Soil aggregate stability and soil organic matter on Chernozems of South Moravia

BEATA HRABOVSKA, ANNA HAMMEROVA, JIRI JANDAK, JANA SIMECKOVA, VITEZSLAV VLCEK
Department of Agrochemistry, Soil Science, Microbiology and Plant Nutrition
Mendel University in Brno
Zemedelska 1, 613 00 Brno
CZECH REPUBLIC

beatahrabovska@gmail.com

Abstract: Soil organic matter positively affects the development of structural elements and therefore it is important to supply organic matter to the soil. In terms of soil protection before water erosion are important structural aggregates. Soil structure is defined as the arrangement of particles and associated pores in soils across the size.

The aim of this paper is to highlight the impact of water erosion on soil structure and soil organic matter Chernozem on loess in southern Moravia, and process the correlation between soil organic matter and macroaggregates.

Soil organic matter was determined by determining the total carbon content on the wet road method Walkley - Black. The structure was determined by a modified method according to Novák.

The stability of soil structure in the arable layer was highest at site Domanín u Bzence in the top position, which reaches 89%. The lowest coefficient stability is of site Svatobořice-Mistřín, where it reaches only 15% in the middle of the slope.

There is a positive correlation between the organic matter content of the soil and aggregation. Positive Spearman correlation relationship macroaggregates and humus content, we managed to prove only one case at the site Domanín u Bzence.

Key-words: macroaggregates, soil, Chernozem, water erosion, soil structure, soil organic matter

Introduction

Interest in the land in recent decades increased significantly, not only because of food security, but also in connection with environmental problems, and protection of human health. [1] Therefore, the function of man, in the relation to the land ceases, is not more only as the user, but increasingly, it is role as guardian, trustee, and directing the development of soils.

The soil structure is an important feature of the soil. Soil structure is defined as the mutual arrangement of the primary mineral and organic soil particles into larger formations (aggregates) of various shapes and sizes [2]. The stability of the structure of the soil must be added to this definition because the structure is not static, and changes with water content, and other agencies of stress, which may be used to the system [3]. The structure is conditional ability to associate solid phase particles or disaggregated larger units the soil matter and thus creating structural aggregates. [4] The formation of soil structure involves the physical forces of shrinking and swelling created by changes in water status of soils, freezing and thawing, tillage, or by movement of the larger biota in soils. Thus changes of structural organization are maximal in clays. The basic unit of the soil structure is soil aggregate (PED) [5, 3]. Primary peds are relatively stable aggregates that are separated from each other pores or places weakened in links of mutual. They are the simplest form of the existence of soil materials. Next, it is naturally not divided into smaller units of soil. On the contrary, they can be further grouped into larger units - aggregates higher order [5]. Most preferably the aggregates for favorable porosity are aggregates from 1 up to 10 mm [6, 7]. To soil quality are best round, crumb formation, and polyhedral structural aggregates [8]. Water-stable aggregates should be porous. The pores between the aggregates should be large enough to allow rapid infiltration [7]. In soil protection against water erosion has important role soil infiltration properties. Rain drops fallen on the soil surface can infiltrate or runoff. Decreasing of soil infiltrability in the combination of the high intensity precipitations leads to the increasing of the surface, and run off negative phenomena as water erosion [9]. Quality of soil structure is considered beneficial earthworms [10]. Earthworms may ingest substantial quantities of soil materials which are then cast on the surface or in earthworm burrows. When earthworms are plentiful, their burrows are large enough to dominate the macroporosity in the soils [3].

Several ways to aggregate soil particles using plants and plant residues. Plant roots (particularly root hairs) and fungal hyphae grow through the crumb, wrap them, secrete polysaccharides and other organic compounds and also create a mucilaginous mass which stick together individual particles and microaggregates into larger units - macroaggregates. Annual plants have a lesser ability to penetrate into strong soil, even thought plants with tap roots have capabilities to penetrate strong layers to depth. The old root channels then become a thoroughfare for new roots [3]. It is necessary to retain crop residues in the soil. On the one hand are a valuable source of nutrients and organic matter, but also protect the soil from the effects of water erosion. In most soils organic matter is the major factor in the formation and stabilization of crumbs and globular structural aggregates. Organic matter provides energy and substrate, which used to drive bacteria, fungi and soil animals [11]. Making of structural aggregates means the protection before humus mineralization. The structural aggregates are formed by the action of the most common mineral humus substances to share with the formation of the organic-compounds of different types - primary (microaggregates) and multiple-aggregates (macroaggregates) [12]. During the aggregation process occurs for coating mineral particles of soil (clay and dust) and pieces of organic matter decomposition of plant residues [11].

Materials and Methods

In the spring of 2013, in the framework of the field survey were identified above four sloping land with arable land - modal calcareous Chernozems on loess [13] on which the erosion either directly visible or has a high probability of its occurrence.

Sampling was conducted at the end of the summer in 2013 on the slopes near the village Domanín u Bzence, Svatobořice-Mistřín, Klobouky u Brna and Stavěšice. On every slope were selected three sampling site. The first place was at the top of the slope (instead of likely preserve the original profile), the second place was in the middle of the slope (instead of the expected erosion of materials) and the third place was at the bottom of the slope (instead of the likely accumulation materials away).

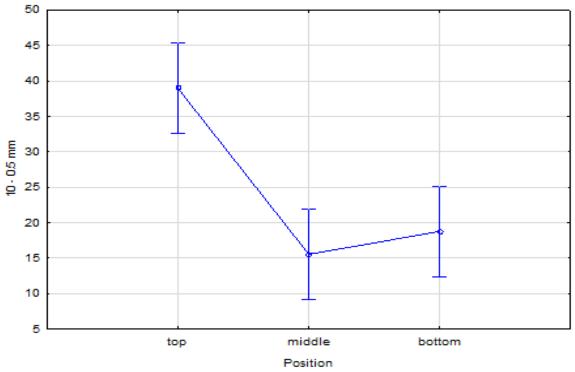
The soil organic matter was determined by the total carbon content in the wet road method Walkley – Black [14]. The soil texture was determined by the modified method of Novak [15]. Subsequently, the stability coefficient determined according Fulajtár [2].

Results and Discussion

Position in the top soil is high humus content 2.93% in the village Stavěšice and the lowest 1.90% in the village Domanín u Bzence. The average value for the selected four plots reaches 2.49%. In the middle of the slope is high humus content of 1.58% in the village Klobouky u Brna and the lowest 1.42% in the village Domanín u Bzence. The average value reaches 1.49%. At the bottom of the slope is high humus content of 2.54% in the village Svatobořice-Mistřín and the lowest 1.63% in the village Stavěšice. The average value reaches 1.91 %.

For the statistical evaluation of the content of humus was used single-factor analysis of variance (ANOVA). The statistical evaluation using Tukey's test found a statistically significant difference between the humus content in the topsoil between all of the slope at the site Domanín u Bzence.

Fig. 1 Statistical evaluation of soil aggregates has sized from 10 to 0.5 mm of arable layer in Domanín u Bzence



According to the statistical evaluation of the site Domanín u Bzence, the macroaggregates size is between 10 to 0.5 mm in the topsoil statistically demonstrable difference between the top and middle part, and the top and bottom of the slope.

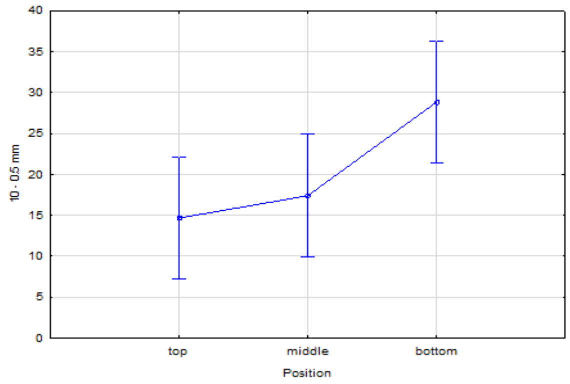
Table 1 Results of ANOVA humus content of the arable layer Domanín u Bzence

	Tukey´s HSD test; variable Humus			
Number	Position	{1} 1,8955	{2} 1,4223	{3} 1,7016
1	top		0,000227	0,000228
2	middle	0,000227		0,000227
3	bottom	0,000228	0,000227	

Table 2 Results of ANOVA soil aggregates of size 10 to 0.5 mm of arable layer Domanín u Bzence

	Tukey´s HSD test; variable 10 - 0,5 mm			
Number	Positon	{1} 38,969	{2} 15,531	{3} 18,751
1	top		0,001908	0,003867
2	middle	0,001908		0,675284
3	bottom	0,003867	0,675284	

Fig. 2 Statistical evaluation of soil aggregates has sized from 10 to 0.5 mm of arable layer in Klobouky u Brna



Location Klobouky u Brna is characterized by a high degree of erosion already in the top position.

Table 3 Results of ANOVA soil aggregates of size 10 to 0.5 mm of arable layer Klobouky u Brna

	Tukey´s HSD test; variable 10 - 0.5 mm			
Number	Position	{1} 14,672	{2} 17,402	{3} 28,846
1	top		0,809339	0,038894
2	middle	0,809339		0,084906
3	bottom	0,038894	0,084906	

Table 4 Results of ANOVA for the content of humus arable layer Klobouky u Brna

	Tukey´s HSD test; variable Humus			
Number	Position	{1} 2,4670	{2} 1,5813	{3} 1,7585
1	top		0,000227	0,000227
2	middle	0,000227		0,000228
3	bottom	0,000227	0,000228	

According to the statistical evaluation of the location Klobouky u Brna macroaggregates size is between 10 to 0.5 mm u topsoil statistically demonstrable difference between the top and bottom of the slope.

The statistical evaluation was found statistically significant difference between the humus content in the topsoil sites Klobouky u Brna between all parts of the slope.

Fig. 3 Statistical evaluation of soil aggregates has sized from 10 to 0.5 mm of arable layer in Stavěšice

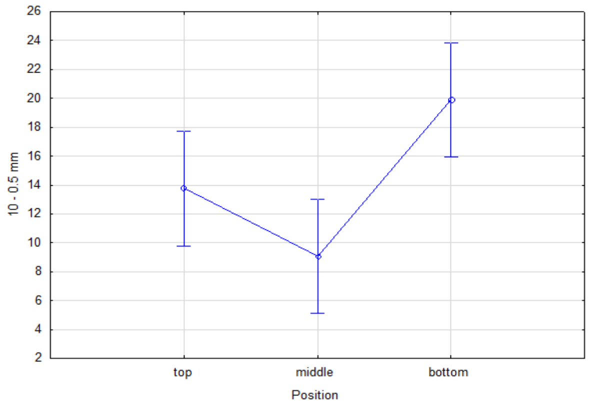


Table 5 Results of ANOVA soil aggregates of size 10 to 0.5 mm of arable layer Stavěšice

	Tukey´s HSD test; variable 10 - 0.5 mm			
Number	Position	{1} 13,754	{2} 9,0738	{3} 19,893
1	top		0,181033	0,080295
2	middle	0,181033		0,007749
3	bottom	0,080295	0,007749	

Table 6 Results of ANOVA for the content of humus arable layer Stavěšice

	Tukey´s HSD test; variable Humus			
Number	Position	{1} 2,9286	{2} 1,4326	{3} 1,6318
1	top		0,000227	0,000227
2	middle	0,000227		0,000454
3	bottom	0,000227	0,000454	

According to the statistical evaluation of the site Stavěšice macroaggregates is between size 10 to 0.5 mm of topsoil statistically demonstrable difference between the middle and the bottom of the slope.

The statistical evaluation was found statistically significant difference between the humus content in the topsoil site Stavěšice between all parts of the slope.

Fig. 4 Statistical evaluation of soil aggregates has sized from 10 to 0.5 mm of arable layer in Svatobořice–Mistřín

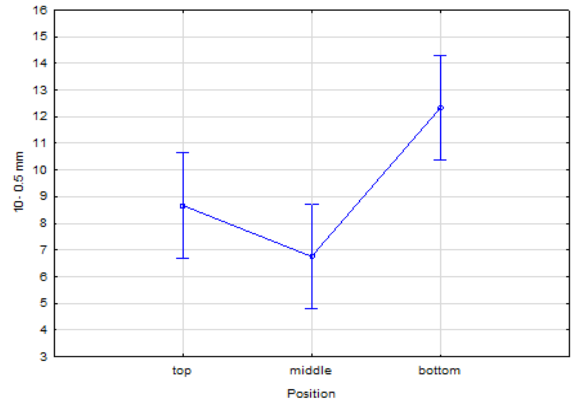
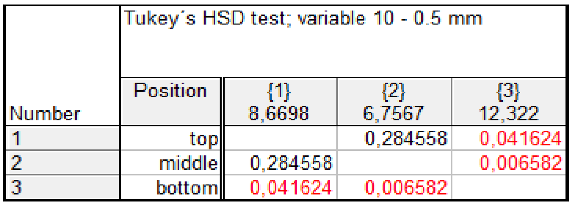
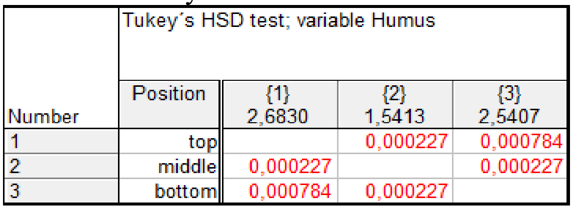


Table 7 Results of ANOVA soil aggregates of size 10 to 0.5 mm of arable layer Svatobořice–Mistřín



	Tukey´s HSD test; variable 10 - 0.5 mm			
Number	Position	{1} 8,6698	{2} 6,7567	{3} 12,322
1	top		0,284558	0,041624
2	middle	0,284558		0,006582
3	bottom	0,041624	0,006582	

Table 8 Results of ANOVA for the content of humus arable layer Svatobořice-Mistřín



	Tukey´s HSD test; variable Humus			
Number	Position	{1} 2,6830	{2} 1,5413	{3} 2,5407
1	top		0,000227	0,000784
2	middle	0,000227		0,000227
3	bottom	0,000784	0,000227	

According to the statistical evaluation of the site Svatobořice-Mistřín is between macroaggregates size from 10 to 0.5 mm of arable layer statistically demonstrable difference between the top and bottom of the slope, and between the middle and the bottom of the slope.

The statistical evaluation was found statistically significant difference between the humus content in the arable layer site Svatobořice-Mistřín between all parts of the slope.

The findings from the statistical compilation are confirmed by the determination of water resistance structure as Fulajtár [2], which provides Kv (coefficient of stability) by:

$$K_v = A/B$$

where:

- K_v is the coefficient of stability,
- A is the weight of water-resistant aggregates of sizes 10 - 0.25 mm,
- B is the mass of aggregates smaller than 0.25 mm.

The rule is that the larger the value of K_v, the lower its stable structure.

Table 9 Evaluation of the structural properties of the soil [2]

The content of aggregates of 10 mm - 0.25 mm in % (K_v)	Status structural and water-stable aggregates
≥ 70	excellent
70 – 55	good
55 – 40	satisfactory
40 – 20	unsatisfactory
≤ 20	inconvenient

Table 10 Results of the observation plots K_v

	Domanín u Bzence		Klobouky u Brna	
	K_v	v %	K_v	v %
AL A	0.89	89	0.28	28
AL B	0.39	39	0.35	35
AL C	0.33	33	0.64	64
	Stavěšice		Svatobořice-Mistřín	
	K_v	v %	K_v	v %
AL A	0.30	30	0.19	19
AL B	0.19	19	0.15	15
AL C	0.41	41	0.23	23

(Legend: K_v - coefficient stability, AL – arable layer, A top slope, B middle slope, C bottom slope)

Stability coefficient is significantly higher for sites Domanin u Bzence in the top position, which reaches 89%. By Fulajtár [2] is a very good condition. The lowest coefficient of stability is on site Svatobořice-Mistřín, where it reaches only 15% in the middle of the slope. By Fulajtár [2] the value is inconvenient.

Basic step was to determine the normality of data. For this test, we selected the Shapiro - Wilk

W test, used for the scanning of less than 50 variables ($n < 50$). Such tests showed that the most of the observed variables are without a normal distribution ($p < 0.05$). Based on this result, we chose to nonparametric statistics Spearman correlation coefficient R.

Table 11 Correlation humus content with the size of aggregates from 10 to 0.5 mm in the arable layer of site Domanín u Bzence

	Spearman correlation	
Variable	Humus	10 - 0.5 mm
Humus	1,000000	0,813676
10 - 0.5 mm	0,813676	1,000000

Table 12 Correlation humus content with the size of aggregates from 10 to 0.5 mm in the arable layer of site Klobouky u Brna

	Spearman correlation	
Variable	Humus	10 - 0.5 mm
Humus	1,000000	-0,133333
10 - 0.5 mm	-0,133333	1,000000

Tisdall and Oades [7] wrote that there is a positive correlation between the organic matter content of the soil and aggregation. Their opinion we managed to check in only one case near the village Domanín u Bzence.

Table 13 Correlation humus content with the size of aggregates from 10 to 0.5 mm in the arable layer of site Stavěšice

	Spearman correlation	
Variable	Humus	10 - 0.5 mm
Humus	1,000000	0,483333
10 - 0.5 mm	0,483333	1,000000

Table 14 Correlation humus content with the size of aggregates from 10 to 0.5 mm in the arable layer of site Svatobořice–Mistřín

	Spearman correlation	
Variable	Humus	10 - 0.5 mm
Humus	1,000000	0,483333
10 - 0.5 mm	0,483333	1,000000

Conclusion

From the attached results is possible to assess the condition of soil structure Chernozem on loess hillsides in selected localities of South Moravia is not very favorable. The statistical evaluation uses Tukey's test found a statistically significant difference between the humus content in the arable layer top, middle and bottom of the slope of the observation plots. There is a spatial variation of humus content - reduce the erosion of the slope.

The stability of soil structure in the arable layer was highest at site Domanín u Bzence in the top position, which reaches 89%. The lowest coefficient stability is of site Svatobořice-Mistřín, where it reaches only 15% in the middle of the slope. But otherwise the stability rates ranged below 40 %, which is by Fulajtár [2] unsatisfactory condition of. Arable layer is the study sites can be characterized as unstable simultaneously with high susceptibility to soil erosion.

Positive correlation relationship macroaggregates and humus content, we managed to prove only one case of site Domanín u Bzence.

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