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# SAZONAL AND INTERANUAL RAINFALL VARIABILITY FOR COLATINA, ESPIRITO SANTO, BRAZIL

*Variabilidade sazonal e interanual da chuva para Colatina, Espírito Santo, Brasil*

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**Abstract** – Rain is one of the climatic elements that exert greater influence on environmental conditions. The frequency of rainfall distribution follows annual trends, and can therefore be based on historical data. This study aimed to evaluate the frequency and intensity of rainfall in the city of Colatina, State of Espírito Santo, from 2000 to 2015, using statistical techniques of exploratory data analysis. Based on these results, it was found that the total annual rainfall average for the series analyzed was 1029.9 mm, revealing the existence of a Z negative trend of -4.98 of annual rainfall by the Mann-Kendall test. It was possible to identify, with the Pettitt test, abrupt change of annual rainfall in relation to the average of the studied period from the year 2013. The water balance resulted in ten months of soil water deficit with a total annual of 350.9 mm and the surplus occurred in November and December with 27.8 mm. It is concluded that the continuation of this downward trend in rainfall totals in the city could result in impacts on economic activities, environment and society.

**Keywords** – climate, drought index, trend analysis.

**Resumo** – A chuva é um dos elementos climáticos que exerce maior influência sobre as condições ambientais. A frequência da distribuição da chuva segue tendências anuais, podendo-se assim, ser realizadas com base em dados históricos. Este trabalho teve por objetivo realizar uma avaliação da frequência e da intensidade da chuva no município de Colatina, Estado do Espírito Santo, no período de 2000 a 2015, utilizando técnicas estatísticas de análise exploratória de dados. Com base nos resultados encontrados, constatou-se que a média dos totais anuais de chuva para a série analisada foi de 1029,9 mm, revelando a existência de uma tendência negativa Z de -4,98 da chuva anual pelo teste de Mann-Kendall. Foi possível identificar, com o teste de Pettitt, mudança brusca da precipitação anual em relação a média do período estudado a partir do ano de 2013. O balanço hídrico resultou em dez meses de deficiência hídrica no solo com total anual de 350,9 mm e o excedente ocorreu nos meses de novembro e dezembro com 27,8 mm. Conclui-se que, a continuidade dessa tendência de diminuição dos totais pluviométricos no município poderá resultar em impactos nas atividades econômicas, meio ambiente e sociedade.

**Palavras-chave** – clima, índice de seca, análise de tendência.

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## INTRODUCTION

Studies on trend and climate variability gain importance at a time when discussions on climate change are happening at the most varied intensities (GALVANI et al., 2016). The Intergovernmental Panel on Climate Change (IPCC) claims that the climate changes taking place will affect housing, human health, agriculture, ecosystems and the security of the world population (IPCC, 2014).

Rainfall is one of the most important climatic elements, as it directly influences agricultural and hydrological planning, transport, tourism and many other sectors. For Reichert and Gomes (2013) the weather most of the time has been responsible for the success or failure of the agricultural production, due to the lack or excessive rains. Delgado and Souza (2014) report that the rain is a determining factor in the characteristics of the region, such as the type of vegetation, agricultural activities in power generation, among others.

Rainfall is also responsible for the occurrence of extreme events that occur mainly as storms and prolonged droughts. These events are the main cause of the natural disasters that have occurred in recent years, directly affecting the population (MARENGO et al., 2010).

Carvalho et al. (2013) state that the availability of water in a region is directly related to the frequency and magnitude of rainfall events. In addition, the higher incidence of days characterized as dry can cause many losses, especially for agriculture. According to Hay (2007) disruption of agricultural activities, soil moisture saturation, as well as runoff and surface erosion are among the main impacts caused by extreme rainfall. The drought stands out as the main meteorological adversity that can affect agricultural activities, (BLAIN; KAINAO, 2011) with its intensity influenced by the physiographic characteristics, such as soil, topography, vegetation and meteorological conditions (SILVA et al., 2013).

According to Minuzzi et al. (2007), Southeast Brazil presents a great climatic diversity, as a consequence of its topography, geographical position and, above all, the dynamic aspects of the atmosphere. The period of highest incidence of rainfall in the Southeast usually occurs between October and March, presenting approximately 80% of the annual total (ALVES et al., 2005). On the other hand, the municipality of Colatina is located in the Southeast region of Brazil to the northwest of the state of Espírito Santo, and is characterized by the irregularity of the rains and occurrence of high temperatures (BUSATO et al., 2011).

In this context, since rainfall is a determining factor in agricultural productivity, a change in its distribution can positively or negatively affect it. Therefore, a more in-depth assessment of the rainfall series behavior becomes of fundamental importance. Thus, the objective of this work was to analyze the temporal variability of drought and rain periods in the Municipality of Colatina, in order to know the frequency and distribution of rainfall, aiming to contribute to a better utilization of rural areas.

## MATERIAL AND METHODS

The study was developed out in the city of Colatina located in the State of Espírito Santo at 19 ° 32 '22 "S; 40 ° 37 '50 "W and altitude of 71 meters (Figure 1). The climate of the region is Tropical Aw, according to the climatic classification of Köppen and is characterized by irregular rainfall and high air temperatures (PEEL; FINLAYSON; MCMAHON, 2007). Daily rainfall data were used and mean air temperature of 16 years (2000 to 2015) were used. The rainfall data were provided by the weather station of the Colatinense Environmental and Sanitation Service (SANEAR), linked to the Capixaba Institute for Research Technical Assistance and Rural Extension (INCAPER), and the air temperature data were obtained through National Centers for Environmental Prediction NCEP / NCAR (KALNAY, 1996).

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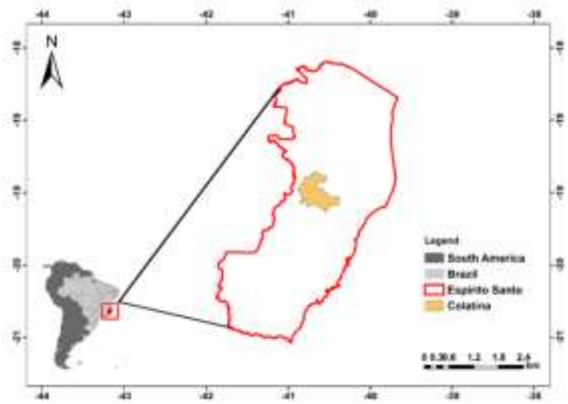

Figure 1. Location of the study area.

Analisys of rainfall behavior was carried out resulting in the monthly values (average, maximum, minimum) of total days with rain and days without rain, seeking to characterize the periods of maximum and minimum rainfall frequency occurred in a year; frequency of accumulated rainfall in the month; frequency of rainy days occurred in the month, showing how many days it rained in the given month and frequency of rainy days accumulated in the year.

The annual variability of rainfall was performed by analysis of the deviations of annual rainfall averages. The frequency analysis of the distribution of the total annual rainfall was characterized using the method proposed by Meister et al. (1981). A variation scale of 25% over the mean for the intermediate months was used; values above the scale were considered as very rainy years and below 25% as dry years.

The beginning and end of the rainy season was determined based on the criterion established by Kassam (1979), according to Equations 1 and 2.

$$Pi > \frac{ETPi}{2} = Ii \quad (1)$$

$$Pi < \frac{ETPi}{2} = Fi \quad (2)$$

Where: Pi is the pluviometric precipitation of the month i (mm); ETPi is the potencial evapotranspiration for month i (mm); I*i* Is the beginning of the rainy season and growth; F*i* it is the end of rainy season.

The dry index was evaluated for the dry (April to September) and rainy (October to March) seasons of the region by the method of Moreno (1994) according to Equation 3.

$$I = \left(\frac{p-P}{P}\right) \quad (3)$$

Where: I is the dryness index; p the total rainfall of the dry or rainy period (mm) and; P the average rainfall in the period - climatological average (mm).

The classification of the drought intensity followed the following criteria: I ≥ - 0,2 (normal situation); -0.2> I≥0.4 (moderate drought); -0.4> I ≥ -0.6 (intense dry) and I> -0.6 (extreme dry).

For the trend analysis of the rainfall series, monthly data were taken from January to December, to which they were submitted to the Mann-Kendall non-parametric statistical test. The Mann-Kendall test (MANN, 1945; KENDALL, 1975) considers that, in the case of stability of a time series, the succession of values occurs independently and the probability distribution must always remain the same (random series).

Considering a time series of Yi of n terms (1 ≤ i ≤ n); The test statistic is given by Equation 4:

$$S = \sum_{j=i+1}^{n} \text{sinal}\left(Y_j - Y_i\right) \quad (4)$$

Where: Signal(x) = 1 for x > 0; Signal(x) = 0 for x = 0; Signal(x) = -1 for x < 0.

For series with a large number of terms (n), under the null hypothesis (H0) of absence of trend, S has a normal distribution with zero mean and variance, according to Equation 5:

$$\text{Var}(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p\left(t_p - 1\right)\left(2t_p + 5\right)\right] \quad (5)$$

From the statistical analysis Z the decision is made to accept or reject Ho, that is, one can confirm the hypothesis of stability of the data or reject it in favor of the alternative hypothesis (of existence of trend in the data). The sign of the Z statistic indicates whether the trend is increasing (Z> 0) or decreasing (Z <0).

Testing the statistical significance of S for the null hypothesis using a bilateral test, this can be rejected

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for large values of the Z statistic, which is given by Equation 6:

$$Z = \begin{cases} S-1/[\mathrm{Var}(S)]^{1/2} & \text{se } S>0 \\ 0 & \text{se } S=0 \\ S+1/[\mathrm{Var}(S)]^{1/2} & \text{se } S<0 \end{cases} \qquad (6)$$

For the Mann-Kendall test, significance level α = 0.05 = 5% was used. If the probability p of the test is lower than the level α, p <α, there is a significant trend while a value of p> α confirms an insignificant trend. For samples where there are no trends, the value of Z is close to zero (FERRARI et al., 2012; DELGADO et al., 2012; MANN, 1945; KENDALL, 1975).

Pettitt's non-parametric statistical test (PETTITT, 1979) uses a version of the Mann-Whitney test, where it is verified whether two samples X1, ... Xt and Xt + 1, ...., XT are from the same population.

The statistical Ut, T makes a count of the number of times a member of the first sample is greater than the second member. This statistic locates the point where there was a sudden change in the mean of a time series, according to the Equation 7.

$$U_{t,T} = U_{t-1,T} + \sum_{j=1}^{T} \mathrm{sgn}(X_i - X_j) \qquad (7)$$

for t = 2, ..., T

Where: sgn (x) = 1 for x > 0; sgn (x) = 0 for x = 0; sgn (x) = -1 for x < 0.

From this, the statistic Ut, T is then calculated for the values of 1 <t <T, and the Pettitt test statistic k (t) by means of the Equation 8:

$$k(t) = MAX_{1 \le t \le T} \left| U_{t,T} \right| \qquad (8)$$

This method locates the point where there was a sudden change in the mean of a time series, in which its significance can be described by Equation 9:

$$p \cong 2\exp\left\{ \frac{-6k(t)^2}{(T^3 + T^2)} \right\} \qquad (9)$$

The abrupt change point is the value for t where the maximum of K (t) occurs, calculated with the following Equation 10:

$$K_{crit} = \pm\sqrt{\frac{-\ln\left(\frac{p}{2}\right)(T^3 + T^2)}{6}} \qquad (10)$$

Statistical procedures were performed using Microsoft Office Excel® 2010 software and the open source R program (R Core Team, 2016). Calculations of potential evapotranspiration and climatological water balance were performed according to the method of Thornthwaite and Mather (1955). These calculations were performed using Excel spreadsheet created by Rolim et al. (1998). When applying this method, it was considered that the water capacity available in the field (CAD) of 100 mm, being this representative value for agricultural plants in general (CAMARGO, 1971; TUBELIS; NASCIMENTO, 1983).

## RESULTS AND DISCUSSION

Table 1 shows that the monthly average ranged from 16.8 mm to 230.5 mm and maximum rain ranged from 48.8 mm to 603.7 mm. The aforementioned value of 603.7mm, found in December 2013 is due to the high rainfall recorded in the northwestern region of Espírito Santo, in areas within the Rio Doce river basin, as a consequence of the formation and prolonged permanence of one Intense South Atlantic Convergence Zone (SACZ) (INMET, 2013).

The driest months are the months of April to September, with average rainfall below 60.0 mm while the highest rainfall concentration is between November and January, with averages above 130.0 mm. The highest monthly records observed were found in December, which presented maximum accumulations above 600.0 mm. Also in relation to rainfall totals, in the months of July, August and September, there were months without rain records.

It can also be observed that the average number of rainy days varies from 5.2 days in July (minimum) to 14.1 days in the month of December (maximum). In the dry months, an average of 5.2 to 6.9 rainy days is observed, and in the rainy months 13.2 to 14.1 rainy days are observed. The maximum number of rainy days was registered in the month of November with 24 days. In the dry months, maximum numbers of 12 to 17 rainy days were recorded. However, the maximum number of

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days without rain ranged from 25 to 29 days in the rainy months, thus highlighting the large rainfall variability in the municipality under study.

**Table 1. Monthly values of rainfall (medium, maximum and minimum), rainy and dry days, in Colatina-ES, from 2000 to 2015.**

| | Rainfall totals | | | Rainy days | | | Dry days | | |
|---|---|---|---|---|---|---|---|---|---|
| | Medium | Maximum | Minimum | Medium | Maximum | Minimum | Medium | Maximum | Minimum |
| JAN. | 133.5 | 241.2 | 0.7 | 13.2 | 21.0 | 2.0 | 17.8 | 29.0 | 10.0 |
| FEB. | 87.7 | 246.0 | 2.0 | 9.1 | 14.0 | 1.0 | 19.2 | 27.0 | 14.0 |
| MAR. | 113.3 | 304.2 | 35.6 | 11.6 | 19.0 | 3.0 | 19.4 | 28.0 | 12.0 |
| APR. | 54.2 | 106.8 | 20.9 | 9.1 | 18.0 | 3.0 | 20.6 | 28.0 | 12.0 |
| MAY. | 48.8 | 216.8 | 1.6 | 6.8 | 17.0 | 1.0 | 24.2 | 30.0 | 14.0 |
| JUN. | 26.1 | 127.0 | 0.8 | 5.9 | 16.0 | 1.0 | 24.2 | 29.0 | 14.0 |
| JUL. | 16.8 | 48.8 | 0.0 | 5.2 | 12.0 | 0.0 | 25.7 | 31.0 | 18.0 |
| AGO. | 25.6 | 124.3 | 0.0 | 6.9 | 21.0 | 0.0 | 24.1 | 31.0 | 10.0 |
| SEP. | 34.5 | 143.3 | 0.0 | 6.9 | 15.0 | 0.0 | 23.2 | 30.0 | 15.0 |
| OCT. | 84.8 | 326.5 | 10.3 | 8.8 | 19.0 | 3.0 | 22.1 | 28.0 | 12.0 |
| NOV. | 174.6 | 310.7 | 36.5 | 13.6 | 24.0 | 5.0 | 16.4 | 25.0 | 6.0 |
| DEC. | 230.5 | 603.7 | 48.7 | 14.1 | 21.0 | 5.0 | 16.8 | 26.0 | 10.0 |

The average rainfall is not one of the most efficient parameters, however, it is important to highlight the data presented in Figure 2, where it is possible to observe the low monthly average winter rates, from the series 2000 to 2015, with values varying from 16.8 mm to 26.1 mm. The year 2015 is shown separately on the bar chart by the color red, in which it is notorious that its values were below the historical average, except for the month of March with 125 mm, 12 mm more than the average.

In the present study, it was observed that the months of April to September represented the dry period with 19.9% of the total rainfall in the year, in other words, the rains that occurred in that period in Colatina have little contribution to the total rainfall regime. On the other hand, the months October to March represented the rainy season with 80% of the total rainfall, and the months of November and December were responsible for 405 mm, considered the wettest months.

At the State level, Uliana et al. (2013), identified two distinct periods for Espírito Santo: the first between October and April, which concentrates much of the precipitation, and the second between May and September, with a marked decrease in rainfall. For Cavalcanti et al., (2009); Mendonça and Danni-Oliveira (2007), the concentrated rainfall that occurs in this region, from October to March, are characteristic of tropical climates, mainly by the performance and maintenance of the ZCAS on the region.

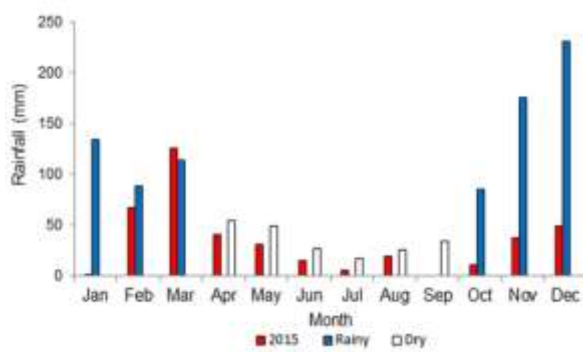


**Figure 2. Monthly average rain in the dry and rainy season, for the city of Colatina-ES, from 2000 to 2015.**

The variability was also expressed in the dry, rainy, or normal, according to the deviation from the mean (Table 2). In all 16 years, 11 were classified as normal, 2 years as very rainy, and 3 as very dry, the last two years being evaluated as very dry. Thus, more than

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65% of the evaluated years were normal. In the first five years, prevailed normal occurrences years (2000-2004), followed by a very wet year (2005), normal (2006) and a very dry (2007). Then, another five years of normal rainfall occurred again, four of them, with variation below 12%. This variation in rainfall behavior reflects the atmospheric dynamics of the region, marked by intense atmospheric variability, with the main activity of the Intertropical Convergence Zone (ZCIT) and, more rarely, the frontal systems (SF) that reach the region with low intensity. It should be noted that the last 3 years evaluated (2013-2015) were characterized by anomalies, being a very rainy year, followed by two very dry years, with a deviation to 2015 above 60%, being this year registered by the National Oceanic And Atmospheric Administration (NOAA, 2016) as the occurrence of a strong El Niño.

**Table 2. Total annual rainfall series (2000-2015). Characterization of the year according to the method proposed by Meis et al. (1981).**

| Year | Total (mm) | Deviation (%) | Characterization |
|---|---|---|---|
| 2000 | 1075.8 | 4.5 | Normal |
| 2001 | 1113.4 | 8.1 | Normal |
| 2002 | 1176.7 | 14.3 | Normal |
| 2003 | 861.2 | -16.4 | Normal |
| 2004 | 1117.6 | 8.5 | Normal |
| 2005 | 1496.5 | 45.3 | Rainy |
| 2006 | 1107.7 | 7.6 | Normal |
| 2007 | 563.2 | -45.3 | Dry |
| 2008 | 1147.0 | 11.4 | Normal |
| 2009 | 1104.1 | 7.2 | Normal |
| 2010 | 1032.6 | 0.3 | Normal |
| 2011 | 1218.5 | 18.3 | Normal |
| 2012 | 911.5 | -11.5 | Normal |
| 2013 | 1462.8 | 42.0 | Rainy |
| 2014 | 691.4 | -32.9 | Dry |
| 2015 | 397.7 | -61.4 | Dry |

Figure 3 shows the historical averages of rainfall occurring in the period from 2000 to 2015, where there is a great oscillation of the annual rainfall regime, accompanied by a decreasing linear trend in rainfall patterns. Using the Mann-Kendall test, a value of Z = -4.98 was obtained, indicating a negative trend of annual rainfall totals in Colatina, with a value of p = 0.01, thus showing that the series presents A statistically significant trend of decreasing in their behavior. Penereiro et al. (2013), analyzing data records from 1991 to 2011 in Vitoria-ES, using the Mann-Kendall test, found no evidence of changes in rainfall behavior over the years. Salviano et al. (2016), using spatially distributed data prepared by the Climatic Research Unit (CRU), also showed no significant changes in rainfall for the State of Espírito Santo in 9 months of the year. The lowest average achieved during the study period are given more recently, confirming this trend line, occurring subsequent to the most rainy years a substantial decrease in rainfall over the previous year.

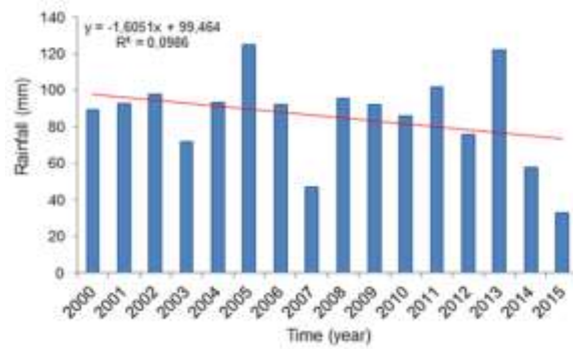


**Figure 3. Distribution of annual average rainfall in Colatina - ES from 2000 to 2015.**

Thus, it is observed that 2005 was characterized as rainy (1496.5 mm), followed by a continuous fall in the years 2006 (1107.7 mm) and 2007 (563.2 mm), repeating again after a rainy period in 2013. This frequency can be associated with several meteorological phenomena, identifying a cyclicity of its own, independent of the negative trend. Among the driest years of the study period are 2007 and 2015, which exhibit averages below 50 mm. The highest annual averages (above 100 mm) occurred in the years of 2005, 2011 and 2013.

In Figure 4, it is possible to observe the variability of the annual rains of Colatina in relation to the anomalies, obtaining a climatological average of 1029.9 mm. During the study period, 11 years had above-average rainfall, with positive deviations ranging from 2.7 mm to 466.6 mm, of which five years had more than 100 mm of annual rainfall in relation to the historical average of Colatina.

During the study period, five years recorded average annual rainfall below average, with variations of

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-118.4 -632.2 mm mm. It is also noted (Figure 4) that significant negative anomalies are strongly associated with the years 2003, 2007, 2012, 2014 and 2015. The markedly positive anomalies are present for the years 2000, 2001, 2002, 2004, 2005, 2006, 2008, 2009, 2010, 2011 and 2013. However, it was possible to identify, with the Pettitt test, a sudden change in the annual precipitation in relation to the average of the studied period from the year 2013, revealing a drought period. On the other hand, Deina and Coelho (2015) reported that data presented by the Climatic Bulletin indicate that SACZ has strongly influenced the Southeast region, with prolonged droughts and / or marked floods, consequently affecting Espírito Santo.

For Nunes et al. (2009) the main factor responsible for generating rainfall in the region are the tropical instability lines with little influence of the polar front. However, it is important to highlight that complementary studies are necessary to identify the causes of this pluviometric behavior in the region

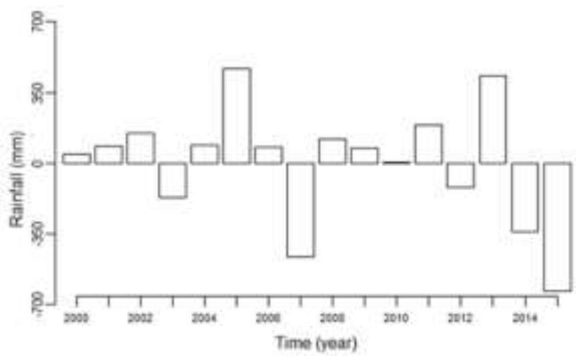


**Figure 4. Deviation of the total annual precipitation in relation to the average of the period (2000 - 2015), in Colatina, ES.**

Figure 5 presents the case of the box obtained for a series of analyzed rain. In this case, it is possible to visualize a positive asymmetry for monthly rainfall systems, since the monthly average is higher than the median in all months of the year, except for November, with an average of 174.6 mm. For the drier months (June to August, mainly), the trend of distribution with a positive asymmetry is accentuated, and it can be observed events in which there were no rains in the months of July and August. On the other hand, it is also possible to observe an occurrence of superior outliers.

The second quartile of each month shows the dispersion of the central half of the data (50%), that is, the monthly rainfall totals less affected by variations in any of the tails of the distribution and with greater probability of occurrence. The month of December is characterized by the highest rainfall, in which the third quartile of its values reaches 311.8 mm. On the other hand, the month of July presented a third quartile with a percentage lower than 8% of the month of December, with 22.5 mm. It should be noted that the month with the highest occurrence of rainfall was January, with the third quartile close to 235 mm, while the month of July presented approximately 135 mm.

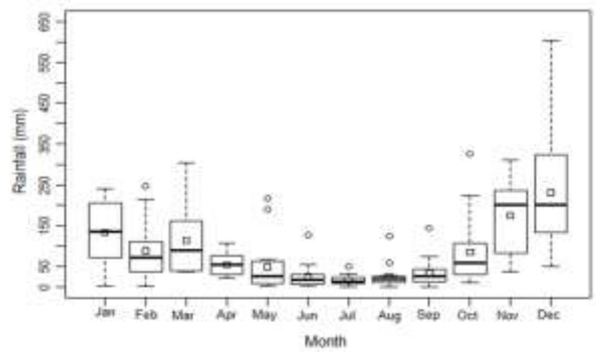


**Figure 5. Box plot of monthly rainfall data (mm) in Colatina State of Espírito Santo, from 2000 to 2015.**

Figure 6 presents a histogram of monthly rainfall frequencies, with 192 observations, in the period from 2000 to 2015 in Colatina, in which a higher frequency is observed for rains concentrated ranges 0 to 50 mm, with an absolute frequency of 100 registers, equivalent to 52% of the data. Thereafter, the range is 51 mm to 100 mm with a relative frequency of 19%. The third largest register was observed in the class interval between 201 mm and 250 mm, with an absolute frequency of 19 corresponding to 9.8% of the data. These three class intervals together represent more than 80% of the data. Between 401 mm and 600 mm, no record was observed, however, at least one record in classes greater than 601 mm was observed.

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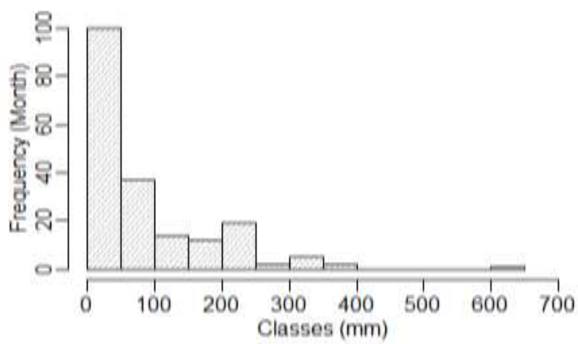


**Figure 6. Histogram of frequency of precipitation (rainfall) during the period from 2000 to 2015, Colatina, ES.**

The monthly mean water balance in the soil for the Colatina region is shown in Figure 7. There is a long period of annual water deficit, totaling 350.9 mm, during the months of January to October. In this period of 10 months of drought in the region it becomes necessary to use water supplementation through irrigation, in order to guarantee a higher quality and agricultural productivity, especially for perennial crops.

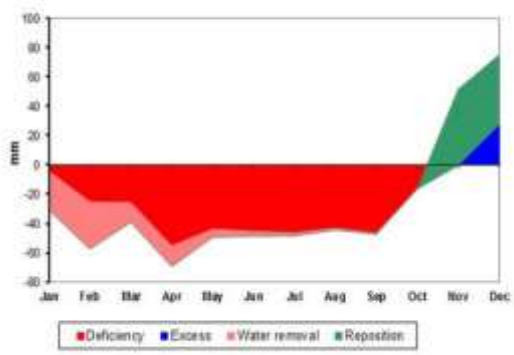


**Figure 7. Extract of the monthly water balance in the soil for Colatina, ES, during the period 2000-2015.**

The balance also showed that the period of water surplus occurs only in December, with a total surplus of 27.8 mm. It is worth noting that the climatic water balance is one of several ways to monitor the variation of soil water storage, which, once calculated and operationalized, becomes an indicator of water availability in a region (PEREIRA et al. 1997), which is fundamental in the planning of agricultural activities. Therefore, it is recommended that future water balance studies be carried out at different spatio-temporal scales for the Colatina region, in order to monitor the water availability in the region.

Figure 8 shows the dry index for the period studied, according to Moreno (1994). For the period considered rainy (October to March), the great majority of the evaluated years were considered normal (I ≥ -0.2), except for 2014 with moderate drought (-0.2> I ≥ -0.4), 2007 with severe drought (-0.4> I ≥ -0.6), with 448.2 mm and 2015, which was classified as extreme drought (I> -0.6), with 287.9 mm. The last two marked by a low rainfall index in the region. For the wet semester (October to March), Anjos et al. (2011) obtained in Maringá 80% of the observations considered normal.

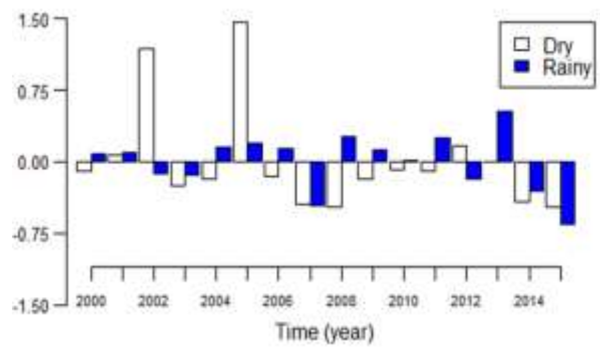


**Figure 8. Drought index for the dry period (April to September) and rainy (October to March) for the municipality of Colatina-ES, from 2000 to 2015.**

In the dry period, considering the dry season (April to October), the drought was classified as normal for 11 of the 16 years evaluated. However, the year 2003 was classified as moderate drought, and the years 2007, 2008, 2014 and 2015 were classified as severe drought with rainfall for the period below 120 mm for the respective years. These results corroborate with those found by Pinheiro et al. (2014), who studied the pluviometric regime of Colatina, located in the northwest region of Espirito Santo, through the Palmer Drought Severity Index (PDSI), from 2000 to 2012. The authors classified moderately dry periods at one year, mildly dry, at four years, and initially dry at nine years. Uliana et al. (2015), using the standardized precipitation index (SPI) to characterize the deficit and the excess of precipitation in the northern region of the State of Espírito Santo, verified that in the rainy months (November, December and January) the recorded rainfall was below normal, with a predominance of drought Incipient, moderate and extreme.

## CONCLUSIONS

In the municipality of Colatina the rainy season is concentrated between October and January. The driest months are the months from April to September, with average rainfall of less than 55.0 mm monthly.

The Mann-Kendall test showed decreasing trends with statistical significance at the 5% level for rainfall in that municipality.

The Pettitt test allowed identifying a significant change of trend in rainfall from the year 2013.
The intervals of classes with higher occurrence were between 0 to 50 mm and 51 mm to 100 mm, representing more than 70% of the data observed during the analyzed period.

The municipality of Colatina presented ten months of water deficiency in the soil, indicating the need for water supplementation through soil irrigation, since the water deficit is critical for most agricultural crops, especially perennial crops.

The drought index stands out due to intense dry season in the year 2007 and extreme drought in the year 2015. The dry season presented intense drought in the years 2007, 2008, 2014 and 2015.

The downward trend in rainfall totals in the city could result in impacts on economic activities, environment and society, it is necessary to conduct additional studies to identify the causes of this behavior.

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