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Characterization of Water Inflitration in the Soil of the São João River Basin on the Municipality of Porto Nacional, in the State of Tocantins, Brazil

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Abstract

The present study of the characterization of the infiltration of the Ribeirão São João river basin has the objective of understanding the behavior of the water infiltration, where infiltration tests were performed in the place by the Kostiakov method and permeability by the method proposed by Radcliffe and Simunek associated with classification criteria of Reichardt, using double ring infiltrometers, associated to the geological knowledge of the area that subsidized the elaboration of the chart of use and occupation of the soil. Some recharge areas are impacted with low susceptibility to infiltration due to the intensive use of agriculture and its expansion, which directly affects the biodiversity around the basin under study. Improving the quality and quantity of water in the São João river basin depends on good planning by the local authorities, taking measures to guide and control the use and occupation of the soil, as well as the activities performed by the population in the surrounding basin area that supplies the city's water supply system (SAA).

Key words: Soil, Infiltration, River Basin.

INTRODUCTION

The fast urbanization process in Brazilian cities occurred in a disorderly and unplanned way, thus generating an increase in areas with large urban centers. According to Targa et al., (2012) the soil surface, when undergoing changes due to urbanization, interferes in the terrestrial phase of the hydrological cycle, since it generally reduces the area of infiltration and increases the surface flow. Allied to this factor has been the excessive consumption and waste of natural resources such as water which is clearly a more wasted natural good among people.

According to MIRANDA, OLIVEIRA, SILVA (2010), the Hydrological Cycle is formed by several continuous processes, where the water circulates and is transformed into the three components of our planet: the atmosphere, the soil and the hydrosphere (rivers, lakes and seas) in which water begins its journey from an initial stage to returning to its original position. The hydrological cycle in the terrestrial surface is constituted by the following seven distinct processes: evapotranspiration, precipitation, rain, precipitation interception, infiltration, water storage in the soil, surface runoff.

In this aspect the flow of the water on the surface of the soil happens the moment in which the volume of precipitation infiltrates in the ground until the same saturates. According to Gondim et al. (2010), water infiltration in the soil is a process in which water crosses the soil surface vertically. For Santos et al (2012), one of the factors influencing the hydrological regime is surface runoff. Knowing the characteristics of the surface runoff of a river basin allows a geoenvironmental analysis and the better management of its water resources.

As for the infiltration process, Brandão et al. (2006) emphasizes that it depends on several factors, such as: Surface condition; Soil type; Soil condition; Initial soil moisture; Hydraulic load; Temperature; Presence of cracks, cracks and biological canals originated by decomposed roots or by soil fauna; Compaction of the soil by machines and / or animals; erosion, Soil compaction by rainfall and Vegetation cover.

In order to determine the water absorption capacity in soils, we have the infiltration tests, which can be by the method of entry and exit of water in the furrow, ring infiltrator, rainfall simulators or spray infiltrometer. According to Vieira (1997), the ring infiltrator is the most used, and studies show that the values of the infiltration capacity of the soil, determined by the infiltrator rings, are always higher than those established by the rainfall simulator.

According to Morais (2007), the infiltration of water into the soil is important for the recharge of aquifers and for maintenance of the base flow of the rivers, which makes it extremely important for the management of water resources. The objective of the present work was to characterize the infiltrations on the surroundings of the São João river basin by means of the land use and occupation charter, from water infiltration tests with a double ring infiltrometer, in order to support studies of planning and management in the basin, in order to provide information that can minimize the existing environmental impacts, as well as contribute to the recovery of impacted areas.

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MATERIALS AND METHODS

1.1. Study Area:

The study was developed in the São João River basin, located in the municipality of Porto Nacional (Figure 1), an affluent of the Tocantins River, located between the parallels 10 ° 46'43 "and 20 ° 41'20" on the south latitude and between the meridians 48 ° 14'16 "and 48 ° 24'51" on the west longitude.

According to Silva (2010), Porto Nacional has an area of 4,464.11 km², corresponding to 1.61% of the total area of the state of Tocantins, with an estimated population of 52,510 inhabitants (IBGE, 2018) and is in 62 km from the capital Palmas.

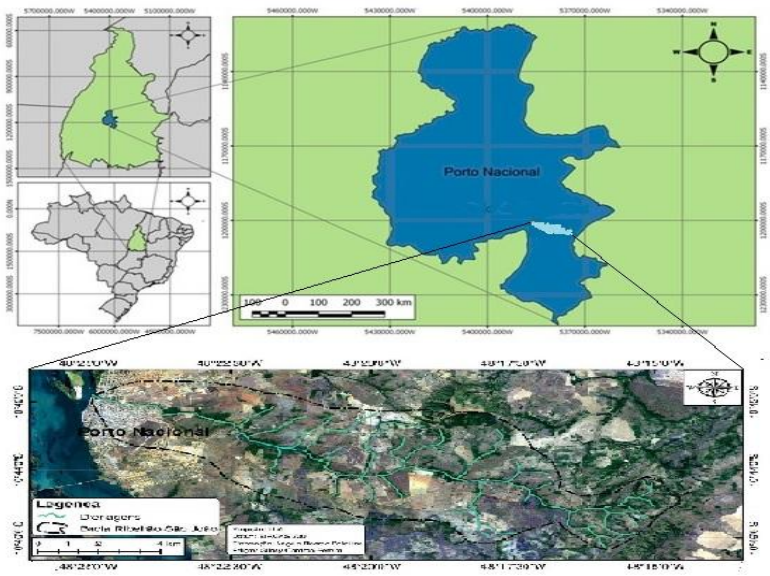

Fig. 1: São João River Basin in the municipality of Porto Nacional – Tocantins.

The São João River basin is of second order, has a drainage area of approximately 81.97 km², presenting seven drainage channels with a total extension of 35.5 km, having 15.75 km in its main channel, the divisor of the waters represent a perimeter of 46.26 km and an altimetric range of 321 meters (OLIVEIRA and FRANCE, 2014).

According to Balduino et al. (2018), the climate of Porto Nacional is humid Subhumid, with two well-defined seasons, rainy and dry, with the dry season happening in the winter with moderate and megathermal water deficiency, with high annual values of potential evapotranspiration, with 28,29% of this evapotranspiration concentrated in the summer season, and can be defined by the formula C2wA'a ', and in the last 20 years analyzed, the annual average precipitation and temperature were, respectively, 1563 mm and 27,28 °C. The dominant natural vegetation in the basin area corresponds to the savanna.

The study was developed from infiltration tests performed in 15 sample places (Figure 2), located in red and yellow latosols soils, dark red latosol, concretionary-lateritic and lithographic soils, according to Ranzani (1996). The choice of each point considered the access permission and the ease and types of land use and agricultural management developed, according to Table 1.

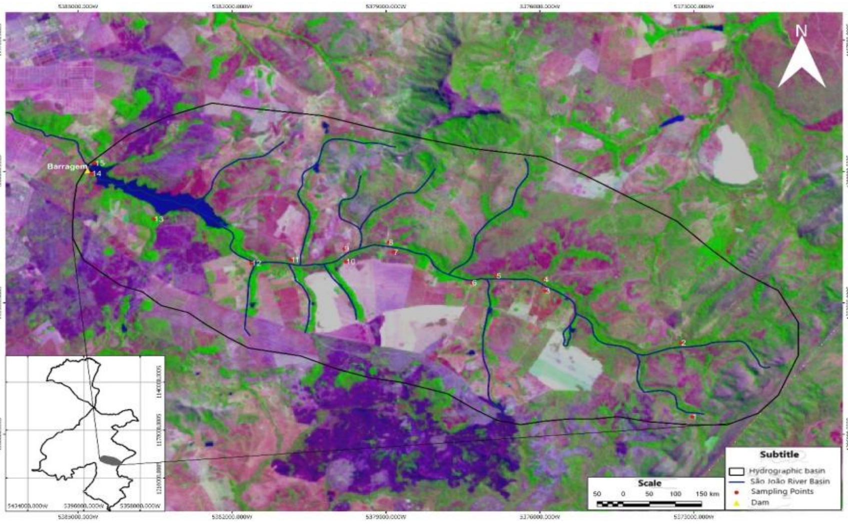

Fig. 2: Sample places of the São João River Basin.

1.2. Double Ring Infiltrator Test:

In order to quantify the infiltration, it was determined, installed and performed tests in fifteen points of the basin, which consists of two rings concentrically placed in the soil, the inner ring having a diameter of 200 mm and the external ring of 400 mm, both with height of 200 mm, as shown in figure 3.

For the calculation of infiltration, the Kostiakov method (1932) was used, which describes the infiltration for short periods, common in the precipitation of medium and small water slides, given by equation 1:

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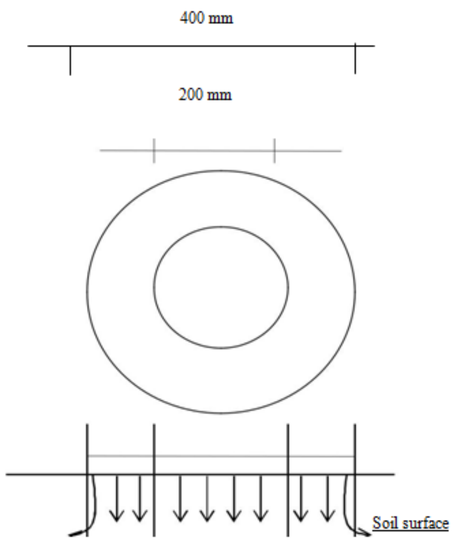

Fig. 3: Schematic drawing of ring infiltrameter Source: Carvalho & Silva (2006) adapted.

Table 1: Characteristic of the sample places

Place	Altitude (m)	Soil Use
1	316	Native Forest
2	296	Native Forest
3	281	Pasture
4	282	Pasture
5	269	Rooted Raising
6	271	Monoculture(soybean)
7	260	Monoculture (soybean)
8	262	Monoculture (soybean)
9	256	Monoculture (soybean)
10	261	Riparian Forest
11	249	Monoculture (soybean)
12	253	Pasture
13	248	Riparian Forest
14	247	Riparian Forest
5	254	Riparian Forest

I = K . Ta (Equation 1)

Where I is the accumulated infiltration (cm); K is the soil-independent constant; T is the infiltration time (min); and a is the soil-dependent constant, ranging from 0 to 1.

To determine the coefficients and exponents of the potential equations, the statistical method of linear regression was used. Applying the logarithms on both sides of the potential equation, we have the equation 2:

logI = loga + n.logT (Equation 2)

With the application of logarithms, the potential equation is transformed into a linear equation of type I = a + bx, where:

$$B = \frac{\sum XY - \frac{\sum X . \sum Y}{N}}{\sum X^2 - \frac{(\sum X)^2}{N}}$$ (Equation 3)

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$A = \bar{Y} - B . \bar{X}$ (Equation 4)

Where N is the number of readings.

It was determined the speed of the instantaneous infiltration (VI) by the method Kostiakov (1932), where for each instant is derived the accumulated infiltration in relation to time, expressed by the equation 5.

VI = dI/dT, ou seja, VI = K . a . T^(a-1) (Equation 5)

The soil saturates, and the infiltration velocity stabilizes, assuming a constant value, called permeability of the saturated soil (K), given by Table 2.

Table 2: Classification of permeability of the saturated soil

K	Value (cm/h)
Pretty High	>3
High	1,5 – 3
Medium	0,5 – 1,5
Low	0,1 – 0,5
Pretty Low	<0,1

Source: Reichardt (1990)

The equation used to calculate the value of the saturated soil permeability (K) was the proposal of Radcliffe and Simunek (2010), associated to classification criteria from K of Reichardt (1990), according to the equation 6.

$$K = \frac{Is}{1 + \frac{4 . \lambda c}{\pi . r}}$$ (Equation 6)

where:
K: soil permeability;
Is: Stable infiltration;
ʎ c: length of the macroscopic capillarity of the soil according to the categories of texture and structure, according to Table 3;
π: 3,14;
r: ring radio.

Table 3: Estimation of macroscopic soil capillary length for texture and structure categories.

Length of the macroscopic capillarity of the soil according to the categories of texture and structure	ʎc (cm)
Coarse sediments, gravel, sand, and may include highly structured soils with large amounts of macroporous and cracks.	2,8
More structured soils from clay and loam; also include moderately structured soils and fine sand.	8,3
Soils with fine texture (clayey) and unstructured.	25
Compacted unstructured soils, clayey material such as landfill liners and liners, lacustrine or marine sediments, etc.	100

Source: Elrick e Reynolds (1992 apud Radcliffe and Simunek, 2010)

RESULTS AND DISCUSSION

The infiltration tests, according to Chowdary et al (2006), indicate a tendency of a downward movement of the water that causes a flood in the lower layers, generating redistribution, indicating a tendency of infiltration value that, considering that the permeability is variable and depends on the geotechnical properties, such as: vegetation, relief, texture, structure, porosity and soil use and occupation.

According to Ranzani (1996), in the São João river basin, sediments are formed in the "A" horizon with 2.5YR 4/2 (weak red) to 2.5YR 4/6 (dark red), clay-sandy, medium-textured and soft-wavy relief. Fifteen analyzes of infiltration tests were performed using the double ring infiltrometer method, which indicated low to very high permeability, according to Table 4.

The chart of use and occupation of the soil (Figure 4) showed low permeability at the P-3, P-4, P-6, P-7, P-8, P-9 and P-11 points in pasture and Soybean areas. Rodrigues Júnior et al. (2007), in a pasture area study in the municipality of Taubaté, state of São Paulo, presented low permeability, the same occurring in areas of monoculture planting in the Concórdia River experimental basin in Lontras, state of Santa Catarina, Pinheiro et al (2009), presented low permeability in no – tillage and high areas in maize crop management.

At the P-5, P-12, P13, P-14 and P-15 points, there was a high permeability, in the areas with rooted raising and riparian forest. At P-1, P-2 and P-10, they presented very high permeability, with the presence in these areas of riparian and native forest, with shrub and herbaceous zones that facilitate water infiltration, according to Figure 4. For Muschler (1999), the presence of trees increases the contribution of organic matter in soils, which increases its water infiltration and absorption capacity, conserves moisture and, consequently, reduces the risk of erosion.

The main environmental problems in the river basin are the exposed soil caused by the intense deforestation for the planting of monocultures and soil impermeabilization. Santos and Pereira (2013), in a work in a sub-basin of the Maracanã River in São Luiz, state of Maranhão, found permeability that varied in a low to high range.

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On-site infiltration tests showed an average infiltration velocity of 0.092 cm.m-1 and reached saturation after 60 minutes (1 hour) of the experiment, according to Figure 5.

Table 4: Permeability values on the São João River Basin.

Samples	Permeability	Classification of Reichardt (1990)
P-1	9,84	Pretty High
P-2	12,97	Pretty High
P-3	0,40	Low
P-4	0,50	Low
P-5	2,68	Alto
P-6	0,50	Low
P-7	0,42	Low
P-8	0,47	Low
P-9	0,50	Low
P-10	16,85	Pretty High
P-11	0,30	Low
P-12	2,37	High
P-13	2,93	High
P-14	2,98	High
P-15	2,91	High

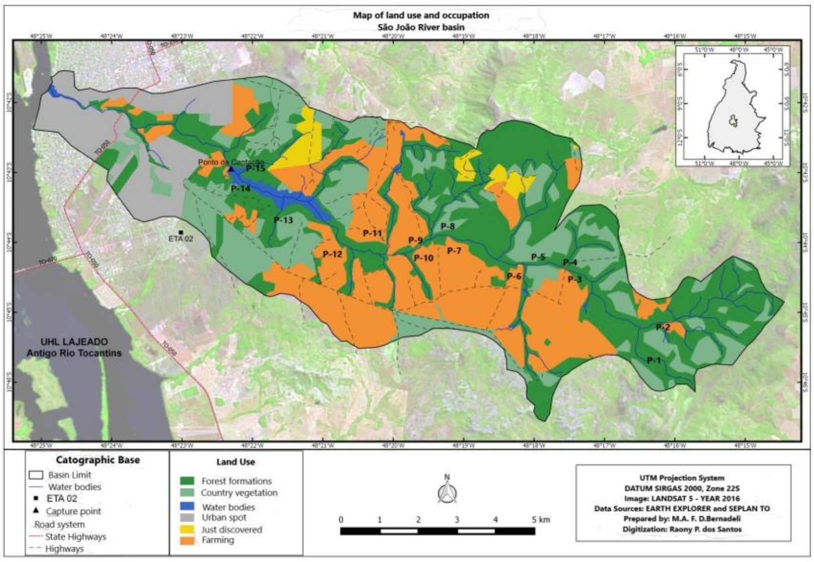

Fig. 4: Chart of soil use and occupation of the São João River Basin Source: Bernadeli (2017) adapted.

The accumulated infiltration presented an average of 4.7 cm, evidencing that the test begun with the soil minimally humid, since it had rained a few days earlier in some points, according to figure 6. Pereira et al (2015), in a field work experimental study from the Federal University of Bahia, presented infiltration velocity of 0.18 cm.min-1, reaching saturation after 110 minutes, with infiltration of 12.3 cm.

The results show the inverse relationship between infiltration velocity and accumulated infiltration, which makes it evident that velocity tends to decrease until saturating with time, and accumulated infiltration tends to increase. According to Nunes et al (2012), probably the vegetal cover made it easier to infiltrate the water, in the preferred paths formed by the roots, which consequently allows a higher rate of infiltration.

Conclusion:

The present study searched, through the infiltration tests on-site with double ring infiltrator, to know the behavior of water infiltration in the São João river basin, associated with the knowledge of the soils in the area, in which it subsidized the elaboration of the chart of soil use and occupation to water infiltration in the soil in the basin

The areas of pasture and soybean planting presented low permeability due to the impacts caused by the use and occupation of the soil without a previous plan for this basin, which is extremely important for the coaptation of water that supplies the municipality, with the recommendation of a potential study of potentiality and vulnerability of hydrographic basin characteristics. The possible causes are linked to the intense mechanized monoculture due to the expansion of the agricultural frontier.

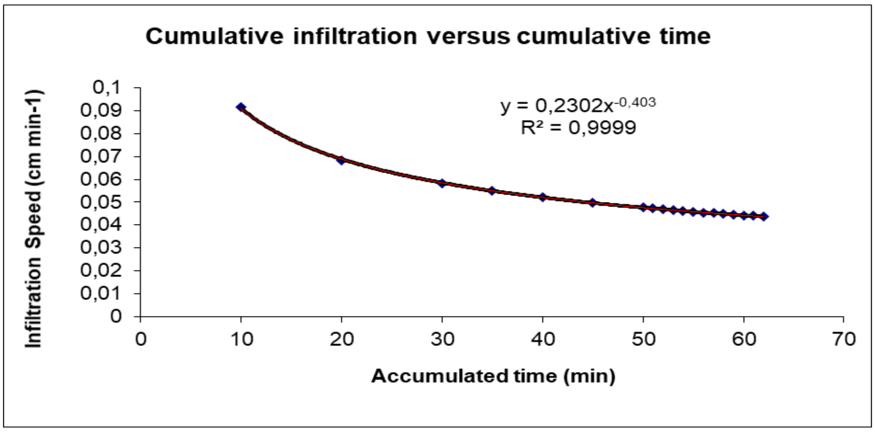

Fig. 5: Infiltration speed curve in the São João River Basin.

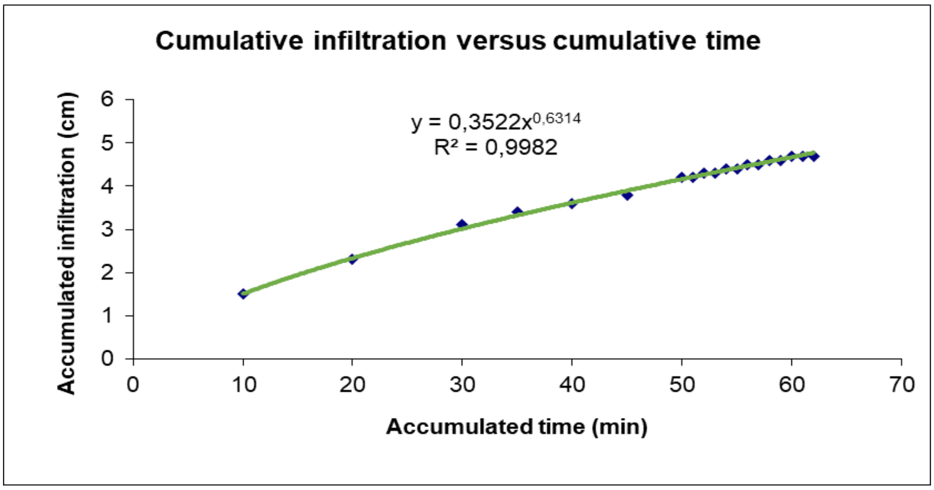

Fig. 6: Curve of the infiltration accumulated in the São João River Basin.

The areas of root cultivation and riparian and native vegetation showed high permeability, because in these sites there is a characteristic arboreal-shrub vegetation of the savanna, with the presence in the area of riparian forest of many buritis, which are bioindicators of the quantity and quality of water. The soil with vegetation cover tends to have a higher rate of infiltration due to the presence of channels formed by the roots, microbiological activity and the presence of organic matter, such as the leaves, organic matter and roots, causing the precipitation of water to concentrate around this climate, thereby increasing the time of infiltration and decreasing the instantaneous flow.

The difference in infiltration velocity with and without vegetation cover in the studied basin was high, reaching 47.83%. Using a river basin as a planning unit for the renewal of water resources enables us to study the environmental impacts of anthropogenic activities. For this reason, it is recommended that temporary hydrographic basin studies be performed in order to have a strategic hydrological replacement planning, as well as measures guiding and controlling the use and occupation, which are of extreme importance, since only then will potentialities and weaknesses be diagnosed for a balance to be struck between man and nature, so that the public power can deliberate the desirable economic and ecological zoning, without detriment to the environment, and consequently, a better quality of life for the population..

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REFERENCES

Balduino, A.R., M.G. Santos, L.B. Souza, D.P. Lima, A.P. Carvalho, 2018. Hydric balance and climatic classification of the city of Porto Nacional, state of Tocantins, inserted in the Legal Amazon, Brazil, 5 -3.

Bernadeli, M.A.F.D., São João stream basin & Water safety urban supply of the municipality of Porto Nacional - TO. Dissertation. Graduate Program in Geography. Federal University of Tocantins. Porto Nacional – TO.

Brandão, V.S., D.D. Silva, H.A. Ruiz, F.F. Pruski, C.E.G.R. Schaefer, M.A. Martinez, S.J.M.C. Menezes, 2006. Hydraulic resistance of the crust formed in soils subjected to simulated rainfall. Brazilian Journal of Soil Science, 30: 13-21.

Carvalho, D.F., L.D.B. Silva, 2006.The Hydrology Handbook. Chapter 5. Rio de Janeiro, 69.

Chowdary, V.M., M.D. Rao, C.S. Jaiswal, 2006. Study of infiltration process under different experimental conditions. AgriculturalWater Management, 83: 69-78.

Gondim, T.M.S., J.A.C. Wanderley, J.M. Souza, J.M. Feitosa Filho, J.S. Sousa, 2010. Infiltration and velocity of infiltration of water by thering infiltrator in sandy-clay soil. Brazilian Magazine of Environmental Management, (Pombal – PB – Brasil), 4(1): 64-73.

IBGE – Brazilian Institute of Geography and Statistics, 2018. Ministry of Planning, Budget and Management, Cities @, Brasília, 2016. Available in: http://www.ibge.gov.br/cidadesat. Acesso em 19/04/2018.

Kostiakov, A.N., 1932. On the dynamics of the coefficient of water - percolation in soils and on the necessity for studying it from a dynamic point of view for purposes of ameliation. Trans. 6t h comm. Intern. Society Soil Science, Moscou, Part A., 17-21.

Miranda, Ricardo Augusto Calheiros de; OLIVEIRA, Marcus Vinicius Siqueira de; SILVA, Danielle Ferreira da, 2010. Planetary hydrological cycle: approaches and concepts. GEOUERJ, Rio de Janeiro, 1(21): 109-119.

Morais, F., 2007. Study of the pedogeomorphological factors involved in infiltration in recharge zones in the metamorphic complex Bação-MG. 191f. Thesis (PhD in Crustal Evolution and Natural Resources). Universidade Federal de Ouro Preto. Ouro Preto.

Muschler, R.G., 1999. Árboles en Cafetales. Módulos de Enseñanse Agroflorestal. Turrialba: CATIE/GTS.

Nunes, J.A.S., M.H.D. Silveira, T.J.A. Silva, P.C.M. Nunes, K.S. Carvalho, 2012. Infiltration velocity by the concentric ring infiltrator method in RED LATOSOIL of savanna. Encyclopedia Biosphere, 8(15): 1685.

Oliveira, M.G.N., W.B. França, 2014. Analysis and Evaluation of the São João river basin for distribution. Porto Nacional. TCC (Bachelor in Civil Engineering) Instituto Tocantinense President Antonio Carlos.

Pereira, M.M., R.S. Moura, A.R.F. Campos, J.G.A. Lima, M.G. Silva, P.C. Viana, 2015. Determination of infiltration velocity by ring infiltrator method. XXV CONIRD – National Congress of Irrigation and Drainage. 1066-1071 p. Universidade Federal de Sergipe - São Cristóvão. Sergipe.

Pinheiro, A., L.P. Teixeira, V. Kaufmann, 2009. Capacity of water infiltration in soils under different uses and practices of agricultural management. Privacy Policy – An Interdisciplinary Journal of Applied Science, 4-2.

Radcliffe, D.E., J. Simunek, 2010. Soil physics with hydrus: modeling and applications. Florida: CRC Press.

Ranzani, G., 1999. Soil chart of the municipality of Porto Nacional and Ipueiras. Palmas. Miolo, 91.

Reichardt, K.,1990. Water in agricultural systems. São Paulo: Manole.

Rodrigues Junior, S., M.S. Targa, G.T. Batista, N.W. Dias, 2007. Compensatory forest with a view to water retention in the soil of the Ribeirão Itaim basin, Taubaté, SP. In: Water Resources Seminar of the South Paraíba Hydrographic Bowl: The Eucalyptus And The Hydrological Cycle, 1, Taubaté, Extended Abstracts, Taubaté, 67-73.

Santos, G.G., P.G. Nori, LF.C. Oliveira, 2010. Heavy rains related to water erosion. Brazilian Journal of Agricultural and Environmental Engineering, Campina Grande, 14(2): 115-123.

Santos, J.N., E.D. Pereira, 2013. Letter of susceptibility to soil water infiltration in the Maracanã River sub-basin - MA. Cad. Pesq., São Luís, 20 special.

Silva, A.A.F., 2010. Geoprocessing applied to the analysis and geomorphological mapping of the. Porto Nacional, TCC (Bachelor of Geography) Federal University of Tocantins.

Targa, M.S., G.T. Batista, H.N. Diniz, N.W. Dias, F.C. Matos, 2012. Urbanization and surface runoff in the Igarapé basin of Tucunduba, PA, Brazil. Privacy Policy - An Interdisciplinary Journal of Applied Science, 7-2.

Vieira, H.A., 1997. Behavior of four infiltrometers in determining the rate of basic infiltration of water into soil. Viçosa: UFV, 52. Master Thesis.