

**SEDIMENTOLOGICAL CHARACTERIZATION OF THE
PEDOLOGICAL COVER OF CAMAÇARI ECOLOGICAL
RESERVATION, CABO DE SANTO AGOSTINHO, PE,
NORTHEASTERN BRAZIL**

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ABSTRACT

This paper deals with the issues of environmental impacts derived from the continuous process of metropolitan growth, and aims at identifying and analysing the erosive processes occurring in an area that has been legally designated as an environmental reservation, therefore said to be of strict permanent preservation. This research is focused on the understanding of causal relationships that unleash events of environmental disequilibrium, following the illegal systematic removal of the regolith for providing building materials to local civil construction entrepreneurs. It was possible to demonstrate the links between the spatial distribution of superficial materials (soils, sediments and regolith) and the level of stability of distinct geomorphic units, through the use of a morphostratigraphic approach. The area portrays a dissected hilly topography, lying within the limits of “Recife Metropolitan Area”, and therefore suffering the consequence of rapid changes in land use, epitomized by the extensive removal of natural vegetation and exploitation of its deeply lateritized regolith, in spite of being protected by State laws. Deforestation allied to the removal of the deeply weathered regolith has caused a rearrangement of the area’s morphodynamic units (Tricart, 1977), as shown by both field and lab-work. However, it was found that the diversity of the pedological cover in the area, as a dynamic response of the lithology to the east coast tradewinds tropical climate, commands the distribution of superficial processes, favoring the occurrence of mass movements, intense linear erosion, damming of superficial waterflow, reworking of sub-recent Aeolian sediments and building of coalescing alluvial fans. Finally the research threw light on the understanding of the linkages between rates of geomorphological dynamics and soil cover in a costal humid tropical environment.

INTRODUCTION

This case-study was developed under the perspective of the environmental impacts derived by the continuous process of growth of urban centers. It is aimed at identifying and analyzing the physical processes in operation within areas of environmental protection. Such areas have been formally designated as environmental reservations and therefore should be permanently protected. It is believed that this work may provide a better understanding of the causal relationships that trigger events of environmental instability, catalyzed by the removal of regolith for construction purposes. According to the above, this work aims at identifying the geomorphological processes involved in the environmental degradation within a natural reservation, as well as characterizing the sedimentological properties of the superficial materials of the landscape. The guiding premise for this study is the idea that erosive superficial processes appear as a response to the unruly removal of sediments for civil construction. Thus, this work seeks to analyze, based on field observation, the impact of the illegal appropriation of the natural resources by some social agents, such as dwellers and holiday-makers, in an area of strict environmental protection. By the use of the morphostratigraphical approach, the ties between the spatial distribution of the superficial materials and the stability level of distinct geomorphic units will be demonstrated.

The Study Area: Camaçari Reservation

The area of the Camaçari Reservation is characterized by an extreme diversity of geomorphological compartments, covered by several types of second-growth forest assemblies referred to semi-deciduous tropical Atlantic rainforest. The landforms overlap each other from east to west, transiting laterally from, likely Pleistocene, fluvial-marine accumulation terraces (from 6 to 10 m in elevation) to low dissected hills (up to 80 m in elevation) carved either on cretaceous volcanic lithologies or on the clastic mesozoic/cenozoic sediments trapped within Cabo pericratonic basin. Notwithstanding the geological framework, in all field circumstances the lithologies exhibit a thick kaolinitic weathering mantle, which is interspersed by more than one layer of lateritic crusts. Geochemical alteration has contributed both to the lateral and horizontal differentiation in the water percolation capacity of the superficial formations, as a consequence of that linear erosion has been catalyzed in all observed contexts.

In this case-study, it is proposed that in order to understand the triggering mechanisms of the anthropic morphogenesis in the area, it is capital to cross information from the geomorphological dynamics with its pedological background (Figure 01).

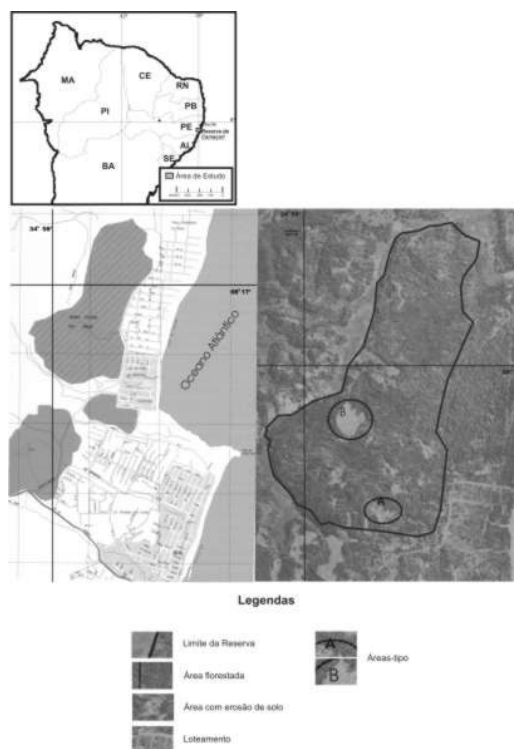


Figure 01 – Localization of the Study Area

MATERIALS AND METHODS

Physical geography has dedicated part of its considerations to the study of the human impact upon the landscape (Conti, 1999; Christopherson, 1994; Goudie 1993), nevertheless most of the works focus on rural areas, where the impact of agrarian activities on the erosive systems play a major role on the methodological considerations, and researchers seek to mitigate the damages caused by erosion and protect the arable soils. In spite of that, the application of geomorphology to urban studies is experiencing a tremendous growth in Brazil, especially because phenomena such as metropolization and the growth of middle-sized cities have become the most influential in the shaping of the country's territory and spatial production. These newly urbanized areas tend to grow over traditionally rural settlements or environmental reservations. Works from the last decade such as Ross (1992), PREFEITURA DA CIDADE DE SÃO PAULO (1993) and Müller-Plantenberg & Ab'Saber (1998) testify that there is a fast growing concern regarding the development of methodologies that enable a

more effective way of assessing the impact of human modified over natural systems, in urban areas and their close vicinity.

Within this framework, the concept of morphodynamic units, established by Tricart (1977) was applied to Camaçari reservation, building a relationship between morphogenetic and pedogenetic processes, by the construction of a typological ordering of degradation evolution based on the resulting forms and their relation with the vegetation cover. In this case the guiding premise is the fact that vegetation constitutes a buffer for the operation of the erosive processes, thus protecting the thick weathering mantle of the area and, as a consequence, its subordinate landforms. Following this line of thought, a landscape typology for area was constructed, based on three levels of growing environmental disequilibrium according to the proposal of Corrêa, Albuquerque & Melo (1995) for the hills of Guabiraba district in Recife, Pernambuco. In the case of Camaçari Reservation the typological levels were so defined: a) forested areas showing morphodynamic stabilization; b) areas of anthropicized savannas showing evidences of incipient erosion and initial rupture of the morphogenetical equilibrium; c) extensively eroded cleared areas - highly unstable environments (figure 02).

At this stage it became necessary to seek for theoretical support in order to provide a methodological basis for understanding the effects of erosion in newly urbanized humid tropical areas, such as those described by Thomas (1994). Based on the crossing between the morphostratigraphical approach, the geomorphological zoning and the soils classes of the area, it became feasible to assess the evolutionary patterns of environmental and geomorphic disequilibrium to this date, which is characterized by the development of an extensive gully network.

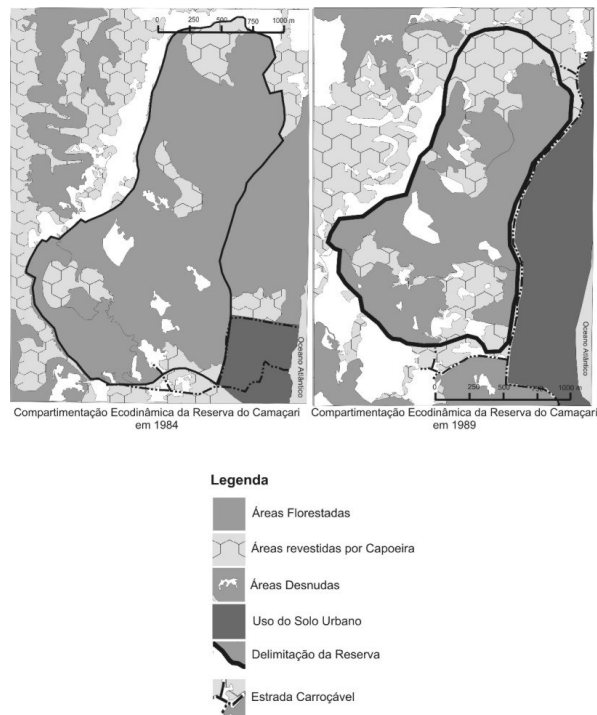


Figure 02 – Eco-dynamic compartments within Camaçari Reservation, Cabo de Santo Agostinho, PE.

RESULTS AND DISCUSSION

Geomorphology and Soils

As put forward by Mabesoone & Silva (1991), the area situated immediately to the south of Recife is marked by a topography of low-lying hills, with ample tops, equally structured on the pre-Cambrian crystalline basement or the Mesozoic sediments and volcanites of Cabo pericratonic basin. Regionally speaking, the study-area lies within a relief compartment whose nomenclature is rather varied: Remobilized Surfaces, “Chãs Pernambucanas” or still Borborema Eastern Piedmont, which comprises the area that lies between the coastal plains and the eastern escarpment of the Borborema Highlands. This landscape unit is formed by convex profile hills (half-orange relief), whose degree of dissection is also a function of structural controls. In the area of Camaçari this compartment is highly dissected in small hills with an elevation that never exceeds 80m.

The convex slope profiles have inclinations that vary from 6^0 to 24^0 , and are ubiquitously covered by a thick yellow-red sandy-claey weathering mantle. The morphogenesis is marled by the dominance of slow paced mass movements such as creeping and, to a lesser degree, debris flows. The narrow flat-bottomed valleys have been infilled by sandy alluvium/colluvium sediments. To the east of the hills lie a series of fluvial-marine terraces.

On the hills the most common soil classes are lateritic and podzolic, whereas on the eastern plains hydromorphic podzols and quartz-sand prevail.

The main soil assembly in the hilly area combines a yellow and yellow-red loamy to clayey podzolic, in the gently rolling slopes, to a yellow loamy to clayey laterite on the flat interfluves. Both types are aluminum rich; show a low CEC, a moderate A horizon and sub-superficial drainage. The indiscriminate removal of vegetation combined with the illegal mining of sand and clay for construction purposes bring to the surface of the terrain internal soil discontinuities, either of pedogenic or depositional origin, which behave as catalysts to the superficial erosive processes (Figure 03).

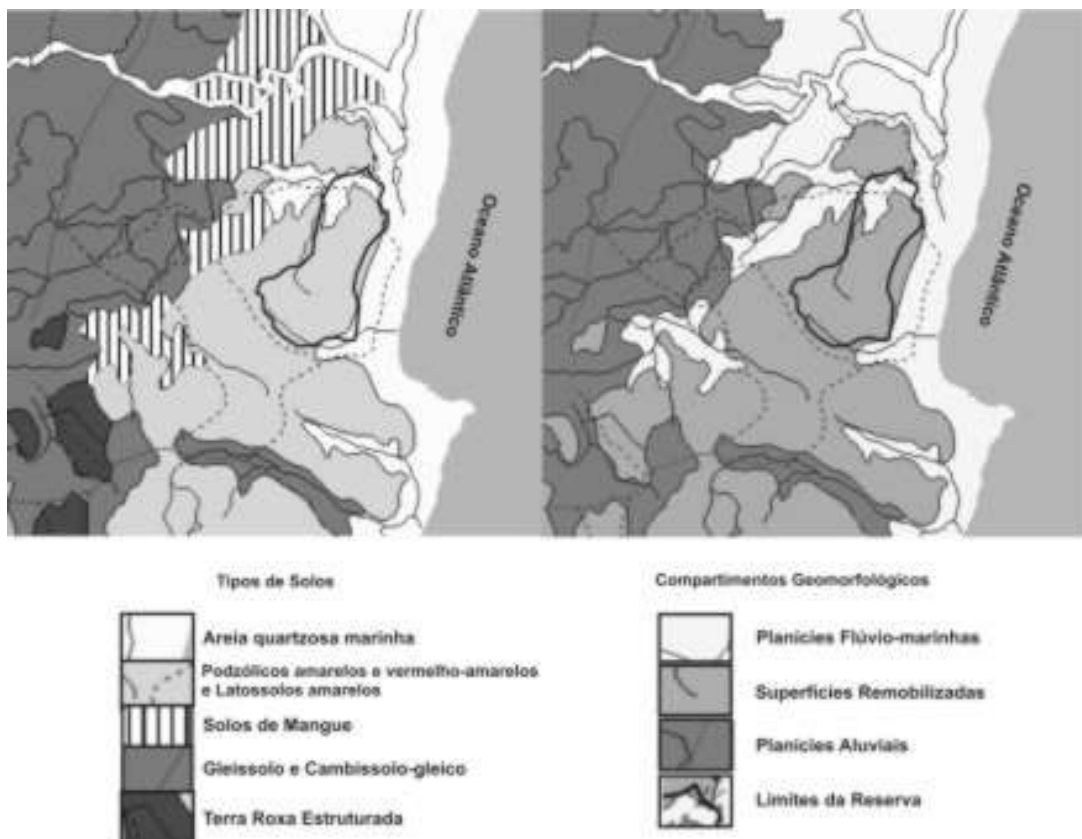


Figure 03 – Geomorphological Compartments and soil types in Camaçari, Cabo de Santo Agostinho, PE.

Sampling Areas

Sample collecting was carried out in two distinct key-areas that have been subjected to the artificial removal of sediments. The first area is situated to the south of the Reservation, close to a local road. This sector is marked by a sharp contact between the slopes of the hilly terrain and the alluvial terraces of the plains to the south of the Reservation. This sampling point is

dominated by a small hill with a maximum elevation of 30m whose southern face was dismantled by the removal of sediments for civil construction. On the base of the hill, a lithological contact between a weathered trachite and finely laminated clayey sediments was observed. In this area it was also observed that above the clayey sediments a deep kaolinic weathering profile has developed. This kaolinic regolith is interspersed by several layers of ferralitic crusts; however two of such indurate levels are more promptly discernible: a basal well preserved crust and an upper highly argilized fragmented one. In spite of the complete destruction of the hill's summit, which impedes the individualization of soil horizons per se, it was possible to distinguish a few zones of eluviation, from top to bottom, with their underlying clay-rich horizons, below which the indurate levels occur (Sample CM01).

As for the morphogenesis two distinct behaviors were distinguished in this area: the sheet flow that act upon the sandy sediments resulting in finely laminated deposits, that crop out to the north of the hill, and block-falls that occur on the highly compacted clayey sediments from the upper half of the hill. The recurring toppling and block-falls impedes the conspicuous development of surface runoff and linear erosion in this area, although on the knickpoint between the free-face of the slope and the deposits at its base, a network of rills and shallow gullies be developed. The gullying process reaches the sandy sediments to the north of the hill; however this is spatially limited due to the thick forest coverage.

The second chosen key-area is the top of a hill to the west of the reservation, that exhibits gentle convex slopes ranging from 6° to 12° , its flat summit reach the elevation of 80m. This area represents the largest sector of illegal removal of superficial material for civil construction within the Reservation. The open mining for sand and clay in this part of Camaçari has been a systematic, large-scale operation, which is still in progress. This procedure has generated a staircase-like landscape composed of diverse impermeable platforms that have become artificial local base-levels, limited by sub-vertical slopes on clayey material. These platforms intensify the capture and channeling of the runoff, causing the slopes to recede by the excavation of deep gullies at each local knickpoint.

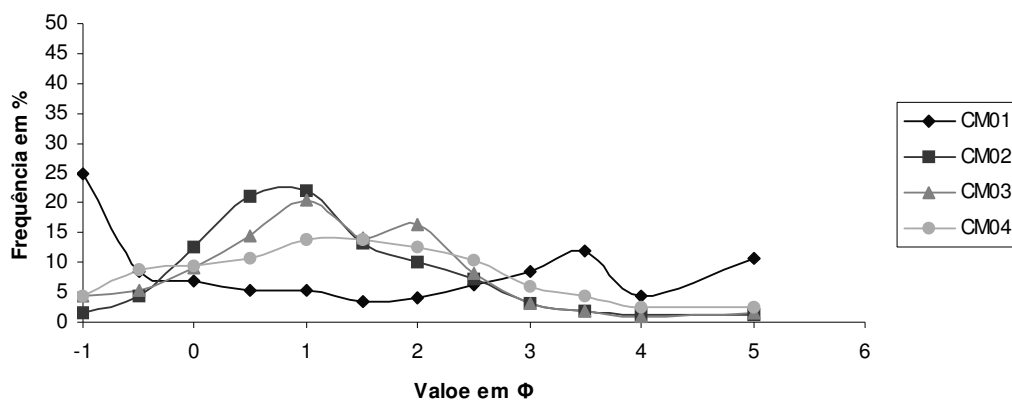
Between the 70m platform and the top of the hill at an elevation of 80m, it became clear that pedogenesis exerts an important control upon erosion in the area; since a thick eluvial sandy horizon is being quickly degraded (Sample CM04). This "paleo-E" horizon lies on the top of a B clayey horizon with a well developed blocky structure (Sample CM03). The loss of lateral support by the sandy material situated on the top of the hill (due to the excavation of the quarry) allied to its high porosity generate earth-flows, that reach the base of the profile on the top of the 70m platform. Downstream of the gullies the clayey material is deposited in the

shape of small alluvial fans and lobes, which seals the surface of the terrain provoking the damming of the runoff to the rear of the lobes noses (Sample CM 02). In those areas the dammed runoff forms seasonal puddles locally known as “banhos de lama” (mud-baths) which increases the sealing of the surface during the dry season and catalyse the runoff in the rainfall season.

Sedimentological Analyses

Samples were subjected to grain-size and morphoscopical analyses in the Laboratory of Geological Oceanography at the Federal University of Pernambuco. The results will be presented in graphic/table formats: cumulative curve (Graph 01) and tabel of statistical parameters (Table 01).

Curva de Frequência Acumulada das Amostras CM01, CM02, CM03 e CM04



Grap

h 01 – Cumulative frequency for samples CM01, CM02, CM03 e CM04.

Sample	Mean	Sorting	Assimetry	Curtosis
CM01	Medium sand	Poorly selected	Very positive	Very Platicurtic
CM02	Coarse sand	Poorly selected	Positive	Mesocurtic
CM03	Coarse Sand	Poorly selected	Approximately Symetrical	Mesocurtic
CM04	Medium sand	Poorly selected	Approximately Symetrical	Mesocurtic

Table 01 – Distribution of statistical parameters for samples CM01, CM02, CM03 e CM04.

The samples from the Reservation show little variation in their grain-size distribution, which indicates little variation of the sediment transport patterns in time. Sand fraction is poorly sorted, which is an evidence of episodes of higher depositional energy, thus suggesting that erosion followed phases of vegetation reduction. The samples do not exhibit prevailing modal classes. The massive presence of quartz in sample CM04 demonstrates that it might have

evolved as a paleo-horizon due to the loss of fines to the underlying B horizon. On the contrary samples CM01 and CM02 reflect the control of weathering imposed upon the Algodois Formation. The morphology of quartz grains was predominantly sub-rounded, attesting that the material derived from a sedimentary source area.

Finally it was observed that in the Camaçari Reservation, time exerts a major control on the pedogenetic evolution of cretaceous sedimentary deposits. Weathering profiles are cut by contemporary erosive processes generating new depositional areas, according to the diversity of soil classes and their respective structures.

CONCLUSION

Urban expansion has systematically pushed itself into natural reservations within the Metropolitan Region of Recife. In the study area, the deliberate destruction of a forest reservation has promoted the clearance of the vegetation, increase of soil loss, onset of gully erosion, siltation of small rivers, brooks and channels and the damming of the runoff due to the sealing of the soil surface by clayey rich flows. Therefore evidences point to the fact that the area is not heading towards the stabilization of its morphodynamic compartments. In the area of Camaçari, as well as along the coast of the Municipality of Cabo de Santo Agostinho it is clear that human activities are directly related to the disequilibrium of geomorphic systems. This observation is supported by the assessment of the fast paced erosion and deposition rates as well as the morphologies that are conditioned by those: depositional and erosive landforms such as gully networks, colluvium (*lato senso*) and varied forms of sedimentary infill.

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