INFLUENCE OF CLIMATE CHANGE ON SOIL EROSION IN THE CZECH REPUBLIC, EUROPE

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Abstract
Torrential rains belong to the most important factors influencing the occurrence and intensity of water erosion. By comparison with the average volume of rainfall between 1901-1950, the period 1961–2000 registered lower volumes of rainfall in all the chosen regions of Czech Republic. This responds with the trend of global warming followed by decreasing of total rainfall. On the other hand, the increasing trend of the torrential rain occurrence is registered in the time period of 1961-2000, and from this the increasing danger of erosion processes follows. Some analyses that are made for the chosen regions of Czech Republic confirm the hypothesis about consequences of the possible climate change. Three climatological indexes that describe the humidity character of the landscape are calculated for the long-term period of 1961-2000. The results show the decreasing trend in the course of individual years of the mentioned time period – the indexes show decreasing of the humidity character of the landscape and decreasing of the soil moisture. Basing on these results it can be deduced that the expected climate change will influence some factors affecting the wind erosion processes.

Additional Keywords: torrential rain, climatological index, landscape humidity character

Introduction
Among the potentially most important characteristics of expected climate change in relation to agriculture, are changes in climate extremes, warming of high latitudes, shift of monsoon rainfall areas toward the poles, and reduction in soil humidity. Possible combination of increased temperature with drought or flood is perhaps the biggest risk for agriculture in many areas during the expected climate change. With the increase in temperature it is possible to expect the extension of vegetative period in the areas, where the agricultural potential is presently limited by the shortage of warmness. During global warming the intertropical convergence zone should move toward the poles as the result of the increased pressure gradient ocean–land. The amount of precipitation and its intensity should increase in some areas, and this could contribute to increased erosion and floods.

It is necessary to know occurrence, distribution and intensity of precipitation for soil erosion control purposes. Torrential rains are a crucial factor for water erosion processes. In Central Europe 99% of them occur between May and the end of September. The amount of winter and spring precipitation plays a big part in wind erosion as it determines the soil humidity and thereby influences the soil erodibility by wind.

Materials and Methods
For the purpose of determination of specific impacts of climate change on the erosive process development, it is necessary to check the mutual relations between climate conditions (precipitation, temperature, etc.) and other factors, which assert themselves during erosion development. Some factors that influence these processes are not static - they are under dynamic change. The evaluation of such changes was made by the determination of trends of certain meteorological factors for the selected areas of Czech Republic, Central Europe. These included data from four professional climatological stations of Czech Hydro-meteorological Institute, Telc-Kostelni Myslova, Velke Mezirici, Znojmo-Kucharovice, and Brno-Turany (Table 1). The analyses of water erosion were done for the period of 1901-1950 and 1961-2000. The analyses of wind erosion for the period of 1961-2000. For the calculations, it was necessary to know annual and monthly rainfall sum in mm, occurrence frequency of the torrential rain with the intensity above 20 mm per hour and abundance above 10 mm, average annual rainfall sum in mm, average annual air temperature in °C, average temperature per a vegetative period in °C, and average wind velocity in m/s at 2 p.m. per a vegetative period.

Analyses of rainfall sums from four chosen professional climatological stations, Telc-Kostelni Myslova, Velke Mezirici, Znojmo-Kucharovice, and Brno-Turany, were done. The data of rainfall sums were evaluated for the period of 1961-2000 and the basic statistical evaluation was done from the database of the data. Trends in annual and monthly rainfall sums and in rainfall sums of the period with the highest occurrence of extreme rainfalls (May and September) were determined for the selected stations. On the basis of the pluviograph records analyses, there were made evaluations of the occurrence frequency of the torrential rain with the intensity above 20 mm per hour and abundance above 10 mm. All the calculations were made by use of statistical programs (Kadlec and Toman 2002).

Table 1. Characterization of selected climatological stations

Indicative	Name	Latitude (North)	Longitude (East)	Altitude (m)
636	Telc-Kostelni Myslova	49° 09' 36"	15° 26' 21"	569
687	Velke Mezirici	49° 21' 14"	16° 00' 31"	452
698	Znojmo-Kucharovice	48° 53' 00"	16° 05' 00"	334
723	Brno-Turany	49° 09' 35"	16° 41' 44"	241

The characterization of a landscape humidity feature is usually conducted by climatological indexes. On the basis of the accessibility of the data, which are needed for the calculation of characteristics, three climatological indexes were chosen, i.e. Koncek's Humidity Index, Lang's Rainfall Factor, and Minar's Moisture Certainty. Their values were compared subsequently for three climatological stations of Czech Republic, Telc-Kostelni Myslova, Znojmo-Kucharovice, and Brno-Turany. The data of average annual rainfall sums, average annual air temperatures, average temperatures per a vegetative period, and average wind velocities at 2 p.m. per a vegetative period were evaluated for the period of 1961-2000 and the basic statistical evaluation was done (Dufkova and Toman, 2003).

Koncek's Humidity Index

Koncek's humidity index comes out of the Humidity Index according to Thornthwaite. As the climatological index, it is usually used for the classification of climate, i.e. macroclimate and mesoclimate. Equation 1 gives the humidity index for the whole vegetative period (April-September) (Koncek, 1955):

$$I_Z = \frac{R}{2} + \Delta r - 10t - \left(30 + v^2\right), \quad (1)$$

where I_Z = Koncek's humidity index, R = rainfall sum per a vegetative period in mm, Δr = positive deviation of rainfall amount of three winter months (December-February) from the value of 105 mm in mm (negative figures are not taken), t = average air temperature per a vegetative period in °C, and v = average wind velocity in m s^{-1} at 2 p.m. per a vegetative period.

Lang's Rainfall Factor

Lang's rainfall factor expresses natural irrigation conditions of landscape by the relationship between rainfalls and air temperature (Equation 2) (Sobisek 1993):

$$f = \frac{R}{t}, \quad (2)$$

where f = Lang's rainfall factor, R = average annual rainfall sum in mm, and t = average annual air temperature in °C.

Minar's Moisture Certainty

Minar's moisture certainty characterizes moisture conditions of study locality (Equation 3). Ratio of average rainfall amount in a definite period and of average air temperature of the same period gives rainfall amount that falls on every degree of average temperature of the definite period (Brablec, 1948):

$$J = \frac{R - 30(t + 7)}{t}, \quad (3)$$

where J = Minar's moisture certainty, R = average annual rainfall sum in mm, and t = average annual air temperature in °C.

Results and Discussion

The comparison of the average values of annual and monthly rainfall sums for the period of 1901-1950 with the period of 1961-2000 shows lower volumes of rainfall in the second period in all the chosen climatological stations. The decrease varies according to the stations and its value fluctuates from 30 to 91 mm per year. The difference is mainly influenced by the precipitation since October till April (26-61 mm). The decreasing value is lower at the stations Telc-Kostelni Myslova and Velke Mezirici than at the stations Znojmo-Kucharovice and Brno-Turany. The largest difference was found out at the station Znojmo-Kucharovice (91 mm), the smallest at the station Telc-Kostelni Myslova (30 mm). The most important decrease in monthly rainfall sums was noted on October, November and December at all the stations. The largest difference was found out at the station Brno-Turany on October (21 mm).

For the determination of the occurrence frequency of torrential rains with the intensity above 20 mm per hour and abundance above 10 mm, there were pluviograph records analysed. The occurrence frequency is in Table 2. Graphic representation of the time course and precipitation trend in the station Velke Mezirici is shown in Figure 1.

Table 2. Occurrence frequency of torrential rains in the period of 1961-2000

	Telc-Kostelni Myslova		**Velke Mezirici**		**Znojmo-Kucharovice**		**Brno-Turany**	
	number	**%**	**number**	**%**	**number**	**%**	**number**	**%**
May	7,0	7,5	7,0	9,9	12,0	14,1	15,0	18,5
June	27,0	29,0	22,0	31,0	27,0	31,8	23,0	28,4
July	29,0	31,2	21,0	29,6	22,0	25,9	22,0	27,2
August	23,0	24,7	15,0	21,1	21,0	24,7	11,0	13,6
September	7,0	7,5	6,0	8,5	3,0	3,5	10,0	12,3
Total	93,0	100,0	71,0	100,0	85,0	100,0	81,0	100
Average occurrence per year	2,3		1,8		2,1		2,0	

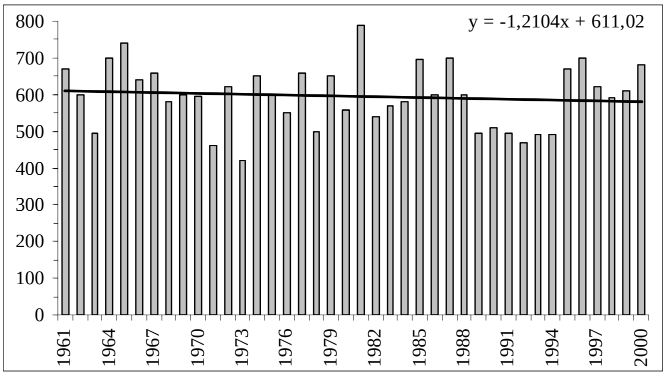

Figure 1. Trend of annual rainfall sums of the period of 1961-2000 at the station Velke Mezirici

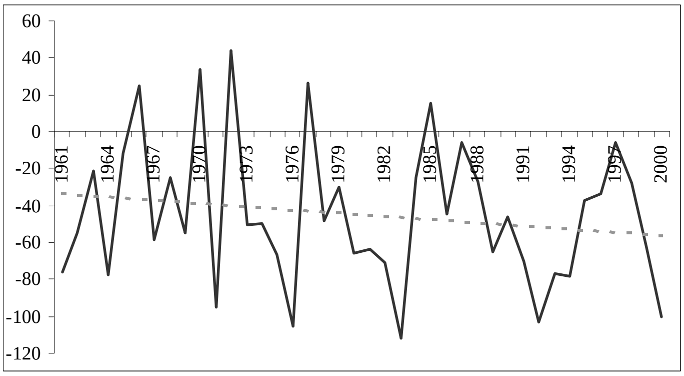

Figure 2. Koncek's humidity index of the vegetative period of 1961-2000 at the station Brno-Turany with its linear trend

Linear trend of Koncek's humidity index that was calculated according to Equation (1) is decreasing for all the stations. The decrease appears during the vegetative period (April-September) as so as during the whole year. The average values of Koncek's humidity index of the vegetative period of 1961-2000 for the station Brno-Turany are shown in Figure 2.

The results from Lang's rainfall factor are very similar to these mentioned above with Koncek's humidity index. Its decreasing linear trend means loss of natural irrigation of the landscape. The average values for the station Znojmo-Kucharovice are in Figure 3.

Only values of Minar's moisture certainty show increasing of the linear trend at the station Telc-Kostelni Myslova (Figure 4). Anyway, this station belongs into the cool and humid area of Czech Republic and this is the reason of the increasing trend.

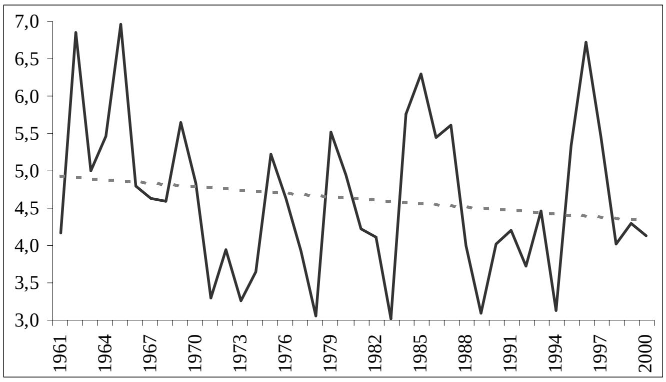

Figure 3. Lang's rainfall factor of the vegetative period of 1961-2000 at the station Znojmo-Kucharovice with its linear trend

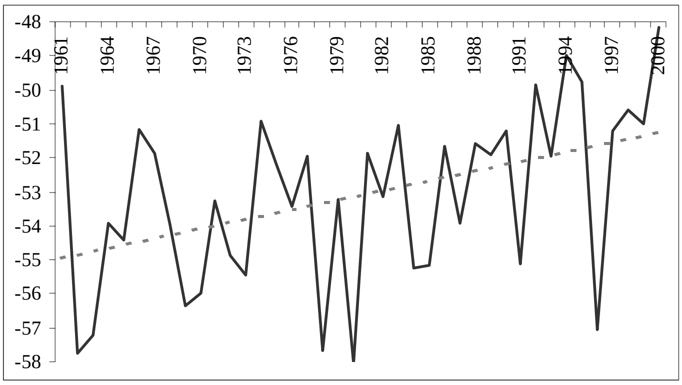

Figure 4. Minar's moisture certainty of the vegetative period of 1961-2000 at the station Telc-Kostelni Myslova with its linear trend

Conclusions

Analyses of expected climate change impacts on the soil erosion confirm the assumption about the rainfall amount decreasing. Various scenarios of climate change mention decrease in the atmospheric rainfalls, potentially maintaining of their amount at the same level, and change in the distribution during the year as so as increase in the occurrence of extremes. All the consequences have, or will have, negative impacts on the soil, so both types of erosion mentioned in this study will then endanger greater areas.

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