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MANGROVE VEGETATION STRUCTURE OF THE CAPIBARIBE RIVER, RECIFE - PE: MONITORING AND CONSERVATION

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Abstract
The mangrove ecosystem is a coastal, transitional between the terrestrial and marine environment, characteristic of tropical and subtropical regions. It consists of woody plant species, called mangroves, to which an associated characteristic flora, creating favorable conditions for food, protection and reproduction of many animal species. The mangroves that thrive in estuaries that flow in the Metropolitan Region of Recife ecosystems are valuable to the city and its surroundings, but are undergoing various types of tensioners that come accelerating its degradation. The Capibaribe is one of the major rivers of Recife and the urban sprawl of recent decades has been responsible for the degradation of its environmental resources, especially mangroves, thus compromising the quality of life of coastal communities. In this context, the present work is to evaluate the structure of mangrove vegetation in the lower course of the river Capibaribe, to provide data for future conservation actions and monitoring the area. The structural characterization was adopted the methodology of multiple plots, demarcated at three sites in that swamp. The swamp was formed predominantly by the species Laguncularia racemosa, with structural parameters of average height ranging from 7.69 to 12.90 m and a maximum of 12 to 16 m and basal area average between 1.54 and 4.12 m² / ha . We recorded a minimum of 400 and a maximum of 4400 stems / ha and the density ranged from 400 to 2100ind/ha. The composition and structural data presented by mangrove vegetation in the lower course of the river Capibaribe reflect tensor anthropogenic actions to which the ecosystem is being submitted.

Keywords: mangrove forest, structural analysis, environmental degradation.

Introduction

Brazil has 12% of the world's mangroves totaling 25.000km (HERZ, 1991). Brazilian coast this ecosystem occupies about 92% of the shoreline (± 6800 km), extending from the north of Oiapoque Amapá ($40^0$30'N) to its southern limit at Dream Beach, in Santa Catarina (28°53'S), with its maximum development structure near the equator (LABOMAR UFC/ISME- BR, 2005).

According to Walsh (1974), the level of development of mangrove depend on five requirements: (1) tropical temperatures, with an average of the coldest month above 20°C, (2) predominantly muddy substrate consisting of silt and clay content and high organic matter, (3) sheltered areas, free from the action of strong tides, (4) presence of salt water since plants mangrove halophytes are optional and depend on this requirement to compete with glicóficas not tolerate salinity; (5) high tidal range.

Lugo and Snedaker (1974), Schaeffer and Cintrón - Novelli (1982) Lacerda (1984), Spring (1998) Dittmar et al. (2006) highlight the important functions of mangroves. They protect coastal areas against erosion; immobilize pollutants, such as heavy metals; to bolster the coastal food chain, for being a source of debris to adjacent coastal waters; they serve as nursery, refuge area, feeding and breeding for many animal species, including those of economic value; produce goods and services that are used by local communities.

The mitt is constituted so on ecosystem key, which is essential for preserving the operation of other ecosystems larger and more diverse, extending beyond its limits (Dinerstein, 1995).

For Vanucci (2002), these factors are responsible for eliminating a significant fraction of the mangrove areas in Brazil.
Soon, the mangroves that thrive in urban areas are subject to various pressures. These uses result in the elimination of mangrove vegetation or altering the structure of the woody community (Soares, 1997).

In the State of Pernambuco, according to Coelho et al . (2004), the mangrove stretches from the average level of the tides to the average level of high tides, between 1.0 and 2.0 m height above mean sea level and the altitude of 1.0 m of land cards, which corresponds to 17,372 ha. The distribution pattern is not always regular, but the red mangrove, Rhizophora mangle L., would be more common in the part closest to the sea, the button mangrove, Conocarpus erectus L., on the outer edge to the mangrove, the black mangrove or Siriúba, Avicennia schaueriana Stapf . & Leechmam and Avicennia germinans (L.) L., is localized in the middle portion and the white mangrove, Laguncularia racemosa (L.) Gaerten ., is localized in the portion furthest from the sea, up the river. This distribution may have been modified many times, sometimes by natural events, sometimes by human intervention.

Each mangrove reflects an adaptation to different environmental conditions which determine its composition and appearance , making them more or less sensitive to particular types of causative factors impacts (Schaeffer - Novelli , 1995). All this diversity of situations and historical usage creates a mosaic of areas with vegetation of different compositions.

The first estimate of the area occupied by mangroves in Pernambuco was proposed by Coelho and Torres (1982), assessing the territorial extent occupied by the ecosystem in the state was 17,372 hectares. Years later Monteiro et al. (2004), using satellite images, discoursed that the area occupied by mangroves in 2004 was approximately 16,139 hectares, occurring in the lower courses of major watersheds and at the mouth of small coastal rivers along the coast.

Melo (2010), in his survey on the level of mangrove degradation in the lower course of the river Capibaribe identified numerous anthropogenic tensor acting in the ecosystem, highlighting how key: urban sprawl, earthworks, embankments, mangrove cutting, waste disposal, dump domestic effluents/industrial deviation of the natural course of the river, among others.

The mangrove forest in Brazil has been studied under various aspects, such as structural, functional zonation patterns, spatial and temporal variation of vegetation through remote sensing measurements of the degree of disturbance, determining environmental vulnerability, among others.

It is known that the structural characterization of the mangrove forest is a valuable tool with respect to the response of the ecosystem to environmental conditions as well as the studies and actions that lead to environmental conservation (SOARES , 1999).

Some studies that weigh in on the composition and structure of mangrove forests in Brazil have been developed and among them we highlight the work of Smith (1999), Soares et al. (2003), God et al. (2003), Bernini and Rao (2004), Menghini (2004), Silva, Bernini and Carmo (2005), Matni et al. (2006), Menghini (2008), Soares et al . (2008) Sales et al. (2009), Bernini and Rao (2010), Kilca et al. (2011), Lignon et al. (2011), Calegario (2012) and Santos et al. (2012).

The plant structure and the degree of disturbance Mangrove Lagoon Tijuca, Rio de Janeiro, were studied by Smith (1999), through the methodology of multiple tranches proposed by Schaeffer - Novelli and Cintrón (1986), also analyzed the temporal variation of the from aerial images . The same identified a wide disparity in the structural development of the forest between the different sampling points; this heterogeneity is considered a strong indicator of the disturbed area. Soares et al. (2003) performed a structural and functional characterization of mangroves in Guanabara Bay, Rio de Janeiro. The work presented results related to action tensor that generate different degrees of degradation and regeneration stages (secondary succession) of the plots studied.

Structural characteristics of mangrove forests were analyzed by Silva, Bernini and Carmo (2005), applying the method of multiple tranches. This study proved altercations on structural development of forests, which correspond to variations in frequency and periodicity of energy subsidiaries.

The lack of planning for urban and industrial development has brought, as a result, the systematic destruction of coastal ecosystems; these are the main natural nurseries of both species characteristic of these environments as other animals that migrate to the region during the reproductive phase (SERAFIM; Hazin, 2005).

Therefore, the mangroves that thrive in estuaries that lead to the Recife Metropolitan Region (RMR) are valuable ecosystems for the city of Recife, but are subjected to various types of tensioners that come accelerating its degradation. In this context, the present work is to evaluate the structure of mangrove vegetation in the lower course of the river Capibaribe, to provide data for future conservation actions and monitoring the area.

Characterization of the Study Area

The city of Recife is located in the eastern coast of South America, on the coast of the Brazilian Northeast, and is the main urban center of the metropolitan area, which concentrates most of the metropolitan population (RCP , 2000) . The area limits on the north, south and west with the meso Forest Pernambuco and east by the Atlantic Ocean. This municipality is part of the River Basin Capibaribe. Its climate is tropical, hot and humid. The average annual rainfall in the city of Recife is 1,651.3 mm and the average annual temperature is 25 ° C (Andrade, 1977).

The vegetation consists of Rainforest (Mata Atlântica), Fields of Lowland , Restinga and Mangroves, the latter ravaged in recent decades due to landfills, illegal logging, urban sprawl and discharge of effluents/industrial (Cruz, 1999).

The studied section is located on the lower course of the river Capibaribe. It lies between the coordinates 8º 01'13 " and 8 ° 02'25 " S , 34 º 56'09 " and 34 º 54'36 " W , in a populated area and considered a high economic standard, totaling 5 km in length (Figure 1).

The landscape of Recife was modified over time with numerous landfills undertaken in the area , which contributed to the design of the islands of the neighborhoods of Recife, in addition to various geo-environmental factors, the feature of the plain Recife displays peculiarities of human actions, emphasizing deforestation, landfills and buildings that significantly distorted your website, increasing and stabilizing soils, restricting the spaces occupied by vegetation and soils (PCR , 2000).

Rio has in its upper and middle course seasonal waters, or in some months of the year dries completely. In the lower course, which starts from Lemon Tree, its waters are perennial. In winter becomes so voluminous that sometimes causes flooding and damage in the riparian areas of the municipalities (CPRH, 2009b).

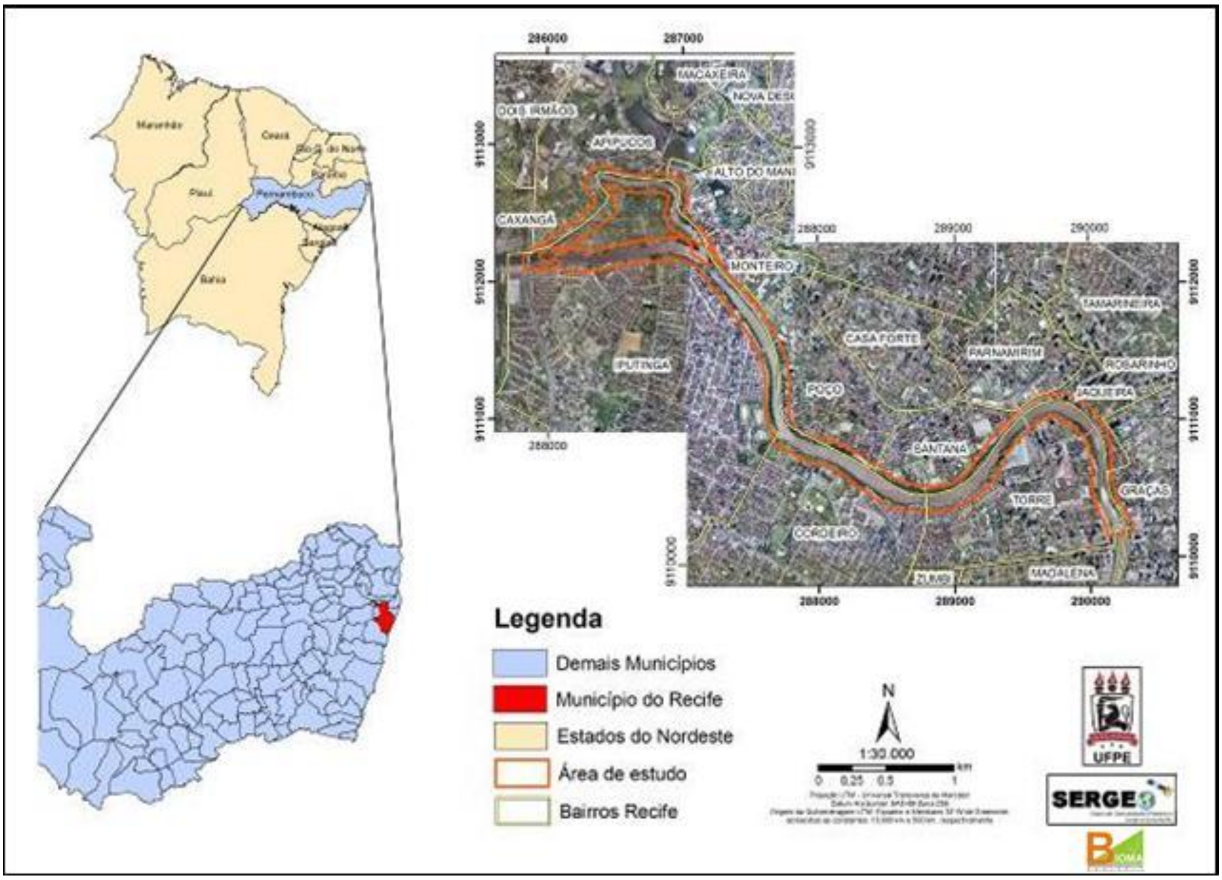

Figure 1. Study area in the lower course of the Capibaribe River, Recife -PE.

In the Metropolitan Region of Recife stand out as major works causing environmental impacts the construction of ports in estuarine areas, beyond speculation, with many projects already implemented or under implementation in mangrove areas such as highways and roads, condos and subdivisions (Neta, 2005). Urban development in the town has degraded large areas of natural vegetation, which are under speculation as well as those who have nowhere to live and build their homes in these places discretion.

Material and methods

The structural characterization was adopted the methodology of multiple tranches proposed by Schaeffer - Novelli and Cintrón (1986), being demarcated plots of 10x10m, positioned perpendicular to physicochemical gradients and are oriented parallel to the river.

Structural analyzes were conducted at three sites (A, B and C) of mangroves, which were demarcated three installments (P1 , P2 and P3) due to the greater extent of mangrove, the B site, which was held a portion (P4), and site C , which was also demarcated a portion (P5) (Figure 2). In the last two sites were carried out only a portion due to the narrow strip occupied by mangroves.

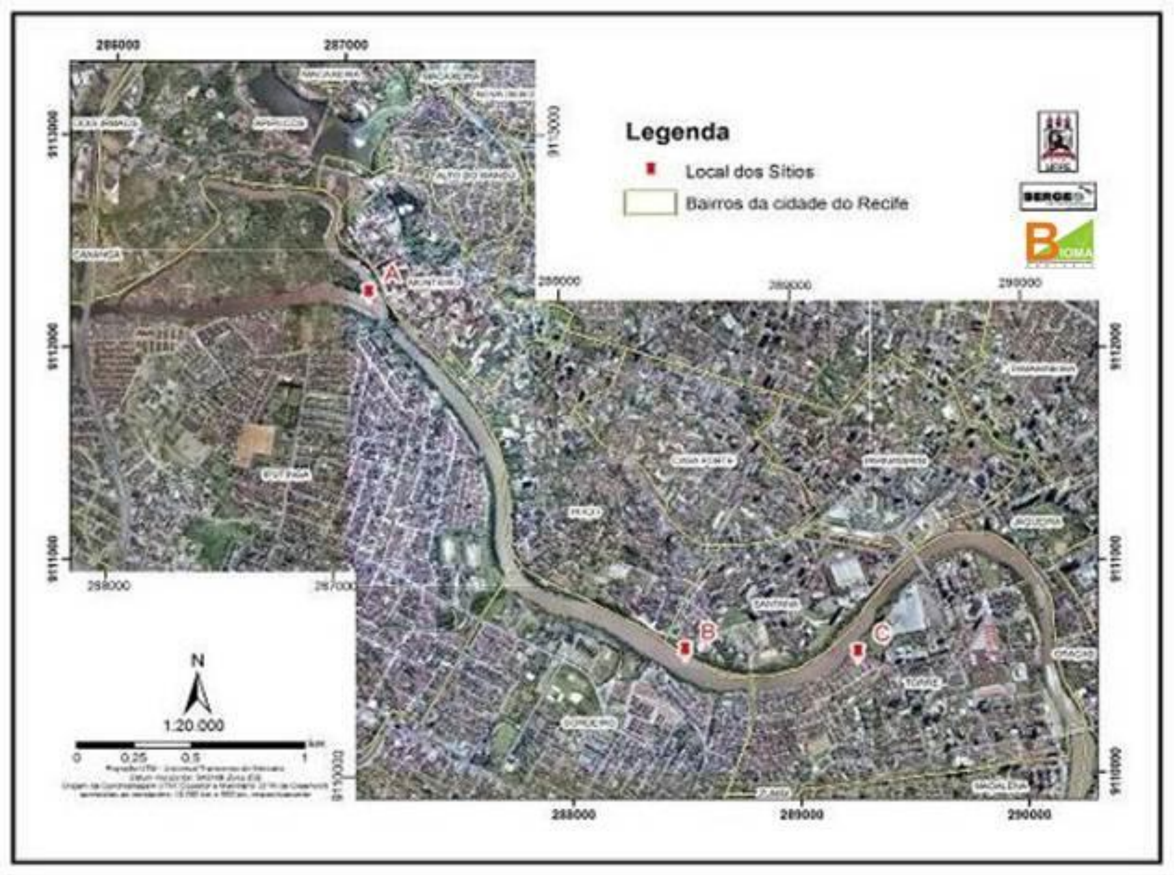

Figure 2. Location of sites studied in the lower course of the river Capibaribe, Recife – PE.

For the application of the structural parameters were considered as some characteristics of the forest: species composition, diameter at breast height (DBH), basal area (BA), average basal area (ABM), average height, number of trunks, density of individuals per hectare.

For the demarcation of plots were used nylon rope, tape measure calibrated and bamboo stakes. As each tree was being cataloged marked up one by one with string or spray paint to avoid counting of individuals.

In each plot were measured diameter at breast height (DBH), obtained at 1.30 m above the ground, using tape graduated in cm. The in situ measurements were recorded on field sheets arranged in columns by diameter class of DAP: ≤ 2.5 cm (small), between ≥ 2.5 cm and ≤ 10.0 cm (intermediate), and ≥ 10 cm (high). Within each plot were considered those with stem diameter less than 2.5 cm.

The tree diameter (dbh) was measured according to rules which satisfy the deficiencies of each. Was used tape graduated in centimeters and the values were divided by π = 3,1416, to obtain the diameter of each individual.

The measurements of the heights of trees were obtained with stick "telescoping" and hypsometer. In all subjects were evaluated and the heights measured the diameters of the stems, the level of the sediment, except for mangle, whose diameters were measured above the highest rhizophore. The lower plants (up to 10m) had their height measured directly using a graduated rod in meters. In larger plants that stick, told with the help of hypsometer.

The average height of the forest for each of the plots in their respective sites was obtained from the total amount of time divided by the number of trees counted. Thus, the calculation was made from the arithmetic mean, ie, added to the height values of individuals living dividing that by the number of live trees.

The basal area of trunks living was defined as the area occupied within a plot by a living trunk with a given diameter, expressed in m² (square meter) per hectare (ha). The basal area serves as an indicator of the degree of development index gained the woods, because it expresses the volume of wood and biomass of the forest.

The basal area (BA) is expressed by the following formula: $g=\pi r^2$, where g is the basal area and r is the radius, replacing the radius of r = dap/2, then one has $g = \pi / 4 \times dap^2$, forming following formula: $g = \pi (DAP)^2 / 4x10.000$. To express the formula in square meters per hectare (m²/ha) we have: g = AB (m²/ha) = 0.007854 x (cm dbh)² Ie, to obtain the value of basal area, multiply the constant (0.00007854) for stem diameter in centimeters, of each tree by species, bringing this to the square. The basal area is calculated from the sum of the par AB same species.

To calculate the average basal area is used dividing the value of total basal area, measured by the number of individuals of each species. The investigation of the density of individuals was performed by counting the number of trunks, considering that when the tree forks below breast height should be accounted trunks but a single individual, preferably that have greater diameter.

To quantify the number of trunks needed is the sum of all the trunks alive, including those forks. Both parameters mentioned above are transformed into ha multiplying them by 100.

The data were organized into an Excel spreadsheet for further analysis using the software SPSS Data Editor, version 15.0. For the treatment and analysis of the data once its complete tabulation were used statistical measures of central tendency of the observations and calculated measures of descriptive statistics such as mean, median, mode and standard deviation . These measures enabled a statistical overview of the degree of compliance of the companies with waste treatment practices, as defined in Magazine Editorial Analysis.

Results and discussion

The mangrove vegetation which is distributed in the studied stretch on the banks of the lower course of the river Capibaribe consists almost exclusively by the species L. racemosa with 98% of the individuals recorded in three sites (A, B and C).

Comparing the three plots it was observed that the P2 had the highest average basal area, 4.12 m² / ha, and P3 the lowest, with 2.16 m² / ha. In relation to the density of individuals were recorded 1800ind./ha in P1 , the highest value , while the P2 400ind./ha reached the lowest value . Regarding the average height of the trees the highest and lowest value (9.87 m and 7.69 m) were recorded in the P2 and P1, respectively.

As regards the number of trunks in 2400 there was a variation in logs / ha (P1) and 400 logs / ha (P2) (Table 1, Figure 3).

Considering the data obtained for the three sites C showed the highest values of average height (12.90 m), density (2100 ind ./Ha) and number of stems / ha (4400) and the lowest average AB (1.54 m² / ha). At site B were found taller individuals (16m) (Table 1, Figure 3).

It was observed that the basal area average showed an increasing trend towards downstream, upstream, while the number of stems, the density of individuals per hectare and the average height increased in the downstream - upstream direction, since the highest values of these parameters were obtained in the B sites (P4) and C (P5) (Table 1, Figure 3).

Table 1 – Value structural characterization of the points in mangrove of the low curse of Capibaribe river.

Site		AB average m^2/ha	**Number of trunks/ha**	Densidad (ind./ha)	**Higth Máx.(m)**	Higth Mín.(m)	**Higth average(m)**
A	**P1**	2,52	**2400**	1800	**12**	3,50	**7,69**
	P2	4,12	**400**	400	**12**	2,60	**9,87**
	P3	2,16	**1500**	700	**11**	4,00	**8,85**
B	**P4**	2,68	**3000**	1800	**16**	4,00	**12,06**
C	**P5**	1,54	**4400**	2100	**15**	1,30	**12,90**

Fonte: Elaborado pelo autor.

Soares et al. (2008) characterized the mangrove forests of the Estuarine System Caravels, which make up the complex Abrolhos / BA, where they observed that the species composition showed a strong organized in patterns and estuarine intertidal zonation, with R. mangle dominated zones with the highest frequency of flooding by tides, A. schaueriana dominating the areas with the greatest influence and salina L. racemosa areas greater influence of freshwater inflow.

Sales et al. (2009) to study the structure of mangrove forests in the river Cajutuba, Marapanim municipality, northeast of the state of Pará, identified the occurrence of the species L. racemosa, A. germinans and R. mangle, the latter being the dominant species in the forests studied.

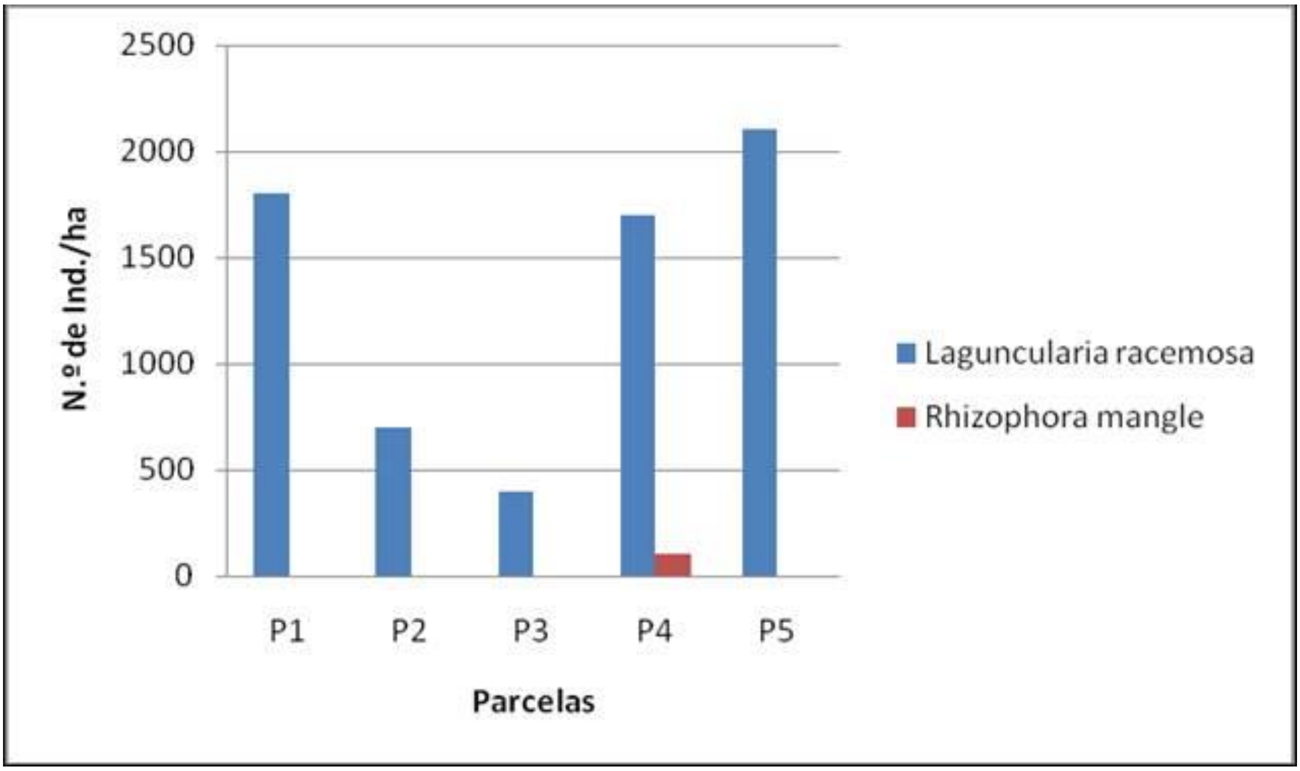

Figure 3 - Distribution of the number of individuals per plot in the lower course of the river Capibaribe.

According to Schaeffer - Novelli and Cintrón (1986), L. racemosa tolerate salinities slightly higher than R. mangle, but appears to compete more effectively in areas of reduced salinity. For Fernandes and Peria (1995), mangrove species are typical of saline environments even though they are able to grow in environments free from the presence of salt, and thus can’t occur under these conditions the development of forests, because they lose these species to place those that grow faster and are better adapted to the presence of fresh water. These authors point out that the genus Rhizophora is less tolerant to salt, growing in environments where water has interstitial levels below 50. Already Avicennia is the genre with more strength, managing to survive in places where the salinity content varies between 65 and 90. Laguncularia has intermediate tolerance when confronted with previous genres.

Thus, in analyzing the structure of the mangrove estuary Itabapoana, located between the cities of Sao Francisco de Itabapoana-RJ and President Kenedy -ES Bernini and Rao (2010) evaluated the woods with better structural development exhibited dominance of A. germinans, while L. racemosa was dominant in woods less developed. The structural results showed that plant community aspects abiotic and biotic factors contribute to the differentiation between sites.

When performing the characterization of a single mangrove forest in the northern sector of the Baía da Babitonga, Kilca et al. (2011) found that L. racemosa had the highest importance value in the community, then the species R. mangle and A. schaueriana. The authors claim that it is possible to infer that the mangrove studied is in the middle stage of succession.

Calegario (2012) examined aspects of the structure of the vegetation in the estuary of the Sao Joao -RJ river with sites marked on the upper and lower estuary, where they recorded the species R. mangle, L. racemosa and A. schaueriana, not observed zonation of species along the gradient flood, but along the estuary, with L. racemosa being dominant in the upper estuary and R. mangle in the lower estuary.

Souza and Sampaio (2001), studying the mangrove forests of Suape, observed that R. mangle appeared most often on the fringe of the woods, especially near the mouth, gradually being replaced by Avicennia and / or L. racemosa more to the interior of the continent.

In the mangrove peninsula of Bragança, Matni et al. (2006) reported L. racemosa as pioneer species in the recolonization of areas of clearings, as well as colonizing degraded mangrove areas, which was also observed on the banks of the lower course of the river Capibaribe, where this species is responsible for recolonization occurred in recent years.

The presence of L. racemosa associated with altered forests that are undergoing restructuring is also cited by Peria et al. (1990) and Smith (1999). According to God et al. (2003), L. racemosa and A. germinans tend to resprout after cutting, in contrast to mangle that hardly regrowth.

Soares et al. (2003) studied the mangrove forests in Baia da Guanabara, RJ, found that the structural heterogeneity observed was strongly influenced by anthropogenic tensioners that operate in the region, and has in some cases reduced by the action current composition of these tensors and in other cases characteristics of woods in the regeneration process (secondary succession).

Recently, Santos et al. (2012) characterized the horizontal and vertical structure of mangrove forest in the estuary of the river São Francisco, Sergipe, identified factors that promote changes in these communities, it was observed that the mangroves had a low structural development, R. mangle was the most important species of the forest, L. racemosa was further explored by the local population in terms of wood, and has been undergoing gradual change in its structure, presenting more branched and undeveloped.

In Pernambuco state, few studies have assessed the mangrove also under the structural point of view, namely: Braga (1989) and Souza and Sampaio (2000, 2001) in Suape, Schuler; Andrade and Santos (2000) in Canal de Santa Cruz; Correia (2002), in the estuary of Timbo and Barbosa (2010) in the Mangrove Pina, accounted values average height between 6.7 m to 16.3 m and maximum of 10m to 18m, and these higher than those recorded in the mangroves of the lower course of the river Capibaribe.

Nascimento Filho et al. (2007) characterized the patterns of zonation and structural development in mangrove river Ariquindá, Tamandaré - Peranmbuco, also including aspects of the environmental gradient, degree of flooding and salinity of the studied areas.

Recently, Barbosa (2010) conducted a structural analysis of vegetation and diagnoses spatiotemporal in mangrove Pina - PE, which were identified and quantified the spatiotemporal changes of the areas, occupied by mangroves over three decades, and have been related to some environmental factors on the composition and structure of the forest. Thus, the structural data presented in this study reflect the actions of drivers and/or anthropogenic tensor discovered by Melo (2010) in his survey of the main indicators of environmental impacts in mangroves of the lower course of the river Capibaribe.

The authors also found high levels of total basal area of 60.8 m²/ha, while the area currently assessed was recorded 45.66 m² / ha . This divergence of basal area is related to the higher contribution of the species R. mangle in mangroves of Suape-PE. In Suape, Pernambuco (SOUZA; Sampaio, 2001), Piauí (GOD et al. 2003), in Paraíba do Sul river - RJ (BERNINI; Rezende, 2004) and Bragança-PA (Matni; Menezes; Mehlig, 2006) were highlighted high levels of structural characteristics of the forest, mangrove compared with the lower course of the river Capibaribe, especially in relation to basal area, density of individuals living and trunks per hectare, and the average height.

Conclusions

The structural features observed in different sites analyzed reflect the impacts of human actions that the watercourse and its banks are being submitted, particularly in the metropolitan area of Recife.

The predominance of Laguncularia racemosa indicates that the forests are degraded and regeneration process, since this species is a pioneer in the recolonization of areas subject to environmental tensioners.

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References

Alarcon, G. G.; Panitz, C. M. N. (1998). Estudo comparativo da percepção ambiental de dois manguezais submetidos a diferentes condições ambientais e de ocupação urbana. In: Simpósio Brasileiro De Etnobiologia E Etnoecologia, 2, São Carlos. Resumos... São Carlos: Universidade Federal de São Carlos, p. 13.

Andrade, G. O. (1977). Alguns Aspectos do Quadro Natural do Nordeste. Recife, SUDENE, 75p.

Barbosa, F. G. (2010). Estrutura e análise espaço temporal da vegetação do manguezal do Pina, Recife-PE: subsídios para manejo, monitoramento e conservação. Dissertação – Universidade Federal de Pernambuco. CFCH. Geografia. 89 f.: il., fig., tab. Recife.

Bernini, E; Rezende, E. R. (2004). Estrutura da Vegetação e Floresta de Mangue do Estuário do rio Paraíba do sul, Estado do Rio de Janeiro, Brasil. Rio de Janeiro. Acta bot. bras. 18(3). p. 491-502.

Braga, R. A. P; Uchoa, T. M. De M; Duarte, M. T. M. B. (1989). Impactos ambientais sobre o manguezal de Suape – PE. Acta bot. bras. 3 (2).

Calegário, G. (2012). Aspectos estruturais da vegetação do manguezal do estuário do rio São João – RJ. Dissertação de Mestrado, 60p. Universidade Estadual do Norte Fluminense Darcy Ribeiro, UENF, Brasil.

Candeias, A. L. B; Tavares Júnior, J. R; Moura, A. R. L. U. De; Medeiros, C. (2008). Reconhecimento das feições do complexo estuarino de Itamaracá usando índices espectrais. Anais II Simpósio Brasileiro de Ciências Geodésicas e Tecnologias da Informação. Recife.

Cintrón, G; Schaeffer-Novelli, Y. (1981). Proposta para Estudo dos Recursos de Marismas e Manguezais. Relatório Interno do Instituto Oceanográfico da Universidade de São Paulo, Nº 10. São Paulo, p. 1-13.

Coelho, P. A; Torres, M. F. A. (1982). Áreas estuarinas de Pernambuco: Trabalhos Oceanográficos da Universidade Federal de PE. Recife, v.17, p. 67-80.

Coelho, P.A.; Batista-Leite, L.M.A.; Santos, M.A.C. ; Torres, M.F.A. O Manguezal. In: Eskinazi-Leca, E.; Neumann-Leitao, S.; Costa. M.F. (Orgs.). (2004). Oceanografia um cenário tropical. Universidade Federal de Pernambuco, Centro de

Tecnologia e Geociências, Departamento de Oceanografia, p.641-688.
Correia, V. L. (2002). O Bosque de mangue do estuário do rio Timbó, estado de Pernambuco, Brasil: características estruturais e vulnerabilidade da área frente às tensões antrópicas. Dissertação de Mestrado, Programa Regional de Pós-Graduação em Desenvolvimento e Meio Ambiente/PRODEMA.
CPRH, (2009). Diagnóstico socioambiental – Litoral norte de Pernambuco. Recursos hídricos superficiais. 2009b. Disponível em: <http://www.cprh.pe.gov.br/downloads/24_Recursos_Hidricos_Superficiais.pdf> Acesso em: abr.
Cruz, U.P. da. (1999). A importância do planejamento para a implantação adequada de um programa de arborização. In: Encontro Nacional De Arborização Urbana, VIII. 1999, Fortaleza; Feira Nordestina De Ecologia E Meio Ambiente, 1ª, 1999. Anais... Fortaleza: Sociedade Brasileira de Arborização Urbana, p. 55.
Deus, M. S. M; Sampaio, E. V. S. B; Rodrigues, S. M. C. B.; Andrade, V. C. (2003). Estrutura da vegetação lenhosa de três áreas de manguezal do Piauí com diferentes históricos de antropização. REVISTA: BRASIL FLORESTAL – Nº 78, p. 8.
Dinerstein, E; Olson, D. M; Graham, D; Webster, A; Primm, S; Bookbinder, M; Ledec, G. (1995). A conservation assessment of the terrestrial ecoregions of Latin America and the Caribbean. The World Bank in association with the World Wildlife Fund, Washington, D. C. USA.
Dittmar, T; Hertkorn, N; Kattner, G; Lara, R. J. (2006). Mangroves, a major source of dissolved organic carbon to the oceans. Global Biogeochemical Cycles.v. 20, GB 1012.
Fernandes, A.J; Peria, L.C.S. (1995). In: Manguezal: Ecossistema entre a terra e o mar. Caribbean Ecological Research: São Paulo. 64 p.
Herz, R. (1991). Manguezais do Brasil. Instituto Oceanográfico, Universidade de São Paulo, São Paulo, 227 p.
Kilca, R. V; Alberti, L. F; Souza, A. M; Wolf, L. (2011). Estrutura de uma floresta de mangue na Baía da Babitonga, São Francisco do Sul, SC. In: Ciência e Natureza, UFSM. v. 33. 57 – 72.
Labomar. (2005). Universidade Federal do Ceará (UFC). Instituto de Ciências do Mar - Sociedade Internacional para Ecossistemas de Manguezal – ISME-BR. Estudo das Áreas de Manguezais do Nordeste do Brasil: Avaliação das áreas de manguezais dos Estados do Piauí, Ceará, Rio Grande do Norte, Paraíba e Pernambuco. Ceará, 62 p.
Lacerda, L. D. (1984). Manguezais: Florestas de Beira Mar. Ciência Hoje. v. 3, nº. 13: 63-70.
LIGNON, M. C; COELHO JR, C; ALMEIDA, R; Menghini, R. P; Schaeffer-Novelli, Y; Cintrón, G; Dahdouh-Guebas, F. (2011). Characterization of mangrove forest types in view of conservation and management: a review of mangals at the Cananéia region, São Paulo State, Brazil. Journal of Coastal Research, SI 64 (Proceedings of the 11th International Coastal Symposium), 349-353. Szczecin, Poland, ISSN 0749-0208.
Lugo, A. E.; Snedaker, S. C.. (1974). *The ecology of mangroves*. Ann. Rev. Ecol. Syst., 5: 39-64.
Matni, A. S.; Menezes, M. P. M.; Mehlig, Ulf. (2006). Estrutura dos bosques de mangue da península Bragança, Pará, Brasil. Bol. Mus. Para. Emílio Goeldi, Ciências Naturais, Belém, v. 1, n. 3, p. 43-52, set-dez.
Melo, J. G. S. (2010). Manguezal do baixo curso do rio Capibaribe: estrutura da vegetação, impactos ambientais e análise espaço temporal. Recife, Pernambuco, Brasil. (Monografia de Graduação), 71p., Departamento de Ciências Geográficas, Universidade Federal de Pernambuco, Recife, PE, Brasil.
Menghini, R. (2004). Ecologia de manguezais: grau de perturbação e processos regenerativos em bosques de mangue da Ilha Baranabé. Baixada Santista, São Paulo, Brasil. Dissertação de Mestrado, 98 p., Instituto Oceanográfico, Universidade de São Paulo, São Paulo-SP, Brasil.
Menghini, R. (2008). Ecologia de Manguezais: Dinâmica da recomposição natural em bosques de mangue impactados. Tese, 22f. Instituto Oceanográfico da Universidade de São Paulo.
Monteiro, L. H. U; Souza, G. M; Maia, L. P; Lacerda, L. D. de. (2004). Evolução as áreas de manguezal do litoral nordeste brasileiro entre 1978 e 2004. Revista da Associação Brasileira de Criadores de Camarão, Recife, p. 36 - 42 01 set.
Neta, M. A. V. (2005). Geografia e Literatura: Decifrando as Paisagens dos Mocambos do Recife. Rio de Janeiro-RJ. (Dissertação) – Universidade Federal do Rio de Janeiro, Instituto de Geociências UFRJ/PPGG, 116 p. vol. 1.
Peria, L.C.S.; Fernandez, P.P.C.P.; Menezes, G.V.; Grasso, M. E Tognella, M.M.P. (1990). Estudos estruturais comparativos entre bosques de mangue impactados (Canal de Bertioga) e não impactados (Ilha do Cardoso), Estado de São Paulo. SP. 183-193. In: Anais do II Simpósio de Ecossistemas da Costa Sul e Sudeste Brasileira. Águas de Lindóia, ACIESP, v. II.
PCR. (2000). Prefeitura da Cidade do Recife. Atlas Ambiental da Cidade do Recife. 151p.
Primavera, J. H. (1998). Mangroves as nurseries: Shrimp populations in mangrove and non-mangrove habitats. Estuarine, Coastal and Shelf Science, v. 46, p. 457-464.
Santos, T. De O; Andrade, K. V. S. De; Santos, H. V. S; Castadena, D. A. F. G; Santana, M. B. S; Holanda, F. S. R; Santos, M, J, C. (2012). Caracterização estrutural de bosques de mangue: Estuário do São Francisco. In: Scientia Plena, V. 8, Nº. 04.
Sales, J. B. De L; Mehlig, U; Nascimento, J. R; Filho, L. F. R; Menezes, M. P. M. de. (2009). Análise estrutural de dois bosques de mangue do rio Cajutuba, município de Marapanim, Pará, Brasil. Bol. Mus. Para. Emílio Goeldi. Ciências Naturais, Belém, v. 4, n. 1, p. 27-35, jan.- abr.

Schaeffer-Novelli, Y. (1995). Manguezal: ecossistema entre a terra e o mar. São Paulo: Caribbean Ecological Research. p.7-15.

Schaeffer-Novelli, Y.; Cintrón, G. (1986). Guia para estudos de áreas de manguezais (estrutura, função e flora). [S.l.]: Caribean Ecological Research. 156p.

Schuler, C. A. B; Andrade, V. C; Santos, D. S. (2000). O manguezal: composição e estrutura. In: BARROS, H. M.; ESKINAZI-LEÇA, E; MACEDO, S. J; LIMA, T. Gerenciamento participativo de estuários e manguezais. Recife: Ed. Universitária da UFPE, p. 27-38.

Serafim, C. F. S; Hazin, F. H. V. (2005). O ecossistema costeiro. In: Serafim, C. F. S.; Chaves, P. T. de (Org.). O mar no espaço geográfico brasileiro. Brasília – DF: Ministério da Educação. v. 8, p. 101-115.

Silva, M. A. B; Bernini, E; Carmo, T. M. S. (2005). Características estruturais de bosques de mangue do estuário do rio São Mateus, ES, Brasil. Acta Botânica Brasílica.19(3), p. 465-471.

Soares, M. L. G; Chaves, F. De O; Estrada, G. C. D; Cavalcanti, V. F; Portugal, A. M. M; Barbosa, B. (2008). Caracterização das florestas de mangue do complexo estuarino de Caravelas – Bahia – Brasil. Bol. Téc. Cient. CEPENE, Tamandaré - PE - v. 16, n. 5, p. 23-41.

Soares, M. L. G. (1997). Estudo da biomassa aérea de manguezais do sudeste do Brasil - análise de modelos. Tese de Doutorado. Instituto Oceanográfico, Universidade de São Paulo. Vol. 2. 294 p.

________, M. L. G.. (1999). Estrutura vegetal e grau de perturbação dos manguezais da Lagoa da Tijuca, Rio de Janeiro. RJ. Brasil. Revista Brasileira de Biologia 59(3): p. 503-515.

Soares, M. L. G.; Chaves, F. O.; Corrêa, F. M.; Júnior, C. M. G. S. (2003). Diversidade estrutural de bosques de mangue e sua relação com distúrbios de origem antrópica: o caso da Baía de Guanabara (Rio de Janeiro). An. do Inst. de Geociências - UFRJ, 26: 101-116.

Souza, M. M. A.; Sampaio, E. V. (2001). Variação temporal da estrutura dos bosques de mangue de Suape-PE após a construção do porto. Acta Botânica Brasílica. v. 15, n. 1, p. 1-12.

Vannucci, M. (2002). Os Manguezais e nós: uma síntese de percepções. 2ª ed. rev. e amp. São Paulo: EDUSP, 244 p.

Walsh, G. E. (1974). Mangroves: a review. In: Reimold, R.J E Queen, W.H. (Eds.). Ecology of halophytes. Academic Press, New York, p. 51-171.