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SOIL ORGANIC MATTER OF CHERNOZEM IN THE PART OF CENTRAL EUROPE

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Abstract

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In this study, we have tried to evaluate the current contents of Soil Organic Matter (SOM) in the Soil Type Chernozem for Central Europe and to determine the site specific level for the Czech Republic. In the past, the observed effect of SOM on the Agronomic characteristics in particular yields. Nowadays it means a very important influence on the Environment, particularly in the terms of ecological functions of soil (the influence of the filter function, sanitation function, protection against degradation etc.).

The statistical analysis included data for all the Chernozems (N = 141) regardless of subtype derived from measurements from 2003 to 2006. Measurements were carried out at selected locations in the Czech Republic.

Profiles at each site were divided into topsoil and subsoil and these were separately statistically processed. When evaluating the frequency distribution, we suppose that the anthropic un-affected Soils would be approximately equal to distribution Gauss normal distribution, and both frequency distribution (in topsoil and subsoil) will be similar (mollic horizon in this Soil Type on non-eroded land is relatively deep and homogeneous).

Next from of the observed properties is relation between Content of Soil organic Matter and the texture, namely the content of particles smaller than 0.01 mm. The average SOM content is higher in clayey soil, clay-loam soil than in sandy soil. Differences between soil sandy-loam and clayey-loam are statistically significant. The paper also outlined the possible future development of SOM on Chernozem soils.

soil organic matter, SOM, Chernozem, Central Europe

The importance of SOM in the soil has been known for about two centuries and up to the present day it has been considered to be of a quite importance. Among the features of soil, which the SOM content has a particular impact on, we can mention for example soil microflora stimulation (followed by an increase in the nutrients use coefficient), soil aggregate production, adsorption process in the soil, moisture regime, detoxification of xenobiotics etc.

According to Campbell (1978), who orders the impacts of some natural factors on SOM and nitrogen content in the soil, the key factor is the climate (climate>vegetation>relief=parent rock>age). Despite the impact of climate factors, in a number of cases the influence of physical and chemical properties of parent substrate can become dominant. In general, speaking of soil of loess and polygenetic loams in lowlands, where chernozem belongs to, there can be noticed a regular decrease in SOM content from Phaeozems and chernozem to Greyzem, minimum in brown soil. SOM is also an important indicator of hydromorfia (Podlešáková *et al.*, 1982).

Apart from an agronomical importance of SOM, recently its importance for the environment has been appreciated with a view to accumulation of carbon and a possibility of its sequestration into the soil (e.g. Středa, Vlček, Rožnovský, 2008) and also with a view to preservation of ecological functions of soil. A claim to keep an adequate level of SOM is being gradually implemented to legislation of particular European countries (Germany) and of European Union as a whole. The claims for"preservation of a level of soil organic components using appropriate practises", as a part of appropriate agricultural procedures can be found for example in Council Regulation EC 1782/2003 and in Commission Regulation 2199/2003 for newly acceding states.

In this piece of work we have tried to evaluate a current soil organic matter content in chernozem for the area of Central Europe and specify its particular level for the area of the Czech Republic.

MATERIALS AND METHODS

The statistical analysis cover all chernozem (N = 141) regardless the subtype. The measurements were taken in selected sites in the Czech Republic and their results were gathered from 2003 to 2006.

The profiles in each site were divided in topsoil and subsoil and these are statistically processed separately. There exist various approaches in defining the term of subsoil. As the most adequate we consider the definition which emphasizes its importance in plant nutrition and according to which it is a layer of soil as thick as topsoil, i.e. 0.31–0.60 m. This layer may be or is important in terms of providing nutrient intake by a plant (Bedrna *et. al.*, 1989; Bujnovský, 1993).

At the soil sampling the probes were selected and excavated according to pedological maps 1:5 000 from Soil Survey (1961–1970). The probes in terrain were focused by GPS-Garmin eTrex with an error of approximately 10 m.

As far as the samples standardly processed concerns Cox content analysis were made by indicator titration according to Walkley-Black's method with Novák and Pelíšek's modification and were followed by a conversion into SOM content (coefficient 1.724).

To evaluate the SOM content descriptive statistics is used (mean, standard error of the mean, median, mode, standard deviation, variance, kurtosis, skewness, max. and min. for confidence level 95 %). Then the values were associated to classes and the frequency histogram was created. It was converted into Excel scatter chart with smooth lines joining (Orwis, W. J., 1996).

To compare the average contents in topsoil and subsoil t-test (anova-test) was used. Regarding Chernozem soil character it is possible in anthropogenicly little affected soil to assume similar characteristics in both layers in most cases in Mollic horizons (i.e. histogram of frequency would be similar in topsoil and subsoil and it would be approaching Gaussian normal distribution).

Skewness/kurtosis evaluation:

Kurtosis

- positive: distribution of observed values is more acute than Gaussian normal distribution (hereinafter GND),
- negative: distribution of observed values is flatter that GND,
- zero: distribution of observed values corresponds to GND.

Skewness

- positive: frequency distribution is skewed to the left (left-sided asymmetry),
- negative: frequency distribution is skewed to the right (right-sided asymmetry),
- zero: frequency distribution is about the average.

The assessment of frequency distribution normality is based on the following assumptions:

- concerning anthropicly little affected soil the values distribution would roughly equal GND,
- both frequency distributions (topsoil and subsoil) should be shape resembling. We stem from the premise that mollic horizon is at this soil type on non-eroded land quite thick and homogeneous.

RESULTS AND DISCUSSION

SOM content in chernozem soil (%)

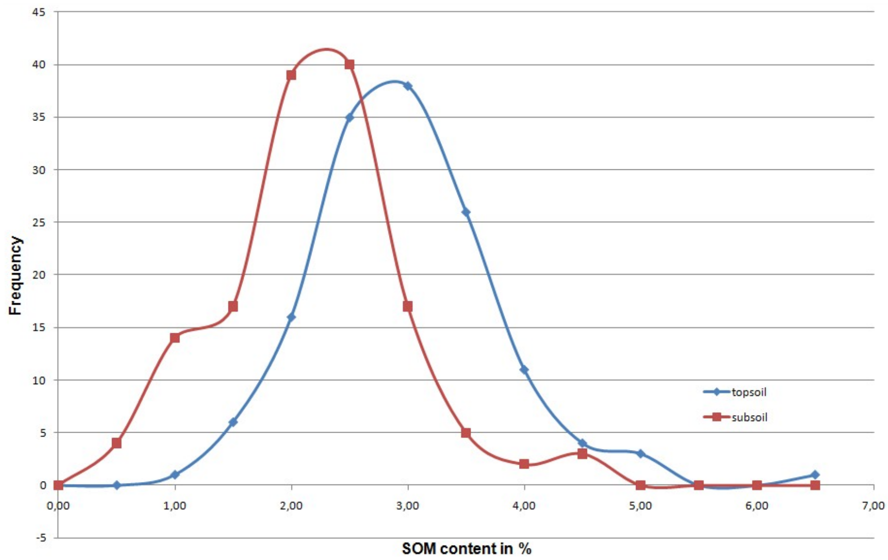
Topsoil (horizon 0.00–0.30 m)

The average values of SOM content in topsoil are 2.73 ± 0.07%. Minimal content in topsoil is 0.80%, on the contrary the highest value is 5.35%. It means that the range of the observed sample is quite wide. The average value nearly coincides with the values from the later measurement by Crop Research Institute (Kubát *et al.* 2008), which for this type of soil states the average SOM content 2.67% and median 2.62% (for top layer 0–20 cm and N = 51). See Frequency distribution of SOM content in % for Chernozem in Central Europe on Picture 1 and Descriptive statistics for SOM content in Table I.

Subsoil (horizon 0.31–0.60 m)

Comparing to topsoil the average values of SOM content in subsoil are lower, as it was expected: on average 1.94 ± 0.07% (which means approximately 0.8% lower than in topsoil). The lowest value is 0.26%, the highest 4.32%. Variation range is more narrow than in topsoil, where there was expected a higher variability caused by anthropic activities. See Picture 1. and Table I.

SOM content in chernozem in Central Europe is 2.73% on average, which is rated as a medium content. In some extremes even as very low or very high. In subsoil the average content is rated as low (on average 1.94 %). In some extremes even as very low or very high. Different content of SOM in



1: *Frequency distribution of SOM content in % for Chernozem in Central Europe*

I: *Descriptive statistics for SOM content*

	topsoil (0.00–0.30 m)	subsoil (0.31–0.60 m)
mean	2.73	1.94
error of the mean	0.07	0.07
median	2.65	1.92
mode	2.02	1.68
standard deviation	0.80	0.78
variance	0.64	0.61
kurtosis	2.11	0.59
skewness	0.80	0.34
minimum	0.80	0.26
maximum	5.35	4.32
number	141	141
confidence level (95 %)	0.133	0.130

topsoil and subsoil is statistically highly significant (F = 70.47).

Supply of SOM in topsoil was after conversion to horizon on average 118.8 ton/ha, in subsoil 84.4 ton/ha. There may be several reasons for the difference between topsoil and subsoil. The most probable could be perennial forage grown in the past and especially application of relatively large doses of mineral fertilizers between the 1970s and the 1990s. Such substances were applied on the surface and plowed afterwards, which means that the growth of SOM content is much more obvious mainly in the topsoil. It is possible to assume that relatively stable supply of SOM was made in the subsoil.

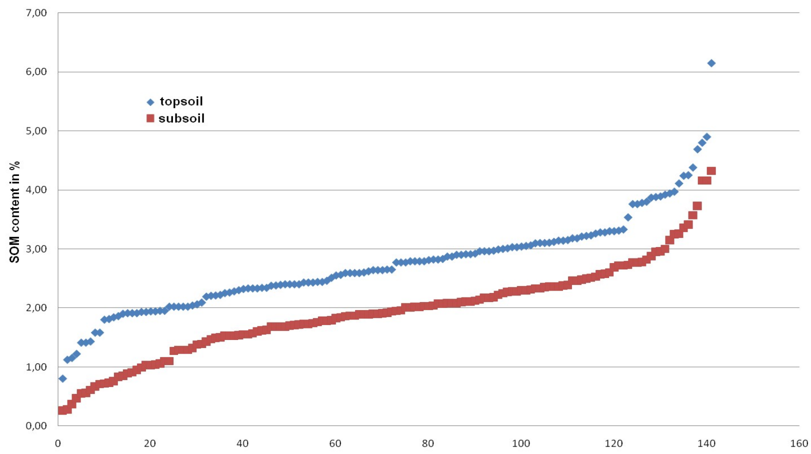
Nowadays there is a significant reduction in livestock production and in mineral fertilizing, which means a lack of organic fertilizers and reduction in acreage of perennial forage. Moreover, mineral fertilizers are less applied. In contrast with the past a higher amount of straw is plowed, which may cause a particular disproportion in C:N ratio.

As expected, there have appeared more significant changes in topsoil than in subsoil. Distribution of observed values in topsoil and in subsoil is more acute than GND, the change in topsoil is approximately three times higher (kurtosis 2.11 in topsoil in comparison to 0.59 in subsoil). Skewness was positive in both observed files, i.e. a frequency distribution was skewed to the left (left-sided asymmetry).

Average SOM content is higher in heavy soils (clayey, clayey-loamy) than in light soils (Sandy soil). The differences between soil types Sandy-Loam and Clayey-Loamy are statistically significant. Variation range of the values in all the sites coincides. SOM content in topsoil and subsoil according to a particles smaller than 0.01 mm (Soil type) is in Graph 2. Values of SOM content in topsoil for Chernozem according to a soil type is in Table II.

Future development of SOM content for the chernozem area of Central Europe can be only estimated:

- Expected increase in CO_2 concentration in the atmosphere together with current temperature increase will probably lead to accumulation of soil organic matter due to a higher productivity of C_3 by plants (i.e. most of the crops currently grown in Central Europe). However, this positive effect will probably be compensated by the fact that at higher temperatures the photorespiration losses at C_3 plants are due to stress higher than e.g. at C_4 plants (e.g. corn). According to Brinkman and Sombroek (1993) there will probably be higher photosynthesis. Moreover, the growth index and the efficiency of water use by vegetation will increase.



2: *SOM content in topsoil and subsoil according to a soil type*

II: *Values of SOM content in topsoil and subsoil for Chernozem according to a soil texture (n = 141)*

Soil type (abbrev.)*	Number of sites	Average SOM content (%)	median (% SOM)	minimum in category (% SOM)	maximum in category (% SOM)
S	1	2.33	2.33	2.33	2.33
LS	4	2.62	2.37	1.95	3.76
SL	8	2.37	2.39	1.58	3.14
L	75	2.67	2.62	0.80	6.15
CL	47	2.83	2.79	1.22	4.80
CY	6	3.38	3.13	2.25	4.90
C	-	-	-	-	-

* S – sandy , LS – loamy-sand , SL – sandy-loam, L – loam, CL – clayey-loam, CY – clayey, C – clay

- Expected climate aridisation will probably cause drying of the soil profile, increase in soil aeration and oxidation of soil material. As a result, mineralization will increase. It will be partly compensated by the processes mentioned in the point above. It will depend on a level of water supply in a particular site.
- At first, soil structure will change in a top horizon most influenced by people (epipedons) and it will highly depend on an amount of carbon. If there is enough soil organic matter, the structure will be relatively resistant. Even nowadays, as the most problematic are considered current crop rotations with so called carbon consumers domination or with a higher proportion of plants which will later start act like carbon consumers. The result can be not only SOM loss but also negative subsequent procedures: soil structure degradation, decrease in buffering capability of soil, erosion increase etc.
- Agricultural use of land without irrigation will be in corn production area, i.e. chernozem area, in the period of summer (July–August) limited or even impossible due to a moisture deficit in this period of year. Profitability of irrigation will face the problem of both wet and dry periods within one year (Pražan, J. *et al*., 2007).
- It is also possible to predict higher risk of water erosion (mainly in South Moravia) and wind erosion (in Elbe Lowlands) mainly during extremely dry periods in the areas, where this danger already exists nowadays.
- SOM content in topsoil will probably decrease until a new balanced state is set. From 12-year Lithuanian experiments arises that organic carbon content is very slowly decreasing as a result of insufficient fertilization (Tripolskaja, Greimas, 1998). According to Škarda and Damašek (1982) the decrease in SOM content in the soil without organic fertilizing is about 0.0123 % per year. At chernozem this situation could be partly compensated by new no-till technologies or green manure.

CONCLUSION

This piece of work should evaluate a current SOM content in chernozem in the area of Central Europe and its local specification for the area of the Czech Republic.

SOM content in chernozem (%):

- Topsoil (horizon 0.00–0.30 m): average SOM content 2.73 ± 0.07 % (118.8 ton/ha). Variation range is between 0.80 % and 6.15 %.

- Subsoil (horizon 0.31–0.60 m): average SOM content 1.94 ± 0.07% (84.4 ton/ha). The lowest value 0.26%, the highest value 4.32%.
- The difference in SOM content between topsoil and subsoil is statistically highly significant (F = 70.47).
- Average SOM content is higher in heavy soils (clayey soil, clayey-loamy soil) than in light soils. The differences between soil types SL and CL are statistically highly significant. However, variation range of the values in all the sites mostly coincides.

SUMMARY

In this thesis we have tried to evaluate a current Soil organic matter content in the Chernozem Soil for the area of Central Europe and specify its particular level for the area of the Czech Republic or other countries in Middle Europe (Slovakia, Austria, Poland, Hungary). The statistical analysis covers all Chernozem (N = 141) regardless the subtype/variety by the Czech Taxonomic Classification System of Soil. The Samples for measurement were taken from 2003 to 2006. The profiles in each site were divided in topsoil (horizon 0.00–0.30 m) and subsoil (0.31–0.60 m) and these were separately statistically processed. To evaluate the SOM content descriptive statistics was used (mean, standard error of the mean, median, mode, standard deviation, variance, kurtosis, skewness, maximum and minimum for confidence level 95 %). Then the values were divided into to classes and the frequency histogram was created.

The average values of Soil organic matter content in topsoil are 2.73 ± 0.07% with Variation range from 0.80%, to 5.35%. Comparing to topsoil the average values of SOM content in subsoil are lower, on average 1.94 ± 0.07% and with the lowest Variation range from 0.26% to 4.32%. Different content of Soil organic matter in topsoil and subsoil is statistically highly significant (F = 70.47).

Supply of SOM in topsoil was after conversion to horizon on average 118.8 ton/ha, in subsoil 84.4 ton/ha. Average SOM content is higher in heavy soils (clayey, clayey-loamy) than in sandy (light) soils. The differences between soil types Sandy-loam and Clayey-loamy are statistically significant but Variation range of the values coincides in all sites.

Other part of the text contains outlined Future development of SOM content for the area of Central Europe.

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