STUDY OF VEGETAL COVER INFLUENCE ON EXPERIMENTAL EROSION PLOTS BY A RUNOFF-EROSION MODELING

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ABSTRACT

The present paper describes the observed data concerning water erosion for different experimental plots of *São João do Cariri* experimental basin located in a typical semiarid region of Brazil. The semiarid area of Paraíba state presents long drought periods, different types of vegetal cover and great spatial variability of intense rainfall events. All those factors are condicionantes to the erosion process, since they directly influence the sediment yield, agricultural soil loss and, consequently, the degradation of rural areas.

This study presents the application of KINEROS2 model (kinematic runoff and erosion model), to the erosion plots of 100 m^2 in São João do Cariri experimental basin located in the semiarid area of Paraíba state. The main objective of this work is to model the erosion process and to try to quantify the influence of the vegetal cover and slope degree for several events observed into two erosion experimental plots. The application of the model enclosed the selection of the precipitation data and calibration of the physical basin parameters. The observed data showed that these bare plots presented, larger sediment yield than when they are with vegetal cover. The simulation results showed that the initial degree of soil saturation (S_i) and the rain splash coefficient (c_f) were the most sensitive parameters during the calibration process, presenting small values of S_i for the bare plots and small values of c_f for the plots with vegetal cover. Finally, the results showed that the KINEROS2 model can be also considered a promising tool for the simulation of the runoff and erosion processes in the semiarid area of northeastern Brazil.

Keywords – vegetation cover; runoff-erosion modeling; semiarid region.

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INTRODUCTION

Integrated hydrological computer models are increasingly used to facilitate watershed planning and management (Joao and Walsh, 1992).

Accurate predictions of sediment yield from distributed models of runoff and sediment yield depends in part of how well matched the model structure is to the input data spatial representation. This study of vegetal cover influence was done through runoff-erosion modeling, when it was investigated the model structure and input data representation affect the sediment predictions. This study the erosion process is modeled in order to quantify the influence of the vegetal cover and slope degree on the sediment yield several events observed into two erosion experimental plots. The present paper describes the observed data concerning water erosion for two different experimental plots of *São João do Cariri* experimental basin located in a typical semiarid region of Brazil, through the evaluation of KINEROS2 model (kinematic runoff and erosion model).

There are basically three categories of soil erosion models, which are empirical, conceptual or partly empirical/mixed, and physically-based model. The empirical models are based on data from field observations, mostly as standard runoff plots on uniform slopes, and are usually statistical in nature. The main limitation of this type of models is their limited applicability outside the range of conditions for which they have been developed. Their adaptation to a new environment requires a major investment of resources and time to develop the database required to drive the model. The conceptual models lie somewhere between the empirically and physically-based models, and their main limitations lie in the poor physical description of the processes which results in distortion of parameter values determined by calibration. The physical basis of the physically-based models can, in principle, overcome many of the deficiencies of empirical and conceptual models. The kineros2 employed a computer solution derived model for infiltration to simulate the production of runoff, and it was intended for rural or urban runoff studies using a design storm.

The main objective of this work is to model the erosion process and to try to quantify the influence of the vegetal cover and slope degree for several events observed into two erosion experimental plots. The present paper describes the observed data concerning water erosion for different experimental plots (100 m^2) of São João do Cariri experimental basin located in a typical semiarid region of Brazil, through the evaluation of KINEROS2 model (kinematic runoff and erosion model).

FIELD DATA

The experimental site is located in the semiarid region of Paraíba state, in the *São João do Cariri* Experimental Basin of (latitude 07 22'44" S and longitude 36 32'00" W) and altitude approximately 465 m, covered with sparse vegetation of the *caatinga* type and pasture. The region is a typical semiarid area with less abundant rainfall from February to April. The soil is rocky type and the vegetation is sparse, which gives the appearance of strips alternatively between the rocky soil and the sparse vegetation. *São João do Cariri* experimental basin located in the medium part of Taperoá river basin, in the proximities of the *São João do Cariri* city, with an area of approximately 15 km^2.

The surface conditions as well as the slope for each experimental erosion plot are different and they are 4.55 m in width by 22.5 m in length (100 m^2). Their mean slope and vegetation cover condition are given in **Table l**. On the bare plot (plot l), the vegetation was removed when it reached 5 cm high. The plot with native vegetation cover (plot 2) received no human intervention until the event number 62 (1999 to 2002). The relationship between observed sediment yield and observed rainfall depth, for the plots are shown in **Figure 1**. It can be seen that when the rainfall depth increases the sediment yield also increases, but for the plot 2 with vegetation cover until 2002, there are more events with small sediment yield. It is observed that when the soil is not well protected the erosion increases, and that the natural vegetation can protect the land against soil degradation. A total of 92 events were registered in the period from 1999 to 2003 in the erosion plots.

Table 1. Characteristic of the erosion plots (100 m²)

Plot number	Slope (%)	Vegetal cover
1	3.4	bare
2	3.6	low vegetation (from event 01 to 62)
		bare (from event 63 to 92)

BRIEF DESCRIPTION OF THE KINEROS2 MODEL

KINEROS2 processes input from two files as well as interactive input from the user. A parameter file describes the watershed geometric, hydraulic and infiltration characteristics. If multipliers are being used, the corresponding parameters of each and all elements will be

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multiplied by the values specified. Multipliers are useful when calibrating parameters based on observed runoff or sediment (Woolhiser, Smith and Goodrich, 1990).

The computational time step can be adjusted automatically by the program to maintain numerical accuracy as put forth by the Courant condition — final output will still be at the user-specified time step can adjust the computational time step automatically. If this option is not chosen the program will still monitor the time step criteria and report a distribution based on three levels: 100, 75 and 50 percent. The time step listed at the 50 percent level would be sufficient for accuracy 50 percent of the time, the time step for the 75 percent level would be sufficient 75 percent of the time, and the time step listed at 100 percent would be sufficient throughout the simulation.

However, the user time step is not completely arbitrary. Even when the computational time step is adjusted, it is possible to choose a time step that is too large. If the time step is too large, outflow hydrographs from individual elements may not be well represented, and the effect may be cumulative as water and sediment are routed through the system. If the automatic time step adjustment is in effect, the outflow volume of each element based on the computational time steps will be compared to the volume computed using the values stored at each user time step, and if the difference is greater than one percent for any element a warning will be printed in the event summary.

CALIBRATION AND SIMULATIONS

- **PARAMETERS USED IN THE EQUATIONS**

The physical equations that are used by the model need some pre-established parameters, which are shown in **Table 2**, in which the S_i and c_f should be optimized for each rainfall event according to the rainfall characteristics and soil moisture content condition.

RESULTS AND DISCURSIONS

The data observed in field regarding the erosion and precipitation, for the two plots, are shown in **Figure 1**, where it is observed that during some of the events in plot 2 with vegetal cover, there was a decrease in the erosion.

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**Table 2. Description of the model parameters**

Description	Symbol	Value	Units
Coefficient of variation of Ks	c_v	3.0	mm
Diameter	d	0.173 mm	-
Manning	n	0.02	mm
Relief	-	2.0	m
Spacing	-	0.3	-
Ksat	Ks	3.0	mm/h
Mean capillary drive	G	260	mm
Distribution	λ	0.32	-
Porosity	ϕ	0.398	-
Fractions	-	0.15	-
Soil cohesion coefficient	c_o	0.01	-
Relative initial soil saturation	S_i	optimized	-
Splash parameter	c_f	optimized	-

For example, the relationship for the plot 1 shows that for a 80 mm precipitation depth it will yield approximately 0.6 ton/ha, while only 0.08 ton/ha will yielded in the plot 2 for the same precipitation depth.

The selected 92 rainfall events were simulated by the KINEROS2 model, where initial relative saturation of the soil parameter (S_i) and in the splash parameter (c_f) were optimized by trial and error method to fit the computed runoff and sediment yield observed data to the observed ones. The first parameter (S_i) concerns mainly to the runoff process and it may vary according to the antecedent soil moisture condition, then different values were obtained for each rainfall event, however, since the selected rainfall events occurred during the rain season, their values did not varied much and mean values were computed: 0.8477 for plot 1 and 0.6870 for plot 2. The second one (c_f), concerning to the erosion process depends mainly on the surface cover characteristics. In the present study it showed a variation from 10^3 to 10^7 for the plot 1 and from 10^2 to 10^7 for plot 2. These obtained values can be considered as references for similar areas in the semiarid region of northeastern Brazil. **Figure 2** shows an example of a computed sedigraph and hydrograph for an event in January 1st 2000. A comparison between observed erosion data and the computed erosion for each plot when using the mean value of c_f, from which can be concluded that these mean values can be used as references to future simulation in similar areas in northeastern Brazil.
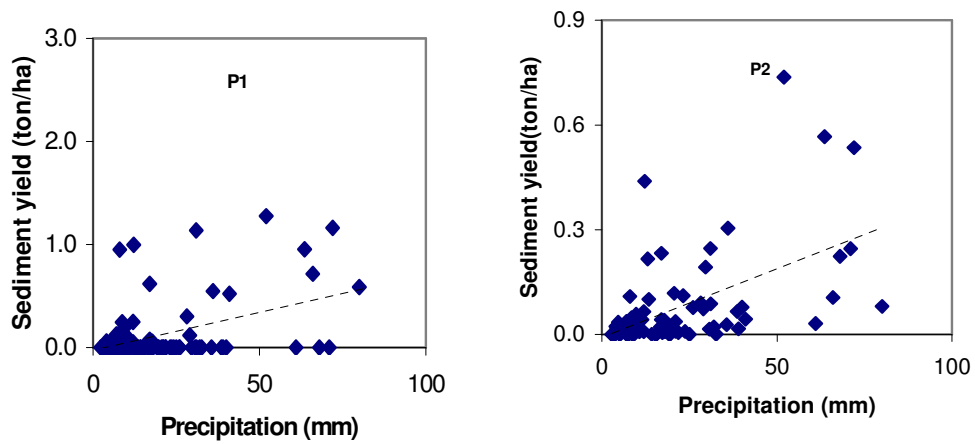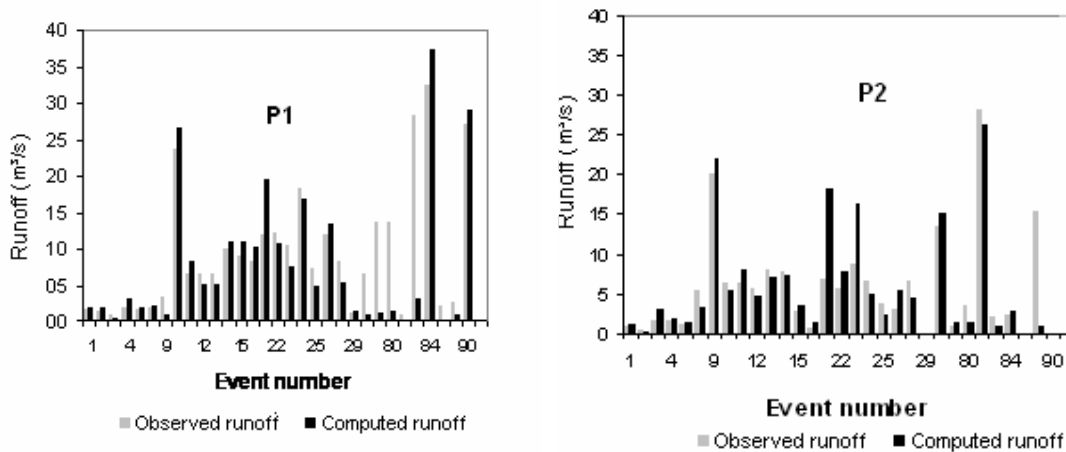
Figure 1: Relation between precipitation and erosion observed in the plots 1 and 2.
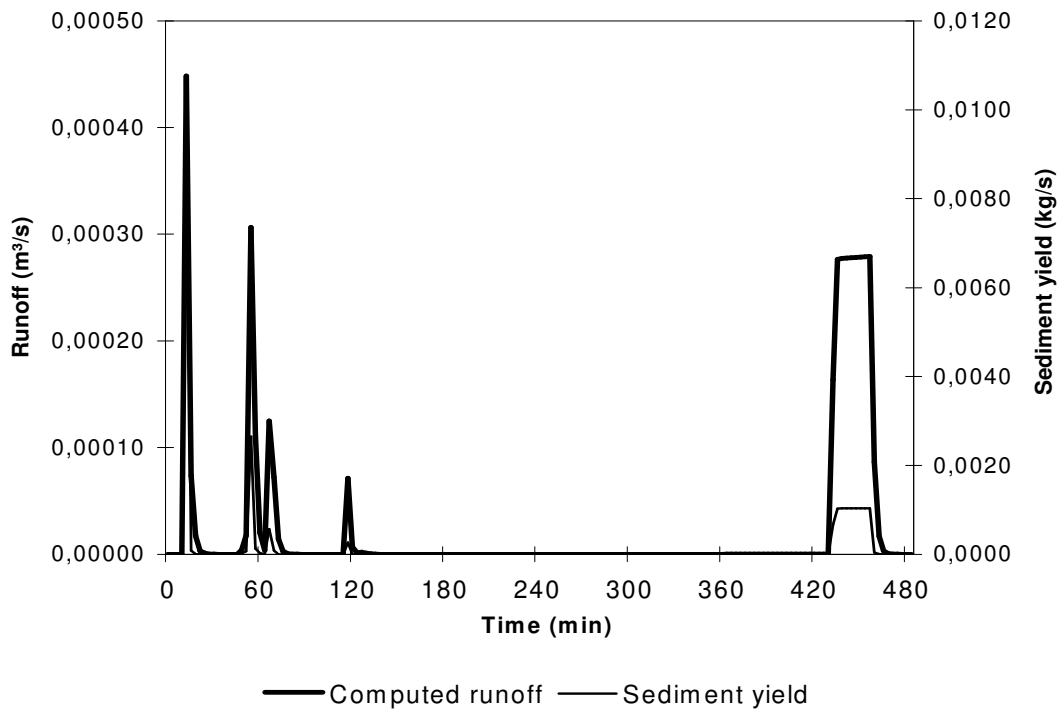
Figure 2: Computed hydrograph and sedigraph for the plot 1 in 16/01/00.
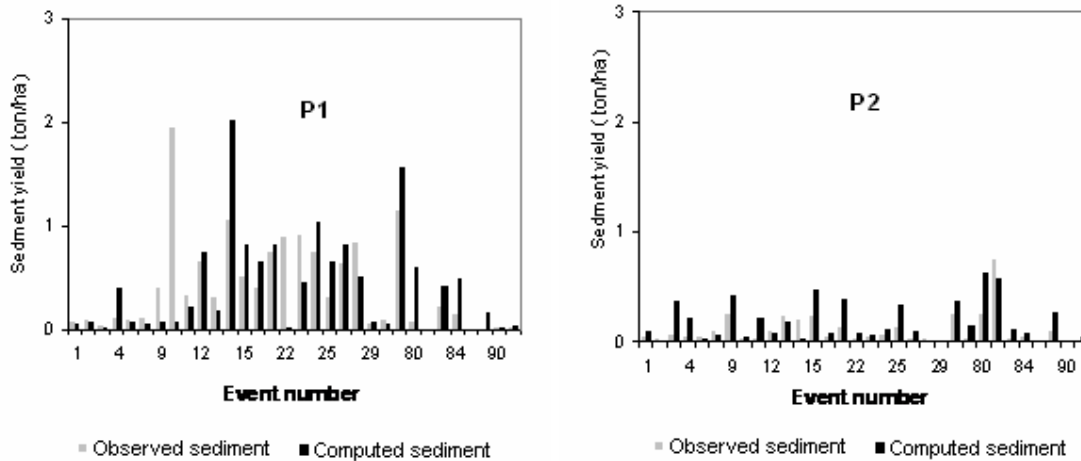
Figure 3: Observed erosion (E_o) versus computed erosion (E_c) using the mean c_f.

Figure 4: Observed runoff (Q_o) versus computed runoff (Q_c) using the mean S_f.

CONCLUSIONS

The results showed that the model can be used to simulate the runoff and erosion processes due to continuous rainfall events. The physical basis of the model allowed its applicability to such studied area, which has climatic differences if compared to the basin used during the model development. The simulation results are satisfactory when compared

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with the observed hydrograph and the sediment yield data and mean values for S_i and c_f parameters can be assumed as reference values to similar areas in northeastern Brazil.

The runoff-erosion Kineros2 model showed to be a robust tool for the calculation of these processes for semiarid regions of Brazil. The results show how the vegetal cover can influence on the sediment yield.

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