SNOW AS A CAUSE OF SOIL EROSION – METHODOLOGICAL APPROACH OF DETERMINATION

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Spring thawing of snow can cause soil erosion. Its intensity is given mainly by water amount of snow, melting speed and soil infiltration capacity. In some regions of the Czech Republic, especially in slope areas with high amount of snow the early spring erosion can be significant factor of soil degradation. The paper introduces a relevant method to assess erosive potential of snow cover. The case study of its determination was carried out for long-term period on the base of available and comprehensive data of Czech Hydrometeorological Institute. Applied data were i) depth of snow cover, ii) water amount of snow, iii) depth of soil freezing.

Keywords: snow thawing, soil freezing, infitration

INTRODUCTION

Water accumulated in snow supply water demand in the beginning of growing season, supply the underground water resources and in general is important element of hydrocycle. Sudden thawing of deep snow cover can however cause destructive flood or at least intense soil erosion.

According to McCool (2002) many areas over globe are supposed to be endangered by snow melting erosion. From erosion viewpoint snow thawing is dangerous mainly in northern part of Europe – Norway, Sweden and Finland (Lundekvam and Skøien, 1998).

Studies of erosion from northern, central and eastern Europe imply that this sort of erosion (snow melting erosion) can even exceed the rain one (Demidov et al., 1995; Edwards et al., 1998; Lundekvam, 2002). In addition, snow thawing combined with potential intense spring rains and frozen or at least partially frozen soil and absence of dense vegetation highly increases the risk of rill or gully erosion.

In the agricultural land of the Czech Republic and other countries of central Europe the intense summer rains or intense spring and autumn winds are commonly viewed as main causes of erosion. Nevertheless, in some years with deep snow cover (spring 2005, 2006, 2016 etc.) the snow thawing can cause significant damages.

The issue of soil erosion caused by thawing snow fro the conditions of the Czech Republic was dealt by Středová and Toman (2012), Smolíková at al. (2009) and Pokladníková et al. (2008).

The paper comes with the methodological description of snow thawing intensity assessment, brings specification of available data inputs and points out all possible weaknesses of their application. Since almost every country has its own system of relevant (soil, weather, geographical) data collecting and administration (different institutions and organizations) all these have been done for condition of the Czech Republic and countries with similar approach.

MATERIALS AND METHODS

Estimation itself is based on well-known USLE equation (Wischmeier and Smith, 1978). It is being used for estimation of average long term soil loss caused by intense rains.

The USLE equation is basically product of several factors. Each of them represents one aspect of soil loss:

- precipitation factor „R“ based on kinetic energy of the rain and its intensity and total;
- soil factor „K“ describing soil susceptibility to erosion;
- topographical factor „LS“ describing length of plots and their inclination;
- vegetation factor „C“ describing protective effect of vegetation or planted crop.

First of all, is important to know which data and inputs in general are needed for snow thawing erosion assessment. We can divide then into several main groups:

- weather or climatic data;
- soil or pedological data;
- crop or vegetation data;
- orographical or topographical data.

By modification of USLE by Zachar (1981) modified by Středová and Toman (2012) we will get the fallowing equation shape:

$$Es = Rs \times L \times S \times C \times K \times P \ (t.ha^{-1}.year^{-1})$$

R factor of USLE is here replacer by Rs factor representing the soil erosion potential of snow cover. Rs then involves water amount of snow cover (m), the rate of its melting (h) and effect of soil freezing (SFC – soil freezing coefficient).

All other factors are methodologically identic to USLE.

RESULTS

Weather/climatic data

Since the method is intended for long-term soil loss, the longest possible data series should be applied (Středová and Středa, 2015). It practically means ideally 3 or 2 decades. This data is being collected and then provided by Czech Hydrometeorological Institute (CHMI, Czech acronym ČHMÚ).

According to Zachar (1981) snow thawing erosion intensity is given by water amount of snow cover and the rate of its melting. These inputs can be derived from measurement of snow depth – daily step and measurement of snow water content – weekly step. Examples of graphical outputs of these two characteristics contain Fig. 1. It is always important to choose proper i.e. representative statin of CHMI. Not just the nearest one but also the one with similar altitude etc. The example of CHMI database represents Fig. 2 (SCE – snow cover depth, SVH – snow water content).

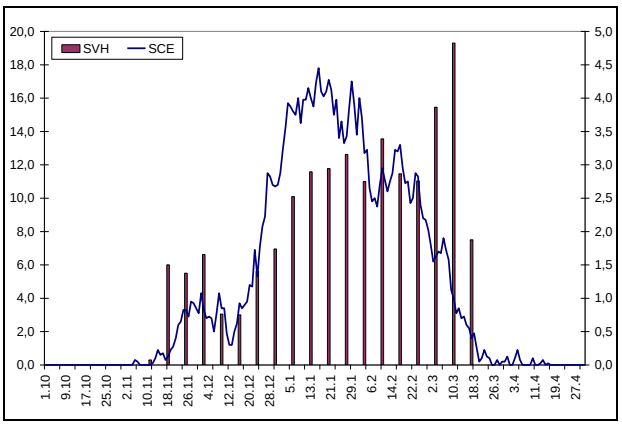

Figure 1. Parameters of snow cover. Left y axis: snow water content SVH (mm), right y axis: snow cover depth SCE (cm), station Pohořelice, 1961 – 2000.

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Erosive effect of thawing water is strongly influenced by infiltration soil capacity. It is pedologically determined by in addition is strongly affected by actual soil moisture. It can be also significantly limited by soil freezing. There is an assumption of high water content in the soil during snow melting. Thus, the data of soil freezing is also needed for the snow thawing erosion estimation.

There are two possibility how to get them:

- Data of soil temperature measurement – carrying out by automatic sensors in 10minute step. There is a simplified assumption: the soil temperature below zero, the frozen soil.
- Data of direct measurement of frost soil depth.

For detail description of both method read for instance Rožnovský and Pokladníková (2005) or Pokladníková and Rožnovský (2006). Comparison of their results could be find in Středová et al. (2012).

There are three possible states of the soil from viewpoint of its freezing: unfrozen soil profile (CFC = 1), all soil profile totally frozen (CFC = 1,5 – Fig. 3 upper part), unfrozen layer above the frozen one (CFC = 2 – Fig 3 lower part).

	A	B	C	N	O	P	Q	R	S
1				Protivanov		Staré Město		Strání	
2	YEAR	M	DAY	SCE	SVH	SCE	SVH	SCE	SVH
2120	1993	2	21	15		7		20	
2121	1993	2	22	20	13,2	6	9,5	25	30,0
2122	1993	2	23	21		6		25	
2123	1993	2	24	19		7		30	
2124	1993	2	25	35		9		32	
2125	1993	2	26	31		6		32	
2126	1993	2	27	26		6		29	
2127	1993	2	28	23		6		25	
2128	1993	3	1	21	23,6	5	12,4	23	44,0
2129	1993	3	2	19		3		21	
2130	1993	3	3	19		2		20	
2131	1993	3	4	18		2		20	
2132	1993	3	5	18		2		20	
2133	1993	3	6	19		3		20	
2134	1993	3	7	20		4		25	
2135	1993	3	8	17	25,4	3	9,5	24	52,0
2136	1993	3	9	17		2		22	
2137	1993	3	10	14		2		20	
2138	1993	3	11	13		0		18	
2139	1993	3	12	12		0		15	
2140	1993	3	13	8		0		10	
2141	1993	3	14	6		0		6	
2142	1993	3	15	4	8,2	0	0,0	4	18,0
2143	1993	3	16	0		0		0	
2144	1993	3	17	0		0		0	
2145	1993	3	18	0		0		0	
2146	1993	3	19	0		0		0	
2147	1993	3	20	0		0		0	
2148	1993	3	21	0		0		0	

Figure 2. CHMI database of snow data

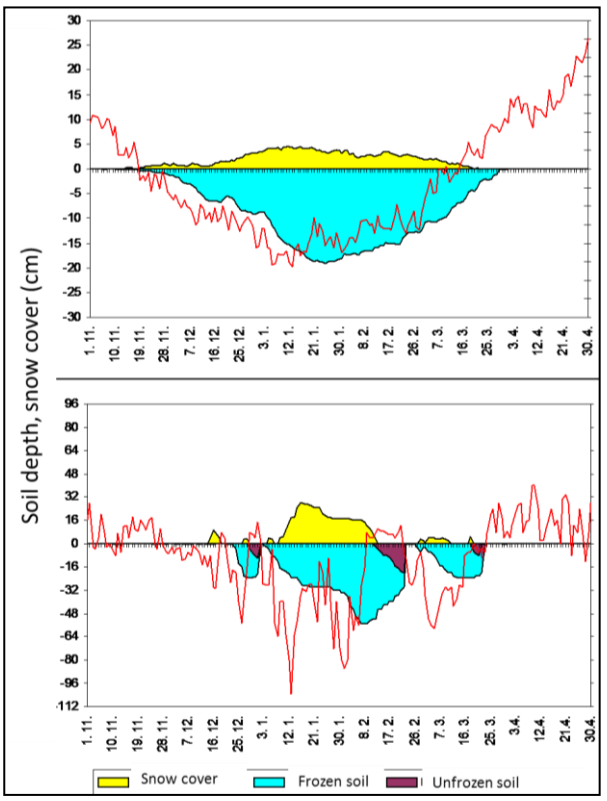

Figure 3. Different CFC

Pedological data

The land fund in the Czech Republic can be classified according to five digit EPEU (Estimated Pedological Ecological Unit) code (Středová et al, 2011). Based on this code (its 2nd and 3rd position) K factor can be estimate.

The institution providing this data in the Czech Republic is State land office (Czech acronym SPU CR).

Vegetation or crop data

The information about actual land-use or land cover are available in various ways (Chuchma et al., 2016). The most precise is to get them directly from farmers. Various data from farmers including information about planted crops are collected in LPIS (Land Parcel Identification System) system. More general information about planted crops in individual region are provided by Czech Statistical Office (Czech acronym ČSÚ).

Topographical data

Needed information could be derived from various map product in both analogical and digital form. One for all is ZABAGED product operating by State Administration of Land Surveying and Cadastre (Czech acronym ČÚZK).

CONCLUSION

The main tast of the paper was to introduce the method for estimation of erosion caused by water from thawing snow cover. All nedded data was devided into several main group. The relevant data source, providing authority or organization and concrete inputs were specified. Final summarizing scheme of the methodological approach to the issue contains Fig. 4.

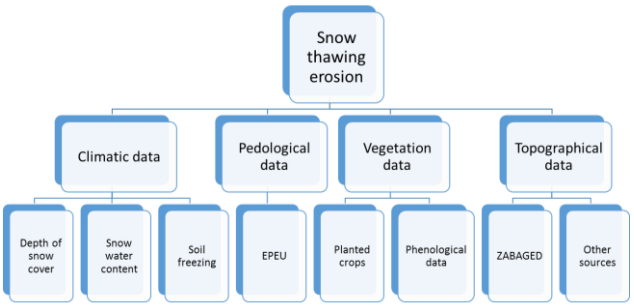

Figure 4. Final scheme of the methodology

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