, should be actively used in the practice of areas distribution (Bryzhko et al., 2004).

Thus, contaminated to an acceptable level the Middle Urals can be used for agricultural purposes, while required quality control

References

Baikin, Y.L. et al. 2001. The method of growing crops on soils contaminated with heavy metals: .Pat. 2189712 Ros. Federation.

Bryzhko, V.G. and Kostina, A.B. 2004. Features of agricultural production at the contaminated territories, Achievements of agricultural science and technology, No 2, P.32-33.

Buraev, M.E. et al. 2008. The sorbent for purification the industrial wastewater from the compounds of lead and cadmium and the method of its application: Pat. 2412756 Ros. Federation.

Gusev, A.S. 2000. The impact of anthropogenic pollution on soil properties of the industrial areas of the Sverdlovsk region, Abstract of dissertation for the PhD degree, Tyumen, 16 p.

Gusev, A.S., Baikin, Y.L. and Zorin, A.P. 2014. The use of mathematical methods in the evaluation of land affected by anthropogenic pollution, Integration of science and education in the modern world: Proceedings of the International scientific-practical conference, Ekaterinburg: UrGAU, P.44-47.

Firsov, I.O. 2014. Perspectives for the use of land at the urban district Pervouralsk, Proceedings of the International scientific-practical conference «Konyaev readings – 2013», Ekaterinburg: Izd UrGAU, P.140-143.

Addresses of authors:

Firsov I.O., Gusev A.S., Belichev A.A., Vashukevich N.V.

Ural State Agrarian University

Ekaterinburg, Russia, e-mail: a_anser@mail.ru; aabel@list.ru ; nadiav@bk.ru

Potential for ecosystem service provision in less favoured agricultural areas compared to other agricultural areas in the European Union

Andrea Hagyo[1], Jean Michel Terres[1], Maria Luisa Paracchini[1]

Introduction

The new Biodiversity Strategy of the EU (European Commission, 2011) aims to halt the loss of biodiversity and also the degradation of ecosystem services in the EU by 2020. As it has been proved that focusing only at protected areas and species is not enough, semi-natural and agricultural land are also targeted in the strategy. (Maes et al., 2011) Though the effects of extensive agricultural activity are complex and local nature conservation objectives and trade-offs between different ecosystem services have to be taken into account (Ford et al., 2012), good management practices may turn trade-offs into opportunities and can maintain ecosystem functions (Power, 2010).

Our aim was to compare the capacity of less favoured agricultural areas for delivering various ecosystem services to other (more productive) agricultural areas at EU level. Less favoured areas are distinguished based on an EU scheme, 'less favoured areas' (LFA, Articles of Council Regulation (EC) 1305/2013) which designates areas where agricultural production or activity is more difficult because of natural handicaps and therefore there is a significant risk of agricultural land abandonment.

Materials and methods

The exercise covers 25 EU Member States. The agricultural area was mapped by the Corine Land Cover 2006 Version 17 (12/2013) (and Corine Land Cover 2000 for Greece) database (European Environment Agency), the spatial database of high nature value farmland (Paracchini et al., 2008) and the utilized agricultural area database (UAA, Source: CAPRI, reference year 2004). The less favoured areas (LFA) were taken from the delineation used in 2008/2009 (EUROSTAT, DG AGRI). The following ecosystem services (CICES Classification, MAES, 2013) were selected for the study: (1) provisioning services: cultivated crops, reared animals, water provisioning for drinking and for non-drinking purposes, (2) regulating and maintenance services: mass stabilization and control of erosion rates, hydrological cycle and water flow, maintaining nursery populations and habitats, pollination, global climate regulation and (3) cultural services: entertainment & aesthetic services. The capacities of agro-ecosystems to deliver the above mentioned services were approximated by the following indicators/proxies, respectively: (1) provisioning services: cropland soil productivity, grassland soil productivity (both indicators are used in two ways, considering or not the current share of land used for crop production and grazing, as a proxy for the potential supply and for the actually used set of supply, respectively), hydrological excess water (mm), (2) regulating and maintenance services: erosion control index (1 – C-factor), water content at field capacity (cm3 cm-3), semi-natural vegetation abundance, pollination potential index, carbon stock in the topsoil (t/ha in 0-30 cm depth) and (3) recreation potential index. The difference between LFA and non-LFA was tested for all indicators for random selections of grid cells in LFA and in non-LFA areas, respectively. Principal component analysis (PCA) was used to detect spatial trade-offs among services for random selections of grid cells.

Results

The capacity of the less favoured agricultural areas is significantly lower than that of other agricultural areas for potential supply for cultivated crops and reared animals and also for actually used set of supply of cultivated crops. In contrast the actually used set of supply for reared animals is already higher in extensive areas. The capacity of less favoured agricultural areas is higher than that of other areas for most of the regulating and maintenance services and also for recreation.

The result of the principal component analysis (PCA) was similar for LFA and non-LFA at EU level. In general, the individual indicators are not strongly correlated with each other (and with the components). Cultivated crops capacity is negatively related (component loading < - 0.5) to the first axis (Figure 1) while habitat maintenance is positively related (component loading > - 0.5). Reared animals capacity is correlated to the second component.

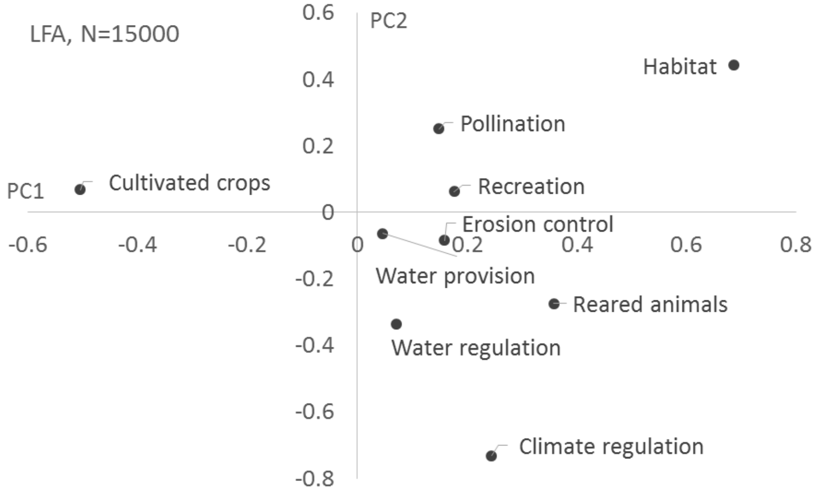


Figure 1. Biplot revealed by the principal component analysis of ecosystem services in LFA (less favoured areas). N = 15000, total explained variance by the first two principal components is 42%.

Conclusions

The lower capacity for crop and reared animal provisioning of the less favoured agricultural areas is in line with the characteristics of the LFA scheme, i.e. areas with natural constraints where it is important to maintain agricultural management. Despite the lower soil productivity, the actually used set of supply for reared animals is higher in less favoured areas due to the higher share of grasslands in LFA which emphasizes that the maintenance of extensive grasslands is important for the reared animal provisioning in EU27.

The higher capacity of less favoured agricultural areas for most of the regulating services and for recreation compared to more productive areas can underpin the hypothesis that in marginal agricultural areas the extreme biophysical conditions and their specific agricultural management can maintain and/or improve the ecosystem capacity for services, besides creating higher landscape diversity and provide habitat for specialized species (Berger et al., 2006).

Based on the structure revealed by the correlation biplot of the PCA only some loose bundles of capacities can be identified. This is in line with the general tendency that the relationships between ecosystem services in agricultural land are highly non-linear (Power, 2010).

References

European Commission 2011. Our life insurance, our natural capital: an EU biodiversity strategy to 2020. COM(2011) 244. Brussels.

Ford, H., Garbutt, A., Jones, D. L., Jones, L. 2012. Impacts of grazing abandonment on ecosystem service provision: Coastal grassland as a model system, Agriculture, Ecosystems and Environment 162, 108– 115.

Maes, J, Teller, A, Erhard, M, Liquete, C, Braat, L, Berry, P, Egoh, B, Puydarrieux, P, Fiorina, C, Santos, F, Paracchini, ML, Keune, H, Wittmer, H, Hauck, J, Fiala, I, Verburg, PH, Condé, S, Schägner, JP, San Miguel, J, Estreguil, C, Ostermann, O, Barredo, JI, Pereira, HM, Stott, A, Laporte, V, Meiner, A, Olah, B, Royo Gelabert, E, Spyropoulou, R, Petersen, JE, Maguire, C, Zal, N, Achilleos, E, Rubin, A, Ledoux, L, Brown, C, Raes, C, Jacobs, S, Vandewalle, M, Connor, D, Bidoglio, G. 2013. Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020. Publications office of the European Union, Luxembourg.

Maes, J., Paracchini, M. L., Zulian, G. 2011. A European assessment of the provision of ecosystem services. Towards an atlas of ecosystem services, JRC Scientific and Technical Research Reports.

Paracchini, M.L., Petersen, J-E., Hoogeveen, Y., Bamps, C., Burfield, I., van Swaay C. 2008. High Nature Value Farmland in Europe. An estimate of the distribution patterns on the basis of land cover and biodiversity data, Scientific and Technical Research series – ISSN 1018-5593, EUR 23480 EN – 2008, Luxembourg: Office for Official Publications of the European Communities.

Power, A. G. 2010. Ecosystem services and agriculture: tradeoffs and synergies, Phil. Trans. R. Soc. B 2010 365, doi: 10.1098/rstb.2010.0143.

Addresses of authors:

[1]European Commission, Joint Research Centre (JRC), Institute for Environment and Sustainability (IES), Monitoring Agricultural Resources Unit, Via Enrico Fermi 2749, I - 21027 Ispra (VA), Italy, andrea.hagyo@jrc.ec.europa.eu, jean-michel.terres@jrc.ec.europa.eu, luisa.paracchini@jrc.ec.europa.eu

Assessment of Land Quality for agricultural purpose based on RS and GIS

Luo Han[1], Tang Yunyi[2]

Introduction

Under the background of the global environmental problems, developing sustainable agriculture is one of the most significant tasks in all countries around the world, especially in the developing country (Yu et al. 2011). The sustainable agriculture is to satisfy the increasing crop requirements with the inherent land resource, in an approach of optimization of resource use towards achievement of sustained productivity over a long period (Kumar 2015). Cultivated land plays a crucial role in sustainable agriculture, and its quantity and quality are directly related to the agricultural development and food security of certain area (Liu et al. 2010). With the rapid economic development, urbanization and industrialization, limited cultivated land is being occupied continually and the heavy pollution causes a lot of risk factors of agricultural production. The situation of cultivated land in the future is extraordinarily severe. The condition of China leads to the fact that cultivated land is an important part of sustainable agriculture (Wang et al. 2012). In order to protect the cultivated land resource and improve its quality, it is essential to investigate and assess the land quality (LQ) objectively.

As an important research approach of observation of agriculture activity, remote sensing (RS), geographic information system (GIS) has a most broad role in the study of agriculture. RS and GIS technologies could collect information on agricultural activities for long time and large area.

In this study, we try to assess land quality of Chengdu, Sichuan Province, China, based on the information provided by RS index in analytic hierarchy process (AHP).

Data and methods

Study area

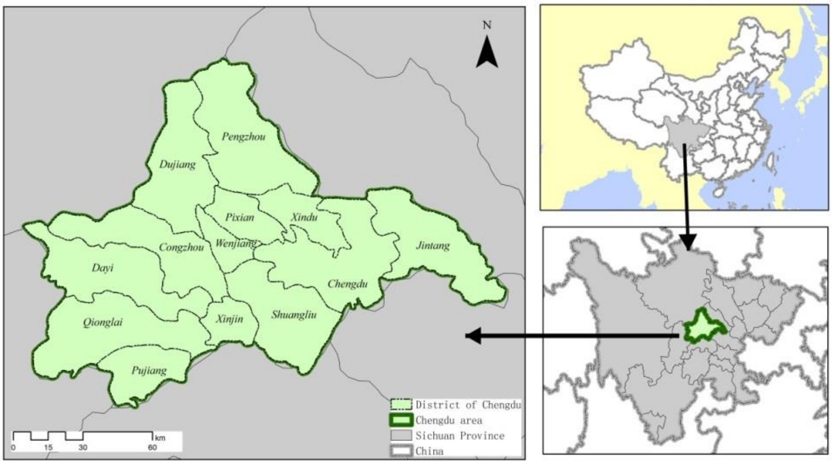


Figure 1 Location of Chengdu and Sichuan Province in China

This study was carried out in Chengdu area, which is the provincial capital of Sichuan province in Southwest China, as well as a major city in Western China. Chengdu area is located between 103°3′ to 104°54′ E and 30°01′ to 31°24′ N (Figure 1) and covers an area about 11,985 km^2. This area has a monsoon-influenced humid subtropical climate and is largely mild and humid. The fertile Chengdu Plain, on which Chengdu is located, is also known as the "Country of Heaven", a phrase also often translated as "The Land of Abundance". Chengdu enjoys favourable agricultural conditions and rich natural resources. It is an important base for high-quality agricultural products.

Data sets

The different types of data have been used in this study: ASTER GDEMv2 (Resolution 30m); MODIS product, MOD13A2 (NDVI, NIR Reflectance, Red Reflectance) (Resolution 1km); Soil data from Harmonized World Soil Database to the area on1:100,000 scale; ENVI 5.0 and ArcGIS software were used to prepare the data.

Method

This study adapted GIS based method of analysis. The integration of GIS, AHP and MCDA method provides powerful spatial analysis functions. AHP was adopted to derive weights for the evaluating model. GIS weighted overlay in spatial analysis operation was used to combine the different indicator to determine the LQI for agricultural purpose.

Derivation and Grading of assessment indicators

Selection of assessment indicators

In this article, the pressure-state-response framework was adopted to establish index system of the land quality evaluation. Different aspects of indicators was selected to evaluate the land quality, including pressure on the land resource(PLI), state of land quality(SLI), societal response(SR).Every group has couples of indicators (Figure 2).

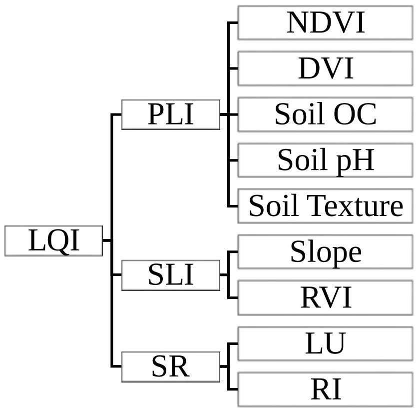


Figure 2 land quality assessment indicator system

Indicator grading and scoring

Based on the expert knowledge, the local conditions and land quality assessment for graded them as listed below (Table 1). A score within the range of [0,100] was assigned to an indicator via linear interpolation (Ochola and Kerkides 2004).

Table 1 Relative weight of indicators and corresponding classes.

Indicator	Value	Score	Weight	Indicator	Value	Score	Weight
Slope	<2	100-95	0.1044	Soil OC	0-0.75	30	0.1336
	2-6	95-75			0.75-1.08	50	
	6-15	75-45			1.08-1.12	70	
	15-25	45-15			1.12-1.45	90	
	>25	0-15			>1.45	100	
RVI	<5	0-20	0.0696	Soil PH	0-5	0	0.1037
	5-10	20-40			5-5.9	20	
	10-15	40-60			5.9-6.1	40	
	15-20	60-90			6.1-6.8	60	
	>20	90-100			6.8-7.1	80	
NDVI	<0.2	0-60	0.1786		7.1-7.5	100	
	0.2-0.3	60-85			7.5-8.0	80	
	0.3-0.5	85-90			8.0-8.5	60	
	0.5-0.8	90-98		RI	77718	60	0.0978
	>0.8	90-100			213152	63	
DVI	<0.03	0-30	0.1015		309775	65	
	0.03-0.15	30-50			347422	68	
	0.15-0.33	50-70			494730	70	
	0.33-0.51	70-90			542074	72	
	>0.51	90-100			593302	78	
LUD	water	0	0.1303		628513	80	
	wastelands	40			703279	85	
	build up	40			865911	88	

	vegetation	80		878168	92
	agriculture	100		1382063	98
Soil texture	0	20	0.0804	1390355	100
	1	40			
	2	70			
	3	100			

Analyses and Results

The spatial framework of land quality in Chengdu area shows in Figure 3.The LQI has been divided into five levels: very good, good, medium, poor and very poor. The LQI with very good and good score is mainly distributed in the middle part of study area, where the terrain is advantageous to agricultural development, and both soil fertility and moisture reflected by remote sensing index are better than other areas. The LQI distributed around the middle area is at the medium level due to the appropriate natural settings including slope, soil fertility and soil moisture. The LQI of poor and very poor score is in north-west of study area, because of the mountainous terrain and there is a small circular region with very poor score, due to the land cover state.

The overall LQI in Chengdu area is very good. The vast majority of land is highly suitable for agricultural activity with 36%. the good and medium one is the second both with 27%, the poor and very poor LQI is just less than 10%.

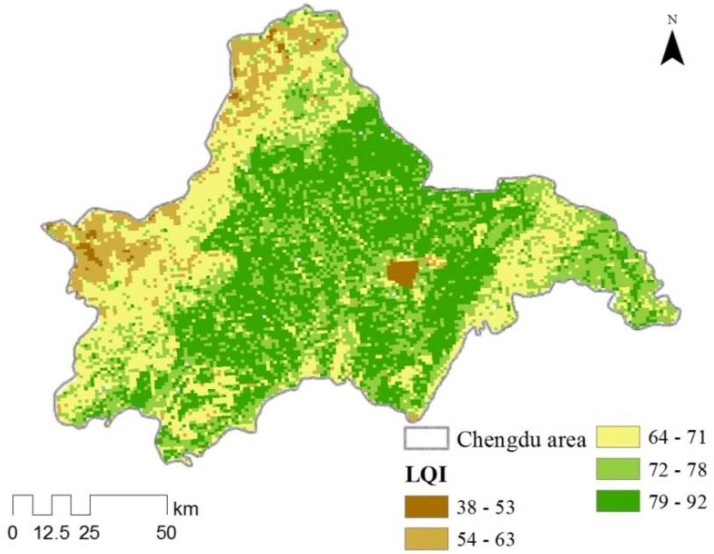


Figure 3 LOI map of Chengdu area

References

Kumar, T., and D. C. Jhariya. 2015. Land quality index assessment for agricultural purpose using multi-criteria decision analysis (MCDA). Geocarto International:1-20.

Liu, Y., Y. Zhang, and L. Guo. 2010. Towards realistic assessment of cultivated land quality in an ecologically fragile environment: A satellite imagery-based approach. Applied Geography 30:271-281.

Ochola, W. O., and P. Kerkides. 2004. An integrated indicator-based spatial decision support system for land quality assessment in Kenya. Computers And Electronics In Agriculture 45:3-26.

Wang, Z., L. Wang, R. Xu, H. Huang, and F. Wu. 2012. GIS and RS based Assessment of Cultivated Land Quality of Shandong Province. Procedia Environmental Sciences 12:823-830.

Yu, G., H. Yang, Z. Tian, and B. Zhang. 2011. Eco-Environment Quality Assessment of Miyun County Based on RS and GIS. Procedia Environmental Sciences 10:2601-2607.

Addresses of authors:

Luo Han[1], Tang Yunyi[2]

[1] Department of Environmental Sciences, College of Architecture and Environment, Sichuan University

Chengdu, China, hanluo2012@foxmail.com

[2] Department of Environmental Sciences, College of Architecture and Environment, Sichuan University

Chengdu, China, tyy.1991@foxmail.com

Predicting the degradation of buried materials

M.G.Kibblewhite[1]

Introduction

Soil supports ecosystem services, including a platform for the built environment and cultural services (Haygarth & Ritz, 2009). It houses buried infrastructure and foundations and anchorages for structures. It preserves artefacts, acting as a cultural archive. These services are affected by the extent to which materials buried in soil degrade and how quickly this degradation occurs. Therefore it is important to predict how different types of materials will or will not degrade in different soils. This paper discusses which materials are substantially degraded in soils. It refers to recently reported predictions of the degradation of materials buried in soil types occurring in Europe (Kibblewhite et al., 2015). Its purpose is to demonstrate how soil information can be used to predict the fate of materials buried in soil.

Results and discussion

The survival or not of materials in soil depends on both the nature of the material and the type of burial soil. Natural and manufactured materials are buried in soil. Rock, stone and wood form foundations and buried structures. Ceramics (e.g. bricks and tiles) and concrete are used in buried structures. Metals, especially iron (Fe) are used in foundations and in anchorages for above-ground structures. Fe and copper (Cu) and lead (Pb) are found in pipes, cables, etc. Organic materials are used in buried seals and connections. Information about the likely degradation of these and other buried components is important when selecting design options and for assessing the likely condition of ageing assets. In addition to construction materials, a wider range of materials are found in artefacts and human and other remains preserved in soil. These include bones and teeth, ceramics and glass, natural organic materials (e.g. human and animal remains and plant products - wood, seeds and pollen and manufactured textiles and leather), metallic materials such as gold (Au), silver (Ag), Cu and bronze, Pb and different Fe-based materials. Soil forming factors (parent material, climate, vegetative cover, land use, time, etc.) produce soils that present different hydrological, pH and other properties affecting the degradation of materials. The most preserving soils for most materials are those that are permanently dry.

Table 1. Effects of soil hydrology and pH on rates of degradation of buried materials

Hydrology	**pH**	**Organic materials**	**Cu and bronze**	**Fe and its alloys**	**Bones and teeth**	**Concrete**
Permanently dry	**Acidic**	Very slow	Slow	Slow	Slow	Very slow
	Neutral	Very slow	Very slow	Slow	Slow	Very slow
	Alkaline	Very slow	Very slow	Slow	Very slow	Very slow
Seasonally wet	**Acidic**	Fast	Fast	Fast	Fast	Slow
	Neutral	Fast	Slow	Fast	Slow	Very slow
	Alkaline	Slow	Slow	Fast	Slow	Very slow
Permanently wet	**Acidic**	Very slow	Slow	Very fast	Fast	Slow
	Neutral	Very slow	Slow	Fast	Slow	Very slow
	Alkaline	Very slow	Very slow	Fast	Slow	Very slow

NOTES:
1. Very slow = no substantial degradation in 2 x 10^3 y; Slow = no substantial degradation in 5 x 10^2 y; Fast = substantial degradation in 10^2 years; Very fast = substantial degradation in < 10^2y.
2. Stone and rock are well-preserved in soil
3. Au, Pb and to a lesser extent Ag are well-preserved in soil
4. Although more fragile ceramics and glass objects may be shattered and dispersed in soil, they are well-preserved as a material.

The key factors controlling degradation materials are hydrology and pH. These control redox potential and acidity, which in turn control chemical dissolution, corrosion and microbe-mediated oxidation. In general, materials degrade more quickly with a flow of oxygenated water, than when either the soil is permanently dry or waterlogged (and anaerobic). Alkaline conditions are less degrading than acidic ones for many materials. Wetting and drying cycles accelerate degradation. Table 1 summarises how factors affect degradation. Organic materials are well-preserved in waterlogged and anaerobic soils; if these are fed by alkaline groundwater they may preserve some metals well. Acidic soils are degrading of bones and teeth and of Cu, bronze and especially Fe objects, with the latter enhanced with elevated chloride. Table 2 summarises anticipated rates of degradation of materials for soil types that are common in Europe. Kibblewhite et al. (2015) used a similar approach for all soil types present in the Soil Geographical Database of Eurasia (SGDBE). Figure 1 shows how results can be combined with soil mapping data. This example is at a continental scale, but the same approach is applicable at finer scales.

Table 2. Rates of degradation of different materials buried in different soil types

Soil type						
Reference Soil Group	**Prefix qualifier**	**Organic materials**	**Cu and bronze**	**Fe and its alloys**	**Bones and teeth**	**Concrete**
Albeluvisols	Haplic	Slow	Fast	Very fast	Fast	Slow
Calcisols	Haplic	Slow	Very slow	Slow	Slow	Very slow
Cambisols	Haplic	Fast	Fast	Fast	Fast	Very slow
	Dystric	Fast	Fast	Fast	Fast	Slow
	Eutric	Slow	Fast	Fast	Slow	Very slow
Chernozem	Haplic	Slow	Slow	Slow	Slow	Very slow
Fluvisols	Haplic	Fast	Slow	Fast	Fast	Very slow
	Dystric	Fast	Fast	Fast	Fast	Very slow
	Eutric	Fast	Slow	Fast	Slow	Very slow
Gleysols	Haplic	Slow	Slow	Fast	Slow	Very slow
Histosols	Dystric	Slow	Fast	Very fast	Fast	Very slow
	Eutric	Slow	Slow	Fast	Slow	Very slow
Leptosols	Haplic	Slow	Slow	Slow	Slow	Very slow
	Dystric	Slow	Slow	Fast	Fast	Very slow
	Eutric	Slow	Slow	Slow	Slow	Very slow
Luvisols	Haplic	Fast	Fast	Fast	Fast	Very slow
	Dystric	Fast	Fast	Very fast	Very fast	Slow
	Eutric	Fast	Slow	Fast	Fast	Very slow
Podzols	Haplic	Fast	Fast	Very fast	Very fast	Slow

Figure 1. Predicted rates of degradation for bronze buried in soils across Europe (green = slow; yellow = fast; red = very fast)

Conclusions

The interaction between the material nature of buried objects and soil properties that leads to degradation of the former is complex but predictable and can be explored spatially using mapping data. The results have application in management of buried physical assets and archaeological artefacts.

References

Cronyn JM. 1990. The elements of archaeological conservation. Routledge, London.

European Commission. 2003. Soil Geographical Database of Eurasia at scale 1:1,000,000 (SGDBE). http://eusoils.jrc.ec.europa.eu/esdb_archive/esdbv2/intro.htm#SGDBE

Haygarth P. and Ritz K. 2009. The future of soils and land use in the UK: Soil systems for the provision of land-based ecosystem services. Land Use Policy. 26, S187-S197.

Kibblewhite M., Tóth G. and Hermann T. 2015. Predicting the preservation of cultural artefacts and buried materials in soil. Science of the Total Environment. (In press, manuscript STOTEN-D-15-00854R2).

Addresses of authors:

M.G.Kibblewhite[1],

[1]Cranfield University
Cranfield, United Kingdom, mark@mksoilscience.eu

Acknowledgements

This paper is based on work carried out for the European Commission under contract CCR.IES.C391026.X0. The author thanks Gergely Tóth and Tamas Hermann for their support and inputs. The GIS analysis was made by Tamas Hermann.

The role of tillage and crops in the existence of the soil

Kisic Ivica[1], Bogunovic Igor[1], Birkas Marta[2], Jurisic Aleksandra[1]

Abstract

In order to estimate the effect of tillage and crops on water erosion soil loss was monitored on Stagnic Luvisol. The highest erosion in the 20-year investigation period was recorded in the control treatment. Following was the treatment that involved ploughing and sowing up and down the slope. Lower soil losses were recorded in no-tillage and treatments with ploughing and sowing across the slope. Higher soil losses were recorded in spring wide row crops growing (maize and soybean) comparing to the in winter crops (wheat and oilseed rape) and double crops (spring barley with soybean). In the investigation period an average loss of 0.44 cm of the plough layer was recorded in the control treatment, which means that the entire plough layer (depth 25 cm) would completely be eroded away in a period of 57 years. In ploughing and sowing up and down the slope treatment average soil loss was 0.09 cm and plough layer would completely be destroyed in a period of approximately 270 years. In all other treatments which we recommend for the area of Stagnic Luvisol the soil should be preserved for the next several thousands of years, more accurately is not endangered by erosion processes.

Key words: soil tillage, crops, soil loss

Introduction and objectives of investigation

Water induced soil erosion is influenced by tillage (especially by the ploughing direction in relation to slope), crop selection, planting direction or orientation, and the amount, distribution, and intensity of rainfall (Boardman and Poesen, 2006).The erosion affects the most valuable surface soil layer, one in which the agrotechnical amelioration measures were implemented, which was prepared by using processing energy, in which nutrients are placed and which is treated with pesticides. The primary objective of this investigation is to determine the characteristics of water erosion on Stagnic Luvisols (IUSS, 2007) and then to find the answer to the question whether it is possible, and to which extent, to reduce erosion to unacceptable level (soil loss tolerance – T values) by applying different soil tillage treatments in growing agricultural crops (Verheijen et al., 2009). Based on the obtained results, the optimal tillage for Stagnic Luvisol, a soil intensely or highly prone to water erosion, should be determined. The physical composition (i.e. high content of fine sand), chemical properties (i.e. low pH value, calcium carbonate deficiency, low content of soil organic matter) and very low structural stability make those soils highly susceptible to water erosion on slopes (Basic et al., 2004). The results should provide guidelines for recommending the optimal method of tillage on Stagnic Luvisol, as a remarkably widespread soil type in this part of Europe.

Materials and methods

The experimental field was located near the town Daruvar in central Croatia (N: 45°33' E: 17°02') and was initiated on Stagnic Luvisols following the oil-seed rape crop harvest in the summer of 1994. Erosion was measured on six plots, according to the USLE (Universal soil loss equation - Wischmeier and Smith, 1978) protocol, which specifies a plot area of 41.3 m^2 (22.1 m long and 1.87 m wide) on a 9 % slope. Sheet metal borders were used to fence off the plots, and were removed before each tillage operation and then placed back into the soil for the remainder of the growing season. Filtration equipment was set up at the lower end of each plot and was designed for volume measurement of sediment yield and water transported by surface runoff transport. After each rainfall followed by erosion, water and sediment yield were collected. To facilitate the use of agricultural machinery, the plots were set 15 m apart to allow the tractor with the longest trailing implement to easily turn at the ends. Mechanical operations, tillage direction (with respect to slope), and the row orientation or planting direction for the six treatments are described in Table 1.

Table 1. Tillage treatments

Description	Tillage direction	Planting direction
Control treatment - bare fallow (USLE protocol)*	Up and down	No crop
Plowed to 30 cm; disked and harrowed	Up and down	Up and down
No-tillage, seed drilled into mulch, weeks after applying total herbicides	Up and down	Up and down
Plowed to 30 cm, disked and harrowed	Across the slope	Across the slope
Plowed to 50 cm, disked and harrowed	Across the slope	Across the slope
Subsoiled to 50 cm with tines spaced at 70 cm, plowed to 30 cm, disked and harrowed	Across the slope	Across the slope

**Maximum runoff and soil loss was expect in this treatment*

The crops on each experimental plot (apart from the control treatment) were grown in a crop rotation that is typical for this agricultural area: maize (1995; 2000; 2008 and 2012), soybean (1996; 2001; 2005 and 2009), winter wheat (1996/97; 2001/02; 2005/06 and 2012/13), oilseed rape (1997/98; 2002/03; 2006/07 and 2010/11) and double crop – spring barley with soybean (1999; 2004; 2010 and 2014). Erosion risk was calculated by comparing annualsoil loss per treatment and crops with soil loss tolerance (T), according to the following equation:

$$\text{Erosion risk} = \text{Soil loss on treatments } (\text{tha}^{-1}\text{year}^{-1}) : \text{Soil loss tolerance } (10 \text{ t ha}^{-1} \text{ year}^{-1})$$

Soil loss tolerance (T value) for this soil type has been estimated at 10 t ha^{-1} $year^{-1}$ (Kisic et al., 2003). Based on the difference between the tolerance value and the recorded erosion in particular treatment, erosion risk has been evaluated for the studied tillage practices using the criteria of Auerswald and Schmidt (1986): insignificant $\leq$ 0,20; small 0,21-0,50; moderate 0,51-1,00; high 1,01-2,00; extreme 2,01-4,00 and disastrous

>4,01.To elucidate the extent to which the studied tillage practices present a hazard to their sustainability, annual soil losses were calculated in centimeters of soil loss recorded in the growing of the test crops. For this calculation the bulk density every treatment and depth of arable layer of 25 cm were used. Relating the weight of such arable layer per treatment to the weight of the recorded soil loss renders data on annual soil loss in centimeters in different tillage practices applied in growing tested crops. The time period, i.e. the number of years in which the plough layer would be completely eroded away if a particular test crop was grown, was estimated.

Results

Figure 1shows soil losses in relation to the crops that were grown. Low density spring wide row crops (maize and soybean), had a higher soil loss compared to high density winter crops (winter wheat and oilseed rape) in all treatments. Likewise, a higher soil loss in growing spring row crops was observed in treatment with ploughing up and down the slope in comparison with the no-tillage and the treatment with ploughing and sowing across the slope. In low density spring row crops growing, in up and down the slope tillage treatment the soil loss exceeded the soil loss tolerance level. In winter crops of high density growing differences between the investigated tillage treatments were not observed. Soil loss in high density winter crops growing, in all tillage treatments, was by far below the soil loss tolerance level.

Based on soil loss tolerance level and the amount of actual soil losses in growing investigated crops under different tillage treatments, the erosion risk was calculated (Table 2). For ploughing up and down the slope treatment, in low density spring crops growing, the erosion risk is extremely high, and for no-tillage treatment it is moderate. For tillage treatment across the slope in spring crops growing the erosion risk is moderate to small. For all tillage treatments of winter high density crops (apart from control treatment) the erosion risk is insignificant. When the whole period of 20 years of crop rotation is taken into consideration, the erosion risk for control treatment is disastrous, for up and down the slope tillage treatment it is high, and for all other treatments the erosion risk is small.

Soil erosion protection considers every tillage treatment as unacceptable if it enables a complete loss of plough layer in the period shorter than 320 years (Njøs, 1994). The observed results obviously show that in row crops growing - maize and soybean, ploughing up and down the slope is unacceptable, even though it is a common practice in this area. There is no doubt: this practice should be abandoned. The results recorded for tillage treatments of high density winter crops in any direction and investigated methods were within the tolerance levels.

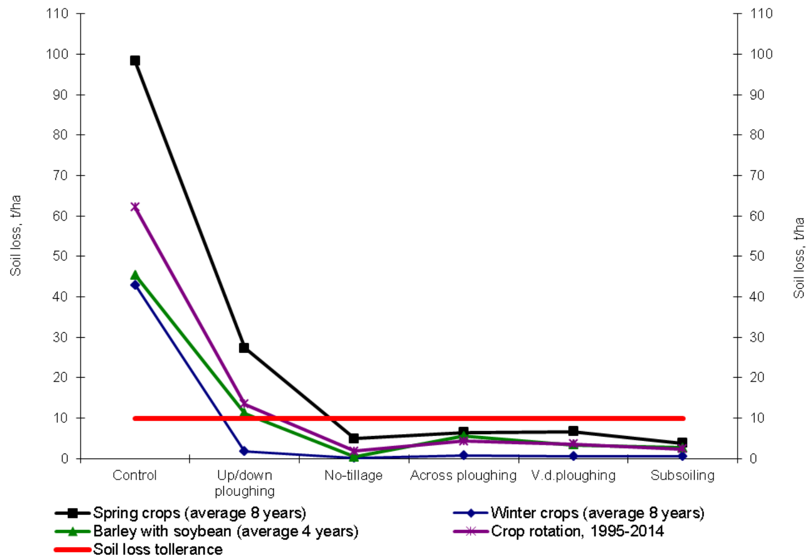


Figure 1.Average soil losses under different tillage treatments and crops

Table 2. Soil loss and erosion risk under different tillage treatments and crops

Treatment	Control treatment	Up/down the slope	No-tillage	Ploughing	Very deep ploughing	Subsoiling + ploughing
		ploughing		across the slope		
Spring row crops (average for maize and soybean – 8 years of vegetation)						

Soil loss, cm ha^{-1} y^{-1}	0.69	0.19	0.03	0.04	0.05	0.02
Loss of arable layer of 25 cm, in years	36	134	791	561	540	966
Erosion risk	Disastrous	Extreme	Moderate	Moderate	Moderate	Small
Winter high density crops (average winter wheat and oil seed rape – 8 years of vegetation)						
Soil loss, cm ha^{-1} y^{-1}	0.30	0.01	0.001	0.006	0.004	0.004
Loss of arable layer of 25 cm, in years	84	1.929	25.333	4.444	6.339	5.887
Erosion risk	Disastrous	Insignificant	Insignificant	Insignificant	Insignificant	Insignificant
Double crops – spring barley + soybean (average for 4 years of vegetation)						
Soil loss, cm ha^{-1} y^{-1}	0.32	0.08	0.002	0.04	0.02	0.02
Loss of arable layer of 25 cm, in years	77	322	10.270	668	1.070	1.369
Erosion risk	Disastrous	High	Insignificant	Moderate	Small	Small
Total crop sequence, 1995-2014 (average for 20 years of investigation)						
Soil loss, cm ha^{-1} y^{-1}	0.44	0.09	0.01	0.03	0.02	0.01
Loss of arable layer of 25 cm in years	57	268	2.033	839	1.028	1.538
Erosion risk	Disastrous	High	Small	Small	Small	Small

These results point to the conclusion that during the year, the soil should be kept bare for the shortest period possible (Birkas et al., 2008). Ploughing and sowing spring crops of low density on sloping fields is unsustainable method of soil management in this area.

Conclusions

The results obtained during the 20 years of investigation lead to the following conclusions:

- in the annual crops growing, winter or spring crops of high density must prevail in crop rotation

- in spring row crops of low density growing, up and down the slope tillage treatment should by no means be applied

- in winter crops growing, up and down the slope tillage treatment can be applied, but with a certain risk of erosion exceeding the tolerance level

- the procedures of reduced tillage should be applied as much as possible, that is the number of procedures should be kept to a minimum

References

Auerswald, K. and Schmidt, F. 1986. Atlas der Erosionsgefährdung in Bayern, Bayerisches
GeologischesLandesamt, GLA-Fachberichte 1.

Boardman, J. andPoesen, J. 2006. Soil Erosion in Europe, Chapter in book: Soil Erosion in Europe:
Major Processes, Causes and Consequences, p. 479-488.

Basic, F., Kisic, I., Mesic, M., Nestroy, O. and Butorac, A. 2004.Tillage and crop management
effects on soil erosion in Central Croatia, Soil & Tillage Research, 78/2:197-206.

Birkas, M., Szemok, A., Antos, G. and Nemenyi, M. 2008. Environmentally-sound adaptable tillage. AkademiaiKiado, p. 353.

IUSS Working Group WRB. 2007. World Reference Base for Soil Resources 2006, first update
2007. World Soil Resources Reports No. 103. FAO, Rome.

Kisic, I., Basic, F., Mesic, M. and Sabolic, M. 2003. Estimation of soil erosion by water in river
basins of Croatia, 3td Croatian conference on Water, p. 301-308.

Njøs, A. 1994. Future land utilisation and management for sustainable crop production, Soil &
Tillage Res., 30, p. 345-357.

Verheijen, F.G.A., Jones, R.J.A., Rickson, R.J. and Smith, C.J. 2009. Tolerable versus actual soil
erosion rates in Europe, Earth Science Reviews, p. 23-38.

Wischmeier, W.H. and Smith, D.D. 1978. A Universal soil-loss equation to guide conservation
farm planning, In Int. Con. Soil Sci., Trans.,7., Madison, p.418-425.

Addresses of authors:

Kisic Ivica[1], Bogunovic Igor[2], Birkas Marta[3], Jurisic Aleksandra[4]
[1]Faculty of Agriculture University of Zagreb
Zagreb, Croatia, ikisic@agr.hr
[2]Faculty of Agriculture University of Zagreb
Zagreb, Croatia, ibogunovic@agr.hr
[3]Szent Istvan University Institute of Crop Production Science
Gödöllö, Hungary, Birkas.Marta@mkk.szie.hu
[4]Faculty of Agriculture University of Zagreb
Zagreb, Croatia, ajurisic@agr.hr

Estimation of climate sensitivity of Hungarian soils based on NPCPD database

Mihály Kocsis[1], Attila Dunai[2], András Makó[3]

Introduction

The hypothetic climate change and stress effects caused by more and more frequently occurring meteorological extremities affect the soil fertility in ever-widening degree. In our climate sensitivity researches, the effect of drought sensitivity evolved by precipitation deficiency to the soil fertility was studied with maize yield data of the National Pedological and Crop Production Database (NPCPD) were used. The database contains complex crop production and soil information for 5 years (1985-89). The yield data of the NPCPD database were characterized with the annual Pálfai Drought Index [PaDI] (Lakatos et al., 2013). The explanation of choosing maize in the statistical analysis is that in Hungary the growing area of maize is the biggest among field crops with its 1,1-1,2 million hectares, and the size of this growing area is constant and stabile (Nagy, 2010).

As an innovative approach in Hungary, the soil-type specific yield reaction of the different seasonal effects were investigated with national-scale yield maps. The results of the research can give a good starting point for preparing large-scale (1:10.000) climate sensitivity site (field) maps, which can help the soil-type specific and climate change-adaptive crop production.

Materials and methods

The NPCPD database provides soil data from approximately 4 million hectares of different land usage (ploughland, meadow, pasture, vineland, orchard, wooded land) fields of Hungary, and it contains complex crop production information from 7 years (1984-1990) (Debreczeniné et al., 2003; Makó et al., 2007). The records contain the important soil analytical results of the bulk samples originated from the upper soil layer (0-25 cm) of the lands on soil sub-type level. Moreover, it provides data from the mineral and organic fertilization by agricultural field parcels and offers time-series yield data and forecrops of 196 plants (Kocsis et al., 2014).

Our investigations were performed on a filtered NPCPD (ver3.0) database, which consists of 56.774 records related to maize information. The filtered database contains 11.349 fields and field parcels (tillage units) on 613.156 hectares, this can be connected to 249.862 soil sampling points. In our work the major results of soil analyses (upper limit of soil plasticity - which is an index of soil texture, humus- $pH_{(KCl)}$- and $CaCO_3$-content) of the sampling points originated from NPCPD database were averaged to tillage units weighted with area of these units. To the GIS works and kriging of national-scale seasonal maize yield maps and the index category map of drought sensitivity, ESRI ArcGIS 9.3 program was used.

For the analysis of seasonal effects, we assigned the annual Pálfai Drought Index [PaDI] to the maize yield. In Hungary, the Pálfai Drought Index composed in the '80's is used for the numerical characterization of the droughts, which describe the drought strength of an agronomic year with one numerical value. To the determination of the PaDI-values, only the monthly mean temperature and precipitation data are required (Lakatos et al., 2013). From the meteorological grid values, 200 x 200 m raster maps – which show the level of the drought - were generated to the country area.

Statistical analyses were performed with IBM SPSS Statistics 18.0 statistical program. During the making of the drought sensitivity index, differences between „normal" and drought-free yields were used. On the results, CHAID (Chi-squared Automatic Interaction Detection) (Tóth et al., 2012) classification tree analysis were performed in consideration of soil varieties' parameters (sub-type, texture, pH_{KCl} value, humus- and $CaCO_3$-content). From the group mean values estimated with CHAID-method, equidistant (ordinal) category variables ranged from 1 to 10 were composed (SPSS / Transform / Visual binning). With this method, the Hungarian soils were described with 7 different drought sensitivity groups (*Figure 1*). After that, country-wide distribution of the drought sensitivity categories were investigated by soil types, texture categories, humus-, $CaCO_3$- and $pH_{(KCl)}$-categories.

Results

Based on the results of our investigations it is determinable that in terms of maize production the skeletal soils with high sand content are the mainly, while the good water supply march soils are the least sensitive for drought (*Figure 1*). Sorted by texture it can be observed that sandy soils are the mainly, while the loam and clayey loam soils are the least sensitive. The drought sensitivity increases at a small rate in case of soils with clay and heavy clay texture.

Soils with medium (average) humus content is the least sensitive for drought (Hermann et al., 2014). Presumably the high drought sensitivity of soils with small humus content is explainable with the relatively high sand content of this soil group. Increasing drought sensitivity of the soils with higher soil humus content is also explainable with combined effect of other soil properties (texture, pH, $CaCO_3$% etc.). An interesting relationship can be discovered between pH and drought sensitivity: it is clearly provable the highest drought sensitivity for the acidic soils, while the lowest sensitivity for the soils with neutral pH. By the $CaCO_3$ examinations the results confirmed that the medium carbonate content is the most favourable.

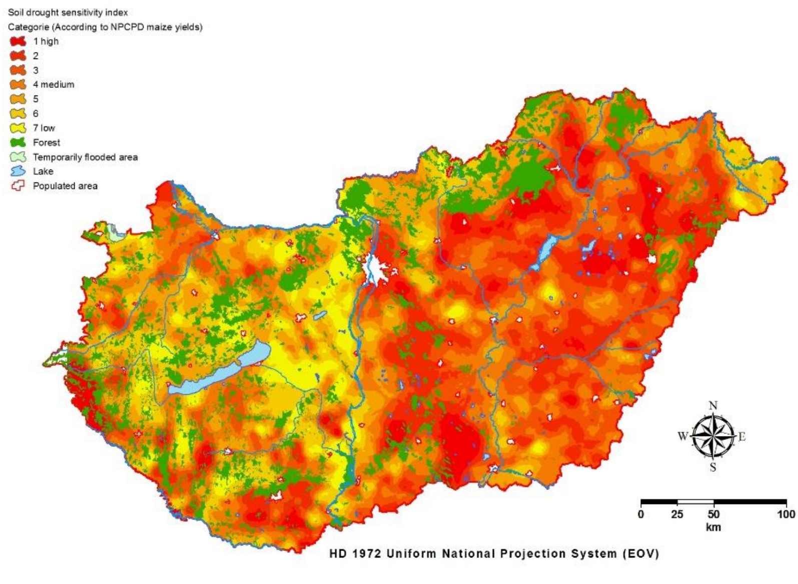


Figure 1. Hungarian soil drought sensitivity index map

References

Debreczeni, B.-né., Kuti, L., Makó, A., Máté, F., Szabóné Kele, G., Tóth, G. and Várallyay, Gy. 2003. D-*e*-Meter földminősítési viszonyszámok elméleti háttere és információ tartalma. In: Gaál, Z., Máté, F., Tóth, G. (eds.) Földminősítés és földhasználati információ. Veszprémi Egyetem, Keszthely. 23–36.

Hermann, T., Kismányoky, T. and Tóth, G. 2014. A humuszellátottság hatása a kukorica *(Zea mays L.*) termésére csernozjom és barna erdőtalajú termőhelyeken, különböző évjáratokban. Növénytermelés. 63 (2): 1–22.

Kocsis, M., Tóth, G., Berényi Üveges, J. and Makó, A. 2014 Az Agrokémiai Irányítási és Információs Rendszer (AIIR) adatbázis talajtani adatainak bemutatása és térbeli reprezentativitás-vizsgálata. Agrokémia és Talajtan 63: 223–248.

Lakatos, M., Szentimrey, T., Bihari, Z. and Szalai, S. 2013. Creation of a homogenized climate database for the Carpathian region by applying the MASH procedure and the preliminary analysis of the data. Időjárás 117 (1): 143–158.

Makó, A., Tóth, G., Máté, F. and Hermann, T. 2007. A talajtermékenység számítása a változati talajtulajdonságok alapján. In: Tóth, T., Tóth, G., Németh, T., Gaál, Z. (eds.) Földminősítés, földértékelés és földhasználati információ. MTA Talajtani és Agrokémiai Kutatóintézet – Pannon Egyetem, Budapest – Keszthely: 39–44.

Nagy, J. 2010. A kukoricatermelés jelene és jövője. Növénytermelés 59 (3): 85-111.

Tóth, B., Makó, A., Guadagnini, A. and Tóth, G. 2012. Water retention of salt affected soils: quantitative estimation using soil survey information. Arid Land Research and Management 26: 103–121.

Addresses of authors:

Mihály Kocsis[1], Attila Dunai[2], András Makó[3]

[1]Department of Plant Production and Soil Science, Georgikon Faculty, University of Pannonia
Keszthely, Hungary, e-mail kocsis.mihaly@2010.georgikon.hu

[2]Department of Plant Production and Soil Science, Georgikon Faculty, University of Pannonia

Keszthely, Hungary, e-mail dunai@georgikon.hu

[3]Institute for Soil Sciences and Agricultural Chemistry, Centre for Agricultural Research, Department of Soil Science, Hungarian Academy of Sciences
Budapest, Hungary, e-mail: mako.andras@agrar.mta.hu

The Use of the Biogeochemical Models to the Assessment the Impact of Anthropogenic Emission of Nitrogen on the Natural Ecosystems

I. Kudrevatykh, K. Ivashchenko

Introduction

During the last two centuries, agriculture and the burning of fossil fuels have increased significantly the global emissions and deposition of reactive nitrogen compounds (nitric oxide [NOx], nitrates [NO3], ammonia [NH3], ammonium [NH4]). Currently the anthropogenic N deposition constantly is increasing in Russian Federation and some parts of the country have one of 10 or more kg N ha-1 yr-1 (Averkieva, Ivashchenko, 2014). The high levels of nitrogen emission may cause environmental disturbances in the structure and functioning of natural ecosystems similar to those observed in recent decades in Europe (Bobbink, 2003; Sutton et al., 2011). Forest ecosystems are of significant scientific interest as an object of study because forests contribute to the flow of pollutant due to dry deposition (2-3 times higher compared to herbaceous and shrub) (Koptsik et al., 2008).

It is known that the conduct of anthropogenic compounds and their transformation products in the environment is regulated by the characteristics of the natural cycles of elements (Intergovernmental Panel ..., 2001; Bartnicki et al., 2013). Therefore biogeochemical models are used to assess pollutants flow in natural ecosystems. Biological effects determining the natural nitrogen cycle can be divided into the effects associated with changes of geochemical parameters of air and soil and ones influenced the plant communities and the microbial species. The mechanism of these effects is as follows: when increased N deposition from the atmosphere the available of mineral nitrogen for plants becomes more and its content exceeds the required level. As a consequence, there is an increase of primary biological product of forest ecosystems. The plants and microorganisms actively absorb the available nitrogen, which increases its concentration in different parts of the trees. The concentrated nitrogen in/of litter enters the soil and leads to an intensification of processes of mineralization (N-NH4/N-NO3>1, expansion the C/N ratio). The initially limited nitrogen primary production of forest ecosystems increases to physiological optimum due to the impact of additional N (De Vries et al., 2007) thus the biodiversity of forest species change in the predominance of eutrophic or neutrophils species in the ground cover (Stevens et al., 2004; De Vries, 2007).

Materials and methods

The snow survey method was used to assess the level of Nmin income from the atmosphere. This method allows assessing the quantity of soluble and insoluble components falling from the atmosphere to terrestrial ecosystems, including both dry and wet deposition (Glazovskii et al., 1983). Snow sampling was carried out in late February and early March (the period of maximum snow accumulation and before intensive melting). The snow samples (a total of 150) at sites with different distance from the anthropogenic sources of nitrogen emissions (distance from highways with heavy traffic and stationary sources was taken into account) were collected. At each site a plot (10 m2) was chosen where mixed samples were taken from five snow cores by the “envelope” method. The snow cores were collected with a plastic sampler (50 mm in diameter) from the snow cover (layer 0-50 cm).

The soil sampling was done at the same sites where the snow was collected. The site was a flat plot (10×10 m), where soil samples were collected from the upper (0-10 cm) layer. It has been shown that the upper mineral layer (0-10 cm) of the soil is characterized by high microbial activity and contains many roots of grass-shrub species (Umarov et al., 2007). Determination of the concentration of ammonium (N-NH4) and nitrates (N-NO3) in snow and soil samples was carried out using the photocolorimetric method by Kudeyarov. The C/N ratio in the soil was determined by an automated analyzer CN VARIO ELIII.

Soil microbial biomass carbon (Cmic) was analyzed by substrate-induced respiration method (SIR). The SIR method based on additional respiration response of soil microorganisms (initial maximum CO_2 production) enriched by the available substrate (glucose, 0.1 ml; 10 mg g^{-1} soil) (Anderson, Domsch, 1978; Ananyeva et al., 2011). Carbon of the microbial biomass was calculated according to: Cmic (μg C g^{-1}) = SIR (μl CO_2 g^{-1} h^{-1}) × 40.04 + 0.37 (Anderson, Domsch, 1978). The basal (microbial) respiration (BR) was measured as described for SIR, but with the addition of water instead of glucose solution (0.1 ml g^{-1} soil), and incubated (24 h, 22ºC). Prior to the estimation of SIR and BR all soil samples (0.3-0.5 kg) were sieved, moistened up to 50-60% water holding capacity and pre-incubated in aerated bags at 22°C for 7 days. Microbial metabolic quotient was estimated as BR / Cmic = qCO_2., it shows an ecophysiological status of soil microorganisms. The vegetation survey included the assessment of the abundance of plant species in the percentage of vegetation cover on the plots and the separation of species on trophic groups.

Study areas

The study area encompasses Moscow and Kostroma regions located in the areas of different nitrogen deposition. In Moscow region the annual temperatures and precipitations amounts are +5.5 ^{0}C and 670 mm, and for Kostroma region these parameters are +3.0 ^{0}C and 570 mm, respectively (Overview of the trends.., 2009). The selected areas were presented by leaved, coniferous and mixed forests (age 40-60 years). In the Moscow region in the tree layer is dominated by Picea abies (L.) H. Karst., Betula pubescens Ehrh., Abies sibirica Ledeb., and by Picea obovata Ledeb., Abies sibirica Ledeb., Betula pubescens Ehrh. in the Kostroma region. Soddy-podzolic (Umbric Albeluvisols) soil is different in texture, with pH value 4.3-5.8.

Results and discussion

The nitrogen deposition

From the data obtained the annual total deposition of Nmin (N-NH_4 and N-NO_3) from the atmosphere for the studied sites ranged from 0.4 to

15 kg N ha-1 yr-1 (on average 1-4 kg N ha-1 yr-1(Fig 1). In many areas (80%) N-NO3 dominated in atmospheric precipitations, reaching up to 10-13 kg N ha-1 yr-1. The nitrate in atmospheric precipitation of about 4 kg N ha-1 yr-1 and higher was detected in the forests in the area of atmospheric transport of pollutants from the main industrial centers and highway. In forest ecosystems located relatively distant from the sources of anthropogenic nitrogen emissions (eastern, western and south-western districts of the Moscow and Kostroma regions), the deposition of nitrates was below 4 kg N ha-1 yr-1.

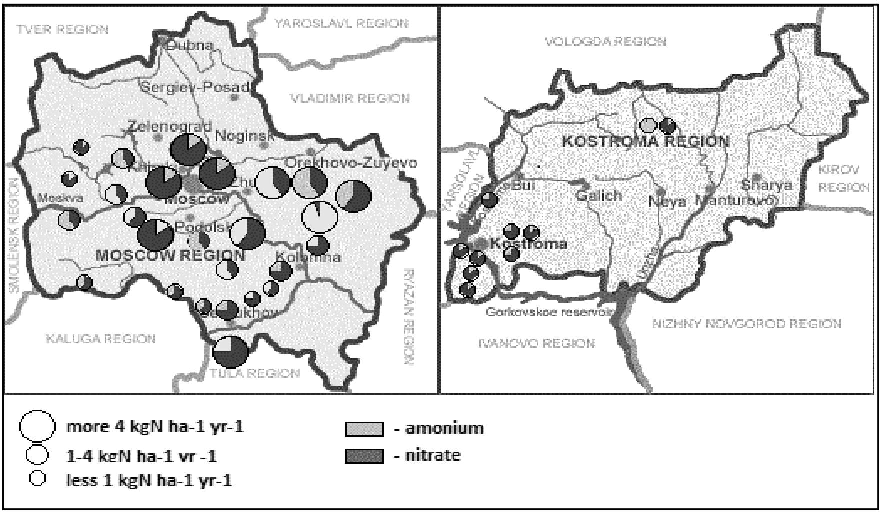


Figure 1: Annual deposition of mineral nitrogen in the study areas

Biogeochemical parameters of soils

In forest soils (0-10 cm) the total mineral nitrogen content was 5-23 mg N kg-1 (on average 9-13 mg N kg-1). In the forest the pool of mineral nitrogen predominantly comprises ammonium. In the investigated forests the ammonium concentration in the soils varied up 4-11 mg N kg-1 (on average 5-8 mg N kg-1) in the middle of the growing season. Nitrate contents in the soils ranged from 0.1 to 13 mg N kg-1 (on average 2-6 mg N kg-1). However, it was found that under the conditions of atmospheric deposition of above 4 mg N ha-1year-1 a total pool of Nmin in forest soils is largely depended on the content NO3 (r =0.85). It can be concluded that the increase of anthropogenic emissions Nmin leads to a predominance in soil of nitrate.

The C/N ratio for the studied soils ranged from 12 to 28 (on average 12-19). It is known that, at 20 <C/N <35 the immobilization of N in soil organic matter is moderately lasting, limiting the pool of soil Nmin. Under 10 <C/N <20 the immobilization in the soil is short-term, which results to an increase in the availability of nitrogen to biota (Heikkinen, Makipaa, 2010). As shown by studies in forest ecosystems in Western Europe there is a relationship between the deposition of nitrogen and this ratio in soils when C/N < 21 (Sutton et al, 2011). However, our study did not show the correlation between the deposition of Nmin and the C/N ratio in the studied soils. It can be concluded that relatively low levels of nitrogen deposition do not have a significant effect on the C/N ratio of soils.

In forest soils the microbial biomass carbon (Cmic) and the basal (microbial) respiration (BR) values ranged from 51 to 476 μg C g-1 and 0.21 to 1.61 μg C-CO2 g-1 h-1, respectively. The microbial metabolic quotient or qCO2 > 3 in soils indicates the high consumption of C to the turnover of nutrients and designates the stressful conditions for the functioning of soil microorganisms (Ananyeva et al., 2011). The values of this index were 3< qCO2< 8 for the study soils, because the soddy-podzolic soil from the point of view of the microbial community is less stable and therefore more "vulnerable" to external influences.

The significant positive correlations between the soil Nmin content and the microbial biomass (r = 0.76) and the microbial respiration rate (r = 0.62) were found. The soil Cmic and BR values were 69 μg C g-1 and 0.49 μg C-CO2 g-1 h-1, respectively, in the soil of aspen (Kostroma region) with Nmin content 1.31 mg N kg-1; however, the microbiological parameters were higher (by 5 and 3 times, respectively) in the soil of birch-wood (Moscow region) with Nmin 12.7 mg N kg-1. In snow samples of forest ecosystems the Nmin values ranged from 0.9 to 8.0 kg N ha-1 yr-1 (on average 2.0 kg N ha-1 yr-1). In the studied forests with nitrogen deposition less than 1.0 kg N ha-1 yr-1 the soil Cmic and BR values amounted on average 192±177 μg C g-1 and 0.81±0.31 μg C-CO2 g-1 h-1, respectively. In ecosystems with deposition values 1.5-8.0 kg N ha-1 yr-1 the microbiological indexes in soil were higher by 1.5 and 1.4 times for Cmic and BR, respectively. The nitrogen content in the studied ecosystems was relatively low possibly being a limiting factor for soil microorganisms, and increasing the concentration of the soil Nmin might stimulate the biomass and activity of microorganisms.

The specific structure of vegetation

The assessment of the distribution of plant on trophic groups showed that in most of the studied ecosystems there are neutrophils species. However, the abundance of these species varies considerably and depends on the level of nitrogen deposition. When deposition of mineral nitrogen above 10 kg N ha-1 yr-1 the abundance of species preferring high soil N (Rubus idaeus, Urtica dioica, Humulus lupulus) are more than 20% of the total number of species on the site. For most of the studied forests the deposition Nmin ranged from 1 to 4 kg N ha-1 yr-1 and the neutrophils was 5-19% of the total ground cover. At low Nmin atmospheric deposition (less 1 kg N ha-1 yr-1) it was dominated species prefer low soil nitrogen content (Vaccinium myrtillus, Luzula pilosa, Linnaea borealis), which is typical for Kostroma region.

Comparison of present deposition Nmin in the studied areas to the literature data on critical N concentrations in the soil solution for different trophic groups of plants (Gundersen et al, 1998) showed that in the ecosystems of Moscow region the nitrogen concentration in atmospheric precipitation exceeds the critical one for oligotrophic and mesotrophic species. If you stay current level of deposition the oligotrophic and mesotrophic species will disappear.

Conclusion

Thus, our study revealed that the chemical composition of atmospheric deposition depends of the proximity of large industrial centers and highways. This dependence appears in the increase in the concentration of nitrates in the total pool of mineral nitrogen. In turn, the increase in the amount of nitrates changes the relation of mineral nitrogen forms in the soil, but does not affect the ratio of C/N. Direct correlation between the level of deposition and microbiological parameters was not found, but there is a relationship between the nitrogen content in the soil and Cmic, BR. At high atmospheric NO3 deposition (≥60% Nmin) the plants preferring soil with a high nitrogen content is dominated.

Acknowledgements

This study was supported by Russian Foundation of Basic Research Grant No. 14-04-00098.

References

1. Ananyeva N.D., Susyan E.A., Gavrilenko E.G Determination of the soil microbial biomass carbon using the method of substrate-induced respiration //Eurasian Soil Science. 2011. V. 44. Issue 11. P. 1215-1221.

2. Anderson J.P.E., Domsch K.H. A phisiological method for the quantitative measurement of microbial biomass in soils // Soil Biol. Biochem. 1978. V. 10. N. 3. P. 215-221.

3. Averkieva I., Ivahenko K. Influence of atmospheric emissions of nitrogen compounds on the biochemical parameters of soils of European Russia forest // Book of proceedings 9th International Soil Science Congress on «The Soul of Soil and Civilization». Editors: Dr. Rıdvan Kızılkaya. Soil Science Society of Turkey and Federation of Eurasian Soil Science Societies, Turkey, 2014. P. 448-454.

4. Bartnicki J., Gusev A., Aas W., Valiyaveeti S, Nyíri A. Atmospheric Supply of Nitrogen, Lead, Cadmium, Mercury and Dioxins / Furans to the Baltic Sea in 2013. OSLO. 2013. P 250.

5. Bobbink R., Ashmore M., Braun S., Fluckiger W., Van den Wyngaert I.J.J. Empirical nitrogen critical loads for natural and semi-natural ecosystems: 2002 update. In Empirical critical loads for Nitrogen. Environmental Documentation No. 164. Air., eds. D. Achermann & R. Bobink, pp. 43-170. Swiss Agency for Environment, Forests and Landshape SAEFL, Bern. 2003. 235 p.

6. De Vries W., Rros H., Reinds G.J. et al. Developments in deriving critical limits and modelling critical loads of nitrogen for terrestrial ecosystems in Europe. Alterra, Alterra –rapport 1382, 2007. 206 p.

7. Glazovskii N.F., Zlobina A.I., Uchvatov V.P. Chemical composition of snow in some areas Verhneokskogo pool // Regional Environmental Monitoring. - Moscow: Nauka, 1983. P. 67 - 86

8. Gundersen P., Callesen I., de Vreas W. (1998) Nitrate leaching in forest ecosystems is related to forest floor C/N ration. // Environ. Pollut. 102 (1), 1998. P. 403-407.

9. Heikkinen Ju., Makipaa R. Testing hypotheses on shape and distribution of ecological response curves. // Ecological Modelling. 2010. V. 221. P. 388–399.

10. Koptsik S., Koptsik G., Alyabina I. Assessment of the risk of excess sulfur input into terrestrial ecosystems of the Kola peninsula // Russian Journal of Ecology. 2008. V. 39. N. 5. P. 327-336.

11. Intergovernmental Panel on Climate Change. Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change (eds Houghton JT, Ding Y et al.) Cambrige University Press, Cambrige. 2001. 400 p.

12. Overview of the trends and dynamics of environmental pollution of the Russian Federation according to the long-term monitoring Roshydromet. 2009. P. 21. http://www.meteorf.ru/ .

13. Stevens C.J., Dise N.B., Mountford J.O. et al. Impact of nitrogen deposition on the species richness of grasslands //Science 303. 2004. P. 1876 -1879.

14. Sutton M.A., Howard C., Erisman J.W. et al. The European Nitrogen Assessment (Eds.) Cambridge University Press. 2011. 612 p.

15. Umarov M.M., Kurakov A.V., Stepanov A.L. Microbiological transformation of nitrogen in the soil. Moscow: GEOS, 2007. 138 p.

Addresses of authors: Institutskaya Street 2, 142290

Authors: I. Kudrevatykh, K. Ivashchenko

Name of organization: Institute of Physical-Chemical and Biological Problems in Soil Science Russian Academy of Sciences

Pushchino, Russia Federation, averkieva.irina@yandex.ru

Time to ponding and initial runoff in a commercial olive orchard (SW Andalusia, Spain) with different cover crops: Numerical simulation and temporal stability

M. López-Vicente[1,], R. García-Ruiz[1], J.A. Gómez[2], G. Guzmán[2], J.L. Vicente-Vicente[1]*

Introduction

Cover crops (CC) in olive groves and other woody crops provide an environmental-friendly alternative to conventional tillage for land management. Indeed, CC reduce soil and nutrient losses and also the average runoff coefficients in comparison with conventional tillage and no-tillage systems (Gómez et al., 2009). Plant covers are also important for retaining and releasing nutrients under different tree demand rates (Gómez-Muñoz et al., 2014). We hypothesize that the hydrological response of the soil in an olive orchard, related to the time of ponding (*Tp*) and the initial runoff at each soil portion (Q_0), is affected by the different CC. In addition, the spatial patterns of *Tp* and Q_0 and their temporal stability depend on the different CC. To achieve this goal we run the water-balance *DR2-2013*© *SAGA v1.1* model in 6 plots under 3 different treatments (tillage, mix and homogeneous CC) at high spatial resolution (0.5 x 0.5 m) and during 2 hydrological years (2009/10 and 2010/11).

Material and methods

Study area and vegetation management scenarios

The study area is made up of 6 micro-catchments (8 m wide and 60 m long) established on the ‘‘Santa Marta’’ farm, 26 km west of Seville, Spain. The olive plantation (*Gordal* variety) was established in 1985 with trees at 8 x 6 m spacing (Gómez et al., 2009). The climate is Mediterranean with an average annual rainfall of 534 mm, mostly in late fall and winter. The slope is uniform (average steepness of 11%). The soil (Petrocalcic Palexeralf) is well drained, with an average OM content of 1.3%, and texture was sandy loam. Two plots (P2 & P4) were devoted to conventional tillage. The second treatment (P1 & P5) consisted in a mixture of different selected plant species as CC (Cover-I) of *Lolium rigidum* and *L. multiflorum* together with other species. The third treatment (P3 & P6) was a CC (Cover-II) of raygrass *L. multiflorum*.

The hydrologic DR2-2013© SAGA v1.1 model

The GIS-based water balance *DR2-2013 v1.1* model (López-Vicente et al., 2014) is the third version of the Distributed Rainfall-Runoff model. Since October 2013 the executable file (DR2.dll) of the *v1.0* is available (http://digital.csic.es/handle/10261/84613) and since January 2014 of the *v1.1* (http://digital.csic.es/handle/10261/93543). Time to ponding, *Tp* (s), is calculated and the unsaturated cells and cells saturated are differentiated:

$$\frac{1}{2}\frac{Sp_{im}^2}{K_{fs}}\ln\left(\frac{I_m}{I_m-K_{fs}}\right)\le Tp_{im}\le\frac{1}{2}\frac{Sp_{im}^2}{I_m-K_{fs}} \tag{1}$$

$$Sp_{im}=\sqrt{2\cdot\left(\theta_{Seff-i}-\theta_{0-im}\right)\cdot\phi_i} \tag{2}$$

where Sp is the soil sorptivity (cm s$^{-0.5}$), K_{fs} is the saturated hydraulic conductivity of the topsoil (cm s^{-1}), I (cm s^{-1}) is the rainfall intensity, ϕ is the matrix flux potential (cm^2 s^{-1}), and θ_{Seff} (% vol.) and θ_0 (% vol.) are the effective saturated and initial water content. The initial runoff per raster cell, Q_{0i} (mm), is estimated as a function of the effective rainfall, ER (mm), the rainfall to ponding, Rp (mm), and the number of rainfall events, e (n):

$$Q_{0im}=ER_{im}-\left(Rp_{im}\,e_m\right)=ER_{im}-\left(Tp_{im}\,I_m\,e_m\right)10 \tag{3}$$

$$ER_{im}=R_m\left(1-A_{im}\right)/\cos S_i \tag{4}$$

where A (0–1) is rainfall intercepted by the canopy in relation to the total rainfall, R (mm), and S (radians) is the slope angle. Later, Q_0 is routed into the DEM using one of the 8 flow accumulation algorithms (with or without threshold-linear flow), and the effective cumulative runoff, CQ_{eff} (mm), is calculated after considering the K_{fs}, the duration of the runoff, and the water retained on the soil surface. In this study CQ_{eff} was not simulated.

Results and discussion

During the two hydrological years evaluated, 108 rainfall events were recorded (58 and 50 during the first and the second year). The *DR2-2013© SAGA v1.1* model predicted runoff in the whole surface in 29 events, and in part of the surface (mainly in the inter-row land) in 58 events. The other 21 events presented low values of I_{30} and thus topsoil was not water saturated. The average soil moisture was slightly higher under tillage treatment (28.5% vol.) than these with CC (28.2% vol.). The average time of ponding (*Tp*) was 57% higher in the plots under tillage treatment (59.1 seconds) than the average duration with CC (25.2 s). Topsoil became saturated sooner in the inter-row land (3.3 times faster), 20.7 and 18.4 s, than below the canopy, 97.4 and 31.9 s, both under the tillage and CC, respectively. The minimum and maximum *Tp* were on average of 3.7 and 3.8 s, and of 446.1 and 115.5 s, under the tillage and CC, respectively.

The effective rainfall (*ER*) and the initial runoff per raster cell (Q_0) were higher in the inter-row land than below the canopy in the six plots (Figure 1a and b) due to the higher values of rainfall interception of the olive trees. The average Q_0 was higher during most of the period in the inter-row land than below the canopy (Table 1) (Figure 2a). The maximum variability of Q_0 generated in the six plots varied markedly during the 2 years (Figure 2b). The effective cumulative runoff (CQ_{eff}) will be simulated in further research and validated with collected runoff on each plot.

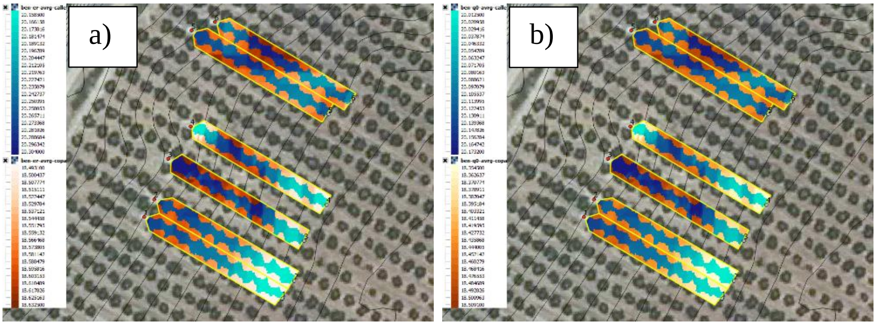


Figure 1. Maps of the average effective rainfall (*ER*; mm) (a) and initial runoff per raster cell (Q_0; mm) (b) after the 74 runoff events.

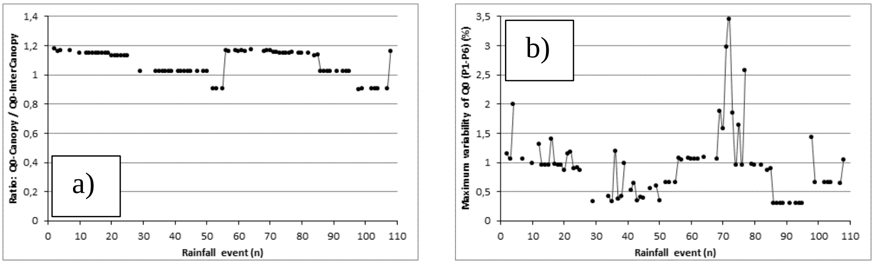


Figure 2. Ratio $Q_{0\text{-}canopy}/Q_{0\text{-}inter\text{-}row}$ (a); max. $Q_{0\text{-}variability}$ in the 6 plots (b).

Table 1. Average values of Q_0 (mm) under the 3 management scenarios.

Land use	Q_0 value	Plot	Canopy	Inter-row	Ratio C/IC
Cover-I	Min	2.05	1.91	2.07	1.0828
(P1 & P5)	Mean	19.31	18.44	20.11	1.0905
	Max	89.11	82.69	94.92	1.1479
Cover-II	Min	2.05	1.91	2.07	1.0826
(P3 & P6)	mean	19.35	18.46	20.13	1.0903
	Max	89.29	82.79	95.02	1.1477
Tillage	Min	2.04	1.91	2.06	1.0808
(P2 & P4)	Mean	19.29	18.41	20.08	1.0906
	Max	89.05	82.59	94.81	1.1480

References

Gómez JA, Guzmán MG, Giráldez JV, Fereres E. 2009. The influence of cover crops and tillage on water and sediment yield, and on nutrient, and organic matter losses in an olive orchard on a sandy loam soil. Soil & Tillage Research 106, 137-144.

Gómez-Muñoz B, Hatch DJ, Bol R, García-Ruiz R. 2014. Nutrient dynamics during decomposition of the residues from a sown legume or ruderal plant cover in an olive oil orchard. Agriculture, Ecosystems and Environment 184, 115-123.

López-Vicente M, Pérez-Bielsa C, López-Montero T, Lambán LJ, Navas A. 2014. Runoff simulation with eight different flow accumulation algorithms: Recommendations using a spatially distributed and open-source model. Environ. Model. & Soft. 62, 11-21.

Addresses of authors:

Manuel López-Vicente[1,*], Roberto García-Ruiz[1], José Alfonso Gómez[2], Gema Guzmán[2], José Luis Vicente-Vicente[1]

[1] Area of Ecology, University of Jaen. Campus Las Lagunillas s/n, 23009, Jaen, Spain.
[2] Agronomy Department, IAS-CSIC. Alameda del Obispo s/n, 14080, Cordoba, Spain.

[*] Corresponding author. E-mail: mvicente@ujaen.es, mlopezvicente@gmail.com.

Spatial interpretation of the measured microclimatic data for the prediction of grape diseases on the basement of morpho-pedotops

László Miklós, **Dušan Kočický, *Anna Špinerová, ***Zita Izakovičová

Introduction

Protecting plants is a major challenge of agriculture globally. The most common protection is the frequent, preventive use of fungicides and pesticides. This solution, however, is rather costly and ecologically harmful due to the usage of significantly more chemicals than necessary.

The decision about the application of different agronomic actions in the correct time and of correct size depends on the information about the climatic, hydrological, pedological and other conditions on each field spot. Those are available partly from real mapping of invariables, e.g. the geology and soil conditions, georelief, partly from variable measured data for forecast – e.g. the meteorological data, soil moisture, underground water stage in given time. The problem is that **all mentioned conditions vary** from spot to spot, but the measured data are really correct only for given measuring point. Therefore the researchers around the world are developing mathematical **models** on the basis of measured hydrologic, climatic and other conditions to predict the formation and spreading of diseases, and, to propose the protective actions. Their effectiveness – beyond the quality of the models - depends upon the **density of the spots** with measuring devices. Since the real terrain is very differentiated, there is no chance - neither in the future - to cover the whole variety of different spots with the measuring devices, methods for **interpretation** and **interpolation** of objective measured data are to be developed.

The concept and objectives

An excellent chance for such interpretation, interpolation and modelling is offered by the micromorphometric analyses and syntheses of the terrain, which result to creation of types of morphotops. The further synthesis of morphotops with the pedological conditions issues the morpho-pedotops. A certain, exactly defined type of morpho-pedotop shows the same microclimatic and soil-ecological conditions on the whole area, thus, if we gain a requested data-set for the definition of those conditions on a defined morpho-pedotop, the same are valid for all spots of that certain type in the whole area. Of course, the data gained by such procedure are suitable not only for plant protection, but generally for the **integrated management of the land-use**, which should at the same time positively effect the agriculture production the lowering the use of chemicals, but also protect against the soil erosion, flooding, biodiversity loss, loss of the overall ecological stability of the landscape.

In this respect several interpretation and modelling procedures have been developed and broadly applied in a whole range of projects for the ecologically optimum use of the landscape also in our country within the methodics of the landscape-ecological planning LANDEP (Ružička, Miklós, 1990, AGENDA 21, Chapter 10, 1992).

The detailed morphometric analyses of the terrain are based on exact calculations. Morover, the measured features of the terrain are visible. The morpho-pedotops – as the result of syntheses record the differences between the physical properties of the landscape and thus present the real material basement and spatial frame for the interpretation of all the microclimatic, run-off, erosion or other modelling. (Miklós, 1991).

The morphometric analyses and their syntheses with the pedological data, as well as the purpose oriented interpretation is the concept of the presented project. The project was , applied for the vine–growing areas on the cross-border region between Slovakia and Hungary.

Methods

The process consisted several methodical steps, as follows:

The delineation of the model territories

As the model territory served selected vine-growing territories in Hungary and Slovakia, where advanced sensor stations for permanent monitoring of specific climatic data for forecast of diseases were installed. The SmartVineyard^{TM} sensor stations were developed by the Quantislabor, Ltd, Budapest, for the forecast of grape diseases, within the frame of the Cross-border cooperation project HU-SK 1101/121/0287.

The project comprised 3 model territories in Slovakia, altogether 2522 km^2, and 12 model territories in Hungary, altogether 9412 km^2, spread throughout the vine-growing regions (Fig.1)

The territories in Slovakia have been processed on topical level, the regions in Hungary on regional level. The GIS creation and calculations were executed by ESPRIT, s.r.o., Banská Štiavnica.

The morphometric analyses and syntheses

They were based on the digital model of the terrain (DTM.) on the grid of 10 x10 m size. As the first step the primary morphometric indices have been developed. – the slope angle, horizontal and normal (profile) curvature, aspect and the contributing area (see below). The morphotops served as the basement for all further interpretations and modelling. They served also as the exact spatial frame for the morpho-pedotops and the abiocomplexes**.** That procedure is based on a long time research experiences (Krcho, 1973, Miklós, 1991, Špinerová, 2010). The methodical basement for those syntheses and interpretations did not change substantively since, but the techniques of the calculation, expression and projection, based on GIS, developed dramatically.

The geographical information system GIS

The **GIS** was a core element of the project. Later on that GIS will serve also for storage, processing and distribution of the data permanently monitored by measuring devices – as the **information system of monitoring.**

The input – the indices

In Slovakia, several more detailed data were developed for the characteristics of the topical conditions. In Hungary the indices intended to show the regional differences, the results are to be interpreted as predominant, average or prevailing values of certain index on the relevant area.

The characteristics of the indices

The indices used in the project have different character as follows:

a) The spatial frame and basement – Digital Terrain Model

The European Terrestrial Reference System (ETRS89 UTM 34N) was applied as the basement.

b) Primary morphometric data

Those are the indices of utmost importance. Serve as the basement for all re-calculations, re-classifications and interpretations, as slope angle (by algorithm "neighbourhood method" Burrough, McDonell, 1998), horizontal curvature and the profile (normal) curvature of the relief (decisive index for the surface run-off direction , orientation of the relief towards the cardinal points – the aspect; contributing area (by the algorithm of Tarboton, 1997).

c) Secondary morphometric/morphoclimatic indices

All these indices are recalculated from DTM, primary morphometric indices and other additional data, as: the lengths of the insolation and the amount of Sun radiation in ***Wh.m***$^{-2}$ for the vegetation period, and, for individual month. from April to October.

d) Other primary indices

Soils: This layer expresses the soil texture (granularity) and the soil types. The attribute accepts the USDA soil properties classification (Soil …, 1993). The source for the spatial distribution of soils was the portal AGROTOPO GIS (http://maps.rissac.hu/agrotopo). The index is of **key importance** for the estimation of surface run-off, erosion, thermic regime of the soils.

e) Complementary indices:

The GIS techniques allowed to process **horizontal dissection** and **vertical dissection of the relief.** The indices are important for the estimation of the optimum use of the territory, for the transportation.

f) Macroclimatic data and their microclimatic interpretation

They were interpolated for each pixel from the long period statistical data collected and processed by 76 meteorological stations in Slovakia. All were recalculated through different coefficients, so, they became a microclimatic character.

g) Landscape-ecological data

- Abiokomplex**.** This layer represents synthetic homogenous, consolidated landscape-ecological units. Encompasses different- analytic, as well as interpreted - data on relief, soils, geology and waters.

h) Complex indices based on the interpretation of morphometric indices, abiocomplexes and climatic indices

- Surface run-off, erosion threat – potential and real (calculated according to the model RUSLE (Malíšek, 1992, Pasák, 1990, Šúri, 1998).

- Potential and actual evapotranspiration – vegetation period (according to Blaney, Criddle, 1950).

- Humidity balance – vegetation period: the difference between the sum of precipitation and potential evapotranspiration.

- Topographical humidity index: It is a final, complex index. Expresses the moisture regime of the soils.

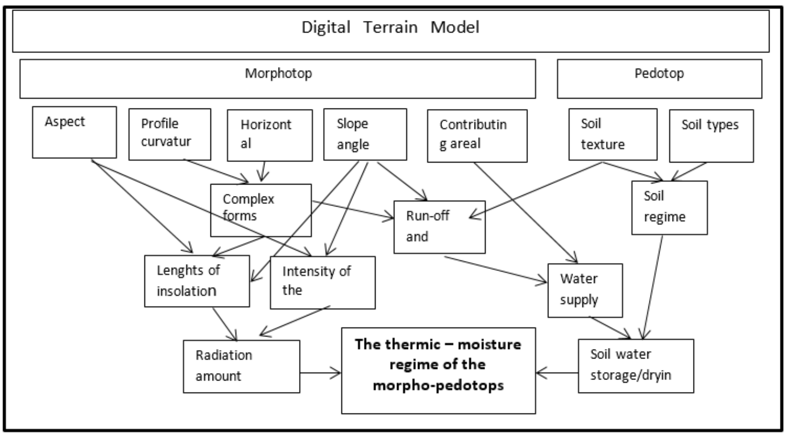
The interpretations and modelling

In our project **two directions** of the interpretation were developed on the basis of analytical data:

- the modelling of the **microclimatic conditions**:

- the modelling of the **morpho-pedological conditions**

The scheme of the sequence of the interpretations from the DMT up to the final thermic – moisture conditions of the morpho-pedotops shows the scheme:



The final interpretation in this direction ids the combined thermic-moisture regime of the morpho-pedotops as the result of both the morphometric and soil-ecologic interpretations.

Results

All the above described analytic, synthetic and interpreted indices were processed in GIS and applied to all model territories in Hungary and Slovakia.

By the mutual comparison of the final indices we defined

- the differences in the thermic-moisture regime on the sites of the sensor stations,

- the differences on the sites of the sensors and the rest of the model territories.

The sensors will permanently measure those microclimatic indices, which create the precondition for the fenological phases and for the formation and escalation of grape diseases.. For each morpho-pedotop of the model territory – thus also for the sites of the sensors - the radiation and the moisture regime had been defined. So, one can basically presume that

a) on each morpho-pedotops with the same defined conditions as those on the sites of the sensor, the time course of the fenological phases and the phases of diseases should be the same, or very similar;

b) on the sites with different morpho-pedotops we can define qualitatively and quantitatively, how big is that difference. The specialists can accordingly predict if the fenological or disease event will develop earlier or later that on the measured site.

Acknowledgement

This publication is a result of the project of Hungary-Slovakia Cross-border Co-operation Programme 2007-2013 HUSK 1101/121/0287 „Adaptív szőlészeti növényvédelmi előrejelző rendszer kifejlesztése a határmenti borvidékek összefogásában a versenyképesség növelése érdekében/Vývoj adaptívneho predpovedného systému ochrany rastlín v spolupráci prihraničných vinárskych oblastí v záujme zvyšovania ich

konkurencieschopnosti“.

References

AGENDA 2l.,l992: United Nations Conference on Environment and Development. Rio de Janeiro (United Nations), A/Conf. l5l/ 4.

Blaney, H. F., Cridle, W. D. 1950. Determining Water Requirements in Irrigated Area from Climatological Irrigation Data. US Department of Agriculture. Soil Conservation Service, Tech. Pap. 96, 48 p.

Burrough, P.A., McDonnel, R.A. 1998: Principles of geographical information systems, Oxford University Press, 333 p.

Krcho, J. 1973. Morphometric analysis of the relief on the basis of geometrical aspect of field theory. Acta geog. Univ. Comenianae, geogr.-physica, 1, Bratislava, p. 3 – 233.

Malíšek, F. 1992. Optimalizácia dĺžky svahu v závislosti od vodnej erózie, Vedecké práce VÚPÚ, 17, Bratislava, p. 201-220

Miklós, L. 1991. Morphometric indices of the relief in the LANDEP methods and their interpretation. Ecology (CSFR), 10, 2, Bratislava, p. 159-186.

Pasák, V. 1983. Ochrana zemědelské půdy před erozí. Metodiky pro zavádění výsledků výskumu do zemědělské praxe, ÚVTIZ, Praha.

Pasák, V. 1990. Zásady ochrany pôdy před věternou erozií. In: Protierosní ochrana v zemědělství ve vztahu k životnímu prostředí. ČSVTS, Praha, p. 91-97.

Ružička, M., Miklós, L. 1990. Basic premises and methods in landscape-ecological planning and optimisation. In: Zonnenveld I.S., Forman R.T.T., (edit). Changing Landscapes: An Ecological Perspectives. New York (Springer Verlag), p. 233-260.

Špinerová, A. 2010: Krajinno-ekologické limity poľnohospodárskeho využitia Ilijského potoka. VKÚ, a.s., Harmanec, 62 p.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18.

Šúri, M. 1998. Mapovanie a modelovanie vodnej erózie pôdy s využitím údajov DPZ v prostredí GIS: dizertačná práca. Geografický ústav Slovenskej akadémie vied, Bratislava, 109 p..

Tarboton, D. G. 1997. A new method for the determination of flow directions and upslope areas in grid digital elevation models. Water Resources Research. 33, 2, p. 309 – 319.

Authors

* Dr.h.c. Prof. RNDr. László Miklós, DrSc. Technical University in Zvolen, Faculty of Ecology and Environmental Sciences, T.G. Masaryka 24, 960 53 Zvolen, miklos@tuzvo.sk

* RNDr. Anna Špinerová, PhD., Technical University in Zvolen, Faculty of Ecology and Environmental Sciences, T.G. Masaryka 24, 960 53 Zvolen, spinerova@tuzvo.sk

** MGr. Dušan Kočický, PhD., ESPRIT, s.r.o, Pletiarska 2, 969 01 Banská Štiavnica, kocicky@esprit-bs.sk

*** RNDr. Zita Izakovičová, PhD., Instutute of Landscape Ecology of the Slovak Academy of Sciences, Štefánikova 3, 814 99 Bratislava, zita.izakovicova@savba.sk

Soil quality in relation to water erosion in forest systems in the eastern region of Mato Grosso do Sul, Brazil.

Bernardo Moreira Cândido[1], Marx Leandro Naves Silva[2], Nilton Curi[3]

Introduction

Forest systems, especially those planted eucalyptus forests are situated in sensitive ecosystems to anthropogenic disturbance due to plantations in rugged terrain, soils with low fertility and most of the plantations established on former agricultural areas and degraded pastures. Thus, quantification of soil quality in relation to water erosion can be an important tool to monitor the sustainability of the production system, it allows to characterize the current situation, alert to situations of possible risk and predict future situations, in other words, identify problems in the management system, demonstrating that contributes to increase or reduce the productive capacity of the soil. The Integrated Quality Index (IQI) (Doran & Parkin, 1994) and Nemoro Quality Index (NQI) (Qin & Zhao, 2000) are examples of Soil Quality Indexes (SQI). The aim of this study was to generate SQI by two indexing methods of quality indicators (IQI and NQI) to assess their accuracy in discriminating different treatments in relation to water erosion.

Material and Methods

The study was conducted in soils under eucalypt plantations in two sub-basins, "Matão" and "Barra do Moeda", in the basin of Paraná River, Municipality of Três Lagoas, Brazil. The dominant vegetation belongs to the biomes Forest in the lower elevations, and Cerrado, in the highest. In both areas the dominant soils were classified respectively as Oxisol typical, medium-high texture, forest phase (LVd1) Oxisol and typical, medium-low texture, phase Cerrado (LVd2). The systems adopted in LVd1 were: bare soil (SD), eucalyptus plantation level without (ES) and with (EC), residue and native forest (FN). In LVd2, the systems were: bare soil (SD), eucalyptus plantation level without (ES) and with (EC) residue, planting hill below (ED) and native cerrado (CN). Soil loss was determined according to standard plot USLE model. The values of physical properties and soil organic matter (SOM), used as indicators of soil quality, are described in Table 1.

Table 1. Physical properties and organic matter of two classes of soil under different management systems in Tres Lagoas, MS, Brazil.

Properties	LVd1				LVd2				
	FN	EC	ES	SD	CN	EC	ED	ES	SD
Clay (g kg^{-1})	250	280	300	310	160	230	210	220	220
Silt (g kg^{-1})	40	60	60	70	50	40	30	30	40
Total sand (g kg^{-1})	710	660	640	620	790	730	760	750	740
Bulk density (g cm^{-3})	1.36	1.32	1.37	1.44	1.47	1.48	1.51	1.51	1.57
Total pore volume (m^3 m^{-3})	0.49	0.51	0.46	0.46	0.45	0.44	0.43	0.42	0.4
Macroporosity (m^3 m^{-3})	0.3	0.2	0.15	0.15	0.27	0.19	0.18	0.19	0.19
Microporosity (m^3 m^{-3})	0.19	0.31	0.31	0.31	0.18	0.25	0.26	0.23	0.21
Index of flocutation (%)	64	59	48	51	80	73	80	69	60
Geometric mean diameter (mm)	4.78	3.13	3.1	1.51	3.56	3.48	4.07	3.61	3.42
Permeability (mm h^{-1})	3829.8	865.5	435.3	190.4	1329.3	256.3	512.3	282	46
Soil organic matter (g kg^{-1})	63.6	66.4	55.0	44.5	30.9	45.0	41.5	40.0	29.5
Resistance to penetration (MPa)	2.6	3.3	3.5	3.8	2.8	3.0	3.1	3.3	3.4

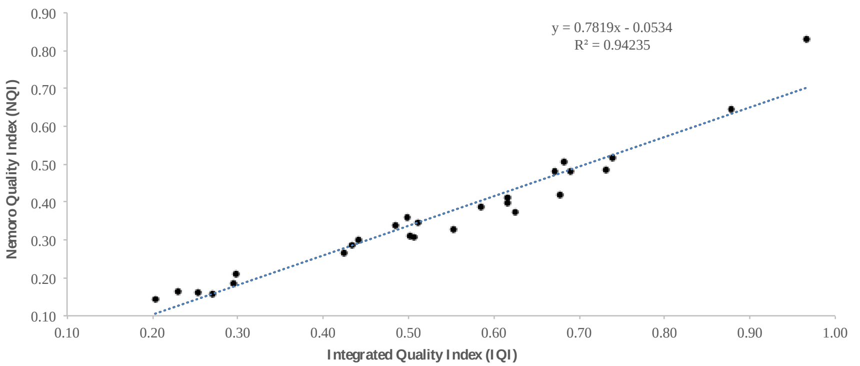
Due to the difference in units between the indicators, standard scoring functions were used for each indicator ranging between 0 and 1. To obtain the IQI, weights are assigned to indicators according to the relevance of each to the conservation of soil and water. At SOM assigned weight was 0.2, twice in relation to other indicators, due to the high importance in the processes of retention and storage of water and plant growth. The rest of the indicators was assigned, also weight 0.1. The IQI and NQI were calculated for all treatments in both soils according to the following equations: $IQI = \sum_{i=1}^{n} W_i N_i$. Where: W_i is the weight of each indicator and N_i is the score of the indicator. $NQI = \sqrt{\frac{P_{avg}^2 + P_{min}^2}{2}} \times \frac{n-1}{n}$. Where: P_{avg} is average, and P_{min} is the minimum of the scores for each of the selected sample of each treatment indicators and n is the number of indicators. Test of means between indices within treatments was conducted in each region, by Scott-Knott test.

Results and Discussion

The two methods of indexing indicators (IQI and NQI) were effective in reproducing the variation of soil quality in the two systems and evaluated using forest management. Qi et al. (2009) and Rahmanipour et al. (2014) gauging the effectiveness of these two indices showed a better estimate of soil quality with IQI instead of IQN, which could be explained by the weight of the indicator as a discrimination factor in IQI in contrast to the IQN. However, in this study, no significant difference was observed between the indices. The linear relationship between the indexes proven high correlation with $R^2 = 0.942$ (Figure 1).

The results of quality indices in LVd1 were higher in the native environment (FN), with respect to soil quality, compared to other treatments, with IQI 0.86 and NQI 0.66. Indexes distinguished three groups according to soil quality, in descending order: FN > EC > ES, SD (Table 2). This indicates deterioration of the environment from the time it leaves the natural balance and starts to be operated.

Between treatments with eucalyptus in LVd1, the results of the IQI and NQI show the positive influence of vegetation cover on soil conservation and water, where the EC presented only index lower than that of native vegetation (FN) (Table 2). This shows that the minimum tillage tends to increase the SQI and that this system should be adopted instead of conventional crops. According Rahmanipour et al. (2014), the indices obtained for EC can be classified as high, medium, and for LVd1 LVd2



respectively. In contrast to the low ES values obtained in the treatment in both soil classes. This occurs because the maintenance of the residue increases aggregate stability, retention and water infiltration and soil porosity, attributes that are indicators of soil quality and contribute to rising indexes. In LVd2, where native vegetation is Cerrado, the IQI and the NQI demonstrated the superiority of CN, ED and EC treatments compared to ES and SD. This highlights that the management of eucalyptus with maintenance of waste, whether it is level or slope, SQI provides high, equalling the reference environment, in the case CN.

Figure 1. Linear relationship between soil quality indexes NQI and IQI.

Table 2. Quality index for both soils in Três Lagoas, MS, Brazil.

Soil Class	System	IQI	NQI
LVd1	SD	0,27 c	0,17 c
	ES	0,39 c	0,24 c
	EC	0,63 b	0,40 b
	FN	0,86 a	0,66 a
LVd2	SD	0,31 c	0,22 b
	ES	0,47 b	0,31 b
	ED	0,58 a	0,40 a
	EC	0,59 a	0,38 a
	CN	0,70 a	0,49 a

Conclusion

The soil quality in relation to water erosion showed an increasing gradient in both indices in the sequence: SD, ES, ED, EC and native vegetation. Minimum tillage of eucalyptus contributed to the SQI stood next to the soil under native vegetation, highlighting the importance of maintaining residue on the soil. The methods used in the indexing of the indicators of soil quality, IQI and NQI, were strongly correlated with each other. However, since the NQI is a simpler method and eliminates the bias of the researcher with respect to the weights assigned to the indicators, it is suggested that this be used in research related to the assessment of soil quality.

Acknowledgement

At FIBRIA, for logistical support and some financial aid and CAPES, CNPq (305010/2013-1) and FAPEMIG (PPM 00422-13) for the scholarships and financial aid for part of the development of this project.

References

Doran, J.W. and Parkin, T.B. 1994. Defining and assessing soil quality. In: Doran, J.W.; Coleman, D.C.; Bezdicek, D.F. & Stewart, B.A. ed. Defining soil quality for sustainable environment. Madison. p.03-21.

Qi, Y.; Darilek, J.L.; Huang, B.; Zhao, Y.; Sun, W. and Gu, Z. 2009. Evaluating soil quality indices in an agricultural region of Jiangsu Province, China. Geoderma, 149:325-334.

Qin, M.Z. and Zhao, J. 2000. Strategies for sustainable use and characteristics of soil quality changes in urban-rural marginal area: a case study of Kaifeng. Acta Geogr. Sin., 55:545-554.

Rahmanipour, F.; Marzaioli, R.; Bahrami, H.A.; Fereidouni, Z. and Bandarabadi, S.R. 2014. Assessment of soil quality indices in agricultural lands of Qazvin Province, Iran. Ecol. Indic., 40:19-26.

Addresses of authors:

Bernardo Moreira Cândido[1], Marx Leandro Naves Silva[2], Nilton Curi[3]

[1]Federal University of Lavras
Lavras, Brazil, bernardocandido@gmail.com

[2]Federal University of Lavras
Lavras, Brazil, marx@dcs.ufla.br

[3] Federal University of Lavras
Lavras, Brazil, niltcuri@dcs.ufla.br

Variability of soil moisture controlled by evapotranspiration and groundwater interaction

Tomas Orfanus[1], Dagmar Stojkovova[1], Viliam Nagy[1], Tamás Németh[2]

Introduction

Soil moisture (SM) is an important parameter regarding the land use and agriculture. Its high spatial variability results from many processes acting over scales ranging from centimetres to thousands of kilometres (Western and Grayson, 1998). Some studies found an increase in SM variance with decreasing mean SM, while others showed an opposite trend. To understand the principles of SM spatial variability may help us to save time and effort with SM detection: The SM data have usually normal distribution in space (Hills and Reynolds, 1969; Nielsen et al., 1973; Loague, 1992). Coefficient of SM variation (CV) ranges between 10 – 30% in the upper soil horizon and there is a tendency that lower mean values of SM are related to higher values of CV. Drainage generally enhances the variability of SM since relatively finer textured soil dries slower than coarser textured soil. When soil is wet, there is no water limit for evaporation and the potential evaporation rate has usually a relatively small spatial variation at field scale. Therefore, evapotranspiration (ET) under wet conditions only reduces mean SM, not its variance. However, if SM is less than is some threshold value and the actual ET is lower than the potential one (ETP), wetter parts of the field evaporate more water than drier parts (selective ET) and SM variability decreases. The objective of this paper is to analyse the spatial variability of SM at field scale with regard to physically defined threshold soil moisture value (θ_{la}) for triggering the selective ET.

Materials and methods

The research was conducted on a 4.5 ha plot situated near village Moravský Svätý Ján in south-western Slovakia. The area belongs to alluvium of the River Moravia. Local soils are *Arenic Regosol* covering undivided 60% of the plot area, and *Mollic Gleysol* extending on the rest

40% of the plot area. The *Arenic Regosol* is loamy-sand while the *Mollic Gleysol* consists of clay loam. Only few meters wide transition area around the easily identifiable borderline is texturally variable.

There are three stages during the soil dry-down process (e.g Hillel, 1998) regarding ET, which can be expressed, as follows:

$$\begin{aligned} &ET/ETP = 1 && \text{for } \theta_{la} < \theta \\ &ET/ETP = \alpha\,(\theta - \theta_{wp}) && \text{for } \theta_{wp} < \theta < \theta_{la} \qquad (1) \\ &ET/ETP \approx 0 && \text{for } \theta < \theta_{wp} \end{aligned}$$

Taking the left side of (Eq. 1 for $\theta_{wp} < \theta < \theta_{la}$) equal to 1 we can express physically defined threshold SM value for selective ET:

$$\theta_{la} = 1/\alpha + \theta_{wp} \qquad (2)$$

θ_{la} is the threshold SM from which the dry-down of soil starts to be selective (ET proportional to SM), θ_{wp} is conventionally estimated as θ(-1.5MPa).

The first sampling date (April 10, 2002) was selected to ensure the bare soil surface and low ETP rate to avoid significant water losses during sampling time. The soil was sampled in a regular 20 x 20 m square grid (128 samples). Soil samples were taken from the horizon 0.10–0.15 m into the stainless cylinders of 100-cm^3 volume and 5 cm height. The actual SM was estimated gravimetrically, the saturated hydraulic conductivity by falling head method and the drying branches of soil water retention curves were estimated standardly in pressure chambers (Santa Barbara, California Device). The same sampling of the plot was performed at July 2nd, 2003, to compare SM variability under substantially different boundary conditions (deeper groundwater, high ETP rate)

Results and discussion

In April 10^{th}, 2002 the groundwater table was 0.77 m under the soil surface. Values of actual SM had bimodal distribution determined by textural heterogeneity of the field (Fig. 1-2). The descriptive statistics is in Tab. 1. Since the soil was wet, there was no water limit for evaporation and the evaporation rate was close to the atmospherically controlled potential rate that had usually a relatively small spatial variation (Pan and Peters-Lidard, 2008). Therefore the variability of SM was relatively small as well.

Table 1. Descriptive statistics of measured SM and SM of limited availability estimated for two textural classes and two evapotranspiration rates, in MSJ-Field experimental site.

	CLAY LOAM			LOAMY SAND		
	θ_W	θ_{la} $(E_{p\text{-}max})$	θ_{la} $(E_{p\text{-}min})$	θ_W	θ_{la} $(E_{p\text{-}max})$	θ_{la} $(E_{p\text{-}min})$
Mean	0.129	0.249	0.152	0.03497	0.161	0.089
Standard Error	0.0144	0.0097	0.00967	0.00876	0.00602	0.00587
Median	0.1	0.230	0.133	0.0143	0.149	0.00958
Standard Deviation	0.0629	0.0422	0.0422	0.0382	0.0262	0.0262
Sample Variance	0.0040	0.00178	0.00178	0.00146	0.000689	0.000689
Kurtosis	0.568	0.568	0.568	0.769	0.698	0.769
Skewness	1.156	1.156	1.156	1.368	1.368	1.368
Range	0.23	0.154	0.154	0.124	0.0797	0.0797
Minimum	0.04	0.189	0.0925	0.001	0.139	0.0733
Maximum	0.27	0.344	0.247	0.125	0.218	0.153

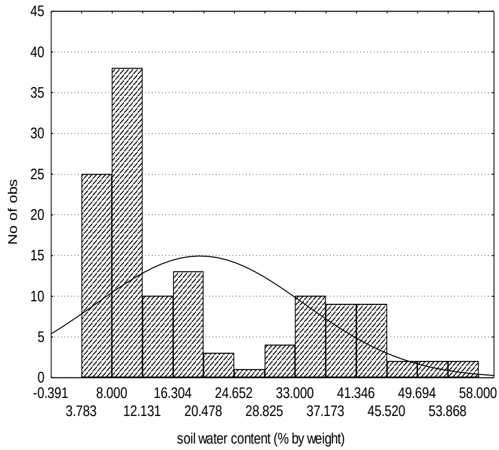


Figure 2. The bimodal distribution of SM data coming from the experimental field in Moravský Svätý Ján on April 10, 2002.

Situation in July 2, 2003 was with long-term high evaporative demand (5 mm/day) and low precipitation evenly distributed during the 30 days foregoing the date of soil sampling with the total of 32 mm. The water table in spring 2003 was similarly shallow as it was in 2002, but it had decreased steadily to the depth of 2.39 m at July 2, 2003. The values of actual SM had also bimodal distribution, determined by textural heterogeneity of the field but its spatial variability has risen in the clay loam part of the plot. Higher variability of SM can here be ascribed to the drainage of soil water after the decline of groundwater table. In case of loamy sand the joint processes of drainage and high evapotranspiration had advanced to the decrease of SM even below the threshold value ($\square_{la}$). In such cases the actual ET rate became proportional to SM and therefore variability of SM had slightly decreased (due selective evapotranspiration) together with the decrease of mean SM.

References

Loague, K. 1992. Soil water content at R-5. Part 1. Spatial and temporal variability. Journal of Hydrology 139, 233-251.

Hillel, D. 1998. Environmental Soil Physics. Academic Press, San Diego, CA.

Hills, R.C. and Reynolds, S.G. 1969. Illustrations of soil water content variability in selected areas and plots of different sizes. J. Hydrol., 8, 27 – 47.

Nielsen, D.R., Biggar, J.W. and Erh, K.T. 1973. Spatial variability of field –measured soil – water properties. Hilgardia 425, s 215 – 259.

Pan, F., Peters-Lidard, C.D. 2008. On the Relationship Between Mean and Variance of Soil Moisture Fields. Journal of the American Water Resources Association (JAWRA) 44(1):235-242.

Addresses of authors:

Tomáš Orfánus[1], Dagmar Stojkovová[1], Viliam Nagy[1], Tamás Németh[2]

[1]Institute of Hydrology, Slovak Academy of Sciences, Račianska 75, 831 02 Bratislava, Slovakia, e-mail: orfanus@uh.savba.

[2]Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, Herman Otto´ u´t. 24, 1022 Budapest, Hungary, nemeth.tamas@agrar.mta.hu

Digital, Optimized, Soil Related Maps and Information in Hungary (DOSoReMI.hu)

László PÁSZTOR[1], Annamária LABORCZI[1], Katalin TAKÁCS[1], Gábor SZATMÁRI[2], Endre DOBOS[3], Gábor ILLÉS[4], Zsófia BAKACSI[1], József SZABÓ[1]

There is a heap of evidences that demands on soil related information have been significant worldwide and it is still increasing. Soil maps were typically used for long time to satisfy these demands. By the spread of GI technology, spatial soil information systems (SSIS) and digital soil mapping (DSM) took the role of traditional soil maps. Due to the relatively high costs of data collection, new conventional soil surveys and inventories are getting less and less frequent, which fact valorises legacy soil information and the inference systems which are able to produce and serve goal-oriented spatial soil information for the optimal satisfaction of user requirements by the means of target-specific spatial modelling. The existing data contain a wealth of information that can be exploited by proper methodology.

Not only the degree of current needs for soil information has changed but also its nature. Traditionally the agricultural functions of soils were focussed on, which was also reflected in the methodology of data collection and mapping. Recently the multifunctionality of soils is getting to gain more and more ground; consequently information related to additional functions of soils becomes identically important. The new types of information requirements however cannot be fulfilled generally with new data collections at least not on such a level as it was done in the frame of traditional soil surveys.

Due to former soil surveys and mapping activities significant amount of soil information has accumulated in Hungary. Present soil data requirements have been mainly fulfilled with these available datasets either by their direct usage or after certain specific and generally fortuitous, thematic and/or spatial inference. Due to the more and more frequently emerging discrepancies between the available and the expected data, there might be notable imperfection as for the accuracy and reliability of the delivered products. With a recently started project we would like to significantly extend the potential, how soil information requirements could be satisfied in Hungary. We started to compile digital soil maps, which fulfil optimally the national and international demands from points of view of thematic, spatial and temporal accuracy. In addition to the auxiliary, spatial data themes related to soil forming factors and/or to indicative environmental elements we heavily lean on the various national soil databases.

Soil property, soil type as well as functional soil maps were targeted. The set of the applied digital soil mapping techniques has been gradually broadened incorporating and eventually integrating geostatistical, data mining and GIS tools. Regression kriging has been used for the spatial inference of certain quantitative data, like particle size distribution components (clay%, sand%, silt%), rootable depth and organic matter content. Classification and regression trees, furthermore random forests were applied for two purposes: (i) for the compilation of categorical soil maps (genetic soil type and texture classes according to various texture classification systems) and (ii) for the understanding of the soil-landscape models involved in existing soil maps, and for the post-formalization of survey/compilation rules. The relationships identified and expressed in decision rules made the creation of spatially refined category-type soil maps (like genetic soil type and soil productivity maps) possible with the aid of high resolution environmental auxiliary variables. For the elaboration of certain functional soil (related) maps crop models were also included in the spatial modelling.

In our paper we give a short introduction to soil mapping and information management concentrating on the driving forces for the renewal of soil spatial data infrastructure provided by the framework of Digital Soil Mapping. The first results of DOSoReMI.hu project are presented in the form of brand new national and regional soil maps.

Acknowledgement

Our work was supported by the Hungarian National Scientific Research Foundation (OTKA, Grant No. K105167). Authors thank J. Matus for her indispensable contribution.

Addresses of authors:

[1] Institute for Soil Science and Agricultural Chemistry, Centre for Agricultural Research, Hungarian Academy of Sciences
Budapest, Hungary, pasztor@rissac.hu

[2] University of Szeged, Department of Physical Geography and Geoinformatics
Szeged, Hungary,

[3] Department of Physical Geography and Environmental Sciences, University of Miskolc
Miskolc, Hungary,

[4] National Agricultural Research and Innovation Centre, Forest Research Institute
Sárvár, Hungary,

Goal-oriented soil mapping for the support of spatial planning and land management in Hungary

László PÁSZTOR[1], Annamária LABORCZI[1], Katalin TAKÁCS[1], Gábor SZATMÁRI[2], Nándor FODOR[3], Gábor ILLÉS[4], Zsófia BAKACSI[1], József SZABÓ[1]

Delineation of Areas with Excellent Productivity in the framework of the National Regional Development Plan or delimitation of Areas with Natural Constraints in Hungary according to the common European biophysical criteria are primary issues in national level spatial planning. These challenges require adequate, preferably timely and detailed spatial knowledge of the soil cover. For the satisfaction of these demands the soil conditions of Hungary have been functionally, digitally mapped based on the most detailed, available recent and legacy soil data, and spatially exhaustive environmental auxiliary information, applying proper DSM techniques.

The main objective of the DOSoReMI.hu (Digital, Optimized, Soil Related Maps and Information in Hungary) project is to significantly extend the potential, how demands on spatial soil related information could be satisfied in Hungary. Although a great amount of soil information is available due to former mappings and surveys, there are more and more frequently emerging discrepancies between the available and the expected data. The gaps are planned to be filled with optimized DSM products heavily based on legacy soil data.

Various soil related information were mapped in three distinct approaches: (i) basic soil properties determining agri-environmental conditions (e.g.: soil type according to the Hungarian genetic classification, rootable depth, sand, silt and clay content by soil layers, pH, OM and carbonate content for the plough layer); (ii) biophysical criteria of natural handicaps (e.g.: poor drainage, unfavourable texture and stoniness, shallow rooting depth, poor chemical properties and soil moisture balance) defined by common European system and (iii) agro-meteorologically modelled yield values for different crops, meteorological and management scenarios.

The applied method(s) for the spatial inference of specific themes was/were suitably selected: regression and classification trees, random forests and support vector machines for categorical data; regression kriging and cubist methods for quantitative data; and indicator kriging for probabilistic management of criterion information.

Our paper will present the mapping processes themselves, the resulted national maps and some conclusions drawn from the experiences.

Acknowledgement

Our work was supported by the Hungarian National Scientific Research Foundation (OTKA, Grant No. K105167).

Addresses of authors:

[1] Institute for Soil Science and Agricultural Chemistry, Centre for Agricultural Research, Hungarian Academy of Sciences
Budapest, Hungary, pasztor@rissac.hu

[2] University of Szeged, Department of Physical Geography and Geoinformatics
Szeged, Hungary,

[3] Agricultural Institute, Centre for Agricultural Research, Hungarian Academy of Sciences
Martonvásár, Hungary,

[4] National Agricultural Research and Innovation Centre, Forest Research Institute
Sárvár, Hungary,

Estimation of phytomass stock through satellite imagery in a semiarid area in Pernambuco state, Brazil

Sampaio, E.V.S.B.[1], Nascimento, D.M.[2], Menezes, R.S.C.[3], Accioly, L.J.O.[4], Pareyn, F.G.C.[5]

Introduction

The vegetation of the semiarid area of Northeast Brazil, which covers about one million km^2, has been extensively substituted by agricultural fields and has been used as native pasture and for fuel wood production (Sampaio, 2010). Lately, agricultural area has been decreasing due to its low productivity and fuel wood production increasing in the abandoned fields. As a consequence, the native vegetation, caatinga, is a mosaic of semi-arid forests in different regeneration phases. In Pernambuco state, besides domestic and small industry fuel wood consumers (bakeries, ceramics, etc) there is intensive consumption by the gypsum industry pole, located in the western part of the state. This consumption has depleted most of the caatinga in its vicinity and wood extraction is moving east. To guaranty a sustainable use ,a planned program is necessary and it is essential to estimate the available biomass stocks over the large semiarid area of the state. Determining these stocks is also an obligation of the Brazilian government in relation to global CO_2 balance and climate change evaluations. To develop a methodology that can provide this information, we estimated biomass in different plots and related this biomass to different vegetation indices obtained from satellite images. These indices are periodically calculated for the whole region and, if they could be used to estimate biomass, programs to monitor caatinga stocks could be established. The objective of our study was to developed equations to estimate vegetation biomass based on satellite data and to apply these equations to the vegetation in a 35000 km^2 pilot area in the semiarid region of Pernambuco state.

Material and methods

The study area extends over 68 municipalities (7.55 to 9.08 ^{o}S and 38.43 to 36.36 ^{o}W) in Pernambuco state and it was covered by two

Resourcesat 1/LISS III satellite images. The native vegetation cover was delimited by photointerpretation of digital images obtained during the rainy period, separating two caatinga types (dense and sparse) at a 1:100,000 scale. The digital data were processed using Erdas Imagine®, version 9.1, and ArcGIS Desktop®, version 10. The pixel digital number was converted to radiance and then normalized to the top atmospheric reflectance. First order atmospheric effect (path radiation) was removed using the dark pixel technique. Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI) and Sample Ratio (RS) were regressed against biomass values of eighty 20 x 20 m plots. Biomass of each tree and shrub in the plot was estimated using allometric equations (Sampaio and Silva, 2005). The best fitting equation was chosen based on the least and average square of residuals, p value and Akaike information criteria. The best equation was used to estimate biomass of the native vegetation in the 35,000 km^2 area.

Results and discussion

Biomass in the plots varied from 4.4 to 75.5 Mg ha^{-1}, with an average of 33.2 Mg ha^{-1}. Separating those classified as dense and as sparce caatingas, the averages were 38.6 and 17.0 Mg ha^{-1}, respectively. Stem basal areas were also about double in the dense caatingas (10.2 and 4.0 $m^2 ha^{-1}$) but plant densities were less different (1953 and 1350 plants ha^{-1}).

Using data of all plots, biomass was significantly related to NDVI and RS but not to SAVI. When the data were separated according the caatinga classification, only those of dense caatinga were significantly related to the indices. The lack of significance for the sparse caatinga was influenced by the lower number of plots (20) under this category. The best fitting equation related biomass of all plots with NDVI (Biomass, Mg ha^{-1}= 5,805 + 48.7763 NDVI). Although significant ($p = 0.00003$), the proportion of variation explained by NDVI was relatively low ($R^2 = 0.36$)

and this low adjustment was explained by large variations in the two extremes of the biomass range (below 22 and above 50 Mg ha^{-1}). In the intermediate range, the error in the estimates of biomass was only 17%. Since this intermediate range corresponds to most of the vegetation in the analyzed area (slightly above 80%) we proceeded to estimate the biomass in the whole area using this equation.

The area covered with native shrub and tree vegetation was 22,927 km^2, corresponding to 64.5% of the study area, and was mostly concentrated in the western portion. This portion receives less and more erratic rainfall than the eastern portion, a fact recognized by their classification as different phsyiographic regions (locally called as “Sertão” and “Agreste”). Therefore, the western portion has less crop and cultivated pasture fields, which are the main land uses of the areas not covered with native vegetation.

The areas with highest phytomasses were located in the highest and more inaccessible places and probably represent vegetation regenerating for longer periods. A large part, notably in the southwestern corner of the studied area, has low phytomass and may correspond to areas where agricultural uses were discontinued in recent periods (less than 10 years). The whole native vegetation stock was estimated at 64.7 million Mg, corresponding to an average of 28.2 Mg ha^{-1}. This average is lower than previously estimations for Northeastern caatinga areas (about 40 Mg ha^{-1}; Sampaio and Costa, 2011) but the vegetated area is larger, indicating that the average is reduced by the incorporation of the recently abandoned fields. The increase in native vegetation represents a good opportunity to plan its adequate use.

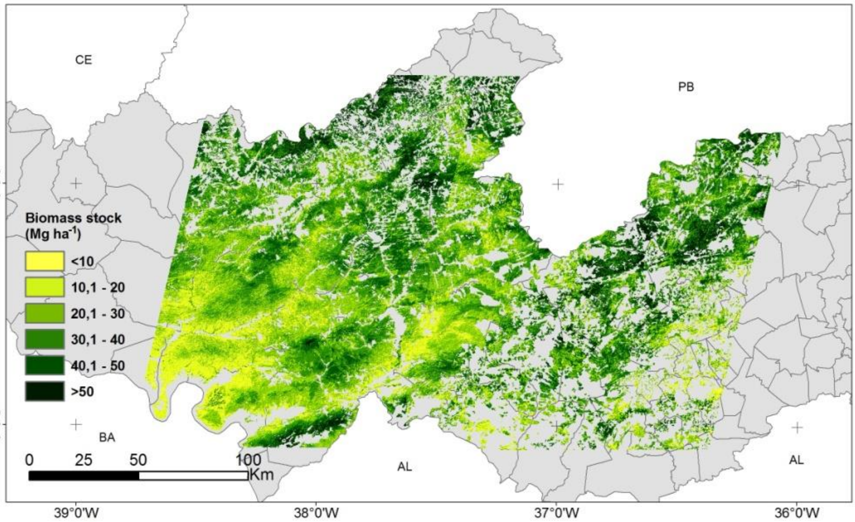


Figure 1.Estimated phytomass stocks of the native vegetation (caatinga) in the central area of Pernambuco state, Brazil

References

Sampaio, E.V.S.B. 2010. Características e potencialidades. In: Gariglio, M.A.; Sampaio, E.V.S.B.; Cestaro, L.A.; Kageyama, P. Uso sustentável e conservação dos recursos florestais da caatinga. Brasília: Ministério do Meio Ambiente. p.29-48.

Sampaio, E.V.S.B. and Silva, G. 2005. Biomass equations for Brazilian semiarid caatinga plants. Acta Botanica Brasilica 19: 935-943.

Sampaio, E.V.S.B. and Costa, T.L. 2011. Estoques e fluxos de carbono no semi-árido nordestino: estimativas preliminares. Revista Brasileira de Geografia Física 6: 1275-1291.

Addresses of authors:

Sampaio, E.V.S.B.[1], Nascimento, D.M.[2], Menezes, R.S.C.[3], Accioly, L.J.O.[4]

[1]DEN, Universidade Federal de Pernambuco
Recife, PE. Brazil, esampaio@ufpe.br

[2]DEN, Universidade Federal de Pernambuco
Recife, PE. Brazil, diegoandaluz@gmail.com

[3]DEN, Universidade Federal de Pernambuco
Recife, PE. Brazil, rmenezes@ufpe.br

[4]Embrapa - Solos
Recife, PE. Brazil, luciano.accioly@embrapa.br

[5]Associação Plantas do Nordeste
Recife, PE. Brazil, franspar@rocketmail.com

The sensitivity of water extractable soil organic carbon fractions to land use

Ćirić V., Belić M., Nešić Lj., Šeremešić S., Pejić B., Milošev D [1]

Introduction

The level of organic matter in soils is one of the key factors that can affect sustainability of ecosystem and global processes. Anthropogenic impact on soil usually causes substantial changes in soil organic matter or soil organic carbon (SOC) fractions. Water extractable organic carbon (WEOC) fractions are the most active compounds of organic matter (Kalbitz and Kaiser, 2008) and thus can strongly affect soil processes as well as surface and ground water quality. Also, these fractions are positively correlated with microbial biomass, mineralisable N and aggregate stability and therefore can be used as integrated indicator of soil quality (Ghani, 2003). Due the fact that WEOC is not homogenous and solubility of SOC fractions depends on temperature, usually two fractions are investigated: cold water extractable organic carbon (CWEOC) and hot water extractible organic carbon (HWEOC)

The purpose of this study was: i) to determine the impact of forest vegetation and arable land to WEOC fractions within 90 cm of soil profile of three soil types (Cambic Chernozem, Gleyic Vertisol, Stagnic Solonetz (IUSS Working Group WRB, 2014)); ii) to establish the relationship between WEOC fractions and soil properties.

Materials and methods

The soil samples were collected from forestland and arable land on three soil types and from three depths (0-30, 30-60 and 60-90). The extraction procedure and for CWEOC and HWEOC is performed by mothod described by Ghani et al. (2003). Soil organic carbon content is determined by a dichromate wet oxidation method followed by titration with ferrous ammonium sulfate (Mohr's salt).

Results and discussion

In the surface layer (0-30 cm) of observed soil types, concentration of CWEOC and HWEOC was significantly lower in arable land compared to forestland (Figure 1), which indicates higher concentration of labile SOC fractions in soils under forests. Ćirić (2014) reported HWEOC as a suitable indicator of anthropogenic impact on ecosystem.

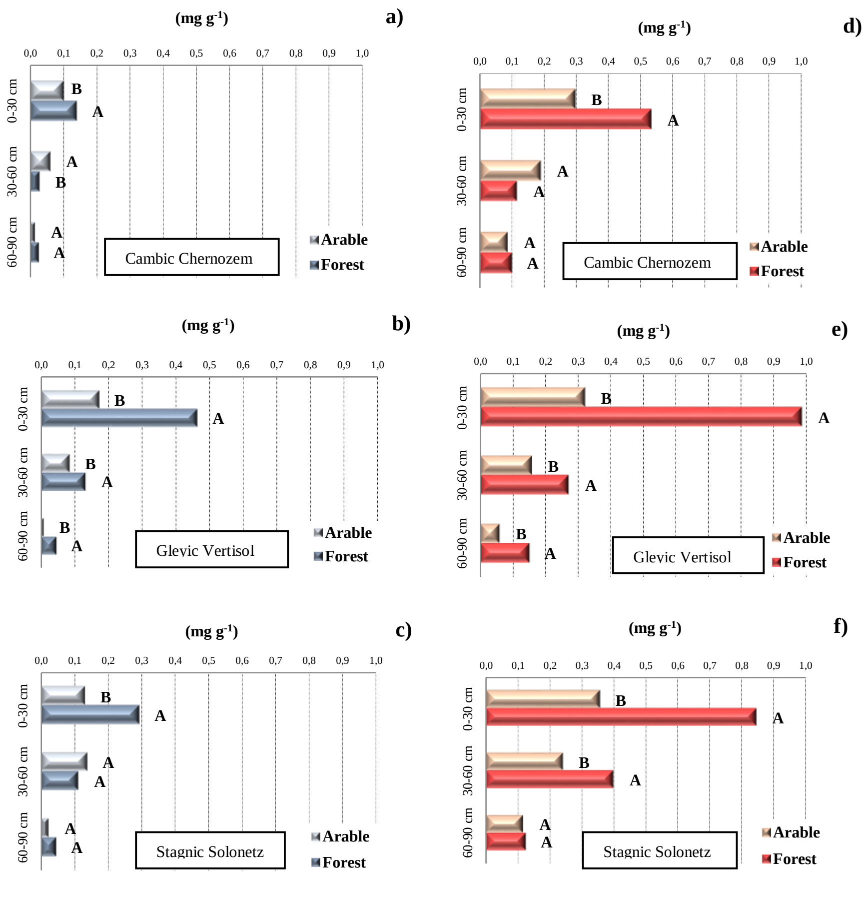


Figure 1. Concentration of CWEOC (a-c) and HWEOC (d-e) in Cambic Chernozem, Gleyic Vertisol, Stagnic Solonetz under arable land and forestland in 0-30, 30-60 and 60-90 cm. Columns with a different letter within soil type and depth are significantly different ($p \leq 0.05$).

The concentration of CWEOC in surface layer of arable land was lower from 28-63% and HWEOC from 44-68%. This indicates higher differences in HWEOC than in CWEOC between two land uses, which that HWEOC is much more informative indicator of SOC quality than CWEOC (Hamkalo and Bedernichek, 2014). The highest changes of CWEOC and HWEOC induced by land use and management are also reported by Ghani (2003) and Chantigny (2003).

The differences in CWEOC and HWEOC between arable land and forestland are less pronounced with increased depth and in Cambic Chernozem and Stagnic Solonetz but not in the Haplic Vertisol. This finding could be explained with the higher absorption capacity and clay content in Vertisols that prevents leaching of SOC fractions in deeper horizons.

The concentration of CWEOC and HWEOC decreased with soil depth, which is the consequence of decreasing of SOC concentration with depth and its correlation with CWEOC (r=0.81) and HWEOC (r=0.86) fratctions. Similar results presented in Haney et al. (2012) were positive correlation (r=0.76) between SOC and WEOC.

Conclusions

Forestlands contain higher concentration of labile water extractable organic carbon (WEOC) fractions than arable land.

Hot water extractable organic carbon (HWEOC) is much more sensitive indicator of organic matter quality than cold water extractable organic carbon (CWEOC).

The concentration of CWEOC and HWEOC decreased with soil depth.

References

Chantigny, M. H. 2003. Dissolved and water-extractable organic matter in soils: a review on the influence of land use and management practices. Geoderma, 113(3), 357-380.

Ćirić, V. 2014. Qualitative and quantitative characteristics of organic matter in different soil types. University of Novi Sad, Faculty of agriculture. Doctoral Dissertation ,193 pp.

Ghani, A., Dexter, M. and Perrott, K. W. 2003. Hot-water extractable carbon in soils: a sensitive measurement for determining impacts of fertilisation, grazing and cultivation. Soil Biology and Biochemistry, 35: 1231-1243.

Hamkalo, Z. and Bedernichek T. 2014. Total, cold and hot water extractable organic carbon in soil profile: impact of land-use change. Žemdirbystė (Agriculture), (101): 125-132.

Haney, R. L., Franzluebbers, A. J., Jin, V. L., Johnson, M. V., Haney, E. B., White, M. J., and Harmel, R. D. 2012. Soil organic C: N vs. water-extractable organic C: N. Open Journal of Soil Science, 2: 269-274.

IUSS Working Group WRB 2014. World Reference Base for Soil Resources 2014. International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports No. 106. FAO, Rome.

Kalbitz, K. and Klaus K. 2008. Contribution of dissolved organic matter to carbon storage in forest mineral soils. Journal of Plant Nutrition and Soil Science, 171: 52-60.

Addresses of authors:

Ćirić Vladimir, Belić Milivoj, Nešić Ljiljana, Šeremešić Srđan, Pejić Borivoj, Milošev Dragiša[1]

[1]University of Novi Sad, Faculty of Agriculture, Department for Field and Vegetable Crops, Trg Dositeja Obradovića 8, 21000 Novi Sad, Republic of Serbia. vciric@polj.uns.ac.rs

SOIL EROSION IN THE RIVER BASIN OF KISJELE VODE, MONTENEGRO

Velibor SPALEVIC[1], Milic CUROVIC[2], Goran BAROVIC[3], Dusko VUJACIC[3] and Nevenka DJUROVIC[4]*

Abstract

The River Basin of Kisjele Vode belongs to the Polimlje Region which is one of the important areas of sediment yield in the upper reaches of the Drina River, of the Black Sea watershed. Soil erosion processes were studied by using a process-oriented soil erosion model IntErO (Spalevic, 2011). Testing of the applied procedures was important for the further establishing of the watershed management methodologies at the National level. For the current state of land use, calculated peak discharge for the River Basin of Kisjele Vode was 96 m^3s^{-1} and there is a possibility for large flood waves to appear in the studied basin. Real soil losses, Gyear, were calculated on 1099 m^3year^{-1}, specific 106.76 $m^3km^{-2}god^{-1}$. The value of Z coefficient was calculated on 0.318 what indicates that the river basin belongs to IV destruction category; erosion process is weak. These data are of significance for the prediction and estimation of the future changing trends of sediment storage in the Polimlje River Basin. Further studies should be focused on the detailed analysis of the land use changes trends with the other river basins at the national level.

Key words: Soil erosion, River Basin, Runoff, IntErO model.

Introduction

Soil erosion is a growing problem in South East Europe and is especially serious in Montenegro (Spalevic, *et al*, 2011). According to Kostadinov *et al*. (2006), water erosion has is a problem of 95% of the total territory of Montenegro. The impacts of runoff and eroded soil, sedimentation and flooding are increasing in this Region. Quantitative information on soil loss and runoff is needed for erosion risk assessment. In their study, Volk *et al*. (2009) encouraged researchers to conduct such analysis highlighting the importance of achieving the aims of the European

Water Framework Directive. According to this directive, land use and land management options are to be used as tools for water quantity and quality control in order to achieve and maintain ecologically stable and productive water bodies. This has been well received in Montenegro taking into consideration the current EU accession agenda of this country. The important results of this study are new particular information about the recent state of the soil erosion and sediment yield in formats that can facilitate its efficient management and protection, illustrating the possibility of modelling of sediment yield with such approach.

Material and Methods

The studied area is located in the hilly area, densely populated, being located close to the town of Bijelo Polje. Rivers in this Region drain to the Black Sea. Lim River, a main waterway of the Polimlje Region, form deep canyons in limestone formations, but further downstream form broader green valley's flowing through softer Paleozoic material. This study was conducted in the area of the River Basin of Kisjele Vode, a left-hand tributary of the river Lim, encompassing an area of 10 km^2, with the highest peak, H_{max}, of 1185 m, along the western watershed boundary; the H_{min} on the inflow of the Kisjele Vode to the River Lim is 545 m. During the filed visit, we defined various physical-geographical characteristics, e.g. form of the slopes, the specific lengths, and the exposition. Soil samples were collected for physical and chemical analysis. According to the European Soil Bureau Institute for Environment & Sustainability and the EEA the USLE model is in use in the most of the European countries. In Montenegro, the Erosion Potential Method of Gavrilovic is the preferred as local model (Gavrilovic, 1972) being the most suitable on the catchment level for SEE watersheds. For this research we used the Intensity of Erosion and Outflow (IntErO) program package (Spalevic, 2011) with the EPM embedded in the algorithm of this computer-graphic method.

Results and Discussion

Climatic characteristics. Analysing temperature and precipitation (1948-2014) we concluded that the studied area is characterised by rainy autumns and springs; and cold winters. The absolute maximum air temperature is 39.2 °C; a minimum of -27.6 °C. The average annual air temperature, t0, is 8.9°C. The average annual precipitation is 873 mm. Temperature coefficient for the region, is calculated at 0.99. The torrential rain, hb, is calculated at 84.7 mm. ***The geological structure and soils of the area.*** Montenegro is a part of the Dinaric Alps. Wider area consists of various types of sediment, magmatic and metamorphic rocks generated in the period from Palaeozoic to Quaternary. The broader area to which the subject river basin belongs consists of clastic and subordinate carbonate rocks from the Palaeozoic, Triassic clastites, volcanites, tuffs, limestone and dolomites, Jurassic clastic rocks with spilite and diabasic effusions and metamorphic rocks and Quaternary, mainly alluvial and deluvial sediments. We extracted specific data from the Geological map of Montenegro. The coefficient of the region's permeability, S_1, is calculated on 0.95. A part of the river basin consisting of poor permeability rocks, fo, is calculated on 82%; of medium, fp, on 18%. Using the data of the Map of Soils of Montenegro, the most common soil types in the studied river basin are Dystric Cambisols, calculated on 79.59%; and Eutric Cambisols calculated on 20.41%. ***Vegetation and Land use.*** The River Basin is located in Dinaridi Province of the Middle-Southern-East European mountainous biogeographical region. Forests are covering 39% of the total watershed area and degraded beech forests (*Fagetum montanum*) are dominating in the upper parts of the basin; on the southern exposures forests of Sessile oak and Turkish oak (*Quercetum petraeae cerridis* Lak.) prevails. The lower part of watershed is covered with hydrophilic forest (*Salicetea herbacea, Alnetea glutinosae*). Afforestation was done 40 years ago with the Black Pine (*Pinus nigra*). Meadows cover around 45% of the river basin. The coefficient of vegetation cover, S_2, is 0.75; the coefficient of the river basin planning, is 0.54. Degraded forests are the most widespread form of vegetation type (25.41%). Other types are as follows: meadows (24.72%), arable-lands (15.56%), orchards (13.72%), well-constituted forests (13.68%) and mountain pastures (6.91%). ***Current erosion.*** In Montenegro, water erosion is the most important erosion type. Water erosion is primarily caused by precipitation, runoff and fluvial erosion in streams. The dominant erosion form in the study area is from surface runoff, but we recorded some gullies and rills also. We used the software IntErO for calculation of the soil erosion intensity and the peak discharge for the River Basin of Kisjele Vode. Part of the report processed by the IntErO model is presented in the following listing:

Coefficient of the river basin form	A	0.68	
Coefficient of watershed development	m	0.36	
(A)symmetry of the river basin	a	0.72	
Density of the river network within the basin	G	0.4	
Coefficient of the river basin tortuousness	K	1.05	
Average river basin altitude	H_{sr}	710.01	m
Average elevation difference of the river basin	D	165.01	m
Average river basin decline	I_{sr}	20.68	%
Analytical presentation of the water retention inflow	W	1.0612	m
Coefficient of the river basin erosion	Z	0.318	
Production of erosion material in the river basin	W_{year}	5048.46	m^3year^{-1}
Coefficient of the deposit retention	Ru	0.218	
Real soil losses	G_{year}	1099.91	m^3year^{-1}
Real soil losses per km^2	G_{year}	106.79	m^3km^{-2}

Conclusion

The area’s climate, relief, geological substrate, pedological composition and land use have influenced erosion processes. (A)symmetry of the river basin, a, is calculated at 0.72. Calculated peak discharge was 96 m^3s^{-1}; there is a possibility for large flood waves to appear in the basin.. Real soil losses, G_{year}, were calculated on 1099 m^3year^{-1}, specific 106.76 $m^3km^{-2}god^{-1}$. The value of Z coefficient was calculated on 0.318: the river basin belongs to IV destruction category; erosion process is weak. These data are of significance for the prediction and estimation of the future changing trends of sediment storage in the Region. Further studies should be focused on the analysis of the land use changes trends with the other river basins at the national level.

References

Kostadinov S., Zlatic M., Dragovic N., Gavrilovic Z. 2006: Soil Erosion in Serbia and Montenegro, Soil Erosion in Europe, p. 271-277; Ed.: John Bordman and Jean Poesen; London

Spalevic, V. 2011: Impact of land use on runoff and soil erosion in Polimlje. PhD thesis, Univ. of Belgrade, Agriculture, Serbia, p 1-260.

Volk, M., Liersch, S., Schmidt, G. (2009): Towards the implementation of the European Water Framework Directive? Lessons learned from water quality simulations in an agricultural watershed. LUP 26: 580–588.

Addresses of authors:
Velibor Spalevic[1], Milic Curovic[2], Goran Barovic[3], Dusko Vujacic[3] and Nevenka Djurovic[4]

[1] Institute of Forestry of Montenegro
Podgorica, Montenegro, velibor.spalevic@gmail.com

[2]Biotechnical faculty, University of Montenegro
Podgorica, Montenegro, curovic@t-com.me

[3]Department of Geography, University of Montenegro
Niksic, Montenegro, geografija@t-com.me

[4] Faculty of Agriculture, University of Belagrade Belgrade, Serbia, marasn@agrif.bg.ac.rs

Unified State Register of Soil Resources of Russia

Stolbovoy Vladimir

Overview

Last 25 years Russia experiences dramatic socio-economic changes affecting use of the soil resources. These changes have been driven by the transition of the country to the market economy, land privatization, diversification of land ownership, land management freeing, the integration into the international institutions, e.g. World Trade Organization, etc. By and large the changes in question need to account soil quality in order to satisfy public awareness on food and environmental safety. In addition, a fragmentation of the land ownership calls for strengthens the State control for compliance with common norms of rational use and protection of soil resources in Russia. All abovementioned resulted in formulation of the State requests on soil data: 1) to cover all country area especially Siberia and Northern territories which are affected by growing exploitation of mineral resources; 2) to be unified allowing application of common legal rules and transparent methodology of land resources valuation; 3) to be based on modern information technology. The EGRPR fully meets the listed above requirements on soil data. The purpose of the paper is to present the EGRPR and demonstrate some recent applications at the country and regional scales.

Materials and discussion

Introduction

The EGRPR is the State soil information resource containing full, standard, unified, digital inventory of soils of Russia. The EGRPR covers the entire territory of the country and holds normative-technical characteristics of soils necessary for execution of land legislation. The latter includes legal norms for soil use and conservation, the State cadaster valuation essential for stabilization of budgetary incomes, tax payment for land use, etc.

The principal source of the EGRPR is a formalized (digital) version of the soil map of Russia accomplished by a series of representative analytical soil profiles. In addition, EGRPR provides a description of the administrative regions of the Russian Federation and soil-ecological regionalization of the country (Figure 1). Technically, the EGRPR operates on the GIS MapInfo and other compatible platforms (ArcGIS, ArcView, etc.).

EGRPR characteristic

The EGRPR consists of four sections, including: 1) Soils; 2) Soil Resources of administrative regions (Subjects) of the Russian Federation; 3) Soil-ecological Regionalization; 4) Digital Model of Soil data description.

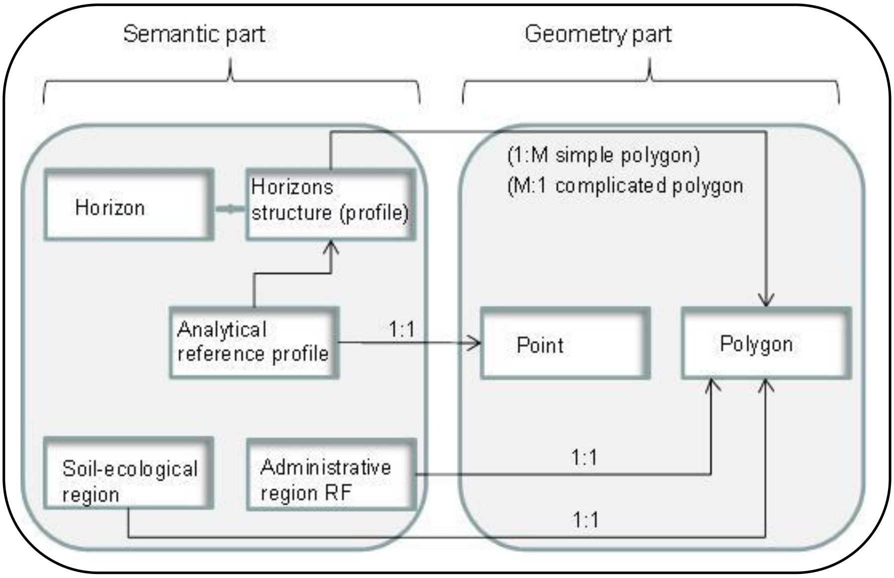


Figure 1. Conceptual structure of the EGRPR. *Semantic part contains items: "Horizon → Horizons structure (profile) → Analytical reference profile → Soil-ecological region → Administrative region of the Russian Federation". Each item has different definitions and characteristics, e.g. "Horizon" includes a list of morphogenetic horizons, their morphological and analytical definitions; "Horizons structure (profile)"describes a list of soil profiles together with their morphological and analytical definitions; "Analytical reference profile" contains a set of*

representative analytical soil profiles associated with the list of soil profiles; "Soil-ecological region" contains a list of regions characterized by specific environmental and soil formation conditions; "Administrative regions of the Russian Federation" includes an official list of the administrative-territorial units of the country registry. Geometry part contains geographical points of the analytical soil profiles and polygons with associated lists of soil profiles and above mentioned regions. Arrow stands for the relations between attributive and geometry parts, e.g. 1:M describes "one to many" relations and M:1 stays for "many to one" relations. "Simple" illustrates polygon with one soil and "complicated" shows polygons having a few soils. Complicated polygons are accompanied by data composition table.

The section "Soils" represents the major part of the EGRPR. The variety of individual soil names contains of 205 soils, 95 soil complexes. In addition, the EGRPR has 6 non soil formations (rock outcrops, loose deposits, sands, glaciers, water bodies, permafrost cracks) and 25 texture classes. Total amount of polygons is 25711.

The section "Soil Resources of administrative regions (Subjects) of the Russian Federation" represents a diversity of soils by administrative regions (83 in total) of the country. The main purpose of the section is to ensure the consistency of the soil data among regions of the Russian Federation.

The section "Soil-ecological regionalization" illustrates the diversity of natural and geographical characteristics of Russia. The main task is to highlight ecological and soil-forming peculiarities of the territory in order to rationalize land management systems across the vast country area. Total number of the soil-ecological regions is 1377.

The section "Digital Model of soil data description" contains electronic forms for 290 metadata descriptions, 410 definitions of laboratory methods, 89 reference-qualifiers, including 2012 descriptions-definitions. The Model is based on specially designed software allowing operating, introducing soil description and visualizing the later.

Application

Cadastral Valuation of Land

Cadastral valuation needs soil details. For this purpose Regional Register of Soil Resources (RRSR) are proposed. The RRSR follows the nomenclature of the EGRPR mapping units working out in details of local soil survey of the agricultural land.

Quality of Russian Soils for Agricultural Exploitation

Based on a specially developed model the EGRPR was applied to evaluate the soil quality of the country for agricultural exploitation (Ivanov *et al.,* 2013).

Carbon Balance in Soils

Current climate change in Russia including rise in temperature and precipitation calls for assessment of carbon balance (CB) in soils. The new estimate based on the EGRPR has shown a sequestration of + 72 ± 32 million tons of carbon (Mt C) annually (Stolbovoy and Ivanov, 2014).

Soil Resources of Russian Arctic

The soil cover area of the Arctic Zone of Russia Federation (AZRF) is about 330 million hectares. The EGRPR data is sufficient to perform a variety of national and international programs (Ivanov *et al.,* 2015).

Summary

The EGRPR is a new State soil information resource which is built on the modern information technology. The design of the EGRPR allows carrying out a wide range of soil resources analysis at different geographical scales such as cadastral valuation, land quality estimate, carbon status assessment, new area soil evaluation, etc.

References

Ivanov, A., Savin I., Stolbovoy V. 2013. Soil quality for agricultural use, Reports of the Russian Academy of Agricultural Sciences. 6, p. 41-45.

Ivanov, A. Savin, I., Stolbovoy, V. 2015. Soil Resources of Russian Arctic. Reports of Russian Academy of Sciences, Earth Sciences, (in publication).

Stolbovoy, V. and Ivanov, A. 2014. Carbon Balance in Soils of Northern Eurasia. Chapter 38. A.E. Hartemink and K. McSweeney (eds.), Soil Carbon, Progress in Soil Science, DOI 10.1007/978-3-319-04084-4_38, © Springer International Publishing Switzerland p. 381-390.

Unified State Register of Soil Resources of Russia. 2014. Version 1.0. Joint monograph, Moscow, Dokuchaev Soil Institute Russian Academy of Agricultural Sciences, 768 pp. (available on website: http://egrpr.esoil.ru).

Addresses of authors:
Stolbovoy Vladimir
Dokuchaev Soil Institute
Moscow, Russia, e-mail: vladimir.stolbovoy@gmail.com

Risk Reduction of Extreme Hydrological Events and Soil Moisture Regime with Rational Land Use and Soil Management

György Várallyay
Centre for Agricultural4 Research Institute for Soil Sciences and Agricultural Chemistry of the Hungarian Academy of Sciences, Budapest, Hungary

The Carpathian Basin is a **"water-dependent" region** hardly predictable spatial and temporral variability, often extremes and sensitively react**,** where the natural conditions are generally and relatively favourable for rainfed biomass production. These conditions, however, show extremely high and to various natural or,human-induced stressesThe favourable agro-ecological potential is often limited by oil degradation processes; extreme moisture regime; and unfavourable bio-geo-chemical cycles of elements (Várallyay, 2006).

The Carpathian Basin is *generally rich* in water resources, especially in the low-lying parts of the Pannonian Plains, as the bottom of this large water catchment area. But due to the irregularity of atmospheric predipitation; the increasing frequency of heavy rains; heterogeneous macro-, meso- and microrelief; unfavourable soil properties; improper land use and cropping pattern results increasing , frequency, duration and intensity of extreme meteorological anuations (floods, waterlogging, overmoistening ↔drought) represents an increasing risk, often in the same year on the same territory (Várallyay Gy. 2010).

Under such conditions it is an unrevitable fact, that soil is the largest potential natural water reservoire.

In ideal cases the 0–100 cm soil layer can store 30–35 km³ water can be stored, which is more than half of the 500–600 mm average annual precipitation. About 50% of this quantity is "available moisture content", that may satisfy the water requirement of the natural vegetation and cultivated crops. But in many this huge water storage capacity is not used because of various limitations and the it results incrasing hazard of extreme hydrological events and soil moisture regime (Várallyay, 2010).

What are the main reasons of this "huge water storage capacity" – "extreme moisture regime contradiction?

Only 31% of Hungarian soils represent an "ideal case" for the efficient use of the potential water storage capacity, having "favourable" hydrophysical properties, but 43% of the soils have unfavourable and 26% moderately favourable water management characteristics, because of various limiting factors (*Figure 1)* (Várallyay et al., 1980).

For the exact characterization a comprehensive soil survey-analysis-categorization-mapping-monitoring system has been developed. The schematic map of the distiguished is given in Figure 2. (Várallyay 2011; Várallyay et al. 1980).

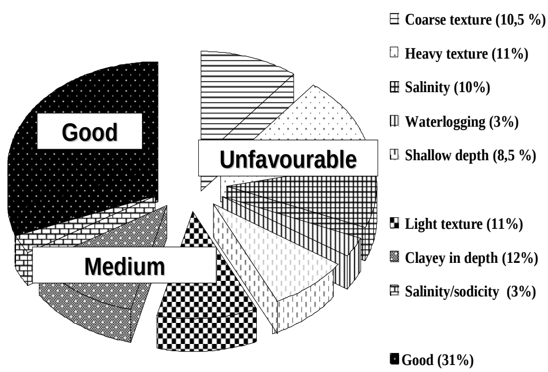


Fig.1. Water management of soils in Hungary and their reasons

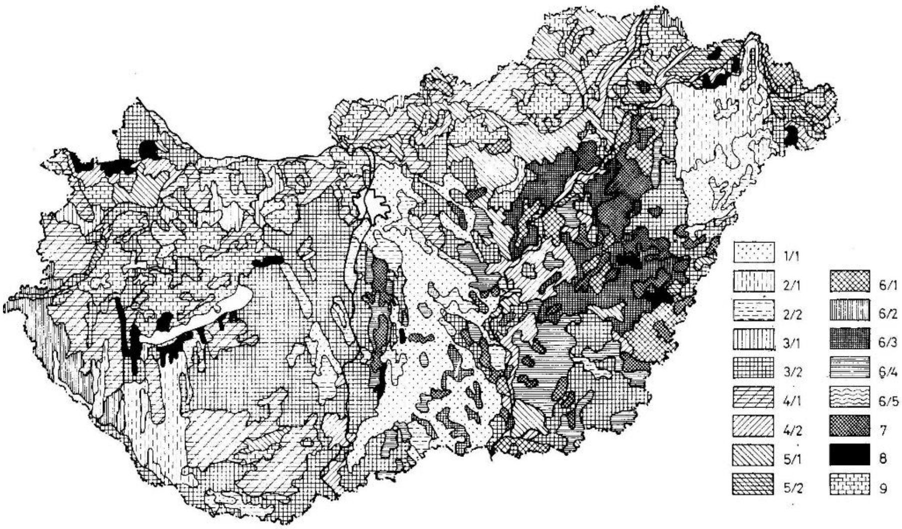


Fig. 2. Hydrophysical characteristics of soils in Hungary

The database can be quantitatively interpreted for soil layers, soil profiles; physico-geographical, administrative, farming or mapping units and so serves as a scientific basis for regional or local water management activities, **reducing the risk and frequency of extreme hydrological events and moisture situations;** preventing or at least moderating their unfavourable economical–ecological–environmental–social consequences (Németh et al. 2005).

The *potential* water storage capacity is not (or only partly) utilized because of the following reasons (Várallyay, 2011):

The pore space is not "empty": it is filled up by a previous source of water (rain, melted snow, capillary transport from groundwater, irrigation etc.): "*filled bottle effect";*

The infiltration of water (rain, melted snow) into the soil is prevented by the frozen topsoil: "*frozen bottle effect";*

The infiltration is prevented or reduced by a nearly impermeable soil layer on, or near to the soil surface: "*closed bottle effect"* ;

The water retention of soil is poor and the infiltrated water is not stored in the soil, it only percolates through the soil profile: “*leaking bottle effect”*

Table 1. Elements and methods for risk reduction of extreme hydrological events

Elements		Methods
Reducing	surface runoff	Increase in the duration of infiltration (moderation of slopes; terracing contour ploughing; establishment of permanent and dense vegetation cover; tillage; improvement of infiltration; soil conservation farming system)
	evaporation	Helping infiltration (tillage, deep loosening) Prevention of runoff and seepage, water accumulation
	feeding of ground-water by filtration losses	Increase in the water storage capacity of soil; moderation of cracking (soil reclamation); surface and subsurface water regulation
	rise of the water table	Minimalization of filtration losses (↑); groundwater regulation (horizontal drainage)
Increasing	infiltration	Minimalization of surface runoff (tillage practices, deep loosening) (↑)
	water storage in soil in available form	Increase in the water retention of soil; adequate cropping pattern (crop selection)
Irrigation		Irrigation; groundwater table regulation
Surface } drainage Subsurface		Surface } moisture control (drainage) Subsurface

The most important elements of sustainable soil moisture control:

- help the infiltration of water into the soil;
- help the useful storage of infiltrated water within the soil without any unfavourable environmental consequences;
- reduce the immobile (strongly bound "dead") fraction of the stored water;
- reduce evaporation, surface runoff and deep filtration losses of atmospheric precipitation and irrigation water;
- drain only the *harmful surplus* amount of water from the soil profile and from the area, improving vertical and horizontal drainage conditions

There are many possibilities for the practical realization of these basic objectives. Some of them are summarized in *Table 1*,(Farkas et al., 2009; Várallyay, 2010).

Soil water management and soil moisture control are of priority significance in rational land use and sustainable soil management in the Carpathian Basin. The hazard, present and expected future risk, increasing frequency, duration and intensity of extreme (and irregular, consequently hardly predictable) climatic and hydrologic events and moisture situations may result in serious damages, with unfavourable economical/ecological/ environmental/social consequences. **Soil** – in the case of adequate, permanent and efficient soil and water management – **may prevent, eliminate or moderate these unfavourable situations and may considerably reduce their harmful consequences.**

References

Farkas, Cs., Birkás, M., Várallyay, Gy. (2009): Soil tillage systems to reduce the risk and unfavourable consequences of extreme weather and hydrological situations. Biologia, (Slovakia) 64 (3) 624–628.

Németh, T., Stefanovits, P., Várallyay, Gy. (2005): Hungarian Soil Conservation Strategy. (In Hungarian). Ministry of Environment Protection and Water Management. Budapest.

Várallyay, Gy. (2006): Soil degradation processes and extreme soil moisture regime as environmental problems in the Carpathian Basin. Agrokémia és Talajtan, 55 (1–2) 9–18.

Várallyay, Gy. (2010): Increasing importance of the water storage function of soils under climate change. Agrokémia és Talajtan, 59 (1) 7–18.

Várallyay, Gy. (2011): Water storage capacity of Hungarian soils. Agrokémia és Talajtan, 60 Suppl. (online) (ATON) 7–26.

Várallyay, Gy. et al. (1980): Hydrophysical properties of Hungarian soils and the map of their categories in the scale of 1:100 000. (In Hungarian) Agrokémia és Talajtan, 29. 77–112.

Research on Monitoring System and Method of Cultivated Land Quality Gradation Change in China

WU Kening

School of land science and technology，China University of Geosciences, Beijing，China，100083

Over the past 30 years,rapid urbanization and industrialization processions have accelerated a higher rate of economic growth, Meanwhile has led to significant loss of cultivated land , especially for high quality gradation cultivated land in southeast coastal areas of China. Effects of land use change on cultivated land quality gradation have drawn close attention recently due to the world wide threat to food security. Since the large Chinese population needs to feed itself, the decreases in both quantity and quality of cultivated land over the last two decades in China presents many challenges. How to monitor and to conserve of cultivated land in China, now become the important issues for the scientists, NGOs,or for the governments.

The level of cultivated land quality is embodied as capability of biological production, or grain potential production in China, is effected by many indicators, the socio-economic factors ,the physical conditions such as temperature, light, water, soil and the biological characteristics. These factors affect each other and codetermine the cultivated land quality ladder series: photosynthetic potential productivity, light-temperature potential productivity, photosynthetice-thermal productivity, photosynthetice-thermale-water potential productivity and photo-temperature photosynthetice-thermale-watere-land potential productivity. Among all the potential productivity, the last one is closer to actual cultivated land quality. stands for the potential land productivity，it’s the capability of cultivated land to produce biological products for humans under certain conditions. Aside from socio-economic factors, cultivated land quality is mainly determined by the site’s temperature, light, water, soil and the biological characteristics of the intended crop, which in the case of China are grains (i.e., rice, wheat and corn).

In order to assign cultivated areas natural quality grades, supported by The National Land Resources Survey Project in 1998,by using the Standards of Agricultural Land Classifications assessment system, the Ministry of Land Resources of China had organized hundreds and thousands sci-tech workers, investigated and evaluated the cultivated land quality gradation across China for ten years. Then the Quality Grade of China's Agricultural (Cultivated) Land nationwide data and reports, was published in 2009.The natural quality grades values were derived from assessments of photosynthetice-thermale-watere-land potentiality, using the same method that the United Nations Food and Agriculture Organization employed to identify Agro-Ecological Zones (AEZ). The cultivated land quality were determined in the county as a unit for provinces by assigning the natural quality grades values in China to 15 ranked categories numbered 1 to15, with smaller natural quality grades representing higher average cultivated land quality.

In order to enhance the cultivated land quantity and quality management level simultaneously， we build the grade of cultivated land quality monitoring system to explain the reasons of cultivated land quality grade changes, include the driving factors, the methods to evaluate changes of the cultivated land quality grade and the comprehensive production capacity of the regional cultivated land, based on the results of Agricultural Land Classification Project and Land Consolidation and Rehabilitation Project.

Firstly, to save test cost and to reduce the workload, we proposed a concept of monitoring and control zone, and gave the methods and procedures to divide it. Monitoring and control zone is a homogeneous region that natural attributes are consistent with social at a given time and space scales. According to the principle of dominant factor and the regional differentiation, by using the natural conditions ,utilization levels, income and variation of cultivated land use patterns . Climate, topography, cultivated land utilization, input and output and cultivated land use patterns should be relatively consistent in the monitoring and control zone, the comprehensive properties above should have a clear distinction in different monitoring areas.

Secondly, according to the grade distribution in each monitoring-control zone, one or more monitoring sites were emplaced in the area. The information of monitoring points can be integrated and abstracted out the characteristic of quality grade change of monitoring-control area, then we can know the overall changes of cultivated land quality and productivity of the study area.

Thirdly, we build the new monitoring index system for evaluation the cultivated land quality change. There are a lot of factors relating to the quality of cultivated land, like natural factors and social-economic factors. Finding out the crucial factors is important to evaluate the quality range of cultivated land by using the least indication. During the survey of grading cultivated land quality, establishing a monitoring index system which based on the original classification index system is a good method to maintain consistency and compare with the primal results. As a consequence, choosing natural factors, utilization factors or investment factors to monitor the cultivated land quality grading should be according to the analysis of the new index system.

In addition, monitoring time cycle was studied too. As different monitoring indicators have distinguish time scales different, we need analysis of the characteristics of different time scales, and decide the adaptive monitoring time cycle to ranking indicators change for the quality of cultivated land. Generally, Characteristic Response Time (CRT) which is a research method to measure the variability of soil properties over time , can be used as a principle to define the time variable in the cultivated land quality research. By literature review, a variety of cultivated land quality monitoring indicators relating to their time scales are divided into three types: constant factors, relatively stable factors and variable factors. By meta-analysis, classifying indicators of different yield is a good way to get the results of distinguished index.

Finally, A data analysis and diagnosis platform was developed to input, analysis and diagnosis the monitoring indicators data with the geography and land use database, and to evaluation the quality gradation change based on ARCGIS.

This research is a powerful scientific and technological support not only to promoting the capability of Chinese cultivated land resources, but also for the management national food security.

Acknowledgement: Thanks for the support of public welfare industry scientific research subject of The ministry of land and resources of China （No.201011006-2）

Integration and demonstration of the remediation technologies of Damaged Farmland in Industrial and Mining Areas

ZHAO Huafu WU Kening

School of land science and technology， China University of Geosciences, Beijing， China， 100083

Mine resources in China are rich, while during the mining process, various types of solid-waste have been discharged and occupied quantities of farmland.Moreover,surface and underground mining activities lead to serious damage of farmland. According to statistics, there are about 13.3 million hectares of damaged or abandoned land in China,among them, about 30% of the damaged land is covered by coal or subsided, destroyed or deserted due to exploitation of mineral resources. In addition to the loss of production function, large amounts of the mine collapse pit, a lot of waterlog, destroyed facilities, disrupted traffic road and other issues are also universal symptoms of damaged farmland in industrial and mining areas. However, the foundation for current restoration and consolidation techniques of damaged farmland in industrial and mining areas is significant scarce, and the actual specific technology research, such as integration and demonstration of remediation and restoration for typical damaged farmland in industrial and mining areas are rare too.

The agricultural land classification, which based on the continue stable indexes from natural factors and economic factors, is carried out as a comprehensive assessment of the quality of agricultural land in the whole China. The agricultural land classification focus on the reflection of differences between the productivity level of agricultural land caused by the differences of the regional natural quality, the average utilization level and the average benefit level. It is divided into natural quality grade, utilized grade and economic grade. The productions of multi-level agricultural land classification can be used across the country, because of the nationwide unified setting of the standards of agricultural land gradation.

For the characteristics of the damaged farmland in industrial and mining areas and the technical requirements of grade improvement, based on the analysis of the factors in the quality of arable land and the following problems caused by the Mining subsidence, the integration technology of arable land quality upgrade in industrial and mining areas was studied, including the overburden stripping technology, the soil reconstruction technology, the water facility remediation technology, the farmland conservation technology and the high-accuracy field leveling technology. Meanwhile, a demonstration experiment was conducted in the subsidence area of Pan'an, Jiawang district, Xuzhou, Jiangsu Province.

Firstly，to protect the topsoil resources of the farmland in industrial and mining areas, we conducted the systematic research on the optimal time and method of overburden stripping, the way to store the topsoil, recover method and thickness of topsoil. Furthermore, we present the reasonable time stripping topsoil, store methods of the topsoil.

Secondly, based on the mechanism of crop growth, this topic deals with a series of laboratory soil-column simulation experiments designed to study relevant technologies of the soil reconstruction. The related technologies include the preferred techniques of filling material, the isolation layer arrangement technology and the design technology for the thickness of covering soil.

Thirdly, we reconstruction the water system by prompt reasonable layout of the depth and mutual distance of the underground pipe and open channel drainage, control groundwater table and preferential filling materials methods to improve the efficiency of water restoration and to obstruct harmful material migration.

Fourthly, some farmland conservation technologies were studied in this topic too. After the implementation of engineering measures for the land reclamation in industrial and mining areas, physical and chemical properties of the soil became bad and barren due to the strong artificial disturbance. There were still hidden troubles of the heavy metals pollution in soil because of the properties of the filling materials. We provided three solutions of the problems including the fertilization technology, the adjustment of cropping system and irrigation mode.

In addition, we proposed technical processes and practical application of carrying land leveling by using laser grader with higher leveling accuracy after topsoil recovering, depending on the demands that land leveling project needs to be easier for mechanized farming, irrigation uniformity, good drainage, beneficial to restrain salt content, improve the soil and meet the requirement of stable and high crop yield for water,

The agricultural land classification, which based on the natural conditions and economic conditions that constituting the stable land quality, which is identified as a comprehensive assessment of the quality of agricultural land in our country. Agricultural land classification focused on the difference rank of agricultural land upon the regional natural quality heterogeneity, the average utilization level and the average benefit level. It can be roughly distinguished as three different types, the natural quality grade, the utilized grade and the economic grade. Based on the nationwide unified setting of the standards of agricultural land gradation, the results of multi-level agricultural land classification can be used across the country.

Finally, based on the theory and result of agricultural land classification, this paper explore the change law of agriculture land quality grade in coal mining subsidence area by comparing the quality grade of damaged farmland before and after consolidation. The evaluation results show that after consolidated, the physical quality grade, utilized quality grade or the economic quality grade are improved obviously. The physical quality grade raises from 0 to 4 grades, the utilized quality grade raises from 0 to 3 grades and the economic quality grade raises from 0 to 2 grades. The quantitative evaluation of consolidated efficiency can provide a reference for other similar work. The reason why the quality grade improved are as follows: the overburden stripping technology，water remediation technology for drainage， soil reconstruction technology, and the precise leveling technology. Meanwhile, farmland conservation technology and cropping system changes from wheat a year into a ripe wheat-maize double cropping a year are applied too. The cultivated land quality of the demonstration area improved significantly by the integrated applying of the relevant engineering technologies.

Acknowledgement: Thanks for the support of The twelfth five year national science and technology support program from Ministry of Science and Technology a（No. 2011BAD04B03/03）

The Analysis of the probable influence of Soil environment for the traditional liquor-making in china

Xilin Zhao *Yunyi Tang*

(Sichuan University, Chengdu, China, 610000)

Introduction

Liquor-making has the obvious characteristics of regional differences what the flavor components of liquor produced by different places are distinct in china. To some extent, the flavor components of liquor depend on crops qualities, especially protein and starch. Soil type is one of the most important ecological factors for causing the difference of crop qualities. Because it decided organic matter content, total N content, total P content, available P content, available K content and soil moisture and so on. Therefore the paper will attempts to reflect which soil characteristics could affect liquor-making through the relevant conclusions of other researchers, Firstly, this paper will sum up the conclusions of the effects of the soil nutrients for protein and starch contents of crops what is used for making liquor on different places in china. Secondly, the paper will review the conclusions of the effects of the soil moisture for protein and starch contents of these crops. The aim is to search the probable factors in soil environment for liquor-making, and provide the basis for further revealing the relationship between liquor-making and the natural environment in producer of liquor.

Method

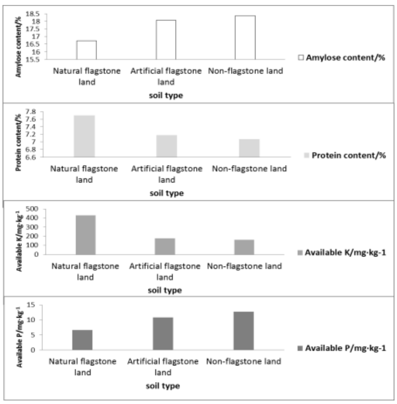
To reveal the probable impact factors of soil environment for liquor-making, the paper gathered the data of crops qualities and the data of soil conditions, and did statistics of the protein content and starch content in different soil types, and compared the change of the content of crop qualities with the soil conditions.

Result

The probable influence of soil nutrients

The paper selects Heilongjiang and Jilin provinces in the northeast of China, Henan province, the mid-east in China, and Hunan that the southeast provinces in China, as the study sites. And we found the correlations of organic matter content, total N content, alkali-hydrolyzed N, pH and crop qualities are unstable, nevertheless, the contents of available K and available P can affect the contents of starch and protein of crops in different place.

In Heilongjiang Province, as the reduction of the content of soil available K， Amylose starch content of rice increased and protein reduced (Fig 1) (Hongliang Li 2013). In Jilin Province, the change of protein content of Soybean had a similar variation tendency of soil available K also. However, the available K content of Saline-alkali soil was higher than the available K content of chernozem, and the protein content of the former was lower than the latter. We found available P content of Saline-alkali soil was the highest through comparing other all indexes of soil nutrients (Fig 2) (Hongbo Fu 2002).



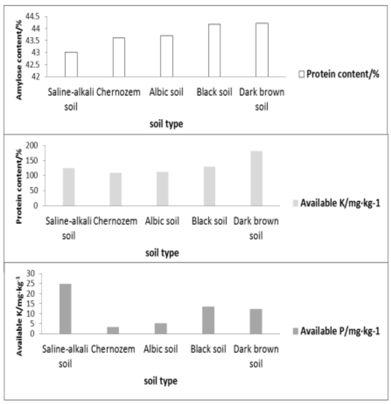
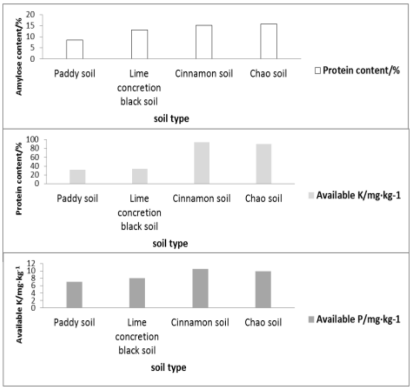


Fig1. Rice qualities and Soil properties in Heilongjiang Province
Fig2. Soybean qualities and Soil properties in Jilin Province

Henan Province had the similar phenomenon, the available K content of cinnamon soil was higher than the available K content of Chao soil, and the protein content of the former was lower than the latter. We also found available P content of cinnamon soil was the highest through comparing other all indexes of soil nutrients (Fig 3) (Dangling Hua 2001).

In Hunan Province, Protein content of potato in the quaternary red clay had the highest level, and available K content of quaternary red clay had the highest level also, the available p content of quaternary red clay was lower, and the protein content in purple soil had the lowest level, its available k content was not the lowest and the available p content had the most level (Fig 4) (Jiehui Zhu 2009).



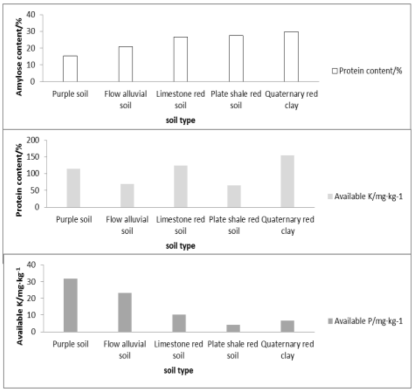


Fig3. Wheat qualities and Soil properties in Henan Province
Fig4. Potato qualities and Soil properties in Hunan Province

The probable influence of soil moisture

The paper selects Shandong and Jiangsu provinces in the eastern coast of China, Shanxi, the inland province in China, as the study sites.

The correlation coefficients sufficiently account that the protein content of had a significant negative correlation with soil moisture in Shanxi (Fig5). The result expressed the starch content, Amylose content, and Amylopectin content of wheat showed rising trends from 40-50 to 60-70 of Soil moisture content, and from 60-70 to 80-90, the contents of them decreased in Shandong(Fig 6). In Jiangsu, with the reduction of soil moisture, the Amylose content of rice increased, yet protein content of rice had the opposite trend (Fig 7).

Conclusion

This paper has two main conclusions.

I. Available K could promote synthesis of protein content of crops, however, when available P content in the soil above a certain amount could restrain the trend.

II. The shortage of soil moisture is good for protein content of crops, and bad for starch content, Amylose content and Amylopectin content, but when the soil moisture content exceeds a certain value, the content of starch could decrease.

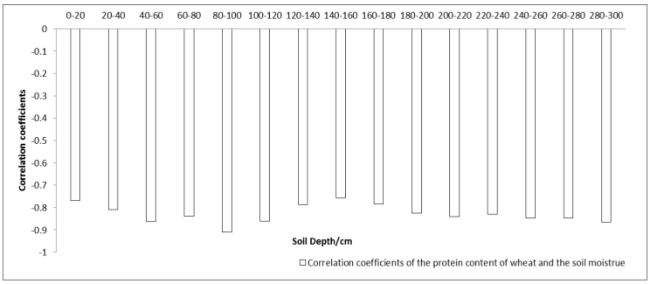
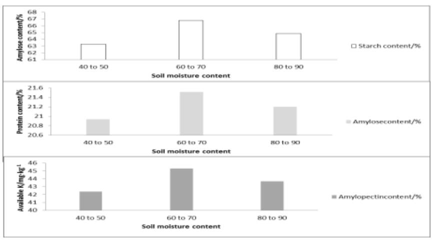


Fig5. The correlation coefficients of soil water storage and Protein content in Shanxi Province



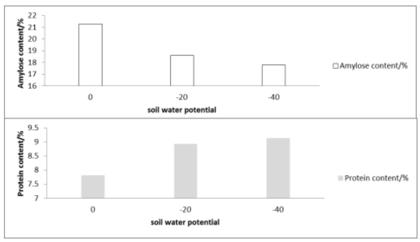


Fig6. Starches contents of Wheat and Soil moisture in Shandong Province

Fig7. Starches and Protein contents of Rice and Soil moisture in Jiangsu Province

Reference

Hongliang Li, 2013, Influence of Soil type on characteristics of photosynthetic production and grain quality of japonica rice in northeast china, Chin J Rice Sci, 287-296.

Hongbo Fu, 2002, Effects of Different soils on Growth, Development, Yield and Quality of small-Seed Soybean, Journal of Jilin Agricultural University, 21-25.

Dangling Hua, 2001,Association between Different Soil Ecotype with Yield, Quality of Three Wheat Varieties with Different Gluten Content, Journal of Triticeae Crops, 286-291.

Jiehui Zhu, 2009, Effect of fertilization in dissimilar Sorts of Soil on Production and Quality of Potato, Journal of Hunan Agricultural University (Natural Sciences), 423-426.

European Commission

EUR 27249 EN – Joint Research Centre – Institute for Environment and Sustainability

Title: Land Quality and Landscape Processes

Authors: Tamás Hermann, Gergely Tóth, Tamás Kismányoky and Attila Dunai (Eds.)

Luxembourg: Publications Office of the European Union

2015 – 142 pp. – 17 x 24 cm

EUR – Scientific and Technical Research series – ISSN 1018-5593 (print), ISSN 1831-9424 (online)

ISBN 978-92-79-48310-3 (print)
ISBN 978-92-79-48311-0 (PDF)

doi: 10.2788/641226

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

LB-NA-27249-EN-N

European Commission

doi: 10.2788/641226
ISBN: 978-92-79-48311-0