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Morphodynamics Of The Curu Estuary Inlet – Brazil

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ABSTRACT

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Estuaries are coastal environments that are transitory in nature who have suffered various environmental impacts and significant changes in the morphology of the mouth of estuaries due to the anthropogenic activities performed within the watershed and coastal processes. Because of this, the present work has as main objective to obtain more meaningful information concerning the progress of the morphodynamics of estuarine mouth to identify risky areas for urban development. The study area is located on the border between the municipalities of Paraipaba and Paracuru, 85 km from Fortaleza, in the northwest portion of the State of Ceará, Northeast Brazil. To perform this research were used: multitemporal satellite images, Global Positioning System, total station and sediment samples. Between the years 2001 and 2007, there was a 622.00 m spit progradation of the right bank, with a rate of 103.65 m.year⁻¹. It has been verified the width losses width of 33.5 m in the sandy spit. In 2007, there was a migration of 29.99 m spit, which implies a rate of 2.50 m.mouth⁻¹. The arrival of swell waves in November 2007 resulted in a loss of 10 m wide beach. The sediments showed particle size ranging from fine sand to very coarse, moderately to poorly sorted. Among the risks areas mapped for urban expansion in this study, there is an entire coastal strip located 2.5 km west and 800 m is situated east of the river mouth Curu.

ADDITIONAL INDEX WORDS: *Estuary, Morphodynamics, Sand Spit.*

INTRODUCTION

Along approximately 8.500 km of Brazilian coast, there are several estuaries and coastal lagoons that have contributed to the development of cities, with the consequence of changes in the processes of sedimentation and erosion and characteristics such as geometry, tidal current, discharge freshwater and water quality, modified by natural and anthropic processes, over the centuries (MIRANDA, CASTRO e KJERFVE, 2002).

In general, these environments have suffered various environmental impacts related to both the activities undertaken within the watershed on the coastal processes. Several activities such as tourism, urban expansion, deforestation, agricultural activities, aquaculture, shrimp farming, industry and the construction of dams has caused significant changes in the morphology of the mouth of estuaries, which in most cases, eventually becoming irreversible to the ecosystem.

The construction of dams closer to the estuarine areas, and reduce the river discharge and sediment supply to the coastal zone, increase the intrusion of the tide and change in hydrodynamic processes downstream (DIAS, 2005).

Although necessary to construct dams for water supply, power generation, fish farming, irrigation, navigation, and even leisure is a fairly common practice and justified in the semi-arid regions. Knowing that its operation leads to significant changes downstream of the dam, in addition to breaking the natural balance of river.

In State of Ceará, the irregularities of the rainy season (January-June) and the regularization of the flow associated with oceanographic variables (waves, tides and currents) and wind action are responsible for morphodynamic processes accelerated. This is reflected in the displacement or closure of river mouths, leading to changes in hydrological parameters, hydrodynamic and sediment system.

Because of this, the present work has as main objective to obtain more meaningful information concerning the progress of the morphodynamics of estuarine mouth to identify risky areas for urban development.

The study area is part of the basin of the river Curu located in the northwest portion of the State of Ceará, Northeast Brazil. The namesake river rises in the Sierra of Machado, receive influence from tributaries of the Sierra Uruburetama and Baturité, covering 195 km to attain the Atlantic Ocean, resulting in an estuarine mangrove colonized by small-to high-profile.

The Curu river estuary is located on the border of the municipalities of Paraipaba and Paracuru, 85 km from the city of Fortaleza (figure 1). The access road from the state capital of Ceará to the Municipal head office of Paracuru is done by the CE-085 highway and follow Highway CE-341. In addition, the study location is inserted in an Environmental Protection Area (APA) which was established through Decree of N° 25.416, of 29th March 1999.

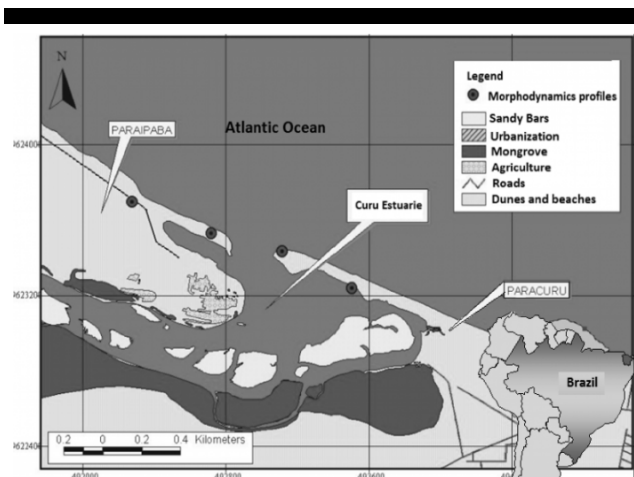


Figure 1. Location of study area.

METHODS

To obtain the data and achieving the results were performed: surveys bibliographic and cartographic, field activities, GIS techniques and laboratory analysis.

Field activities consisted of georeferencing the mouth of the river, surveying topographic profiles perpendicular to the shoreline and sediment samples collected in January, March, May, July, September and November 2007, taking into account the spring tide.

Was used for georeferencing the Global Positioning System (GPS) Garmin GPSMAP 60CS model, using the coordinate system Universal Transverse Mercator (UTM) projection SAD-69. The information collected in the field were imported into the program MAPSOURCE version 06. Subsequently, the database was manipulated in GIS program with the purpose of mapping related to the river mouth migration on a scale of 1:8.000.

Based on the methods proposed by Emery (1961) and Muehe (1996) were established in 04 topographic profiles in a span of about 1.3 km in order to identify areas of retreat and progradation of the shoreline and quantify gain and loss of sediment near the river mouth Curu. For this, we used a total station GTS-230N Series of Topcon.

The geoprocessing techniques were also applied in multi-temporal satellite images to calculate the width and length of the bar sandy to estimate the migration rate per year.

Sediment samples were collected at backshore, intertidal, and shoreface beach zones for purposes of characterization and distribution along the coast.

RESULT AND DISCUSSION

According to the classification proposed by Pritchard (1952b, apud MIRANDA, CASTRO AND KJERFVE, 2002), the Curu estuarie is of type spit (figure 2). This fact is justified because of the recent sedimentation in the estuarie that leads to the formation of a large sand spit which hinders the exchange of matter and energy between the river and ocean. The morphodynamics of spit is controlled predominantly by longitudinal coastal current, with

transportation capacity of approximately 800.000 m³/year-1. The effective reduction hydraulic of river mouth (the construction of a dams to 7.3 km from the mouth and the siltation of the river channel) and other processes (wave action, tidal and wind) have contributed directly and indirectly in geomorphological changes.

In 2001, the sand spit located on the right bank of the Curu river had a length of 453.33 m average width of 88.08 m. On the left bank, the average width of the bar was 74.76 m extension and corresponding extension 780.60 m. In a range of up to 1.0 km away from the mouth, there is the accumulation of sediments in the river channel.

In 2004, the spits were more elongated features in the year 2001 and the sandy banks took greater proportions in nearly 04 years. Although the annual precipitation was more significant in 2004 (1763.3 mm) than in 2001 (1153.7 mm), the spit located on the right bank of the river had an average width of 89.62 m with an increase of 68.67 m in its length. Other side, the spit migrated toward the river showing a length of 1062.19 m and width averaging 85.82 m.

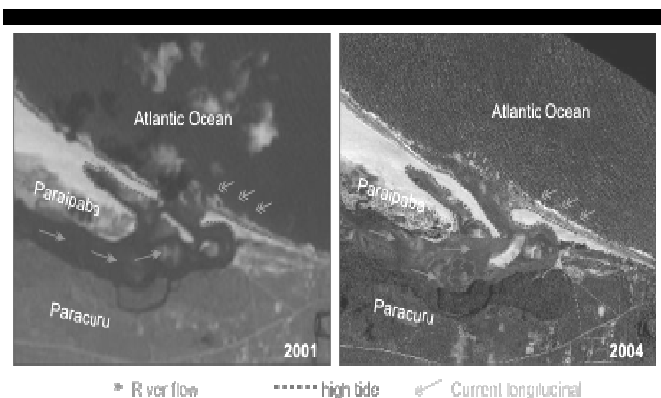


Figure 2. Morphological variations of the mouth of the Curu river estuarie in 2001 and 2004. Images: Landsat (2001) and Quick Bird (2004).

According with Pinheiro (2003), coast of the State of Ceará is formed by a large number of rivers that are barred by the dune fields and / or sandy barrier that isolate with partial or total communication with the estuaries of the Atlantic Ocean, leading to extensive flood plains which, in most cases develops systems for lake or lagoon.

Between the years 2001 and 2007, there was a progradation of approximately 622.00 m of sandy spit located on the east bank of the river Curu at a rate of 103.65 m/year. Also, a reduction of width of up to 19.40 m of this interval of time mentioned. On the west bank of the river, the sandy bar of 470.26 m was reduced from a period of six years, showing a rate of 78.38 m/year.

This may cause changes in the use and occupation of land in the basin area, for example, the expansion of agriculture and irrigation of fruit in the city of Paraipaba. Knowing that the river is the physical boundary between two cities studied, we can say that the migration of the bar means the territory increase Paracuru and loss in the area of Paraipaba.

Considering the high frequency of monitoring during the months of January, March, May, July, September and November 2007, it found that the rate of migration of the sand spit located on the east bank of the river was 29.99 m, which corresponds to a rate of 2.50 m/month. And on the west bank, the spit lost 181.81 m in length between the period January-September 2007 (figure 3 / table 1).

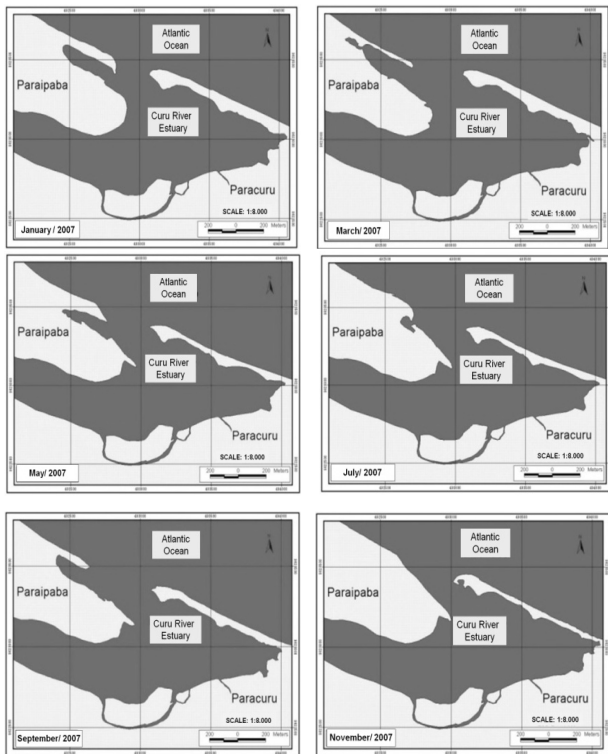


Figure 3. Morphodynamic behavior of the mouth of the estuary of the river Curu in January, March, May, July, September and November 2007.

May, July, September and November 2007. The dimensions and distances of the profiles were standardized to maintain reason in a uniform area.



Figure 4. Fixing and increasing the area of mangrove on the east bank of the river Curu.

In figure 5, we can see the sediment budget of the range of sand beach adjacent to the mouth of the river Curu. The variation of sediment between the period January/07 and November/07 was 60% negative, the loss of sediments ranging from sand beach is higher than the gain.

In November 2007, observed the absence of the sandy spit on the west bank and the narrowing of the same on the east bank, this fact was associated with the arrival of waves of type swell on the coast of Ceará. However, it was the period whose mouth had the second biggest opening during the study period (427.11 m).

The amount of the sand bar was observed retention of sediments finer grain size (silt and clay) in September 2007. This fact favored the establishment and expansion of the mangrove area on the east bank of the river Curu (figure 4).

Through the cross-sections, it was found that the range is wide sand beach in a highly variable length of approximately 1.3 km. During rain, the track had sand beach wide average of 101.58 m. While the drought, the average width was 79.58 m, ie, a decrease of 21.65%. The sediments deposited along the study area are composed of quartz sand grain size of fine to very coarse, moderately to poorly selected.

The sediment of sand beach strip was calculated using the kriging interpolation of data obtained from a distance, elevation and width of each profile during the months of January, March,

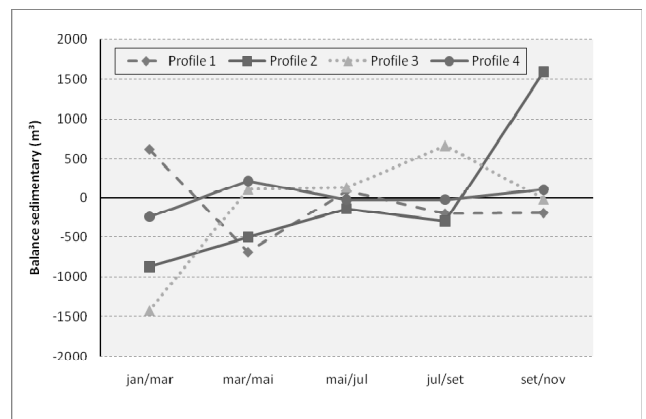


Figure 5. Sediment profiles monitored during the months of January, March, May, July, September and November 2007.

Table 1: Dimensions of the sand bar and the mouth of the estuary Curu the monitoring period.

Month/year	Average width (east bank)	Extension (east bank)	Average width (west bank)
January/2007	86.78 m	1084.81 m	56.39 m
March/2007	76.90 m	1052.49 m	44.36 m
May/2007	61.88 m	1074.70 m	76.48 m
July/2007	65.34 m	1058.31 m	49.18 m
September/2007	66.61 m	1066.12 m	43.33 m
November/2007	54.54 m	1114.80 m	---

The profile 02 showed a negative balance of 80% between the months of January/07 and September/07, however, managed to present a positive balance between the months of September/07 and November/07. The profile 03 presented 60% of balance positive between March/07 and September/07. Therefore, the deposition was greater than the erosion in this sector.

In profile 04, the sediment corresponded to 60% negative, with higher losses observed in the period January/07 - March/07 (242.75 m³) and lower in July/07 - September/07 (21.80 cubic meters). However, the positive sediment budget of this profile was most significant among March/07 and May/07.

Based on the above information, the strip of sand beach of the study area has little tendency to erosion. It is observed that between the months of March 2007 and September/2007 the lowest values occurred of sediment.

CONCLUSION

The process of silting of the mouth river Curu is quite intense, because the river is not competent enough to carry up the sandy material located 1.0 km away from the mouth longshore, let alone have the capacity to break the sandy spit. Therefore, the mouth has a tendency to continue moving toward the city of Paraipaba.

The municipality Paraucu tends to increase its territory in the coastal area in relation to paraipaba. Thus, one should not occupy a coastal area of up to 2.5 kilometers on the west bank and 800.00 m on the east bank. These data come from monitoring the dynamics of the river mouth held in 2007, expansions can occur or not, as other studies related to coastal dynamics.

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