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ANTHROPIC ACTION IN SOIL EROSION IN HYDROGRAPHIC BASINS IN THE BRAZILIAN SEMIARID

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ABSTRACT

Soil erosion is extremely variable, and this variability is due to differences in the soil surface conditions along the basin, which directly affects surface runoff. Thus, the objective of the work in question was to carry out a bibliographical survey on soil erosion in the semiarid geographical basins to better understand the subject and the problems involved. Erosion is seen as a process of wear, transport and sedimentation of soil, subsoil and rocks caused by water, water erosion, or wind, wind erosion, as well as the action of living beings. In Brazil, water erosion is of greater interest, largely in the tropical region, because it is more frequent, acts more quickly and causes high losses both in the agricultural sector, as well as several other economic activities besides the environment itself. Regarding the semiarid region, erosive processes become unsettling, since the soil is increasingly vulnerable due to the intensifying anthropic action and the very fragility of the soil material.

KEYWORDS: Erosive processes; Hydrosedimentology; Environmental impacts.

AÇÃO ANTRÓPICA NA EROSÃO DE SOLO EM BACIAS HIDROGRÁFICAS DO SEMIÁRIDO BRASILEIRO

RESUMO

A erosão dos solos é extremamente variável e essa variabilidade deve-se ao fato das diferenças nas condições da superfície do solo ao longo da bacia, que afeta diretamente o escoamento superficial. Dessa forma, o objetivo do trabalho em questão foi realizar um levantamento bibliográfico sobre a erosão do solo em bacias geográficas do semiárido para melhor entendimento do assunto e da problemática envolvida. A erosão é tida como um processo de desgaste, transporte e sedimentação tanto do solo, quanto dos subsolos e das rochas causado pela ação da água, erosão hídrica, ou do vento, erosão eólica, bem como ação dos seres vivos. No Brasil, a erosão hídrica apresenta maior interesse, em grande parte na região tropical, por ser de ocorrência mais frequente, atuar com maior rapidez e causar altos prejuízos tanto no setor agrícola, como também a diversas outras atividades econômicas além do próprio meio ambiente. Com relação à região semiárida os processos erosivos tornam-se inquietantes, uma vez que o solo é cada vez mais vulnerável devido à ação antrópica intensificadora e à própria fragilidade do material pedológico.

PALAVRAS-CHAVE: Processos erosivos; Hidrossedimentologia; Impactos ambientais.

1 INTRODUCTION

The river basins can be understood as a natural catchment with large area in which a main rive is fed by other rivers around it, to which they drain to a certain exit course, where a set of surfaces converge in a confluent drainage network and that result in a bed only (Silveira, 2013). Brazil has approximately 12% of the freshwater of the land, with 200,000 micros basins that are distributed in 12 hydrographic regions, the largest among these being the Amazon Basin, considered the most extensive of the planet (Ministério do Meio Ambiente, 2019).

The semiarid region of northeastern Brazil has remarkable scarcity of water resources, and such a picture may be related to the poor distribution of water and the instability of rainfall precipitations, and the indiscriminate use of this resource can contribute to water quality degradation and mitigate the environmental impacts of the region (Silva et al., 2014). Moreover, according to the authors, the climatic conditions characteristic of the Brazilian semiarid can further intensify the impacts on the fauna, flora, soil, and water resources, thus contributing to the desertification process. Cunha et al. (2014) claim states that changes related to rainfall may also interfere directly in the vegetation and in the factors associated with the hydrological cycle.

Given the impacts generated by the poor management of water resources, there is the erosion process, which can be understood as a process of chemical and physical modifications through the wear and sedimentation of the soil and rocks resulting from natural or anthropogenic actions. In addition, population growth for urban areas, lack of planning of agricultural activities, inadequate management of solid waste in cities, deforestation of native forests, lack of management in soil paving of large cities and mining-derived activities can be cited as factors that intensify the soil erosion process (Carvalho, 2008).

Soil erosion has a very expressive form of decline and environment degradation, being of remarkable importance the study of soil erosion from the social and economic point of view, and that it is possible with such surveys to understand soil losses for as well as the impacts caused by rivers and water reservoirs (Silva et al., 2012; Medeiros & Silva, 2014).

Among the types of erosivity, water erosion is one of the main modes of degradation of the Brazilian cultivable soils, where it is characterized by a process of surface runoff of rainwater with degradation and sedimentation of organic matter, soils, and nutrients (Dechen et al., 2015). Given this scenario, the vegetation present in the soil and the appropriate management system are factors that are directly associated with the water flow intensity, as well as the water erosion of the vegetation systems (Cândido et al., 2014).

In view of the above, the present work aimed to conduct bibliographic research on soil erosion in river basins in the Brazilian semiarid region in order to better understanding the problem of the issue and to bring possible solutions to the management of water resources.

2 METHODOLOGY

The bibliographic research method was applied, which aims to gather and synthesize research data on a theme or question delimited in a systematic and orderly manner, which contributes to a better understanding of the subject investigated. For the elaboration of the article, the following steps were adopted for the elaboration of the review: identification of the research question and objective of the study, literature search, data selection, presentation, and discussion of them.

For the selection of scientific articles, we used online access to databases as journal portal of the coordination for the improvement of higher education personnel (CAPES); Scientific Eletronic Library Online (Scielo) and Google academic platform. For the research, we also used the search for information in books related to the theme addressed. For the research, we also searched for information in books related to the topic covered. Original articles published were selected, selecting the expressions “reservoirs of the Brazilian semi-arid region” “soil erosion” “watersheds” “water resources”, the works were organized and analyzed.

This search in countless sources aimed to broaden the scope of the research. The established inclusion criteria were complete articles electronically available that address data related to soil erosion in semiarid river basins, available in Portuguese and English languages.

3 RESULTS AND DISCUSSION

3.1 Factors in the erosion process

Soil erosion is a process that may be caused by both natural wear and anthropic actions that act on a given area, which can be intensified if there is no adequate environmental management. According to Carvalho (2008), there are two modalities of soil erosion, these being geological and advanced. Geological erosion (also known as naturals erosion) occurs with the modifications of particles, transport, and displacement, without the intervention of man. Still in agreement with Carvalho (2008), the erosive agents (elements present in the physical environment) that directly affect the erosivity process can be active or passive. Among the active agents, the temperature, wind, water, insolation, microorganisms’ action, human action, among others can be cited.

According to the World Meteorological Organization, the natural factors (or passive agents) associated with natural erosion may be the geology (related to the composition of the rocks and the movement of the tectonic plates); the topography; Characteristics inherent to the soil; the vegetation that covers the surface of the soil, as well as the weather (action of the winds, rains etc.) (World Meteorological Organization, 2003). The advanced erosion (or anthropic erosion) is the type of erosivity induced by the action of man, being the agricultural activities and construction works good examples of attitudes that can lead to soil erosion.

There are several types of erosion, which can cause environmental impacts of the most diverse magnitudes, among these can be cited: erosion by removal of mass, erosion caused by human or animal action and water erosion. For Carvalho (2008), erosion by removal of mass may result from the detachment of land, to which there is a saturation of the soil with the presence of water, contributing with the increase of sediment and consequently the slipping of mass. Erosion resulting from human or animal action is related to productivity needs, whether these agricultural activities or construction works, which bring with its consequences that negatively impact nature. Water erosion has a great relevance among the erosion processes since it can generate a great impact on the environment and bringing with its irreversible modifications in nature.

3.2 Hydric erosion modality

Erosion is a natural geomorphic process, being one of the main processes that generate soil degradation in tropical regions. Except for wind erosion, every erosive process requires the presence of water over the relief, in which as main erosive agents are the impact of gout on the soil and the surface runoff (Bertoni & Lombrardi Neto, 2014). However, this natural process can be intensified by the human actions (anthropic) through land occupation through deforestation and practices of inadequate land use and management (Schultz et al., 2013).

The water erosion process consists of three phases: detachment or disaggregation, transport, and when there is not enough energy to drag the disaggregated particles then the deposition occurs. Erosion begins by disaggregation or detachment of the soil, and this step is defined as the release of particles from the aggregates present on the soil surface. This release is promoted by the impact of water droplets on the soil surface devoid of vegetation or by operations during preparation. The small and light particles of the soil, such as organic matter and clay, are preferably disfastened by the impact of these drops. During this stage, there is energy expenditure, and this expense is greater as the more aggregate and protected the soil is decreasing the total energy of rain and consequently its ability to drive the soil material detached in the next stage of the erosive process (Pruski, 2009; Silva et al., 2010; Campos, 2014).

The breakdown of soil particles is a continuous process, remembering that the particles, once received, can remain close to the aggregate, or be transported by the runoff, initiating the following stage of the erosive process the drag or transport. After the material is unfastened this is then transported by the action of the raindrops itself that throws it away, through the flood and, or by the wind that drags it. In the same way as in the previous step, there is also energy expenditure. The dominance of energy from the impact of water droplets or runoff in the detachment and transport of these sediments depends on whether erosion occurs in grooves or in areas between grooves (Carvalho et al., 2006; Pruski, 2009; Guerra et al., 2010).

Lastly, the deposition of the material that was unfastened and transported is carried out. This deposition would be the accumulation of this material (organic matter, clay, sand, gravels etc.). It depends on several factors, such as alteration of the soil surface geometry, runoff blade and slope of the soil surface, among others. This accumulation of material is originated when the erosive agents, that is, the means transporters lose energy, failing to continue with the drag of the material (Pruski, 2009; Guerra et al., 2010). According to Bezerra et al. (2010), water erosion is one of the main elements associated with environmental degradation, being its most relevant erosion agent, particularly for the tropical and subtropical regions, the intense rainfall that generates rupture of the aggregates and the dispersion of the clays. Thus, this type of erosion causes serious environmental damage, such as pollution of water sources and siltation, and decreases the productive capacity of crops (Schultz et al., 2013).

3.3 Erosive process and pollution sources

Soil erosion is one of the most important environmental problems, capable of achieving urban centers, natural areas, and agricultural regions. In agricultural areas especially, it represents a major loss both environmental and economic (Lepsch, 2010). In tropical soils, hydric erosion occurs more frequently due to high rainfall rates and the large sediment removal and transport capacity (Bertoni & Lombardi Neto, 2014).

The identification of areas susceptible to erosion is fundamental for the adoption of soil conservation practices, to mitigate the erosive processes or even as a tool for the future planning of soil use in the basin according to its potential (Falcão & Leite, 2018). Soil erosion is extremely temporal and spatially variable, and this variability is due to the fact of differences in soil surface conditions along the basin, which directly affects the surface runoff (Silva & Santos, 2009).

The research makes a substantial contribution to the understanding of cavitation degradation and holds promise for advancements in numerous industrial applications and engineering projects (Mohammadizadeh et al., 2023). Furthermore, methods for evaluating erosion processes are fundamental. Therefore, it is essential to evaluate and validate these methodologies. Among these, satellite images are used to identify advanced erosion processes such as voices. For example, the study that compares the Universal Soil Loss Equation (USLE), with the Embrapa Erosion Susceptibility Map, both using geospatial data and current data at different river basin planning scales (Soares et al., 2023).

A hydrographic basin collects the precipitation that falls on its surface and leads part of this water to the river through the runoff and groundwater flow. The soils and vegetation influence the speed at which this water reaches the river. The lithology determines the soil texture that controls the ability to infiltrate and store water. The geological structure defines the morphology of the basin and, thus, controls the erosion and leaching processes, in addition to the area's productivity potential (Frota & Nappo, 2012).

Even so, the erosive processes occur naturally, slowly, and gradually, but are intensified by virtue of anthropic actions, such as deforestation, farming activities and inadequate soil management (Nunes et al., 2011). Partial or total removal of the vegetation alters the hydrological behavior, influencing the water availability of the basin. Soil cover is an important aspect in the prevention and control of erosion, constituting a fundamental principle in soil and water conservation (Frota, 2013).

In the areas of tropical climate, as in the northeast, rainfall occurs with high intensity and are concentrated in a short period of time, which further aggravated the erosive process due to the strong impact of raindrops (Martins et al., 2010; Santos et al., 2010).

Losses, from the point of view of soil loss, contribute to environmental degradation as they may cause: (a) Reduction of water quality by the presence of sediments and their associations with agrochemicals and nutrients; (b) Siltation of streams and lakes; (c) Flooding; and (d) floods caused by changes in the river regime, which affect the fauna, flora and human activities (Silva et al., 2003; Guerra, 2005).

The impacts generated on water resources by the production and transport of nutrients in the river basins were accelerated in the last 50 years due to the modification of the landscape for the development of agricultural and urban activities (Rivers et al., 2011). One of the reflections of these modifications has been verified through the excess of nutrients in aquatic ecosystems, specifically nitrogen and phosphorus, which are the main responsible for the process of eutrophication of water bodies (Silva et al., 2015).

According to Jesus et al. (2004), to carry out an assessment of the level of contamination in aquatic ecosystems, the study of sediments is extremely important because it can influence the metabolism of the whole system due to its ability to accumulate several compounds as organic and inorganic materials (heavy metals) by the decanting process and adsorption in low hydrodynamic areas. Sediments cause alterations in the environmental conditions and physicochemical systems of water (Lima et al., 2001). Pollution stems from a change in the physical, chemical, radiological, or biological quality of water caused by anthropogenic activities, which may be harmful to the present and future use of the respective Hydric resource (Bilich, 2007).

Libos et al. (2003) assures that agriculture contributes to the contamination of water resources, this stems from the leaching of pesticides present in plantations to the springs. But not only the agricultural, industrial, and urban occupation activities cause changes in water quality. Hernani et al. (1999) portrayed that erosion contributes to the increase of nutrients in the body of water, thus provoking the eutrophication of it. Merten et al. (2002) explains that water contamination can be caused by animal manure. In his research Queiros (2001) depicts that the diffuse source of mining can generate large amounts of feelings that are carried by the superficial runoff to the water resources. Research evaluating the erosive process and the quality of the waters in the semiarid were carried out in the watershed of the weir Oros-CE (Frota & Nappo, 2012); In the Experimental Basin of Iguatu-CE (Moura et al., 2017); Apodi-Mossoró River basin (Bezerra et al., 2018); among others.

3.4 Hydrosedimentology in watersheds

The hydrographic basins are highlighted in this context because their study recognizes the interrelations between the various components of the landscape (geology, geomorphology, climatology, hydrography, pedology, vegetation cover and land occupation) and helps Identify the problems configured, from a perspective of intervention and territorial planning (Sousa & Nascimento, 2015). According to Gomes (2010), the analysis of vegetation cover and its degradation levels, in a hydrographic basin study, assists in the understanding of the dynamics of use and occupation and serves as a tool for the development of public policies for the management of the basin.

For Silva and Santos (2009), the realization of hydrosedimentological studies, has as one of the main problems faced is the obtaining of data that allow describing the spatial variability of the variables of rain, flow, and erosion, due to the difficulties of monitoring and the costs that the collection of this data requires. An alternative used is the implantation of experimental basins to acquire these types of data. Thus, due to the need for long-term hydrological studies in specific environments, as in the case of the semiarid northeast, several experimental basins were installed in northeastern of Brazil. However, these basins were deactivated after a short period of data acquisition due to maintenance costs and drougts, except for the Sumé experimental basin. The knowledge of the dynamics of hydro sedimentological processes in the watershed provides information that bases decision making and subside a management planning of rational use of natural resources (Vestena, 2009).

The sediment causes positive impacts, such as reduction of the erosive action of water in the flow of rivers, acts as a reducer of other pollutants, thereby improving the purification of water, allows transporting microorganisms or organic matter that improve the fluvial fauna, can carry nutrients fertilizing land and serve for landfills, as waterproofing the general construction (Carvalho, 2008). However, high sediment production values are very harmful and may affect the reservoir with undesirable deposits. According to international criteria, the values of Table 1 can be considered as an indication for studies (Carvalho et al., 2000).

Table 1: Acceptable sediment production values according to international criteria.

Tolerance	Sediment Production t km^{-2}. $Year^{-1}$
High	> 175
Moderate	70 to175
Low	< 70

4 CONCLUSIONS

In Brazil, water erosion is of greater interest, largely in the tropical region, because it is more frequent, acts more quickly and causes high losses both in the agricultural sector, as well as several other economic activities besides the environment itself. Regarding the semiarid region, erosive processes become unsettling, since the soil is increasingly vulnerable due to the intensifying anthropic action and the very fragility of the soil material.

Reservoirs and basins analyzed tend to have processes present erosive and silting in less or greater degree, what needs to be monitored is the level of these processes so that they can take the necessary measures, not only after the occurred, but preventive measures to reduce these impacts are caused by anthropic or natural actions.

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