The detailed characterization of land threatened by water erosion with soil type chernozem on loess at Dambořice

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Abstract: In the Czech Republic chernozems are among the most fertile soils and are intensively farmed. It turns out that when using intensification measures, enlarging fields, using substandard farming practices and cultivating wide-row crops, water erosion becomes a major problem. The result is degradation of physical properties, compaction and depletion of the most fertile part of the soil - topsoil.
For wider pedological characteristics a plot with chernozem on loess affected by water erosion has been selected. Three probes were dug and described at three places of the slope and physical characteristics of topsoil and subsoil were conducted along with grain size analysis with the determination of carbonates in the topsoil, subsoil and in the loess cover to the depth of one meter.
Physical analysis showed that the eroded slope suffers a serious problem of soil compaction. Porosity in the topsoil and subsoil is around the critical value of 45% or below. Minimum air capacity indicates critical condition of most horizons. On average, the topsoil and subsoil classifies as loamy soil type. The grain size is dusty loam. Loess exhibits relatively high homogenity which does not dramatically change with depth, not even on the plots with the risk of land erosion. The highest carbonate content in the topsoil and subsoil is on the hillside, where occures mixing of the loess to the topsoil horizon. In the loess, the contents of CaCO3 are highly variable. Mean values range from 13.2 to 17.9% of the carbonates with a standard deviation of 2.99.

Key-Words: chernozem, loess, water erosion

Introduction

For a long time farmers are troubled by water erosion and soil degradation, which often occurs on the most fertile soils due to intensification of agriculture, the use of substandard farming practices and cultivation of wide-crops in places where there is a high risk of erosion.

The method of farming is one of the factors that create the conditions for further development of soil processes. According to [1] it has been shown that the intensification measures were not sufficiently sophisticated and compensated, so their side effects on soil created new problems related to the degradation of formerly fertile soils. This leads to degradation of soil properties, compaction, accelerated erosion, etc.

The occurrence of water erosion in the landscape is a destabilizing element that damages the soil and water, which are the two most valuable components of the natural environment. According to [2] there is about 50% of arable land in the Czech Republic which is threatened by water erosion. On the vast majority of the endangered area no measures that would prevent loss of the soil are implemented.

From the perspective of pedology, the soils on loess belong to the most fertile in the Czech Republic. Chernozems were formed under steppe and forest steppe vegetation on mostly forest-free areas. Soils that formed in loess cover, were quickly adopted by man who, by his activities, prevented the forest to expand to the areas that were used by him.

Loesses as a eolian sediments have characteristic grain composition. Grain composition is one of the properties by which we can sort loess covers and describe them. As the rocks they are composed of three main parts: the clay particles, dust particles and calcium carbonate [3].

Another characteristic, that is considered to be one of the basic distinctive ones for loess, is content of CaCO3, that is, according to [3] supposed to be 10% or more. Along with typical structural characteristics of true loesses (porosity, non-stratification, vertical cleavage)

Carbonate compounds occure in the loess in various forms. Fine dispersed carbonates usually bind mineral grains. The most common are secondary precipitated carbonates, which occur in the form of e.g. pseudomycelium, coatings on seperable surfaces or in the form of concretions [4].

Material and Methods

For a detailed pedological characteristics we have selected a plot close to Dambořice with soil type of chernozem on loess.

Three soil probes were dug, described and sampled - on the top of the hill (A), its slope (B) and foot (C). To determine the physical properties, undamaged soil samples were taken using Kopecky cillinders from the of topsoil (currently usually from depth of 0-0.2 m) and subsoil.

For grain size distribution and the determination of content of carbonates, damaged samples were taken from topsoil, subsoil and from loess, where the samples were taken using a hollow drill with Edelman head from the depth of 0-0.1 m, 0.1-0.2 m and 0.2 m to 1 m of loess layers.

Sampling was performed according to [5]. Samples were collected according to the methodology for determining the physical properties and characteristics of water and air soil regimes. According to the methodology by [6] density, minimum air volume weight capacity and porosity were established.

To determine the grain size the sedimentation, pipetting techniques were used [7].

Determination of $CaCO_3$ content was carried out according to the methodology [5], by the Janko's lime meter.

Results and Discussion

Description of soil profiles

In order to select the location, at least partly preserved original profile was important. The profile at the top of the hill thus had to meet the requirements of the chernozem soil type, ie. more than 30 cm Ac horizon. On the slopes of the hill there were some eroded areas, where occures mixing of topsoil with shallowly deposited loess material. These cases are classified as carbonate regosoil. At the foot of the hill there is colluvium which stores erosion silt from the higher elevations of the hill. Soil type of these positions is colluvial soil modal.

Top of the hill (A)

According to the structure we can specify a segment of the original topsoil horizon (0-0.3 m), which is currently only subject to disking to a depth of 0-0.2 m. In the disked horizon, the structure is crumbled and weakly developed. In the former topsoil horizon, now at a depth of 0.2-0.3 m, the structure is polyhedral. We can find a medium recovery and weak rooting. At a depth of 0.3-0.4 m is a horizon Ac, which differs from the above-lying by a strongly polyhedral structure and a weaker rooting. The transitional horizon is at a depth of 0.4-0.47 m with a polyhedral structure and from 0.47 m there is loess with ocher color. It is dry, hard, without a clear structure with the appearance of pseudomycelium.

Hillside (B)

In the middle of the slope it was already evident according to the color that the surfaces were and currently still are experiencing water erosion, where the original Ac horizon is taken away and its remnants are gradually mixed with loess. Also here the Ap horizon is divided into two layers, while up to 0.13 m the structure is moderately developed, crumbled and medium rooted and from 0.13 to 0.27 m the structure is then developed, polyhedral with weak rooting. Throughout the horizon, there are loess nodules. After a sharp transition caused by plowing there is the mother substrate in our case loess Ck. Abundant occurrence of loess nodules decreases with depth.

Foot (C)

In locations under the hillside alluvial material gets accumulated, that buries the original humus horizon. Ap horizon extends to a depth of 0.34 m. To 0.13 m, the structure is crumbled and lumpy, moderately or well developed. In 0.13-0.34 m the structure is lumpy to polyhedral, moderately developed. Infrequent occurrence of loess nodules. Biological activity and rooting – moderate to 13 cm and weak from 0.13 to 0.34 m. Below that is the horizon AZx - formed by accumulative deposition of materials of humic horizons of colluvial soils that extends to a depth of 0.73 m. The horizon has a weakly to moderately developed checked structure with weak rooting and biological activity. Transition to loess gradual in 0.73 m. In the depth of 0.73-0.93 m we can find original Ac horizon with crumbled structure and medium biological activity. The transition to the loess is slow.

In all three probes the soil content of carbonates was in the whole depth of the profile.

Fig. 1 Top of the hill (A)

Fig. 2 Hillside (B)

Fig. 3 Foot (C)

Physical properties

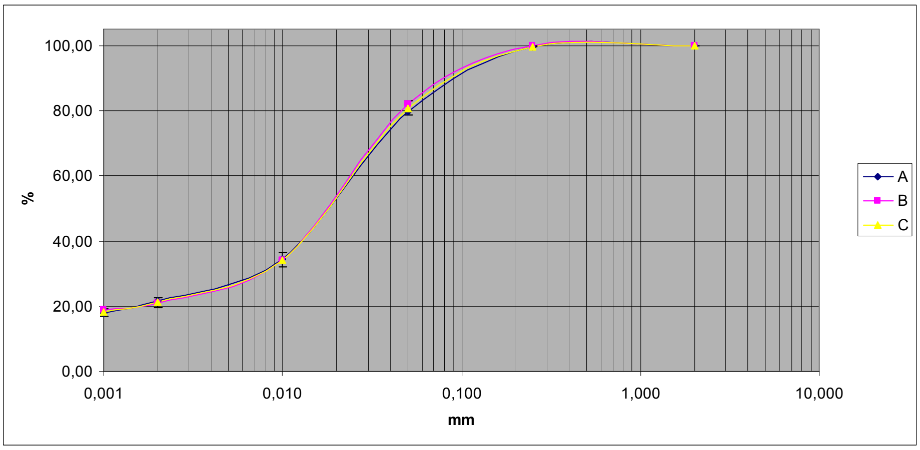
The critical value of porosity is 45%. The topsoil in position B and subsoil in all slope positions are below this value. Density indicates looseness or compactness of the soil. The measured values ranged from 1.23 to 1.6 g.cm-3 and correspond to the detected values of porosity.

According to [8] when the minimum air capacity is less than 10% the subsoil or topsoil is in critical condition. The minimum air capacity is below the critical value of 10% in the topsoil at the upper and lower position, on the slopes it reaches 17.82%. Subsoil is below the critical value at all positions.

Grain size analysis

Topsoil and subsoil on the plots contains 33-38% percent of the clay particles. According to Novak's grain size classification, it is therefore classified as moderately heavy, loamy soil.

Fig. 4 Grain curve of loess in the depth of 0-1 m of the slope in positions A, B and C



Variation range of the dust fraction content (from 0.05 to 0.01 mm) of all samples of loess ranges from 40.88 to 53.34% with the average value of 46.58 ± 0.76%. According to [3] central europian loesses contain 45-60% of dust particles.

When averaging the values of loess grain size of individual positions, the grain size curve has very similar shape in all three positions. Granulometric curves are of convex-concave shape corresponding to the loamy soil. The standard deviation is the lowest in grain size of 0.25-2 mm and it is 0.05-0.09. It is highest in the content of dust particles - its value ranges from 0.57 to 4.0 %.

Topsoil, subsoil and loess of all the plots belong, according to the triangular diagram, to the dusty loam grain size class.

Carbonates

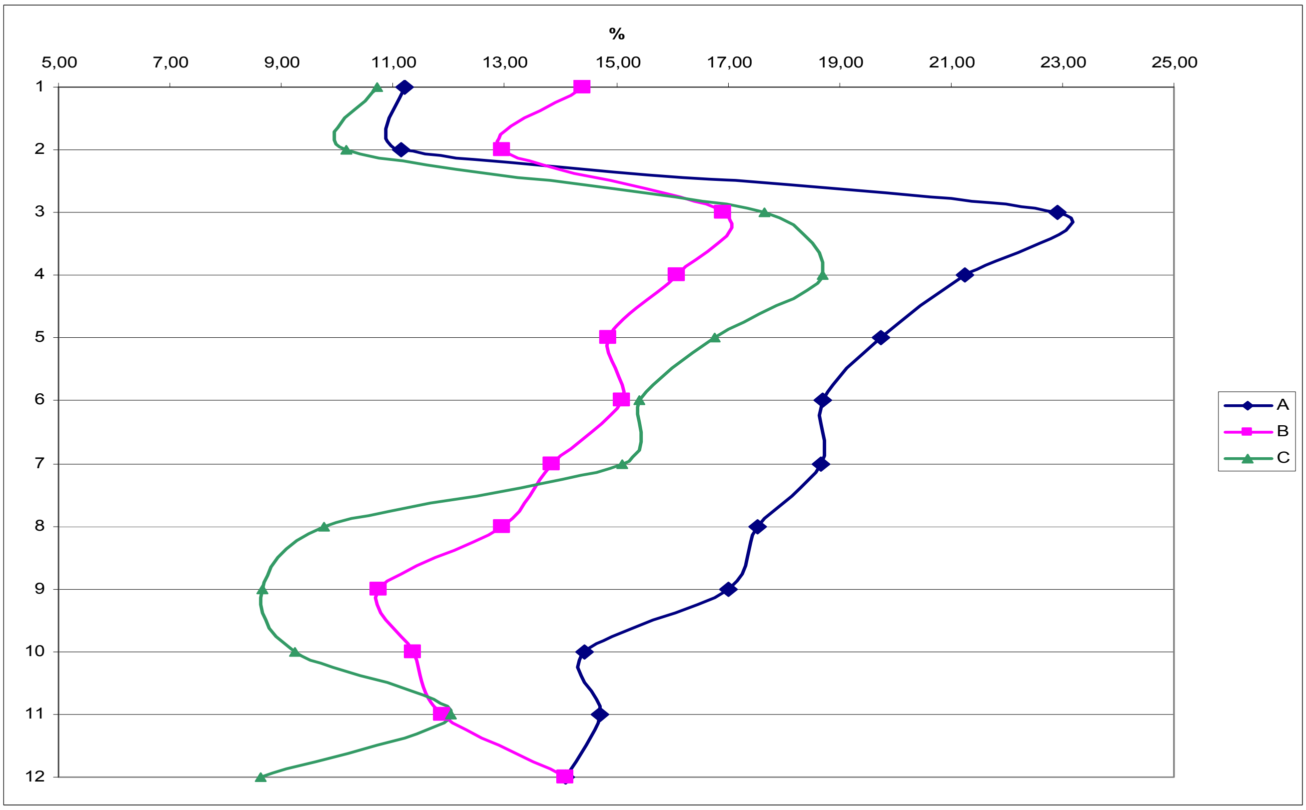
According to [4], certain amount of caution is necessary in the evaluation of carbonates, as their contents may be quite variable. The hallmark of values is considerable variance caused by the occurrence of specific forms of carbonates in loesses.

Carbonate content on top of the hill in the topsoil and subsoil are around 11% in the loess is the average content of 17.9 ± 0.94%, with a minimum of 14.08% and a maximum of 22.9%.

On the slopes of the topsoil it is 14.4% and 12.9% in the subsoil. Average value of loess is 13.79 ± 0.65%, with a minimum of 10.7% and a maximum of 16.9%.

At the foot of the slope the value of topsoil and subsoil is slightly over 10%. In the loess, the carbonate content is similar to the value on the slope with the average of 13.2 ± 1.26 with a minimum of 8.6% and a maximum of 18.7%.

Fig. 5 Carbonate content in the profiles of individual positions of the slope



Axis Y; 1 Topsoil, 2 Subsoil, 3 Loess 0-0.1 cm, 4 Loess 0.1-0.2 m, 5 Loess 0.2-0.3 m, 6 Loess 0.3-0.4 m, 7 Loess 0.4-0.5 m, 8 Loess 0.5-0.6 m, 9 Loess 0.6-0.7 m, 10 Loess 0.7-0.8 m, 11 Loess 0.8-0.9 m, 12 Loess 0.9-1 m

Conclusion

For pedological characterization we selected a plot with soil type chernozem on loess, which is threatened by water erosion and which is located in the cadastral Dambořice. The effect of water erosion was evident at the first sight, by the soil moving down the slope to its foot. At the slope of the hill the soil gets mixed with loess and is gradually fertilized. Physical analysis showed that the eroded slope suffers a serious problem of soil compaction. Porosity in the topsoil and subsoil is around the critical value or below, and in the subsoil it is below the critical value. Minimum air capacity indicates the critical condition of most horizons.

On average, the topsoil, subsoil and loess of all the positions classifies as loamy soil type. Regarding the grain size it is dusty loam. As for the loess, the particle analysis showed that it exhibits relatively high homogeneity and it does not dramatically change with depth, not even on the plots with the risk of land erosion. The content of each fraction varies always in the span of a few percent.

The highest carbonate content in the topsoil and subsoil is on a hillside, where there occures mixing of the loess to the topsoil horizon. In the loess, the contents of CaCO3 are highly variable. Mean values range from 13.2 to 17.9% of the carbonates with a standard deviation of 2.99.

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