The exploitation of the hydroelectric potential of the Amazon region

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Foreword

The main hydrographic basins of the Brazilian South and Southeast were regulated by the construction of countless reservoirs for hydroelectric power generation, which constituted a significant impact on the quality and quantity of the waters of those hydrographic basin's rivers, but at the same time supported the economic development and the infra-structure progress, mainly in these regions. The impacts and the benefits of the construction of dams are well-known and described in details in several analyses, case studies and scientific researches in the areas of Limnology, Engineering, Geology and Geography. Key processes have been described, mechanisms concerning how dams work and their insertion in the hydrographic basins have been detailed and quantified and the evolution of the spatial and temporal organization of those large aquatic artificial ecosystems has been characterized (Tundisi et al., 2006a). In turn, the hydroelectricity generation technology and the production and management systems are quite advanced, attending 92% of the Brazilian households concerning electricity (Kelman et al., 2006).

In 2002, the Brazilian hydroelectric power plants produced 313, 811 GWh of the national market as a whole (88% of the total) to attend the national market and the complementary thermal generation was of 35, 037 GWh, 11,2% of the total. The connection of the systems is one of the important advances in the hydroelectric production and distribution in Brazil. Figure 1 shows the location of the Brazilian hydroelectric power plants with capacity higher than 30 MW. That figure demonstrates the huge and complex reservoir network of the South and Southeast regions. On a detailed study about the negative impacts and benefits of the construction of reservoirs, Straskraba & Tundisi (1999) showed that, despite environmental restrictions that result from the impact caused on the land and water ecosystems and of the changing of both the hydrosocial and hydroeconomic cycles, there was a set of positive and economic revitalization processes with access to energy, consolidation of waterways, leisure, tourism and irrigation, in such a way that, in process of time, the negative impacts were minimized by the expansion of the regional economies, a new organization of the hydrosocial and hydroeconomic cycles and adaptations of the flora and fauna of the reservoirs to these new conditions (Agostinho et al., 1994, 1999).

The main decurrent problems *after* the construction of the reservoirs have to do with the need for an integrated management of the multiple uses and with the integration between the system's operation, the limnologic and hydrologic functioning, the control of the impacts originating from the hydrographic basin, which are produced by the very expansion of the regional economy and its diversification due to the existence of the reservoir (Straskraba et al., 1993; Tundisi, 1994).

Figure 1 – Distribution of the main hydroelectric power plants in Brazil. Notice the concentration in the South and Southeast regions (Kelman et al., 2006).

The construction of the Curua-Una, Balbina, Samuel and Tucuruí dams in the Amazon region resulted in great environmental changes both upstream and downstream, jeopardizing both the local and regional ecosystems and generating difficult to control indirect effects, including in human health (Barrow, 1983; Garzon, 1984; Junk & Melo, 1987; Matsumura-Tundisi et al., 1991).

The impacts of the construction of hydroelectric power plants in the Amazon region derived above all from the effect of the decay of flooded land vegetation, from the great flooded area, the deterioration of the quality of water and the loss of services of the land and water ecosystems, including biodiversity and the changing of the processes (Tundisi et al., 2006a).

Another process that is being currently studied refers to the greenhouse gases in the reservoirs of the South and Southeast regions and in Amazonian reservoirs (Abe et al., 2005 a, b, c, d; Tundisi et al., 2005). According to those authors, besides the accumulation of organic matter coming from the hydrographic basins and from the flooded land vegetation, the retention time of each reservoir plays a crucial role in the emission of gases, especially CH_4 and CO_2 (Matvienko & Tundisi, 1996). Both Fearnside (1995, 2002) and Rosa et al. (2002, 2003) also tackled that problem.

Therefore, the set of hydroelectric reservoirs built in Brazil in the last fifty years promoted an extensive and deep change in the mechanisms for the functioning of rivers, lakes, flooded areas, and swamps, mainly in the South and Southeast regions of Brazil, also changing the hydrosocial and the hydroeconomic cycles. The Basin of Paraná River and its tributaries from the upper basin, the Tietê-Paranapanema Basin, as well as the formers of the Paraná, Rio Grande and Paranaíba Rivers have suffered a great impact with that construction of the great hydroelectric structures (Tundisi, 1993; Straskraba et al., 1993; Henry, 1999; Straskraba & Tundisi, 1999; Nogueira et al., 2006; Braga et al., 1998). The dams that were built in the Amazon region present other kinds of problems, as well as both spatial and time scales that are very different from the hydric systems of the South and Southeast.

According to Vörïsmarty et al. (1997), the extensive construction of reservoirs altered the transportation of sediments by the rivers to the oceans in great scale, and, besides, significantly increased the retention time of the continental ecosystems, which contributed to the growth of eutrofization and contamination, altering the food chains and producing a reduction of the volume of water available through sedimentation. Studies carried out in ten reservoirs in China showed that almost 40 km^3 were lost at an annual rate of 0.5 km^3. It is common to occur the erosion of the rivers' margins downstream along with degradation of the natural environments and special niches.

Functioning mechanisms of the land and water ecosystems in the Amazon

The scientific knowledge of the ecological processes, those of biodiversity and of the interaction between aquatic and land systems broadened considerably in the last ten years. The functioning of the Amazon region was synthesized by Sioli (1984) and more recently contributions by Vale et al. (1996), Ayres et al. (1999) and Junk (2006), consolidated that description of the structures and functions of the organisms, ecosystems and their temporal and spatial processes. Junk (1997, 2006) described the ecology of the pulse system in the great internal deltas of the Central Amazon region. According to that author, the flooding pulse system is the main power function in the great systems of flooding valleys and meadows of the Amazon region. Those power functions promote several environmental conditions, periodic alterations in the vegetable and animal communities and multiple and intensive alterations between the aquatic and the land phases with biotic processes for the production of organic matter and decay, sediment deposition and with a great variety of species. That pulse process that occurs in other meadow ecosystems in all continents reaches its maximum scale exactly in the Amazon region. The connectivity between flooded areas, natural channels, lakes, rivers and swamps has a gradient of direct and indirect interactions that are very important both ecologically and economically, with reflexes in the hydrosocial cycle (Figure 2).

Those great internal deltas with their natural variability to the aquatic biodiversity and the responses to the flooding and drought pulses, due to their spatial-temporal dynamics and of the genic flow of the land and aquatic organisms, are, according to Margalef (1997), "active evolution centers", promoting connectivity, altering biotic interactions and also promoting the animal and vegetable biodiversities, in a dynamic way. The biogeophysical connectivity of the systems and their large scales are also replicated in the hydrosocial cycle and in the exploration of the Amazonian meadow (Paddock et al., 1999; Sternberg, 1998; Roosevelt, 1999). Hydrosocial and hydroeconomic cycles in those large meadow areas and with differentiated mosaics are very important in the human exploration of the meadows. The different kinds of meadow and the ecological-social gradient in the Amazon region foster, according to Junk et al. (2000), four main economic activities in the meadow: fishing, forest exploration, aquiculture and cattle raising. According to Petrere (1992) and Barthem (1999), the artisan fishings in the Amazon provide jobs for seventy thousand people, support 250 thousand people and produce between one hundred and two hundred million dollars per year.

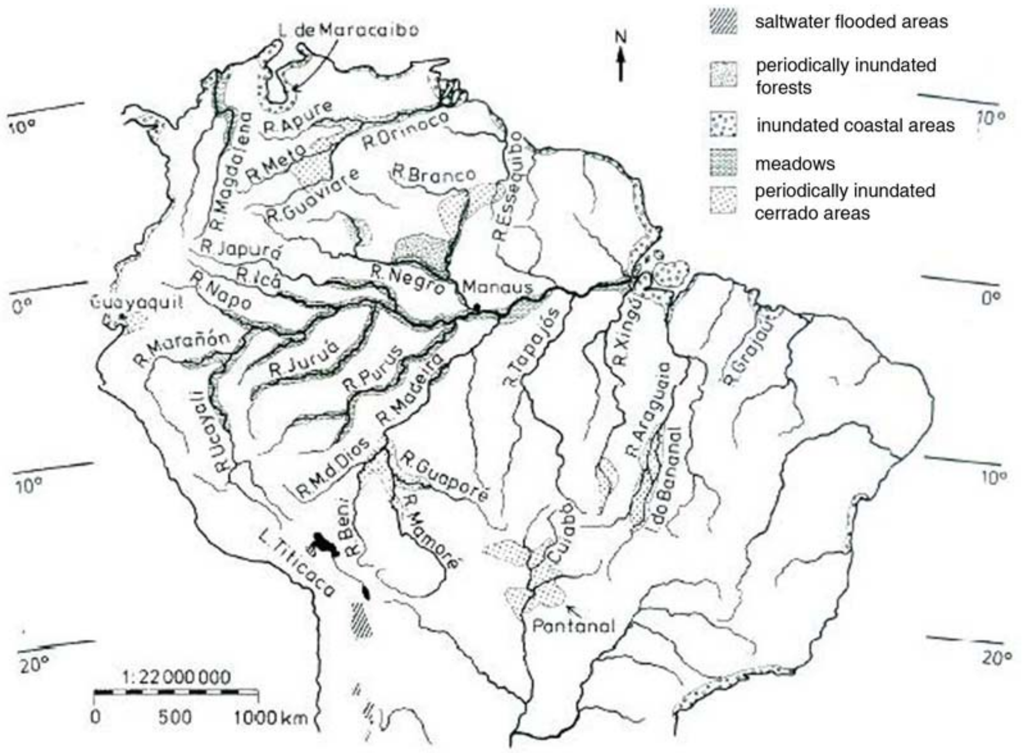

Figure 2 – Main flooded areas in the Amazon in a gradient of latitudes in Brazil (Junk, 1997).

Conclusions

The building of hydro power plants in the Amazon region, mainly in the Amazon River tributaries, will require profound alterations in the hydrological cycle, in the aquatic biodiversity, in the hydrosocial and hydroeconomic cycles of the region, requiring high level detailed interdisciplinary studies to solve the problems of those impacts and to minimize them. However, there must be a set of strategic, ecological and economic studies with the goal to promote a long-term view of State in the hydroenergetic exploration in the Amazon. It's necessary to develop studies that make possible the adequate choice of the rivers that will impact and those that will be preserved in relation to the economic and social benefits of the hydroenergy exploration and of preservation. Those analyses must consider that reservoirs are complex systems, particularly taking into account its interaction with the hydrographic basin, the multiple uses and the functioning and operation mechanisms in those reservoirs (Tundisi, 1999; Tundisi et al., 2007 a, b), including direct and indirect effects.

As for the construction of new hydro power plants in Brazil, its continuity, its dimensioning, control and management will depend on the long-term strategies to establish an exam and an emphasis, but detailed in dynamic processes and those of the future energy matrix in Brazil. The existent reservoirs also need investments in the technology of the restoration, recovery and control of the pollution, contamination and eutrophication, which already reach countless systems that are in critical conditions (Tundisi et al., 2006 a, b). Those investments also depend on environmental public policies and on long-term State strategies with a scientific and technological basis to support the enterprises already existent.

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Abstract: The continuity of the current Brazilian energy mix implies an expansion of Amazonian hydropower exploitation, where 52% of the hydropower potential is. Conciliating hydroelectric power production and preservation of the Amazon region and biodiversity is one of the greatest challenges of the next 30 years. The Amazon region, with its innumerable tributaries, internal deltas, meadow areas and flooded regions, is one of the active centers of evolution of the planet. Construction and management processes of new reservoirs and the strategic planning in hydro resources appropriation must undoubtedly consider this conciliation of the hydropower expansion and conservation of ecological, hydrosocial and hydroeconomic processes in the Amazon. In this context of hydropower exploitation, a stable integration of planning and management into the scientific and technological bases is essential.

Keywords: Amazon, Hydroelectric power plant, Preservation.

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