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AN OVERVIEW OF EROSION PREDICTION MODELS IN BRAZIL

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Abstract

Soil erosion models are useful tools for the evaluation of soil losses and can support a sustainable management planning of an area. In this study, we reviewed the use of empirical and physical-based models for rill and interrill processes and gully erosion models in order to quantitatively evaluate its applications in Brazil. Data from the SCOPUS database were used, making comparisons between Brazil and the world and analyzing publications by country, year and type of document. In Brazil, 35 studies on gully erosions and 178 on erosion models were found, of which empirical models predominate. Physical-based models require a large amount of input parameters, limiting their applications in countries where there is little data availability. The number of Brazilian studies on erosion models does not follow the trend of global growth, which can be justified by the fact that the researches are punctual, discontinuous and not regularly applied in national soil conservation policies.

Keywords: Soil Erosion Models; Soil Loss; Gully Erosion.

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Introduction

Soil erosion is one of the major environmental problems of the 21st century directly affecting soil structure, soil productivity, hydrological systems, habitats and the ecosystem services (LAL, 2001). It is essential to understand the effects of water erosion to implement the best land management practice. Model simulation is a quick method to evaluate alternative paths to the use of land, and is a tool to study the erosion factors, supporting the management and improvement of conservation practices (ARNOLD et al., 1998).

The models are divided into three categories: empirical, conceptual and physical based. The first to be developed and most used is the Universal Soil Loss Equation (USLE) empirical model (WISCHMEIER & SMITH, 1978), from which others emerged according to studies developed in different regions that fit the data available and the needs of local applicability (RENARD 1997). Empirical models, such as USLE and Revised Universal Soil Loss Equation (RUSLE) (RENARD et al., 1997), due to a small number of input data, are easier to use and have less potential for errors. Physical-based models, such as the Water Erosion Prediction Project (WEPP) (NEARING et al., 1989), European Soil Erosion Model (EUROSEM) (MORGAN et al., 1998) and Limburg Soil Erosion Model (LISEM) (DE ROO & JETTEN, 1999), have a more complex structure that allows to better describe the influence and interactions of intervening factors in the erosive processes (NEARING, 1998).

Although many studies on soil loss estimation models were published, none of them proposed a quantitative research considering the publications. Therefore, our goal is to evaluate the number of publications involving soil loss models and gully erosion in Brazil and their distribution around the world.

Methodology

We reviewed soil loss models (USLE/RUSLE, WEPP, LISEM and EUROSEM) and gully erosion publications using Scopus database. Every publication indexed in the database from 1950 to 2017 was considered and analyzed per country, per year, and document type. A spatial distribution was made using the number of publications per continent and temporal data were plotted in cumulative graphs. The document types were classified as "article", which considers article and review publications, "conference paper", which includes conference papers and conference reviews, "book chapter", and "others". We compared Brazil and World data in each of those three distributions.

The empirical models considered in this study were the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE). USLE is an erosion model designed to predict the longtime average soil losses in runoff from specific field areas in specific cropping and management systems (WISCHMEIER and SMITH, 1978). The equation computes the soil loss for a given site as the product of six major factors. On the other hand, RUSLE is only ones of many modification of USLE, especially for more complex situations of rill and interrill erosion in conservation planning and land uses.

For the physical-based models, we analyzed the Water Erosion Prediction Project (WEPP), the European Soil Erosion Model (EUROSEM) and the Limburg Soil Erosion Model (LISEM). WEPP is a process-based

distributed forecasting model originally developed in agricultural soils (LAFLEN et al., 1991) by the United States Department of Agriculture (USDA) and improved for simulating soil loss under various conditions, use and occupation. EUROSEM is a dynamic distributed model able to simulate erosion, transport and deposition of sediment over the land surface by interrill and rill processes. Finally, LISEM is a spatial hydrological model that simulates surface runoff, sediment dynamics and surface flooding in rural and urban areas (JETTEN & DE ROO, 2001).

Most models for predicting rill erosion do not include the assessment of gully and ephemeral gully erosion (CAPRA et al., 2005). Models that estimates soil loss in ephemeral gullies include the Ephemeral Gully Erosion Model - EGEM and the EUROWISE (JETTEN, 2002). The EGEM is composed of two components: the hydrology component and the erosion component. In the EUROWISE, the gully incision and formation are modelled for various combination of soil and climate (JETTEN, 2002). Gully erosion models include the WaTEM / SEDEN and the SEDNET. The WaTEM / SEDEN model is able to calculate water and tillage erosion, including sediment delivery to rivers, using multiple flow proportional calculations and the SEDNET identifies erosive areas and processes within sedimentary basins, using spatial modeling to build the budgets.

Results and Discussion

The largest number of publications are in Europe (742), Asia (442) and North America (275) (Figure 1). On the other hand, studies in South America on gully erosion account for 59 publications representing 2.79% in the world. Several studies on gully erosion have developed models that claim great potential for predicting soil loss, but there is still no standard measurement procedure for soil loss by gully erosion due to lack of testing (POESEN et. al, 2003).

Studies of soil loss models for rill and interrill erosion are concentrated in the northern hemisphere, with 25% of publications in Europe, 24% in Asia and 22% in North America (Figure 1). Only 6.5% of the studies were published in Central America and South America and 4% in Africa. The USLE / RUSLE is the most used model, WEPP is used remarkably in several continents and the EUROSEM / LISEM are the least used.

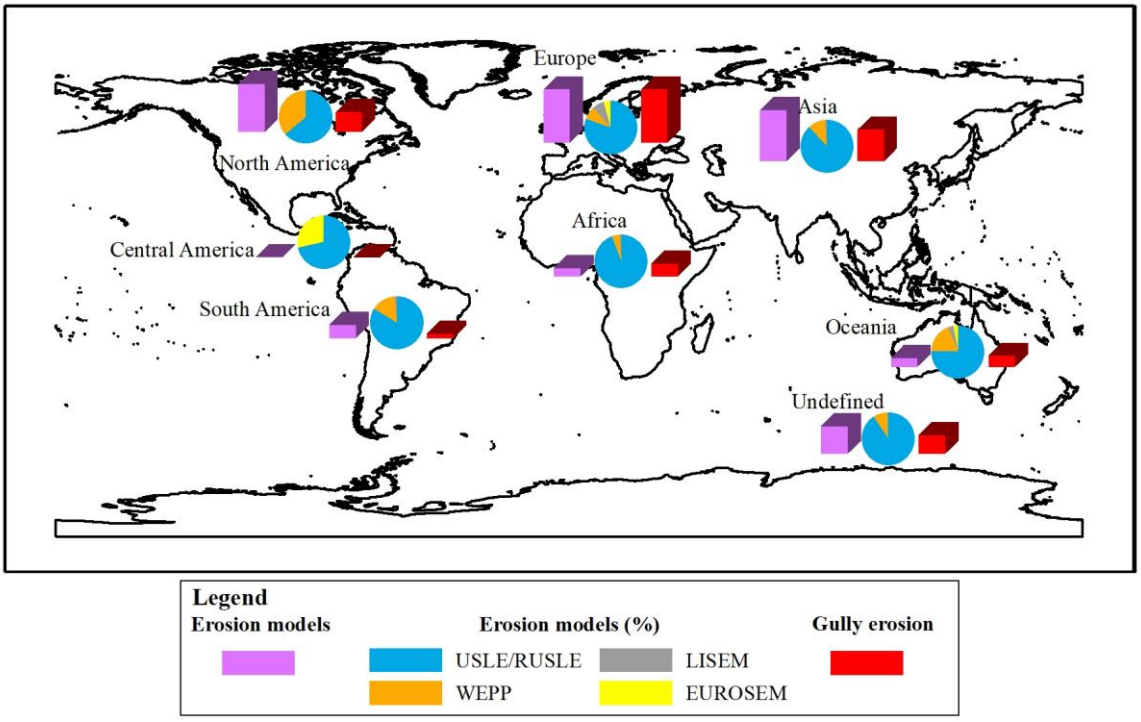

Figure 1. Spatial distribution by continents of soil loss models and studies.

Regarding the studies conducted worldwide compared to Brazil, we found 178 studies with applications of erosion prediction models in Brazil. Of these studies, 88% are USLE / RUSLE models, following the world trend, with 80% of these models (Figure 2). There are no studies using the EUROSEM model in Brazil. This can be justified by the fact that it is a model developed for European conditions.

Figura 2. Percentage of estudies of erosion models performed in Brazil and worldwide.

The number of soil erosion model studies showed exponential growth from 1953 to 2017 (Figure 3a). We have seen a large increase in the use of erosion forecasting models around the world, but in Brazil this growth was timid. This is due, in part, to the fact that the adoption of soil conservation measures does not always directly benefit farmers (FAO, 2015), and, since there is a lack of incentives, the research turns out to be timely and inconstant, implying in a limited number of scientific publications.

With regard to erosion surveys in gullies, we observed a substantial increase in the number of publications from the year 1980 (Figure 3b). This is because in the 1980s the term ephemeral gully erosion was introduced, as a consequence of the growing concern that this sediment source used to be overlooked in traditional soil erosion assessments (FOSTER, 1986; GRISSINGER, 1996). However, in Brazil, the number of studies is still low, representing only 2% of the total publications in the world. One of the possible causes is that modeling or predicting ephemeral gully erosion processes is extremely complex (BERNARD et al., 2010).

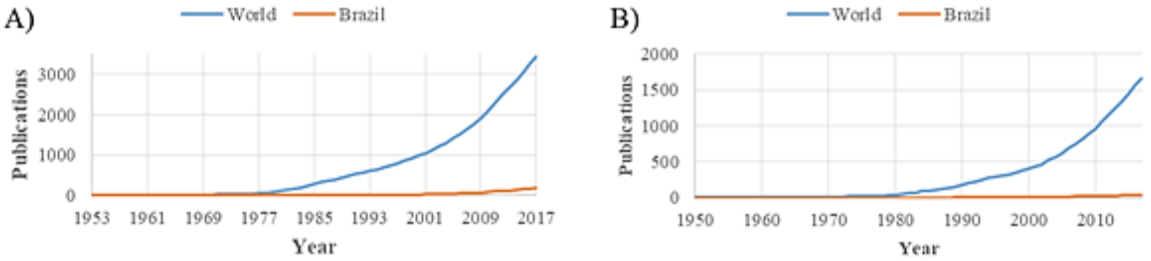

Figure 3. Growth in the number of a) erosion model studies; and b) gully erosion model studies in Brazil and worldwide over time.

Conclusions

American erosion forecasting models lead the number of publications worldwide. Most of the researches uses USLE and its modifications. In Brazil, studies also focus on the use of these models, presenting few publications on European models. This tendency is due to the fact that these models are specific to the geographical and environmental conditions of Europe, being necessary a complex calibration and validation for use in different conditions.

In relation to studies on gully erosion, Brazil contributes inexpressibly to the number of publications. In addition, studies in Brazil do not follow the growth of research related to erosion models in the world. This is mainly due to the lack of incentive that makes the researches punctual and inconstant, and because they are not routinely applied in soil conservation policies in the country.

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