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ABSTRACT

Coastal erosion is present in many parts of the Rio Grande do Norte coast, with origin attributed mostly to the small fluvial contribution of sediments and lost of sediments to the land, with the field dunes formation. The methodology used in this study used multitemporal products of remote sensing and air photographs, current beach profiles and hydrodynamic measurements, as well as geological and geophysical survey on land and on the shelf. The integration of these data sets allows a better comprehension of the causes and origins of coastal erosion. The most important factors and causes observed on this study are related to i) coastal circulation dynamics, ii) Holocene evolution of the coastal plain, iii) naturally inefficient sediment supply, iv) construction of hard interface structures, and v) tectonic factors. The results showed erosion areas are linked to large scale bottom morphology on the setentrional sector, and to large scale coast morphology on the oriental sector. The changes are mainly due to longshore drift contributions and negative sediment budget.

ADDITIONAL INDEX WORDS: Coastal tectonic, coastal geomorphology, coastal evolution.

INTRODUCTION

The term coastal erosion applies to the shoreline proper and to a strip of seafloor immediately bordering on the coast. The most “visible” manifestation is coastline recession (Charlier and Meyer, 1998).

Coastal erosion results from beach-ocean interaction coupled with human activity. Because there are so many factors involved in coastal erosion, including human activity, sea-level rise, seasonal fluctuations, and climate change, sand movement will not be consistent year after year in the same location.

Wind, waves, and longshore currents are the driving forces behind coastal erosion. This removal and deposition of sand permanently changes beach shape and structure. Sand may be transported to land-side dunes, deep ocean trenches, other beaches, and deep ocean bottoms. Coastal erosion poses many problems to coastal communities in that valuable property is permanently lost to the dynamic beach-ocean system.

Over 70% of the world’s sandy beaches are currently eroding (Bird, 1985), and the percentage increases to 80 to 90% for the better studied and better-documented U.S. sandy coasts (e.g. Leatherman, 1986; Galgano et al., 1998). In contrast the tropical coasts, in which the Rio Grande do Norte (RN) is included, are almost unknown.

Coastal erosion is present in many parts of the Rio Grande do Norte (RN) coast, with origin attributed mostly to the small fluvial contribution of sediments and lost of sediments to the , with the field dunes formation. However, the studies carried along this coast never take in account the whole coast, been restrict to small sectors.

In this way, the main goal of this work is to identify the indicators of coastal erosional processes observed along the whole RN coast, as well the causes of coastal erosion, their most important effects, and associated processes on this tropical coast. This work is part of a major effort to assess the knowledge about coastal erosion along the coasts of Brazil (Muehe, in press).

Located on the “corner of Brazil”, the Rio Grande do Norte (RN) State has a coastal length of around 410 km, predominantly constituted by sandy beaches and active cliffs. This coast is submitted to trade winds which promotes efficient unidirectional longshore currents. It is generally divided in two distinct sectors according to the preferential orientation of the coastline, the Oriental coast, with North-South direction, and the Setentrional coast, with East-West direction (Figure 1). A humid to sub-humid, hot tropical climate is present on the Oriental sector, while the Setentrional one presents a semi-arid climate (Nimer, 1989).

The dune fields, coastal plain and coastal cliffs from the Barreiras Formation characterize the geomorphology of this littoral (Figure 2a, 2b); the area is drained only by small rivers, and the fluvial plain is restrict to the mouth of the most important rivers of the area (e.g. Curimatau, Potengi, Açú). A marked characteristic of this littoral is the presence of beachrocks aligned almost parallel to the coastline, which impact the beach and surf zone through their influence on wave refraction and attenuation (Figure 2c).

METHODS

The methodology used in this study used multitemporal products of remote sensing and air photographs to construct a basis chart. Oblique photos were taken from the shoreline with a Fox ultralight and in situ investigations was performed to characterize the whole coast. Data from beach profiles and hydrodynamics measurements, as well as geological and geophysical survey on land and on the shelf were taken from students developing master and doctor thesis at PPGG/UFRN and from the recent liter ature. These data were integrated and the whole Rio Grande do Norte coast was classified according to the morphological and morphodynamic units (Muehe, in Press). Indicators of coastal erosional processes, as well the causes of coastal erosion, their effects and associated processes were classified according to Sousa et al. (2003).
RESULTS AND DISCUSSIONS

The integration of these data set allow a better comprehension of the causes and origins of coastal erosion on the Rio Grande do Norte (RN) State.

Oriental sector has a coastal length of 166 km (41% from the RN littoral). 101 km constituted by narrow sandy beaches, and 65 km by active cliffs from Barreiras Formation (Figure 2b). Blowouts or parabolic dunes are predominant. Reflective beaches are generally linked to beaches limited by cliffs.

The Setentrional sector presents 244 km of coastal length. 194 km of them constituted by sandy beaches, 10 km by muddy beaches, and 40 km by active cliffs. Barchan and barchanoid sandy dunes are predominant (Figure 2b).

The most common indicators of coastal erosional processes observed on the Rio Grande do Norte Coast are i) general and progressive landward shoreline displacement (retrogradation) trend, during the last five decades, ii) severe erosion of Tertiary Barreiras Formation, as well as from the Quaternary eolian and/or marine deposits along the coastline, iii) destruction and burial of mangrove adjacent to the beach, iv) subaerial exposure of peat bog from ancient lagoonal or mangrove deposits on foreshore and upper shoreface surfaces, v) heavy minerals concentrations on foreshore zone, vi) development of beach embayment. The most important factors and causes of coastal erosion observed on this study are presented below:

Coastal Circulation Dynamics

The presence of beachrocks aligned parallel and intermittent to the beach, change the wave energy causing accentuated erosion and embayment on the beach. When the beachrocks are continuous they protect extensive stretches of coast; on the other hand, accentuated erosion take place were the beach rocks breaks (Figure 2c).

When beaches are eroded, the beachrocks remains as natural breakwaters to modify wave energy and thereby the retreating shoreline.

Holocene Evolution of the Coastal Plain

The sedimentation during the Holocene has been controlled mainly by the variation of the sea level, longshore currents and the advance of active dunes along the coast (Caldas, 2002). Intensive erosion present in some stretches of the coast can be related to the intense longshore drift (from south to north on the Oriental sector and from east to west on the Setentrional sector) associated to a negative sedimentary budget and losses of sediments towards the land with dune field and spit-barrier island formation.

The dune fields are present in both sector. However the spits are restricted to the Setentrional sector (Figure 3). Lima et al. (2001, 2002) registered for the Galinhos spit a growth of approximately 230 m in the end west, from 1954 to 1988 and a regression of 330 m from 1988 to 2000 in its coastline. Evolution of these barrier systems has been cyclic in a decade scale (Xavier Neto et al., 2001; Lima et al., 2001, 2002; Silveira, 2002; Souto, 2002) indicating ancient system of island barrier developing for the current spits and spits which were recently detached to form island barrier.

Naturally Inefficient Sediment Supply

Long-term trends of coastal erosion in Northeastern Brazil related to inefficient sediment supply has been already reported in the literature (e.g. Dominguez and Bittencourt, 1996). In fact, the rivers of the study area are small and do not contributed with significant sediment amounts. Moreover, the most expressive rivers (e.g. Açu river) are dammed, and so prevent the sediments to reach the ocean.

Construction of Hard Interface Structures

Hard structures are built to prevent the further erosion of a beach or to impede the motion of sand along a beach. For a given site, with its unique environment and causes of erosion, different structures may be useful. It is clear, however, that an inappropriate structure can exacerbate the situation and harm adjacent beaches as well (Dean and Dalrymple, 2002).
On the RN coast groin field were constructed in different beaches coast (e.g. Caicara do Norte, Macau, Touros). Probably because they are traditionally used to prevent erosion on shorelines with significant alongshore transport as in the RN coast. However, these structures are built without enough background-knowledge of the most important aspects of coastal erosion, and of the major mechanisms involved aggravating the coastal erosion. These structures are expensive and without proceedings survey may cause more severe erosion-problems than exist today.

On the RN coast tectonic activity also played an important hole on the coastal erosion. On the Oriental sector the graben and horst structural architecture, resulting from intense tectonic movement, origins the embayed beaches configuration, while on the Setentrional sector the shelf bottom morphology, strongly conditioned by the tectonic configuration, also contribute to coastal erosion by the sediment trapped on specific places of the shelf and wave refraction due to offshore bathymetry.

According to Vital et al. (2003a) the spit-barrier systems occur only on the E-W northern coast, and they are confined between two important fault systems: The Carnaubais and The Afonzo Bezerra systems. Great scale submerged sandy dunes seems to be associated to the Carnaubais fault system (Tabosa et al., 2001, 2002; Vital et al., 2003b) and has important implications to the hydrodynamic processes of the coastal area between these fault systems, promoting depositional areas, such as the Galinhos and Ponta do Tubarão spits, and erosional ones such as Caicara do Norte and Guamaré.

Different indicators of coastal erosional processes are observed on the Rio Grande do Norte Coast. The most common are i) general and progressive landward shoreline displacement (retrgradation) trend, during the last five decades, ii) severe erosion of Tertiary Barreiras Formation, as well as from the Quaternary eolian and/or marine deposits along the coastline, iii) destruction and burial of mangrove adjacent to the beach, iv) subaerial exposure of peat bog from ancient lagoonal or mangrove deposits on foreshore and upper shoreface surfaces, v) persistent destruction of engineering works, vi) heavy minerals concentrations on foreshore zone, vii) development of beach embayment.

This study shows that the most important factors and causes of coastal erosion on this coast are related to i) coastal circulation dynamics, ii) Holocene evolution of the coastal plain, iii) naturally inefficient sediment supply, iv) construction of hard interface structures, and v) tectonic factors.

The results showed erosion areas are linked to large scale bottom morphology on the setentrional sector, and to large scale coast morphology on the oriental sector. The changes are mainly due to longshore drift contributions and negative sediment budget.

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LITERATURE CITED


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