PHYSICAL PARAMETERS OF CHERNOZEM LANDS AFFECTED BY WATER EROSION

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ABSTRACT

There has been a lot of attention given to chernozems on loesses. These soils are among the most fertile soils in Czech Republic, which are intensively farmed. Farmers have been troubled for some time by the water erosion and soil degradation, which often affects these soils due to agricultural intensification, use of unsuitable farming practices and cultivation of wide-row crops even in areas where the risk of erosion is high.

One can often encounter soil compaction and water erosion on chernozems, which even reveal loess in some places. Most agrotechnical methods for soil characteristics improvement aim at topsoil, i.e. to the depth of 30 cm. Some authors found out, though, that the compaction after traverson of heavy machines can occure as deep as 77 cm below the surface. So the problem is not only the loss of material itself, but also the change of soil characteristics, which further contributes to the increase in erosive processes and reduce the soil fertility.

Three soil horizons were described on five different plots - at the top of the slope, in its centre, and at the foot of the slope and the physical properties of the soil were examined.

Large amount of avulsion and accumulation of the soil material under the slope were noticed on the selected plots. The soil compaction in the topsoil usually is at the edge of agroecological limits, while in subsoil, these limits are exeeded and the soil compilation reaches extreme values.

Key words: soil degradation, chernozems, loess cover, erosion.

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INTRODUCTION

Accelerated erosion of agricultural lands is a serious threat to productive and non-productive soil functions and causes damage in millions. Erosion is a natural phenomenon which is characterized by steady forms of relief. In contrast, during the ongoing erosion at present time, there is a continual erosion of the soil surface (Švehlík, 2005). With the intensification of agriculture, we can observe a significant increase in soil erosion processes.

Water erosion is caused by the destructive activity of raindrops, it manifests on the soil surface by selection of soil particles and the formation of drainage pathways of different sizes. The soil particles usually get stored in depressions and in places of lesser steepness. The intensity of water erosion is determined by the character of precipitation and surface drainage, soil conditions, the region morphology (grade, length and shape of the slope), vegetation conditions and methods of cultivation of the land. Erosion deprives the land of the most fertile component - topsoil, deteriorating physical and chemical properties of soils, reduces the thickness of the soil profile, increases grittiness, reduces the amount of nutrients and humus, damaging crops and cultures and causes loss of seeds and fertilizers. Transported particles and substances that are bound on them also cause problems in water resources, pollute and clog streams and the storage tanks (Janeček, 2012).

The occurance of water erosion in the landscape is a destabilizing element that damages the soil and water, i.e. the two most valuable components of the natural environment. According to Janecek (2012), about 50% of the arable land in the Czech Republic is threatened by water erosion. The majority of the area of the endangered soil has implemented no soil protection which would reduce the loss of the soil.

Water erosion is often accompanied by soil compaction. The degree of compaction can be expressed by the increase of bulk density, decrease of porosity and pore shape change (Pagliai, et al., 2003). There is thus a general deterioration of the soil, especially the deterioration of water retention and hydraulic conductivity of the soil. There are many options for remedying the soil compaction. These measures, however, are in most cases focused only on the topsoil. The authors Berli, et al. (2003) found that, the compaction after traversion of heavy machinery occurs to a depth of 77 cm below the surface. This information is particularly alarming in the case of chernozems affected by water erosion, where the topsoil layer can be often washed off almost to the underlying loess. Compaction then causes degradation not only of the chernozem properties, but also of the underlying loess. And it is soils derived from loess that are among the most fertile soils in the Czech Republic. Their excellent agronomic characteristics are given by ideal chemical and physical properties of loess. This paper examines the impact of water erosion on selected physical properties of the soil with a focus on the loess cover.

MATERIAL AND METHODS

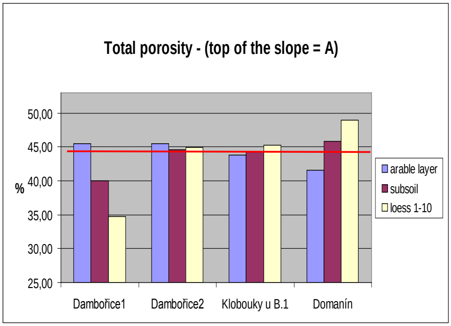
Four plots in South Moravia endangered by water erosion were selected. The plots are located in the cadastral of Dambořice, Klobouky u Brna and Domanín u Bzence. Probes and samples were always carried out at the top of the hill, on the slope and at its foot.

The sampling was performed according to Hraško (1962). Samples were collected according to this methodology in order to determine the physical properties and characteristics of water and air modes of the soil.

According to the methodology by Zbíral (1997) we determined density, soil bulk density, maximum capillary capacity, minimum air capacity and porosity.

RESULTS AND DISCUSSION

The soil type which was selected is chernozem on loess. *Fig. 1,Total porosity - top of the slope (A)*

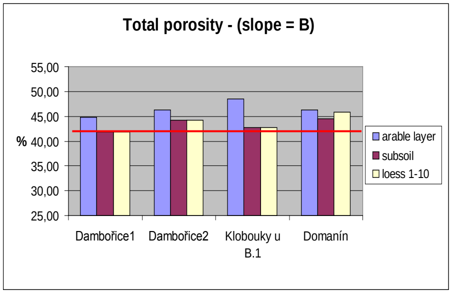


Plots are pitched and intensively farmed.

Porosity:

The values of total porosity at the top of the slope (Fig. 1) in the topsoil horizon are around 45% on two of the plots. This value is on the edge of porosity state, which is evaluated as good. On the remaining plots, the topsoil porosity is unsuitable. In the subsoil, the value of the porosity is close to the 45 % limit, except for the first plot, where the state porosity is unsatisfactory. In the loess horizon the situation is similar to the subsoil, on the first plot the porosity status fell below 39% - the status evaluated as non-structural.

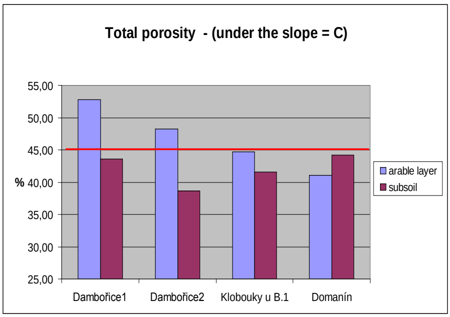
Fig. 2, Total porosity – slope (B)



In the centre of the slope (Fig. 2), the value of porosity is in the range of 44-48 %, i.e. close to the boundary of being good. Condition is unsatisfactory in the subsoil of the first, second and third plot where the subsoil is already in the loess .

In the position under the slope (Fig. 3) the state of total porosity is unsatisfactory, even non-structural, except for the first and second plot, where the state in the topsoil is good.

Fig. 3, Total porosity – under the slope (C)

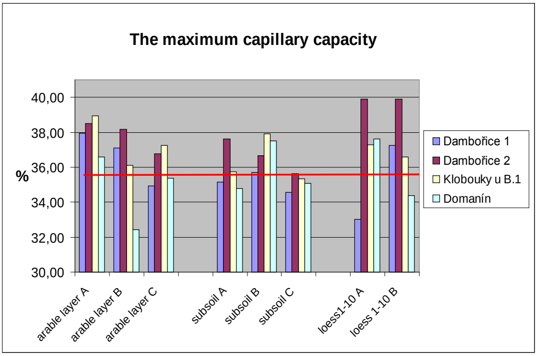


Density:

Density indicates mellowness or settleness of the soil. The measured values ranged from 1.38 to 1.6 $g.cm^{-3}$ and correspond to the porosity values described above.

The maximum capillary capacity (MCC):

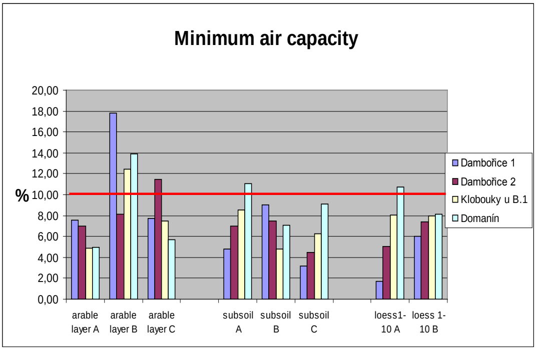
Another indicator of soil compaction is MCC (Fig. 4) .*Fig. 4, The maximum capillary capacity*



It has a critical threshold of 36%, values above this threshold indicate a failure in the soil structure (Pokorny, Střelková et al. 1996). The greatest frequency of exceedance of the critical value is in the topsoil and loess cover, where, on the second plot, the values were significantly high.

Minimum air capacity:

Fig. 5, Minimum air capacity



If the minimum air capacity is less than 10 %, the subsoil or the topsoil is in a critical condition (Pokorny, Šarapatka et al. 2007). The graph (Fig. 5) implies that all values of the topsoil on the top of the slope are below the critical value, there is an improvement in the centre area of the plot, and at the foot area, it deteriorates again on all but one plots. The subsoil is mostly below the critical value.

The compaction means a severe damage to the soil, in which its volume decreases, porosity is reduced and so is the space for water and air. According to Sommer (1990), the critical value of porosity for loamy soils is 45% , for bulk density it is 1.41 to 1.46 g.cm^{-3} and for minimum airiness it is 12% (Šarapatka, 2002).

CONCLUSIONS

Fig. 6

For the survey, plots with soil type chernozem on loess were selected, which were threatened by water erosion. On all the plots, impact of water erosion was evident, indicating very clearly a shift of soil particles into location below the slope. The topsoil on these plots is washed away in such an extent, that there is an occurence of the loess in the upper part of the slope (Fig. 6).

On these plots there is a wash-off of the topsoil in such an extent that in the upper part of the slope the loess gets mixed with the topsoil during the plowing and sometimes the loess cover is completely exposed and gradually reclaimed. With continued erosion in the accumulative part of the slope, the dark topsoil is further overlaid with less fertile soil from the upper position as shown in Figure 1.

Physical analysis showed that the eroded slopes become a serious problem of soil compaction. Porosity in the topsoil and subsoil is around the critical value or below. In accordance with the porosity of the soil compaction is also the bulk density. Minimum air capacity indicates the critical state of most horizons. More than a half of the results of the maximum capillary capacity refers to the failures of the soil structure. Chernozems on loess are among the most fertile soils in the Czech Republic, therefore these results point to ä serious disruption and loss of soil fertility.

REFERENCES

BERLI M., Kirby J.M., Springman S.M., Schulin R, 2003: *Modelling compaction of agricultural subsoils by tracked heavy construction machinery under various moisture conditions in Switzerland*. Soil and Tillage Research 73 (1-2), pages: 57-66, ISSN: 0167-1987

HRAŠKO, J., 1962: *Rozbory pôd*. 1. vyd. Bratislava

JANEČEK, M., 2012: *Ochrana zemědělské půdy před erozí: metodika*. 1. vyd. Praha: Powerprint, 113 s. ISBN 9788087415429.

PAGLIAI, M., et al., 2003: *Changes in some physical properties of a clay soil in Central Italy following the passage of rubber tracked and wheeled tractors of medium power*. Soil and Tillage Research 73 (1-2), pages: 119-129, ISSN: 0167-1987

POKORNÝ, E., et al, 1996: *Vliv dlouhodobě vedených osevních postupů na vlastnosti ornice černozemě.* Obilnářské listy, roč. 4, s. 7-11

POKORNÝ, E., ŠARAPATKA, B., 2003: *Půdoznalství pro ekozemědělce*. Praha: Ústav zemědělských a potravinářských informací, 40 s. ISBN 8070842954.

ŠARAPATKA, B., BEDRNA, Z., a DLAPA ,P., 2002: *Kvalita a degradace půdy*. 1. vyd. Olomouc: Univerzita Palackého, 246 s. ISBN 8024405849.

ŠVEHLÍK, R., 2005: *Vodní eroze na jihovýchodní Moravě v obrazech*. V Uherském Hradišti: Přírodovědný klub, 2005, 64 s. ISBN 8086485080.

ZBÍRAL, J., MALÝ S., a HONSA I., 1997, *Analýza půd: jednotné pracovní postupy*. Vyd. 1. Brno: Ústřední kontrolní a zkušební ústav zemědělský, 150 s.