Design Project – SIE 2022

Water Quality in the Amazon River Basin

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Introduction

Problem statement: Amazon River Basin water quality has been degraded by untreated sewage discharge, oil extraction, mining activities, erosion due deforestation, large infrastructure development, agro-industry. These activities threaten the quality of the water, putting the survival of certain ecosystems and the human health at risk.

Objective: To assess the influence of the land use over selected water quality parameters considering the spatial distribution of the available water quality data points in the Amazon Basin.

Methods

Data collection → Raw data analysis → Principal component analysis (PCA) → Spatial autocorrelation and model construction

- Selection of water quality parameters and collection from government reports and databases
- Land use data
- Monthly and annual flow

- Exceedance of water quality standards
- Pollution hotspots
- Concentration of land uses potentially impacting water quality
- Flow seasonality

- Correlation between parameters
- Identification of underlying phenomena
- Parameters priorization for modelling

- Global and local spatial autocorrelation
- Geographically Weighted Regression (GWR)
- Analysis of residuals and model coefficients

Results

Water Quality Problematics

Statistical summary of water quality parameters

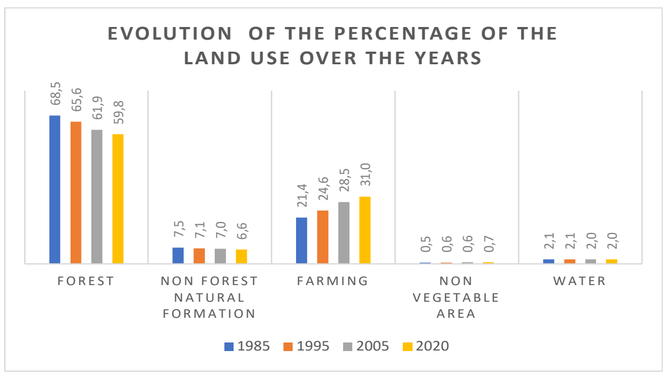
Variables	Mean	STD	Min	Max	Permissible Range	# exceedances	% Exceeding	Peak month
pH [-]	6.85	0.96	4.19	11.16	6.5 – 8.5	119	38.76	DEC
Electrical Conductivity [µS/cm]	101.41	123.83	1.45	828	< 400	10	3.50	DEC
Dissolved Oxygen [mg/L]	6.3	2.44	0.13	12.90	6.5 – 8	146	48.83	DEC
Temperature [°C]	25.9	3.93	6.8	34.20	-	-	-	SEP
BOD5 [mg/L]	9.22	21.59	1	140	1 – 8	35	23.33	DEC
COD [mg/L]	36.63	41.84	10	219	< 200	2	2.50	DEC
Total Phosphorus [mg/L]	3.59	14.90	0.009	86	< 0.05	53	24.88	JUN / NOV
Total Nitrogen [mg/L]	1.79	1.74	0.126	10.17	< 0.30	61	88.41	NOV
Total Suspended Solids [mg/L]	130.20	411.70	0.80	5378	< 10% Of seasonal mean []	52	26.67	NOV
Thermotolerant Coliforms [MPN/100ml]	3065.83	10253.83	1.80	79000	-	-	-	NOV

- The parameters considered problematic according to the proposed standards are **pH**, **dissolved oxygen**, **BOD5**, **total phosphorus, total nitrogen** and **total suspended solids**.
- Variations are primarly due to the activity and discharges in the region including wastewater discharges, urban settlements, runoff from agricultural activities, often rich in organic compounds and metals, and fossil fuel emissions. The variability of these parameters is strongly related to the seasonality of the water flow throughout the year.

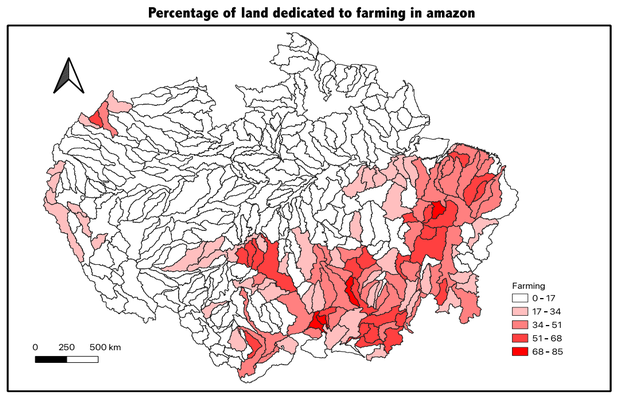
Flow effects on some water quality parameters

Parameter	Low Flow	High Flow
Water Pollutants	Can reach toxic levels	Eliminate the risk of toxicity and transport the pollutant elsewhere
Nutrients	Eutrophication, acidification, toxic nitrogen levels	Denitrification, removed by transport
High temperature	Lowers oxygen and then productivity, contaminants become more toxic	-

Land Use



- The surface of the forest decreases.
- The area of farming, mining and oil exploitation is increasing.
- These land uses result in the release of untreated wastewater.



The use of pesticides to cultivate different products in the Amazon is also a risk to the health of ecosystems. Intensification of agriculture is the result of the increasing demand for products for export

PCA

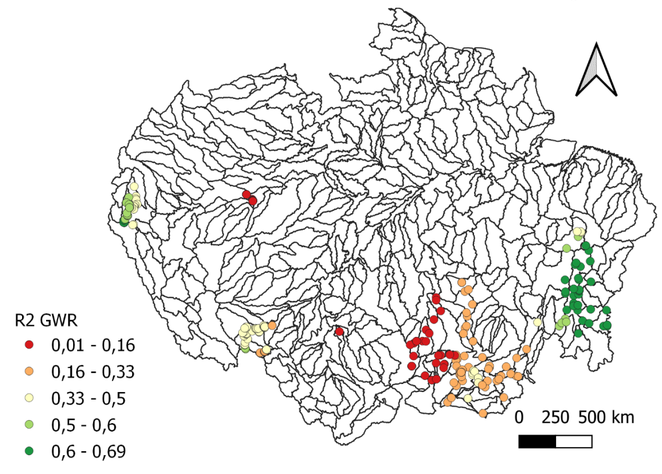
BOD_5 demonstrated to be the variable with the strongest impact on the model. Also, the one with highest data availability among the measurement points.

Statistical model for BOD_5

GWR to obtain one model for BOD_5 concentration per measurement point following the form:

$$[BOD_5] = \beta_0 + \beta_1 * (Local\ runoff) + \beta_2 * (Total\ flow) + \beta_3 * (\%\ farming) + \beta_4 * (\%\ urban) + \beta_5 * (\%\ farming) + \varepsilon$$

Goodness of fit R2 for model obtained for each point through GWR



- Values for goodness of fit >50% clustered in southeastern Brazilian Amazon and north of Peruvian Amazon.
- Extreme values for BOD_5 measured close to urban settlements, assumptions regarding the flow in these cases can play a determining role.

Conclusion and future perspectives

- The accuracy of models to predict the water quality parameters concentration depends on the location and the quality of available information.
- The inclusion of other land uses can refine the performance of the model, for instance for other water quality parameters such as heavy metals.
- Include the temporal variations of land use if water quality information from previous years is available.
- Use methodologies such as Spatial Statistical Modeling on Stream Networks (SSN) to consider the particularities of water streams.

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