

## SHORT NOTES

# Water quality assessment of the Mogi-Guaçu River in Brazil: proposal of a system-based model

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### 1. Introduction

The Water Code, created in 1934, was the first attempt of governmental intervention in Water Basin Management in Brazil. It was a centralized bureaucratic system established to regulate the use of water. Since the beginning, Water Management suffered significant changes and the model currently used is an integrated participative systemic model.

The distribution of water resources in Brazil is very irregular, 70% of water is located in the North region, 15% to the Central-West, 12% in the South and Southeast and 3% in the Northeast region (BNDES 1997). The state of São Paulo is located in the Southeast region, which has the biggest water consumption. The Water Resources Agency of São Paulo State (CETESB) has an advanced water management system with 20 Watershed Management Committees. Groups from different social sectors compose these committees. They constitute a new kind of organization that is responsible for the watershed planning. Actually, these committees use to obtain relevant information but they are not able to develop future scenarios, objectives, strategies and temporary goals for the water basin.

The Mogi-Guaçu watershed is the most important basin in São Paulo State from the economic point of view, but the river has problems of erosion, silting, flooding and low water quality. The water quality problems are due to non-point sources of pollution from agriculture and municipal and industrial point sources.

In order to support the committees to improve Basin Planning this study propose to apply a system dynamic model to understand watershed dynamics to evaluate the human impact to water quality through the use of scenarios. It considers that Brazilian water quality database is in a initial stage of developing and also that only a few rivers have been studied for modeling purposes. Therefore, the use of highly complex data demanding models is not practicable. The systemic model under construction intends to provide an adequate model for a simulation considering limitations of Brazilian database and also includes new variables (turbidity and organic matter in the sediment) that are considered critical to simulate a turbid river with highly sedimentary organic matter content.

The longitudinal observed data is presented here and it shows an evident relation between the urban sites and the water quality degradation and self-depuration. Hopefully it will allow the evaluation of impact under different scenarios of economic and population growth, technical changes in agriculture and environmental and social policies for watershed management.

### 2. Methodology

The model is based on systems ecology of rivers and uses Odum's energy language (Odum 1983, 1996). The river is described as a web of interconnected compartments individually described for each variable. It takes into account

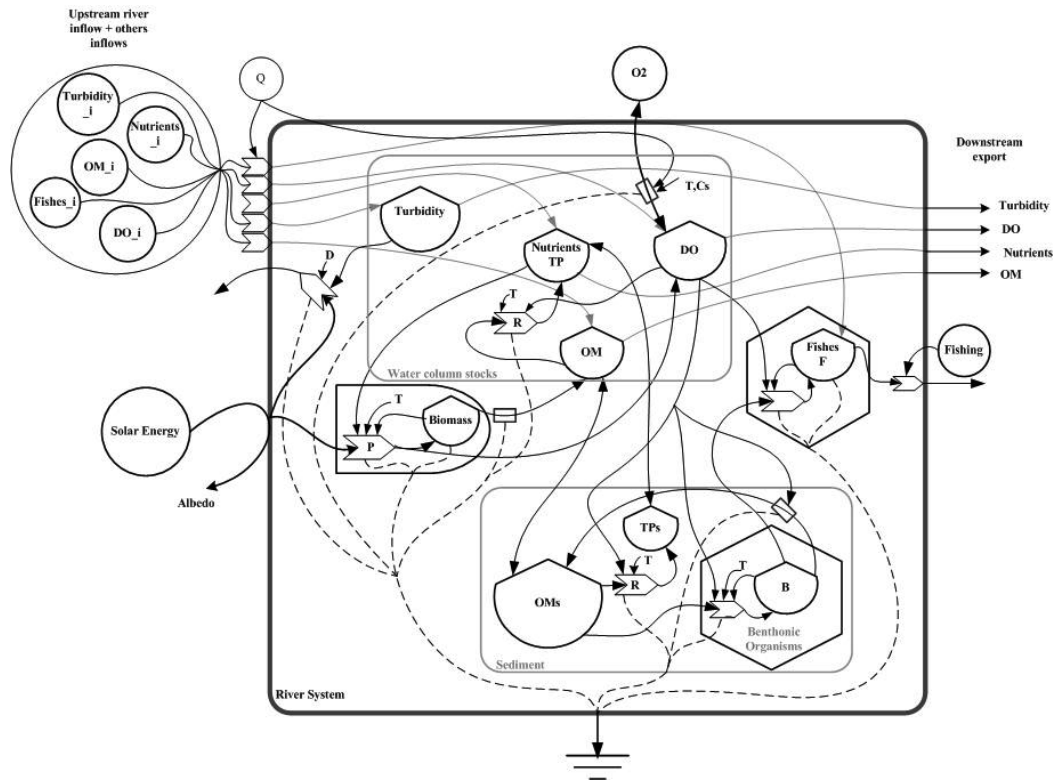


Figure 1. Systemic diagram for the river system

models described by Odum (1983), Schnoor (1996) and applications developed by Whitehead et al. (1997) and Sincock et al. (2003). Figure 1 depicts a compartment with multiple inputs, outputs, internal processes and interactions that contribute for non-linear behavior of variables.

The differential equations were written for each variable based on energy language.

Total Phosphorus in water column:

$$d(TP)/d(t) = +TP_i * k_{p_i} - TP * k_{p_o} + TP * k_{p_{res}} - TP_s * k_{p_s} - k_{max} * Biom * (JR/JR + Imi) * (TP/Kmp + TP) + M * DO * k_{om}$$

Total Phosphorus in sediment:

$$d(TPs) / d(t) = + TP * k_{p_s} - TP_s * k_{p_{res}} + OMs * DO * k_{oms}$$

Dissolved Oxygen:

$$d(DO) / d(t) = +DO_i * k_i - DO * k_o + k_{rea} * (Cs - DO) + k_{max} * A * (JR/JR + Imi) * (TP/Kmp + TP) * k_o - DO * OM * k_{res} - DO * B * F * k_f - DO * OMs * k_{rs} - DO * B * F * k_{fo} - DO * OMs * B * k_{bp}$$

Algae Biomass:

$$d(A) / d(t) = + k_{max} * A * (JR/JR + Imi) * (TP/Kmp + TP) * k_b - A * k_{om}$$

Organic Matter in water column:

$$d(OM)/d(t) = +OM_i * k_i - OM * k_o + A * k_{rOM} - OM * k_s - OM * DO * k_{om}$$

Sedimentary Organic Matter:

$$d(OMs)/d(t) = -OMs * DO * B * k_{bc} + B * DO * k_{bi} - OMs * DO * k_{rOM} + OM * k_{sOM}$$

Benthonic Organisms:

$$d(B) / d(t) = -B * DO * k_{fish} + OM * DO * B * k_{bp} - B * DO * k_{dom}$$

Fish population:

$$d(F) / d(t) = +/- F_i * k_{fi} - F * k_{fishing} + B * DO * F * k_{pf}$$

### 3. Water Quality Evaluation from Experimental Data

The Mogi-Guaçu River sustains an economy with intensive agriculture use and industrial urban centers with no sewage treatment plants that discharge crude sewage into the river. The next figures show the river longitudinal dynamics from observed data (2004 and 2005 annual mean values) available from the monitoring system of Company

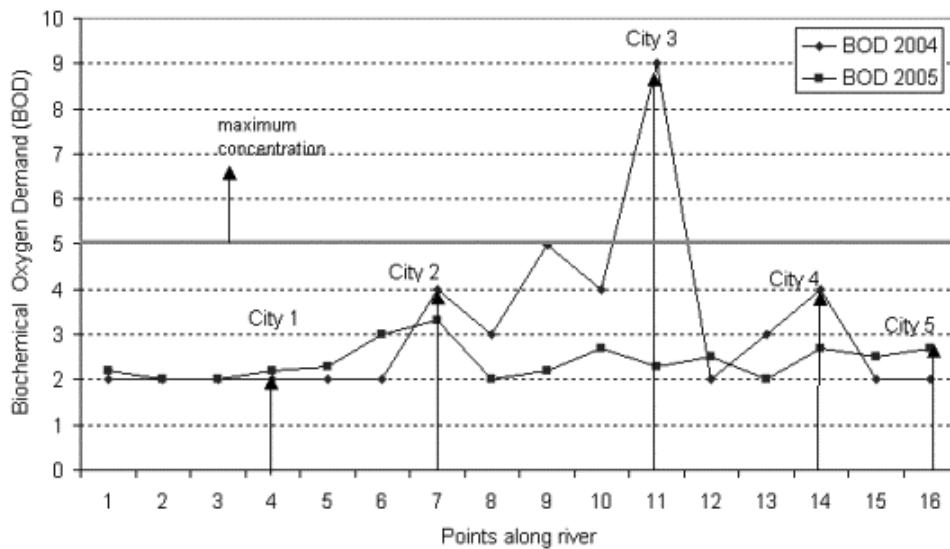


Figure 2. Longitudinal behavior of biochemical oxygen demand

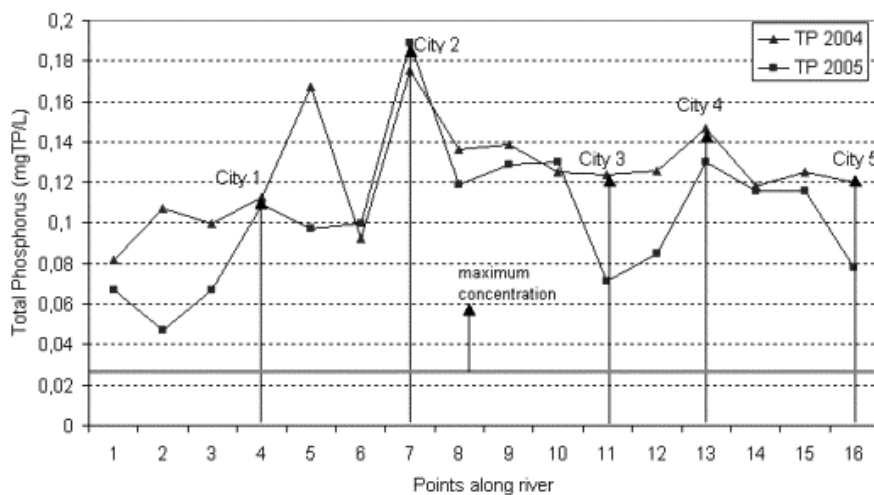


Figure 3. Longitudinal behavior of total phosphorus

of Environmental Sanitation and Technology of São Paulo State (CETESB). Figure 2 presents the total phosphorus, dissolved oxygen and biochemical oxygen demand concentrations for 5 cities along the Mogi-Guaçu River. For some cities the parameters values in the Figures 2, 3 and 4 exceed the limits permitted by environmental Brazilian legislation.

The five larger cities influence both quantitatively and qualitatively the water body. The river gets polluted but its natural self-depuration allows partial recovering of water quality.

#### 4. Conclusions

The modeling under construction takes into account a previous research (Rivera et al., in press) that developed a system model to evaluate the dynamics of a Brazilian lake however it does not assess the water quality of a river.

The modeling and simulation of future scenarios will be defined considering the ability of the water body to maintain its natural self depuration processes as well as its capacity to support wildlife. The model is now under

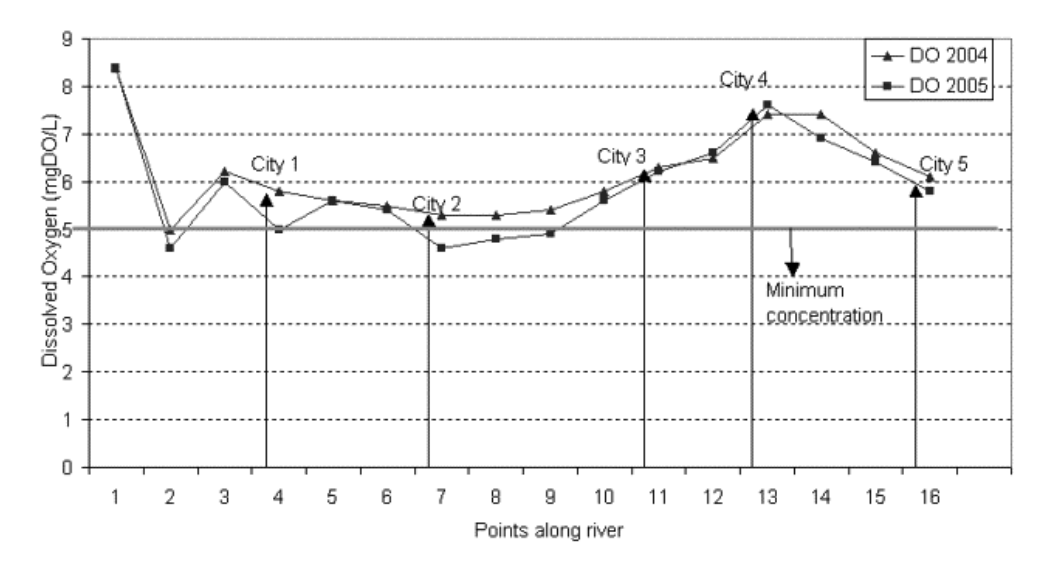


Figure 4. Longitudinal behavior of dissolved oxygen

in calibration process and it is expected that will fit to observed data allowing the building of future scenarios for Mogi-Guaçu watershed planning.

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