

# ASSESSMENT OF METHODS FOR PREDICTING SOIL ERODIBILITY IN SOIL LOSS MODELING

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## Introduction

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**ABSTRACT** - Indirect methods are frequently used to determine soil erodibility (K-factor) because its direct assessment in the field is expensive. Predictive models, however, cannot be applied indiscriminately. The coherence between model outputs and soil features of specific localities must be checked as the models were developed for reference areas with specific features that may not correspond to those in the study area. Accordingly, the present study applied indirect methods to estimate soil erodibility in an area showing soil erosion and evaluated the results obtained for soil characteristics, observed K-factor values and bibliographic data. The soil in the Guariroba stream subwatershed (study area) is mostly loamy sand (*Neossolo Quartzarênico órtico*, an entisol). However, loam (*Neossolo Quartzarênico hidromórfico*, an entisol) and clay (*Latossolo Vermelho distrófico*, an oxisol) soils are also found in the area. The statistical evaluation of the models for K-factor estimation showed that the Sharpley & Williams (1990) model was the most suitable for the study area.

**Keywords:** K-Factor, USLE, soil features, erosion prediction.

**RESUMO** - A determinação direta da erodibilidade dos solos (fator K) é dispendiosa, levando os pesquisadores a recorrerem aos métodos de estimativa indireta da erodibilidade dos solos. Entretanto, a aplicação destes modelos não deve ser feita de forma indiscriminada. Deve-se observar se os resultados apresentam coerência com a área de estudo, pois as equações foram elaboradas a partir de medições diretas do fator K em solos que podem apresentar comportamentos diferentes daqueles de onde se pretende estimar indiretamente. Portanto, são objetivos deste trabalho: estimar a erodibilidade do solo através de métodos indiretos e avaliar a coerência dos modelos de erodibilidade utilizados para a área de estudo a partir de valores observados e dados da literatura. O solo na sub-bacia hidrográfica do Córrego Guariroba (área de estudo) é em sua maioria arenoso (*Neossolo Quartzarênico órtico*). Porém, texturas franco-arenosa (*Neossolo Quartzarênico hidromórfico*) e argilosa (*Latossolo Vermelho distrófico*) também são encontradas na área. Após a avaliação estatística dos modelos de predição do fator K, conclui-se que a equação de Sharpley & Williams (1990) é o modelo mais adequado dentre os avaliados para a área de estudo.

**Palavras-chave:** Fator K, USLE, características do solo, predição da erosão.

## INTRODUCTION

Erosion is a process that removes materials from any place on the Earth's surface. It can result from the action of weathering and the transport of solids (sediments, soil, rocks and other particles) deposited in sites other than the original. Although it is a natural process, erosion is affected by land use policies and occupation, especially agriculture, deforestation and urbanization.

Erosion modeling in developing countries such as Brazil is difficult because of the lack of data, especially regarding soils. It is difficult to obtain the key parameters of erosion prediction models, such as soil erodibility, expressed as K-factor (Panagos et al., 2012). To remedy this situation, indirect methods are applied to estimate this factor and make these studies feasible (Bonilla & Johnson, 2012).

A number of studies were carried out worldwide, but especially in the USA, in order to establish the relationship between measurable soil characteristics and erodibility (K). This factor is determined by mean soil loss per unit area (A) divided by the rainfall erosion index (R) in a standard plot of 22.1 m length (L) and 9% slope (S) (Olson & Wischmeier, 1963), as shown in equation 1:

$$K = \frac{A}{RLSCP} = \frac{A}{R} \quad (1)$$

where LS (topography), C (soil cover and management) and P (support practices) are nondimensional and have a value of 1, if soil erodibility is assessed in a fallow experimental plot that is not managed with support practices.

In an attempt to establish associations between soil features and erodibility, Bouyoucos (1935) concluded that the (sand+silt)/clay ratio expresses soil susceptibility to erosion. It can therefore be considered as an erodibility index, because it was shown to efficiently match field data.

Some years later, with the development of the Universal Soil Loss Equation (USLE), experimental plots were allocated to units of different taxonomic classification in the USA in order to create an indirect method for calculating the K-factor. Given that field tests are expensive, these procedures were based on easily-measured soil features, such as texture and organic matter. In this respect, a nomograph was developed based on soil erodibility and features to estimate soil erodibility according to their texture analysis, organic matter content, structure and permeability (Wischmeier & Smith, 1978).

Despite the survey performed for USLE development, the K-factor estimated by the nomograph is limited to application outside the USA. In Brazil, for instance, K-factor estimates obtained by the nomograph are inconsistent because soils have different properties, features and behavior. Thus, Denardin (1990) followed the same nomograph principles originally proposed by Wischmeier & Smith (1978) in order to develop a K-factor estimation model for Brazilian soils based on soil features assessed in standard plots.

With the development of the Revised Universal Soil Loss Equation (RUSLE), researchers attempted to develop a method for indirect K-factor determination based on global data in order to apply it to any part of the world. As such, they grouped erodibility data directly assessed in standard plots (225 taxonomic soil units in the world) into texture classes and elaborated an equation relating the mean geometric particle diameter (obtained from texture analyses) to the K-factor (Renard et al., 1997).

The consequences of erosion promoted the EPIC model (Sharpley & Williams, 1990), which is used by international organizations such as the United Nations to calculate the impact of soil erosion on agricultural production. The model contains two basic components: the physical and the economical. The EPIC model is considered physical and is different from USLE, which is empirical. However, the K-factor is a component of the EPIC model, which also estimates this factor indirectly.

In a number of studies, K-factor values estimated by the models described contrast with experimental data obtained in standard plots (Hussein et al., 2007; Wang et al., 2013; Zhang et al., 2004; Zhang et al., 2008). Their main conclusion is that the equations for indirect K factor estimation fit better when the soils subjected to indirect erodibility estimation experience similar conditions to those used for model validation.

The present study was carried out in a protected area bounded by the Guariroba stream sub-watershed, with 2 soil classes typical to Brazil, mostly sandy-clayey textured, in a tropical climate, high rainfall rates and high temperatures. According to the Brazilian System of Soil Classification, the classes are *Latossolo Vermelho distrófico* (LVd, an oxisol) and *Neossolo Quartzarênico órtico* (RQo, an entisol). The latter is the most susceptible to erosion (Oliveira et al., 2010).

Given that direct methods of erodibility measurements are expensive and time-consuming, erodibility for the above mentioned soils may be assessed indirectly using models that use secondary data whose outputs are coherent with the study area conditions. Brazilian soil, in fact, has features and

properties that differ from soils in which most models of indirect K-factor estimates were developed.

Models for indirect assessment of soil erodibility must therefore be evaluated for specific areas, and the coherence of their

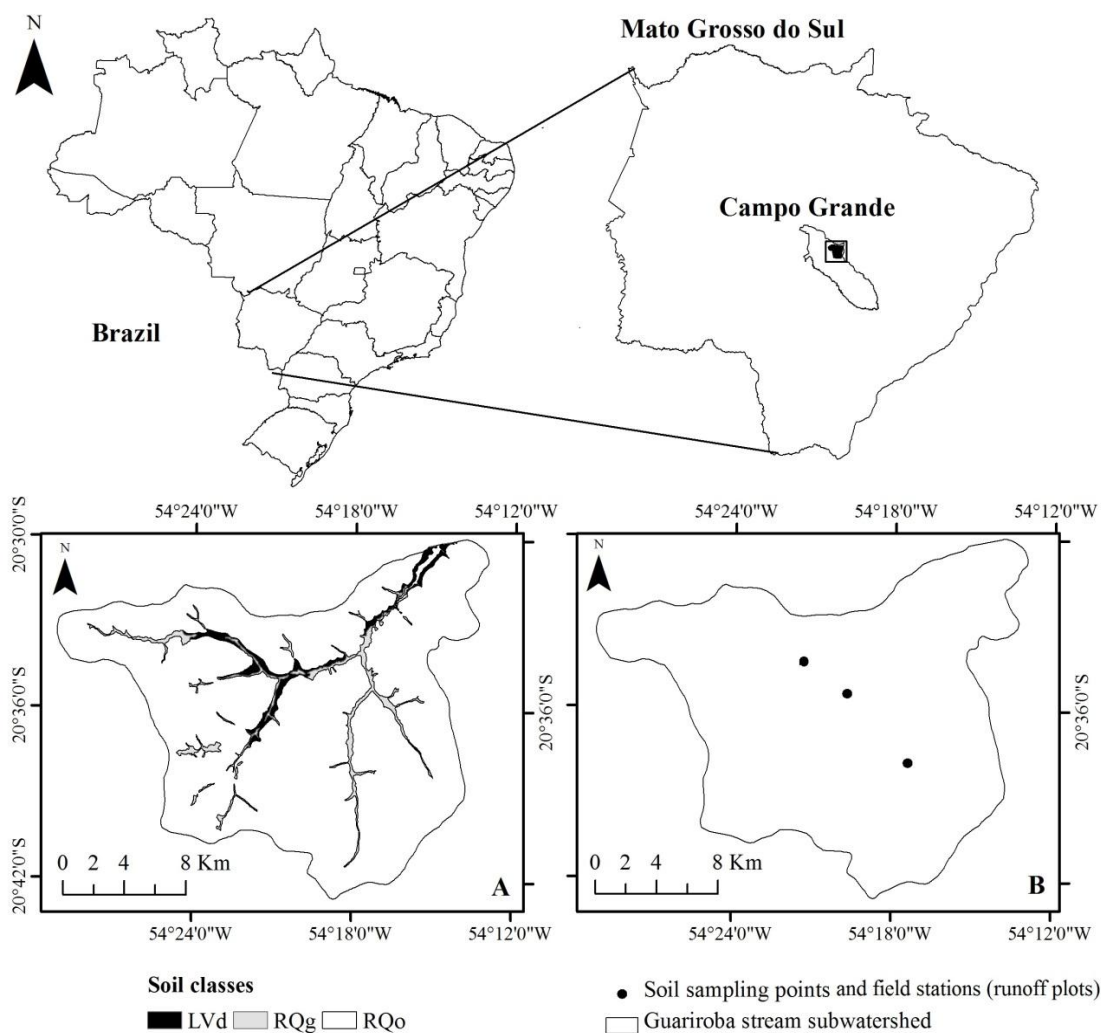
outputs analyzed based on the hypothesis that satisfactory results can be obtained or not according to the procedures adopted. In this regard, the present study aimed to estimate soil erodibility by indirect methods and to evaluate the models tested for erodibility prediction.

## MATERIALS AND METHODS

### Study area

The study area covers 362 km<sup>2</sup> and is located in the Guarairoba stream subwatershed, between 20° 28' and 20° 43' South and 54° 29' and 54° 11' West (Figure 1). Three soil classes were identified in the area (Figure 1A): *Latossolo Vermelho distrófico* (LVd, oxisol), *Neossolo Quartzarênico hidromórfico* (RQg, entisol) and *Neossolo Quartzarênico órtico* (RQo, entisol),

corresponding to 2.4%, 3.5% and 94.1% of the study area, respectively. To estimate the K-factor indirectly, soil physical features (texture and organic matter) were obtained in surface and subsurface horizons of specific sampling points in the study area (Figure 1B), which were inside the soil erosion field stations, used to observe values for the K-factor.



**Figure 1.** Location of the Guarairoba stream subwatershed (upper frame), soil class distribution (A) and soil sampling points (B). Soil classes are in accordance with the Brazilian System of Soil Classification.

### Observed soil erodibility

Three field stations containing 3 runoff plots each were built in order to measure soil

erodibility directly. One station was built in each soil class, so that the K-factor between the classes could be compared.

The K-values were calculated using Eq. (1), which is a modified USLE equation. Rainfall erosivity was calculated using data from rainfall gauging stations installed in the study area and the recommended method from RUSLE (Renard et al., 1997). The LS (topography), C (soil cover and management) and P (support practices) are non-dimensional and have a value of 1 as the soil erodibility was assessed in a fallow experimental plot that is not managed with support practices and has a standardized design (plot length of 22.1 m and slope of 9%).

### Soil sampling and analysis

$$K = [2.1 \times 10^{-4} M^{1.14} (12 - a) + 3.25(b - 2) + 2.5(c - 3)] \times \left(\frac{0.1317}{100}\right) \quad (2)$$

where: M is the percentage silt plus very fine percent sand multiplied by 100 minus percent clay; a is the organic matter content; b

Soil samples from surface and subsurface horizons were collected at 3 points inside the field stations throughout the study area. Each station was located in a different soil class of the study area. Texture analysis was performed by the pipette method after chemical (1 mol.l<sup>-1</sup> NaOH) and physical (mechanical stirrer 14000 rpm) particle dispersion. Organic matter was determined in a furnace at 440°C.

### Indirect calculation of soil erodibility

Methods for indirectly estimating soil erodibility were applied by equations based on soil physical properties (texture and organic matter content) as input data: Wischmeier & Smith (1978), Eq. (2); Renard et al. (1997), Eq. (3); Bouyoucos (1935), Eq. (4); Denardin (1990), Eq. (5); and Sharpley & Williams (1990), Eq. (6).

$$K = 0.0034 + 0.0405 \times \exp\left[-0.5 \left(\frac{\log D_g + 1.659}{0.7101}\right)^2\right] \quad (3)$$

where: D<sub>g</sub> is the geometrical particle diameter, based on the fractions of the texture

is the non-dimensional code related to soil structure; c is the non-dimensional code related to soil permeability.

classes and arithmetic means of the particle diameter of each texture class.

$$K = \frac{SAN + SIL}{CLA} \times \frac{1}{100} \quad (4)$$

where: SAN, SIL and CLA are percent sand, silt and clay, respectively.

$$K = 0.00000748(M) + 0.00448059(b) - 0.0631175(DMP) + 0.010396(REL) \quad (5)$$

where: M is percentage silt plus very fine percent sand multiplied by 100 minus percent clay; b is the nondimensional code related to the soil structure; DMP is the weighted mean of

the particles smaller than 2.0 mm; REL is the ratio between organic matter content and the content of particles between 0.1 and 2.0 mm.

$$K = A \times B \times C \times D \times 0.1317 \quad (6)$$

$$B = \left[\frac{SIL}{CLA + SIL}\right]^{0.3} \quad (6.2)$$

where:

$$C = \left[1.0 - \frac{0.25 C}{C + \exp[(3.72 - 2.95 C)]}\right] \quad (6.3)$$

$$A = [0.2 + 0.3 \exp(-0.0256 SAN (1 - SIL/100))] \quad (6.1)$$

$$D = \left[1.0 - \frac{0.70 SN1}{SN1 + \exp[(-5.41 + 22.9 SN1)]}\right] \quad (6.4)$$

where: SAN, SIL and CLA are percent sand, silt and clay, respectively; C is the organic carbon content; and SN1 is sand content subtracted from 1 and divided by 100.

### Statistical analysis and model fitting

Data on texture, organic matter and erodibility fail to meet normality assumptions and were therefore analyzed by non-parametric tests. The Kruskal-Wallis test was used to test the null hypothesis that all the groups (soil classes and horizons) have identical distribution functions against the alternative hypothesis that at least 2 groups show different distribution functions.

Moreover, the erodibility results obtained by each method were associated with soil physical properties (texture and organic matter) using Spearman's correlation. The significant correlations at a 95% confidence interval were considered to evaluate soil erodibility prediction models for the study area.

In addition, the evaluation of K-factor estimation equations require analysis of residual errors, the difference between predicted and observed values and prediction characterization between over- and underestimates. To that end, we used the statistical parameters described by Loague & Green (1991), such as the following equations:

Root mean square error (RMSE)

$$RMSE = \left[ \sum_{i=1}^n \frac{(P_i - O_i)^2}{n} \right]^{0.5} \quad (7)$$

Coefficient of determination (CD)

$$CD = \frac{\sum_{i=1}^n (O_i - \bar{O})^2}{\sum_{i=1}^n (P_i - \bar{O})^2} \quad (8)$$

Model efficiency (EF)

$$EF = \frac{[\sum_{i=1}^n (O_i - \bar{O})^2 - \sum_{i=1}^n [(P_i - \bar{O})^2]]}{\sum_{i=1}^n (O_i - \bar{O})^2} \quad (9)$$

Coefficient of residual mass (CRM)

$$CRM = \left( \sum_{i=1}^n O_i - \sum_{i=1}^n \frac{[P_i]}{\sum_{i=1}^n O_i} \right) \quad (10)$$

Maximum error (ME)

$$ME = \text{Max } |P_i - O_i| \quad (11)$$

Mean difference (MD)

$$MD = \sum_{i=1}^n [(P_i) - O_i] / n \quad (12)$$

where  $P_i$  is the predicted value;  $O_i$  is the observed value;  $i$  is the sample index;  $\bar{O}$  is the mean of the values observed; and  $n$  is the number of samples. The lower limit for parameters ME, RMSE and CD is zero. The highest EF value is 1. CD determines the variance of observed values in relation to predicted values. Data were not pooled to run the tests, and RMSE, CD, EF, CRM and ME values were expected to be as close as possible to 0.0, 1.0, 1.0, 0.0 and 0.0, respectively.

## RESULTS AND DISCUSSION

### Observed soil erodibility

Based on the amounts of eroded soil in the runoff plots, a database was created to calculate the mean K-factor for each soil class of the

watershed. We found that K-factor values varied from 0.055 to 0.072 (Table 1). The highest values were found in the RQo soils and the lowest are related to RQg soils.

**Table 1.** Mean ( $\pm$  sd) observed erodibility for different soil classes (t.ha.h/ha.MJ.mm).

Soil Class	N	Observed K-factor
LVd	3	0.067 $\pm$ 0.018
RQg	3	0.055 $\pm$ 0.016
RQo	3	0.072 $\pm$ 0.034

### Soil properties in the study area

The distribution functions of organic matter, sand, silt and clay have at least two groups with different means at a 95% confidence interval (Table 2). LVd (A and B horizons) and RQg (H horizon) soils showed the highest organic matter content. With respect to texture, RQo soils (A and C horizons) were found to be

loamy sand, RQg (H horizon) loam, RQg (C horizon) sandy loam and LVd (A and B horizons) clay. According to Miqueloni & Bueno (2011), the predominance of sandy texture may account for the low soil surface resistance against erosion, favoring significant soil loss and high sediment production.

**Table 2.** Mean ( $\pm$  sd) organic matter and texture for different soil classes (in percent value).

Class/Horizon	N	Organic Matter	Sand	Silt	Clay
LVd/A	3	6.37 $\pm$ 0.84 <sup>abc</sup>	27.61 $\pm$ 7.80 <sup>abc</sup>	30.30 $\pm$ 8.24 <sup>abc</sup>	42.08 $\pm$ 2.41 <sup>ab</sup>
LVd/B	3	5.80 $\pm$ 0.97 <sup>ade</sup>	19.23 $\pm$ 5.73 <sup>ad</sup>	31.93 $\pm$ 5.75 <sup>ade</sup>	48.84 $\pm$ 2.13 <sup>a</sup>
RQg/H	3	7.06 $\pm$ 0.91 <sup>bd</sup>	49.18 $\pm$ 6.38 <sup>cdeh</sup>	42.24 $\pm$ 5.36 <sup>cef</sup>	8.57 $\pm$ 2.81 <sup>fg</sup>
RQg/C	3	0.57 $\pm$ 0.29 <sup>fg</sup>	77.54 $\pm$ 8.31 <sup>befg</sup>	17.05 $\pm$ 9.51 <sup>bdfg</sup>	5.41 $\pm$ 1.66 <sup>cde</sup>
RQo/A	3	1.19 $\pm$ 0.21 <sup>cefh</sup>	86.16 $\pm$ 1.40 <sup>fi</sup>	4.29 $\pm$ 0.62 <sup>h</sup>	9.55 $\pm$ 1.18 <sup>bh</sup>
RQo/C	3	0.91 $\pm$ 0.26 <sup>gh</sup>	83.45 $\pm$ 2.75 <sup>ghi</sup>	7.55 $\pm$ 2.42 <sup>gh</sup>	9.00 $\pm$ 2.29 <sup>h</sup>

Means followed by different superscript letters in a column are statistically different (Kruskall-Wallis test,  $P \leq 0.05$ ). N is the number of samples.

### Soil erodibility in the study area: pedological aspects

K-factor estimates were evaluated for the taxonomical groups and soil horizons sampled (Table 3). To ensure that the erodibility prediction model used expresses the real

conditions of the study area, the results obtained for each taxonomic group must match the properties of the respective soil class in relation to the other classes, and given that each soil type has distinct features, erodibility values are expected to be different in the study area.

**Table 3.** Mean soil erodibility ( $\pm$  sd) of the soil classes estimated by different models.

Class Horizon	/ N	K-factor (t.ha.h/ha.MJ.mm)				
		Wischmeier & Smith (1978)	Renard (1997)	Bouyoucos (1935)	Denardin (1990)	Williams (1990)
LVd/A	3	<b>0.010</b> <sup>a</sup> ( $\pm$ <b>0.003</b> )	<b>0.043</b> <sup>ab</sup> ( $\pm$ <b>0.001</b> )	<b>0.014</b> <sup>ab</sup> ( $\pm$ <b>0.001</b> )	<b>0.039</b> <sup>ab</sup> ( $\pm$ <b>0.008</b> )	<b>0.028</b> <sup>abc</sup> ( $\pm$ <b>0.001</b> )
LVd/B	3	0.011 <sup>a</sup> ( $\pm$ 0.002)	0.043 <sup>ac</sup> ( $\pm$ 0.001)	0.011 <sup>a</sup> ( $\pm$ 0.001)	0.041 <sup>ac</sup> ( $\pm$ 0.004)	0.027 <sup>ad</sup> ( $\pm$ 0.001)
RQg/H	3	<b>0.013</b> <sup>a</sup> ( $\pm$ <b>0.004</b> )	<b>0.025</b> <sup>bcdg</sup> ( $\pm$ <b>0.004</b> )	<b>0.119</b> <sup>cfg</sup> ( $\pm$ <b>0.042</b> )	<b>0.040</b> <sup>bc</sup> ( $\pm$ <b>0.005</b> )	<b>0.039</b> <sup>bdehi</sup> ( $\pm$ <b>0.002</b> )
RQg/C	3	0.018 <sup>a</sup> ( $\pm$ 0.010)	0.012 <sup>def</sup> ( $\pm$ 0.003)	0.190 <sup>cde</sup> ( $\pm$ 0.057)	0.021 <sup>de</sup> ( $\pm$ 0.007)	0.045 <sup>efg</sup> ( $\pm$ 0.003)
RQo/A	3	<b>0.013</b> <sup>a</sup> ( $\pm$ <b>0.005</b> )	<b>0.010</b> <sup>eh</sup> ( $\pm$ <b>0.001</b> )	<b>0.096</b> <sup>bdfh</sup> ( $\pm$ <b>0.013</b> )	<b>0.020</b> <sup>df</sup> ( $\pm$ <b>0.004</b> )	<b>0.039</b> <sup>efh</sup> ( $\pm$ <b>0.002</b> )
RQo/C	3	0.013 <sup>a</sup> ( $\pm$ 0.004)	0.011 <sup>fgh</sup> ( $\pm$ 0.001)	0.109 <sup>egh</sup> ( $\pm$ 0.032)	0.019 <sup>ef</sup> ( $\pm$ 0.003)	0.042 <sup>gi</sup> ( $\pm$ 0.004)

Means followed by different superscript letters in a column are statistically different (Kruskall-Wallis test,  $P \leq 0.05$ ). Rows in bold correspond to erodibility of surface horizons. N is the number of samples.

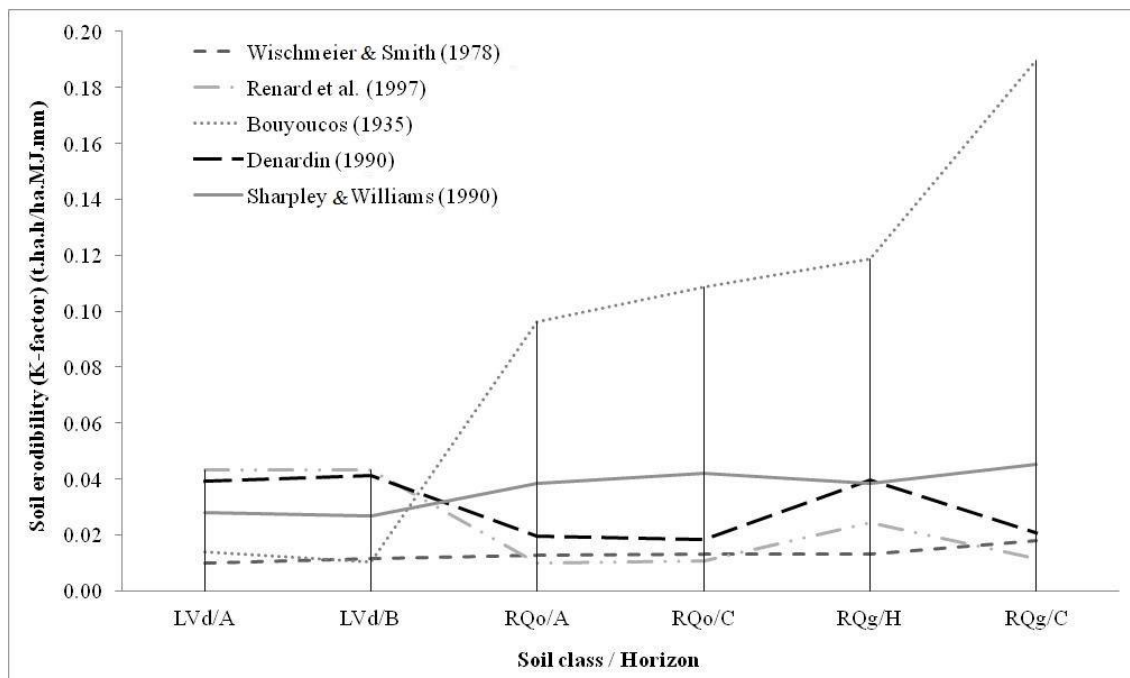
The nomograph model (Wischmeier & Smith, 1978) was the only one that produced erodibility values with a similar distribution function between the sampling points at a 95% confidence interval, indicating its inadequacy in predicting erodibility in the study area. Although the 3 soil classes in the study area

show different features and properties, the outputs of this model did not differ. According to Bonilla & Johnson (2012), K values must be specific and correlated with textural aspects and soil organic matter content.

Other studies show that erodibility is higher in *Neossolo Quartzarênico (RQ)* than *Latossolo*

*Vermelho (LV)* under similar conditions of slope, cover and rainfall intensity (Oliveira et al., 2010; Silva & Alvares, 2005). In addition, Nunes & Cassol (2008) observed that more clayey soils tend to show lower erodibility. The Bouyoucos (1935) and Sharpley & Williams

(1990) models indicated higher erodibility in RQo and RQg and lower in LVd (Figure 2). However, the magnitude of the responses obtained using the Bouyoucos model (1935) does not match the other methods and reference values for erodibility (Silva & Alvares, 2005).



**Figure 2.** Soil erodibility (K-factor) estimates for soil classes in the Guariroba stream subwatershed, predicted by different models.

The distribution functions of erodibility means produced by Bouyoucos (1935) and Sharpley & Williams (1990) did not differ between these models, or between Renard et al. (1997) and Wischmeier & Smith (1978) models at a significance level of 0.05. Therefore, the difference between the outputs produced by the models tested indicates that they were built based on different sets of K-factor observation (Wang et al., 2013).

One aspect to highlight is that erosion prediction models must consider soil erodibility of surface horizons, which are the most susceptible to rainfall erosion, as well as soil use and management (Baskan et al., 2009; Bonilla & Johnson, 2012; Wang et al., 2013). In field observations in the study area, horizon A in LVd and RQo and horizon H in RQg were considered superficial.

### Relationship between soil erodibility and features

The Wischmeier & Smith (1978) model is not linearly correlated with soil texture and organic matter content ( $P \leq 0.05$ ). The other methods, however, showed at least one significant correlation with some soil attribute. The Denardin (1990) and Renard et al. (1997) models show a positive correlation with silt, clay and organic matter and negative correlation with sand levels. The Bouyoucos (1935) model is negatively correlated with clay levels. The Sharpley & Williams (1990) model, in turn, has a significant positive correlation with sand levels and negative with organic matter, silt and clay levels (Table 4).

According to Nunes & Cassol (2008), soil organic matter and clay content is inversely proportional to the K-factor since both organic carbon and clay contribute to maintaining soil aggregate stability. Thus, the inadequacy of Renard et al. (1997) and Denardin (1990) erodibility prediction models in the study area is reinforced.

**Table 4.** Matrix of correlations between soil features and K-factor estimates produced by the models tested.

<b>K-factor</b>	<b>Organic Matter (%)</b>	<b>Sand (%)</b>	<b>Silt (%)</b>	<b>Clay (%)</b>
Wischmeier & Smith (1978)	-0.15	0.14	0.18	-0.19
Renard et al. (1997)	0.68*	<b>-0.96*</b>	<b>0.79*</b>	0.64*
Bouyoucos (1935)	-0.50*	0.56*	-0.19	<b>-1.00*</b>
Denardin (1990)	<b>0.75*</b>	<b>-0.87*</b>	<b>0.78*</b>	0.57*
Sharpley & Williams (1990)	-0.60*	0.60*	-0.28*	<b>-0.93*</b>

\* Significant for a 95% confidence interval. Stronger correlations are shown in bold.

Erosion processes in tropical soils are associated to their sandy nature (Miqueloni & Bueno, 2011). Indeed, under the study area conditions, the soil erodibility factor is directly proportional to sand levels. Therefore, the Sharpley & Williams (1990) model, which shows a positive correlation with sand levels and negative correlation with clay and organic matter was the most suitable for estimating K factor under the study conditions.

### Statistical fitting

The performances of the 5 equations were assessed by comparing them to the values obtained with field plots, using the calculated

statistical parameters (Table 5). The statistical fitting showed that almost all models underestimated the K-factor values, except Bouyoucos (1935), which had a negative value for CRM, overestimating the referred value. The other parameters (RMSE, CD, EF, ME, MD) showed that the Sharpley & Williams (1990) model had the best performance to predict the erodibility factor for the study area soil classes, which represents the majority of Brazilian soils. As expected, Wischmeier & Smith's (1978) nomograph used to predict K-value did not show adequacy for the studied soils, having the worst performance in the statistical fitting among the analysed models.

**Table 5.** Statistical fitting of K-factor estimation equations.

<b>K-factor equation</b>	<b>RMSE</b>	<b>CD</b>	<b>EF</b>	<b>CRM</b>	<b>ME</b>	<b>MD</b>
Wischmeier & Smith (1978)	0,05	0,88	-10,96	0,80	0,06	0,05
Renard et al. (1997)	0,04	0,91	-8,04	0,64	0,06	0,04
Bouyoucos (1935)	0,05	0,91	-7,99	-0,18	0,06	0,04
Denardin (1990)	0,03	0,94	-5,15	0,55	0,06	0,03
Sharpley & Williams (1990)	0,03	0,97	-2,12	0,40	0,04	0,02

## CONCLUSIONS

Soil in the Guariroba stream subwatershed is mostly loamy sand (RQo). However, loam (RQg) and clay (LVd) soils are also found in the area. The soil erodibility values calculated indirectly by the different models tested are distinct for each soil class, except for the Wischmeier & Smith (1978) model, which produced K-factor estimates with a similar distribution function for the groups evaluated.

Soil erodibility can be estimated indirectly by models fed with data on soil texture and organic matter. However, the models proposed by Wischmeier & Smith (1978), Renard et al. (1997) and Denardin (1990) are not suitable for the study area because they overestimate K-

factor values in LVd, which are less vulnerable to erosion than RQg and RQo. In addition, the statistical evaluation showed that these models did not fit with observed data for K-factor.

The outputs from Bouyoucos (1935) and Sharpley & Williams (1990) models confirm the higher susceptibility of RQo and RQg soils to erosion compared to LVd, in accordance with observations in the study area. However, the magnitude of the responses obtained using the Bouyoucos (1935) model is not compatible with values reported in the literature and showed by statistical parameters comparing predicted and observed data. Thus, the equation proposed by Sharpley & Williams (1990) is



more suitable for indirectly estimating the K-factor in the study area.

The erodibility of surface horizons must be considered in erosion modeling. Given that the

Sharpley & Williams model (1990) is the most suitable for the study area considering statistical fitting, the erodibility values for the taxonomical classes can be estimated.

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