



Annual Symposium  
IGCP 582-Tropical Rivers:  
hydrophysical processes, impacts, hazards  
and management  
Belem- Brazil, 2010



Tropical Rivers



Meeting related to the Large Rivers Working Group of  
GLOCOPH-Global Commission on Continental Paleohydrology,  
Tropical Rivers Working Group-International Association of  
Geomorphologists and PROSUL Program-CNPq  
Hold at the 45<sup>o</sup> Brazilian Congress of Geology



REGHRAS-Repota hidrofisica  
da mudanca global e dos impactos  
antrpicos em grandes rios da  
America do Sul





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**BELEM, BRAZIL**  
SEPTEMBER 29 TO OCTOBER 1<sup>st</sup>, 2010

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## **PAST AND PRESENT RELATIONSHIPS IN THE MORPHODYNAMICS OF THE PARANÁ RIVER**

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The floodplain of the Middle Paraná River (10 to 50 km-width between 27° 17' S and 32° 57' S) had been under construction from the Upper Quaternary to present times, dominantly with sandy sediments. In some places, sand beds are covered by 4 to 10 m-thick of lacustrine and swampy sediments, silty and clayey in grain size. Coarse sands (with gravelly sand lenses) are dominant in the sedimentary record, from 10-15 m below the floodplain surface to lower levels; coarse sediments include fossils of Lujanean Mammal Age (Late Pleistocene-SALMA).

The floodplain was built by eastward shifting channel belts. Some channel belts were generated under climatic conditions and base levels that were different to the present ones. Remains of aeolian dune fields exist in the floodplain. Furthermore, some of the superficial silty-clayey sediments have gypsum indicating aridity in the area.

Several properties of the current dynamics of the entire fluvial system result from their interrelationships with the ancient sediments and Quaternary history; some of that are:

**Sedimentology:** bed sediments of the largest river channels are medium sands in size, mainly; sometimes, fine gravels are present in recent sandbars; gravels come from the coarse strata of the floodplain subsoil, reworked by the channel thalwegs. The old sediments are the exclusive source of bed sediments in some channels of the anastomosed network: sandy patches are found in their silty-clayey bottoms; sandy sediments include soft ferruginous concretions (up to 3 cm-long), suggesting short distances of bedload transport.

**Morphologic stability:** channel bank movements in the Paraná fluvial system are measured as some m/year, up to dozens or hundreds m/year in the main channel. Everywhere the channels attain ancient silty-clayey sediments the displacements radically decrease, and the banks remain nearly "fixed" during dozens years.

**Morphodynamics:** the pattern of the channel bank movement is influenced by the ancient silty-clayey sediments, also; in turn, changes in the pattern of growth of channel islands are recorded. On the other hand, the connection between two floodplain belts (different in age and slope) by split channels during floods, originates new channels (some that enlarged as secondary channels of the system in recent times); the sandy sediments deposited by these new channels come, partially or entirely, from the sandy strata of the floodplain subsoil.

# **FLUVIAL EVOLUTION ON THE VELHAS AND JEQUITAIÁ RIVER BASINS (MINAS GERAIS STATE, BRAZIL): LITHOLOGIC VARIABILITY AND CENOZOIC TECTONICS**

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The Velhas and Jequitaiá river basins are important affluents on the right margin of the São Francisco river. They drain three morphotectonic domains of Minas Gerais State (Brazil): Quadrilátero Ferrífero, Bambuí Sedimentary Basin and Espinhaço Range. Each of these domains has clearly distinct topographic, structural and lithologic properties.

In these basins the fluvial morphosedimentary patterns are strongly conditioned by the aforementioned contrasts. A series of morphological flats around the two basins is the main result of this dynamics. Nonetheless, there is a lack of systematic investigations of the specific flat conditionings.

In order to find out the baselevel installation mechanisms, tridimensional slope models were generated over SRTM images. The analysis of these models provided the identification of 40 and 392 morphological flats in the Jequitaiá and Velhas river basins respectively.

A preliminary field trip pointed serious logistic problems related to the research site. For this reason only 26 flats (14 on Velhas river basin and 12 on Jequitaiá river basin) were accessed by car and studied in the field. Each was surveyed at 1:500 scale. Log profiles were also described.

The geological properties of each point were compiled from the available regional geological maps. The existence of neotectonic traces in the vicinities of each point was searched in the specialized literature.

In the Velhas river basin the associated analysis of morphological, stratigraphic, geological and neotectonic data showed that the baselevels were installed due to carstic collapse (2 points), fluvial confluences (1 point), lithologic contacts (3 points) and Cenozoic tilting (the remaining points). In the Jequitaiá river basin, the flats were installed due to carstic collapse (11 points) and Cenozoic tectonics (1 point).

Despite the expressive number of baselevels associated with carstic collapse, limestone outcrops were only seen on two occasions. All other collapse flats were developed over a metapelitic stratigraphic unit, where limestones occur only as thin beds or lenses. This fact suggests an anomalous evolution of the regional relief, where the local variabilities are controlled by the predominance of one of these two lithologies.

The neotectonic tilting process is supported by many morphological and sedimentary data, for example the asymmetry of some valleys of Velhas river basin. In the Jequitaiá river basin, the southern portion has a fluvial incision pattern that increases systematically southward. On the other hand, the incision process is increased northward on the northern portion.

The neotectonic patterns are congruent with some previous works and suggest that:

1 – the Velhas river basin is tilting eastward along Brazilian reverse faults due to the compressive regime of the South-American Plate and the contrasting density of the Espinhaço Range and Bambuí Sedimentary Basin and

2 – the southern and northern portions of the Jequitaiá river basin are tilting to the middle axis of the basin following the slow deepening of the NW-SE Jequitaiá graben, where the main channel of Jequitaiá river has installed.

# **RELATIONSHIPS AMONG VEGETATION, SURFACE SEDIMENTS, SURFACE WATER AND GROUNDWATER IN THE FLOODPLAIN OF THE PARANA RIVER, ARGENTINA.**

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The expression of vegetation is regulated by the interaction among different components of prevailing environment. The hydrosedimentological dynamics is an environmental variable of great importance in the floodplain of the Parana river due to its influence on the distribution and characteristic of vegetation units. However, little is known about the role of components as the chemical characteristics of sediments or groundwater. The aim of this work was to establish at local scale relationships among vegetation, surface sediment, surface water and groundwater and, at regional scale, to reproduce the groundwater dynamics. The vegetation units were identified at different topographic levels along a section across the floodplain of the Parana river. Physical and chemical characteristics of samples of sediments and groundwater were defined for each defined vegetation unit, as well as for the Parana river and three different water bodies. Finally, five hydrogeological information layers were integrated in a groundwater model that reproduces its regional dynamics. Four vegetation units were identified and described along of topographic gradient: Simple forests of marginal levee, Mixed forests of internal levees, Tall grass herbaceous community and Flooded herbaceous community. Locally, differences between woody and herbaceous units – the first two and the latter two, respectively- could be explained from flood frequency and texture of sediments; however, this fails to explain the differences in forest distribution and its characteristics. An explanation of the differences could be related to physical and chemical quality of groundwater found. On the other hand, geomorphological dynamics from which each site in the flood plain is developed could explain too the differences between forests. Regionally, the hydrological dynamic model supports physical and chemical analyses of groundwater which revealed that the floodplain of the Parana River constitutes a discharge area of groundwater recharged outside the studied floodplain. This conclusion was supported by stable isotopes  $^{18}\text{O}$  y  $2\text{H}$ .

# **HISTORICAL FLOODS OF THE YANGTZE RIVER, CHINA: CHARACTERISTICS, CAUSES AND CONSEQUENCES**

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This paper is an attempt to examine the characteristics and causes of floods in the Yangtze basin, which has a long history of catastrophic flood events, especially in its middle reaches. On the basis of in-situ field observations and data collected on fluvial morphology, discharge (both maximum and mean) distribution, hydrographic fluctuations, and flood duration, aided by RS and GIS techniques the flood history of the Yangtze basin revealed: 1) an increasing trend in flood frequency from a 18-year cycle hundreds of year ago to a 3-year cycle in the recent times over millennial scale; 2) 16.4-year and 2.5-year cycles of the major flood events in the centennial scale; 3) a rising tendency of high water stage and increasing flood duration with time, but with a marked decrease in area of inundation in the basin; and 4) a 60-year return period for the major basin-wide flood events such as the series of flood waves generated by monsoon precipitation in 1998, initiated from the middle Yangtze, which is an example of the climate-induced flood hazards in the basin. Intensified anthropogenic activity in the last century, including deforestation, dyking, wetland reclamation and farming that results largely in the aggradation of riverbeds and shrinkage of lake area, etc., specifically in the middle Yangtze reaches, can be interpreted as the major causes for the recent human-induced flood events in the basin.

# THE SPATIAL BIOGEOMORPHOLOGICAL HETEROGENEITY OF A FLOODPLAIN TYPICAL OF TROPICAL RAINFOREST HYDROSYSTEMS THE UPPER NYONG RIVER (CAMEROON)

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An integrative approach based on multi-scalar analysis and taking into account various data sources (air photographs and satellite images, topographic ground surveys, hand corings, particle-size analysis, radiocarbon dates) has been implemented to highlight the biogeomorphological variability in the Nyong floodplain on a 52-km-long valley section that is characteristic of the upper river course.

The geomorphic characterization of this floodplain through the definition of spatial patterns and the genetic classification of relief features existing at the surface show a complex mosaic of fluvial landforms that derive from accretion and reworking processes ongoing since the Lateglacial and, especially, since the early-Holocene. Amongst the geomorphic units resulting from the depositional processes, remnant Lateglacial fans and Holocene floodplain 'highs' or alluvial ridges appear prominent and spatially extensive, whereas the scrolled floodplain, often below the main channel banks and levees tend to be featureless. Floodplain features related to reworking processes are various and include anabranching paleochannels, ponds, ox-bow lakes and avulsed channels. Depositional features are associated with sedimentary bodies that are characteristic of laterally unconfined medium to low-energy river environments.

The mapping of vegetation types using key species shows that the Nyong floodplain is covered by a relative heterogeneous mix of plant communities. With a very few exceptions, their spatial patterns fit those of the fluvial landform units. Even though meadow and raffia are the most dominant vegetation types, the variability observed locally largely reflects the hydroperiod (duration of inundation), the depth of water-table and the degree of disturbance (e.g. forest clearance, bush fires).

Linking hydrogeomorphic conditions of the floodplain features and the distributional patterns of plant communities revealed by spectral properties of end-members of the riverine environment (especially water and vegetation), a bottomland or wetland typology obtained from image classification and principal component analysis is ultimately proposed. The results reveal that the biogeomorphological heterogeneity of the Nyong floodplain is more significant than it might be expected. Yet, remnant Lateglacial fans and Holocene floodplain 'highs', colonized by a typical meadow, are the dominant wetland classes. Because they account mostly for the total variance, the vegetation type and the substrate moisture conditions determined by the sediment texture and the seasonal shifts in the depth of the water-table appear as the key factors of the diversity.

## **INTER-ANNUAL VARIABILITY IN THE FLOW REGIME OF THE SANAGA RIVER (CAMEROON): A RESPONSE TO HYDRO-CLIMATIC CHANGES OR AN EFFECT OF REGULATING RESERVOIRS?**

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Shifts in the flow discharges of the Sanaga River, one of the Sub-Saharan largest and greatly regulated rivers, are ascertain over a 60-year period trough comparisons made between unregulated and observed conditions. Discontinuity detection tests applied to discharge data series corresponding to average flow conditions reveal the existence of two main homogenous periods separated by a major break that occurred in 1970-1971. The first ones corresponds to a wet phase (1945-1946 to 1970-1971) characterized by surplus discharges (+12.7 to +14%, according to the scenario taken into consideration). Although it is contrasted, the second homogenous period shows a wide deficiency (-9.6 and -10.3% under unregulated and observed conditions, respectively).

Linking these shifts alternatively to basin precipitation and to groundwater inputs revealed by baseflow time series, the conclusion is that the inter-annual variations in streamflows are spatially and temporally more correlated to the dry season rainfall than to the wet season precipitation inputs, confirming that the tropical catchments may be very sensitive to the former. Despite the progressive exhaustion of the groundwater inputs since 1970-1971, the annual discharges did not yet decrease during the post-1988 period proportionately to the amplitude of variation the dry season rainfall. This suggests possible changes in land cover/land use at the catchment scale.

For the extreme flow conditions, a comparison of IHA statistics, calculated from unregulated and observed streamflow data, shows that shifts in maximum and minimum discharges are principally due to the action of dams. However, the impacts on minimum discharges appear most significant. It is thus confirmed that the prime objective of these regulating structures is to enhance the lower dry season flows.



# SUSPENDED SEDIMENT QUANTIFICATION IN THE HYDROGRAPHIC BASIN OF THE RESERVOIR OF PCH-ANHANGUERA, MIDDLE SAPUCAÍ RIVER, NORTHEASTERN STATE OF SÃO PAULO

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This study was conducted by the Instituto de Pesquisas Tecnológicas do Estado de São Paulo – IPT (Institute for Technological Research of São Paulo State) under a request of the SEBAND (Sociedade Bandeirantes de Energia Ltda), in order to get data for the "Monitoring of erosion, and siting up process and induced elevation of the groundwater around the reservoir of PCH-Anhangüera Sapucaí River, northeast of São Paulo". Given the importance of Sapucaí River and the lack of information concerning the production and dynamic of sediments, it was decided to quantify the solid discharge of suspended sediments in the Sapucaí River and tributaries. This paper shows the technique used for the sampling of sediments and the results of measurements of flow, concentration and suspended solid discharge, performed from July 2008 to November 2009. The watershed of the reservoir was divided into five sub-basins in accordance with sampled sections. These sampled sections showed the river depth, the total distance between banks, the shape of the channel bottom besides the UTM coordinates. We used 02 kinds of hydrometric equipments for the flow measurements: Valeport and Metheortec. In each vertical section was measured flow velocity in two points: 20% and 80% of the water surface. The collection of suspended sediments was made with samplers for vertical integration DH-48 and DH-59. The methodological procedures were followed according to the "Guide to Sedimentometric Practice" (ANEEL, 2000), and this guide provided the lines for the definition of sites to be monitored, sampling frequency, methods of measurements, sampling techniques and types of equipments, types and methods of analysis and calculation of concentration and suspended solid discharge. The calculation of the value of Discharge Suspended Solid is done taking into account that sediments move with the flow velocity across the cross-section. The concentration corresponds to the average value in the section, and the suspended solid discharge (t/day), equal to the liquid discharge ( $m^3/s$ ) by concentration (mg/l) following the formula:  $Q_{ss}=Q_l \times C \times 0,0864$ . It was concluded that the data represent the characteristics of the sections and sub-basins studied. Only at some points the values extrapolated, being higher than expected. For example, the five sub-basin case (SPA-5 section), in the São Joaquim River, downstream from the São Joaquim da Barra urban area, presented a discharge of suspended solids (average) of about 3,3601 t/day. In this section the load of total dissolved solids (TDS), for an average flow of  $1,250m^3/s$  average concentration of total dissolved solids of 98,647 mg/l, was 10,602 t/day. The sub-basins 3, 4, 6 and 7 also require measures to improve the level of water quality, since the discharge of total dissolved solids is greater than the discharge of suspended sediments, indicating the presence of polluting sources in these sub-basins.

**keywords:** Sapucaí River, suspended sediments, solid discharge.

## REFERENCES

ANEEL – Agência Nacional de Energia Elétrica, 2000. Guia de Práticas Sedimentométricas. Brasília, 154p.

# DECIPHERING CLIMATE INDUCED FLUVIAL DYNAMICS IN TROPICAL AFRICA USING MULTIPLE PROXY DATA FROM CAMEROONIAN ALLUVIAL SEDIMENTS

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## Abstract

New findings on the palaeoenvironmental and -hydrological conditions in western tropical Africa have been acquired through the analysis of alluvial sediments from Cameroonian fluvial systems (i.e. Boumba, Ngoko, Ntem, Nyong and Sanaga Rivers; Sangen, 2010). The alluvial archives have recorded repeated fluvial activity fluctuations since the Late Pleistocene (53 ka). Besides the analysis of granulometric and pedological as well as sedimentological characteristics of these alluvia (Sangen, 2009), also pollen (Ngomanda et al., 2009), clay minerals (Weldeab et al., under review) and the phytolith as well as sponge spicule records (Sangen et al., in prep.) have been intensively studied. The latter highlight hydrological, ecological and fluvial-morphological changes across Cameroonian fluvial ecosystems during the Last Glacial Maximum and adjacent humidification in the course of the African Humid Period and the northern hemispheric Bølling-Allerød. The multi-proxy approach of combining remote sensing methods and archaeobotanical, mineralogical, geomorphological as well as sedimentological analysis of numerous <sup>14</sup>C-dated alluvial stratigraphies offers excellent opportunities for palaeoenvironmental studies in those regions, where 'conventional' terrestrial proxy data archives (i.e. lakes, swamps, mires) are lacking or non-existent. Because of the absence of clay, pollen as well as diatoms in Late Pleistocene sandy Cameroonian alluvia, which are often associated with braided palaeochannels, the innovative approach of analysing abundantly present phytoliths and sponge spicules is very helpful and promising. The results contribute to sophisticated understanding of Late Quaternary and especially last glacial-interglacial changes in western equatorial African fluvial ecosystems and corroborate earlier findings from marine and terrestrial proxy data archives in tropical Africa.

## REFERENCES:

- Ngomanda, A., Neumann, K., Schweizer, A., Maley, J. (2009). Seasonality change and the third millennium BP rainforest crisis in Central Africa: a high resolution pollen profile from Nyabessan, southern Cameroon. *Quaternary Research* 71, 307-318.
- Sangen, M. (2009). Physiogeographical research on Pleistocene and Holocene palaeoenvironmental conditions in southern Cameroon derived from alluvia of the Ntem interior delta and alluvial sediments of the rivers Boumba, Ngoko, Nyong and Sanaga. PhD-thesis, Johann Wolfgang Goethe-University Frankfurt, 1-343.
- Sangen, M. (2010). New results on palaeoenvironmental conditions in equatorial Africa derived from alluvial sediments of Cameroonian rivers. *Proceedings of the Geological Association*, doi: 10.1016/j.pgeola.2010.06.004.
- Sangen, M., Neumann, K., Eisenberg, J. (in preparation). Climate induced fluvial dynamics in tropical Africa around the LGM? Alluvial sediments, phytoliths and sponge spicules from southern Cameroon. *Quaternary Research*
- Weldeab, S., Frank, M., Stichel, T., Schneider, R., Haley, B., Sangen, M. (under review). Decoupling between past ITCZ movement and rainfall intensity over West African monsoon area.

## TEMPORAL VARIABILITY IN TRANSPORTATION OF SEDIMENT IN THE RIVER IVAÍ (1977-2007)

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This paper evaluates the behavior of suspended sediment load of the river Ivaí over a period of 32 years measured by the station further downstream the river (Novo Porto Taquara). The most suitable parameters for this assessment were the annual discharge of suspended sediment and water obtained from SUDERHSA. The relationship between the concentration of suspended sediment and discharge of water had not a very good correlation ( $R^2 = 0,56$ ) and hysteresis effect is quite clear. The justification for this behavior is given by the heterogeneity of the hydrological regime and basin occupation. There were no significant changes in annual flows which have remained the same during the study period. Already the discharge of suspended sediment showed a small gradual decline in which the end of the period (2007), the river carries less than 0.65Mton at the beginning (1977). This reduction in suspended sediment transported is probably due to changes in soil management for agriculture.

**Key words:** suspended sediment, river regime, basin management, river flow, river discharge

## FLUVIAL STYLES OF THE NEGRO RIVER ON THE PANTANAL WETLAND, BRAZIL

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The Pantanal wetland is a Quaternary sedimentary basin located in the Upper Paraguay River basin. The modern landscape resulted from the interaction of complex morphological processes that have been taken place since the Late Pleistocene. The Paraguay is the trunk river of an alluvial depositional tract composed by several fluvial megafans, whose geologic evolution is constrained by alogenic processes, such as climate changes and tectonic movements. This contribution focuses on the geomorphology of the Negro river that differs significantly from other tributaries of Paraguay River. Flowing from east to west, the Negro river exhibits contrasting fluvial styles along its course. The catchment area is situated on a dissected plateau, underlain by Paleozoic sandstones and Neoproterozoic metamorphic rocks. Strata dip gently eastward in the plateau and the river flows westward, displaying a rectilinear pattern controlled by systems of NE and NW trending fractures. The river emerges from a confining gorge in the catchment area and reaches the Pantanal wetland, forming a meander belt/incised valley cross-cutting sediments of a former proximal fan system. The river turns southwest after the Anhumas River confluence, bordering distal portions of the Taquari megafan, and acquires a distributary pattern with several channel bifurcations. Most of the channels disappear in a large frequently flooded area, in which there are remains of Pleistocene landscape made up of fresh and brackish-water ponds. After the Santa Clara stream confluence, the river deflects to west and collects most of the water of the entire distributary system, changing its style and becoming a meandering river. Running between Taquari (north) and Taboco and Aquidauana (south) river megafans, the river collects waters from these systems, being the most important tributary system in the south portion of the Pantanal wetland. Before its interaction with the Aquidauana megafan, the fluvial style changes dramatically to an anastomosing pattern with several bifurcations and confluences because of the entrance in a tectonically subsiding area. The river loses water to the floodplain, given rise to a large swampy area drained by the neighbor Miranda and Abobral Rivers. Downstream of this subsiding area, some channels rejoin and the river reassumes its position bordering the Taquari megafan, collecting waters running from it till the confluence with the Paraguay river (Thanks to FAPESP for supporting the research 2007/55987-3; to CNPq for grants to Mario L. Assine; to CAPES for grants to Deborah Mendes).

## **FLOW AND SILTAGE IN DAMMED RIVERS OF SEMIARID REGIONS.**

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The sediment transport in rivers of the semi-arid region of Brazil is of remarkable importance for water resources management in the Northeast region. Despite this, it is poorly studied. In the Northeast region, Hydro sedimentology research is relatively recent in the northeast. Historical data regarding sediment transport in Brazil are scarce and mostly involving the North, South and Southeast areas. Taking into consideration the significant socio-economic development currently experienced by Northeast region, it is necessary to investigate of the hydro dynamic and sedimentology behavior of the rivers. The aim of this study was to investigate the sediment transport processes in a controlled –dammed river, especially the middle-lower reaches of the Jaguaribe River in Ceará State. We the correlation and analysis of flow and sediment concentration. The methodology was based in Graf (1988), Carvalho (2008) and Charlton (2008), involving measurements of flow and sediment concentration in channel cross sections. Six stations were selected for monitoring, and field work was done between 2006 and 2007. The results show that runoff and sediment concentration are strongly influenced by the Castanhao Dam. In particular, the concentration rates were very low compared to those in the upper reaches of the basin, which may be related to damming. However, further investigation regarding transportation should be performed for an analysis of total transport rates. The most degraded areas (sections 4, 5 and 6) are shown as the largest producers of sediment and possibly continue to be areas of high transmission during the rainy season, given the increased availability of suspended sediment. Moreover, sections 4 and 5 are outside the catchments area of Castanhao and other smaller dams may have higher rates of transport during raining periods.

**INTEGRATED ANALYSIS OF FLUVIAL SYSTEMS: STUDIES OF IMPACTS  
OF THE MINING OF IRON IN QUADRILÁTERO FERRÍFERO REGION  
(MINAS GERAIS, BRAZIL)**

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The Quadrilátero Ferrífero region in the Minas Gerais State, the most important mineral province in Brazil, has about 7000km<sup>2</sup>. During the XVII, XVIII and XIX centuries gold was extracted from placer, terraces and from lateritic deposits. During the XX century manganese and iron turns the main ore. Nowadays, more than 55 million tons of iron ore have been annually exploited. This amount of ore exploitation requires a multidisciplinary approach in order to evaluate the environmental impacts and to give support to planning the protection of the natural resources.

In order to investigate the influence of the iron ore mining in the fluvial systems of the Quadrilátero Ferrífero it was selected a small fluvial basin named Macacos stream which has its headwaters nearby iron mining areas. The iron mining has been the main economic activity in the Macacos basin for more than 40 years more than. This activity has been the main cause for the silting up Macacos basin channels.

Analyses of the use of the ground based on the interpretation of satellites images ALOS were done. Cartographic and fluvial morphometric analysis of the basin was carried out in order to obtain longitudinal profiles of the main tributaries, transversal profiles to the draining (typology of the valleys), length and catchment areas. For the Macacos river assessments the analysis of the criteria for identification of functional zones and of the definition of the points of sampling, with the use of topographical, geologic, geotechnical, and geomorphologic maps were done.

The typology studies of the water courses of the Macacos basin was based on system B of the European Streams Assessments Directives (AQEM), that considers as important parameters the ecorregion, the altitude, geology, the slope, and the size of the drained area. Samples of waters and water of pores in the sediments had been collected in order to analyze metals.

The carried out studies had allowed to identify the geologic, geomorphologic and hydrologic processes that control several aspects of the river as listed now: the typology, morphometry, zoning, gradients and habitats of the water courses; the standards of distribution of the use and occupation of the land for distinction of the natural and anthropogenic areas; the stressors on hydrossystems; the nature and distribution of the sources of contamination of waters; and the state of preservation of the riparian zone. In the large scale, such as fluvial basin and fluvial corridors - the geology has been important to identify and to delimit the homogeneous ecorregions, and to distinguish areas with specific draining and lithology patterns. This scale also made possible the evaluation of the use and occupation of the land (e.g. native forest, grass field, pasture, urban nuclei and suburb neighborhood, dams and mining areas).

The authors wish to thank to FAPEMIG for financial support

## ANALYSIS OF EMBRYONIC SAND BARS (SUBMERGED) IN THE MIDDLE PARANÁ RIVER

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Sand bars and islands are conspicuous landforms in the main channel of the Middle Paraná River. Their growth rates and enlargement modes have been studied since the seventies, but the primary origin of these forms is little known.

We present some results concerning with the geometry and shifting of “embryonic” submerged bars, studied from satellite images of high spatial resolution (CBERS 2B and Google Earth ®) and 1:5,000 bathymetric charts. The influence of these bars in the origin of emerged bars during low and medium water stages of the river is also considered.

The study was conducted between Corrientes (km 1208 of the navigation way) and Rosario (km 420) by means of images and bathymetries from the year 2002 to 2009. Several properties of embryonic bars were evaluated: frequency, displacement rates, relationship with emerged bars, and typical morphology (or 3D geometry).

Submerged bars become evident in satellite images by “U” geometries in the water surface, with the “U” base pointing the water flow. The “U” geometry results from the 3D form of the embryonic bar, whose geometry is properly linguoid. The locally higher zones of a linguoid bar promote the trace in “U” advised from aerial views.

The analysis of images from different times permit us the measurement of the downstream displacement of linguoid bars; shift rates up to some hundreds m/year were measured. The first-time emergence of “common” (emerged) isolated bars could be recorded as part of this multitemporal analysis. The geometry and location of emerged bars ratify the linguoid morphology of the embryonic bars. Chains of dunes were observed on the back of linguoid bars, and it is suggested that the bar acts like a ramp for these bedforms.

Channel islands are more abundant than the emerged bars in the Paraná River during low-medium water stages or higher, but embryonic bars occur more frequently than island, up to 2:1.

Embryonic or linguoid bars occurs isolated or as coalescent group, in the center of the main channel as well as near the channel and island banks.

The morphological diversity of the emerged bars in the Middle Paraná River during an early stage of development is well explained by the migration, coalescence and juxtaposition of linguoid bars.

Aerial photographs and satellite images are normally used in the study of bars and islands in the large rivers of the world, but this is the first time that they were used for the study of “embryonic” submerged bars.

The application of this knowledge has a significant potential for the design and maintenance of waterway river engineering in this large fluvial system.

**Pereira M. S., C. G. Ramonell, E. M. Latrubesse y R. N. Szupiany (2009).** “Análisis de Bancos Sumergidos del Río Paraná Medio a través de Imágenes Satelitales”. XXIV Congreso Latinoamericano de Hidráulica 2010, Punta del Este, Uruguay.

## **BIOCHEMICAL ORIGIN AND DIVERSITY OF SALINE-ALKALINE AND HYPO SALINE LAKES OF THE NHECOLANDIA PANTANAL, BRAZIL**

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The Pantanal, the largest of floodable plains on Earth, includes the largest and diversified field of tropical lakes: about ten thousand lakes with great variability of salinity, pH, alkalinity, color, physiography and biological activities, covering an area of 14.000 km<sup>2</sup>. The hyposaline ones have variable pHs, low alkalinity, macrophytes and a low density of phytoplankton. The saline lakes are at a lower topographic level than the neighboring hyposaline ones and rarely become completely dry by evaporation and have pHs above 9 or 10, high alkalinity, absence of macrophytes, high density of phytoplankton and a prevalence of Cyanobacteria and sand beaches. The saline lakes are relatively isolated from the recharges of the phreatic zone and the seasonal floods, raising their salinities to hundreds or thousands of times above those of their neighboring hyposaline ones. This isolation is also indicated by the ratios of the stable isotopes of H and O. The cause of the diversity of the lakes of the Nhecolândia Pantanal has not been clarified in literature, which comes to conclude that the salinity diversity is due to current processes and not an effect of drier climatic periods in the past. We here propose two main causes: (i) a climate with important water deficit and poverty in Ca<sup>2+</sup> in the superficial and phreatic waters; (ii) a pH elevation during cyanobacteria blooms. These two aspects destabilize the general tendency on Earth towards a neutral pH. This imbalance results in an increase in the pH of lake waters, which dissolves silicates and quartz and promotes, at extreme draught, the amorphous silica precipitation in the intergranular spaces of sand, increasing the isolation of the lake from the phreatic levels. This paper discusses this biochemical problem in the light of phytoplanktonic, physico-chemical and chemical data obtained from three field surveys in the area.



## PRELIMINARY BEHAVIOR OF TIDES IN THE RIVER ESTUARY CAETÉ (AMAZON REGION)

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The estuary of Caeté's river is located in the Bragantina Coastal Plain covering the coastal zone of Bragança located 210 km from Belém, capital of Pará extends from the Maiaú Spit to the mouth of the river Caeté (00 ° 43 ' 18 " - 00 ° 04'17" S and 46 ° 32'16 " - 46 ° 55'11" W). The Bragança's coastal plain is classified as a transgressive coast, including tidal flat environments, estuaries and beaches, forming then a highly complex sedimentation environment. In the Caeté river estuary, the tidal regime is still poorly studied, which prompted this preliminary research on the tides behavior in the region through the analysis of measurements performed in a series of tidal elevation data. This estuary is influenced by macro-semi-diurnal tides with mean amplitude of 5.6 m, coastal currents (approximately 0.75 m / s average speed), waves of 0.7 m and the trade winds, which have preferentially toward NE average speed of 6 ms-1. This estuary is located in a tropical humid climate, with average annual temperature of 27 ° C and high rainfall with an annual average of 2500 mm / year. In the region, there is also the existence of periods with distinct characteristics: wet (December-May), dry (June-November) and intermediate. The Caeté river estuary fits as an estuary dominated by tides (on the physical processes), formed in the coastal plain (as the geomorphology) and well blended (about the movement of water). The sea level rise records, through the establishment of two digital tide gauges Orphimedes brand OTT-Hidrometrie, located in the village of Bacuriteua and the bridge over the Maguary Channel, where values were obtained every 20 minutes daily for 7 consecutive days with results ranging from a minimum of 0.01 m to a maximum of 5.08 m and 0.42 to 5.18 at the point on the bridge over the channel and the village of Maguary and Bacuriteua respectively. The data obtained in the tidal field were measured over 7 days and tides ranged from a minimum of 0.42 m to 5.18 m for the point in Maguary Fishery (M1) and a minimum of 0.01 m to a maximum 5.08 m at the point on the bridge over the Maguary channel (M2) (Figure 1). They were related to tidal elevation data for the two collection points, observing a small lag of the tide, because the distance between the tide gauge to be approximately 22 km. The estuary has a Caeté macrotidal scheme, semi-diurnal (2 cycles of tidal flooding and two cycles of ebb tides). The greatest increase were recorded within the estuary, possibly due to its geometry which favors the channeling of water and a narrowing of the channel, the bottom topography is another factor that contributes to the highest elevation within the estuary.

# **NEW PARADIGMS IN FLOOD MANAGEMENT: LINKING TO ECONOMIC GROWTH IN BIHAR, INDIA**

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Most rivers draining the north Bihar plains are flood-prone as well as dynamic. These two processes, river dynamics and flooding, are almost inseparable in case of north Bihar rivers. Historically, the embankment strategy has been the most common flood control measure in this region which has in turn affected the flood intensity, frequency and pattern. These rivers are also very highly sediment-charged which adds to the complexity. The causative factors of flooding in north Bihar can be grouped into four categories: (a) excessive rainfall and overbank flooding, (b) breach of embankment and inundation, (c) avulsion of rivers and flooding, and (d) unplanned releases from barrages/dams.

The flooding due to excessive rainfall is generally predictable, except for sudden cloud bursts, if proper monitoring of water gauge stations is done and proper communication system is in place. The breach of embankment and consequent inundation is partly attributed to the wrong strategy of river management and partly due to poor maintenance of bunds and formation of seepage channels. Excessive sedimentation within the bunds and reduction in carrying capacity of rivers has aggravated the situation further and has pushed the rivers closer to avulsion threshold. Apart from the embankments along the river which have created a 'false sense of security' among the people living in the region, the unplanned roads and bunds have caused severe drainage congestion and channel disconnectivity. The engineering assumption that jacketing the river would increase the velocity leading to scouring has been borne out in Kosi and elsewhere and has instead resulted in extensive waterlogged areas and soil salinity.

Further, the rivers of north Bihar have been described as 'hyperavulsive' with decadal-scale avulsion histories. They are mostly caused by sedimentological readjustments due to river bed aggradation although some influence of tectonics has also been documented. Such avulsions not only cause extensive inundation of areas which are not likely to flood otherwise but also result in extensive bank erosion. In many cases, the breaches of the embankment are primarily 'failed avulsions' and therefore, the causative factors (b) and (c) are closely interlinked. The unplanned release from barrages/dams is a potential threat in this region which may arise if the standard rules of barrage operation are flouted. The Orissa flood in September 2008 is a good example although no major incident from Bihar has been reported in recent years. In any case, these structures are not designed for storage in case of excessive rainfall, and therefore, their utility for flood control is debatable. The problem is compounded by poor channel maintenance in most reaches.

It is indeed ironic that despite large expenses on flood management, the recurrence of floods as well as flood damages has increased in all basins of north Bihar as noted in the Report of the Second Irrigation Commission. Most floods cause a huge loss of life and property and add to the misery of weaker sections of the society. The loss to the crops every year due to recurring floods is enormous. There are several other ways in which the floods have impacted the economic growth of Bihar. An astronomical expenditure on the maintenance of embankments every year has proved to be ineffective not only due to inherent characteristics of the rivers but also due large scale malpractices; this expenditure could have contributed significantly to the economic growth of the state. In addition, floods pose a constant threat to engineering structures and public utilities and a large expenditure on flood relief and repair/ restoration of embankments and public utilities uses a significant chunk of public money. There are also issues of bad planning and non-considerations of river processes and dynamics in designing these structures. For example, frequent abandonment of bridges even before they are completed due to river movements reflects a poor understanding of river dynamics, and therefore, has costed heavily to the exchequer of the state. Further, these embankments have blocked the inflowing drainages into the main river thereby resulting in extensive water logging and soil salinity. The seepage from bunds and canals adds to the problem. As a result, a sizable agricultural land has been lost.

The issues discussed above are helpful to set up the basic premise of the research agenda. River management in India has always been dominated by water allocation (considers rivers as 'conduits' of water) and pollution problems (considers rivers as 'sinks'). There is a strong need to consider rivers as a 'live natural system' meant for supporting not just human civilizations but also a complete eco-system. This means that we need to understand how river functions as a system and how does it maintain the 'dynamic equilibrium'. This is time to move from 'river control' to 'river management' which necessitates the appreciation of the role of geomorphology – the science of form and processes of rivers and the concepts of threshold, lag and complex response in river adjustment. Keeping this in view, the following research themes are proposed:

- (a) Process-based understanding of rivers in river management emphasizing an 'eco-system' based approach. This is a key item in the national programme of the Ganga River Basin Management Plan (GRBMP) being prepared by the IIT's at the initiative of the Ministry of Environment and Forests, Government of India.
- (b) Impact of engineering structures on river systems primarily focusing on natural equilibrium and assessment of degradation due to anthropogenic factors; this may include geomorphic assessment of rivers as well as impact on ecosystem.
- (c) Cost-benefit analysis (long term) of major interventions in the river basins and their utility in the present context; this should include the benefits accrued as well as the impact on livelihood and ecology.
- (d) Basin scale flood-risk maps based on scientific data and reasoning; such GIS based, interactive maps may be based on historical data analysis as well as modeling approaches and can be linked to an online data base and flood warning system.
- (e) Drainage improvement and land reclamation in low-lying areas; several successful case histories are available from north Bihar and elsewhere but they need to be taken up systematically.
- (f) Assessment of soil salinity and mitigation strategy; this may include the use of salinity resistant crops as well as soil improvement practices.

- (g) Alternatives to embankments for flood management with an emphasis on 'living with the floods' concept. This may include floodplain zoning and other non-structural approaches.

It is important draw attention to the fact that floods in most rivers in north Bihar are different from the usual notion of 'overbank' flooding as in most cases they are associated with river dynamics. This situation is even more problematic because this often leads to flooding of areas which are not usually flood-prone, and therefore, people are caught unaware leading to severe loss of life and property. This needs situation need to be corrected soon to see a prosperous Bihar. There is an urgent need for a wide section of people from academia, governmental organizations, NGOs, social institutions and the society at large to get together to fight out the evils which are plaguing the flood management policies in Bihar.

# SPATIAL VARIATION IN THE DYNAMICS FLOWS OF THE IVAÍ RIVER

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Despite the existence of studies dating back to 1865, the river Ivaí, the second largest river in the state of Parana, is considered in that although its economic importance of a river course understudied, especially in its entirety. In this sense, the study was developed in order to understand the processes that occur along its 798 km long, through the analysis of some characteristics of hydraulic geometry, obtained by means of cross sections called: Patos, Teresa Cristina, Cândido de Abreu, Porto Ubá do Sul, Porto Paraiso do Norte and Foz. Changes in the width, depth and flow velocity were observed in cross sections studied. Ducks, Teresa Cristina Cândido de Abreu and Foz sections showed asymmetric, since Porto Ubá do Sul and Porto Paraíso do Norte symmetrical sections with talweg centralized. Sections studied, only Foz presented bedload, mostly clay texture (81%), the remaining bedrock. In general, homogeneous distribution was observed in flow velocities. Average velocities were recorded in sections Patos, Teresa Cristina and Porto Paraíso do Norte, turn the minors were found to section Foz. Over the course of the river Ivaí, there was an increase in flows downstream, the largest flow Instant recorded was obtained at Porto Paraiso do Norte section ( $1743.00 \text{ m}^3 / \text{s}$ ), already the lowest was measured at the station Patos ( $108.32 \text{ m}^3 / \text{s}$ ). The station Foz, showed a drastic reduction in relation to flow ( $200.34 \text{ m}^3 / \text{s}$ ), due to low flow velocities recorded along the section, caused by damming caused by the Parana River. Patos, Cândido de Abreu, Teresa Cristina and Porto Paraíso do Norte were the sections that showed the highest values stream power and specific stream power in turn Foz had the lowest values. Stream power and specific stream power as a function of the width of your section but also because the very low speeds. From the data obtained, the river Ivaí could be classified as a river of turbulent flow, non-uniform, unstable and quiet power. Although this study was a simple proposal to investigate one of the most important rivers in the state of Parana, however, compared to studies of the dynamics of flows, there is still need for further refinements on the morphology and river dynamics, such as the carrying out further study sections along the channel so that we can gain greater understanding of the variation of stream power and hydraulic geometry, since, as previously mentioned in its importance, this river is one of the only rivers in the state of Parana, that still does not present major engineering works, such as large hydropower plants.

Key works: Ivaí river, dynamic flows, morphology

## **APPLICATION OF PHYSICAL-CONSERVATIONIST DIAGNOSIS (DFC) IN ASSESSMENT OF ENVIRONMENTAL VULNERABILITY OF MICRO BASINS IN STATE OF PARÁ**

**Aline Maria Meiguins de Lima, Fábio Monteiro Cruz, Luciana Miranda Cavalcante, Verônica Jussara dos Santos**

The methodology called physical-conservationist diagnosis (DFC) aims to identify the potential for environmental degradation in micro basins, using indicators which define the stability and change degree of natural components of river systems. In this case, some parameters are selected in accordance with their potential capacity to contribute to degradation of natural renewable resources or to reflect them. This work presents the DFC analysis in 10 micro-basins of Pará state and the physical degradation risk index for each one. The methodological procedures were: basins location and definition with cartography in GIS; field surveys; field sections characterization, analysis and identification of system dynamics. The main stages of DFC implementation were: modeling micro basins fluvial dynamics; DFC parameters determination; and definition of a descriptive formula by sector. The sum of DFC parameters weights obtained for Northeast Atlantic Coast micro basins were: a) Toras channel (that drains toward Maguari river) is 21, meaning an "impacted" and "unstable" system, in terms of its hydrological characteristics; b) Maratauíra, Abaeté, Jacarequara and Capim rivers (that drain toward Pará River) is 18, also having a greater vulnerability to lose its water potential; c) Peixe boi river basin (that drains toward Maracanã river) is 15, this value is in the beginning of the lower stability zone; d) Caixa d'água channel (component of Marapanim basin) is 15, very similar to Peixe boi river but as a urban basin, it is able to change to stability zone if one or more factors associated with the urbanization process were modified. Ambé, Panela and Altamira channels are located in northwest Altamira city (draining to the Xingu river basin), the values obtained ranged from 14 to 15, indicating a situation where the basins are classified as nearby to "instability", but this situation is more associated with land use and occupation, than to local natural water dynamic. Conclusively DFC is an efficient methodology for assessment of micro basins current state, especially to complement environmental risk assessments associated with fluvial dynamics interventions. However, its effectiveness depends on: analyzed variables; their characterization; and the adopted criterions to define the weights assigned to each component identified.

# **EVOLUTION OF THE LAKES IN THE PARANA RIVER ALLUVIAL PLAIN HALF, DURING THE SECOND HALF OF THE XX CENTURY. A SYSTEMIC VIEW.**

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The Middle Paraná River (Fig. 1) contains extensive floodplain a heterogeneous mosaic of lotic and lentic environments with different forms depending mainly on the local and regional river dynamics as well as the evolutionary processes of short and long term affect it. The morphology of the lakes, its evolution and diversity are important factors in ecological studies of these coastal lakes, providing information for the detection and analysis of the changes, both natural and manmade, are subject to these river systems. There are few studies on the evolution of these environments, in relation to its importance to the ecology of these aquatic environments. Therefore, the results will be the first contribution to quantify over all alluvial valley, which is necessary for investigations of the ecological integrity of these hydro basins covering also a very large gap in the existing basic information on major rivers. The overall objective is to understand the evolution of alluvial lakes Middle Paraná River (from the city of Corrientes to the town of Diamante, Argentina) and specific objectives are to identify the morphology of the lakes in terms of geomorphological units, identify incidents key factors in the evolution of the lakes, generate cartographic models of evolutionary processes and to obtain baseline information for use in management planning of large floodplain rivers.

The hypotheses that will guide the research are as follows:

H1) The alluvial lakes in the Middle Paraná River show a characteristic morphology according to the geomorphological unit in which they were generated and can be identified in various categories on the basis of morphogenetic processes that originated them.

H2) The alluvial lakes Middle Paraná River evolve according to the diversity of hydro-geomorphological processes and biotic-plain river system. The evolution of the lakes in the floodplain is differentiated in time and space for each category identified. This happens because they are dependent on genesis, morphology and life time, morphogenetic processes, sediment transport, nutrients, sedimentation and erosion processes of the host.

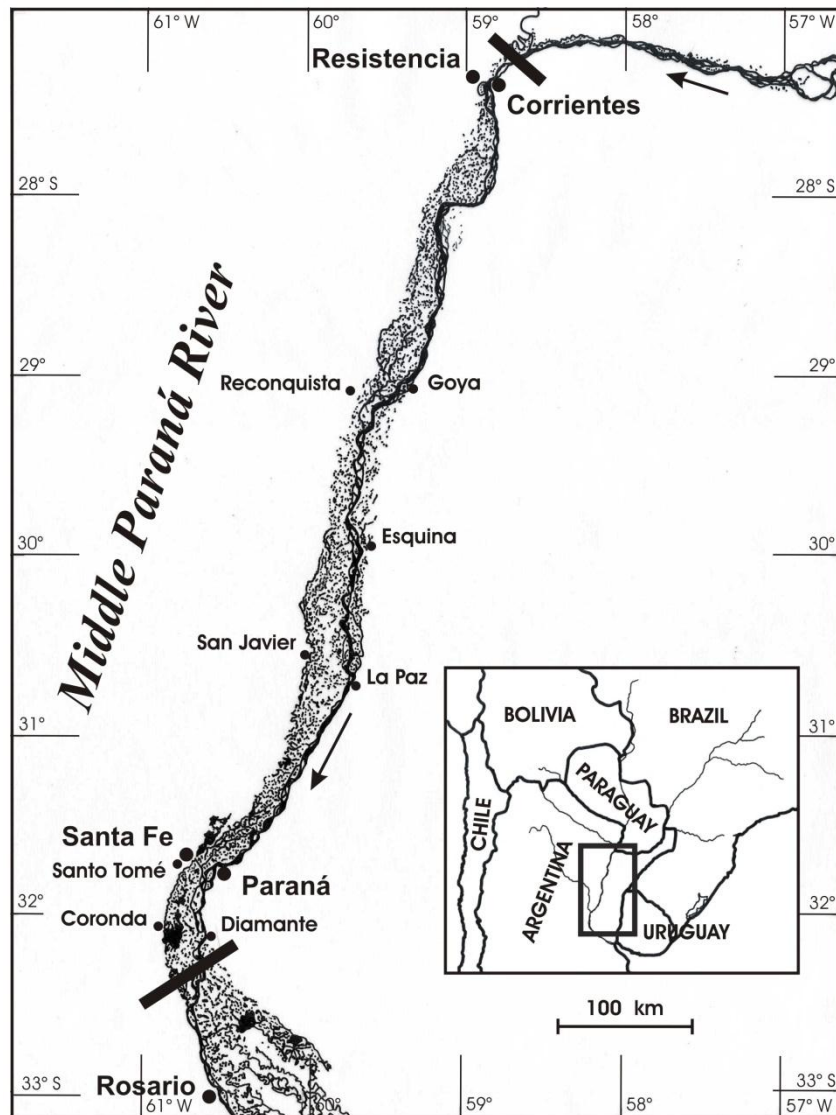


Figure 1: Study area of the floodplain of the Middle Paraná River bounded by the segments north of the city Corrientes and south through the town of Diamante (Argentina).



## **EVALUATION OF INADEQUATE OCCUPATION BESIDE THE PITIMBU RIVER - NATAL/RN/BRAZIL, USING GIS TOOLS**

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This study presents the relations between the main geomorphic elements of Pitimbu river and impacts resulting from the completion of engineering works nearby. At this analysis are evaluated the behavior of river floodplain before the disorderly occupation. The human processes that lead to the modeling of relief can be very fast, even instantaneous in agreement with the time scale considered, and they are not always associated with the clear, simple and obvious processes, but with human decisions that are not always in harmony with nature. In the case of Pitimbu River, current studies are done on a very modified terrain impacted by engineering works, where the greatest change occurred with the cross-sectioning of the river by a Federal Highway, in the 1970s. In this analysis it was used a planialtimetric map executed in 1977, on a scale of 1:2000, it was made fieldworks to measure the current situation, analysis of aerial photos, and numerical modeling of terrain. The limit of floodplain was represented by the contour lines of 12 meters and 10 meters. These limits are taken based on the noticeable change of the slope of the relief, which can be quantified through the use of GIS tools. The analysis emphasizes the narrowing of the valley and of the floodplain caused by the Highway. This narrowing reflects the decrease of the flow of the river with consequences not yet understood for the river system. The altered morphology is used to lead to the construction of residential condominiums too close to the river margin, where, the damaged area, suggests a higher degradation and not its recovery. In order to understand the evolutionary history of key morphological features testimonials of Natal, it's suggested the use of old planialtimetric surveys revisited using modern GIS tools, capable of quantifying attributes and give easy understanding of results to public officials responsible for preserving the environment.

# **LAND USE EFFECTS ON RUNOFF AND SEDIMENT YIELDS IN SMALL COASTAL WATERSHEDS OF THE NORTHEASTERN CARIBBEAN- SYNOPSIS OF A DECADE-LONG RESEARCH PROGRAM**

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Alterations to runoff, erosion, and sediment delivery regimes are an almost inevitable consequence of land use and development. These changes are of primary concern throughout the Insular Caribbean where increased sediment delivery into its coastal waters is considered to be one of the main stressors responsible for a multi-decadal deterioration of its coral reef ecosystems. This presentation will summarize the current status of previous and ongoing research intended to quantify the effects of land development on runoff response, and both sediment production and delivery in the Northeastern Caribbean. Particular attention will be given to small (<10 km<sup>2</sup>), dry tropical (~700 – 1200 mm yr<sup>-1</sup> rainfall) watersheds fronting bays that still harbor nearshore reef systems of importance but that are being threatened by ongoing upland development.

Empirical evidence shows that vegetation removal and soil compaction associated to the types of land disturbances occurring on these watersheds are responsible for decreasing the precipitation threshold for generating surface runoff by a full order of magnitude (from ~ 60 mm to 6 mm), thus increasing the frequency at which sediment-laden runoff may be delivered to coastal waters. Field-based observations also have shown that hillslope-scale erosion rates on disturbed surfaces (i.e., unpaved roads) are between one- to four-orders of magnitude higher than undisturbed conditions (undisturbed: 10<sup>-2</sup> Mg ha<sup>-1</sup> yr<sup>-1</sup>; disturbed 10<sup>0</sup> – 10<sup>2</sup> Mg ha<sup>-1</sup> yr<sup>-1</sup>), and these are responsible for an up to tenfold increase in watershed-scale sediment yields (undisturbed: 10<sup>-2</sup> Mg ha<sup>-1</sup> yr<sup>-1</sup>; disturbed: 10<sup>-1</sup> Mg ha<sup>-1</sup> yr<sup>-1</sup>).

Study results are currently being used in the design and implementation of erosion control mitigation strategies in both Puerto Rico and in the U.S. Virgin Islands. Monitoring activities are underway to test the effectiveness of such measures in reducing erosion and sediment delivery rates. Proof on the effectiveness of these efforts will serve as an aid in their further proliferation throughout the Caribbean to solve existing problems and to prevent further deterioration by incorporating the newly gained knowledge into the planning stages of future land development activities.

# **HIGH SEDIMENT YIELD AND AN EXTRAORDINARY CHANNEL DIVERSION IN THE PATÍA RIVER, WESTERN ANDES OF COLOMBIA: AN OVERVIEW OF ENVIRONMENTAL IMPLICATIONS**

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The Pacific rivers of Colombia are small fluvial systems with high sediment yield. The Patía River occupies a 22046 km<sup>2</sup> basin with a mean sediment load of  $26.5 \times 10^6$  t yr<sup>-1</sup> and basin-wide sediment yield of 1713 t km<sup>-2</sup> yr<sup>-1</sup>. Overall, the Patía exhibits the highest sediment yield of all medium-large sized rivers of South America due to the interplay of (1) high rates of runoff (5.300 mm yr<sup>-1</sup>), (2) steep relief within catchment, with narrow alluvial plains, (3) low values of discharge variability ( $Q_{max}-Q_{min}$ ), (4) episodic sediment delivery due to either geologic events or climatic anomalies, and (5) soil conversion as a result of deforestation; large areas of tropical forests in the Patía catchment have been cut-off due to increasing trends in the never-ending cultivation of illicit cocaine crops. Analysis of sediment load anomalies suggest that there were two high discharge periods in the Patía River during the 1970s and 1990s, both increasing trends in sediment load coinciding with the overall decline of tropical forests due to deforestation. In the lowlands of the basin, near the Patía delta apex, a wood merchant called constructed during the seventies a 3 km-long channel (Canal Naranjo), which was dredged to connect the Patía Viejo distributary with the much smaller Sanguianga River to the north in 1972. A temporal analysis of major morphological changes in the Patía River allow to make some generalizations: (1) prior the construction of the Canal Naranjo in 1972, the Patía Viejo distributary channel joined the Patía River at the delta apex and the whole Patía River discharge flowed to southern coast, where the active delta lobe was during this time; (2) after the construction of Canal Naranjo, some floodings events started the widening of Canal Naranjo and most of the Patía River and Patía Viejo distributary discharges started to flow in the direction of the Canal Naranjo due to differences in relief, since the Patía River in the delta apex follows an structural high; (3) during the 1979 earthquake, when a large tsunami impacted the coast, vertical elevations of the basins changed, and the Sanguianga River captured approximately 70% of the Patía's discharge; (4) the Sanguianga River, which was a small creek draining internal lakes in a tropical rain forest, started to increase its water discharge from approximately 50 to 1500 m<sup>3</sup> s<sup>-1</sup>; (5) After 1990, more than 80% of the Patía River discharge was captured by the Canal Naranjo - Patía distributary - Sanguianga River system; (6) Current conditions show that more than 90% of the Patía River flux flows to the Sanguianga; also, the Patía River flowing to the southern coast, the retreating delta lobe, has become a dry system for almost 9 months every year. The diversion of the Patía River has caused major environmental impacts, including distributary channel erosion, sediment deposition, mangrove die-off, delta-front erosion, changes in fishing resources, transportation and communication difficulties. This is the most impressive environmental change documented for any coastal system along the western coast of South America.

# **ISLAND FORMATION AND RIPARIAN VEGETATION: AN EXAMPLE OF CONNECTIVITY PROCESSES IN REGULATED RIVER (PARANÁ RIVER, BRAZIL)**

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The relationship between the dominant variables (e.g. formation of islands) and the dependent ones (e.g. riparian vegetation) in a river system is called connectivity. The main variables of the systemic fluvial geomorphology (hierarchy, cascade, feedback, and sensitivity), hydrological regime (pulse intensity, recurrence, and continuity), and longitudinal profile (space-time) are used to define the connectivity between the variables of river systems and subsidizing in its management. The studied segment is located 30 km downstream from Porto Primavera Dam (closed in 1999) in the Islands and Floodplain of the Ivinhema River Natural State Park and constitutes the last and unique “natural” reach of the Paraná River on Brazil. This paper analyzes the connectivity elements and processes controlling the island riparian vegetation. This control is made by the morphosedimentary evolution of the islands, which in this case, operates by attaching bars. Islands grow by annexation of sand bars deposited in their shore. This process begins by forming an elongated sand bar that develops parallel to the shore line of the islands or plain. When stabilized, they become progressively less able to eupotapic conditions up to be totally incorporated to island or floodplain (terrestrial conditions). The older islands formed by this process have ages from 1.9 ka BP. This process builds complexity islands formed by a mosaic of morphological units, which operate at different temporal and spatial scales, control the connectivity of the vegetation units of the system. The changes in flow regime of water and sediment introduced in the reach by the closure of the Porto Primavera Dam, are affecting and will continue to affect the connectivity between hydro-sedimentary (regime and sediment load) and riparian vegetation variables. Such changes occur at different temporal and spatial scales and may cause irreversible imbalance of the system.

## **GEOARCHAEOLOGY OF TROPICAL FLUVIAL SYSTEMS: APPLIED EXAMPLES FROM UPPER MADEIRA RIVER, RONDONIA, BRAZIL**

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Among tropical Brazilian environments fluvial terraces, less influenced by seasonal floods, present soils that favor the development of forest vegetation and the human settlement. Archaeological sites are found within all types of Amazonian ecosystems and landscapes, but a large number of prehistoric settlements are found within floodplains and fluvial terraces. In fluvial environments erosional processes as well as biological agents such as *burrowing animals* and tree roots can uncover and/or obliterate archaeological structures. In contrast archaeological structures can be buried by sediments deposited during periods of high or low fluvial energy. The upper Madeira river region is a key region for understanding paleoenvironmental and archaeological Amazonian history of the past 10,000 years. The region is believed to have been the center of crops domestication such as peach-palm (*Bactris gasipaes*) and manioc (*Manihot esculenta*), and presents the oldest settlement-related Amazonian dark earths in the Amazon basin. The archaeological record of the region spans the entire Holocene period, and the occurrence of a rich paleontological record along the Madeira River can shed light on the issue of human contemporaneity with extinct megafauna in the neotropics. Recent archaeological survey carried out in the upper Madeira region near the city of Porto Velho as part of the CRM project “Preventive Archaeology in the Santo Antonio Hydroelectric Power Plant, Madeira river, Rondonia” has generated information that suggests high demographic human occupation of the region in the past, and has corroborated claims of early Holocene occupations that continued throughout the Holocene, as well as the presence of ancient anthropogenic soils (Amazonian black earth). Multicomponential archaeological sites have been found with pre-ceramic settlements dated to 7740±50BP and 4910±100 associated with anthropogenic soils, sites with artificial mounds, and complex stratigraphic sites with several fluvial sediment depositions interdigitized with anthropogenic erosional soil have all been uncovered by archaeological survey and excavation. The upper Madeira is a crucial region for understanding anthropogenic landscape transformations and the origins of sedentarism in Amazonia. The paleoenvironmental contextualization, specifically the fluvial system and paleohydrological reconstruction during the Holocene is critical for understanding and interpreting the archaeological record.

## **ASSESSMENT OF WASH LOAD TRANSPORT IN THE ARAGUAIA RIVER (ARUANA GAUGE STATION), CENTRAL BRAZIL.**

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With an area close to 377,000 km<sup>2</sup> and a mean annual discharge of ~6,420 m<sup>3</sup>s<sup>-1</sup> the Araguaia River is the main river draining the central highlands of Brazil.

The Araguaia Rivers is a particularly sandy anabranching system that has been suffering geomorphologic and sedimentary changes because of the effect of high rates of deforestation during the last decades. Little is known, however, on the amount of wash load transport. We will present the first relatively systematic results on wash load transport for the Araguaia River at the Aruana gauge station. The drainage area at Aruana is 77000km<sup>2</sup> and the mean annual discharge is ~1200m<sup>3</sup>/s. A total of 140 samples from 20 field surveys were analyzed and the wash load transport was estimated. We calculated that from 2001-2007 the average annual transport oscillated between 8Mt/y and 6Mt/y.

An interesting aspect that makes the Araguaia unique when compared to other large alluvial rivers of Brazil is the relation between sandy load and wash load. The Araguaia at Aruana carries up to ~56%% of the total sediment load as sandy load. We can now conclude that wash load just represents near 44 to 49% of the total sediment load in this system. Our results demonstrate that previous works overestimated the total wash load transported by the Araguaia.

Taking into account that these are the first systematic results on wash load transport in the Araguaia, proposed human interventions in this system that affect sediment flows such as dams, can be extremely harmful for the fluvial system. A more systematic analysis of sediment transport and an integrated and multidisciplinary plan of basin management must be done so that the detrimental effects of these human interventions will be understood.

**MORPHODYNAMICS IN THE CONFLUENCE OF LARGE REGULATED  
RIVERS:  
THE CASE OF PARANÁ AND PARANAPANEMA RIVERS<sup>3</sup>**

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The confluence of the Paraná and Paranapanema Rivers is studied according to morphology and dynamics. It is probably the only example of this type of fluvial environment involving a large, tropical and intensive regulated river. Confluence channels were monitored along a hydrological cycle (high-low water level) in terms of morphology, flow velocity, magnitude, structure, and bedload dynamics. In this case, hydrology is controlled by the flow of the tributary which develops a continuous and well-defined thalweg since the collector channel (a secondary channel of the Paraná River) that presents relatively large bedforms that reduce stream power by increasing roughness. Although significant differences in channel morphology were not observed along the hydrological year, bed material texture indicates that the channel bottom is suffering a slight *armouring process*. This is probably the reason for the large asymmetry of channel confluence where the depth of the tributary channel is larger than that of the main collector channel (the Parana left branch). The Rosana Dam, closed in 1987 and located 26 km upstream from the confluence, is the cause of the changes in sediment transport and the generation of the channel pavement. With the closing of the Porto Primavera Dam (2000) in the Paraná River ( 27 km upstream from the confluence) a new morphodynamics is foreseen for this environment, and this paper can be seen an relevant pioneer reference for environmental monitoring and management.

## **ARCHITECTURAL ANALYSIS OF THE ARAGUAIA RIVER FLOODPLAIN, CENTRAL-BRAZIL.**

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The Araguaia River is the main fluvial system of the Cerrado biome. The river is characterized for presenting a well-developed floodplain along more than 1100km in the middle reach from the locality of Registro do Araguaia until for hundred kilometers upstream the confluence with the Tocantins River. Results on the sedimentary architecture of the floodplain based on facies analysis are presented. Field surveys of river banks, islands and fluvial bars were complemented with cores obtained with a vibracore and a mechanic auger. Absolute dating was obtained through C14.

The floodplain is a complex morpho-sedimentary unit composed at least for three main geomorphologic units : a hindered drainage plain, a unit of paleomeanders and the younger one formed by accreted sand banks and islands.

The younger units is suffering significant transformation because the increasing amount of sediments provided to the fluvial system because the high rates of deforestation experienced by the basins since 1970s. For that reason the main channel of the Araguaia is suffering an incipient metamorphosis.



## **QUATERNARY GEOMORPHOLOGICAL EVOLUTION OF THE APURE RIVER ALLUVIAL PLAIN. LOW VENEZUELAN PLAINS.**

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The Venezuelan plains covers an area of approximately 240.000 square kilometers of which 100.000 km<sup>2</sup>, according to the RAMSAR criteria, should be consider as a wetland; most of them are located in the denominated low flood plains. They are important not only by its extension (10% of the national territory), but also because of the diverse economical activities that it supports. The ecological importance of the area has motivated many multidisciplinary research about its natural dynamic and for preserving its hydrological and ecological processes, also to propose alternatives for its sustainable use, specially to study the impact that can be produced by the new projects for incorporating all the area to the big scale agricultural and cattle production trough the navigability of the Orinoco – Apure rivers axis. In the present study, the most important geomorphological features of the Apure River's alluvial plains along its 650 km of length were surveyed and investigated with the aims of contributing to understand the landscape evolution through the Quaternary period, to help in the project that allows its navigability and minimize the environmental impact that can cause the construction of physical infrastructure for navigation. The entire stratigraphic outcrop along the river was investigated and it permitted a framework presentation of the evolution since the pre-Quaternary time, when this land began to emerge with the Plio-Pleistocene orogeny, through the establishment of the initial drainage network and its posterior development along in the Quaternary period. This evolution allowed visualizing the many sedimentary environments that were formed as a consequence of the successive climatic changes that characterized this geological period. We have put special emphasis on the areas where probably channel correction needs to be done for the maintenance of the caudal flood during the dry season. Also, the relationship observed among the vegetation patterns and the geomorphological sedimentary units was studied because they, and the Quaternary geological processes, can help in explaining the abiotic control of the vegetation in this wetland area. This research project was mainly founded by the Universidad Pedagógica Experimental Libertador and the CABAH network of the Cytcd.

# **GEOLOGICAL, GEOMORPHOLOGICAL AND PALEO-HYDROLOGICAL PROCESSES THAT AFFECT THE FLUVIAL DYNAMIC OF THE PORTUGUESA RIVER, VENEZUELA.**

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We present a preliminary description of the geological, geomorphological and paleohydrological processes that have controlled the fluvial dynamic of the Portuguesa River during the Late Pleistocene – Holocene. We conducted a field-descriptive research with the help of topographic and geological maps; we steered the river during the 2005-2009 period, in different seasons; we selected some sections (high, medium and low) along the main canal with the use of orto-photomaps and Google Earth images; we described the canal patterns of the river according to Schumm (1963) and Brice (1984) and finally we calculated the sinuosity index (S.I.) and entanglement index (E.I.) according to Rust (1978). The results indicate that in the high section, the river behaves as an individual canal, which is embedded in the bedrock which consists of sedimentary and metasedimentary rocks (Cretaceous-Tertiary) and that it is partially controlled by faults oblique to the Boconó fault system. Transitionally, in the piedmont zone the canal transforms into a braided canal pattern (E.I. ~ 1.15) when in contact with the soft sediments of the Mio-Pliocene age, the Quaternary terraces and the excess load and decreased slope. In the mid section, the river is embedded in a silty clay material and changes to a single canal model of low sinuosity to high sinuosity (S.I. ~ 1.4-1.9) or meandering, observing several types of modern meanders, abandoned paleomeanders and paleocanals originated by the shortening, hanging and avulsion processes. In the low section the river continues over a cohesive plain and is meandering (S.I. ~ 1.6), but with wider wave lengths than in the prior section and it is also observed along its flood plains the presence of meander bars (scroll bar), lagoons (owbox lake) and big paleomeanders associated with Quaternary paleohydrological conditions. In conclusion, the Portuguesa River's fluvial dynamics is controlled by the geology (substrate), geological structures, slope, topography and paleohydrological conditions associated with climate changes in the Late Pleistocene-Holocene.

**Key words:** Portuguesa River, fluvial dynamics, Late Pleistocene, Holocene.