ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol., Formatio Circumiectus 12 (3) 2013, 21–27

COMPARISON OF DIFFERENT CALCULATION METHODS OF RAIN FACTOR FOR AREA OF SOUTH-WESTERN PART OF SLOVAK REPUBLIC

PORÓWNANIE RÓŻNYCH METOD OBLICZANIA WSPÓŁCZYNNIKA OPADU DLA OBSZARU POŁUDNIOWO-ZACHODNIEJ SŁOWACJI

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Abstract. The aim of this paper is to compare different methods of rain factor calculation. In this research were used two methodologies i.e. Wischmeier–Smith [1978] methodology and Hudson's [1971] methodology. The main difference between these two methodologies is in the data processing especially in the calculation and choosing of kinetic energy intervals. These factors influence the resultant values of rain factor. The data for this research were provided by Slovak Hydrometeorological Institute in Bratislava, concretely were prepared data from rain-guage station Sereď for period 1962–1966. Obtained and calculated values show that Hudson relations and consequence resultant values are lower than the values calculated with Wischmeier–Smith's methodology. After these calculations were resultant values of rain factor compared with existing values of rain factor calculated in the past by Soil Science and Conservation research Institute in the map form. This comparison showed that values calculated with using Hudson's methodology are closer to past values. This fact is significant because it will be useful to revaluate the used methodology also because that there are deficient data about rain and the Hudson's methodology can be use also for deficient data.

Streszczenie. Celem niniejszej pracy jest porównanie różnych metod obliczania współczynnika opadu. W badaniach wykorzystano dwie metody, tj. metodologie Wischmeiera–Smitha (1978) i Hudsona (1971). Główna różnica między tymi metodami polega na przetwarzaniu danych, zwłaszcza w obliczeniach i wyborze interwałów energii kinetycznej. Te czynniki wpływają na wynikowe wartości współczynnika opadu. Dane do badań zostały pozyskane ze Słowackiego Instytut Hydrometeorologii w Bratysławie,

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This paper was supported by grant VEGA 1/057/11 and grant KEGA 003SPU-4/2012.

konkretnie dane pochodzą ze stacji deszczowej Sereď z okresu 1962–1966. Uzyskane i obliczone wartości pokazują, że wartości wynikowe przy metodzie Hudsona są niższe niż przy metodzie Wischmeiera–Smitha. Następnie porównano uzyskane wartości współczynnika opadu z istniejącymi wartościami tego parametru obliczonymi w przeszłości przez Instytut Gleboznawstwa i Ochrony Gleb, odczytanymi z map. Porównanie wykazało, że wartości obliczone przy użyciu metodologii Hudsona są bliższe wartościom odczytanym z map. Fakt ten jest istotny, ponieważ będzie on użyteczny do aktualizacji wartości stosowaną metodologią, ponadto metodę Hudsona można wykorzystywać tam, gdzie nie dysponujemy danymi opadowymi.

Key words: rain, erosion, rain factor, Wischmeier–Smith methodology, Hudson methodology, rain erosivity

Słowa kluczowe: deszcz, erozja, współczynnik opadu, metodologia Wischmeiera–Smitha, metodologia Hudsona, erozyjność deszczu

INTRODUCTION

Soil creates the environment for plants, animals and definitely for man and also represents irreplaceable resource for man. World population increased from 2 to 10,000,000 from the beginning of agricultural production 10 to 12,000 years ago, to 6.5 billion in 2006 and may stabilize to 10–12 billion in 2100. This constantly growing numbers lead us to think about the importance of soil protection, which has incalculable value to mankind.

Soil water erosion consider serious problem in the Europe Union. Almost 12.0% of all areas in Europe are endangered by water erosion and of course in Slovak Republic is endangered as many as 43.3% of agricultural soils. These alarming numbers incite detailed research of water erosion factors. One of the factors which meaningly influenced the soil erosion caused by rain is the rain factor *R* or rain erosivity. The rain factor was calculated for conditions of Slovak republic in the past by the research worker A. Malíšek and then with using GIS devices by the Soil Science and Conservation Research Institute. In the present time is increasing the need for detailed research of soil erosion and this is the main reason why was made this research.

MATERIAL AND METHODS

The data for this research were provided by Slovak Hydrometeorological Institute in Bratislava. It was used data for rain-guage station Sereď (which is localized in the south--western part of Slovak republic) for period 5 years i.e. 1962–1966. The provided data were in digital form, in one minute step. The data were proceeding in the MS Excel The first used methodology was designed by Wischmeier–Smith [1978]. This methodology consider for erosive effective rainfall that rainfall which is higher than 12.5 mm and with intensity higher than 24.00 mm · h^{-1} at least one rain division. The following equations for calculation were used:

$$R = E \cdot I_{30}, \quad \text{MJ} \cdot \text{ha}^{-1} \cdot \text{cm} \cdot \text{h}^{-1} \tag{1}$$

where:

R – rain erosivity factor, MJ · ha^{-1} · cm · h^{-1},

I_{30} – maximum 30-minutes rain intensity, cm · h^{-1}.

$$KE = (11.87 + 8.73 \cdot \log_{10} I) \cdot H_2 \text{ , } \text{J} \cdot \text{m}^{-2} \cdot \text{mm}^{-1} \quad (2)$$

where:

KE – kinetic energy, J · m^{-2} · mm^{-1},
I – rain intensity, mm · h^{-1},
H_z – rain depth, mm.

For the data preparation was design new methodology, i.e. the chosen effective erosive rainfalls were not divided into rain divisions but each minute of selected rains were considered for individual rain division. This designed methodology eliminates the individual mistakes for choosing of rain divisions.

According Hudson [1971] is calculation of EI_{30} and $KE > 1$ the same, but advantage of $KE > 1$ index is that it can be used also for less detailed records about rains. For both these methodologies it is necessary to know rain depth, which fall down and also appropriate intensities. Simple calculation is introduced in table 1.

Procedure of calculation according this methodology is following:

1. For chosen rain depth is calculated the rain intensity.
2. Then is the rain arrange according intensities shown in the table 1.
3. For each intensities groups is calculated kinetic energy according following equation:

$$KE = 29.8 - \frac{127.5}{I}, \qquad \text{J} \cdot \text{m}^{-2} \cdot \text{mm}^{-1} \quad (3)$$

where:

KE – kinetic energy, J · m^{-2} · mm^{-1},
I – rain intensity, mm · h^{-1}.

4. At the end the sums of each intensity are sum up and the total kinetic energy of rain is calculated.

Table 1. Example of calculation according Hudson's methodology
Tabela 1. Przykładowe obliczenia według metodologii Hudsona

Intensity Intensywność mm · h^{-1}	Precipitation amount Ilość opadów mm	Rain kinetic energy Energia kinetyczna J · m^{-2} · mm^{-1}	Sums Column 2 · Column 3 Iloczyn kolumn 2 i 3
0–25	30	–	–
25–50	20	26	520
50–75	10	28	280
> 75	5	29	145
Total / Suma	65		945 J · m^{-2}

After calculation of kinetic energy of each rain we proceeded according Wischmeiers–Smith's methodology i.e. maximal 30-minutes intensity was chosen and the values were inducted to the equation for calculation of rain factor.

RESULTS AND DISCUSSION

The first created chart shows the comparison of frequency of precipitation in each years of examined period on the locality Sereď. The both methodology have different criteria for choosing of erosive effective rainfalls.

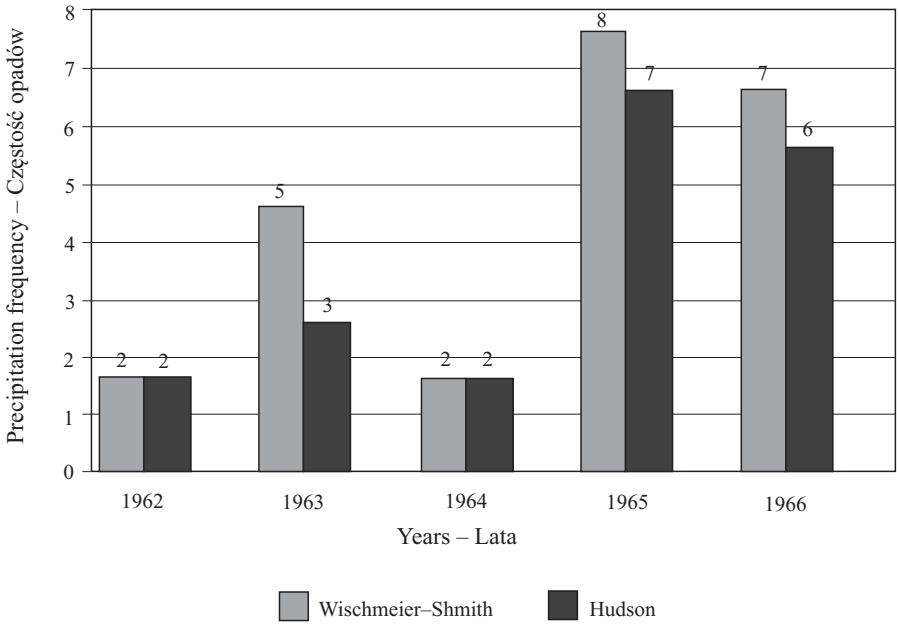

Fig. 1. Comparison of precipitation frequency according Wischmeier–Smith and Hudson, Sereď 1962–1966

Rys. 1. Porównanie częstości opadów według Wischmeiera–Smitha i Hudsona, Sereď 1962–1966

As we can see from created chart (fig. 1), in the years 1963, 1965 and 1966 there occurred the differences in precipitation frequency. In others examined years were number of erosive effective rainfall same for both methodology. According Hudson's methodology is number of erosive effective rainfall lower than number of erosive effective rainfalls according Wischmeier–Smith's methodology.

The table 2 shows comparison of *R*-factor values, which was calculated with using both mentioned methodology i.e. Hudson's and Wischmeier–Smith's methodology for each year of examined period on Sereď locality.

Table 2. Comparison of annual and average
Tabela 2. Porównanie rocznych wartości i średnich

	$R_{\text{annual W.–S.}}$	$R_{\text{annual } KE > 1}$
1962	28.7243	18.3626
1963	32.3413	18.6151
1964	25.3072	18.3626
1965	83.3082	40.3854
1966	65.8864	59.4856
Average Średnia	47.1135	31.0423

On the base of calculation method was created following fig. 2, which illustrates comparison of average values of rain factor.

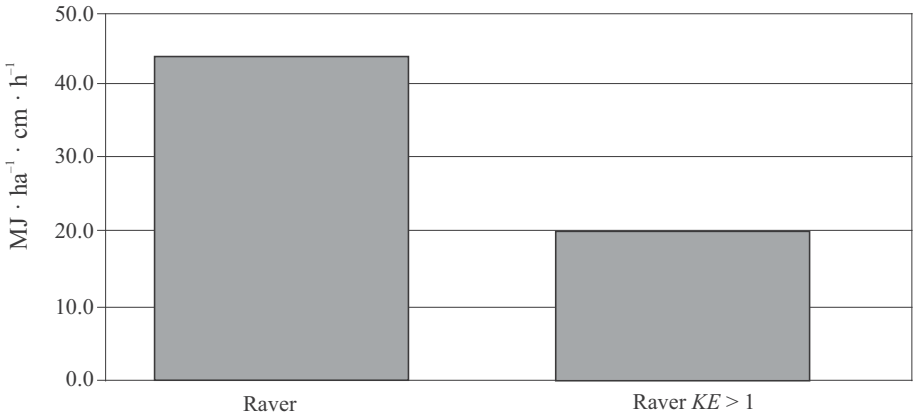

Fig. 2. Comparison of average rain factor values (Wischmeier–Smith and Hudson), Sereď 1962––1966
Rys. 2. Porównanie średnich wartości współczynnika opadu (Wischmeier–Smith i Hudson), Sereď 1962–1966

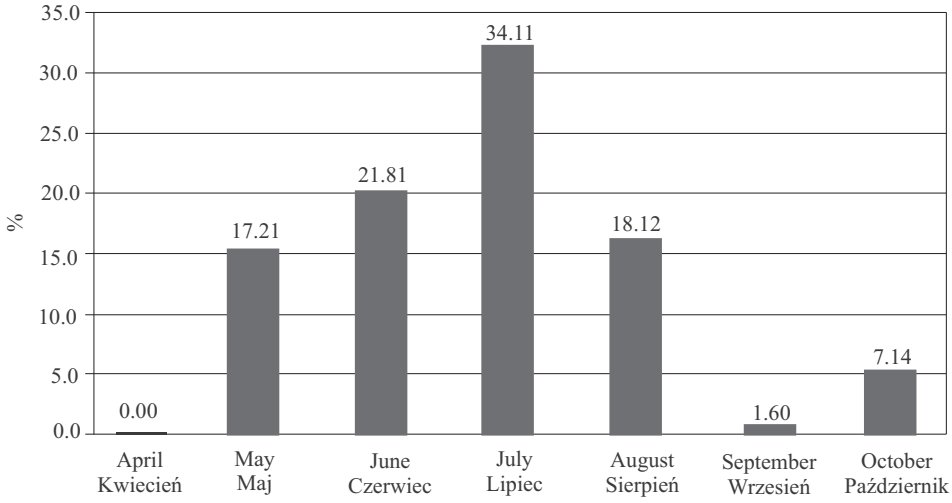

Fig. 3. Redistribution of rain factor according Wischmeier–Smith on the particular months of vegetation period, Sereď 1962–1966

Rys. 3. Rozkład wartości współczynnika opadu według Wischmeiera–Smitha dla okresu wegetacyjnego, Sereď 1962–1966

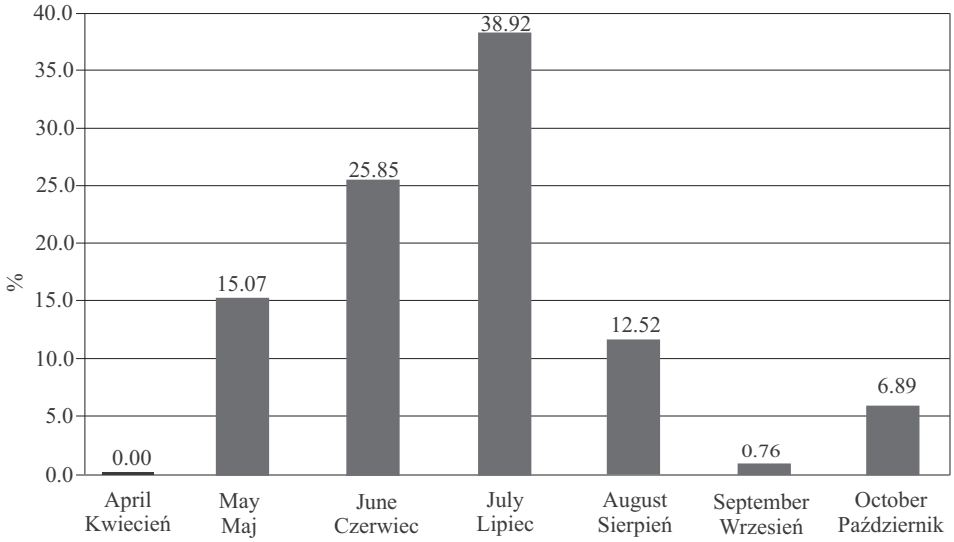

Fig. 4 Redistribution of rain factor according Hudson on the particular months of vegetation period, Sereď 1962–1966

Rys. 4. Rozkład wartości współczynnika opadu według Hudsona dla okresu wegetacyjnego, Sereď 1962–1966

As we can see from listed chart, the value, which was calculated according Wischmeier–Smith's methodology for meteorological station Sered' for period 1962–1966 is more than 2-times higher than value calculated according Hudson's methodology.

Consequently were created charts from obtained values about redistribution of rain factor for each months of vegetation period. This step was necessary because we want to know how different methods of rain factor calculation influenced its redistribution during the vegetation period.

Despite the fact that values of redistribution of rain factor are different, the highest percentage fall on the same months of vegetation period i.e. on months June, July and August and the lowest on April (when no erosive effective rainfall was observed according both methodologies) and then on September and October.

CONCLUSION

Comparing the Hudson's methodology ($KE > 1$) and Wischemeier–Smith's methodology, it was found out that the Hudson's methodology used for the calculation and the calculated values of *R*-factor are almost 2-times lower than with using Wischmeier–Smith's methodology. Also it was found out that aside from used methodology the redistribution of rain factor for individual months of vegetation period is the same. The mentioned fact has very important influence on prevention measures against erosion caused by rain, because especially in this period is soil endangered by erosion, so it is very important to design right anti-erosion measures. This fact point at re-evaluation of used methodology for calculation of rain factor in our conditions.

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Accepted for print – Zaakceptowano do druku: 12.12.2013