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Plot-Scale Experimental Studies

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1. Introduction

1.1 Plot-scale experimental studies: structure, equipment, hydrologic monitoring

Plot-scale experimental studies are generally part of broader research projects aimed at improving the understanding of interrelations between processes involving hydrological, climatic and biological factors (Wainwright et al., 2000). Recently, these studies have become multidisciplinary, integrating fields such as hydrology, ecology and geomorphology. In a global environmental change and degradation context, plot-scale studies may provide information about runoff mechanisms, soil erosion and vegetation dynamics processes that result from these changes (Abrahams et al., 1995; Parsons et al., 1996). Furthermore, plot-scale studies may focus on water fluxes and sediment transport processes at controlled conditions using rainfall simulation (Wainwright et al., 2000; Rickson, 2001). It is important to note that process control generally involves simplifying a complex system that is highly variable in time and space (Wainwright et al., 2000; Abrahams et al., 1998; Parsons et al., 1998). However, plot-scale studies have the advantage of allowing for detailed process monitoring at small scale, providing a basic description of the most relevant aspects (Michaelides et al., 2009).

Plot-scale studies are also useful in providing experimental data involving rainfall, surface runoff and soil erosion. These data are used as reference in modeling conception, calibration and validation. However, there can be considerable variability in soil erosion processes, as well as limitations of models atempting to simulate these complexities (Nearing, 2004). For example, in a study using 40 cultivated plots in the United States the experimental data coefficient of variation ranged between 18-91%. In addition, this variation was found to decrease with increasing rainfall erosive power (Wendt et al., 1986). Ruttimann et al. (1995) found that soil loss varied up to 173% between replicates under the same treatment. In general, the capacity of the model in representing local physical system can be tested by comparing observed and simulated model data, using regression analysis. Regression coefficient values from several studies demonstrate that model efficiency increases as erosion variability decreases, such as when mean annual soil loss data are used (Nearing, 1998; Risse et al., 1993; Zhang et al., 1996). The USLE-Universal Soil Loss Erosion (Wischmeyer & Smith, 1978) soil erosion model was originally conceived by using statistical analysis of 20 years soil erosion data in natural and cultivated experimental plots, installed at 49 stations across the United States. It incorporated approximately 1000 events, producing a significantly representative database. In fact, USLE soil erosion model was developed primarily for agricultural purposes, in an atempt to simplify complex erosive interactions. Indeed, it paved the way for more refined modeling structures which consider the physical characteristics of the process.

Establishing an experimental plot often involves hydrological monitoring by using manual and automatic devices and fieldwork surveys to collect information on details such as plot topography, soil hydraulic characteristics, flora and fauna. In general terms, it is hypothesized that the plot represents local climate, soil and plant conditions. A plot-scale experimental study involving precipitation, surface runoff, soil erosion processes as well as the biological dynamics of local fauna and flora was developed in the semi-arid Brazilian Northeast (Moreira et al., 2009). Plot-scale studies often include topographic survey, analysis of soil surface characteristics such as roughness, crusting, cracking, and soil as an environment of biological activity for arthropods and other organisms. The plot is delimited and identifies the study area.

Hydrologic monitoring involves the measurement of variables, often requiring the installation of manual and automatic devices. Indeed, plot-scale studies in uncontrolled conditions tipically require the use of automatic devices. Water discharge monitoring implies the use of a measurement structure such as a Parshall flume or a tank at the downstream end of the plot. If a Parshall flume is used, discharge is monitored by using a stage-discharge relationship. Once the measuring structure is established, water surface monitoring is conducted by using manual (graduated rule) or automatic devices (water level logger). In case a tank is used, discharge is monitored by water surface variation as a function of time during the storm. After each event, the tank must be emptied and the sediment and particulate organic matter is collected, dried and analyzed. For each storm event, runoff was obtained by applying water balance equations including runoff, rainfall and the variation of the tank water level during the storm.

A plot-scale study was developed in New Mexico-USA using 15 small plots composed of 5 different grassland and shrubland species. The aim was to identify the hydrological and erosional processes resulting from these species in a context of degraded environment caused by the advance of shrub species in the region. 54 small-scale rainfall simulations (125 $mm.h^{-1}$) found that shrub specie and canopy density were the main vegetation control on runoff and erosion. Significant interactions and feedbacks were found to occur between edaphic carachteristics and vegetation, which influenced both runoff and erosion responses (Michaelides et al., 2009; Wainwright et al., 2000).

Some researchers have highlighted the role of experimental studies at different scales, in light of the need to increase levels of complexity and connectivity in the study of processes (Bergkamp, 1998; Cammeraat, 2002). The results obtained on small-scale investigations present serious limitations and cannot be extrapolated to other scales without careful analysis. Experimental conditions at small-scale do not usually capture the interactions of a complex physical system (Kirkby, 1987; Zhang et al., 1999). Different processes can be dominant or observable at specific scales. For example, at a fine scale processes such as rain splash and rill and interill erosion are important, and at a larger scale, gully erosion, sediment deposition and other processes become more dominant (de Vente & Poesen, 2005).

Several plot-scale studies have also been developed under natural conditions. The aim of these studies is often to obtain data involving hydrologic and erosion processes and its relationship with biological factors, such as faunal and vegetation species dynamics (Reynolds et al., 1999). Although a reasonably long monitoring period is required, data obtained from these studies can produce a broader description of the actual system and existing interrelationships.

2. Plot-scale experimental study in semi-arid Brazil

An experimental plot-scale study subjected to natural conditions was carried out in the semi-arid municipality of Serra Negra do Norte, northeastern Brazil (Moreira et al., 2009). The study aimed to analyze interrelationships between surface runoff, sediment transport and the aspects of undisturbed native vegetation in this region. The plot was installed at the Seridó Ecological Station (coordinates 6°34’42”,S; 37°15’56”,W), an environmentally protected area located at approximately 300 km from the city of Natal. Plot area was bounded by a 0.3 m height brick wall. Plot relief and situation within the Seridó Ecological Station catchment are shown in Figure 1. During the rainy season, around 70% of the plot area is composed of annual xerophyte species. Climate factors such as rainfall and temperature regulate water availability and biological processes in the region. In the drought season, plants are subjected to water stress. At the end of this period, the permanent species Mimosa tenviflora covers about 20% of the plot, along with substrate accumulated at the soil surface composed of leaves, seeds and dry twigs. In semi-arid areas, native vegetation plays an important role in infiltration and rainfall interception. For example, the stem structure direct flow to the plant roots, enhancing both soil infiltration and soil water storage. Similarly, residue and organic matter accumulated on the surface protect soil from the impact of raindrops (Puigdefábregas, 2005).

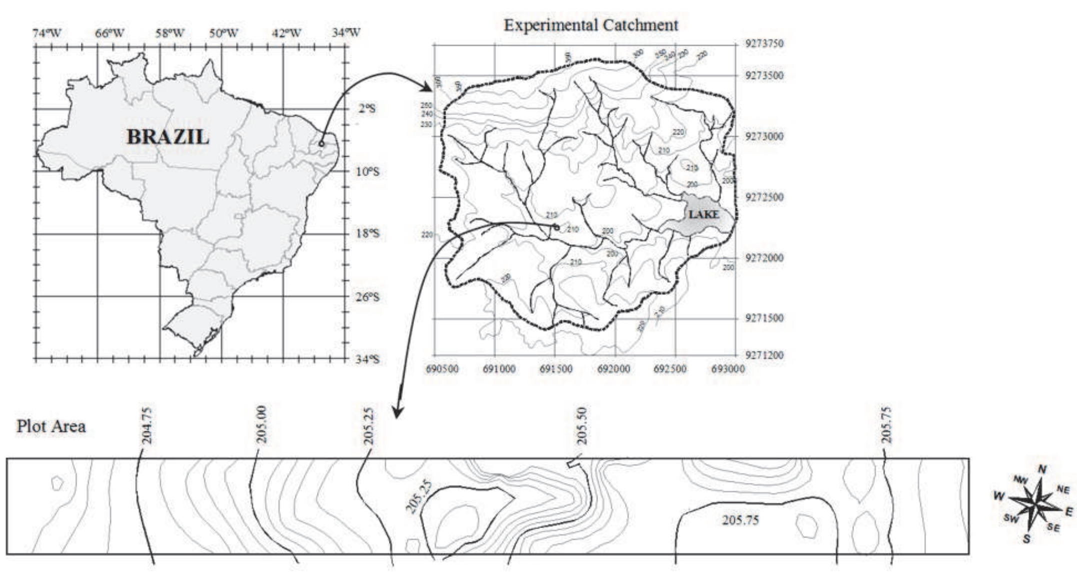


Fig. 1. Plot location within the catchment and terrain relief.

The average annual rainfall over the past 11 years (1995-2005) is 689 mm. Precipitation is highly variable from year to year in the area, where approximately 52% is high intensity thunderstorms of limited area extent. A study has shown the effect of high spatiotemporal rainfall heterogeneity on runoff in the watershed area (Moreira et al., 2006). Monthly rainfall shows considerable variation during the rainy season, especially in the period January-May. Daily rainfall data statistical analysis revealed that approximately 25% of the annual depth occurs during the maximum daily precipitation.

2.1 Biological fauna in the soil and substrate

The experimental plot-scale study enabled analysis of the biological fauna dynamics in the soil and substrate throughout the drought and rainy seasons in 2008-2009. For this purpose, five core sample collection campaigns were conducted at three randomly established points adjacent to the plot site. Soil samples were retrieved at 0.05 m depth and packed for subsequent laboratory analysis. Similarly, substrate samples were collected at three points, in squares measuring 0.30 x 0.30 m². Material was then submitted for biological analysis at the UFRN Entomology Laboratory to identify the main arthropod groups observed in the soil and substrate. To that end, specific taxonomic identification keys were used [Zeppelini-Filho & Bellini (2004), Buzzi (2005), Triplehorn & Johnson (2005)]. Screening, counting and organism identification was conducted using a tray, metal tongs, Petri dish, test tube and sterile microscope. Organisms not identified in the previous phase were removed with a Berlese-Tullgren funnel. After counting, arthropods were then stored in a test tube containing alcohol at 70° (v/v). Figure 2 presents daily precipitation data on the plot during the study period of 2008-2009. Samples were collected during drought and rainy periods.

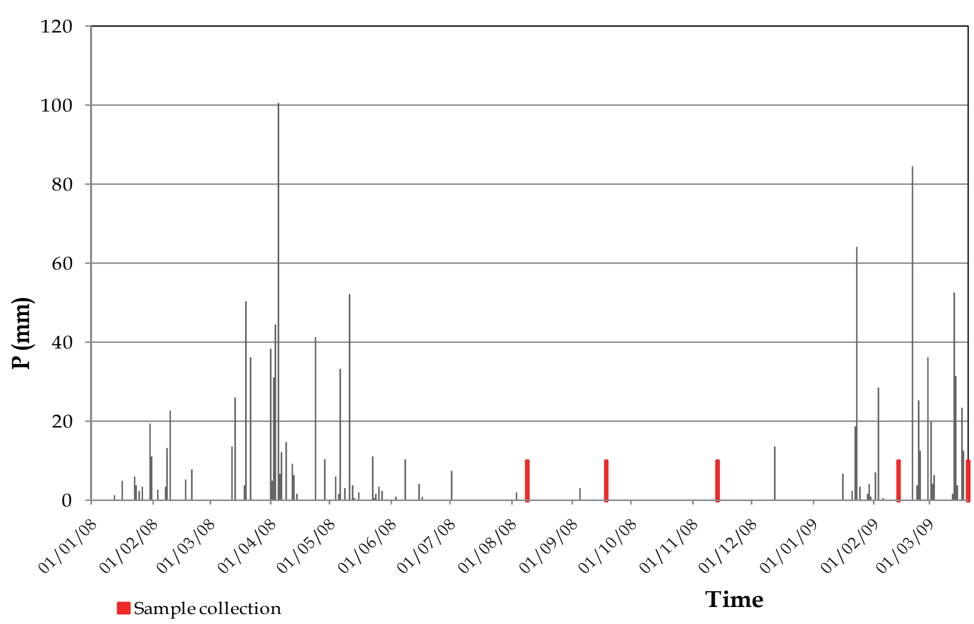


Fig. 2. Daily precipitation and sample collection as a function of time.

It is observed that after a period of several precipitation events during the first half of April 2008, further precipitation events occurred for the next couple of months. The first collection campaign was conducted on 08/08/2008. This was preceded by a period of sporadic low-magnitude rainfall, which produced a deficit on soil moisture and significant effects on annual species. The period between June and December 2008 received close to zero precipitation, with only an isolated event (13 mm) on 12/12/2008. A well-defined 165-day drought was observed during this period, which increased soil water stress level. The rainy

period began in the second half of January 2009 when events of substantial magnitude occurred. This period was followed by high-magnitude events in February and March 2009. During the rainy period, soil water moisture increased and annual plants showed progressive changes over a period of aproximately 2-3 weeks. As the rainy period continued, vegetation and biological activity interacted with soil, increasing porosity and enhancing soil storage capacity. Indeed, vegetation may act as sinks of overland flow and sediment due to the velocity reduction as runoff encounters plants (Ludwig et al., 2005). Collection campaigns showed a vigorous transformation in the natural landscape, with soil water availability as a crucial factor.
Analysis of plot core samples provided quantification of the arthropod fauna and its effect on both seasonal periods. Organisms observed were classified into twelve different taxa: *Homoptera, Hemiptera, Hymenoptera, Coleoptera, Orthoptera, Psocoptera, Embioptera, Diptera, Collembola, Ácari, Araneae* and *Geophilomorpha*. Soil fauna demonstrated nine orders of insects, with a clear predominance of *Ácari* group, which occurred in the substrate mainly during the rainy season (Figure 3). It is important to note the mutual and positive relationship between the anual plant species and *Ácari, Collembola* and *Orthoptera*, found primarily in the organic substrate at the soil surface. The annual species offers suitable habitat for the arthropods, including provision of shade, refuge and food. However soil moisture is the most important factor for both the plants and arthopods. Accordingly, an increase in soil water moisture was followed by a marked increase in faunal activity during the rainy period in comparison with the drought period. The quantity of observed organisms in these 2 periods is classified by taxonomic rank and presented in Figure 3.

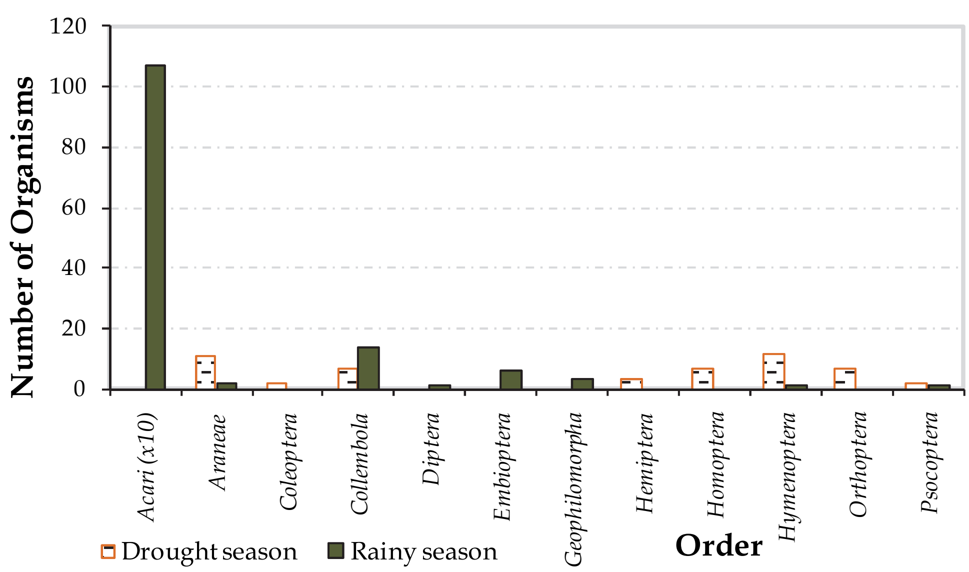


Fig. 3. Arthropod fauna observed in the plot during the dry and rainy seasons, classified by taxonomic rank.

2.2 Hydrological monitoring and sediment yield

With the aim of monitoring surface runoff and soil erosion processes, automatic devices (rainfall recorder and water level logger) were installed adjacent to the plot. A 5 m^3 tank was built at the downstream end of the plot in order to collect water discharge and sediment flowing from the plot during each event. The water level logger was programmed to take measurements every 5 minutes. After each event, the tank was emptied using a portable pump and sediment deposited at the bottom was collected, dried, weighed and analyzed. Calculation of surface runoff in the plot included precipitation and the variation of the tank water level during the storm, in accordance with the water balance Equation 1,

$$RO = \frac{1}{\Delta t}\left[A_{sw}(h_t - h_{t-1}) - (P_{sw}.A_{sw}) - (P_{ramp}.A_{ramp}) \right] \tag{1}$$

where RO ($L^3.T^{-1}$) is the surface runoff; Δt (T) is the interval between measurements; Psw and Pramp are the precipitation height on tank water surface and the paved ramp (L), respectively; Asw e Aramp are the tank and ramp water surface areas (L^2), respectively; h_t and h_{t-1} are the surface water levels in the tank (L) at times t and t-1, respectively.

2.3 Soil hydraulic properties

Soils in the plot site can be classified as a variation between clay-gravel textured Chromic Luvisol and the expansive clay Vertisoil. The soils in the plot site are well drained, shallow, gravelly, with depth varying from 0 to 1.40 m, with rocky outcrops on approximately 15% of its surface. Soil samples were collected from the top 0.1 m and taken to the laboratory for size distribution analysis, which allowed determination of the representative diameters D_{50}, D_{16}, D_{84} (in milimeters) and standard deviation, whose values are presented in Table 1.

Sample	A1	A2	A3	A4	A5	A6	A7
D_{84}	1.8	0.6	0.43	0.55	0.6	0.39	0.49
D_{16}	0.04	0.029	0.035	0.053	0.053	0.049	0.035
D_{50}	0.17	0.06	0.15	0.17	0.17	0.15	0.15
S.D.	6.71	4.55	3.51	3.22	3.36	2.82	3.74

Table 1. Soil representative diameters from the plot.

Table 1 indicates that soil size distribution is composed of gravel, fine, medium and coarse sand, silt and clay. Standard deviation values indicate bimodal composition of the soil (fine and coarse modes present in the bulk sample). The natural roughness of the surface area during the dry season is mainly due to the occurrence of randomly crusted rock fragments, which results from both physical and chemical weathering processes. During the first rainstorm events, readily mobilized sediment dominate sediment yield. Seeds and organic matter are also transported by overland flow across the plot.

To determine soil hydraulic properties in the plot, field infiltration experiments were conducted during the drought and rainy periods. Experiments were performed using a constant head disc permeameter at sixteen points, with care taken to avoid disturbing the native vegetation. The objective was to investigate vertical flow behavior through soil profile as a function of time. The field infiltration experimental data was used to adjust the Horton infiltration parameters, which characterise soil hydraulic properties as an unsaturated porous media. Infiltration curves exhibit declining behavior, with a constant and asymptotic tendency as a function of time. Thus, the profile achieved steady regime at soil saturation level. The Horton infiltration equation (1933) is as follows,

$$f(t) = f_c + (f_0 - f_c).e^{-k.t} \quad (2)$$

where f(t) represents infiltration capacity at time t ($L.T^{-1}$), fo is the initial infiltration rate ($L.T^{-1}$), fc is a final infiltration capacity ($L.T^{-1}$) and k is an empirical constant. Horton equation parameters reflect the spatial heterogeneity of soil hydraulics. In addition, the average observed saturated hydraulic conductivity rates in the rainy period are approximately six times higher than in the drought period, which indicates a marked difference in soil hydraulic behavior. Indeed, during the rainy season soil infiltration capacity is enhanced by an increase in soil moisture, roots osmotic effect, vegetation cover and faunal activity. Higher soil infiltration capacity rates were observed in areas beneath the canopy of permanent species such as *Mimosa tenviflora* (medium-sized trees). In these areas, a higher density of annual plants was observed, mainly due to canopy shade which provides protection from high temperatures and radiation.

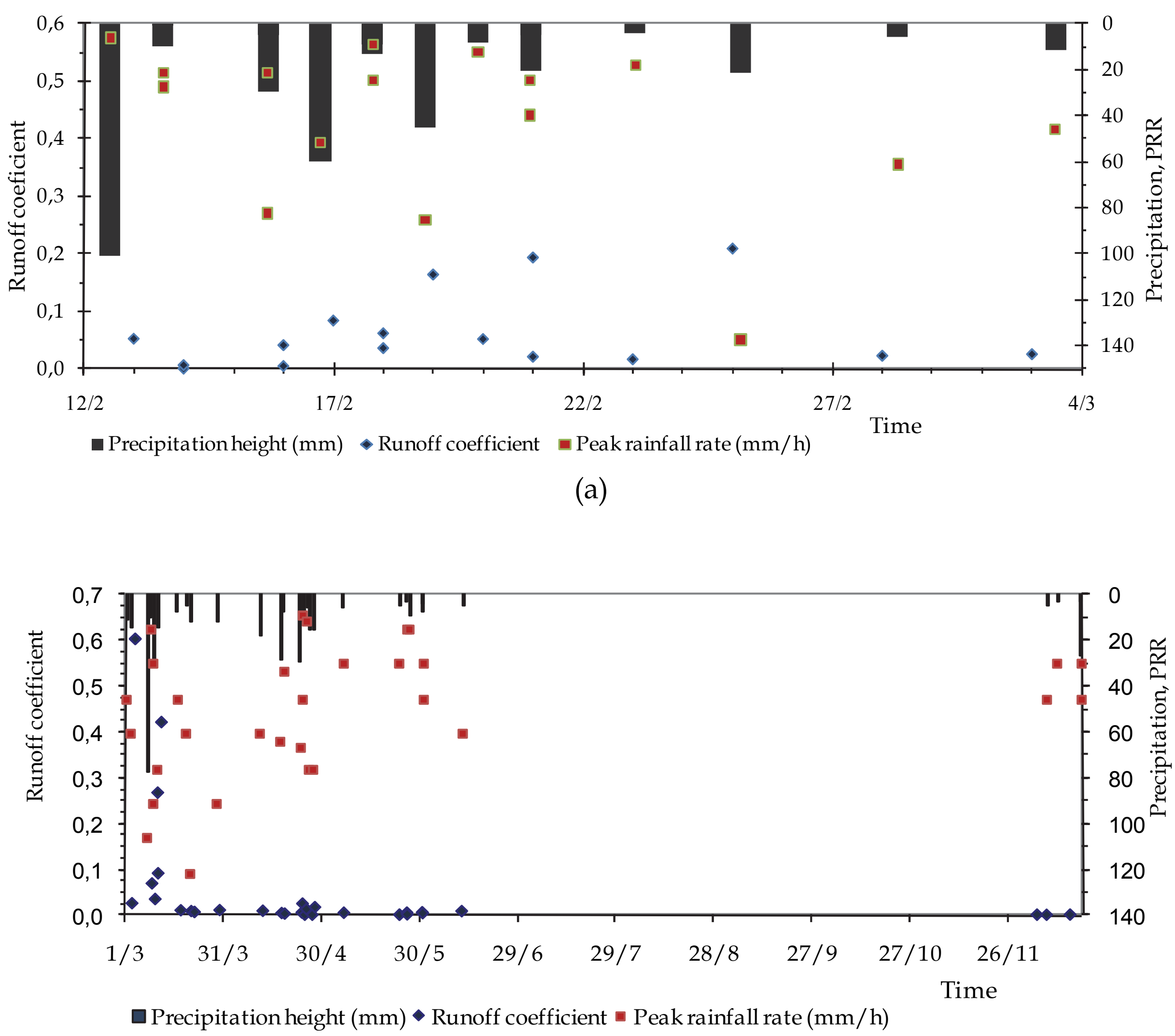
	Experimental run	Parameters			Experimental run	Parameters	
		fo	fc			fo	fc
Drought period	1	30	4	Rainy period	1	300	195
	2	25	3		2	160	85
	3	120	50		3	180	120
	4	60	6		4	35	10
	5	35	10		5	240	170
	6	36	12		6	170	155
	7	30	5		7	180	160
	8	80	57		8	90	40

Table 2. Infiltration parameters of the Horton equation ($mm.h^{-1}$).

2.4 Runoff generation mechanisms

Surface runoff and erosion in semi-arid areas are the result of various factors associated with rainfall (duration and intensity), soil (moisture, cracking, crusting, and soil infiltration capacity), plant cover (density) and terrain relief. During the study period, 46 precipitation-runoff-sediment yield events were recorded and their main characteristics and the corresponding hydraulic responses were evaluated. 55% of the rainfall events duration were less than 60 minutes in duration and 66% between 18h00 and 06h00. Rainfall peak rate ranged between 9.14 and 137.16 $mm.h^{-1}$. In 56% of events peak rate surpassed 40 $mm.h^{-1}$ and in 5 events it exceeded 90 $mm.h^{-1}$. The runoff coefficient is the relationship between surface runoff and rainfall levels during the event. Observed values of runoff coefficient, rainfall peak rate and precipitation height are presented for the beginning and the end of the rainy periods in Figures 4(a) and 4(b), respectively.

33% of the observed events didn't produce runoff. Observed runoff coefficients were lower than 0.1 for 82% of events, which indicate high soil water storage capacity. Only 5 events exhibited runoff coefficients higher than 0.2; these higher values were possibly due to influence of antecedent rainfall, soil water storage capacity and the density of vegetation cover.



(b)

Fig. 4. Runoff coefficient, precipitation height and rainfall peak rate at the (a) beginning of the rainy period and (b) end of the rainy period.

Furthermore, these values above 0.2 were observed at the beginning of the rainy period when the vegetation cover density was low. Indeed, vegetation density increased as the rainy period progressed, thereby increasing infiltration capacity and soil water storage. During the rainy period, runoff coefficients were lower than 0.05, and seemed to be independent from rainfall characteristics. This demonstrates the role of native vegetation in improving infiltration capacity and soil water storage. Also, a feedback relationship seemed to control the regeneration of annual species influenced by soil moisture, intense faunal activity and seed supply followed the first week of the wet season. The graph in Figure 5 presents empirical relationships involving sediment yield and precipitation height in 2006 (plot installation) and 2007. The impact of disturbance to the soil surface during plot installation is clearly visible. In 2007, undisturbed natural conditions in the plot and a decrease in sediment supply are reflected in an empirical relationship that seems to be more independent from precipitation characteristics.

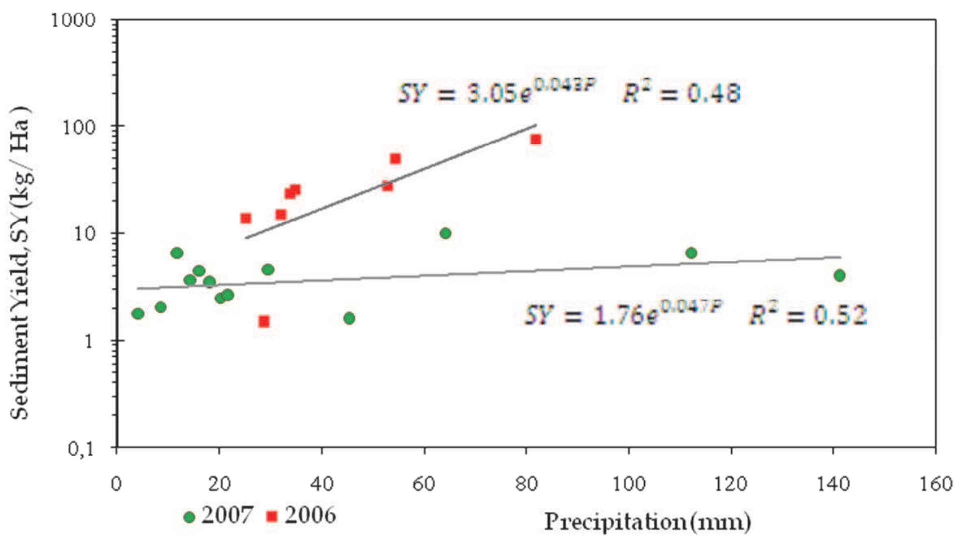


Fig. 5. Empirical relationships between sediment yield and precipitation height in 2006 and 2007.

2.5 Vegetation cover

Flora in the plot is formed by the *Caatinga* biome composed of xerophilous species. These species possess mechanisms to adapt and cope with water dryness spells and their physiological processes are conditioned to water availability. Climate factors and the soil water availability are determinants of natural ecosystem functioning. Accordingly, two distinct landscape scenarios may be observed during the drought and rainy periods. In the dry season, annual species typically become absent (herbaceous); permanent species survive due to their root structure and ability to store water during this period. Another adaptation of the permanent species in the area is their ability to lose their leaves when water is scarce to avoid water loss through transpiration. Figures 6(a) and 6(b) illustrate the vegetation landscape scenario during the wet and dry seasons.

Vegetation cover in the plot is most dense at the end of the rainy season. A survey of existing species in the plot identified 31 individuals of the *Mimosa Tenuiflora* species (medium-sized tree) and 15 *Cróton campestris* (shrub). A predominance of annual species was observed, whose life cycle (germination, flowering, fruiting and death) is completed in less than one year. Table 3 depicts the observed vegetation species in the plot during the rainy period.

2.6 Summary of plot-scale experimental observations

The results from the analyses highlight the stark difference between the soil hydraulic properties, faunal activity and vegetation cover in the rainy season and dry season. This is consistent with other studies in semi-arid regions, which have also found that water availability is the key driving factor of biological and geomorphological processes (Cammeraat, 2002; Cerda 2002). In contrast, Cammeraat (2002) found that in a humid temperate climate (Luxembourg) these processes were dominated by water surplus. In this semi-arid Brazilian plot study, the soils were composed of gravel, fine, medium and coarse sand, and also rock fragments, which provides natural roughness to the soil surface. This natural roughness is particularly important in reducing water and soil loss during the dry season, when vegetation cover is sparse.

(a) (b)

Fig. 6. Vegetation landscapes in the (a) drought and (b) rainy periods.

Strata	Family	Scientific name	Popular name
Arboreo	Leguminosae-mimosoideae	*Mimosa tenuiflora*	Jurema Preta
Shrubby	Euphorbiaceae	*Cróton campestris*	Velame
	Sterculiaceae	*Waltheria bracteosa*	Corre-campo
	Sterculiaceae	*Waltheria indica*	Malva-branca
Annual species	Amaranthaceae	*Froelichia humboldtiana*	Ervanço
	Euphorbiaceae	*Acalypha communis*	Algodãozinho
	Asteraceae	*Hyptis suaveolens*	Alfazema-braba
	Leg. Papilionoideae	Stylozanthes	Stylozanthes
		Sida rhombifolia	Relógio
	Malvaceae	Pavonia cancellata	Malva-rasteira
	Leg. Mimosoideae	*Mimosa ursina*	Jureminha
	Turneraceae	*Turnera subulata*	Chanana
	Rubiaceae	*Diodia teres*	Quebra-tijela
	Asteraceae	Centratherum punctatum	Perpétua-roxa
	Poaceae	*Aristida adscensionu L.*	Capim Panasco

Table 3. Observed vegetation species in the plot during the rainy period.

The runoff coefficient values were generally quite low for the study site, with a third of events not resulting in any runoff and the majority (82%) of events producing values less than 0.1. The 5 events that produced runoff coefficient values over 0.2 occurred at the beginning of the rainy period when vegetation cover was low. It was observed that as the rainy period progressed, the vegetation density increased, along with increased infiltration capacity and soil water storage, and consequently the runoff coefficients dropped to below 0.05. Indeed, the saturated hydraulic conductivity rates in the rainy period were approximately six times higher than that observed during the drought period. Also, the soils beneath the permanent plant species were found to have higher infiltration capacity rates. Another important observation from this study was the higher sediment yields in 2006 following the installation of the plot, compared to 2007. In 2007, the soils were relatively undisturbed and accordingly there was a decrease in sediment yield. A significant increase in the number of arthropods was also observed during the rainy season. This phenomenon between microbial and hydrological processes in arid and semi-arid environments was explored by Belnap et al. (2005) using the *trigger-transfer-reserve-pulse* framework (Ludwig et al., 1997). Under this framework, rainfall can be considered as the *trigger* which results in the *transfer* of resources such as water, nutrients and soil to the receiving patch (referred to as the *reserve*) downslope. Patches within a semi-arid landscape are typically formed by plants, under which soils tend to have higher organic matter, nutrients and microbial activity. The rainfall and subsequent transfer of materials to the patch triggers a *pulse* of biological activity, which in turn produces positive feedbacks including the formation of stronger or new soil aggregates that improve soil stability and water infiltration (Belnap et al., 2005). Human activities that disrupt this positive feedback loop between the abiotic and biological activities, for example native vegetation clearance or overgrazing, can lead to negative impacts on the system. For example, removal of vegetation will reduce organic matter input to the soil, which can lead to decreased microbial activity and poorer soil structure and lower soil storage capacity.

3. Impact of human activities on erosion processes and the effect on the environment

Sedimentological processes operate on the earth's crust over thousands of years. Climatic factors are the main drivers of the processes of erosion, sediment transport and deposition over different time-scales. When subjected to the action of natural forces, soil particles are transferred to other sites within the watershed. Sediment processes may occur in several forms: surface erosion, erosive formations such as channels and gullies, mass transfer including collapsed riverbanks and hillside landslides. When incorporated into the river system, sediment is carried by the flow to downstream areas, where sedimentation may occur. It is important to note that erosion processes occur in a continuous and dynamic system, which is in constant reworking and subject to geomorphologic changes (Walling, 2006). Therefore, erosion processes can be due to storm events or the wind action over dunes formations. Extreme events such as high magnitude floods may produce highly significant geomorphologic changes unrelated to human intervention. Natural events cause weathering processes on mineral rocks, which are subjected to erosion and transported to sedimentary formations, where they are subjected to other chemical processes.

Although erosion processes are directly linked to climate factors, human activity tends to accelerate their impact on the environment, provoking considerable negative effects (Dedkov & Moszherin, 1992). According to Panin (2004), the suspended sediment load released into oceans annually in continental regions varies between 15-20 GT.year-1. Historically, erosion processes have increased worldwide as a result of several different types of human activities, including agriculture, mining, urbanization and industry (Walling & Fang, 2003). Intensification of these erosion processes has led to long-term negative social and economic impacts. For example, siltation of reservoirs built for hydropower production can cause economic losses that affect society as a whole. Mahmood (1987) estimated that reservoir storage capacity in the world decreased by approximately 1% every year as a result of siltation, causing an annual loss of US$ 6 billion. This impact is far-reaching considering that approximately 40% of the worldwide river system capacity is stored in large dams (Vörösmarty et al. 2003).

Deforestation of native vegetation for agriculture and wood extraction are the main causes of erosion over the world. Ives & Messerli (1989) presented a model illustrating how changes in the population structure of Nepal in the 1950s affected natural processes on several scales. It is estimated that the global area dedicated to agriculture has increased five times over the last 200 years, prompted by population growth and higher food demand (UNEP, 1995). On the other hand, reservoir construction and the damming of water and sediment significantly reduce the amount of sediment reaching floodplains and estuaries. A recent survey using long-term records of large basins subjected to the impact of human activity found that, in some cases, increased sediment in river systems may not impact deltas and estuaries (Dai & Tan, 1996; Walling, 2000; Walling & Fang, 2003) due to sediment retention in reservoirs located upstream. Thus, erosion processes reflect the combined action of climate factors and disturbances in the basin as a result of unsustainable human activities.

Urbanization may also cause substantial changes in hydrologic behavior and erosive processes (Taylor, 2007). Land occupation of urban areas brings together the production of liquid and solid residues that, if not adequately collected, may be detrimental to water and sediment quality. Urbanization is associated with building construction and infrastructure service. Paved surfaces in urban environments result in lower amounts of water infiltration, which, in turn, can produce adverse social and economic impacts such as floods. In developing countries, it can be observed that urban development does not commonly occur in line with infrastructure and urban services investments. Often public services such as health and education are inadequate and planning and provisions to prevent or cope with extreme events (e.g. prevention measures and land occupation control) are lacking. In addition, urban occupation generates sediment contaminated by toxic substances (heavy metals, pesticides, oils, organic compounds), which can adhere to the fine fractions in the fluvial environment (Robertson et al., 2003; Lecoanet et al., 2003). Primary sources of sediment contamination in urban areas are domestic sewage and the construction of buildings and roadways. The presence of contaminants significantly affects aquatic organisms that feed on the sediment, which highlights the implications of land management on other parts of the system.

4. Acknowledgment

The research of this study was supported by CNPq–Technologic and Scientific National Development Council/Science and Technology Ministry/Brazilian Government. This support is gratefully acknowledged.

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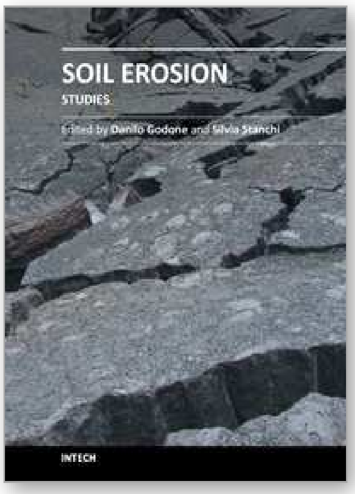

Soil Erosion Studies
Edited by Dr. Danilo Godone

ISBN 978-953-307-710-9
Hard cover, 320 pages
Publisher InTech
Published online 21, November, 2011
Published in print edition November, 2011

Soil erosion affects a large part of the Earth surface, and accelerated soil erosion is recognized as one of the main soil threats, compromising soil productive and protective functions. The land management in areas affected by soil erosion is a relevant issue for landscape and ecosystems preservation. In this book we collected a series of papers on erosion, not focusing on agronomic implications, but on a variety of other relevant aspects of the erosion phenomena. The book is divided into three sections: i) various implications of land management in arid and semiarid ecosystems, ii) erosion modeling and experimental studies; iii) other applications (e.g. geoscience, engineering). The book covers a wide range of erosion-related themes from a variety of points of view (assessment, modeling, mitigation, best practices etc.).