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QUALITATIVE ASSESSMENT OF THE GEOMORPHOLOGICAL HERITAGE OF GALINHOS SPIT, IN THE NORTHERN COASTAL ZONE OF RIO GRANDE DO NORTE

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Abstract

In the 90's, at the height of discussions about the exploitation of natural resources and the search for sustainable development, the term "geodiversity" appears. At first, the therm was used in geological and geomorphological studies to describe physical characteristics of the planet. Since then, researches has been developed with the aim of presenting abiotic elements with scientific, educational, tourist, cultural and economic importance to societies, among others. In this perspective, the coastline stands out, composed of elements of unquestionable scenic beauty, which promotes the development of activities focused on the appreciation of geomorphological elements such as dunes, beaches and cliffs, for example. Thus, this work aimed to evaluate the geomorphological heritage of the *spit* in Galinhos, RN, performed by abiotic elements with characteristics inherent to the theme presented. Therefore, the metodology used was the bibliographic research and photo analysis of the area for the selection of the elements and inventory, carried out through the application of the geodiversity characterization files. Thereby, it was concluded that the Galinhos *spit* is composed of representative elements of local geodiversity such as beaches, dunes, reefs and eolianites that are fundamental for the economic development of the county due mainly to the touristic activity.

Keywords: Inventory; Geomorphosites; Galinhos-RN

Resumo

Na década de 1990, no auge das discussões a respeito da exploração dos recursos naturais e da busca pelo desenvolvimento sustentável, surge o termo geodiversidade. Inicialmente o mesmo foi utilizado nos estudos geológicos e geomorfológicos para descrever características físicas do planeta. Desde então, pesquisas desenvolveram-se com o objetivo de apresentar às sociedades elementos abióticos com importância científica, educativa, turística, cultural, econômica, entre outras. Nessa perspectiva destaca-se o litoral, composto por elementos de beleza cênica indiscutível, que promove o desenvolvimento de atividades focadas na apreciação de elementos geomorfológicos como dunas, praias, falésias, por exemplo. Assim, esse trabalho teve como objetivo avaliar o Patrimônio Geomorfológico do *spit* de Galinhos-RN, representada por elementos abióticos com características inerentes à temática apresentada. Para tanto, a metodologia utilizada foi a pesquisa bibliográfica e análise de fotografias da área para a seleção dos elementos e a inventariação, realizada por meio da aplicação da ficha de caracterização da geodiversidade. Com isso, concluiu-se que o *spit* de Galinhos é composto de elementos representativos da geodiversidade local como praias, dunas e recifes que se configuram como fundamentais para o desenvolvimento econômico do município em função, principalmente, da atividade turística.

Palavras-chave: Inventariação; Geomorfossítios; Galinhos-RN

EVALUACIÓN CUALITATIVA DEL PATRIMONIO GEOMORFOLÓGICO DEL SPIT DE GALINHOS, FRACCIÓN NORTE DE LA ZONA COSTERA DE RIO GRANDE DO NORTE

Resumen

En la década de 1990, durante el auge de las discusiones al respecto de la exploración de los recursos ºnaturales y de la búsqueda por el desarrollo sustentable, surgió el término geodiversidad. Al comienzo fue utilizado en los estudios geológicos y geomorfológicos para describir características

físicas del planeta. Desde entonces se desarrollaron investigaciones con el objetivo de presentar a las sociedades, elementos abióticos con relevancia científica, educativa, turística, cultural, económica, entre otras. Dentro de esa perspectiva se destaca el litoral, compuesto por elementos de belleza indiscutibles, que promueven el desarrollo de las actividades enfocadas en la apreciación de los elementos geomofológicos como dunas, playas y peñascos, por ejemplo. De esta forma, este trabajo tuvo como objetivo, evaluar el patrimonio geomorfológico del Spit de Galinhos en Rio Grande do Norte, representado por elementos abióticos con características intrínsecas a la temática representada. Por tanto, la metodología utilizada fue la investigación bibliográfica y el análisis de fotografias del área, para la selección de los elementos y su inventario realizados por medio de la aplicación de fichas de caracterización de la geodiversidad. Con esto se determinó que el Spit de Galinhos está compuesto de elementos representativos de la geodiversidad local como; playas, dunas y arrecifes, que se configuran como fundamentales para el desarrollo económico del municipio en función, principalmente de la actividad turística.

Palabras-clave: Inventario; Geomorfositos; Galinhos-RN.

1. INTRODUCTION

In the early 1990s, the term geodiversity was coined to express the growing concern with environmental protection, given the continuous exploitation of the planet's natural resources and the rising awareness about the importance of the abiotic nature.

Initially, when it became evident the need for a term that also included the non-biological components of the natural environment, the newly coined geodiversity term was used as a conceptual tool applied to manage protected areas as opposed to the biodiversity term (SERRANO and RUIZ- FLAÑO, 2007, p. 81). Therefore, it was adopted as the technical terminology in geological and geomorphological studies to describe such characteristics of the planet.

Conceptually, besides the variety of geological environments, phenomena and active processes, Stanley (2000) stated that geodiversity is the link between people, landscapes and their culture, through the interaction of biodiversity with the physical elements (minerals, rocks, fossils, soils), active processes and the built environment.

To evaluate the geomorphological heritage Panizza (2001) suggested using the geomorphosite term that was correlated with all shapes with an attributed set of values (e.g., scientific, aesthetic, cultural, ecological and economic) arising from human perception (VIEIRA, 2014, p.38). Thus, in this study, geomorphosites refer to the abiotic elements of geomorphological character inventoried and evaluated.

This emerging theme allowed, therefore, to include several sciences and among them Geography, given its attributions, and the possibility of developing research based on the understanding of the relationship of human beings with the planet abiotic resources and, more specifically, with landscapes and landforms, which are, par excellence, geomorphological heritage features (Claudino-Sales 2018).

In this context, the intense exploitation of natural resources along the Brazilian coast (prominent geomorphological environment) together with its marked fragility, has been the focus of study in several areas, justifying the importance of research-based on evaluating local geodiversity.

This study analyzes the Geomorphological Heritage of the Galinhos-RN spit, highlighting important aspects of the landforms determined in the inventory process, considered the initial step for future geoconservation strategies.

Due to changes caused by anthropic actions and natural degradation (NASCIMENTO et al., 2015), geoconservation may be necessary to maintain the geological, geomorphological and soil aspects, and processes, as well as their natural evolution (SHARPLES, 2002).

1.1. Study site

The Galinhos municipality is located on the northern coast of Rio Grande do Norte, approximately 174 km from Natal, the state capital. This study focuses on landforms spatially distributed on a sandy spit approximately 10 km long and 550 m wide. This E-W spit borders the Atlantic Ocean to the North, the Catanduba tidal channels to the South, the continent to the east, and the mouth of the Rio Camurupim, Pisa Sal, Tomás and Galinhos to the West (LIMA, 2004) (Figure 01A, B).

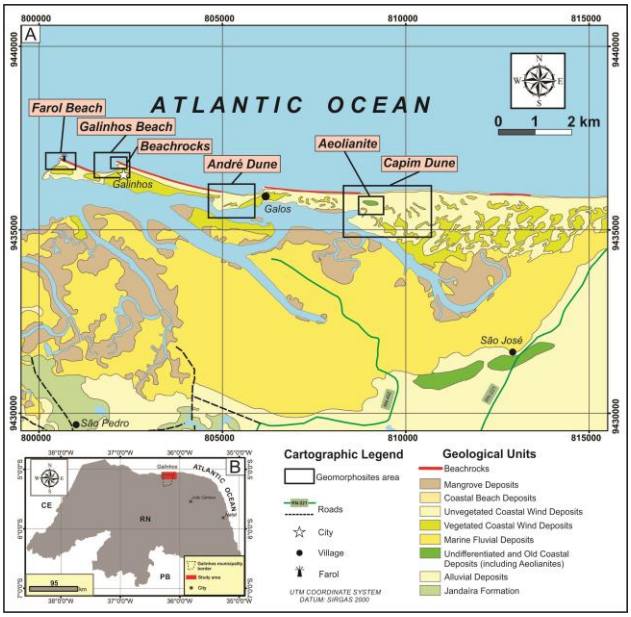

Figure 01- (A) Geological map of the northern Galinhos spit highlighting the areas of occurrence of the abiotic components studied in this research; (B) Location of the study area. Source: compiled and adapted from Vital et al. (2011).

2. METHODOLOGY

Initially, the research was based on a literature review, a continuous process throughout all research phases. Additionally, photographs and touristic map of the area were analyzed to choose the relief features to be investigated based on their

relevance to the area within the context of the coastal dynamics and previous research conducted by Lima (2004).

The inventory stage applied during fieldwork was adapted from the work of Lopes (2017) (Table 01). To characterize each selected landform, the inventory was conducted during three different periods, February, May, and October 2019.

Table 01- Characterization sheet used. Source: Adapted from Lopes (2017).

Field Sheet			
Author:	Date:		
Identification of geomorphosite:	Geographical location:		
Type of access:			
Accessibility: Easy ( ) Moderate ( ) Difficult ( )			
Scale (Visualization): Point ( ) Strip ( ) Area ( )			
Observation condition: Good ( ) Satisfactory ( ) Bad ( )			
Main classification: Geoform ( ) Process ( ) Type:			
*Natural Vulnerability: (Mb-1; B-2; M- 3; A-4; Ma-5) Very low ( ) Low ( ) Average ( ) High ( ) Very high ( )			
*Anthropic Vulnerability: (Mb-1; B-2; M- 3; A-4; Ma-5) Very low ( ) Low ( ) Average ( ) High ( ) Very high ( )			
State of conservation (B; Ra; Ru): Good ( ) Reasonable ( ) Bad ( )			
Legally protected area: Yes ( ) No ( )			
*Local added value: (Very low -1; Low - 2; Average - 3; high - 4; Very high – 5)			
Ecological	B ( )	M ( )	A ( )
Cultural:	B ( )	M ( )	A ( )
Esthetic:	B ( )	M ( )	A ( )
Touristic:	B ( )	M ( )	A ( )
Paleontological:	B ( )	M ( )	A ( )

*Each geomorphosite was scored between 1 and 5 to indicate, respectively, very low, low, average, high, and very high vulnerability and added value.

In the above characterization sheet, the studied geomorphosite is identified by the landform or the usual local name, type of access, means of transport used, as well as whether accessibility is easy, moderate, or difficult.

The used visualization scale was adapted from the criteria used by Fuertes-Gutiérrez and Fernández-Martínez (2010), in which point indicates small dimensions (generally about 1 ha and considered, therefore, more fragile and vulnerable). However, in this research, the point criterion was referenced to the smallest surface identified, the Galinhos aeolianite, so all other elements with areas less than or equal to 40 m² were considered "points". The strip refers to elements arranged linearly and area, to dimensions > 40 m².

Following, geoform refers to all observed relief shapes that characterize coastal environments such as dunes, beaches, rocks, cliffs, estuaries, among others, while processes were defined as coastal geomorphological dynamics that resulted from erosion, transport, and sediment deposition.

The term vulnerability was defined by Veyret (2007) as the extent of a likely impact of an event and the probability of it occurring and affecting physical structures, environmental systems, environment, as well as human beings. This definition includes both natural and man-made aspects when analyzing the vulnerability degree. Thus, for a qualitative assessment of the vulnerability of the studied landforms to the possible occurrence of natural and anthropic disturbances, this work highlights the results reported by Rocha (2019), which intersected Geology, Geomorphology, soils, vegetation cover as well as land use and occupation, to classify the vulnerability of Galinhos areas as very low, low, medium, high and very high. Similarly, in this research, we followed the same classification range and scored the vulnerability of the area features between 0 and 1.

The analysis of the anthropic interferences on the Galinhos spit geodiversity, specifically, required adapting a few parameters concerning Land use and occupation since the spatial cutoff defined for this research refers only to the extended beach sandy stretch, the spit. Thus, the parameters were the water bodies (small lagoons on the dunes), mobile and fixed dunes, wind farm, urban area (mainly the infrastructure installed in the beach compartments) besides the development of the tourist activity (buggy/off-road cars driving over the dunes, carriage rides, and other activities related to local tourism).

Thus, the final analysis consisted of interpreting the natural vulnerability map prepared by Rocha (2019), considered satisfactory for achieving the objective proposed here. To identify the current conservation state of the area features, possible changes in their structures and shapes were considered, through on-site observation. The value-added score was attributed to the local area by evaluating and quantifying the link of each feature with ecological, cultural, touristic, aesthetic and paleontological aspects, to add even more value to local geodiversity.

3. RESULTS AND DISCUSSION

The coastal landscape in Galinhos is represented by fields of dunes, beaches, beachrockss, mangroves, estuaries, lakes, and lagoons. The mobile dunes have areas with the occurrence of plant subfossils, whose distribution and modeling result from the joint action of waves, sea currents and winds related to sea-level variations, during the Quaternary (LIMA, 2004).

The Galinhos area is geologically inserted in the Potiguar Basin, extreme Northeast of Brazil, and geomorphologically part of the Quaternary sedimentary sequences, represented by the Holocene deposits of beach, wind and fluvial/lagoon environments responsible for the current morphology of the Galinhos spit (LIMA, 2004). The Coastal tablelands, the Barreiras Formation sandy rocks, and the alluvial deposits along drains and river channels are the predominant geomorphological features in the area (SILVA, et al., 2005).

The climatic panorama of Rio Grande do Norte presented by Diniz and Pereira (2015) demonstrates that the Galinhos region is inserted in a semi-arid climate polygon with between seven and

eight months of drought and predominance of dune, mangrove and caatinga vegetation environments (ECOPLAM, 1990). Hydrographically, the area has lagoons while the Camurupim and Catanduba rivers flow into the Atlantic Ocean forming the Galinhos-Guamaré estuary system, where tidal channels occur (CHAVES *et al.*, 2017).

3.1. Qualitative analysis of the Galinhos spit geodiversity

3.1.1. Dunes

Sand dunes stand out in several areas of the Brazilian coast. Mobile dune fields develop from the constant accumulation of sediments that originate from the beach and are deposited on the continent by the constant and strong winds that predominate in coastal areas. Holocene deposits represented by semi-consolidated beach sandstones (eolianites) are also found associated with the dunes (LIMA, 2004).

The dunes are part of the relief and, therefore, classified according to their morphology (transverse, barchan, parabolic, star, longitudinal and barchanoid, in addition to the so-called fossil dunes and sand seas) as well as their internal structure concerning how the sand grains are placed in the dune interior (SÍGOLO, 2009).

The Galinhos spit exhibits predominantly mobile dunes of the barchan type in the most eastern part and fixed dunes in the central and western parts (LIMA, 2004), representing a total of 14.07 km^2, equivalent to 4.15% of the 338,788,846 km^2 of the municipality total area. These deposits consist of well-selected medium to very fine, unconsolidated sand, devoid of vegetation cover, and subject to dissipation by winds (SILVA *et al.*, 2005).

André Dune geomorphosite

The André dune (Figure 02), known as Morro do André by the local community, is located west of the Galos village and one of the postcards of the Galinhos municipality. In geomorphological terms it is a longitudinal dunes.

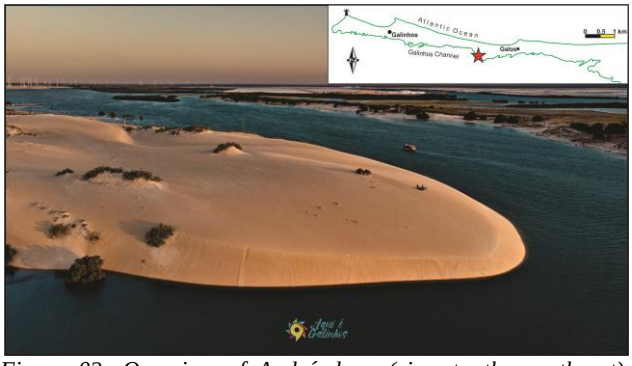

Figure 02- Overview of André dune (view to the southeast) showing the surrounding tidal channel. Geomorphosite (red star) location shown in the photo upper right corner. Source: Galinhos municipality photo collection.

The dune is named after a former resident named André who lived for many years in the dune vicinity. The site can be visited starting from Galinhos or Galos' town, accessible by either buggy or any other 4x4 vehicle, therefore, classified as moderate accessibility.

The geoform visualization classified as area type allows observing the dune and its surroundings with minimum locomotion. The landscape glimpsed from this viewpoint shows the contact of natural elements such as the tidal channel waters with vegetation and other dunes.

The natural and anthropic vulnerabilities of this geomorphosite were classified as high level since the local natural dynamics are constant and ongoing tourist activity, however, the current conservation state was considered good since no significant changes were identified regarding its shape or threats that may decharacterize the area.

In general, according to Law No. 6,950 of August 20, 1996, providing for the State Coastal Management Plan, dunes are under legal protection and included in the preservation areas and fragile ecosystems forming the Reserve of the Atlantic Forest Biosphere (RIO GRANDE DO NORTE, 1996).

Given the above, the scenic beauty of this place has guaranteed the highly touristic added value since it is on the itinerary of tourists from different parts of the country and the world.

Capim Dunes geomorphosite

Capim Dunes is a dune complex (Figure 03) named after the low vegetation that occurs in the lower areas of the dune field, the high humidity where the water table emerges allows this vegetation to develop. The area natural beauty has important characteristics that promoted the development of certain anthropic activities, among them tourism, since the path is traveled by the tourists visiting Galinhos.

Figure 03- Capim Dunes showing the disembarkation place during boat trips. Geomorphosite (red star) location shown in the photo upper right corner. Source: authors' field research (2019).

These mobile dunes cover most of the spit eastern portion and can be accessed by boat and/or four-wheel drive vehicles or buggy leaving from either Galinhos city or Galos' district. The visitor can access the place by boat leaving directly from the pier located in the public parking, named Prata Gil, on the edges of the

Pisa Sal tide channel. Accessibility was also classified as moderate with good observation conditions while the offered access routes are also attractive, as tourists end up enjoying a beautiful landscape on the way to their destination.

This landform has great geomorphological representativeness in the area where the barchan dunes predominate. The area's high natural and anthropic vulnerabilities are related to local intrinsic natural dynamics and tourism use, as well as land occupation due to the installed wind farm (as seen in the photo). This landscape has a high tourist value since it has become one of the main visitation points during a buggy ride. Additionally, the paleontological potential also stands out, given the presence of areas with occurrences of plant subfossils (Figures 04A, B).

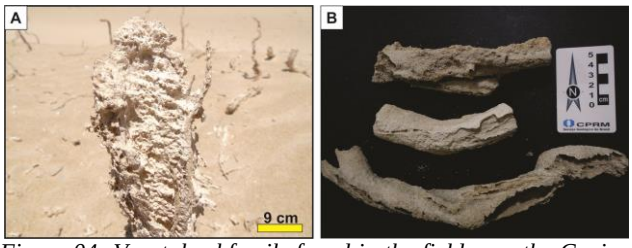

Figure 04- Vegetal subfossils found in the field over the Capim Dunes, known as rhizoconcretions (A) preserving a vertical feature, a position dating back to its formation time; (B) details showing the vegetable tissue replaced by quartz and carbonate cement. Source: authors' field research (2019).

Before presenting the Eolianite de Galinhos geomorphosite, it's utmost importance to bring some considerations about eolianites, mainly in conceptual terms and areas of occurrence, since it's a type of dune with some unique characteristics, when compared to the dunes commonly arranged in coastal areas. In this context, Sayles (1931, p. 390), in a work developed in the Bermuda Islands, claims to be "all consolidated sedimentary rock that was deposited by the wind".

On the other hand, Pye (1983) considered aeolianites as sandy dunes formed at the expense of the cementation process by calcium carbonate, occurring in arid and semi-arid areas in several regions of the planet, especially in coastal areas with a large accumulation of sediments. Lima defined them (2004) as semi-consolidated beach sandstones that are part of the wind quaternary sedimentary sequences.

Studies conducted in other parts of the world claim that aeolianites are predominantly of Pleistocene age. A study on the coastal plain of Coorong, in Australia, reveals that "the main phases of the carbonate accumulation occurred during the interglacial and some interstitial drops of the sea level throughout the Quaternary" (BROOKE, 2001, p. 135).

The Ceará state law on the State Policy for Coastal Management, and the State Plan for Coastal Management No. 13,796 from 06/30/06 defines aeolianites, known locally as "cascudos", as:

> Wind deposits cemented by carbonates in a continental environment with diagenesis close to the surface, involving mainly rainwater. They are relatively recent, with no defined shape, but mark the coastal morphology due to the horizons more resistant to erosion and wind transport (CEARÁ, 2006).

Indeed, aeolianites are part of the landscape of some coastal areas in the states of Ceará, Piauí, Maranhão, and Rio Grande do Norte (CARVALHO et al., 2008) while their relevance to Ceará is confirmed by the number of studies addressing the theme. Legally, in the State of Ceará, aeolianites are called Geoenvironmental Units and inserted in Law No. 13,796/2006, Section II dealing with Coastal Ecological-Economic Zoning and Art. 14 that refers to permanent preservation areas. They belong to an important geo-historical context regarding wind dynamics and climatic conditions that characterized the coastal environment and should be legally protected to maintain their original features.

In Rio Grande do Norte, the characteristics of semi-consolidated beach sandstones reported for the aeolianites found in Galinhos (LIMA, 2004) are like some of the structures found on the coast of Ceará, for example.

Galinhos Aeolianite geomorphosite

Among the several aeolianite occurrences identified in this research, we highlight an outcrop (Figures 05A, B) measuring approximately 9.0 x 4.20 x 1.15 m (length x width x height) that presents a peculiar shape with layers dipping 10° and parallel plane stratification varying between 2 and 5 cm, features remarkably different from its surroundings. This aeolianite is located 7.2 km east of the Galinhos city center.

The Galinhos aeolianites found occasionally in the oldest terraces, as well as outcropping terraces at the channel edges, exhibit coarse to fine-grained sand, with carbonate cementation (LIMA, 2004 p. 39).

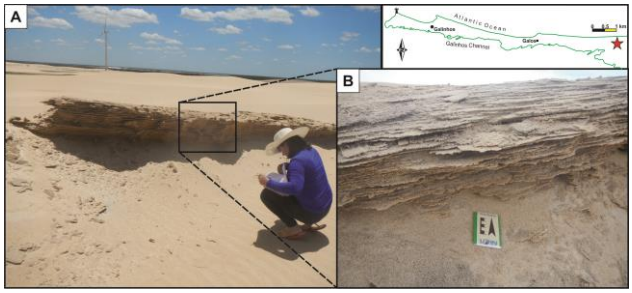

Figure 05- Overview of Capim Dunes showing: (A) aeolianite outcrop arrangement and (B) structure detail showing the plane-parallel layers formed predominantly by quartz. Geomorphosite (red star) location shown in the photo upper right corner. Source: authors' field research (2019).

Located on a dune field (Capim Dunes), this geomorphosite accessibility is moderate. It can be reached using a 4-wheel drive vehicle, or on foot, starting at the channel edge from where the dune can be accessed. Even with limited access, this outcrop is also part of the touristic route of the area, and can thus be better explored, especially regarding its formation.

This aeolianite was classified as a point-type visualization with good visibility conditions that presents a high degree of

natural and anthropic vulnerability. Once exposed, the dynamic character of the coastal areas submits this aeolianite to the natural erosion process (rain and, mainly, wind) and the developing tourist activity since no approximation restrictions had been in place at the time of the study.

3.1.2. Beach Environment

Beaches are considered one of the most sensitive of the several environments making up the planet (SOUZA *et al*., 2005). This high sensitiveness is attributed to the inconsistency of its components, Suguio (2003) defines beaches as basically sandy material (0.062-2 mm) or, more rarely, gravel material (2-60 mm), or even shells, among others, accumulated predominantly by the action of waves that adjust to hydrodynamic conditions due to their mobility (LIMA, 2004).

Souza *et al.* (2005) point out that beaches have multiple functions, besides acting as coastal protection for adjacent ecosystems and urban activities, and a natural habitat for various animal and plant species, beaches are popular recreation and tourism areas. The beach environment is defined as the range starting at submerged points and reaches the strip of dunes and/or escarpments behind the beach environment itself, or even structures built by humans such as walls/small walls, bulkheads, among others. Several technical terms are used in the literature to describe the beach compartments such as foredunes, backshore, foreshore, shoreface (LIMA, 2004).

Reading and Collinson (1996) characterized the backshore as relatively flat, lacking vegetation cover and rarely flooded, except for the occurrence of extremely high tides. The foreshore, also known as beach face, is the area regularly washed by the waves, presenting a steep profile.

The shoreface refers to the submerged zone, whose surface covered by benches and gutters has maximum sediment movement due to extremely active coastal processes (REINECK and SINGH, 1975).

Galinhos Beach geomorphosite

Galinhos beach (Figure 06) is one of the main tourist attractions of the area, with several important characteristics regarding the geodiversity context.

Figure 06- Panoramic view of Praia de Galinhos. Geomorphosite (red star) location shown in the photo upper right corner. Source- authors' field research (2019).

The proximity to Galinhos town makes it even more dynamic, regarding both natural and man-made aspects. From the city, access to the area is on foot or driving a 4x4 vehicle along the beaches and dunes located east of the city and, therefore, classified as easy access.

This geomorphosite was cassified as "process", with good observation conditions, while presenting high natural and anthropic vulnerability due to beach occupation that accentuated the erosive processes in determined locals during high tide. Considering these occurrences, the conservation status was deemed reasonable but deserving of some conservation actions.

Important for tourism development, this landform is popular with beachgoers while the post-beach compartment is widely used for practicing kitesurfing (Figure 07 A,B), an action sport that harnesses the power of the wind with a large controllable power kite to be propelled across the water.

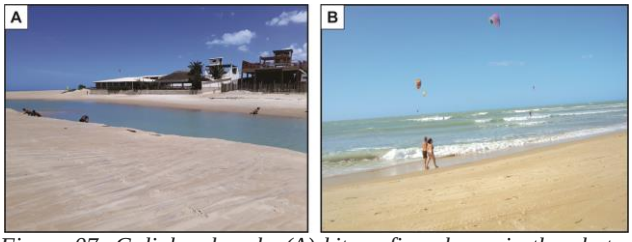

Figure 07- Galinhos beach: (A) kitesurfing shown in the photo background; (B) small lagoon within sandbanks formed by high tides, in the post-beach compartment, used by beachgoers. Source: authors' field research (2019).

Farol beach geomorphosite

Farol beach (Figure 08) is one of the most attractive places in the municipality of Galinhos. Several nature aspects come together in this calm place, in addition to watching beautiful sunsets, the sea overflows the barrier beachrockss and sandbanks, forming a lagoon used for swimming.

Figure 08- Aerial view of Praia do Farol, showing the lagoon (left side of the photo) formed by the sea waters during high tides; in the background a beautiful sunset and the lighthouse (hence the name, farol means lighthouse in Portuguese), on the beachrockss that developed on the beach strip, giving its current configuration. Geomorphosite (red star) location shown in the photo upper right corner. Source: Galinhos municipality collection.

This beach, classified as a process, can be accessed by horse carts or buggy (specific transportation to the dunes) or/and other 4x4 vehicles (Figure 09), or even on foot, from the Galinhos town.

Figure 09- Horse carts used by visitors/tourists to stroll between the Galinhos and Farol beaches. Source: authors' field research (2019).

With easy access and range visualization, this geomorphosite also presents good observation conditions with no obstacles to prevent or hinder visualization of its surroundings.

Due to the constant occurrences of tidal occlusions, the area natural dynamics deem this area as highly vulnerable to sudden morphological changes. Despite this, it is in good condition. Given the above, it is plausible to conclude that the Praia do Farol geomorphosite has high tourist and aesthetic values, justified by the developing local touristic activity and its natural beauty.

3.1.3. Beachrocks

Beachrockss (rocky beachrockss, beach sandstone, or beach rock) are (geo)forms representative of coastal dynamics that show changes in sea level, specifically during the quaternary. They are sedimentary rocks formed in coastal areas, especially in the beach area, friable to well-cemented, whose constitution may involve all types of sediments, such as sands and gravels of clastic and/or biogenic origin cemented via carbonate cement precipitation (CABRAL NETO et al., 2014). Still according to these authors, morphologically, the beachrockss have a tabular shape of varied dimensions, while being similar to the coastline where they were formed (Gischler 2007).

Beachrocks Geomorphosite in Galinhos Beach

In Galinhos, beachrocks occurrences are common and appear as long strings arranged parallel to the coastline. The highlighted geomorphosite (Figures 10A, B) has dimensions compatible with others found on the northeastern coast, is close to Galinhos town, and easily accessible. Its formation is linked to the current configuration of Galinhos beach which reflects a local geomorphological feature similar to an inlet.

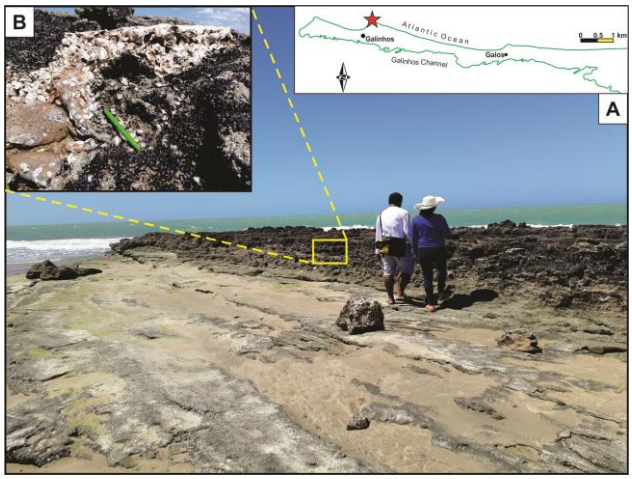

Figure 10- (A) Beachrocks in Galinhos beach highlighted in this work; (B) detail of the structure bioclastic material and rock fragment. Geomorphosite (red star) location shown in the photo upper right corner. Source: authors' field research (2019).

This beachrocks shapes the beach and acting as a natural protective barrier against the incident waves in the adjacent areas, which have been already quite occupied by the population. The range-type visualization is conferred by the beachrocks general arrangement along the coastline, and good observation conditions.

The natural vulnerability was classified as average due to its direct contact with the sea. Although the beachrocks is more resistant to oceanic processes, it becomes submerged in high tides and more vulnerable to the occurring processes. Furthermore, the anthropic vulnerability was also identified as average and linked to the beach use by kite surfers, who prepare their equipment remarkably close to the geomorphosite. Additionally, we also observed cars riding very close to the beachrocks site, thus making it more vulnerable to structural changes. This structure has a high aesthetic value, due to its shape and placement in the landscape, as well as a high paleontological value since it provides evidence on varying average sea level.

Cabral Neto (2011) and Cabral Neto et al. (2014) revealed that the beachrockss in Galinhos are one of the largest and most

extensive exhibitions on the state northern coast. Like the other structures in Galinhos, the highlighted beachrocks exhibits crossed and flat stratification, consisting of bioclastic material and fragments of rocks.

Finally, Table 02 summarizes the characteristics of the studied geomorphosites, highlighting the geological and geomorphological aspects and other information relevant to the geodiversity theme.

Table 02- General characteristics of the Galinhos spit geomorphosites. Source: Prepared by the authors.

GENERAL FEATURES	GEOMORPHOSITES					
	André Dune	Capim Dunes	Galinhos Beach	Farol Beach	Galinhos Aeolianite	Galinhos Beach Beachrocks
UTM Geographical coordinates*	804657600 km E 9432570100 km S	808726000 km E 9432512600 km S	802029000 km E 9436664400 km S	803047900 km E 9436909000 km S	803897900 km E 9435389600 km S	802290000 km E 9436887700 km S
Geological characteristics	Medium to fine-grained windsediments, forming the dune relief in constant activity	Medium to fine-grained wind sediments, forming the dune relief in constant activity	Coarse to fine sand forming beach cusps in the post-beach; beachrocks (beach rocks) promoting lower incidence of waves	Beach sediments fine to coarse grain in the postbeach area; presence of beach rocks promoting less wave incidence	Semiconsolidated sandstone composed of quartz sand with carbonate cementation	Poorly selected sediments (bioclastic and rock fragment), with fine to coarse grain, and carbonate cementatio
Geomorphological characteristics	Mobile dune, longitudinal, well outlined in contact with the tidal channel waters; depositional direction of sediments almost perpendicular to the coastline	Mobile dunes with predominance of structures with morphology characteristic of barchanoid ridges	Cove-shaped beach; beachfront with wave marks and channels; sandbank forming a small lagoon; Post beach and shoulders	Beachfront with wave marks and channels; sandbank forming a small lagoon; Postbeach and frontal dunes; occurrence of berms	Layers with 10° dive; parallel plane stratification (2-5 cm); horizons more resistant to wind transport and erosion.	Elongated Structure basically arranged as plane-parallel layers, with a slight inclination towards the sea.
Principal classification	Geoform	Geoform	Process	Process	Geoform	Geoform
Accessibility	Moderate	Moderate	Easy	Easy	Moderate	Easy
Visualization scale/range	Area	Area	Strip	Strip	Point	Strip
Observation conditions	Good	Good	Good	Good	Good	Good
Natural vulnerability	High	High	High	High	High	Average
Anthropic vulnerability	High	High	High	Average	High	Average
Preservation status	Good	Reasonable	Reasonable	Good	Good	Good
Added value	Touristic/Esthetic	Touristic/Esthetic/ Paleontological	Touristic/Esthetic	Touristic/Esthetic	Touristic/Paleogeographic	Touristic/Esthetic/ Paleostratigraphic

*UTM Coordinates and WGS 84 Datum.

4. FINAL CONSIDERATIONS

Studies assessing coastal areas while emphasizing geodiversity became a necessity recently since they address environments with a high degree of natural fragility, often aggravated by anthropic processes, recurrent of the large population concentrations, which increase the pressure on natural elements.

Currently, the scientific community seeks to present to society as a whole, the best way to explore abiotic components, highlighting those of singular importance, as to guarantee the maintenance of local geodiversity and, consequently, that of the planet, while improving the lives of people.

The Galinhos municipality stood out, especially given the potential presented by its abiotic features such as dunes and beaches, as well as the tidal channels outlining the spit.

The Capim Dunes and André Dune are important geoforms representing the natural dynamics of this region and fundamental for developing tourism in the area. The same applies to the beaches highlighted in this work. However, clearly, they need to be better explored to guarantee their conservation.

Furthermore, the aeolianite found over the Capim Dunes and the beachrocks outcrop, which is fundamental to the dynamics of Galinhos beach, are little known. Even though they are located on tours and visitation routes, their touristic and educational importance should be highlighted as to make them more attractive while adding even more value to the area geodiversity..

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