Latin American Data in Science
LADS

Latin American Data in Science, v.1, n.3
datainscience.com.br
ISSN: 2763-9290

Database of rainfall erosivity factor for 141 locations in Brazil.

Recebido: 28/11/2021 | Aceito: 12/12/2021 | Publicado: 20/12/2021
https://doi.org/10.53805/lads.v1i3.37

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ABSTRACT

Soil erosion is a serious agricultural and environmental problem considered as a threat to sustainable development around the world. Rainfall is the primary cause of soil erosion, what leads the knowledge of its potential to cause soil erosion (rainfall erosivity – R-factor) to be a valuable tool for the design of land conservation best practices. As Brazil has a lack of information about rainfall erosivity, the present paper has determined the R-factor of 141 pluviographic stations distributed over Brazilian territory. Initially, erosive rainfalls were identified, and then the EI_{30} erosivity index was used to obtain the rainfall erosivity values. Regression models for the estimation of rainfall erosivity using daily rainfall data were established based on the correlation between the monthly average values of erosivity and the modified Fournier index. Results showed that the annual rainfall erosivity in the Brazilian stations analyzed ranged from 368.7 to 16,850.6 MJ mm ha^{-1} h^{-1} $year^{-1}$. The results presented help to expand information about the spatial distribution of rainfall erosivity in Brazil, contributing to better conservation planning of land use.

Keywords: Erosion; Rainfall homogeneous zones; USLE; Modified Fournier index.

PRIOR PUBLICATIONS

OLIVEIRA, J. P. B. de, et al. Assessing the use of rainfall synthetic series to estimate rainfall erosivity in Brazil. CATENA, v. 171, p. 327-336, 2018. DOI: http://dx.doi.org/10.1016/j.catena.2018.07.031.

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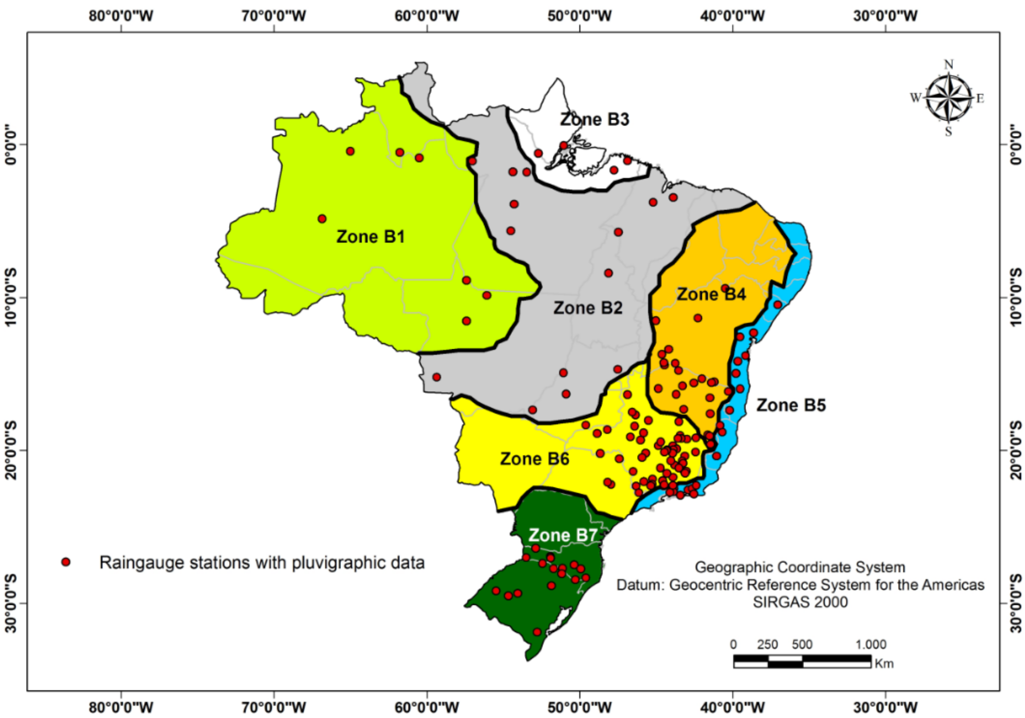
DATA IMPORTANCE

- Database has enormous potential to be applied for soil erosion and soil conservation studies;
- Largely increases the availability of rainfall erosivity (R-factor) values for Brazil;
- Many of the data are still unknown and consists in original data to Brazilian researches (specially at Semi-Arid Region);
- Provides a better spatial distribution of known Brazilian stations R-factor's values;
- Presents a set of still unknow regression equations to predict R-factor from monthly rainfall amounts.

MATERIALS AND METHODS

Rainfall erosivity was calculated for 141 Brazilian raingauge stations (Fig. 1) using daily rainfall pluviographs. All the raingauge stations belong to Brazilian Institute of Meteorology (INMET). To better present and discuss the results later, Brazilian territory was divided into homogeneous zones according to rainfall characteristics (BAENA et al., 2005), as also showed in Figure 1. The number of years with daily pluviographs varied from 3 to 11 in Zone B1; 6 to 14 in Zone B2; 3 to 10 in Zone B3; 10 to 27 in Zone B4; 12 to 22 in Zone B5; 10 to 31 in Zone B6 and was equal to 5 years in Zone B7.

Figure 1 - Spatial distribution of Brazilian raingauge stations and division of Brazilian area into homogeneous zones according to rainfall characteristics (BAENA et al., 2005).



In order to proceed the calculation of the R-factor, all the isolated rainfalls must be first classified as either erosive or nonerosive. The erosive events were all the individual rainfall with depth equal or higher than 10 mm, or that one with depth lower than 10 mm, but with a 15-minute depth equal or greater than 6 mm (CABEDA, 1976).

Kinetic energy (KE) of each erosive rain was computed individually by the equation 1 (FOSTER et al., 1981) when erosive rainfall intensity was equal to or lower than 76 mm h^{-1}. KE of erosive rains with greater intensities was assumed to be equal to 0.283 MJ ha^{-1} mm^{-1} (FOSTER et al., 1981).

$$KE = 0.119 + 0.0873 \log I \quad (1)$$

where KE is the kinetic energy, MJ ha^{-1} mm^{-1}; and I is rainfall intensity, mm h^{-1}.

The erosivity index (EI30) (WISCHMEIER; SMITH, 1958) for each rainfall event was calculated as the product of total kinetic energy (KE) and the maximum 30 min intensity (WISCHMEIER; SMITH, 1958). The total KE of each event was calculated using the one-minute time step. Monthly and annual values of the R-factor were determined as the sum of the EI30 for all the individual rainfall events that occurred in one month or year. Then mean monthly and annual values for R-factor were computed average values for the number of years with measured data available to each station.

Due to the scarcity of raingauge stations with pluviographic data in Brazil, regression models for the estimation of rainfall erosivity using daily rainfall data were established. These models were based on the correlation between the monthly average values of erosivity and the modified Fournier index (MFI). The MFI, obtained from Equation 2, relates the mean monthly rainfall and the mean annual rainfall and was used as an independent variable to obtain the erosivity estimation models. Only models that presented values of coefficient of determination (R^2) for the regression above 0.70 were considered representative. Models with $R^2 < 0.70$ were omitted from the results.

$$MFI_i = \frac{(R_i)^2}{R_a} \quad (2)$$

where MFI_i is the modified Fournier index for the month i; R_i is the mean monthly rainfall in month i, mm; and R_a is the mean annual rainfall, mm.

DATA DESCRIPTION

The tables of the supplementary database presents monthly and annual R-factors calculated with pluviographic measured data to the stations located on Zones B1 to B7.

Zone B1 can be classified as the one that presents the higher average R-factor values in Brazil. The average erosivity (± standard deviation) observed was 12,124 ± 1,489 MJ mm ha^{-1} h^{-1} $year^{-1}$. The only previously known R-factors (calculated with pluviographic data) on the same region are the ones of Manaus station (14,129 MJ mm ha^{-1} h^{-1} $year^{-1}$) (OLIVEIRA JÚNIOR; MEDINA, 1990) and Vera station (15,965 MJ mm ha^{-1} h^{-1} $year^{-1}$) (OLIVEIRA; WENDLAND; NEARING, 2012), that are close to the R-factor calculated in the present paper.

The average erosivity of Zone B2 (10,144 ± 2,340 MJ mm ha^{-1} h^{-1} $year^{-1}$) is only lower than average R-factor of Zone B1 and quite similar to Zone B3 average. A review of scientific papers that calculated rainfall erosivity on this Zone (DIAS; SILVA, 2003; OLIVEIRA; WENDLAND; NEARING, 2012; SILVA et al., 1997) showed R-factor ranging from 6,641 to 14,756 MJ mm ha^{-1} h^{-1} $year^{-1}$.

Zone B3, on the mouth of Amazon basin, presents R-factor average values are about 10,270 ± 793 MJ mm ha^{-1} h^{-1} $year^{-1}$. Bragança city, on this Zone, has calculated R-factor equals to 12,351 MJ mm ha^{-1} h^{-1} $year^{-1}$ (OLIVEIRA; WENDLAND; NEARING, 2012).

On Zone B4 were observed the lower average R-factor values (1,089 ± 267 MJ mm ha^{-1} h^{-1} $year^{-1}$). Literature review shows only one published research related to R-factor on this Zone, referring to Pernambuco State (CANTALICE et al., 2009). It shows R-factors ranging from 1,672 to 3,480 MJ mm ha^{-1} h^{-1} $year^{-1}$, which are higher than the ones calculated in the present paper. However, all the stations presented on Cantalice et al. (2009) belongs to the northern site of Zone B4, where rainfall amounts are greater (MARENGO, 1995). Besides, the results of the present paper were calculated using precipitation dataset with 10 to 27 years in extension; meanwhile, Cantalice et al. (2009) used dataset only with 5 to 11 years in extension. However, concerning to Zone B4 R-factors values, it can be observed that they were similar to R-factors of other arid or semi-arid regions worldwide. For example: Nigeria – 1,985 MJ mm ha^{-1} h^{-1} $year^{-1}$ (DELWAULLE, 1973); Kenia – MJ mm ha^{-1} h^{-1} $year^{-1}$ (MOORE, 1979); Cape Verde – 2,000 MJ mm ha^{-1} h^{-1} $year^{-1}$ (MANNAERTS; GABRIELS, 2000); Chile – below 500 MJ mm ha^{-1} h^{-1} $year^{-1}$ (BONILLA; VIDAL, 2011); and Canary Islands (Spain) – 640 MJ mm ha^{-1} h^{-1} $year^{-1}$ (RODRÍGUEZ et al., 2004).

The higher variability on R-factor occurred at Zone B5, which presented average value equals to 5,438 ± 2,020 MJ mm ha^{-1} h^{-1} $year^{-1}$. Lower values occurred on Northern site while the higher ones took place on Southern site. Other papers (CANTALICE et al., 2009; CARVALHO et al., 2005; GONÇALVES et al., 2006; MACHADO et al., 2008; MARTINS et al., 2010) found similar R-factors; even to Northern site, on Pernambuco State (ranging from 3,212 to 6,325 MJ mm ha^{-1} h^{-1} $year^{1}$); or to Southern site on Rio de Janeiro and Espírito Santo States (between 4,118 and 15,806 MJ mm ha^{-1} h^{-1} $year^{-1}$).

Average rainfall erosivity of Zone B6 was about 7,022 ± 1,092 MJ mm ha^{-1} h^{-1} $year^{-1}$. Similarly, other researches on the same Zone (OLIVEIRA et al., 2012; ROQUE; CARVALHO; PRADO, 2001; SANTOS et al., 2012) have found R-factor ranging from 5,056 e 18,646 MJ mm ha^{-1} h^{-1} $year^{-1}$, with higher values associated with the Western site, not covered by any stations of the present paper.

The rainfall erosivity values of Zone B7 were quite similar to Zone B6, presenting average value equals to 6,681 ± 1,100 MJ mm ha^{-1} h^{-1} $year^{-1}$. These values are close to the ones calculated on several stations of the Zone on other papers (BAZZANO; ELTZ; CASSOL, 2007, 2010; BERTOL, 1994; CASSOL et al., 2007, 2008; ELTZ; CASSOL; PASCOTINI, 2011; HICKMANN et al., 2008; MAZURANA et al., 2009; OLIVEIRA; WENDLAND; NEARING, 2012), that ranged from 5,135 to 11,217 MJ mm ha^{-1} h^{-1} $year^{-1}$.

Regarding the regression models established to estimate rainfall erosivity using daily rainfall data, a significant correlation ($R^2 > 0.70$) was found for 89 of the 141 rainfall gauges used. Unlike the other zones, there were no rainfall gauges that presented a significant correlation for Zone B7, so no regression model was established for this zone.

These regression models become important since they are an easy-to-apply alternative for estimating rainfall erosivity on a local scale, or for a specific dataset. Thus, the models proposed in this study aim to update and expand the spatial availability of rainfall erosivity values in Brazil.

As the availability of calculated R-factor in Brazil is considered small (OLIVEIRA; WENDLAND; NEARING, 2012), it can be considered that the presented data contributes to increasing the Brazilian database. Besides, as also pointed out by Oliveira et al. (2012), the previous papers concentrated the determination of R-factor on the stations of the south and southeast regions (Zones B6 and B7), with only a few studies in other zones. The R-factor presented in this paper can be considered as a great increase in the availability of information to Zones B1, B2, B3, B4 and North part of Zone B5 (Brazilian North, Northeast, and Central-West Regions) where the data are scarce.

In the present paper, the extension of pluviographic data used to calculate R-factor of some raingauge stations is still less than the recommended standard for the application of RUSLE (20 years of data). However, hydrological and meteorological information is very scarce or frequently difficult to access in Brazil (OLIVEIRA et al., 2012). In that way, the authors of the present paper must agree with Oliveira et al. (2012) that recommended the maintenance of the existing raingauge stations and also the establishment of new stations.

Database

File database.xlsx

- Column A: Homogeneous rainfall zone
- Column B: State
- Column C: Station Code
- Column D: Station location (city)
- Column E: Station latitude (decimal degree)
- Column F: Station longitude (decimal degree)
- Column G: January's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column H: February's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column I: March's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column J: April's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column K: May's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column L: June's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column M: July's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column N: August's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column O: September's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column P: October's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column Q: November's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column R: December's rainfall erosivity (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column S: Annual's rainfall erosivity - R-factor (MJ mm ha^{-1} h^{-1} $month^{-1}$)
- Column T: Regression model for the estimation of rainfall erosivity
- Column U: Determination coefficient for Column T's regression model.

SUPPLEMENTARY MATERIALS

Dataset: Zanetti et al_Dataset

ACKNOWLEDGEMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) - Finance Code 001; and, Conselho Nacional de Desenvolvimento Científico e Tecnológico – Brasil (CNPq) – Finance Code 304916/2017-

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