Quantitative insights into phosphorus loadings and speciation in urban catchments

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GWF FINALE
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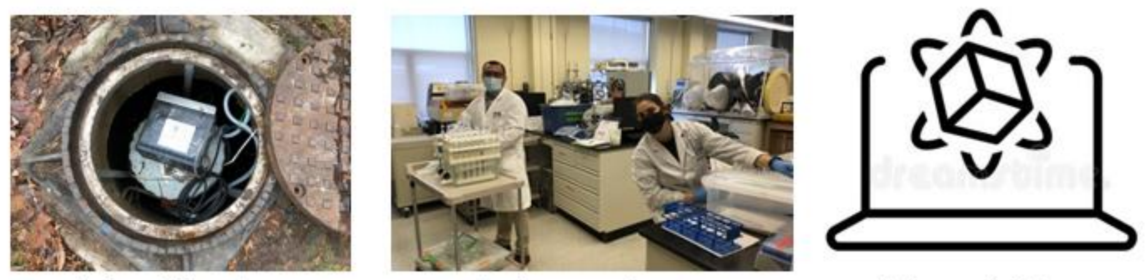
Motivation & Objective

Phosphorus (P): Water quality impairment, eutrophication, harmful algal blooms, etc.
Stormwater runoff: Main driver of urban P pollution, intensified by excessive urbanization and extreme events caused by climate change.

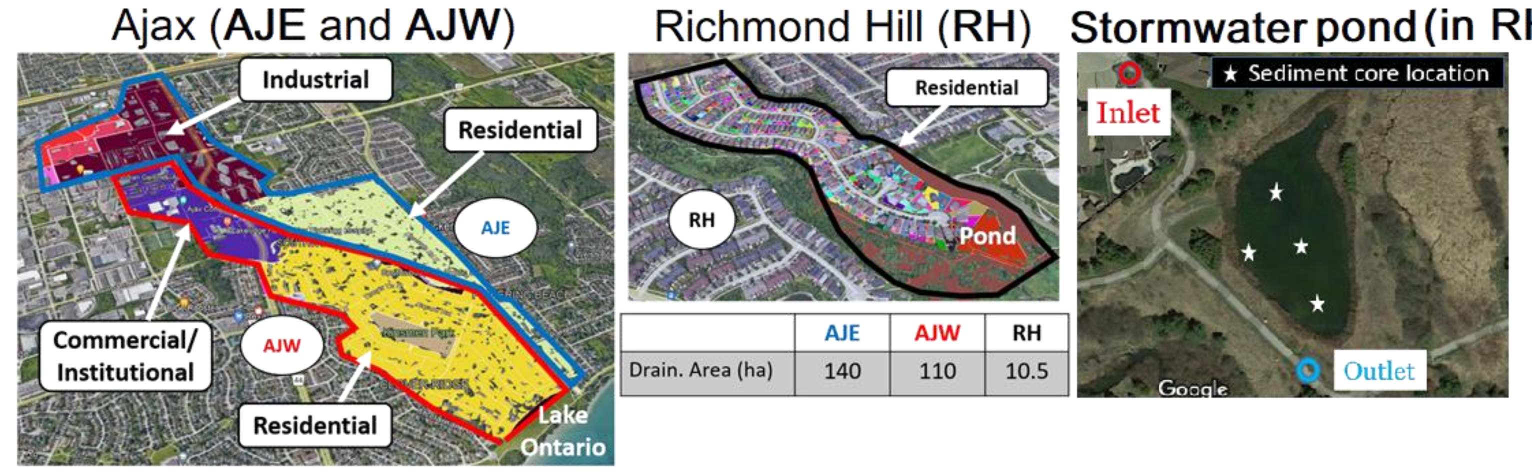
Identification of P magnitudes and forms: an essential need in the context of stormwater and nutrient management in urban landscapes.
Our main objective: Quantify loadings of P species in multiple urban catchments in southern Ontario, using fieldwork data, P speciation lab analyses and numerical modeling.



Monitoring · Lab analyses · Simulation

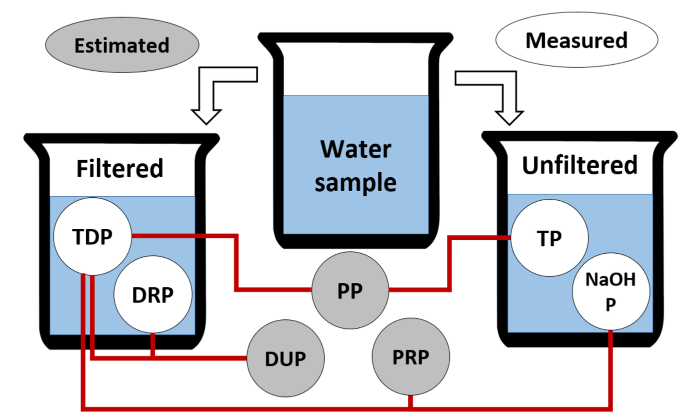
Material & Methods

- **Study sites:** 3 catchments & 1 pond; data collected in 2020 – 2022



	AJE	AJW	RH
Drain. Area (ha)	140	110	10.5

- **P species analyzed:**



- **Statistical modeling:** estimated P species' load using multiple linear regression (MLR) models:

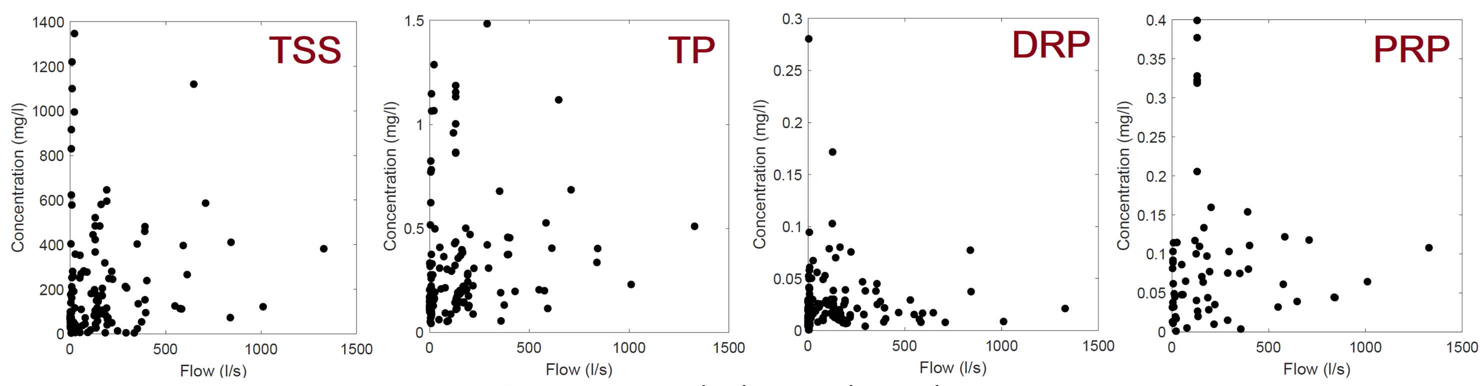
$$L_{n\times1} = X_{n\times(k+1)}\beta_{(k+1)\times1} + \varepsilon_{n\times1}$$

with predictors:
- Flow/Precipitation
- Time of sample/event
- Temperature
- # dry days prior to events

Findings

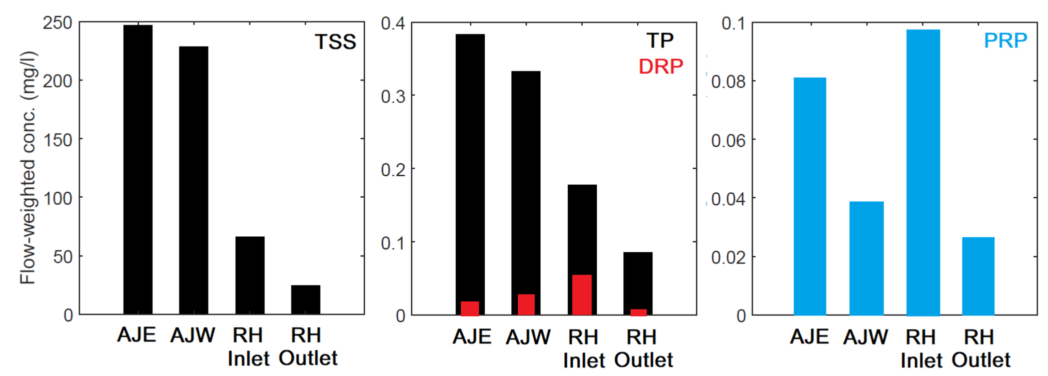
What data showed:

- Non-linear relationship between flow and concentrations indicating that flow cannot be the only predictor of concentration.



Concentration-discharge relationship

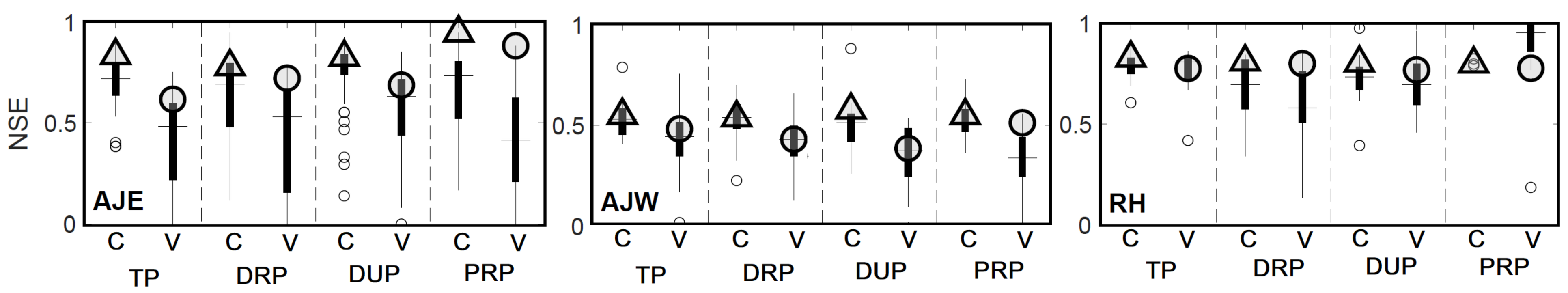
- Total P flow-weighted concentration decreased from Ajax sites to RH (similar to total suspended sediments). However, DRP and PRP, as bioavailable P forms, were higher in RH compared with Ajax sites.



Constituents' flow-weighted concentrations

MLR simulations:

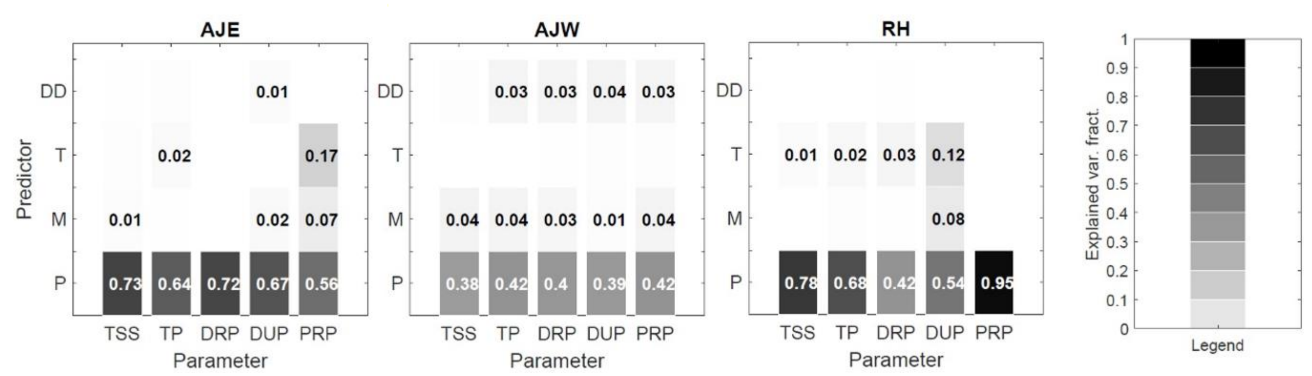
- Model performance (assessed with Nash-Sutcliffe Efficiency (NSE) metric) was promising, especially in AJE & RH that were more impervious than AJW (i.e., the greenest catchment)



C: Calibration
V: Verification

Verification was assessed to ensure models' transferability to time windows in the past.

- Despite many predictors, hydrology (precipitation/discharge) explained the majority of variations in loads.
- Statistical modeling is a reliable load estimation tool in urban catchments, but performance might be not be as promising when green spaces are abundant across catchments.

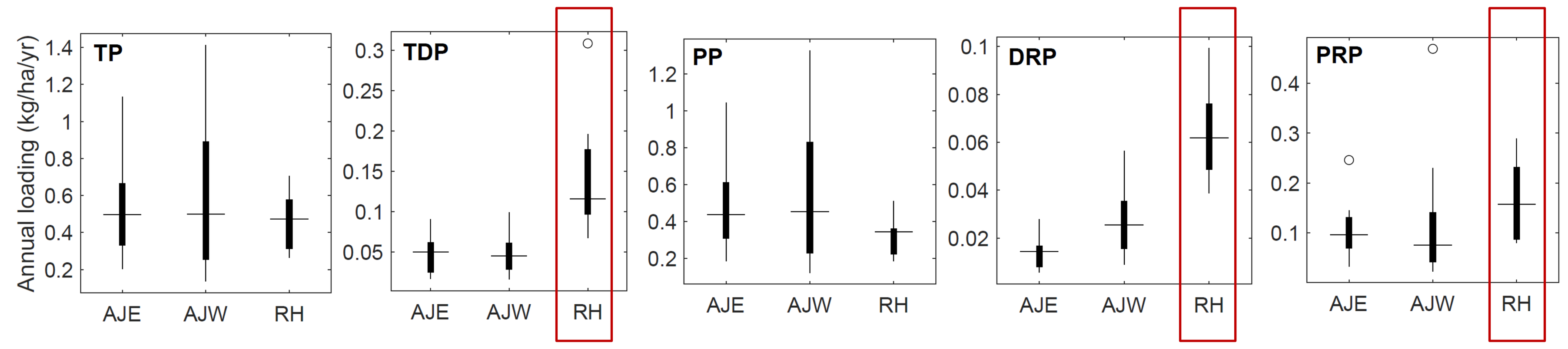


Percentage of loadings' variability explained by each predictor

Findings & Conclusions

Model simulations:

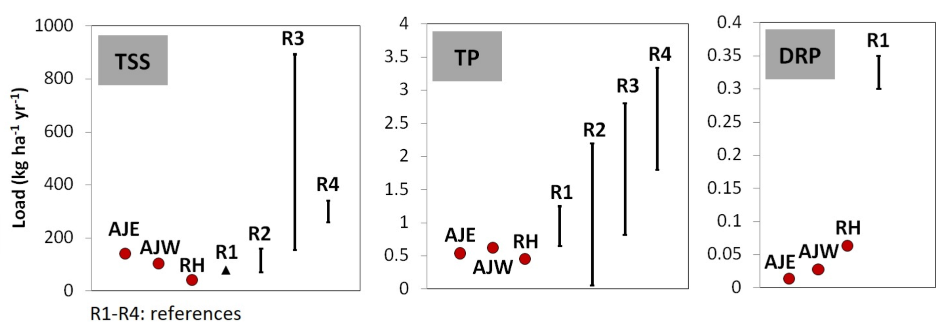
- Relatively higher export of reactive/bioavailable P in RH, the fully-residential young catchment.



Reactive/bioavailable forms in fully-residential RH site

Loading boxplots for different constituents

- Estimated loads revealed that average annual loadings in study sites were close to lower bounds in the literature.

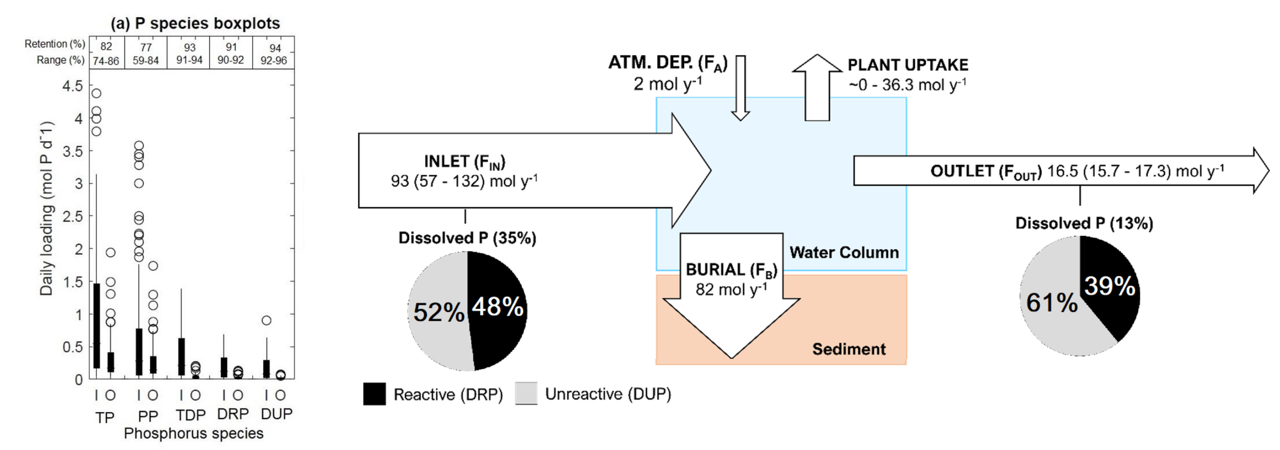


Comparison with previously published results

- Larger fraction of reactive P forms within total P and particulate P pools in RH.

Species fraction

- Mass balance analyses in the pond, using MLR-generated simulations, proved high retention of all forms of P both physically (sedimentation) and chemically (calcium-phosphate co-precipitation).



Daily P export (left) and P mass balance in stormwater pond (right)

Conclusions:

- MLR models offered as a tool for P load estimation in impervious urban catchments
- Fully-residential young catchments (e.g., RH) potentially as major exporters of reactive P forms
- Stormwater control measures a great tool for P load mitigation

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