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Numerical Modeling as an Essential Tool for Efficient Water Quality Management

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Highlights:

- Modeling study in the Ocoy River sub-basin;
- Analyze the environmental benefits brought by future improvements in the sewage system of Medianeira/PR;
- The results demonstrate an average reduction of 40.3% in pollutant concentration.

Keywords: Numerical modeling; Water quality; DELFT-3D

INTRODUCTION

To evaluate the effect of improvements in the sewage system of Medianeira, mathematical and computational models will be proposed as diagnostic and prognostic tools for water quality. Mathematical models are indispensable tools for studies, projects, and the management of natural water bodies, as they provide an understanding of process dynamics and predict situations by simulating future scenarios. These river water quality models have been applied since 1925 by Streeter and Phelps. Subsequently, various models have been developed, offering a greater range of parameters, such as Lima (2018) and Silva (2017), with the aim of evaluating the impact caused by the discharge of effluents into water bodies.

This summary presents a water quality modeling study in the Ocoy River sub-basin. The objective of the study is to apply the DELFT-3D numerical model, using hydrodynamic and water quality data, to analyze the environmental benefits brought by future improvements in the sewage system of Medianeira/PR. Five water quality parameters were analyzed for this purpose: Dissolved Oxygen, Biochemical Oxygen Demand, Ammoniacal Nitrogen, Nitrate and Total Phosphorus.

The present study is still ongoing, with initial results obtained for the Alegria River, marked in red in Figure 1.

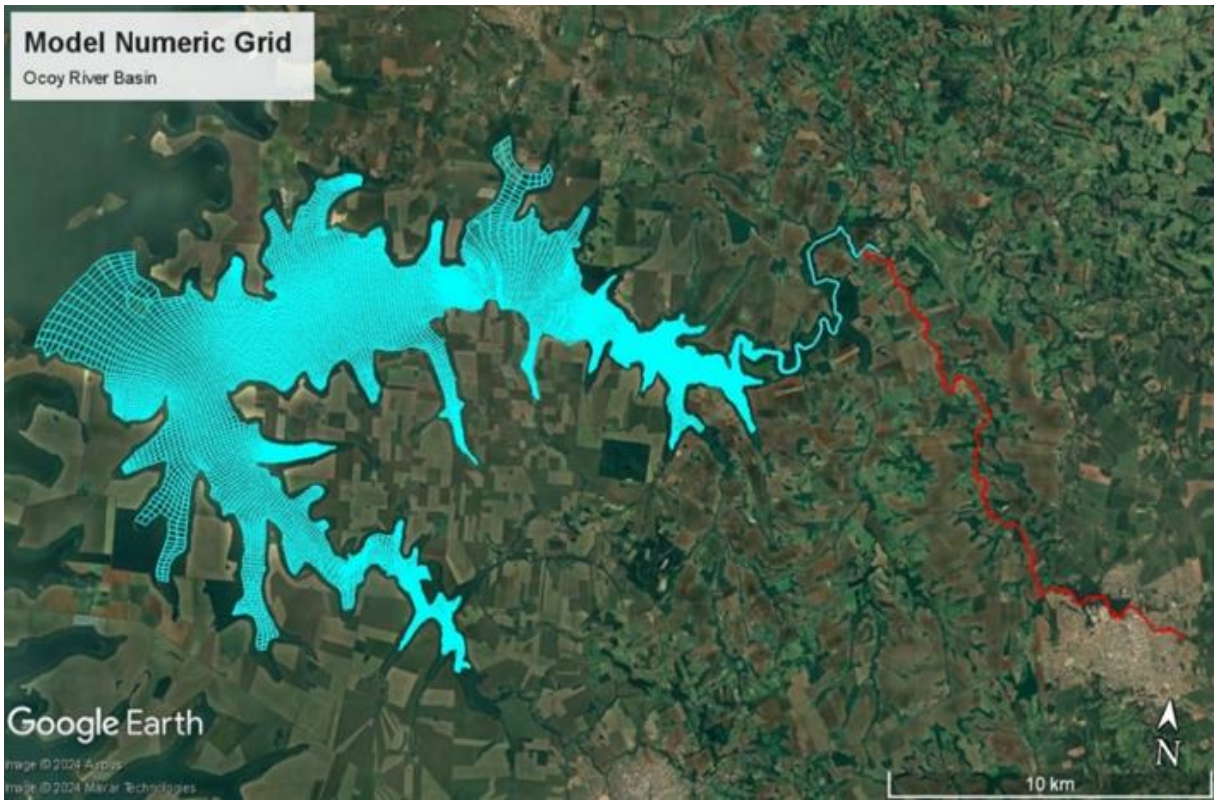

Figure 1: Study area coverage. In red, the Alegria River, the subject of the study.

METHODOLOGY

The methodology involves three main phases: input data, where data such as flow, level, bathymetry, and pollutant concentrations are collected; the second phase concerns model preparation, where configurations and hydrodynamic and water quality calibration are conducted. Finally, in the last phase, scenario simulations and result analyses are performed.

Two different scenarios were simulated: the first taking into account the current conditions observed in the field; and the second considering future conditions, projecting improvements resulting from interventions in the sewage system of Medianeira/PR. In both scenarios, no other point loads along the river were considered.

Table 1 presents the percentage reduction in sewage discharge concentration in relation to the actual wastewater treatment plant, considering the planned future improvements in sewage treatment. Table 2 shows the effluent discharge flow, with the current scenario having a flow rate of 35 liters per second, and the future scenario projecting a flow rate of 80 liters per second. The river flow used in the simulation was based on daily data from 2019, with the lowest observed flow during this period (0.131 m^3/s) representing the most critical point. This value was used as the reference for the present study.

Parameter	Reduction in sewage discharge concentration in relation to the actual wastewater treatment plant (%)
BDO	54%
Total Phosphorus	73%
Ammoniacal Nitrogen	82%
Dissolved Oxygen	0%
Nitrate	0%

Table 1: percentage reduction in the projected sewage discharge concentration for the future scenario.

Scenario	Flow (L/s)
Current	35
Future	80

Table 2: effluent discharge flows.

RESULTS AND CONCLUSIONS

To exemplify this work, results for the simulation of the ammoniacal nitrogen parameter were presented. Figure 2 summarizes the results, indicating a reduction in ammoniacal nitrogen in the future scenario for the Alegria River.

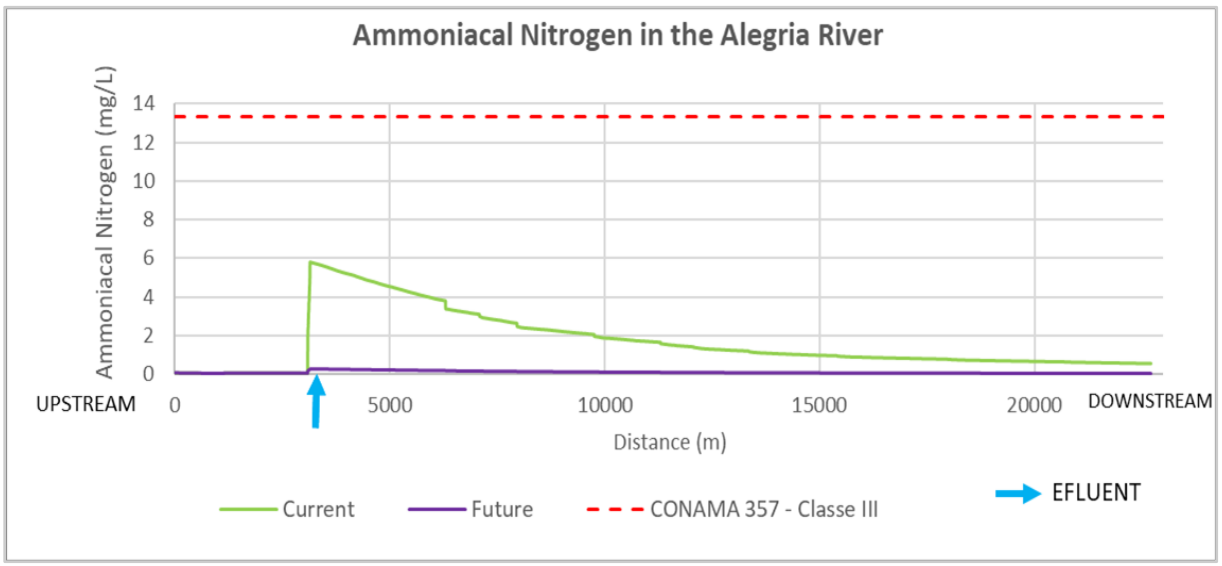

Figure 2: Results of ammoniacal nitrogen concentration in the current and future scenario.

The percentage reduction in concentration for each parameter is presented in Figure 3, considering the difference between the simulation of the current scenario and the future scenario in the Alegria River.

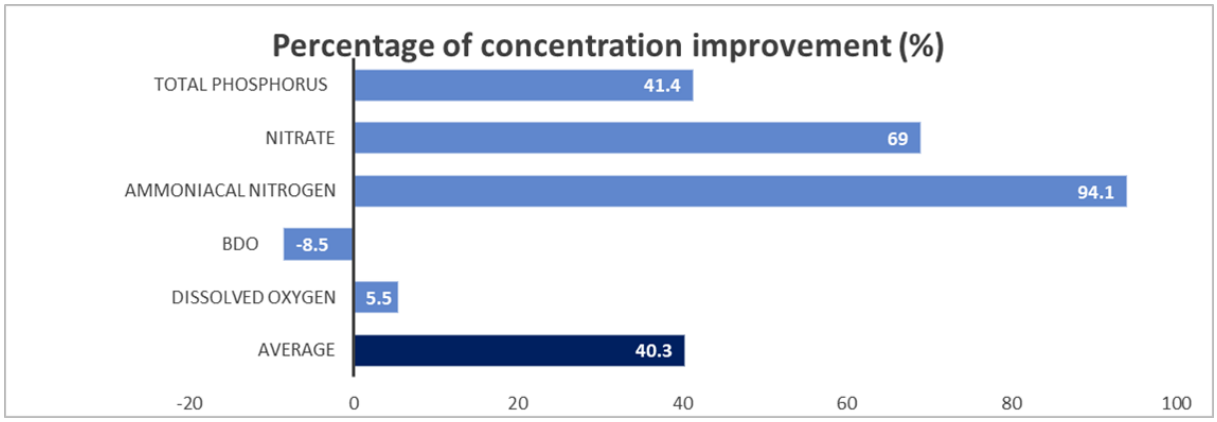

Figure 3: Results of the percentage reduction in the concentration of each parameter between the current and future scenarios.

It is important to note that, although the discharge concentrations of nitrate and dissolved oxygen are the same in both the current and future scenarios (as shown in Table 1), there is a reduction in the future concentration of these two parameters in the river due to the influence of other water quality parameters, especially BOD and ammoniacal nitrogen.

Regarding BOD, a slight deterioration is observed. This occurs because, despite the improvement in efficiency, the increase in flow rate predicted for the future scenario (from 35 L/s to 80 L/s) results in a small increase in the concentration of BOD along the river.

In conclusion, it was observed that there was an improvement in water quality in the future scenario, especially concerning the parameters of Ammoniacal Nitrogen, Nitrate and Total Phosphorus. The results demonstrate an average reduction of 40.3% in pollutant concentration, showing that the improvements planned for the sewage system in Medianeira contribute positively to the environmental enhancement of the Ocoy River basin.

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