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CLIMATOLOGICAL WATER BALANCE AND CHARACTERIZATION OF WATER RESOURCES IN THE MUNICIPALITY OF PENTECOSTE, CEARÁ

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ABSTRACT
The present work aimed to analyze the climatological water balance and the characteristics of surface water resources in the municipality of Pentecoste, Ceará. The research was divided into three stages: organization and inventory, field studies, and desk research. For the water balance the historical series of 30 years, 1991 to 2020, was investigated and applied to the Normal Water Balance program with the data referring to the coordinates of the rainfall station and average monthly data of precipitation and temperature. It was obtained as a result the description and detailing of the main water courses present in the municipality. In analyzing the volume of reservoirs for the historical series 2004-2021 it is identified that the water supply decreased with the dry period that began in 2011, being the most critical situation during the year 2017, in which the Sítios Novos weir recorded a volume of 0.12%, followed by the Pentecoste and Caxitoré weir with 0.14% and 3.61%, respectively. In regards to the water balance, it is highlighted that the largest precipitation is concentrated in February, March, and April, with respectively 122.35mm, 188.57mm, and 181.46mm. The potential evapotranspiration reaches its apex in December with 180.05mm, the highest temperature of the series, 28.3°C, occurred in November and December and the lowest was 26.7°C in April. The actual evapotranspiration reached the highest level in March with 145mm. It is also noteworthy that 10 months of the year are of water deficiency, except March and April, marked as a replacement, because they are the rainiest months.
Keywords: Water balance; Semi-arid; Water resources.

BALANÇO HÍDRICO CLIMATOLÓGICO E CARACTERIZAÇÃO DOS RECURSOS HÍDRICO DO MUNICÍPIO DE PENTECOSTE, CEARÁ

RESUMO
O presente trabalho visou analisar o balanço hídrico climatológico e as características dos recursos hídricos superficiais do município de Pentecoste, Ceará. A pesquisa se dividiu em três etapas: organização e inventário, estudos de campo e pesquisa de gabinete. Para o balanço hídrico investigou-se a série histórica de 30 anos, 1991 a 2020, aplicados ao programa Balanço Hídrico Normal com os dados referentes às coordenadas do posto pluviométrico e dados médios mensais de precipitação e temperatura. Obteve-se como resultado a descrição e detalhamento dos principais cursos de água presentes no município. Ao analisar o volume dos reservatórios para a série histórica de 2004-2021 identifica-se que a oferta hídrica diminuiu com o período de seca iniciado em 2011, sendo a situação mais crítica durante o ano de 2017, em que o açude Sítios Novos registrou um volume de 0,12%, seguido pelo açude Pentecoste e Caxitoré com 0,14% e 3,61%, respectivamente. Quanto ao balanço hídrico, destaca-se que as maiores precipitações se concentram nos meses de fevereiro, março e abril, com respectivamente 122,35mm, 188,57mm e

181,46mm. A evapotranspiração potencial atinge o seu ápice no mês de dezembro com 180,05mm, a maior temperatura da série, 28,3ºC, ocorreu nos meses de novembro e dezembro e a menor foi de 26,7°C no mês de abril. A Evapotranspiração real atingiu o maior nível no mês de março com 145mm. Destaca-se ainda que 10 meses do ano são de deficiência hídrica, com exceção apenas de março e abril, marcados como de reposição, pois são os meses mais chuvosos.
Palavras-chave: Balanço Hídrico; Semiárido; Recursos Hídricos.

INTRODUCTION

The climate is determined predominantly by the general circulation of the atmosphere, resulting from the differential heating of the globe by solar radiation, the asymmetric distribution of oceans and continents, as well as the topographical characteristics of the continents (FERREIRA; MELLO, 2005). The climate of Northeast Brazil (NEB) is the result of the action of several physical mechanisms and atmospheric systems operating in this region that interact and are responsible for the distribution of rainfall (KAYANO; ANDREOLI, 2009).

The main atmospheric systems and mechanisms governing the rainfall regime in the NEB are (i) Intertropical Convergence Zone (ITCZ); (ii) El Niño-Southern Oscillation (ENSO); (iii) Tropical Atlantic (TA) Sea Surface Temperature (SST), Trade Winds, Sea Level Pressure (SLP); (iv) Cold Fronts; v) Lines of Instability (ILs); vi) Cyclonic Vortices in High Level (CVHLs); vii) Convective Mesoscale Complex (CMC) and viii) sea and land breezes (FERREIRA; MELLO, 2005; KAYANO; ANDREOLI, 2009).

For Lima (2004), besides these large-scale circulation systems, one must consider the position of the coast and the hills in relation to the trade winds, generating wind corridors, windward zones (orographic rains) in the most humid areas, leeward zones (shadow areas, with lower rainfall and less humid) and the predominant low altitudes of the relief with elevations below 400m, except the crystalline and sedimentary plateaus, and which form spatial climatic conditioning factors of local and regional influence.

The location of Ceará, near the Equator, contributes to intense insolation in the State all year round, which characterizes a typical area of hot climates, and the action of atmospheric systems influences the seasonality and variability of precipitation. Other factors such as altitude, the disposition of the relief, and the proximity or distance from the oceans provide the local differentiation of climates in the State (LOURENÇO, 2013; ZANELLA, 2007).

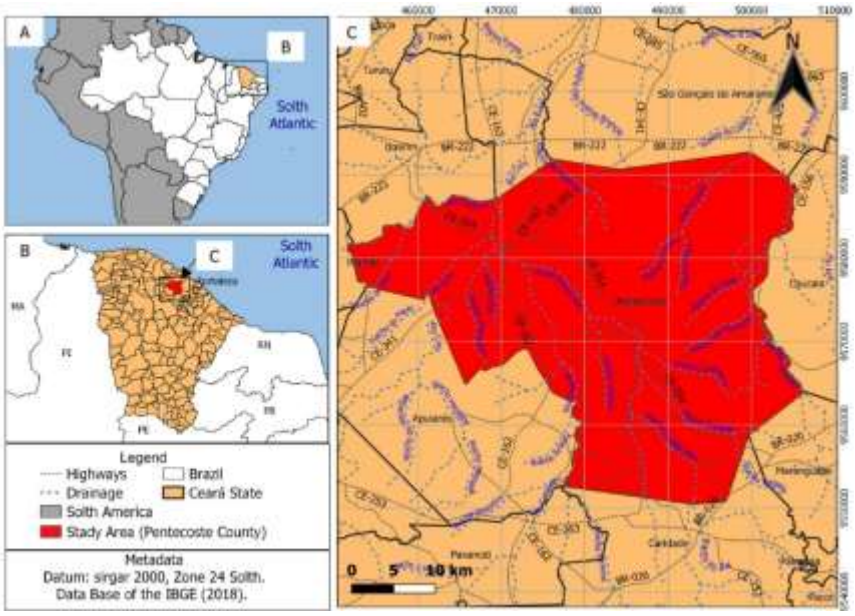
Ceará has about 92% of its territory, or approximately 136,328 km², under the influence of the semi-arid climate. Of the 184 municipalities that compose Ceará, 117 are entirely inserted in the semiarid climate, marked by climatic irregularity, with a short rainy period of around 3 to 5 months and a prolonged dry period, of 7 to 9 months. It is also characterized by high temperatures, averages over 26°C, with high water evaporation and diurnal temperature range (CEARÁ, 2010; SOUZA, 2000; ZANELLA, 2007).

Knowing the climatic characteristics and water resources of the states and municipalities enables planning strategies to rationalize and optimize the use of water resources, especially in semi-arid areas. According to Pereira, Angelocci, and Sentelhas (2002), the water availability of an area can be quantified by the water balance that shows the seasonal variations of water surplus and deficiency through the relationship between inflow and outflow, measured by precipitation and temperature data.

From this perspective, the climatological water balance corresponds to the total water gains and losses of a given surface, being essential for the study of the water resources of a territory. For Ribeiro, Simeão, and Santos (2015) the water balance aims to analyze the water conditions of a given area, allowing the study of water deficiency with direct consequences on the planning of agricultural production.

The present work aimed to analyze the climatological water balance of the municipality of Pentecoste (Figure 1), located in the northern sector of the state of Ceará, arranged between the coordinates 3° 47' 34" S and 39° 36' 13" W, distant 88 km from the city of Fortaleza, comprises an area of 1,378.3 km² that is divided into four municipal administrative districts: Pentecoste, Matias, Porfirio Sampaio and Sebastião de Abreu (IPECE, 2016).

Figure 1: Location of the municipality of Pentecoste.



Source: Prepared by the authors.

The study area is located in the area surrounding the Desertification Nucleus of Irauçuba /North Central, being a municipality susceptible to desertification and presents, in the southern portion, heavily degraded areas in the desertification process. The article also discusses the climatic characteristics and the superficial water resources present in the study area. The research was divided into three stages: organization and inventory, field studies, and desk research.

MATERIAL AND METHOD

The research was conducted in three stages: organization and inventory, field studies, and desk research. In the organization and inventory phase, a survey of secondary data, bibliographic and cartographic data of the study area was carried out. Field visits were also carried out in the municipality to collect primary data on the area and photographic records. In the office stage, there was the interpretation of data, primary and secondary,

obtained in the field relating them to the information compiled in the literature review, as well as the realization of the climatological water balance of the municipality.

The precipitation data were collected from the Meteorology and Water Resources Foundation of Ceará - FUNCEME from the rainfall station installed in Pentecoste, in the coordinates latitude 3° 45' 4" S and longitude 39° 15' 39" W, installed in the Experimental Farm of Curu Valley. A 30-year historical series were analyzed, from 1991 to 2020, to analyze the climatological water balance of the municipality, from the program called Normal Water Balance by Thornthwaite and Mather (1955), prepared by Glauco and Sentelhas (1999) where data are placed relating to the coordinates of the rainfall station, latitude, temperature, and precipitation data.

To determine the potential evapotranspiration (ETP) the considerations of Pereira, Angelocci and Sentelhas (2002) were used:

$$ETP = 16\left(10\frac{Tn}{i}\right)a \qquad \text{When: } 0< Tn<26.5°C \quad (1)$$

$$ETP = -415{,}85 + 32{,}24Tn - 0{,}42Tn^2 \qquad \text{When: } Tn \geq 26.5°C \quad (2)$$

$$I = 12(0{,}2Ta)^{1{,}514} \qquad (3)$$

Where Ta is the normal annual average temperature. The exponent "a" being a function of I, is also a regional thermal index and is calculated by the expression:

$$a = 6{,}75x10^{-7}I^3 - 7{,}71x10I^2 + 1{,}72x10^2I + 0{,}49 \qquad (4)$$

For the determination of the temperatures of Pentecoste, the Celina 1.0 Program was used - Estimation of Temperatures for the State of Ceará, developed by Costa (2007) through the coordinates and attitude of the rainfall station. The data on the volume of the reservoirs were taken from the Hydrological Portal of Ceará of the Secretary of Water Resources of the state, which discloses the information on the dams monitored by the Company and Management of Water Resources of Ceará-COGERH. On the subject, the volume of water storage of the weirs were analyzed: Pereira de Miranda, Sítios Novos, and Caxitoré for the series 2004-2021.

RESULTS AND DISCUSSIONS

Climatological water balance and climatic characteristics of Pentecoste

According to Moro et al (2015), the state of Ceará is under the influence of a semi-arid macroclimate, however, the gradients of rainfall, temperature, and humidity vary considerably from the coast to the inland conditioning the diversity of landscapes in the state. This climate is characterized by high average annual temperatures and oscillation between the dry and wet periods with prolonged periods of drought in winter and irregular and concentrated rains in summer (AB'SABER, 2003).

According to Oliveira (2009), the hinterland of the semi-arid regions of Ceará presents the following climatic characteristics: low cloudiness indexes, strong insolation, high temperatures and evaporation rates, and scarcity of rainfall, marked annually by irregularity in time and space; which characterizes strong interruptions in water courses and deficient water balance.

From Köppen's climate classification proposal, discussed by Lima (2004) and Maia Júnior and Caracristi (2012) it is established that the climate types of Ceará are: A (hot

climates) and B (arid climates), these being subdivided into Aw' (tropical rainy climate, with a dry season delayed until autumn - Coastal Region); Amw' (tropical rainy monsoon climate, with a rainy season delayed until autumn - Humid Sierras Region); BSw'h' (hot and semi-arid climate, with a rainy season delayed until autumn and a temperature above 18 ºC in the coldest month - Hinterland Region).

In this perspective, the climate of Pentecoste is BSw'h' - hot and semi-arid characterized by irregular rainfall, with 7 to 8 dry months, high average temperatures ranging from 26° to 28°C, and high rates of evapotranspiration. The data of the historical series from 1991 to 2020 of precipitation of the pluviometric station of the municipality, show that the average rainfall for this period was 747 mm (Figure 1A). The year 2009 stood out as the rainiest, were 1460.5 mm with higher precipitation in March, April, and May with 375.6 mm, 345.6 mm, and 224.4 mm, respectively. The year 2012 showed less precipitation with a total of 176mm.

Regarding the years of below average rainfall for the historical series (1991-2020), the years 1992 with 642mm, 1193 with 212.5mm, 1997 with 421.9mm, 1998 with 417mm, 1999 with 593,9mm, 2001 with 630.4mm, 2005 with 536.5mm, 2007 with 654.5mm, 2010 with 418.2mm, 2012 with 176mm, 2013 with 558.5mm, 2014 with 483.5mm, 2015 with 579mm, 2016 with 508.8mm and 2017 with 728.8mm. It is perceived that of the 30 years of the historical series, 15 years were with below average rainfall and 15 with above average rainfall (Figure 1A).

In the last three years of the historical series, precipitation was above average, 2018 with 1135.9mm, 2019 with 890.7mm, and 2020 with 1005.4mm, demonstrating the end of the dry period and the decrease of the drought that hit the state of Ceará from 2010 to 2017. This increase in precipitation values improves the water supply and quality of life of farmers who inhabit and derive their livelihood from the natural resources of the semi-arid region.

Alongside these questions, the climatological water balance of Pentecoste was carried out to evaluate in more detail the climatic conditions of the municipality, because from this analysis it is possible to understand the behavior of the water regime of the study area.

From the precipitation and temperature data, it was possible to define the actual evapotranspiration (ETR), the potential evapotranspiration (ETP), the water storage in the soil (ARM), the water deficit (DEF), and the water surplus (EXC). Table 1 shows the climatological water balance results for the municipality with historical series from 1991 to 2020 with a soil storage capacity (CAD) of 100 mm.

Table 1- Water balance of the municipality of Pentecoste (1991-2020), considering a soil storage capacity (CAD) of 100 mm.

Months	T (ºC)	P (mm)	ETP (mm)	P-ETP (mm)	ARM (mm)	ALT (mm)	ETR (mm)	EXC (mm)	DEF (mm)
Jan	28,1	85,71	169,39	-83,7	0,0	0,0	85,7	0,0	83,7
Feb	27,6	122,35	146,38	-24,0	0,0	0,0	122,4	0,0	24,0
Sea	26,9	188,57	145,04	43,5	43,5	43,5	145,0	0,0	0,0
Apr	26,7	181,46	135,15	46,3	89,8	46,3	135,2	0,0	0,0
Mai	26,9	94,35	143,05	-48,7	55,2	-34,6	129,0	0,0	14,1
Jun	26,9	35,25	137,76	-102,5	19,8	-35,4	70,6	0,0	67,1
Jul	26,8	20,47	140,05	-119,6	6,0	-13,8	34,3	0,0	105,8
Aug	27,7	3,87	160,91	-157,0	1,2	-4,7	8,6	0,0	152,3
Set	27,9	0,72	161,38	-160,7	0,2	-1,0	1,7	0,0	159,7
Out	28,1	1,46	172,93	-171,5	0,0	-0,2	1,7	0,0	171,3
Nov	28,3	0,63	173,46	-172,8	0,0	0,0	0,7	0,0	172,8
Ten	28,3	12,12	180,05	-167,9	0,0	0,0	12,1	0,0	167,9
Total	330,2	747,0	1865,5	- 1118,6	------	0,0	747,0	0,0	1118,6
Average	28	62	155	------	------	±90	62	0,0	93

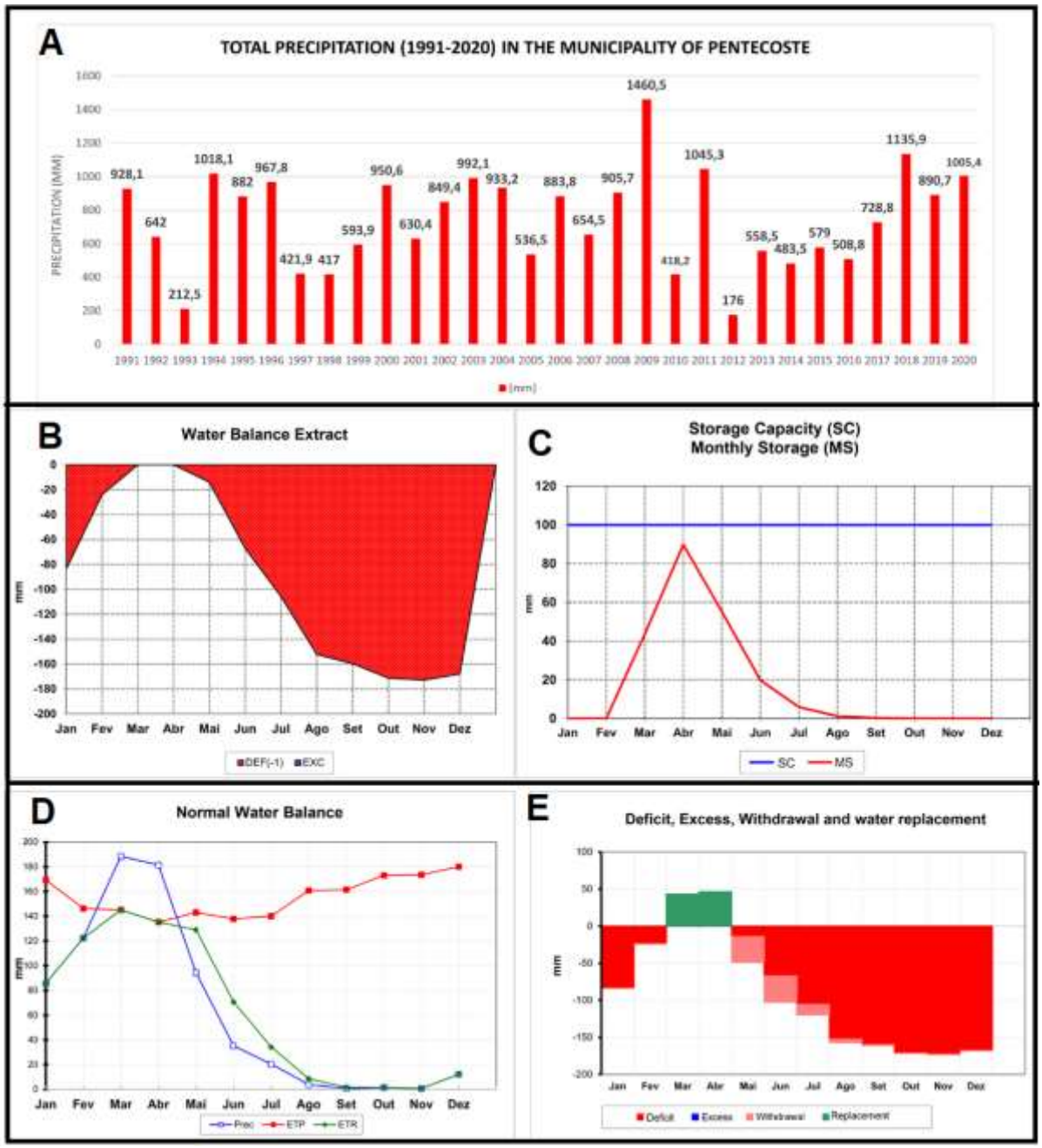
Source: THORNTHWAITE; MATHER, 1955; FUNCEME, 2020.

Legend: (T)-Temperature; (P)-Precipitation; (ETP)-Potential evapotranspiration; (ARM)-Soil water storage; (ALT)-Variation of storage; (ETR)- Actual evapotranspiration; (EXC)- Surplus hydric; (DEF)-Hydric deficiency.

According to Table 1, it can be seen that the highest rainfall of the historical series is concentrated in February, March, and April, with respectively 122.35 mm, 188.57 mm, and 181.46 mm. The annual potential evapotranspiration (Table 1 and Figure 2D) was 1865 mm with a monthly average of 155 mm and peaked in December with 180.05 mm. The highest temperature of the year, 28.3ºC, occurred in November and December and the lowest was 26.7°C in April. The actual evapotranspiration (Table 1 and Figure 2D) reached the highest level in March at 145mm.

In regards to water deficiency in the municipality of Pentecoste (Table 1 and Figure 2B), it is noteworthy that 10 months of the year are water deficient, except March and April, considered the replenishment months, which are also the wettest ones. This severe water deficiency requires farmers to plan for agricultural production with the need for irrigation and techniques for living with the semi-arid climate. The withdrawal period is concentrated from May to August (Table 1 and Figure 2E).

Figure 2: Total precipitation and climatological water balance of Pentecoste.



Source: Prepared by the authors.

Characteristics of Pentecoste's surface water resources

In the semi-arid hinterlands with a predominance of the crystalline substrate, there is a great occurrence of rivers and streams with the seasonal intermittent flow with exorheic

drainage. Zanella (2007) points out that the irregularity of rainfall, the intermittent character of the rivers, and the lithological characteristics affect the availability of water resources in the semi-arid region.

The rivers of the NEB, at certain times of the year, reach the sea, an original characteristic of the regional hydrographic and hydrological systems, unlike other semi-arid regions of the world, in which the drainages converge to closed depressions, the rivers of this region go to the Atlantic Ocean (NASCIMENTO, 2011).

The main superficial water courses in the municipality of Pentecoste are the streams Croatá, Mocó, Cedro, Cachoeira, Volta, Salgado, Mel, and Capitão Mór, as well as the rivers Curu and Canindé, the latter being an important affluent of the right margin of the hydrographic basin of the Curu river. This basin makes up the set of 12 basins of Ceará, together with the Jaguaribe River, divided into Upper, Middle, and Lower, the Banabuiú River, the Acaraú River, the Coreaú River, the Salgado River, the Metropolitan, the Coastal, the Serra de Ibiapaba and the Crateús Hinterland (CEARÁ, 2016).

The Curu basin has an area of 8,750.75 km², equivalent to 6% of Ceará's territory and drains besides Pentecoste another 14 municipalities: Itatira, Canindé, Caridade, Paramoti (in the upper Curu); General Sampaio, Apuiarés, Tejuçuoca, Itapajé, Irauçuba, Umirim, São Luís do Curu (in the middle Curu); and São Gonçalo do Amarante, Paraipaba and Paracuru (in the lower Curu) (CEARÁ, 2009).

The Curu River has a total area estimated at 8,600 km², with its sources in the hills of Céu, Imburana, and Lucas, in the municipality of Canindé. Its mouth is located on the border of the municipalities of Paracuru and Paraipaba (BRANDÃO; FREITAS, 2014). The Canindé River has its sources in the Baturité Massif and assumes a relevant role in the context of the Curu watershed since it is the main affluent of its right margin.

According to Soares (2006), the landscape of the Curu hydrographic basin was transformed by anthropic intervention through the removal of natural vegetation and its substitution by subsistence agriculture and the construction of surface water dams to store water and prevent stretches of the rivers from drying out during periods of drought.

Water reservoirs play an important role in flood control and the increasing demand for drinking water for humans, livestock, aquaculture, and agriculture (GUNKEL, 2019). The Curu river basin is characterized by a high level of damming, having 818 reservoirs. The Pentecoste and General Sampaio weirs are responsible for approximately 70% of the accumulation volume of this basin (CEARÁ, 2009).

As in most municipalities of Ceará, the limitation of water availability is a recurring problem in Pentecoste, aggravated by the drought that began in 2011. The construction of weirs and the drilling of wells are mitigation measures for drought. According to Dantas and Rodrigues (2015), the process of damming is intended to provide the development of the northeastern region through water availability for agricultural, industrial, and service activities, in addition to human supply.

The weirs in Ceará are divided into small, medium, large and macro, and are built by the government, by individuals, and in cooperation schemes. The Water Resources Management Company (COGERH, 2008) establishes a classification of weirs according to their volumetric capacity: macro (> 750,000,000m³), large (from 75,000,000 to 750,000,000m³), medium (from 7,000,000 to 75,000,000m³) and small (from 0.5 to

7,000,000m³). The small weirs are generally built to supply the rural population of the municipalities of Ceará, mainly for human consumption and animal feeding.

In Pentecoste, there are three large weirs, Pereira de Miranda, Caxitoré and Sítios Novos. It was built by the National Department of Works Against Droughts-DNOCS in 1957, it has 2.840 km² of the drainage area and the hydraulic basin has 5.700 ha with a storage capacity of 360.000.000 m³ (COGERH, 2021).

The Caxitoré weir is partially located in Pentecoste, it has a drainage area of 1,430 km² and the hydraulic basin has 4,574 ha with a storage capacity of 202,000,000 m³. The Sítios Novos weir is also partially located in Pentecoste, it has a drainage area of 446 km² and the hydraulic basin has 2,010 ha with a storage capacity of 126,000,000 m³ (COGERH, 2021). Table 11 specifies the technical characteristics of the three large weirs in the municipality of Pentecoste.

Table 1: Technical characteristics of the main weirs in Pentecoste, CE.

WEIR	MUNICIPALITY	CAPACITY	SYSTEM	RIO BARRADO
Pentecoste	Pentecoste	360.000.000 m³	Curu	Canindé River
Caxitoré	Umirim-Pentecoste	202.000.000 m³	Curu	Caxitoré River
Sítios Novos	Caucaia-Pentecoste	126.000.000 m³	Metropolitan	São Gonçalo River

Source: COGERH (2021).

The Pentecoste weir is the main large-scale reservoir in the municipality as it is the only one entirely within Pentecoste and is the main source of water supply for the various economic activities and human and animal consumption. According to Oliveira (2009), the Pentecoste weir is responsible for controlling the floods of the Canindé River and the Capitão-Mor stream, assisting in the perennialization of the Curu River for the irrigation of land downstream, as well as providing the development of fish farming and the use of crops upstream.

Due to the great variation of river runoff and the long period of absence of water, the construction of weirs emerges as an alternative to accumulate water and ensure water supply in long periods of drought (FARIAS, 2015).

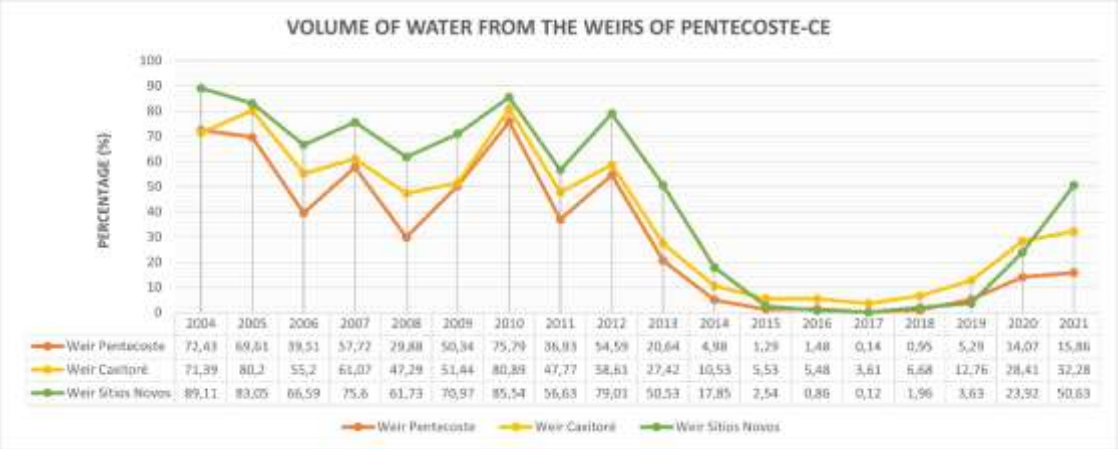
> In the last decade, the water shortage has significantly affected the activities developed in the most different economic sectors of the Brazilian semi-arid region. The low rainfall index recorded and, consequently, the low recharge of the reservoirs, caused, for example, suspension of water supply for irrigation, reduction of water availability for human supply, and animal desedentation (LOPES, 2016, p. 69).

The hydric supply of the reservoirs in Ceará has decreased considerably with the period of drought that began in 2011. In the period from 2004 to 2021 (Figure 3), the Pentecoste weir considerably decreased its volume, in 2010 it obtained the highest storage, 75.79%. In the period from 2014 to 2019, it showed the lowest values, with emphasis on the year

2017 which obtained the lowest volume, 0.14%.

The Caxitoré weir in 2010 had the highest storage volume, 80.89%, and from 2015 to 2018 it decreased dramatically with values of 5.53%, 5.48%, 3.61%, and 6.68%, respectively. The Sítios Novos weir presented 89.11% of the stored volume in 2014, the highest value for the series analyzed. From 2015 to 2019 it had the lowest values, especially in 2017, with 0.12% of storage capacity. The reduction in the volumes of dams in the municipality of Pentecoste has aggravated the water quality situation of these water bodies.

Figure 3: Volume of the dams in the municipality of Pentecoste.



Source: Prepared by the authors.

The water used for the supply of Pentecoste comes mainly from the dam Pereira de Miranda, a demand of 65 L/s, being distributed in the urban area of the municipality by the Water and Sewerage Company of Ceará - CAGECE. In the rural zone of the municipality, water consumption is guaranteed through cisterns, wells, and tanker trucks that are distributed to the local population.

Bearing in mind the multiple uses of water and the importance of this resource for water security and people's lives, COGERH monitors the water quality of Ceará's reservoirs and launched a study with the results of this monitoring over the last 12 years (2008 to 2020), through analyses of water samples collected from the Pentecoste, Caxitoré and Sítios Novo's weirs. The data made available by COGERH has shown a process of eutrophication of the weirs that compromises the quality of the water and demands strategies to improve and recover these resources.

Eutrophication is caused by a load of nutrients carried to the reservoirs, especially nitrogen (N) and phosphorous (P). The main sources of pollutants that cause the eutrophication of the reservoirs in Ceará are a) the discharge of domestic and industrial sewage; b) the inflow of soil particles containing nutrients due to water erosion; c) the presence of cattle, especially in the surroundings of the reservoir; and d) exploitation of intensive fish farming in the weir's water mirror (PAULINO; OLIVEIRA; AVELINO, 2013; COGERH, 2021).

Domestic effluents contain high concentrations of organic matter and nutrients, favoring the process of eutrophication when discharged unprocessed in aquatic ecosystems (JARVIE; WHITTON; NEAL, 1998). Eutrophication is a dynamic process that usually occurs in lentic environments, i.e. those that have still or slow moving waters. This process alters water quality and causes a series of damages to aquatic biodiversity and its multiple uses (LIMA; MONTEIRO, 2015).

Regarding the salinity of the reservoirs in the municipality of Pentecoste, Ceará (2009) highlights that the reservoirs belonging to the Curu River basin present chloride concentrations below 250 mg/l, a value tolerated by the Ministry of Health for human consumption, except the Caracas and Salão reservoirs. Taking into consideration the salinity characteristics for irrigation, the reservoir waters are classified as having high salinity.

Another important form of water supply in the hinterlands of the NEB is the use of plate cisterns built through the Training and Social Mobilisation Programme for Living with the Semi-Arid: 1 Million Rural Cisterns - P1MC, coordinated by the Articulation in the Semi-Arid-ASA. In Pentecoste, cisterns are part of the landscape in the rural area, and there are currently 1,350 plate cisterns with the capacity to store 16,000 liters of water each, enabling domestic water supply for the population (ASA, 2021). The construction of plate cisterns in the NEB to store rainwater for human consumption is a policy tool for coping with drought through a simple and inexpensive technology that improves the quality of life of the people of the northeastern hinterland.

CONCLUSION

Through the study of the climatological water balance, it is possible to carry out a planning of the water resources of the territory. In this perspective, it is highlighted that the municipality of Pentecoste, conditioned by the climatic characteristics and rainfall regime, has water deficiency during 10 months of the year, which demonstrates the need to mitigate the effects of drought and deficiency through irrigation projects and construction of reservoirs and cisterns to ensure water for human supply and agricultural activities.

Therefore, it is concluded that the water balance analysis of Pentecoste is relevant because it allows knowing the water regime, which is influenced by climatic characteristics, and enables the planning of rationalization strategies and optimization of the use of water resources in the municipality. It is also observed that the main surface streams of the municipality, Curu, and Canindé, are important affluents of the left margin of the Curu River Hydrographic Basin and together with several reservoirs, small, medium, and large, are intensively used by the population of the municipality for human supply, animal feed, leisure and irrigation of subsistence agriculture.

The multiple uses are not always accompanied by planning, being perceptible the impacts on this environment, especially eutrophication, pollution, irregular occupations, and silting of waterways in the municipality. From the foregoing, the expansion of studies on surface water resources, among them the watersheds and reservoirs of the semi-arid Ceará is urgent, to ensure the rational use, conservation, and proper management of natural resources and consequently the improvement of the quality of life of the inhabitants.

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