Determination of Climate Change Influence on Wind Erosion in Chosen Areas of the Czech Republic

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Abstract: The influence of climate conditions on the intensity and spreading of wind erosion was considered in the area of Southern Moravia, Czech Republic. For this purpose, 16 climatological stations were selected. It was necessary to make the database of climatological factors (such as wind velocity, precipitation and air temperature) in the period between 1961 and 2003 for the analyses of climatological data. The climatological data was then evaluated for the periods of 1961–2003, 1961–1990, 1991–2000, and 1971–2000. Climatic erosion factor, which explains potential erodibility of soil by wind, was determined through the analyses of factors influencing the wind erosion. Climate change scenarios were then applied on the data of the selected climatological stations and the assessment of changes in data sets and the comparative analysis of the outputs of the scenarios with measured data from the normal period of 1961–1990 were done.

Introduction

The aim of the paper was to determine the influence of climate conditions on the intensity and spreading of wind erosion in the selected areas of Southern Moravia (Czech Republic) and consider the influence of expected climate change on the wind erosion.

Materials and Methods

Wind erosion consists of a destruction of the soil surface through the mechanical force of wind (abrasion), of a carrying away of soil particles by wind (deflation) and of their depositing at another place (accumulation).

Wind erosion is influenced above all by these basic factors:

- meteorological factors – wind velocity, time of wind duration and occurrence frequency,
- pedological factors – soil structure and soil humidity.

The soil humidity is defined by the amount and distribution of precipitation and influenced by temperature, air humidity and wind, which define the evapotranspiration and loss of soil humidity. Wind erosion is dependent on the three main climatological (meteorological) factors – on wind, precipitation and air temperature. The influence of climate conditions on the intensity and spreading of wind erosion is well represented by the equation including all the mentioned climatological factors. Chepil et al. (1962) has called the equation the erosion climatic factor C. The erosion climatic factor C expresses the influence of the average soil surface humidity and the average wind velocity on the average soil erodibility by wind.

The changes of the erosion climatic factor influenced by the variability of meteorological factors that come from were monitored on the data coming from 16 selected climatological (meteorological) stations of Southern Moravia. The meteorological stations were chosen on the basis of accessibility of required data, their adequate representativeness, homogeneity, and setting of the stations.

Erosion climatic factor C depends on the wind velocity and effective soil surface humidity. Chepil et al. (1962) presents the relationship for the erosion climatic factor by equations (1):

$$C = \frac{v^3}{(I_T + 60)^2} \quad \frac{100}{1{,}9}, \qquad (1)$$

where C = erosion climatic factor, v = average annual wind velocity in the high of 10 m above the ground (mile per hour) and I_T = Thornthwaite's humidity index.
Erosion climatic factor C from the equation (1) expresses the loss of soil which can arise in the particular area as the percentage rate from the soil loss in Garden City, when the other factors of the two comparative areas are similar (Pasak et Janecek, 1971).
The Thornthwaite's humidity index I_T can be substitute for Koncek's humidity index I_Z (Koncek, 1955) (2):

$$I_Z = \frac{R}{2} + \quad r \quad 10t \quad \left(30 + v^2\right), \tag{2}$$

where R = sum of precipitation during the vegetative period (IV–IX) (mm), Δr = positive deviation of precipitation amount of three winter months (XII–II) from the value of 105 mm (mm) (negative values not reflected), t = average air temperature of vegetative period (°C), v = average wind velocity at 2 p.m. during the vegetative period ($m.s^{-1}$).
The equation (1) for the determination of the erosion climatic factor in our conditions was modified to the following form (3) (Dufkova, 2004):

$$C = \frac{5620{,}23 \quad v^3}{\left(I_Z + 183{,}59\right)^2}, \tag{3}$$

where v = average annual wind velocity in the high of 10 m above the ground ($m.s^{-1}$) and I_Z = Koncek's humidity index.
Various soil types are differently threatened by wind erosion. Light soils with the content of clay soil particles 0–20 % have the largest erodibility. Soils with the higher content of clay particles are threatened by wind erosion less (Pasak et Janecek, 1971). Therefore the threatened areas of the Czech Republic by wind erosion were divided into six degrees according to the erodibility of soil depending on percentage content of soil particles < 0,01 mm (Janecek, 1997).
Modification of the climate data influencing the wind erosion, e.g. wind velocity, precipitation amount and air temperature, was done with two models – ECHAM4 and HadCM2 (Kalvova et al., 2002) with various climatic sensitivity and various emission scenarios. Altogether, four scenarios of climate change were used – four variants of future climate trend within 2050. Normal time period 1961–1990 was taken as the reference period.
Proposed climate change scenarios were applied on the data from 16 selected meteorological stations and the results were compared with month averages of the standard climatological period 1961–1990. Obtained results were analysed with respect to the differences between measured data and individual scenarios for the evaluated climatological factors of the measured period. Subsequently, the erosion climatic factor was calculated as from the data of present climate, as from the data of changed climate (by climate scenarios).

Results

The values of erosion climatic factor grow up during the studied period of 1961–2003 what theoretically means the increasing of potential threat of soil by wind erosion. The increasing trend is the most apparent at the stations of warm and dry areas. Also climate change scenarios predict the increase in values of erosion climatic factor.

Discussion and Conclusion

Climate conditions have substantial influence on the intensity and spreading of wind erosion especially in the dry areas of Southern Moravia. Thus, negative impacts of climate change will appear at first in these areas. Therefore at least from the beginning the humid areas with higher elevation will be spare from the negative impacts of warming. In the future it must be

taken into account that threat of soil by wind erosion will extend into the areas heretofore not threatened by wind erosion. The wind erosion is dependent also on the soil type. And if it is impossible to influence the climate process, then it should try to prevent the soil degradation and change of its structure state.

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