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Scientific Paper

Morphometric characterization of the Mole River basin in Vitoria da Conquista - BA

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Abstract

The present study aimed the morphometric characterization of the Verruga River basin. The studied area is located in the city of Vitória da Conquista – BA, between the geographic coordinates 14º48' to 15º18' latitude S and 40º56' to 40º32' longitude, WGr, and average 700 m altitude. From the estimate of some physical parameters, the results presented a basin of 4th order with area of 883.38 km2, low drainage density of 0.77 km km^{-2}; average declivity of 19.63%, presenting areas with flat terrain to gently undulating, and also areas with mountainous to steep relief; channel gradients of 1.43% declivity of the water courses. It presented circularity index of 0.44 and shape factor of 0.29, indicating that the studied basin has elongated shape. The sinuosity index of 1.39 indicates tendencies to slightly sinuous channels, the compactness coefficient under value of 1.48 and the extension of the superficial course of 641.0 m, which results in a good water infiltration in normal conditions, favoring the basin conservation.

Keywords: morphometry, hydrographic basin management, geographic information systems.

Caracterización morfométrica de la cuenca de drenaje del río Verruga, en Vitória da Conquista - BA

Resumen

Este estudio tiene como objetivo describir las propiedades morfométricas de la cuenca de drenaje del río Verruga. El área de estudio se encuentra en Vitoria da Conquista - BA, entre las coordenadas geográficas 14º48' a 15º18' de latitud S y 40º56'a 40º32' de longitud W, con una altitud media de 700 m. Los parámetros físicos sugieren que la cuenca de drenaje es de cuarta orden y tiene 883.38 km2 de superficie total, con una baja densidad de drenaje de 0,77km km^{-2}. La inclinación de la cuenca es de 19,63%, lo que incluye áreas relativamente planas para áreas de laderas de montañas escarpadas. El gradiente del canal es de 1,43%. La cuenca también tiene un coeficiente de redondez de 0,44 y un factor de forma de 0,29, lo que indica que la cuenca tiene una forma alargada. El índice stándar de sinuosidad de 1,39 indica tendencias para flujos no sinuosos, combinado con un coeficiente de compacidad de 1,48 y una extensión superficial de 641m, lo que indica buena infiltración en condiciones normales, lo cual es favorable para la conservación .

Palabras clave: propiedades morfométricas, la gestión de las cuencas de drenaje, sistemas de información geográfica.

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Caracterização morfométrica da bacia do rio Verruga, em Vitória da Conquista - BA.

Resumo

Este estudo tem o objetivo de descrever as propriedades morfométricas da bacia de drenagem do rio da Verruga. A área de estudo está localizada em Vitória da Conquista - BA, entre as coordenadas geográficas 14º48 ' a 15º18' de latitude S e 40º56 ' a 40º32' de longitude WGr, com uma altitude média de 700 m. Os parâmetros físicos sugerem que a bacia de drenagem é de quarta ordem, e tem 883,38 km2 de área total, com uma baixa densidade de drenagem de 0,77km km^{-2}. A inclinação média da bacia é de 19,63%, o que inclui áreas de relativamente planas para áreas de encosta montanhosa íngreme. O gradiente do canal é 1,43%. A bacia também tem uma proporção de circularidade de 0,44 e fator de forma de 0,29, indicando que a bacia contém uma forma alongada. O índice de sinuosidade padrão de 1,39 indica tendências para fluxos não sinuosos, combinado com um coeficiente de compacidade de 1,48 e um comprimento de 641m de extensão superficial, indicando boa infiltração em condições normais, o que é favorável para a conservação.

Palavras chave: propriedades morfométricas, manejo de bacias de drenagem, sistemas de informação geográfica.

Introduction

Water is a natural resource that increasingly occupies an important role, mainly regarding human consumption. The government agencies are more and more aware of the importance of preservation and maintenance of springs, since there is an increased tendency of consumption and it is directly related with the demographic expansion of the country.

The sustained mamagement of agroecosystemsn is done by planning their utilization, using concepts introduced for addressing the environmental complexity, evaluating the problems and taking into account its various interdependent aspects: geology, soils, vegetation, climate, actual use, hydrology and anthropic aspects (SANTOS et al., 1996).

The several types of use or targets are easily identified through the use of data from the Remote Sensing. That is, the spectral behaviors of the targets or detected objects are made with the aid of remote sensors.

The development and application of adequate tools to the environmental management has been the target of several studies and researches, highlighting the application of geoprocessing, which includes the Geographic Information Systems (SIG), Remote Sensing, among others.

The advantages of using data from remote sensing in surveys of current land use, according to FREITAS FILHO and MEDEIROS (1993), is that fly are used for reaching great areas of difficult access and making the picturing of high altitudes, enabling a synoptic view of the land surface, with repeatability, enabling, thus, monitoring actions.

The surveys about degradations suffered by the environment are of utmost importance for knowing the reality and searching its recovery (ROCHA, 1978).

In this context, the adequate use of land, in a way of protecting it against erosion and aiming to increase gradually its productive capacity, always requires an initial planning, effective and efficient (CAMPOS et al., 2010).

The hydrographic basin is an open geomorphological system, which receives energy through climatic agents and loses it by runoff. The hydrographic basin, as an open system, can be described in terms of interdependent variables, which oscillate around a pattern and, this way, a basin, when not disturbed by anthropic actions, finds itself in dynamic balance (LIMA, 1994).

The activities of soil use and handling, protection of springs, control of rain water, stabilization of ramps and slopes, infrastructure and road systems must be elaborated in consonance with the characteristics of the hydrographic basin, on which it shall be implanted. Such characterization involves its delimitation, identification and the mapping of relief components, hydrography, geology, soil, vegetation, erosion, declivity classes, among others (POLITANO et al., 1990).

The morphometry is a fundamental tool on the diagnosis of susceptibility to environmental degradation, delimitation of the riparian zone, planning and handling of micro basins (MOREIRA and RODRIGUES, 2010), because its characterization allows to describe the geomorphologic formation of the landscape in its topographic variation (CHRISTOFOLETTI, 1980), and has a significant role on the conditioning of responses connected to water erosion, generated after relevant rainfall events (ARRAES et al., 2010).

In this study we used the classification presented by STRAHLER (1957), where the channels of first order are those that do not have tributaries; the channels of second order are those that are originated from the encounter of two channels of first order; the channels of third order are originated in the junction of two channels of second order, and so on. When channels of elevated order receive channels of inferior orders, always prevails the elevated one, according to CARDOSO (2006).

In this context, due to the importance of the Verruga River basin for the city of Vitória da Conquista–BA, the present study aimed to perform its morphometric characterization, by estimating physical parameters, using Geographic Information Systems – SIGs.

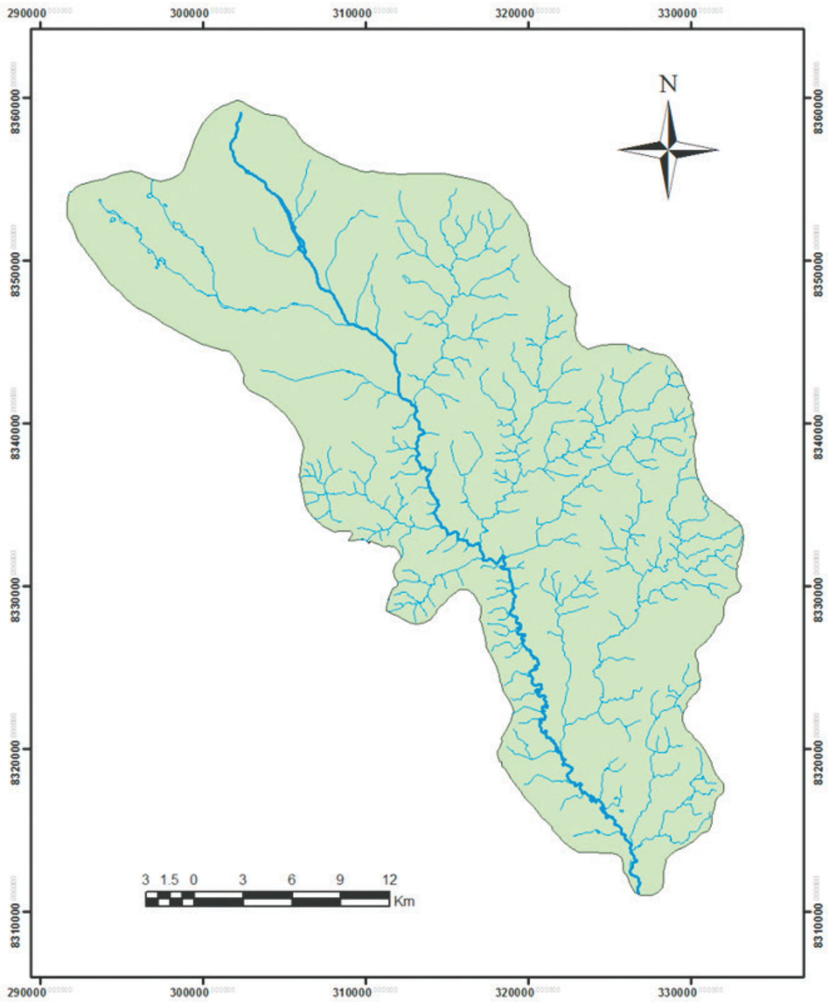

Figure 1. Verruga River basin, Vitória da Conquista - BA.

Material and Methods

The Hydrographic basin of Verruga River drains the South-Central portion of the city of Vitória da Conquista – BA, part of the Southwest portion of Barra do Choça and part of the North portion of Itambé city. Its waters run from Northwest to Southeast, flowing on Pardo River, next to the city of Itambé-BA. It occupies an area of approximately 883.38 km². It is located between the geographic coordinates: 14º48' to 15º18' latitude S and 40º56' to 40º32' longitude, WGr.(Figure 1).

Verruga River originates on the Periperi Sierra – urban area of Vitória da Conquista, in an ecological reserve that preserves its spring, also known as Poço Escuro spring. The most important tributaries, of the right bank, are: Santa Rita brook, Lagoa de Baixo stream and Piriquito River, while on the left bank, they are: Leão and Jeribá streams, Moreira stream and D'Água Fria, Canudos and Santa Maria Rivers, José Jacinto brook, Riacho Seco stream and Areia brook.

The climate of the basin area has a variation that follows the different topographic sets, according to its dynamic; there is a predominance of Humid and Subhumid climate on the range correspondent to the Eastern Slope of the Conquista Plateau, with total rain averages that vary from 1000 to 1500 mm annually (ROCHA, 2008).

In the morphometric characterization we used a topographic map from IBGE, on the scale of 1:100.000, sheet of Vitória da Conquista SD.24-Y-A-VI and Itambé SD.24-Y-C-III, curves with vertical equidistance of 40 m. The map was georeferenced on the SIG-Quantum GIS and subsequently made the delimitation of the basin and vectoring of the drainage network and the level curves.

After the basin delimitation we analyzed the parameters referring to the relief and the drainage network.

The compactness coefficient (Kc), is the relation between the basin perimeter and the circumference of a circle of equal area of the basin and it was calculated from the following equation: $Kc=0,28x(P\sqrt{A})$, in which Kc is the compactness coefficient, P is the perimeter in km and A is the basin area in km². This coefficient is a dimensionless number that varies with the basin shape, independently of its size, thus, the more irregular it is, the more it will be the compactness coefficient, that is, the closer to the unit, more circular it will be the basin, and presenting higher tendency to floods (VILLELA and MATTOS, 1975).

The shape factor (Ff), is the relation between the basin area (A) and the shaft length of the basin, from estuary to outfall, expressed in km2/km. This index also indicates the higher or lower tendency to floods in a basin. A basin with low Ff will have fewer propensity to floods than other with same area, but higher Ff. This must be due to the fact that, in a narrow and long basin (low Ff), there is fewer possibility of occurring intense rains, covering simultaneously all its extension.

The circularity index tends to the unit 1.0, as the basin appro'Hm=(AM+Am)/2, where: Hm: average altitude (m), AM: altitude of the higher quota and Am: altitude of the lower quota; as for the altimetric amplitude calculation we used H=AM-Am.

The Roughness Coefficient (Rn) is a parameter of the potential use of lands, directing them to agricultural activities, livestock and other ends. According to ROCHA (1991), the Rn is defined according to the expression: Rn = Dd x S, where: Rn = Roughness Coefficient; Dd = Drainage Density and S = average declivity (%).

Relief Rate is the relation between the altitude difference of extreme points of the basin and its length (SCHUMM, 1956). To CARVALHO (1981), the Relief Rate demonstrates that, the higher the values, the rougher it will be the relief on the region. The higher the relief rate, the higher the general declivity of the basin, therefore, the speed of water runoff will be faster to flow towards the way of its higher length. According to PIEDADE (1980), the following values are used to quantify the relief rate: low relief rate = 0.0 to 0.10; medium relief rate = 0.11 a 0.30; and high relief rate = 0.31 to 0.60. The relief rate (Rr) was calculated as follows: Rr = (H/C), where: H: altimetric amplitude (m) and C: basin length (m).

On the composition and pattern of the drainage network we analyzed the following parameters: Basin Order; Drainage Density: Dd= L/A, where L: total length of all channels (km) and A: basin area (km²); Superficial Course Extension: Eps= (1/2Dd); Gradient of Channels: Gc = (Am/Ccp).100, where: Am: maximum altitude (m) and Ccp: main channel length (m); Sinuosity Index: IS = Ccp/dv, where dv: vectorial distance of the main channel points (m); Coefficient of Maintenance: Cm=(1/Dd).1000.

The declivity classes were separated into six intervals, suggested by LEPSH et al. (1991): interval from 0 to 3% with plain relief; 3 to 6% gently undulated; 6 to 12% undulated; 12 to 20% strongly undulated; 20 to 40% mountainous; and higher than 40%, steep relief.

Results and discussion

According to the results (Table 1), we can affirm that the hydrographic basin of the Verruga River shows low susceptibility to floods in normal rainfall conditions, that is, excluding events of abnormal intensities, due to the fact that the compactness coefficient presents a value distant from the unit (1.48) and, as for its shape factor, exhibits a low value (0.29). Thus, there is an indication that the basin does not have a circular shape, having, therefore, a tendency of elongated shape. Such fact can still be proved by the circularity index, having a value of 0.44. In basins with circular shape, to there are more possibilities of intense rainfall occur simultaneously in all its extension, concentrating a great volume of water in the main tributary.

The relief rate determines a higher or lower water speed to flow in the basin; in this study the value found (0.014) was considered low, indicating a slower speed of superficial flow, enabling, thus, a better water infiltration in the soil.

The drainage density found in the

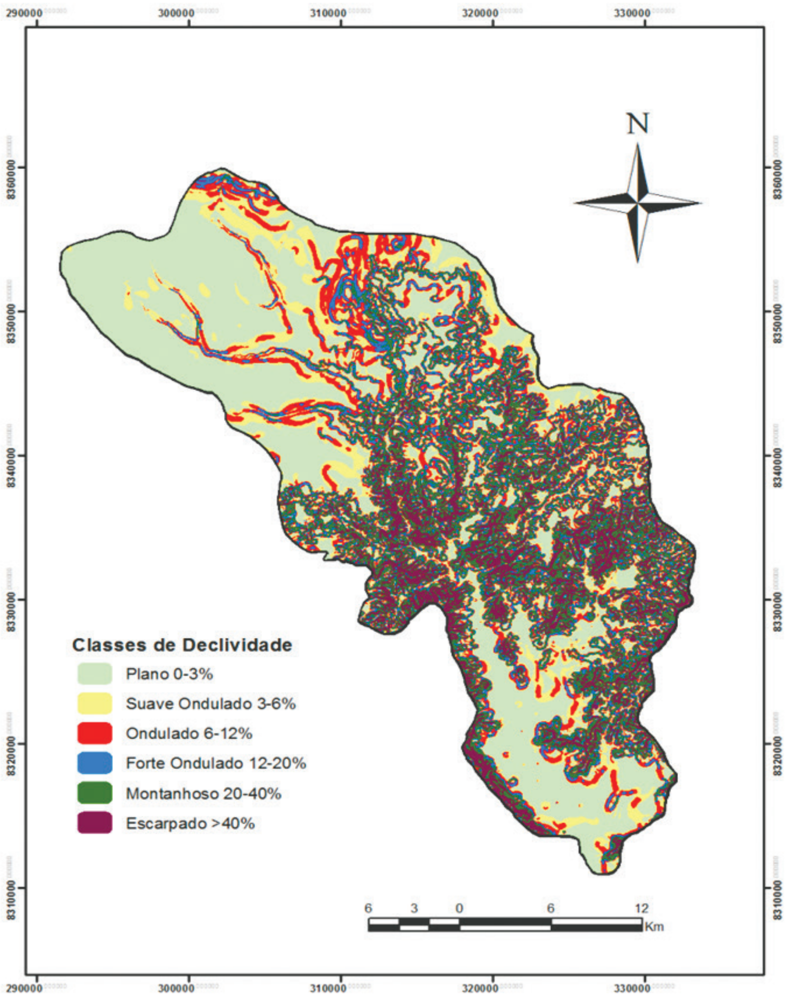

*Figura edited in portuguese by the author.

(Declivity classes | Plain 0-3%, Gently Undulated 3-6%, Undulated 6-12%, Strongly Undulated 12-20%, Mountainous 20-40%, Steep >40%)

Figure 2. Spatial distribution of the declivity classes of the Verruga River basin, Vitória da Conquista - BA.

Table1. Physical characteristics of the Verruga River basin, Vitória da Conquista - BA.

Physical characteristics	Units	Results
Dimensional parameters of the basin		
Area (A)	km^2	883.38
Perimeter (P)	km	157.17
Length (C)	km	55.12
Main canal length (Ccp)	km	75.36
Total length of the contour lines (Cn)	km	4336.13
Relief characteristics		
Compactness coefficient (Kc)	-----	1.48
Shape factor (Ff)	-----	0.29
Circularity index (Ic)	-----	0.44
Average declivity (S)	%	19.63
Average altitude (Hm)	m	700.00
Highest quota altitude (AM)	m	1080.00
Lowest quota altitude (Am)	m	320.00
Altimetric amplitude (H)	m	760.00
Roughness coefficient (Rn)	-----	15.30
Relief rate (Rr)	-----	0.014
patten drainage rates of the watershed		
Basin order (W)	----	4ª
Drainage density (Dd)	km km^{-2}	0.77
Maintenance coefficient (Cm)	m m^{-2}	1282.73
Superficial course extension (Eps)	m	641.00
Gradient of the canals (Gc)	%	1.43
Sinuosity index (IS)	-----	1.39

hydrographic basin of Verruga River was of 0.77 km/km^2. According to VILLELA and MATTOS (1975), this index can vary from 0.5 km km^{-2} in basins with poor drainage to 3.5 km km^{-2}, or more, in basins well drained, indicating, thus, that the studied basin has a low capacity of drainage.

According to ALVES and CASTRO (2003), values of sinuosity index next to 1 indicate a channel close to rectilinear, with possibility of elevated structural control or high energy, while values above 2 indicate low energy, the values being intermediate, related to transitional shapes between rectilinear and sinuous channels, this way, the Verruga River basin presents a sinuosity index of 1.39, which indicated little sinuous channels.

The drainage system of the studied basin, according to the Strahler hierarchy, has a fourth order ramification, which means a lot of ramifications for the scale in the map used (Figure 1).

As for the average declivity (19.63%), the area is encompassed in the interval of 12 to 20%, classified as strongly undulated relief, since the declivity can influence the relation between the rainfall and the runoff of the hydrographic basin, according to SILVEIRA (2001).

The declivity classes (Figure 2 and Table 2)

Table 2. Declivity classes of the Verruga River basin, Vitória da Conquista - BA.

Declivity (%)	**Micro basin area**	
	ha	**%**
0-3% Plain	29482.50	33.37
3-6% Gently undulated	11924.40	13.50
6-12% Undulated	12382.30	14.01
12-20% Strongly undulated	8911.20	10.09
20-40% Mountainous	15471.00	17.51
>40% Steep	10167.60	11.51

show that there was a higher predominance of areas with 0 to 6% declivity, constituting in 46.87% of the basin (41406.9 ha). These areas were classified as plain relief to gently undulated by CHIARINI and DONZELI (1973) and LEPSCH et al. (1991), who defined those as areas destined for the planting of annually crops with use of simple practices of soil conservation, since the planting in crop level already controls the erosion process of the soil. These classes encompass 29482.50 ha (33.37%), with slopes varying from 0 to 3% and 11924.40 ha (13.50%) with slopes of 3 to 6%. However, it is important to emphasize that the areas with 20-40% declivity and >40%, are also expressive in the basin, totaling 29.02% of the basin (25638.6 ha), which, according to the referred authors, are not recommended for agriculture.

Conclusions

The Verruga River basin presents an area of 883.38 km^2 and 157.17 km of perimeter and 4th order of ramification; it presents elongated shape and, thus, is less prone to floods.

It also presents low relief rate, which indicates a slower speed of superficial flow, enabling, thus, a better water infiltration in the soil.

According to the declivity classes, most of the basin is found apt to agriculture, however, there are inadequate areas for such purpose.

In a general way, the basin is found well preserved, however the preservation of riparian forests and agricultural practice on the recommended areas are essential factors to its preservation.

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