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THE INFLUENCE OF ATMOSPHERIC SYSTEMS AND URBAN AREAS ON THE BEHAVIOR OF THE MANACAPURU WATERSHED

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ABSTRACT

This article aimed to analyze the precipitations and flows of the Manacapuru Hydrographic Basin and possible hydrological impacts caused by the el Niňo and La Niňa climatic phenomena on it, with the objective of providing subsidies for the formulation of public policies for the management of water resources and policies that favor the development of the sustainable economic activities of the municipality. To compose this article, collections were collected from the database of the Hydroweb Platform of the National Water Resources Information System (SNIRH) of the National Water Agency (ANA) and daily and monthly flow averages were calculated and precipitation from the period 2010 to 2013, applying the Arithmetic Method.

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INTRODUCTION

Advancing warming of the near-surface atmosphere and the consequent climate change have alarmed researchers, public managers, non-governmental organizations (NGOs) and society in general with regard to resource degradation processes resources (SILVA *et al*., 2016). According to the National Water Agency (ANA), global warming can change rainfall (intensity and variability) rainfall patterns and significantly affect the availability and temporal distribution of flow in rivers (ANA, 2010). For Horikosi and Fish (2007), it is necessary to know the hydrological cycle within a hydrographic basin, and it is essential to compare two opposite elements in the water balance: precipitation and evapotranspiration. Vieira (2015) shows that water availability can be measured by climatological water balance, through which periods of abundance or scarcity of water resources in a given region are evidenced. Water balance is a method to account for the availability of water (inlet and outlet) in the soil.According to Nobre and Assad (2005), the water balance of a region tends to remain in balance, without major natural changes, for several years. However, with the increase in the population and the indiscriminate use of water, it is observed that anthropic actions end up interfering in the hydrological cycle. Hamada (2007) says the global average temperature of the Planet has been increasing over the decades. Lima *et al*. (2009) also points out that the increase in temperature is proportional to the increase in evapotranspiration, thus reducing the availability of water in the soil. This fact that for Olympia (2013) can result in phenomena such as changes in biomes existing by biomes more adapted to dry climates, such as forests being replaced by savannas.By highlighting the global water crisis, this will be the most valuable natural resource of the 21st century, due to the difficulty in equating the need to meet increasing consumption due to the frantic increase in the world population and the economic activities arising, with the advance of scarcity due to climate factors, contamination and deforestation (INPE,2015; AUGUSTO, 2012; SILVA, 2010). For Venâncio *et al*., (2015), as the population and economy intertwined with consumerism increase, the natural cycle of water is modified. Compounded by degradation, these resources are becoming unfit for consumption. In Bicudo's vision (2010), a wide water crisis is faced, which makes concern about water resources an even greater magnitude. Neto (2008) shares the idea that the amount of water on the planet will not decrease, but access to its drinking form will be increasingly scarce, so one must seek the sustainable use of it to meet the needs of humanity.Together with the change in the precipitation regime, there may be an increase in drinking water shortages. Clarke and King (2003) observed that, associated with scarcity, other problems are evidenced such as the spread of water borne diseases (cholera, thifus, filaria, diarrhea, among others), water rationing for domestic consumption in urban centers, among other problems. It is known that Brazil is a country with the largest territory bathed by freshwater springs, having 12 Hydrographic Basins, with the Amazon Basin being the largest in Brazil and in the world, with 7,050,000 km² (IBGE, 2003). The Amazon Basin is powered by numerous watersheds, responsible for the flood and leaking system (SILVA, 2013). The Manacapuru basin is one of them responsible for supplying the region. According to Costa (2010), the Miriti River Basin is part of the land area in the transition phase from rural to urban area. The main pollution factors in the Watersheds, in Moura *et al*., (2010), are the removal of forests and the removal of vegetation on the banks of waterways, mining, the use of pesticides and urban expansion with the construction of bridges, highways and roads, condominium construction and incorrect disposal of solid waste. The main uses of water in the Miriti River Basin are, according to Damasceno *et al*., (2017), the capture of water for the public supply of the municipality of Manacapuru, artisanal and commercial fishing, leisure, transport and disposal of effluents from the residences and commercial activities, because the municipality does not have sewage collection and treatment. Barreto (2008) points out that in the seasonal dry season the water quality of the Miriti River is greatly compromised and with this this contaminated water is pumped for the supply of the city, compromising the health of the population.Through the considerations presented, this work shows the nature of the impacts on the behavior of the waters of the Manacapuru basin, contributing to the formulation of mitigating measures to be adopted by the public authorities, especially at this time in which the municipality experiences a population, economic and tourist explosion triggered by the construction of the Phelippe Daou Bridge that connects the municipality to the capital Manaus.

MATERIALS AND METHODS

The area of study delimited for the development of this research is the Manacapuru Hydrographic Basin, located around the municipality of the same name, in the Metropolitan Region of Manaus/AM, with 96,236 inhabitants (IBGE-2018). This Basin is located on the left bank of the Solimões River (3°18'33" S and 60°33'21" W), bathed by the Jari, Manacapuru, Solimões and Purus rivers. The region has humid tropical climate, characterized by dry winter and rainy summer, where vegetation is formed by land forest firm and floodplain (QUEIROZ, 2009). To obtain the results, a methodology similar to that used in Dehaini *et al*., (2016) was applied. This methodology consists of using the database of precipitations and average/day flows of the drainage basin in question. For the purposes of this study, data were collected from 2010 to 2013. Hydrometeorological data were obtained by access to the Hydroweb Platform of the National Water Resources Information System (SNIRH) of the National Water Agency (ANA), as characterized in Table 1. This system allows the monitoring of occurrences of hydrological events considered critical, floods and droughts. In a second moment, the Arithmetic Method was applied to calculate the daily means of precipitation and flow, considering that on the Hydroweb platform each day presents several points and times of data collection. After the daily means, the same Method was applied to obtain the monthly means from which the maximum and minimum precipitations and flows of each year studied were identified.

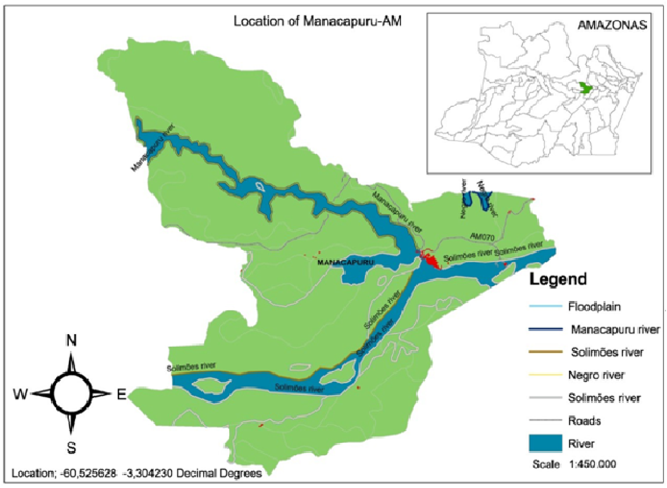

Figure 1. Location of the study area

Table 1. FluviometricStation

Code (Fluviometric)	Station Name	Observation Period
4-14100000	Manacapuru	2010 a 2013

The Arithmetic Method consists of calculating the arithmetic mean of records extracted from the Station's HydroWeb platform under study, adding them all and dividing them by the number of elements added, as shown in the equation:

$$M=(P1+P2)/2 \quad (1)$$

Where: M, is the average obtained with the sum of values (P1 and P2), divided by the number of elements summed (2). Subsequently, histograms were constructed regarding the frequency of precipitation and flow analyzed, displayed in the form of graphs. Finally, based on histograms, the Permanence Curve was reproduced for maximum flows (TUCCI (2013); DEHAINI *et al*., 2016).

RESULTS

Analysis of flow and precipitation averages in the years 2010 to 2013 related to the Manacapuru Hydrographic Basin, as described in the methodology: The systematics used in the present study consists in the analysis of descriptive statistical methods such as mean, maximum value and minimum value for calculating daily and monthly analyses of the series on precipitations and fluviometric flows. For analysis, the data were used in the following formats: mean precipitation in millimeters (mm) and daily/monthly flows in cubic meters per second (m^3/s). From the analysis of histograms resulting from the consolidations of monthly averages each year, it is necessary to highlight the absence of data made available by the Hydroweb platform for the flows of February and March 2010, June 2012 and December 2013, which compromises the identification of minimum flows. Therefore, it mischaracterizes the bullish movement as can be seen in the 2010 and 2013 charts. In an analysis of the graphs with the monthly averages of the years under study, it is observed that the highest flows occurred in 2010 and 2011, proving 2010 as the year of greatest drought in the Amazon, which is evidenced in rivers and Hydrographic Basins, including in the Manacapuru Basin (Figure 2).

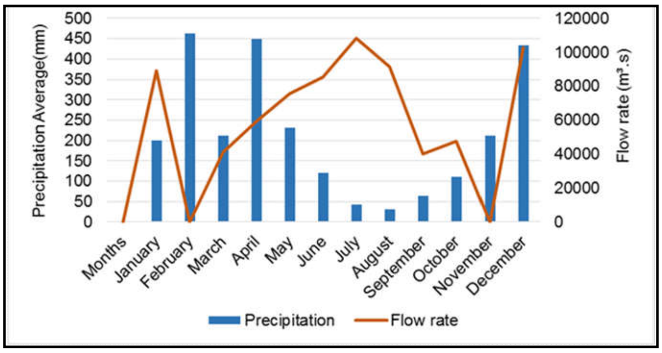

Figure 2. Average flow and precipitation in 2010

A study conducted in Tomazella and Marengo (2011), attributed the great drought of 2010 to the el Niño phenomenon and the cooling of heat from October 2010 with the arrival of La Niña, a climatic phenomenon that punished with Manaus rains and 54 other Amazonian municipalities, including Manacapuru (Figure 2). Under the impact of El Niño, the strong drought of 2010 was felt in the dynamics of the economic activities of the municipality, especially those dependent on river transport that has its performance committed to the low level of water in the Basin for the navigation of passengers and cargo. Precipitation and flow data in 2011 (Figure 3) show that even with the precipitations on the rise, the flows were also upwards mainly in January, February, November and December, confirming the studies of the Time Prediction Center and Climate Studies (CPTEC) on the fact that La Niňa would cause more rainfall in river flows in the Northern Region in 2011.

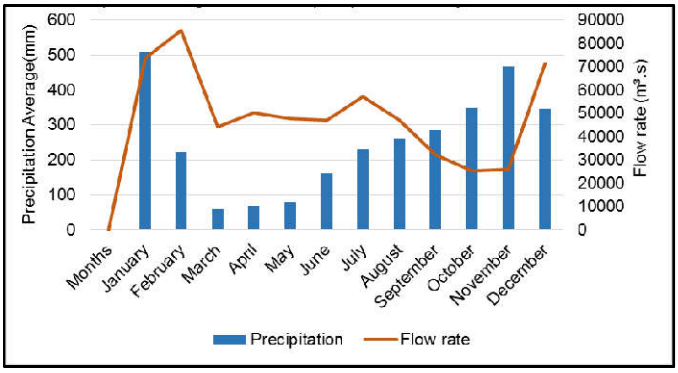

Figure 3. Average flow and precipitation in 2011

In the first half of 2012, rainfall followed the upward trend begun in October 2011, a fact that defined a large flood in the municipality of Manacapuru, with negative impacts on the daily lives of the population, requiring residents to implement creative alternatives such as the wooden construction of bridges and suspended walkways to get around the streets of the municipality hardest hit by the rise of the waters (Figure 4). In the comparison of precipitation between the four years under analysis, the lowest average rainfall occurred in September 2012 (22.50mm), as shown in Figure 4. Also, with regard to precipitation, they continued to present constant highs from January (784.26mm) to April (1,579.99mm) of 2013, considering a neutral year without the presence of south oscillation (Figure 6).Figure 6 demonstrates the graph of the permanence curve of flow rates of Fluviometric Station 4-14100000 of the Manacapuru Hydrographic Basin that symbolizes the relationship between flow rate and frequency (time). The curve was produced from the results of the monthly averages from 2010 to 2013. The graph indicates the complete ratio of 0 to 100% of the permanence curve. Thus, it was possible to verify that in the period the flow rate is equal to or exceeds between 50% to 90%.

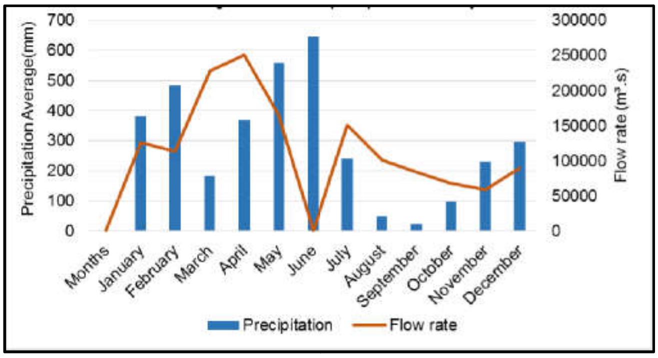

Figure 4. Average flow and precipitation in 2012

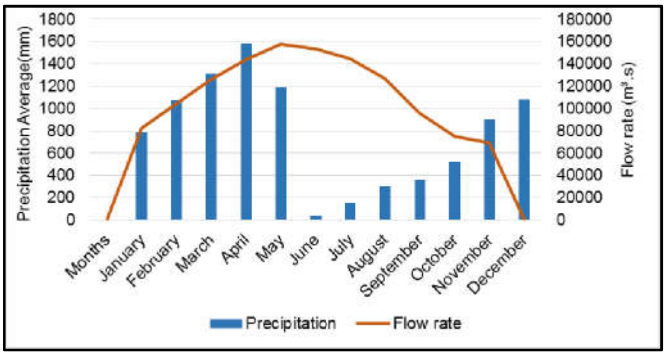

Figure 5. Averageflow and precipitation in 2013

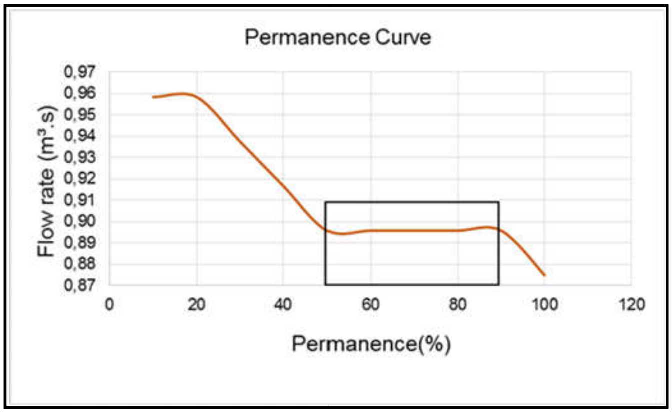

Figure 6. Permanence Curve of annual average flows

Environmental Impacts: The municipality of Manacapuru para Souza (2010), is an important center of rural agricultural production because it has soils with lowland land, characterized by receiving nutrients from the waters of the Solimões River in the flood period, benefiting the crops during the streaming from the river, mostly fed crops of vegetables, vegetables and fruits.As an attractive factor, the municipality has several places and changing rooms. The most frequented of them is the Spa of Miriti, but all the others became very frequented from the inauguration of the PhelippeDaou bridge that connects it to Manaus. After this, it is possible to highlight numerous impacts, such as the change of the physical, chemical and biological properties of the soil, as well as water contamination, modification of air quality and variation in atmospheric precipitation.According to Golvea's study (2015), urbanization causes the attenuation of vegetation cover and soil waterproofing, leading a large portion of rainwater to a surface runoff and limiting aquifer reload, besides limiting efficiency natural hydrographic basin. Thus, the impacts of the construction of the bridge are also related to the migration of industries and trades to the region, contributing to population growth due to the increase of new employment opportunities, in a way negatively interfering in the region's ecosystem through deforestation, land use alteration, emission of polluting gases into the atmosphere, also interfering in climate events.

Final Considerations

The present study made it possible to demonstrate that the Amazon has actually suffered extreme and increasingly intense and short-term weather events between one and the other event. It also proves the influence of the El Niño and La Niña climate phenomenon throughout the Amazon Basin and consequently on the Manacapuru basin.Research in the Manacapuru Hydrographic Basin, in addition to serving as a laboratory of phenomena that expand on Amazonhydrography, is also configured as a laboratory of the man-nature relationship, since the waters are true roads to the Amazonian man who gets his life impaired when extreme droughts and flooding occur. The greater the understanding of the el Niño and La Niña climate phenomena and their impacts on the hydrological regime of the Manacapuru Basin, as well as the anthropic impacts, the more reasoned may be public policies for the management of water resources and developments of sustainable economic activities in the Municipality.

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