
Physical Characterization of the Rio Saltinho Watershed, in the cities of Cascavel and Santa Tereza do Oeste, Paraná

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Abstract: The study of the physical characterization of watersheds is extremely relevant for the conservation and management of water resources. This present work aimed to study the physical characteristics of Rio Saltinho watershed, located in the cities of Cascavel and Santa Tereza do Oeste – PR. Using the AUTO CAD 2008 software, it was calculated the area to determinate the morphometric parameters, for the hydrological characterization of the watershed. It was indicated the order of the watershed watercourse and its hypsometric curve. The drainage area of the watershed is 42 Km² and the perimeter is 28,3 Km. The form factor of the watershed is 0,414, the index of compactness obtained was 1,22, indicating that the watershed shape resembles a rectangle; the index of conformation obtained was 0,3861. The watercourse slop was analyzed in three different ways: S₁ 0.0115, S₂ 0.00678 and S₃ 0.00610. The physical characteristics found on the watershed indicate that it is has low probability of flooding.

Key-words: Watershed; Morphometric; Superficial runoff.

Introduction

Water consists in an essential element for life. Besides it direct consumption, it is necessary for food and resources production, both indispensable for life.

The current rate of population growth has been forcing to increase exploited areas by the agricultural segment, one of the main responsible for the water consumption in the world, along with the consumption of water by other market segments, which has been increasing the preoccupation regarding to the water availability for the population consumption.

In a global perspective, the amount of water is enough to supply all the population, although it has to be considered that approximately 99% of the water on the planet is salted or is frozen in the poles and glaciers, becoming inappropriate or unavailable for human consumption. Furthermore, it has to be considered that the distribution of drinking water on the surface of the planet is not even, for this reason several regions in the world are not properly supplied with this resource.

Brazil is a privileged country, when analyzed by the abundance of water found in its territory, however it also face an uneven distribution of this resource, whose great amount of

it is found in Amazon, region that is sparsely populated when compared to the other regions of the country.

For the development of environmental studies, the analysis of the morphometric characteristics of watersheds is essential (Oliveira *et al.*, 2010). The biotical and physical characteristics of a watershed exert an important role on the hydrological cycle processes influencing, amongst others, the infiltration, the amount of water produced as runoff, the evapotranspiration, the superficial and sub superficial runoff (apud Oliveira *et al.*, 2010).

In tropical coastal regions, the passage of a cold front with intense rainfall, especially when combined with elevated astronomical and meteorological tide effects, might produce the accumulation of water inside a drainage watershed in an amount superior than the one that the channels can tolerate, causing floods that can last from a couple of hours to several weeks (Souza, 2005).

Factors that affect the incidence of floods can have a natural and/or an anthropic origin. The natural determinants are divided into two: climatic-meteorological (magnitude and frequency of rain associated with cold fronts, climatic phenomena such as El Niño and La Niña etc.), geologic-geomorphologic (geological substratum, morphometric of the drainage watershed, soil and vegetation coverage), fluvial-hydrological (river hydraulics, ocean currents created by tides in estuarine and lagoon areas etc) and oceanographic (influence of tides and coastal circulation dynamics along the river mouth or the lagoon mouth). The anthropic determinants result from human interventions, directly or indirectly, in the drainage watershed and they can be generically gathered in: use and occupation of marginal areas of the drainage channel (freshwater and mixohaline); modification of the drainage network (landfills, construction of linear structures and dams; implantation of structural measures to minimize flooding, disposal of solid and liquid wastes in inappropriate places or in the channel itself etc) and modification of the natural sedimentary processes and of the sedimentary balance of the coastal system (Souza, 2005).

One of the instruments for the watershed management is the a management program, because it arranges a technique that prioritize the hydric sustainability of the watershed using integrated actions amongst federal, state and municipal governments, civil society and technical-scientific community (Andrade *et al.*, 2008).

The morphometric characterization of a watershed consists on the characterization of physiographic parameters, which are physical indicators of the watershed. This characterization has large application as indicators on the forecast of the vulnerability level of

the watershed to suffer with phenomena such as floods and erosion, inter alia (apud Andrade *et al.*, 2008).

This present work is aiming to study the physical characteristics of Rio Saltinho watershed, which will help the study and characterization of its hydrological behavior, allowing the surveying of the critical area, important to the maintenance and conservation of the region in question.

Material and Methods

Rio Saltinho watershed is located at the geographical coordinates 25° 01' 06,50" South latitude and 54° 30' 48,95" West longitude of Greenwich, encompassing part of the cities of Cascavel and Santa Tereza do Oeste, both located in Paraná state. The weather of the region is mild temperate, super humid without dry season. The soil is characterized as Red Latosol typical distroferic Embrapa (1999), that is characterized by its depth and high fertility. The geology is formed by Mesozoic sedimentary coverage. The topography is characterized by Third Plateau, contemplating quotas in a range from 580 to 780 meters of altitude.

It was used a digitalized topographic map, granted by SANEPAR – Company of Sanitation of Paraná (translated from the Portuguese and stands for *Companhia de Saneamento do Paraná*), containing basic information about the studied area, and by the means of AUTOCAD 2008 software, on which it was inserted the topographic map, the calculations and the measurement of factors and coefficients were performed.

According to Amorim *et al.* (2002), the rainfall density of Cascavel, where more than half of the watershed is located, has an order of 2011 mm/year, lacking periods of dry season during the year, presenting months with higher rainfall density such as May and October and others with lower density such as July and August.

Drainage area

The drainage area of a watershed is an important element to be considered regarding hydrological studies. It corresponds to the measurement of the horizontal projection, considering all the area located between the water divisors (Andrade *et al.*, 2008).

The watershed area is the basic element for the calculation of other physical characteristics. The characterization of the drainage is performed by contouring the watershed surroundings, over the highest quotas between the two closest watersheds. The area of Rio Saltinho watershed was calculated by planimetry over a topographic map, on which the

contour lines, the watershed boundaries, main riverbed, its tributaries, borders amongst cities and another data were represented, according to Figure 1.

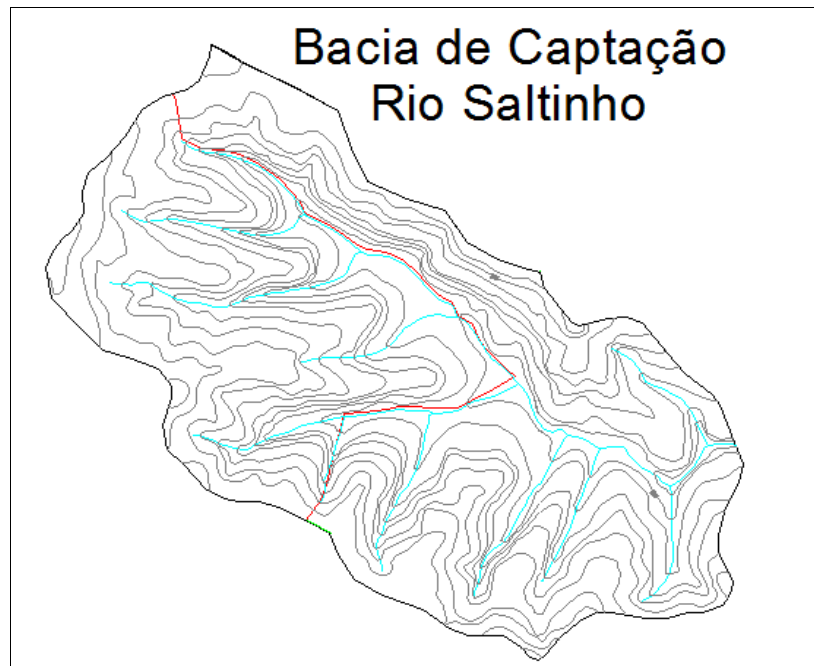


Figure 1 – Rio Saltinho watershed.

Watershed form

Big watersheds usually are fan-shaped or pear-shaped, while small watersheds can present several shapes. Rounded watersheds have higher tendency to flood, because the water tends to run to the same spot. Elongated watersheds present less susceptibility of incidence of these phenomena.

Form factor

It is obtained from the relation between average width and axial length of a watershed Villela e Mattos (1975) that goes from the mouth until the farthest waterheads, as displayed in Figure 2. This factor provides a very important characteristic of the watershed, whose value express how submitted to flood the analyzed micro-region is. A watershed with low F presents less propensity to flood than others with the same area but with higher F, when in a narrow and long watershed (low F) is observed less possibilities of intense rain incidence covering simultaneously all its length (Oliveira *et al.*, 2010).

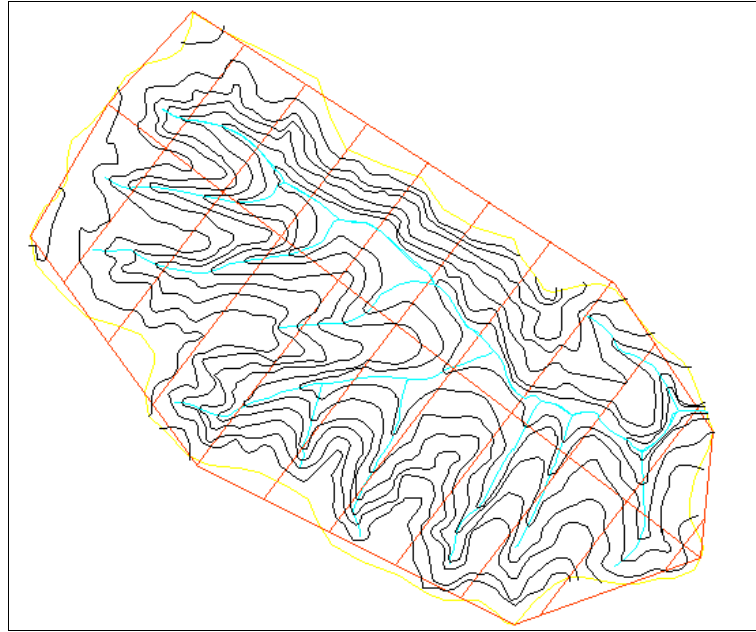


Figure 2 – Form Factor

$$F_F = \frac{B}{L}$$

Where:

L: Watershed length;

B: Average width $= \frac{1}{n} \sum_{i=1}^n B_i$

Coefficient of Compactness

The index of compactness relates the perimeter of a watershed with the circumference of a circle with identical area as the watershed (Villela e Mattos, 1975). This index is used to define the watershed shape, independently of its size, when the more irregular the shape is, more is its index of compactness. It is important because it denotes the time, from the beginning of the precipitation that the water will take from the borders of a watershed to arrive until its exit. Therefore, the closest the watershed shape is to a circle, more is its capability to proportionate big flooding.

$$K_e = 0,28 \cdot \frac{P}{\sqrt{A}}$$

Where:

P: Watershed perimeter

A: Watershed area

Index of Conformation

It is the relation between the watershed area and a square with the same axial length as the analyzed watershed, expressing the watershed capability to generate floods. In cases where there are no other factors that interfere, the closest the number is to 1, higher is the propensity to flood, because each time the watershed resembles more a square.

$$F_c = \frac{A}{L^2}$$

Where:

A: Watershed area

L: Watershed axial length

Watercourse slope

Water from precipitation concentrates on the riverbeds after draining (on the surface and underground), through the land of the watershed and it is conducted towards the mouth.

Álveo Slope is important for the watershed management due to its direct influence on the water drainage speed on the watershed trough and at its concentration time. Thus, the water drainage speed of a river depends on the river channels slope (Porto *et. al.*, 1999).

A first approximated value of the watercourse slope between two spots can be obtained by the quotient between the difference of its extreme quotas and its horizontal length, nominated S_1 and calculated by the following equation:

$$S_1 = \frac{\Delta H}{L}$$

Where:

ΔH : Quota variation between two extreme spots of the river;

L: Length in plant of the river.

Another way to define the watercourse slope consists in drawing a graphic of the watercourse longitudinal profile and to define a S2 line, on which the area within the line and the x-axis (horizontal length) is the same as the area within the profile curve and the abscissa (Porto *et. al.*, 1999).

$$S_2 = \frac{2A_{BP}}{L^2}$$

Besides the two slope values that were defined, there is the slope which uses the cinematic concept, on which the accumulated time translation along the watercourse stretches is equal to the translation time of a constant slope line, whose value is more accurate. It starts from the hypothesis that the speed of a stretch is inversely proportional to the slope (Porto *et. al.*, 1999).

$$S_3 = \left(\frac{L}{\sum_1^n \frac{L_i}{\sqrt{I_i}}} \right)$$

Where:

L: Length in plant of the river.

L_i : Horizon length in each of the n stretches;

I_i : slope in each of the n stretches ($I_i = H_i / L_i$).

Watercourse area

The main watercourse area of a watershed reflects the ramification of its drainage system, on which an integer number is established according to several criteria. According to STRAHLER (1957), the main watercourse area of a watershed is obtained by small former currents, which are according Costa e Lara (2011) to the waterlines and the ones that do not have tributaries are considered first order. When two first order lines get together, it becomes a second order river. Two n order rivers become an n+1 river.

Watercourse density

It is the relation between the number of watercourses or rivers and the watershed area. Its calculation is extremely important because it represents the hydrographical behavior of a particular area in one of its essential aspects: the capability to generate new watercourses (Christofolletti, 1970).

$$D_s = \frac{N_s}{A}$$

With N_s : number of watercourses and A : watershed area (Km^2).

Drainage density

Drainage density of a watershed represents the development of the drainage system. The values of this index for natural watersheds, according to Costa e Lara (2011) is in a range from 0,5 km / km² for watersheds with poor drainage to 3,5 km/ km² for well drained watersheds, on which the inferior limit characterize watersheds with poor drainage and the superior limit apply for exceptionally well drained watersheds.

$$D_D = \frac{L}{A}$$

Where:

L: Watercourse total length

A: Watershed area

Hypsometric curve

Hypsometric curve is the way to represent graphically the average relief of a watershed, in other words, it presents the variation of the relief elevation regarding to the sea level. The graphical construction is performed by the percentage of the watershed drainage area that is found above (or below) the several elevations.

With the hypsometric curve, the maximum altitude, the minimum altitude, the average altitude and the median altitude of a watershed are obtained (Costa e Lara, 2011).

Results and Discussion

Throughout the studies that were performed, it is possible to state that Rio Saltinho watershed is formed by an area of 42 Km², where 24,3 Km² are located in Cascavel city and 17,7 Km² in Santa Tereza do Oeste city; and by a perimeter of 28,3 Km, being classified as a small watershed. It is compounded by rural area, blending with pasture and agricultural areas (79%), and forest (21%). The form factor of the watershed resulted in 0,414, showing low propensity to big floods. The index of compactness obtained was 1,22, which indicates that the watershed presents considerable tendency to flood, even though its shape does not resembles a circle, but a rectangle. The index of conformation obtained was 0,3861, which indicates that Rio Saltinho watershed presents low tendency to have flood peaks.

The watercourse slope can be analyzed with three different techniques: S₁, S₂ and S₃, whose results were 0.0115, 0.00678 and 0.00610, respectively, according to the representation on Figure 3.

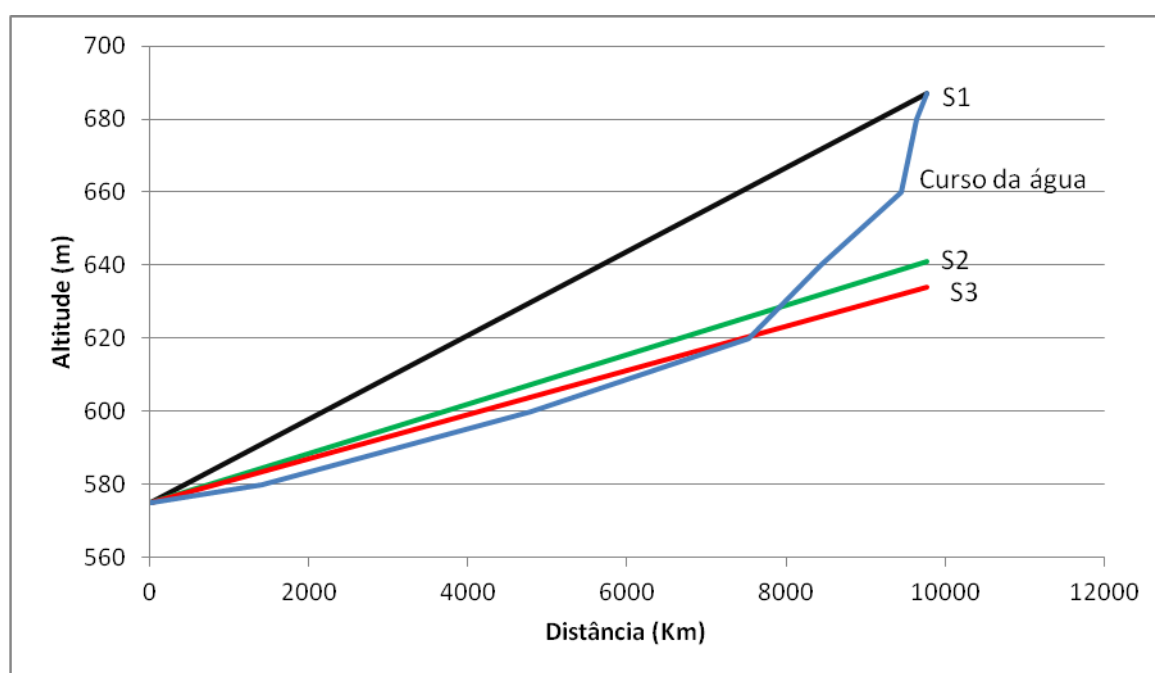


Figure 3 – Watercourse slope

The river was also analyzed regarding to its order, according to Figure 4, where can be seen that it is a third order river, and regarding to the watercourse density the result was 0,26 watercourses per Km².

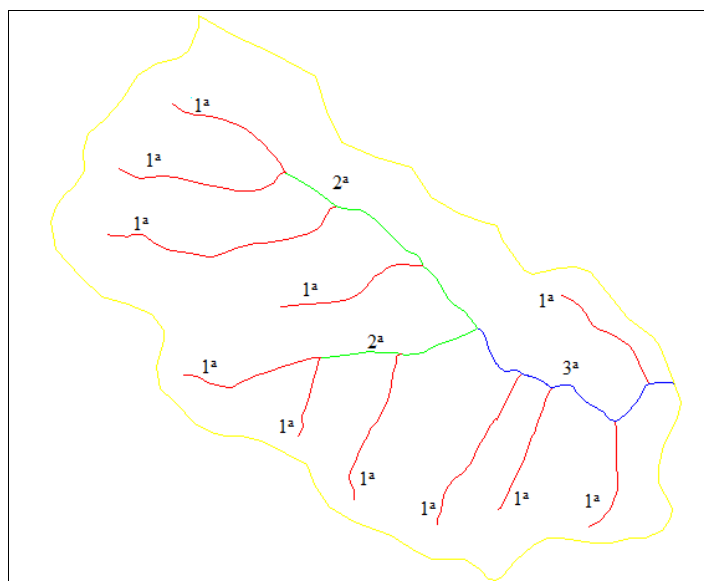


Figure 4- Watercourse order of Rio Saltinho watershed, Cascavel, PR, according to (Strahler methodology 1957).

Another way to represent the watercourse was by the hypsometric curve, according to Figure 5.

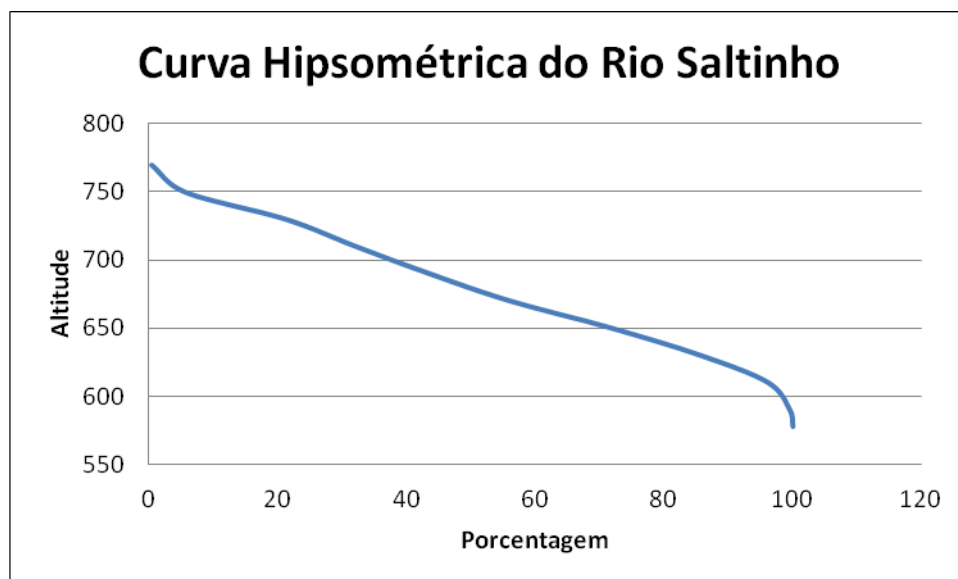


Figure 5 – Rio Saltinho hypsometric curve

Conclusions

Rio Saltinho watershed, when physically analyzed, without considering the use and occupation of the soil, presents low propensity to flood, being considered a small watershed

with rectangular shape. It is considered as a well drained watershed due to its high amount of watercourses and their distribution.

References

AMORIM, R. C. F.; RICIERI, R. P.; FILHO, J. S. D. V.; AMORIM, R. F. C.; PACE, E. L. T. D.; SEGUNDO, C. H. C.; LEITE, C. C.. **Análise das condições climáticas de Cascavel**. XIII Congresso Brasileiro de meteorologia, Foz do Iguaçu, PR, 2002.

ANDRADE, N. L. R de; XAVIER, F. V.; ALVES, É. C. R. de F.; SILVEIRA, A.; OLIVEIRA, C.U. R. de. Caracterização morfométrica e pluviométrica da bacia do rio manso – MT. **Geociências**. v. 27, n. 2, p. 237-248, 2008.

COSTA, T. & LARA, R. **Hidrologia de Superfície**. Faro, 72 p., 2011.

CHRISTOFOLETTI, A. **Análise morfométrica de bacias hidrográficas no Planalto de Poços de Caldas**. 1970. 375 p. Tese (Livre Docência) - Instituto de Geociências, Universidade Estadual Paulista, Rio Claro, 1970.

EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA – EMBRAPA. Centro Nacional de Pesquisa de Solos. **Sistema Brasileiro de classificação de solos**. Brasília, 1999. 412p.

MORAES, D.S. de L.; JORDÃO, B.Q. Degradação de recursos hídricos e seus efeitos sobre a saúde humana. **Revista saúde pública**, São Paulo, 36(3):370-4. 2002.

OLIVEIRA, P.R.SS de; SOBRINHO, T.A.; STEFFEN, J.L.; RODRIGUES, D.B.B. Caracterização morfométrica de bacias hidrográficas através de dados SRTM. **Revista Brasileira de Engenharia Agrícola e Ambiental**. v.14, n.8, p.819–825, 2010.

PORTO, R. L. L.; FILHO, K. Z.; SILVA, R. M. D. **Bacias hidrográficas**. USP, 1999.

SETTI, A.A.; LIMA, J.E.F.W.; CHAVES, A.G. de M.; PEREIRA, I. de C. **Introdução ao gerenciamento de recursos hídricos**. Agência Nacional de Energia Elétrica, Superintendência de Estudos e Informações Hidrológicas. Brasília. 2000.

SOUZA, C.R. de G. **Suscetibilidade morfométrica de bacias de drenagem ao desenvolvimento de inundações em áreas costeiras**. São Paulo. Ano 6. N.1. p. 45 – 61. 2005.

STRAHLER, A. N. **Quantitative analysis of watershed geomorphology**. New Halen: Transactions: American Geophysical Union, 1957. v.38. p. 913-920.

TUCCI, C. E. M.; CLARKE, R. T. Impacto das Mudanças da Cobertura Vegetal no Escoamento: Revisão. **Revista Brasileira de Recursos Hídricos**. v. 2, n.1 Jan/Jun, p. 135-152, 1997.

VILLELA, S. M.; MATTOS, A. **Hidrologia Aplicada**. São Paulo, McGraw-Hill, 1975. 245p.