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Ecological Restoration on the Lower São Francisco River, Brazil

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Abstract

The construction of dams promotes great benefits to society in terms of meeting their needs (such as human consumption, irrigation and hydropower generation). However, despite all its benefits, its construction causes significant impacts on the river system. Changes in hydrodynamic characteristics cause changes in the components, processes and functions of the river ecosystem. The Basin of the São Francisco River has undergone major changes in his aquatic ecosystem from the construction and operation of his many reservoirs it has located in Minas Gerais and Bahia states. Therefore, this article aims to analyse the changes on the lower São Francisco river hydrodynamics because of the operation of his reservoirs, with the purpose of its restoration. The methodology consisted of analysing the aquatic biota present at the lower São Francisco River and comparing with its hydrodynamic behaviour. The results shown that the reservoir operation rules do not consider the natural seasonality of flows throughout the year to attend the demands of the aquatic ecosystem and coastal communities. In addition, the reservoirs operations do not consider the river flow natural variability thus interfering with the hydrodynamic conditions both lateral and in depth throughout the lower São Francisco river flow in the longitudinal direction.

Keywords: Rio São Francisco, Environmental flow, Aquatic system, River restoration

Introduction, scope and main objectives

São Francisco river undergone significant changes in his aquatic ecosystem due to the construction and early operation of the reservoir Three Marias, located in Minas Gerais, and Sobradinho in Bahia State, both for the generation of hydroelectric power (Martins, 2011). The lower São Francisco river, located after Xingó reservoir, is the most affected by power generation as it is situated downstream of this river dam cascade, as shown in Figure 1. The successive changes in the flow imposed on the downstream of the many dams, due to the hydropower plants operating rules, increased the saline intrusion producing drastic changes on the aquatic ecosystem.

For Matos et al. (2010), the need to expand the storage of water in large reservoirs to meet the demands, mainly to the hydroelectric power generation cause negative impacts on the ecological and social context. Indeed, the construction of dams causes significant impacts on the river system, modifying its hydrodynamic characteristics that cause alterations in the components, processes and functions of the river ecosystem. The dams' reservoirs reduce the magnitude and frequency of floods,

consequently reducing flood areas downstream and oxbow lakes. According to Menninger et al., (2006) from the hydropower plant reservoirs, the water flow effluent causes damage to native species that often replaced by exotic species more able to tolerate greater temperature and current speeds variability. The river current speed is a crucial parameter in the natural selection of aquatic species related to the species swimming characteristics (VICENTINI et al. 2009).

Wang et al. (2013) presents the concept of environmental flow, as the necessity of water allocation to meet the demands derived from various human activities and conservation of the aquatic environment. The term environmental flow refers to the amount, quality, and seasonality of water needed to maintain the integrity of the aquatic ecosystems (MEDEIROS et al. 2013), also a basic condition for the restoration of the aquatic ecosystem. The Brazilian National System of Nature Conservation Units - SNUC (BRAZIL, 2000), defines restoration or restitution of a degraded ecosystem or wild population, as the return, as close as possible, to its original conditions.

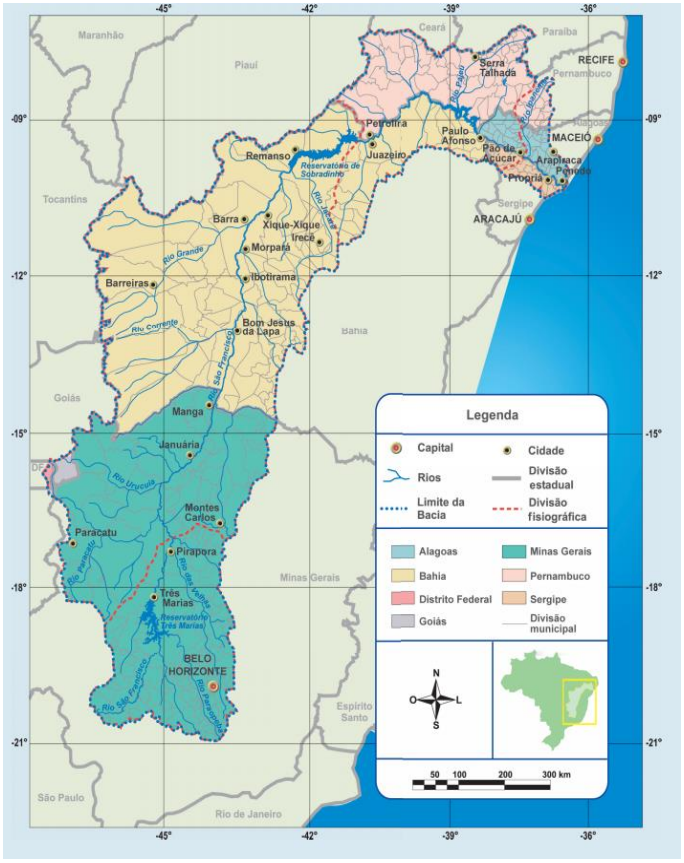


Fig 1 – Localization of São Francisco River

Source: SOUSA (2014)

For instance, the Xingó UHE used as mitigation measure, to introduce some fingerlings of native species in order to repopulate the river and recover the degraded ecosystem. .

This article analyzed the changes in the lower São Francisco river hydrodynamics and its consequence on the aquatic ecosystem as a result of reservoirs operation, with the purpose ofits restoration.

Methodology

The methodology consisted of analysing the aquatic biota present at the lower São Francisco River section comparing with its hydrodynamic behaviour. This section has a total distance of 152 km, from Piranhas to Propriá city (Fig 2 and Table 1), subjected to the Xingó reservoir operations. The Piranhas' section was emphasized because of this have little influence of saltwater intrusion and therefore presents greater number of freshwater species. The applied boundary condition was the

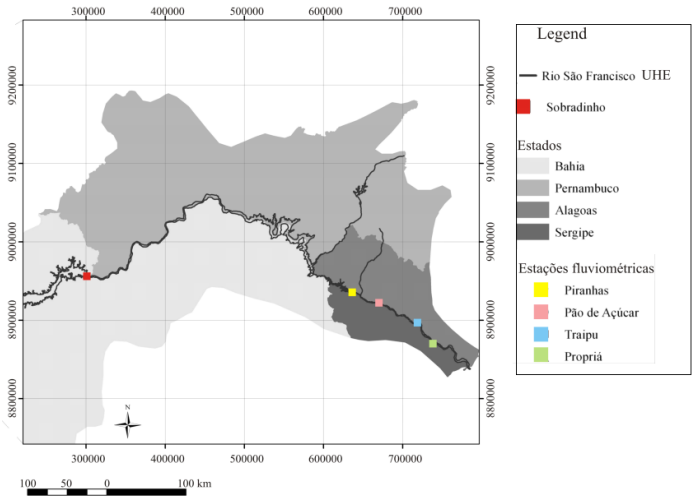


Fig 2 – Localization of the Lower São Francisco River

Source: Modificated from Martins et. al. (2011)

environmental flow for dry and wet season. The hydrodynamic model, HEC-RAS (River Analysis System), in unsteady flow, generated the hydrodynamic analysis. The analysed parameters were height (depth of the waterline) and flow speed. The reported biota present in the section is from Ecovazao Network Report (Notice # 45/2006 - CTHidro - Ecological Flow in Watershed Brazilian - Research Projects).

Table 1: Location of stations in this study

STATION	COD.	LOCATION	LATITUDE (UTM)	LONGITUDE (UTM)
PIRANHAS	49330000	PIRANHAS – AL	(E) 636623	(N) 8935760
PÃO DE AÇUCAR	49370000	PÃO DE AÇUCAR – AL	(E) 670355	(N) 8921826
TRAIPU	49660000	TRAIPU – AL	(E) 719014	(N) 8897023
PROPRIÁ	49705000	PROPRIÁ – SE	(E) 738389	(N) 8870132

Results

Chart 1 and Chart 2 show the hydrograph monthly seasonality of the parameters speed and height in the section immediately downstream of the Xingó dam, the lower São Francisco River section.

Chart 1: Monthly variability (Year 2014) for height and speed in Piranhas' section: Hydrograph of the dry period

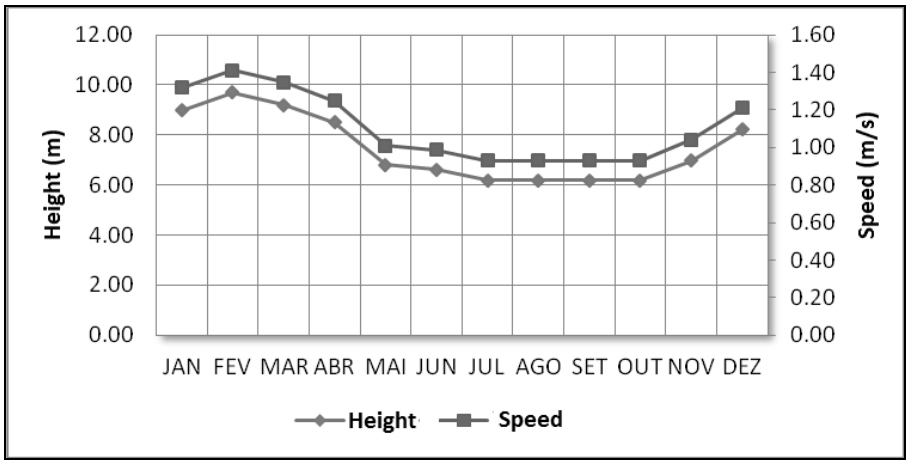
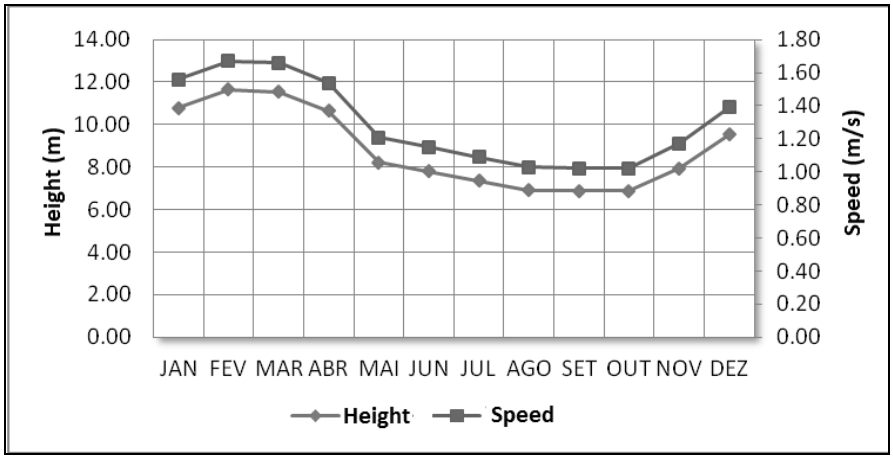


Chart 2: Monthly variability (Year 2014) for height and speed in Piranhas' section: Hydrograph of the wet period



Along the lower São Francisco River, the forty-seven fish species identified are strictly from freshwater (Ecovazao Network report, Notice No. 45/2006 - CTHidro - Ecological Flow in Watershed Brazilian - Research Projects). Table 2 presents some species found downstream the Xingó dam (Piranhas' section).

Table 2: Fish species present in Piranhas' section

SPECIES		CHARACTERISTCS
POPULAR NAME	**CIENTIFIC NAME**	
Caris	*Hypostomus spp.*	**Invasive Species.** Siluriformes; Dependent on rocky bottom for survival (growth of algae, daytime refuge in dens) and speed of water relatively quickly; Reaches an adult size of 10 to 60 cm; It survives at a pH ranging from 6.5 to 7.4; 26 ° C; Omnivorous diet.
	Megalancistrus cf. barrae	
Mandis	*Pimelodus maculatus*	**Native Species**. Found some species on the lower São Francisco River. Siluriformes; carnivores; Generally associated with sandy / muddy bottoms; Reaches an adult size of 51 cm; Supports pH ranging from 6.5 to 7.5 and a temperature between 22 to 27ºC.
	Duopalatinus emarginatus	
Chira ou Bambá	*Prochilodus argenteus*	**Invasive Species.** Unique species of freshwater. They are iliophagous. Their reproductive period extends from November to January in flood seasons. It is a **migratory species**.
Piau Cutia	*Leporinus cf obtusidens*	**Invasive Species** .The reproductive period extends from December to January, the spawning is complete, seasonal with peak. It is **not a migratory species**.
Piau Preto	*Leporinus piau*	**Invasive Species.** Can achieve size above 400 grams of body weight. It is **not a migratory species**.
Piau Branco	*Schizodon knerii*	**Invasive Species** Reaches an adult size of 23 cm; It supports a pH ranging from 6.2 to 7.2 and a temperature between 22 to 28ºC. It is a **migratory species**.

Source: Adapted from Aguiar (2006); Costa et. al. (2003); Melo (2011)

Table 3 presents the fishes quantities found on the studies (AGUIAR, 2006).

Table 3: Quantity found for each species in station of Piranhas

POPULAR NAME	JANUARY	MARCH	MAY	JULY	SEPTEMBER	NOVEMBER	TOTAL
Chira	2	3	5	2	4	4	20
Piau Cutia	1	0	3	0	0	1	5
Piau Preto	10	1	19	3	6	5	44
Piau Branco	1	1	6	4	0	3	15

Source: Aguiar (2006).

Discussion

Charts 1 and 2 for the hydrographs on both seasonality (dry and wet) for the river Piranhas' section show higher heights of water level from December to May. Also the simulations show that the parameters flow speed and height have a drawdown from upstream to downstream within the section due to the increased width of the main river channel. .

The height interferes with the dynamics of the fish amount. The greater the depth, greater the quantity due to the wide availability of habitat. Seasonal flow volumes within a year are necessary to maintain these environments favorable to the occurrence of the fish full life cycle, also providing refuge during the full period (DEPHILIP and MOBERG, 2010). Table 3 shows this dynamic, mainly for the species popularly called "piau preto".

In Piranhas' section due to the inclusion of new fish species for recovering the riverbed after the dam's construction the native fish species (mandi) was reduced because of invasive species. Table 2 shows that "chira" is the only migratory specie still found in Piranhas' section. The other migratory species became extinct because demand floodplain in flood seasons of for their later reproduction. The invasive species adapted to Piranhas' section probably obtained this favorable condition due to elements such as, background grain size, nutrients, turbidity, depth (elevation) and bed flow speed.

Conclusions

This article analysed the hydrodynamics changes in the lower São Francisco river, as a result of reservoirs operation. It related the hydrodynamic river behaviour with fish populations, using the simulation of environmental hydrograph (dry and wet period) with the purpose of restoring the river section studied here.

To provide the ecological restoration desired here, the reservoir operation rules should consider the natural seasonality of flows throughout the year in order to meet the demands of the aquatic ecosystem and coastal communities. The flow natural variability interferes with the hydrodynamic conditions, which influence the lateral and in depth connectivity of the river.

Acknowledgements

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References

AGUIAR, M. C. P. Caracterização de ictiofauna bioindicadora da vazão ecológica para o Baixo Curso do Rio São Francisco. Rede Ecovazao. Edital nº 45/2006 - CTHidro - Vazão Ecológica em Bacias Hidrográficas Brasileiras - Projetos de Pesquisa. Universidade Federal da Bahia. Brasil.

BRASIL, Lei n° 9985 de 18 de julho de 2000. Institui o Sistema Nacional de Unidades de Conservação da Natureza. DOU: 19.7.2000.

COSTA, F. J. C. B. Recomposição da Ictiofauna Reofílica do Baixo São Francisco. Projeto de Gerenciamento Integrado das atividades desenvolvidas em terra na Bacia do São Francisco. ANA/GEF/PNUMA/OEA. Sergipe, 2003. In.: < http://www.sfrancisco.bio.br/arquivos/ANA%20001.pdf>.

DEPHILIP M., MOBERG,T. Ecosystem flow recommendations for the Susquehanna river basin. In: The Nature Conservancy, 2010

MARTINS, D.M.F.; CHAGAS, R.M.; NETO, J.O.M.; JÚNIOR, A.V.M. Impactos da construção da usina hidrelétrica de Sobradinho no regime de vazões no Baixo São Francisco. In: Revista Brasileira de Engenharia Agrícola e Ambiental v.15, n.9, p.1054–1061, 2011.

MATOS, J.P.; COHEN, J.T.; BOILLAT,L, SCHLEISS, A.J.; PORTELA, M.M. Analysis of flow regime changes due to operation of large reservoirs on the Zambezi River. In: Environmental Hydraulics - Christodoulou & Stamou (eds) Taylor & Francis Group, London, 2010.

MEDEIROS, Y. D. P.; FREITAS, I. M. P.; STIFELMAN, G. M.; FREIRE, R. R.; O´Keeffe, J. Participation In The Environmental Flow Assessment: The São Francisco River Case Study. Gesta - Revista Eletrônica de Gestão e Tecnologias Ambientais, v.1, p.122-130, 2013.

MELO, B.F. Genética de populações de Prochilodus argenteus e P. costatus do médio São Francisco. (Dissertação de mestrado). Universidade Estadual Paulista, São Paulo, 2011.

SOUSA, M. M.. Cinco curiosidades sobre o Rio São Francisco. Aquafluxus Consultoria Ambiental em Recursos Hídricos. Brasil, Agosto de 2014. In.: < http://aquafluxus.com.br/?p=5343>.

VICENTINI, G. C., MARTINEZ, C. B. Levantamento da Velocidade Prolongada de Peixes — Um Estudo de Caso com o Mandi (Pimelodus Maculatus). In: Revista Brasileira de Recursos Hídricos. V14, n.2, Abril-Maio. 2009. In: <https://www.abrh.org.br/sgcv3/UserFiles/Sumarios/f10e52bf7bb1090719a7caf29b099f4a_bb879e f4f806a8613682314e8e1a4103.pdf>.

WANG, J; DONG, Z; LIAO, W; LI, C; FENG, S; LUO, H; PENG, Q. An environmental flow assessment method based on the relationships between flow and ecological response: A case study of the Three Gorges Reservoir and its downstream reach. In: Science China, v.56, 2013.