Estimation of the erosive potential of rainfall in the municipality of União dos Palmares-AL

Estimativa do potencial erosivo das chuvas no município de União dos Palmares-AL

DOI: 10.55905/oelv21n7-052

Recebimento dos originais: 19/06/2023
Aceitação para publicação: 19/07/2023

Leonardo José Aparecido de Vasconcelos Brandão
Bachelor in Agronomy
Institution: Universidade Federal de Alagoas (UFAL)
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,
CEP: 57309-005
E-mail: leonardo-ljvb@hotmail.com

Mayara Rodrigues Nascimento
Master in Agriculture and Environment from the Programa de Pós-Graduação em Agricultura e Ambiente (PPGAA)
Institution: Universidade Federal de Alagoas (UFAL)
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,
CEP: 57309-005
E-mail: mayararodrigues011@gmail.com

Albiane Borba Noronha
Bachelor in Agronomy
Institution: Universidade Federal de Alagoas (UFAL)
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,
CEP: 57309-005
E-mail: albiane51@gmail.com

Maiane Rodrigues do Nascimento
Master in Meteorology from the Programa de Pós-Graduação em Meteorologia (PPGMET)
Institution: Universidade Federal de Alagoas (UFAL)
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,
CEP: 57309-005
E-mail: maianerodrigues707@gmail.com
Renata Rikelly Silva Barbosa  
Master in Agriculture and Environment from the Programa de Pós-Graduação em Agricultura e Ambiente (PPGAA)  
Institution: Universidade Federal de Alagoas (UFAL)  
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,  
CEP: 57309-005  
E-mail: rrenatab.27@gmail.com

José Ferreira de Oliveira  
Bachelor in Agronomy  
Institution: Universidade Federal de Alagoas (UFAL)  
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,  
CEP: 57309-005  
E-mail: jose.oliveira1@arapiraca.ufal.br

Fabiana Fontes da Silva Macedo de Carvalho  
Master in Agriculture and Environment from the Programa de Pós-Graduação em Agricultura e Ambiente (PPGAA)  
Institution: Universidade Federal de Alagoas (UFAL)  
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,  
CEP: 57309-005  
E-mail: fabianafsmcarvalho21@gmail.com

Thaís Rayane Gomes da Silva  
Doctorate in Agronomy from the Programa de Pós-graduação em Agronomia (PPGA)  
Institution: Universidade Estadual Júlio de Mesquita Filho (UNESP)  
Address: Via de Acesso Prof. Paulo Donato Castellane, s/n, Jaboticabal – SP,  
CEP: 14884-900  
E-mail: tsgomes4@gmail.com

Marcio Aurélio Lins dos Santos  
Post-doctorate in Water Resources from the Programa de Pós-Graduação em Recursos Hídricos da Universidade Federal de Sergipe (PRORH - UFS)  
Institution: Universidade Federal de Alagoas (UFAL)  
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,  
CEP: 57309-005  
E-mail: mal.santo@arapiraca.ufal.br

Cicero Gomes dos Santos  
Doctorate in Agronomy from the Programa de Pós-Graduação em Agronomia da Universidade Federal Rural de Pernambuco (PGAGRO - UFRPE)  
Institution: Universidade Federal de Alagoas (UFAL)  
Address: Av. Manoel Severino Barbosa, Bom Sucesso, Arapiraca – AL,  
CEP: 57309-005  
E-mail: cgomes@arapiraca.ufal.br
ABSTRACT
Erosivity is the potential capacity of rainfall to cause soil erosion, causing environmental impacts that degrade the soil. This study aims to estimate the erosivity of rainfall and characterize the hydrological pattern of the Municipality of União dos Palmares, Alagoas. Rainfall data from 2 rainfall stations located in the city of União dos Palmares, Alagoas, were analyzed. Erosivity was evaluated by monthly and annual estimation models, the rainfall erosivity factor (R) and the hydrological pattern of rainfall. The results found that the erosivity presented an annual average Coefficient of Variation (CV) of 55.37. The municipality showed an average erosivity of approximately 3,699.91 MJ mm ha⁻¹ h⁻¹. The model designed by Bertoni & Lombardi Neto (1999) in December showed the highest erosivity 6,184.19 mm ha⁻¹ h⁻¹, while the model designed by Leprun (1981) in November showed the lowest average 2.69 MJ mm ha⁻¹ h⁻¹ over the evaluated years. The equations proposed by Rufino, Biscaia & Herten (1993) and Bertoni & Lombardi Neto (1999), used to estimate the erosivity of rainfall, showed the highest values when determining the erosivity of the municipality’s soils. It is necessary to apply techniques that reduce the erosivity factor of the soil, linked to the sustainable management of areas with greater vulnerability.

Keywords: erosivity, rainfall intensity, rainfall behavior.

RESUMO
A erosividade é a capacidade potencial das chuvas de provocar erosão do solo, provocando impactos ambientais que degradam o solo. O presente estudo tem como objetivo estimar a erosividade das chuvas e caracterizar o padrão hidrológico do Município de União dos Palmares, Alagoas. Foram analisados dados pluviométricos de 2 estações pluviométricas localizadas no Município de União dos Palmares, Alagoas. A erosividade foi avaliada por modelos de estimativa mensal e anual, o fator de erosividade da chuva (R) e o padrão hidrológico das chuvas. Os resultados constataram que a erosividade apresentou Coeficiente de Variação médio (CV) anual de 55,37. O município apresentou erosividade média de aproximadamente 3,699,91 MJ mm ha⁻¹ h⁻¹. O modelo idealizado por Bertoni & Lombardi Neto (1999) no mês de dezembro apresentou a maior erosividade 6,184,19 mm ha⁻¹ h⁻¹, já o modelo idealizado por Leprun (1981) no mês de novembro apresentou a menor média 2,69 MJ mm ha⁻¹ h⁻¹ no decorrer dos anos avaliados. As equações propostas por Rufino, Biscaia & Herten (1993) e Bertoni & Lombardi Neto (1999), utilizadas para estimar a erosividade das chuvas, apresentaram os maiores valores ao determinar a erosividade dos solos do município. Torna-se necessário a aplicação de técnicas que diminuam o fator de erosividade do solo, atrelado ao manejo sustentável das áreas com maior vulnerabilidade.

Palavras-chave: erosividade, intensidade da chuva, comportamento das chuvas.
1 INTRODUCTION

Soil loss processes are systematic, causing disaggregation, transport, and deposition of soil particles. These processes take place in a natural way, where the kinetic energy generated by heavy rainfall carries, through surface runoff, the disaggregated particles of the soil (BOARDMAN and POESEN, 2006). Soil erodibility is a natural process and one of the factors conditioned by different aspects related to soil and climate typology, characteristics and relief arrangement, which are intrinsic to the morphological structures and lithological composition of the terrain, which are influenced and soil erodibility intensified by human activities (AGUIAR, 2022) (2).

The slope of the land influences the loss of soil by water erosion, acting in a directly proportional manner, since, as it increases, it decreases the basic speed of water infiltration (VIB) in the soil and increases the volume and speed of the flurry. In this way, it promotes the transport of soil particles by the flood, with the deposition of sediments in the bed of the watercourses (COGO et al. 2003).

Studies have been carried out addressing the prevention of soil degradation by erosion, so mathematical hydrological modeling is a tool that has been used to evaluate soil management and conservation practices serving as a subsidy in agricultural planning (KINNELL, 2010).

For Lal and Elliot (1994) the emergence of eroded areas can be easily understood by the influence and capacity of the water coming from the rains to generate a process of soil disaggregation and transport through the surface runoff from higher areas to lower areas. Rainwater has a certain degree of energy depending on the size of the drops and the intensity of the precipitation, which contributes to the formation of soil erosive processes.

Morais et al. (1988) studied the correlation between erosion and soil loss, and found that the EI30 index is considered suitable for estimating the erosive potential caused by the action of rainfall in the State of Rio Grande do Sul (RS). Pinheiro et al. (2018) studied the spatialization and the correlation of erosion with soil loss, the authors observed that the EI30 index is highly efficient in estimating rainfall erosivity in the state of Pernambuco-PE.
In this sense, the present study aims to estimate the erosive potential of rainfall using mathematical models, evaluating the monthly and annual distribution of erosivity and identifying which mathematical models best represent erosivity for the municipality of União dos Palmares-AL.

2 MATERIAL AND METHODS

The Municipality of União dos Palmares is located in the North-Northeast region of the State of Alagoas in the Zone of Alagoana Forest, north of the capital, located at 7º 51' 13" latitude south and 35º 14' 10" longitude West of the Meridian of Greenwich (IBGE, 2020). It has a minimum approximate altitude of 67.40 meters and maximum approximate altitude of 606.57 meters with slope ranging from 0% to 51% (Figure 1), is inserted in five distinct geological units, in which the Belém do São Francisco Complex unit has greater representativeness with 67% of the area of the Municipality. As for the pedological aspect, the soil of the Municipality is represented by the Latossolos and Podzolics in the stopos of plateaus and residual tops; by the Podzolics with Fregipan, Podzolica Plíncticos and Podzóis in the small depressions in the trays; by the Concretionary Podzolics in dissected areas and slopes and Gleissols and Alluvial Soils in the areas of floodplains (MASCARENHAS et. al 2005; OLIVEIRA and ANTÔNIO, 20).
Data on pluviometrics were used, obtained through the conventional station of the hydroclimatological database of the Superintendence of Northeast Development (SUDENE, 1990). Analyzes, systematization and calculation of monthly and annual erosivity are carried out. The geographical location and altitude of the stations is illustrated in Table 1, with their respective data periods.

<table>
<thead>
<tr>
<th>Post</th>
<th>City</th>
<th>Latitude (S)</th>
<th>Longitude (W)</th>
<th>Altitude (m)</th>
<th>Years Observed</th>
<th>Series (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,887,392</td>
<td>Union of Palmares</td>
<td>09° 10' 00&quot;</td>
<td>36° 03' 00&quot;</td>
<td>155</td>
<td>1950-1985</td>
<td>35</td>
</tr>
<tr>
<td>3,887,393</td>
<td>Union of Palmares</td>
<td>09° 11' 00&quot;</td>
<td>36° 03' 00&quot;</td>
<td>155</td>
<td>1950-1985</td>
<td>35</td>
</tr>
</tbody>
</table>


2.1 RAIN COEFFICIENT ANALYSIS

Fournier's index is the variable that determines the conformity of models estimating soil erosivity indices, which was obtained by the following equation

\[ Rc = \frac{p^2}{P} \]  

(1) (2)

Where:

\( Rc \) = Rain coefficient (mm) for the month in question;
\( p^2 \) = Average monthly precipitation (mm);
\( P \) = Annual average rainfall (mm).

2.2 DETERMINATION OF RAIN EROSIVITY

There are some models used to determine the erosivity of rain for different regions of the Brazilian territory developed by the highlighted authors (Table 2), these models presented good relations with linear equations. The test of these models aimed to verify which shows the best performance in the estimation of erosivity. These equations were used to determine the monthly and annual values of erosivity based on the literature.

<table>
<thead>
<tr>
<th>Number</th>
<th>Templates</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>[ EI = 67.355 \left( \frac{M_x^2}{P} \right)^{0.85} ]</td>
<td>Bertoni &amp; Lombardi Neto (1999)</td>
</tr>
<tr>
<td>2.</td>
<td>[ R_x = 3.76 \times \left( \frac{M_x^2}{P} \right) + 42.77 ]</td>
<td>Oliveira Junior &amp; Medina, (1990)</td>
</tr>
<tr>
<td>3.</td>
<td>[ R_x = 36.846 \times \left( \frac{M_x^2}{P} \right)^{1.0852} ]</td>
<td>Morais et al. (1991)</td>
</tr>
<tr>
<td>4.</td>
<td>[ R_x = 0.13 \times \left( \frac{M_x^{1.24}}{P} \right) ]</td>
<td>Leprun (1981)</td>
</tr>
<tr>
<td>5.</td>
<td>[ Rx = 19.55 + (4.20 \times M_x) ]</td>
<td>Rufino, Biscay &amp; Herten (1993)</td>
</tr>
<tr>
<td>6.</td>
<td>[ R_x = 12.592 \times \left( \frac{M_x^2}{P} \right)^{0.6030} ]</td>
<td>Val et al. (1986).</td>
</tr>
</tbody>
</table>


Where:
IS is the monthly average of the erosion index, in MJ mm ha\(^{-1}\) h\(^{-1}\) month
P is the average annual precipitation in mm.
Rx is the R-factor (MJ mm ha\(^{-1}\) h\(^{-1}\) month\(^{-1}\)).
Mx is the average monthly precipitation depth (mm).

The average annual rainfall erosivity index of a given site (R) used for the models covered in the study was estimated as the sum of the values of the monthly average rainfall erosivity indices (BERTONI and LOMBARDI NETO, 1999; BERTOL, 1993). In order to obtain a reliable R-factor, data of at least 30 years were used (WISCHMEIER and SMITH 1978; PRUSKI, 1996; CASSOL et al. 2008). The results obtained were classified in accordance with the classes proposed by Carvalho (2008) shown in Table 3.

Table 3. Ranges of R, with their denominations of the classes corresponding to each range.

<table>
<thead>
<tr>
<th>Ranges of R</th>
<th>Erosivity class</th>
</tr>
</thead>
<tbody>
<tr>
<td>R ≤ 2 452</td>
<td>Poor erosivity</td>
</tr>
<tr>
<td>2 452 &lt; R ≤ 4 905</td>
<td>Moderate erosiveness</td>
</tr>
<tr>
<td>4 905 &lt; R ≤ 7 357</td>
<td>Moderate to strong erosivity</td>
</tr>
<tr>
<td>7 357 &lt; R ≤ 9 810</td>
<td>Strong erosivity</td>
</tr>
<tr>
<td>R &gt; 9 810</td>
<td>Very strong erosivity</td>
</tr>
</tbody>
</table>

Source: Carvalho, 2008.

2.3 DESCRIPTIVE STATISTICS

After the application of these models in the data sets of the rainfall stations, the data were processed with the help of the Microsoft Office Excel 2013 software, in order to perform the descriptive statistics of the results of precipitation and erosivity, such as: average, standard deviation (SD), coefficient of variation (CV), maximum and minimum. In addition, the correlations between precipitation and erosivity were performed using the same software.

3 RESULTS AND DISCUSSION

3.1 SPATIAL AND TEMPORAL CLASSIFICATION OF PRECIPITATION AND EROSIVITY OF RAIN MONTHLY

Figure 2 shows that the models proposed by Oliveira Junior; Medina, (1990), Leprun (1981), and Val et al. (1986), (Figure 2 B, D and F), respectively, presented the lowest values of erosivity. The monthly precipitation data from the meteorological
stations of União dos Palmares provided evidence of the average erosivity indices for the different models studied in a range of 66 years from 1913 to 1985.

It was observed that the highest values of erosivity for the analyzed series were in the months of April, May, June and July, corroborating with the high intensity of rainfall in these months, corresponding to approximately 74% of the annual erosive potential. It is also possible to identify that erosivity is low in the months corresponding to the early autumn, spring and summer seasons. This is due to the low rainfall recorded during the period studied.

Analyzing Figures 2 and 3, it was noted that all models indicated that the month of June is responsible for the highest average of erosivity throughout the year with approximately 21%, that is, it is the month with the greatest susceptibility to soil losses due to erosive processes arising from rainfall caused by the climatic characteristics of the Municipality of União dos Palmares. This can be explained by the amount of heavy rainfall during the month of June, resulting in the direct impact of the drops on the surface layer of the uncovered and sloping soil, thus increasing the disaggregation of soil particles, initiating soil erosion (PINHEIRO et al, 2018; GUERRA, 2001).
3.2 SPATIAL AND TEMPORAL DISTRIBUTION OF RAINFALL AND EROSIVITY OF ANNUAL RAIN

Figure 3 shows the rainfall and average annual erosivity distributed to the Municipality of União dos Palmares. Note that the erosive potential of the rainfall is directly associated with the rainfall volume incident in the study area, this fact can be observed by the variations of the results present in Figure 4, as well as Figures 5 and 6.
In the time range analyzed, the average annual rainfall index in União dos Palmares, AL, was 1064.55 mm. The year 1978 was the year with the highest rainfall, with a total precipitation of 1584.2 mm, while the year with the lowest rainfall was 1952, with 588.6 mm of rain. Divergent results were observed in one of the studies by Mazurana et al. (2009), which identified erosivity, noting hydrological patterns, the return interval and probability in which precipitation ran, thus generating a degree of erosion, using rainfall data for the years 1975 to 2003.

It is observed that in the mid-70s there is a high volume of rainfall and, consequently, Erosivity has a proportional response to precipitation, this proportionality is observed, on average, throughout the period studied. The aforementioned proportionality of erosivity associated with rainfall volume was also observed by Pinheiro et al. (2018) when characterizing the spatial and temporal variability of the hydrological pattern and the potential occurrence of erosive processes due to precipitation in the State of Pernambuco.

The results of the annual variability of the Rainfall Erosivity for União dos Palmares differ slightly from the results found by Pinheiro et al. (2018) in the State of Pernambuco, the authors found that from the month of January there is a high precipitated volume and, therefore, the erosivity index EI30, was considered high, this fact, which extends, on average, throughout the year.
3.3 RAIN EROSIVITY

Erosivity was estimated and was evidenced in the (Figure 4 B, D and F), in which there is only one classification "Weak Erosivity" for the whole period studied. This is supported by the low correlation coefficients obtained by both models with $R^2$ equal to 0.78, 0.76 and 0.65, respectively.

Figure 4, represents the correlation between the monthly average erosivity and the monthly precipitation for the Municipality of União dos Palmares. It was found that
among the models studied, the models of estimation of erosivity proposed by Rufino, Biscay and Herten (1993) and Bertoni and Lombardi Neto (1999) showed the greatest correlations with R² equal to 0.99 and 0.97, respectively. However, in spite of the high correlations between the two models, the analysis of Erosivity presented values that were in contrast with each other, with amplitudes of 4181.52 and 6184.58 MJ mm ha⁻¹ month⁻¹, respectively. On the other hand, the models proposed by Oliveira Junior; Medina, (1990), Val et al. (1986) and Leprun (1981) show the lowest correlations with R² equal to 0.78, 0.65, indicative of low quality of the model adjustment. It should be noted, that the other models showed satisfactory data correlation with R² higher than 0.94.

The high correlation coefficient obtained in this work fundamentally shows that the models proposed mainly by Rufino, Biscay; Merten (1993), Bertoni; Lombardi Neto (1999) are valid and indicated for estimating erosivity by the rainfall method with the rainfall data of the Municipality of União dos Palmares.

Waltrick et al. (2015) found in one of their studies where they estimated and revalidated the annual erosivity of rainfall occurrence in the state of Paraná by means of the model devised by Rufino, Biscay; Merten (1993), using a series of rainfall data from 1986 to 2008, found correlations that corroborate with this work with R² higher than 0.90. However, a low correlation between rainfall and rainfall was observed in studies in the Santa Rosa region, State of Rio Grande do Sul (MAZURANA et al., 2009).

According to Pinheiro et al. (2018), Wischmeier; Smith (1978) the erosivity of annual rainfall is highly dependent on the total rainfall of the region, as well as secondary factors such as the type of soil, type of cover and slope of the terrain. In these terms, it can be stated that the susceptibility to erosion follows a pattern, that is, the behavior of erosivity follows the pattern of the rainfall indices, consequently, it shows a greater incidence in regions with a poor distribution of rainfall, with heavy rainfall in a short period of time, as is the case of the State of Alagoas, a region where monoculture predominates, as well as large areas destined to pasture.
Figure 4. Correlation between average erosivity and precipitation for the Municipality of União dos Palmares. A, model proposed by Bertoni & Lombardi Neto (1999); B, model proposed by Oliveira Junior & Medina, (1990); C, model proposed by Morais et al, (1991); D, model proposed by Leprun (1981); E, model proposed by Rufino, Biscaia & Herten (1993) and F, model proposed by Val et al. (1986)

Source: Authors, 2023.

3.4 DETERMINATION OF THE NUMBER OF EROATIVE DAYS

Figure 5 shows the average number of erosive rains of each model studied for the Municipality of União dos Palmares, in the periods sampled. It was found that the models proposed by Oliveira Junior and Medina (1990) and Leprun (1981) showed a tendency to underestimate the levels of erosivity of rain, thus causing a single classification "Weak erosivity" for the whole period studied (Figure 7). Mazurana et al. (2009) also reported an underestimation of erosivity values using models of rainfall erosivity analysis.
It is observed that the model devised by Morais et al., (1991) stands out from the others with the highest average number of erosive events (moderate to strong erosivity, strong erosivity and very strong erosivity) with approximately 60 events during the period studied. This fact indicates that the model tends to overestimate the levels of erosivity of rain. Pinheiro et al. (2018), when studying the hydrological pattern and erosive potential of rainfall in the State of Pernambuco, found that the municipalities of Barreiros and Olinda stand out from the other municipalities with the highest average number of erosive events with approximately 46 and 48 events, respectively.

Figure 5. Average number of erosive rains for the Municipality of União dos Palmares, in the periods sampled. A, model proposed by Bertoni & Lombardi Neto (1999); B, model proposed by Oliveira Junior & Medina, (1990); C, model proposed by Morais et al, (1991); D, model proposed by Leprun (1981); E, model proposed by Rufino, Bicaia & Herten (1993) and F, model proposed by Val et al. (1986)

Source: Authors, 2023.
3.5 DESCRIPTIVE STATISTICS AND RAIN COEFFICIENT

Table 3 represents the rainfall erosivity data of the studied models, based on the rainfall data series of the stations of the Municipality of União dos Palmares, with the respective descriptive statistics.

According to the results obtained, there is a great variability in the Erosivity of the rains between the months and years evaluated. Erosivity is observed to have a monthly and annual average coefficient of variation (CV) of 5.68% and 6.44%. Erosivity presents mean monthly and annual Standard Deviation (SD) of 218.78 and 4077.83, respectively, for the entire study area. The largest amplitude of the Coefficient of Variation and DP is 596.41% and 2487.62, respectively, occurring for both statistical indices between November and December.

The average rainfall coefficients (Rc) obtained for the months of the year by the mathematical models studied, based on the Fournier coefficient (1966) [12] which establishes a correlation between monthly rainfall values for an annual period, the determination of this coefficient was carried out for the series of 66 years (1913 to 1985) for the rainfall data of the Municipality of União dos Palmares, AL.

The distribution of the rainfall coefficient (Rc) analyzed related to the municipality is similar to the way the distribution of rainfall occurs, it is evident that the largest records of rainfall take place in the months of April, May, June and July (Table 4). Bazzano et al. (2010), noted in one of their works on the characteristics of rainfall in Rio Grande, RS, results that were similar in the occurrence of this phenomenon. Lombardi Neto and Moldenhauer, (1992); Mazurana et al. (2009) described results that also corroborate the results obtained in this research for the values of rain coefficient.

Pinheiro et al, (2018), characterizing the spatial and temporal variability of the hydrological pattern and the erosive potential of rainfall in the State of Pernambuco, observed that the values of the Coefficient of Variation were significantly higher than those of this study (CV= 52.6%), in contrast, the authors obtained values of Standard Deviation significantly lower than those of this study (2517.9). Barbosa et al. (2014) observed the distribution of the hydrological pattern in the Northeast region of Brazil,
finding that the intensity and concentration of rainfall in specific areas in certain months of the year can substantially affect its potential erosion.
Table 3. Monthly, annual and monthly average values of erosivity (MJ mm ha\(^{-1}\) month\(^{-1}\)) of the models studied for the Municipality of União dos Palmares, with the respective descriptive statistics.

<table>
<thead>
<tr>
<th></th>
<th>JAN</th>
<th>FEB</th>
<th>SEA</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>TEN</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Template 1</td>
<td>43.57</td>
<td>128.28</td>
<td>727.00</td>
<td>1030.91</td>
<td>1166.02</td>
<td>1073.05</td>
<td>400.47</td>
<td>137.22</td>
<td>15.17</td>
<td>14.</td>
<td>12.08</td>
<td>6,184.19</td>
<td>10932.04</td>
</tr>
<tr>
<td>Template 2</td>
<td>44.44</td>
<td>46.69</td>
<td>55.34</td>
<td>104.55</td>
<td>136.75</td>
<td>150.00</td>
<td>139.92</td>
<td>73.13</td>
<td>52.10</td>
<td>43.34</td>
<td>43.35</td>
<td>43.38</td>
<td>932.98</td>
</tr>
<tr>
<td>Template 3</td>
<td>15.26</td>
<td>38.50</td>
<td>136.85</td>
<td>768.41</td>
<td>1211.60</td>
<td>1255.95</td>
<td>355.46</td>
<td>98.76</td>
<td>4.74</td>
<td>4.88</td>
<td>5.</td>
<td>5.293.44</td>
<td></td>
</tr>
<tr>
<td>Template 4</td>
<td>5.54</td>
<td>10.70</td>
<td>18.44</td>
<td>55.34</td>
<td>63.49</td>
<td>76.45</td>
<td>74.40</td>
<td>36.41</td>
<td>15.58</td>
<td>3.40</td>
<td>2.69</td>
<td>2.82</td>
<td>365.25</td>
</tr>
<tr>
<td>Template 5</td>
<td>106.07</td>
<td>166.76</td>
<td>247.82</td>
<td>573.53</td>
<td>638.42</td>
<td>738.38</td>
<td>414.77</td>
<td>218.84</td>
<td>77.93</td>
<td>67.85</td>
<td>69.74</td>
<td>4,042.95</td>
<td></td>
</tr>
<tr>
<td>Template 6</td>
<td>7.71</td>
<td>12.90</td>
<td>25.90</td>
<td>68.10</td>
<td>87.70</td>
<td>262.60</td>
<td>89.47</td>
<td>44.37</td>
<td>21.78</td>
<td>4.</td>
<td>4.10</td>
<td>4.17</td>
<td>632.83</td>
</tr>
<tr>
<td>Rc</td>
<td>0.45</td>
<td>1.31</td>
<td>3.15</td>
<td>18.55</td>
<td>23.16</td>
<td>31.27</td>
<td>29.92</td>
<td>9.44</td>
<td>2.40</td>
<td>0.20</td>
<td>0.14</td>
<td>0.15</td>
<td>120.19</td>
</tr>
<tr>
<td>PA</td>
<td>37.92</td>
<td>64.85</td>
<td>271.36</td>
<td>417.95</td>
<td>537.81</td>
<td>541.94</td>
<td>467.68</td>
<td>166.20</td>
<td>79.49</td>
<td>30.24</td>
<td>26.99</td>
<td>2,514.61</td>
<td>4,077.83</td>
</tr>
<tr>
<td>CV</td>
<td>4.92</td>
<td>5.</td>
<td>10.48</td>
<td>6.14</td>
<td>6.13</td>
<td>2.06</td>
<td>5.23</td>
<td>3.75</td>
<td>3.65</td>
<td>7.51</td>
<td>6.59</td>
<td>603.00</td>
<td>644</td>
</tr>
<tr>
<td>Medium</td>
<td>29.42</td>
<td>42.59</td>
<td>96.09</td>
<td>339.04</td>
<td>387.59</td>
<td>500.49</td>
<td>270.20</td>
<td>105.18</td>
<td>36.94</td>
<td>9.40</td>
<td>8.48</td>
<td>24.23</td>
<td>2487.96</td>
</tr>
<tr>
<td>Median</td>
<td>29.42</td>
<td>42.59</td>
<td>96.09</td>
<td>339.04</td>
<td>387.59</td>
<td>500.49</td>
<td>270.20</td>
<td>105.18</td>
<td>36.94</td>
<td>9.40</td>
<td>8.48</td>
<td>24.23</td>
<td>2487.96</td>
</tr>
<tr>
<td>Max</td>
<td>106.07</td>
<td>166.76</td>
<td>727.00</td>
<td>1030.91</td>
<td>1211.60</td>
<td>1255.95</td>
<td>414.77</td>
<td>218.84</td>
<td>77.93</td>
<td>67.85</td>
<td>6184.19</td>
<td>10932.04</td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>5.54</td>
<td>10.70</td>
<td>18.44</td>
<td>55.34</td>
<td>63.49</td>
<td>76.45</td>
<td>74.40</td>
<td>36.41</td>
<td>15.17</td>
<td>3.40</td>
<td>2.69</td>
<td>2.82</td>
<td>365.25</td>
</tr>
</tbody>
</table>

Rc: Fournier's index; SD: standard deviation; CV: coefficient of variation; Max: maximum value. Min: minimum value.

Source: Authors, 2023.
4 CONCLUSION

The models proposed by Rufino, Biscay and Herten (1993) and Bertoni and Lombardi Neto (1999) estimated erosivity and showed a good correlation coefficient with $r^2$ equal to 0.99 and 0.97, respectively, allowing a good adjustment of the equation for the determination of erosivity caused by the action of rainfall in the region, demonstrating that the indices with the highest erosivity values were observed in the months that coincide with the months of the greatest occurrence of rains of the year.

The models proposed by Oliveira Junior, Medina and Leprun (1981) tended to underestimate the values of erosivity of rain, inferring in a single classification "weak erosivity" for the whole period studied.

It was noted that the months of April to July are characterized by the occurrence of rainy events with high capacity to provoke erosion in the soil, being the month of June the highest average month during the year. Because of this, attention should be paid to the use of measures that aim at an adequate management of the soil by applying conservationist techniques, promoting the reduction of soil degradation in areas more prone to erosion in the municipality.
REFERENCES


