

GEOSCIENCE AND ENVIRONMENTAL EDUCATION IN THE BRAZILIAN SEMIARID REGION: A CASE STUDY IN THE PRIVATE RESERVE OF NATURAL HERITAGE OLHO D'ÁGUA DAS ONÇAS

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ABSTRACT

The Brazilian semiarid region is an environmentally fragile that suffers from deforestation and land degradation. In the sustainable development debate, it's essential integrating sustainability into geoscience education and training. In order to have sustainable development, it is necessary to sensitize people about the functioning of environmental dynamics, considering not only biotic factors, abiotic and biotic factors work together to create an ecosystem. Environmental Education offers objective instruments to elaborate and re-elaborate personal beliefs, values, attitudes and behaviour. We aimed to analyse and discuss how geoscience and environmental education can work together to environmental conservation and preservation in the Brazilian semiarid region. The study was conducted in the Private Reserve of Natural Heritage Olho d'água das Onças (Picuí-PB) in the Northeast of Brazil. Geomorphological, geological and pedological characterizations of the study area were carried out, in order to discuss the processes involved and understand the semiarid dynamics. Our results show two distinct environments with contrasting dynamics: the flat tableland domain with Latossolo Amarelo and edge of tableland with Neossolo Litólico. Environmental educational practices in the semiarid region need to take a holistic approach with interconnected environment (abiotic and biotic). It is essential to understand and discuss the processes, especially in relation to erosion and siltation processes, which generate

different impacts with economic and social consequences. It is noteworthy that Environmental Education must be assumed as an educational process of continuous training, regardless of age and location. Knowing the dynamics of the physical environment of the semiarid is of paramount importance in order to avoid land degradation and restoring degraded lands.

Keywords: Semiarid landscape; Physical environment; Geotourism; Geodiversity; Desertification.

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RESUMO

O semiárido brasileiro é uma região frágil do ponto de vista ambiental e que sofre com o desmatamento e degradação de suas terras. Na busca pela preservação ambiental, as Geociências tem muito a contribuir. Para que se tenha um desenvolvimento sustentável é necessário sensibilizar as pessoas sobre o funcionamento da dinâmica ambiental, considerando não somente os fatores bióticos, mas também os abióticos. A Educação Ambiental oferece instrumentos objetivos para elaborar e reelaborar valores, condutas e atitudes. A presente proposta teve como objetivo a busca por promover a popularização do conhecimento Geocientífico e discutir sobre sua importância para preservação ambiental no semiárido, a partir da prática da Educação Ambiental considerando as especificidades, potencialidades e fragilidades do semiárido, tendo como área de estudo a Reserva Ecológica Olho d'água das Onças, no município de Picuí-PB. Nessa perspectiva, realizou-se caracterizações geomorfológicas e das coberturas superficiais da área de estudo, com o intuito de discutir sobre os processos envolvidos e como esses afetam o ambiente em questão. As áreas com relevos com topos planos e solos estruturados e profundos, possuem dinâmicas muito distintas em relação a áreas com relevo mais íngreme. Ao tratar de práticas educativas ambientais no semiárido, é preciso que se faça uma abordagem holística. Nessa conjuntura é essencial entender e discutir os processos, principalmente em relação aos processos erosivos e assoreamentos, os quais geram impactos diversos com consequências econômicas e sociais. Ressalta-se que a Educação Ambiental deve ser assumida como um processo educativo de formação contínua, sem distinção de idade e local. Conhecer a dinâmica do meio físico do semiárido é de suma importância para que se possa evitar sua degradação e/ou propor medidas de recuperação.

Palavras-chave: Sustentabilidade; Meio físico; Geoturismo; Geodiversidade; Desertificação.

INTRODUCTION

Environmental conservation is one of the essential components for sustainability in its dimensions (PRIMACK and RODRIGUES, 2001; OLIVEIRA, 2004). In this context, not only biodiversity, but also geodiversity must be considered. Thus, it is essential that society has knowledge about the environment as a whole in order to create awareness in order to seek its preservation. Education emerges as a means by which values are a process through the construction of social values, skills, attitudes and changes that occur for environmental conservation, at that moment, changes for environmental conservation, thus, of environmental changes (BRASIL, 1999; 2005).

The global environmental issue gained notoriety, mainly from the 1960s onwards, when popular movements raised their banners with concerns about the way society relates to nature (BRASIL, 2016). In this context, environmental issues were worsening with the

explosion of consumption, deepening social inequalities, rapid population growth, extinction of non-renewable natural resources, among others (BRASIL, 2016).

When referring to the Brazilian semiarid region, environmental degradation is not different. The semiarid region is an environmentally fragile that suffers from the degradation of its lands, often associated with deforestation, caused by agricultural practices, agricultural production, industrial production, population growth, among others (SILVA et al., 2018). Deforestation and fires cause a series of negative consequences, such as loss of biodiversity, soil degradation, erosion processes, silting, reduction of water for aquifer recharge, etc. (SILVA et al., 2018).

In the search for environmental preservation, there is a need for greater appreciation of Earth Sciences and understanding of its dynamics and processes involved, in order to have sustainable development. This practice can promote people's awareness of Geosciences, within the scope of a concept that considers the principle of sustainability. Environmental Education can effectively contribute to this process, since it offers objective instruments to elaborate and re-elaborate values, behaviors and attitudes. Environmental Education, with its set of experiences and observations, helps everyone realize their relationship with the environment and their responsibility towards it (SATO, 2003).

There are multiple ways, times and spaces to promote environmental education. In Conservation Units, this approach is highly applicable, where not only the biotic environment must be considered, but also the information related to the physical environment. Landforms are important stratifier of environments and can be very useful in territorial planning and management, considering land use potential and limitations.

Despite advances in recent years, there are still few studies dealing with Environmental Education in the Brazilian semiarid region, even considering that it refers to an area that covers about 20% of the national territory, which preserves the only exclusively Brazilian biome. being one of the most populous semiarid regions in the world (BARBOSA and SANTOS, 2015). It is noteworthy that scientific production is a strong mechanism for disseminating experiences, being an important guiding instrument for practice and educational actions, which can help and contribute to public policies (BARBOSA and SANTOS, 2015).

Geological, pedological and geomorphological knowledge has much to contribute to promoting and encouraging geoconservation and geotourism practices. We aimed to analyse and discuss how geoscience and environmental education can work together to environmental conservation and preservation in the Brazilian semiarid region.

MATERIALS AND METHODS

Study area

The study was conducted in the Private Reserve of Natural Heritage Olho d'água das Onças, located in the municipality of Picuí, Paraíba, in NE Brazil (FIGURE 1). The climate of the region is semiarid, type "As" (KOPPEN, 1931). The creation of the Protection Area was 2005, with focus to maintain caatinga biodiversity, environmental

education and to increase people's quality of life. The study area covers about of 20.73 hectares.

The region is geologically located in Borborema Province (SANTOS; FERREIRA; SILVA JR., 2002), where the lithotype in the study area are Serra do Martins Formation, which also occurs in several other locations in the states of Paraíba and Rio Grande do Norte (SANTOS; FERREIRA; SILVA JR., 2002). These geological formations are associated with tablelands (ranging from 700 to 800 m.a.s.l.), correlated with several others tablelands such as Portalegre, Martins, João do Vale and Santana (ANGELIM et al., 2006).

The Serra do Martins geological formation is associated with residual forms of an ancient continuous capping, dissected and eroded, associated with the South American pediplanation with fluvial depositional environment, with a thickness ranging from 30 m to 70 m (SANTOS; FERREIRA; SILVA JR., 2002). At the base of the formation, there are whitish, poorly selected, locally conglomeratic, kaolinic, homogeneous and friable sandstones, with silicified layers (SANTOS; FERREIRA; SILVA JR., 2002). Its middle portion is represented by banks of homogeneous clayey sandstones, yellow to red, with subangular to rounded quartz grains (SANTOS; FERREIRA; SILVA JR., 2002). The top of the sequence is formed by red to purple lateritic crust (Fe-rich cemented crust), angular and poorly sorted quartz pebbles (SANTOS; FERREIRA; SILVA JR., 2002).

Cartographic content analysis

We used the literature and cartographic review of the study area. In order to characterize the Conservation Unit, cartographic products were prepared using GIS (Geographic Information System). The morphologic aspects maps were produced through field work and photointerpretation, was generated using the ALOS-PALSAR satellite image (Advanced Land Observing Satellite Phased Array L-band Synthetic Aperture Radar), with the Phased Arrayed type L-Band SAR (PALSAR) microwave sensor with a spatial resolution of 12.5 m. Field work consisted in identifying the main landforms and morphogenetic processes on Private Reserve of Natural Heritage Olho d'água das Onças.

Digital Elevation Model (DEM) was generated by ALOS-PALSAR satellite image using remote sensing techniques. The DEM provided good terrain representation of the study area. All processing was done using QGIS software.

The elevation map was generated from the DEM. The slope map was classified accordingly with the proposed by Embrapa (2018), considering six (6) categories: i) Flat 0 – 3 %; ii) Gently Undulated 3 – 8 %; Undulated 8 – 20 %; Highly Undulated 20 – 45 %; Mountainous 45 – 75%; Cliff > 75 % (FIGURE 1).

Field observations, description, sampling and analyses

Fieldwork was carried out during the December of 2021 and January of 2022. During the detailed field sampling at the Private Reserve of Natural Heritage Olho d'água das Onças, we identified and mapped landforms and their physiographic aspects and georeferenced using portable GPS.

We collected seven soils to represent the different landforms. However, the present study evaluate morphological and physical properties of two selected soils were also analyzed along two different types of landforms (Latosolo Amarelo in flat tableland area and Neossolo Litólico at the edge of tableland) (FIGURE 1).

Soil morphological descriptions and sampling followed the recommendations at Embrapa (1997). Soils were classified according to the Embrapa (2018). Deformed samples from all soil horizons were sampled according to Santos et al. (2013). The deformed samples were air-dried and sieved to obtain “air-dried fine earth” (< 2.0 mm) and were used in physical analyses. Soil color was determined using the book of color chips that follow the Munsell System of Color Notation (MÜNSELL, 1994).

RESULTS

Characterization of the physical environment

The slope map (FIGURE 1) provides important information capable of guiding the proper land use and occupation, enabling the identification of susceptible areas to erosive processes and mass movements (IBGE, 2009). Information about the slope is relevant to indicate critical and restrictive factors for certain land uses (IBGE, 2009).

The use of slope information is an essential factor to regulate land use and occupation of urban and rural areas, environmental legislation uses this criterion as an identifier of environmental weaknesses regarding the slope's dynamics, especially, in susceptible areas for occurrence of mass movements, associated with steep slopes and the presence of material with lower resistance to erosive agents (IBGE, 2009). For conservation planning purposes, a survey of the slope degrees of the terrain in zones can be used, according to the relief phases adopted by EMBRAPA (2018).

The Private Reserve of Natural Heritage Olho d'água das Onças has its territory predominantly located in a tableland area with a flat top and another part located on the edge of the tableland, with a steeper relief. The two compartments have very different characteristics (lithologies, soils and processes), consequently there are different potentialities in relation to land use and occupation.

The flat-topped area has extremely deep, structured, porous and well-developed soils, conditions that provide greater water infiltration and percolation. The main soils found in this compartment are the Latossolos Amarelos (EMBRAPA, 2018) (FIGURE 1).

In the tableland edge, is characterized by mountainous relief (EMBRAPA, 2018), with shallower, less developed and less structured soils. The steeper relief favors surface runoff and, consequently, this compartment is more susceptible to erosive processes. In this area were identified Neossolos, Cambissolos and rocky outcrops (FIGURE 1). These environments have a series of land use limitations, being areas that must be destined for preservation.

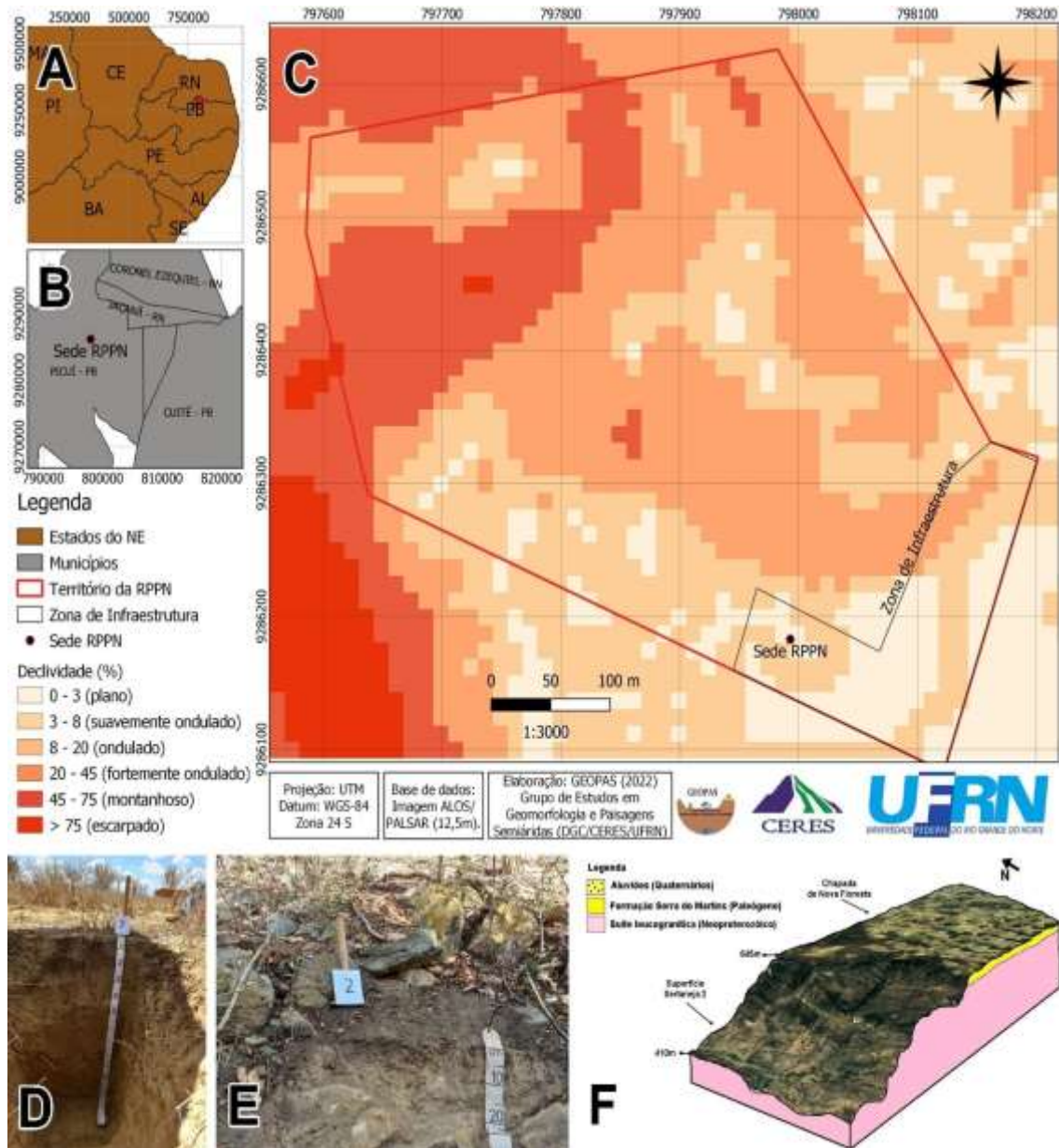


Figure 1: A – Location of the Private Reserve of Natural Heritage Olho d'água das Onças. B – Location of the RPPN in the municipality of Picuí-PB. C – Slope Map of the RPPN. D – Latossolo Amarelo of the tableland area. E – Neossolo Litólico of the tableland edge. F – Schematic block diagrams showing interpreted the study area with tableland and their dissected edges, on the Serra do Martins Formation.

Environmental characterization

The environmental characterization of the semiarid region and understanding of its dynamics is essential to understand land use limitations and potentials. In this context, it is valid to understand that the semiarid region has its intrinsic characteristics and that each geomorphological compartment has its own dynamics (FIGURE 2).

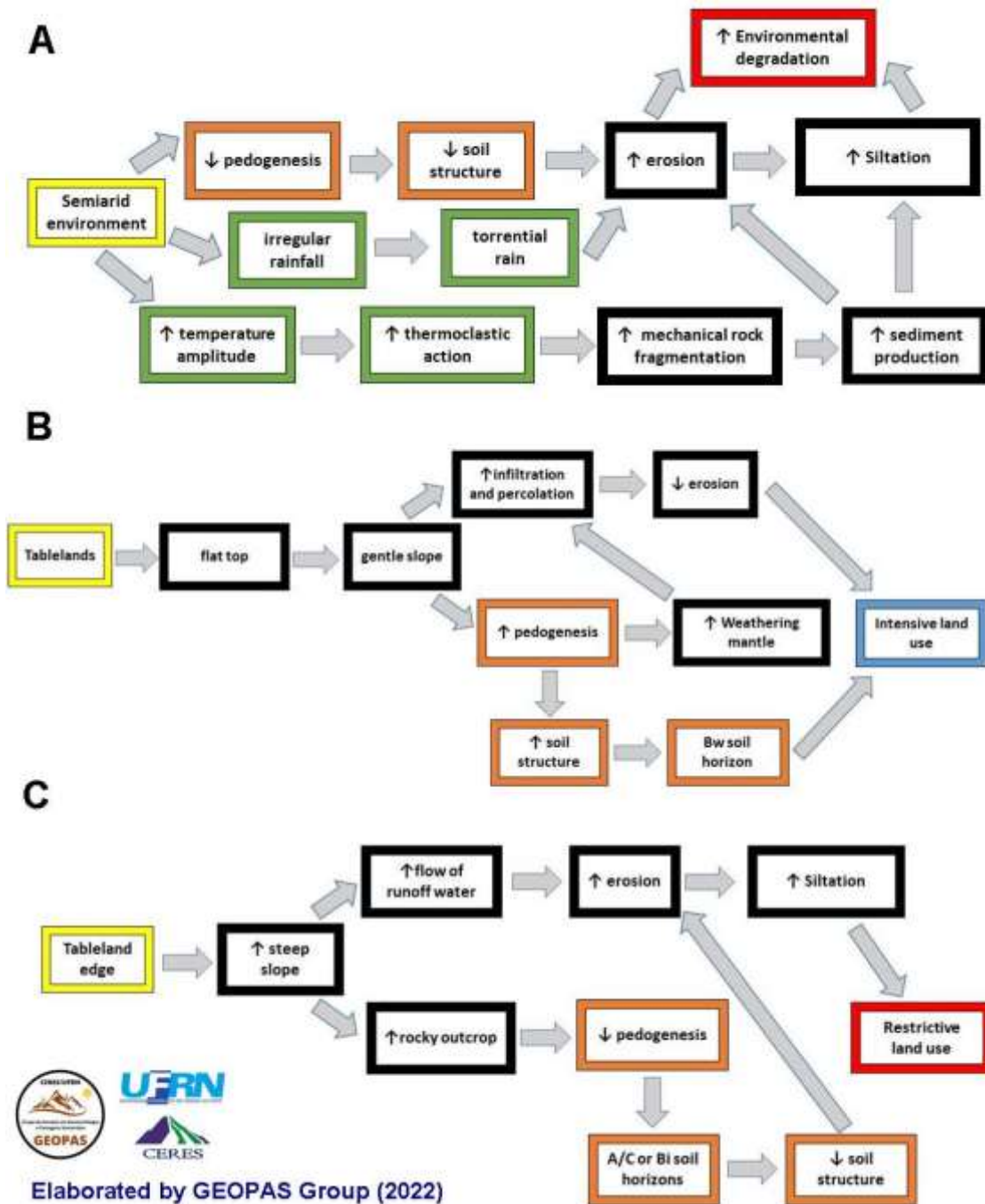


Figure 2: Didactic schemes representing the processes involved in semiarid environments. A – Representation of the processes intrinsic to the semiarid environment, which naturally tend to favor intense erosive processes and environmental degradation. B – Representation of environmental dynamics in tableland areas with flat tops and developed soils, where conditions are more favorable to intensive use. C – Representation of the environmental dynamics in areas on the tableland edges, where there is greater environmental fragility and, consequently, restrictive land use.

The semiarid environment is characterized by the low performance of chemical weathering processes, due to water deficits, consequently there is a low performance of pedogenesis and the occurrence of shallower soils and commonly associated with rocky outcrops ("lajedos") (FIGURE 2). This scenario, combined with irregular rainfall and torrential rains favor a greater performance of morphogenesis to the detriment of pedogenesis that cause intense erosive processes and silting (land degradation) (FIGURE 2). The high temperature amplitude also favors a greater performance of physical weathering (mechanical degradation) and consequently there is a high production of coarse sediments, forming the so-called stony pavements. The genesis of these pavements is also allied to the washing of fine particles (silt and clay).

In the flat tops, associated with sedimentary rocks, the flat/gently undulated slopes favor a greater performance of pedogenesis, forming well-structured and deep soils, with the presence of Bw soil horizons that provide more resistance to the erosive process, contextually appropriate areas that support intensive land uses (PEREIRA et al., 2019) (FIGURE 2). The flat top relief, together with the structured and wide pore spacing at the soil surface increases the rate of water infiltration and percolation (TUCCI, 2009), consequently, there are excellent conditions to ground water recharge, conditions even more potentiated with the existence of sedimentary rock packages in the area, associated with the Serra do Martins Formation. As the infiltration is more intense, there are reduced rates of runoff and soil erosion (FIGURE 2).

In the tableland edge, very different characteristics and processes were identified, compared to the flat top areas (FIGURE 2). On the edges, the steeper relief, being characterized as mountainous (FIGURE 1), favors the morphogenesis/pedogenesis balance towards the former, with rocky outcrops and less developed, less structured and shallower soils. The Neossolo and/or Cambissolo identified are more susceptible to erosion processes (PEREIRA et al., 2019). The mountainous relief still favors more intense surface runoff, catalyzing erosion processes in poorly developed soils. The transported sediments cause other impacts, such as the silting. In this scenario, we suggest to this area more restrictive land use, and should be aimed mainly at environmental preservation, including care even with the trails that cut this geomorphological compartment.

DISCUSSION

Environmental education in the Brazilian semiarid region

The Brazilian semiarid region occupies approximately 969,589 km², encompassing the states of Rio Grande do Norte, Ceará, Piauí, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia and the northern part of Minas Gerais. The characteristic vegetation is Caatinga dry forest, with a Köppen semiarid climate (Bsw type) with a short summer rainy season (AB'SABER, 2003).

Additionally, for the long dry season, when the trees shed their leaves, the soils tend to be even more exposed, with this naturally advancing erosion processes (AB'SABER, 2003). These conditions, combined with torrential rains and poorly developed soils, further catalyze the soil erosion processes and consequent land degradation. This landscape

changes suddenly with the short periods of torrential rain, which are enough for the regrowth of the caatinga (AB´SABER, 2003), however, the recovery of degraded lands is not as fast as the regrowth of the caatinga.

The Brazilian semiarid is a region with rich geodiversity, however, the environmental characteristics impose a series of land use limitations. Under these conditions, it is urgent to adopt conservation practices, which can be subsidized with Environmental Education as a point of awareness and effectiveness of man's relationships with his environment (DIAS, 2004; SILVA, 2012). The importance of environmental education to stimulate the formation of sustainable practices and help the construction of an environmental conscience in our society is increasingly assuming an uncontested position among all those who believe in the need to reverse the current rates of environmental degradation (SILVA, 2012), this urgency is even more necessary in the semiarid region.

Environmental Education must be contextualized in different sectors of society, whether in schools, at work, in Conservation Units, or on the streets, thus enabling the understanding of the nature and processes involved in different social agents, which tend to form and spread environmental awareness. In this scenario, Environmental Education provides an opportunity to improve the quality of life and add a new concept in relation to natural resources and their use (DIAS, 2004; BAPTISTA and CAMPOS, 2013).

Furthermore, when dealing with Environmental Education, its entire sphere of influence must be taken into account, interacting between the physical and biotic environments. In this context, Environmental Education can even boost a source of income for certain populations, especially through geoconservation or geotourism, activities that have been gaining notoriety with different audiences.

Environmental education practice

In order to establish the man-nature relationship in the study area, it is suggested the creation of educational points (“Educational Geosites”) on the trails of the Private Reserve of Natural Heritage Olho d’água das Onças. In this way, the characteristics and functioning of the environmental dynamics of the semiarid region can be demonstrated in practice to the visitors of the Conservation Area, considering land use potentials and limitations of each sector. These educational experiences in direct contact with nature tend to enhance the teaching/learning process, promoting greater changes in the environmental perception of the subjects involved (MENDONÇA, 2007; VALENTI et al., 2012). These environmental education actions are intended to promote changes in individuals' attitudes towards protected spaces, contributing to the construction of new knowledge and values necessary for conservation (BRASIL, 2016).

In the study area, two geomorphological compartments are very didactic for understanding environmental dynamics in the semiarid region. In the flat top area, one can discuss water flows, in this case, with predominance of water movement into and through the soil profile, due to the smooth/wavy relief and the porous, structured and deep soils. Hence, it can be demonstrated that the environmental dynamics is linked to the balance between morphogenesis and pedogenesis, in the specific case favoring a greater performance of pedogenesis. In the aforementioned compartment, a soil profile

can be opened and demonstrated how the performance of pedogenesis is much more intense, with extremely deep soil.

Another educational geosite can be made in the tableland edge, where one can discuss and show that surface runoff increase with slope gradient and more runoff was produced on convex and straight slopes. Some procedures can also be adopted on the trails themselves, in order to reduce the erosive impact, such as the construction of small hydrological/sedimentological containment dams and measures to dissipate water energy, such as barriers made with the materials from the local rock outcrops.

This information about the physical environment must be associated with the biotic environment and interventionist practices must undergo constant evaluations so that adaptations are made that enhance the teaching/learning process (VALENTI et al., 2012). This way, it is possible to build educational practices that generate environmental awareness that allow subjects to acquire new knowledge, values, skills, experiences and new visions, which tend to support the practice of conservation actions (DIAS, 2004).

CONCLUSIONS

Environmental educational practices in the semiarid region need to take a holistic approach, considering not only the biotic aspects, but also considering all spheres of the physical environment and the processes involved.

When considering the approach to the physical environment in Environmental Education in the semiarid region, it is essential to understand and discuss the processes, especially in relation to erosion and siltation processes, which generate different impacts with economic and social consequences. Each geomorphological compartment has its specific dynamics, understanding these differences can support the awakening of environmental awareness and the adoption of conservation practices.

Environmental degradation in the semiarid region is directly linked to the lack of understanding of the weaknesses and potential of each area, this environmental awareness is essential for sustainability.

The creation of educational geosites can be excellent strategies to demonstrate the functioning of the environmental dynamics of the semiarid region using real information in the field. Hence, the teaching/learning process tends to be enhanced.

Environmental Education must be assumed as an educational process of continuous training, regardless of age and location, and can be implemented in homes, schools, workplaces and Conservation Units, always in favor of contributing to the that all subjects involved perceive their relationship with the environment and their responsibilities.

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