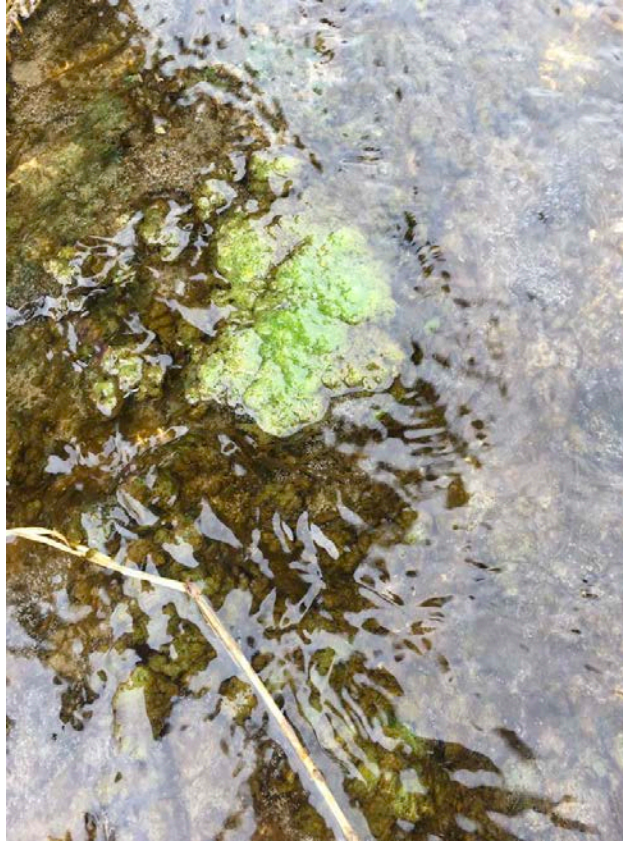

Long-term Phosphorus Monitoring in the Bay of Quinte: P from non-point sources: bioavailable input during extreme events, tracking the sources and remediation and internal loading

Professor Maria Dittrich
Biogeochemistry Group
University of Toronto
Canada
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Today…Long-term objectives of phosphorus management in the Bay of Quinte

Catchment

- **Monitoring P loading from** the catchments: the role of the extreme **precipitation in bioavailable P transpor**
- **Tracing P sources from the catchments**
- **Monitoring the sustainable BMP on a farm-scale**

Water body Bay

- **Monitoring internal P loading from sediments in the Bay o Quinte**

Phosphorus and carbon sequestrations in lake sediments and soils: the role of climate-driven factors

Assessing phosphorus leaching and plant efficiency of manure application and other BMPs, tracing phosphorus sources using oxygen isotopes

Dr. S. Mugalingam, LTCA

Dr. A. Blukacz-Richards & F. Ouellet, ECCC

Prof. G. Arhonditsis, UTSC

Eric and Max Kaiser, Kaiser' Lake Farm

Thanks to the funding agencies

Remediation Action Plan

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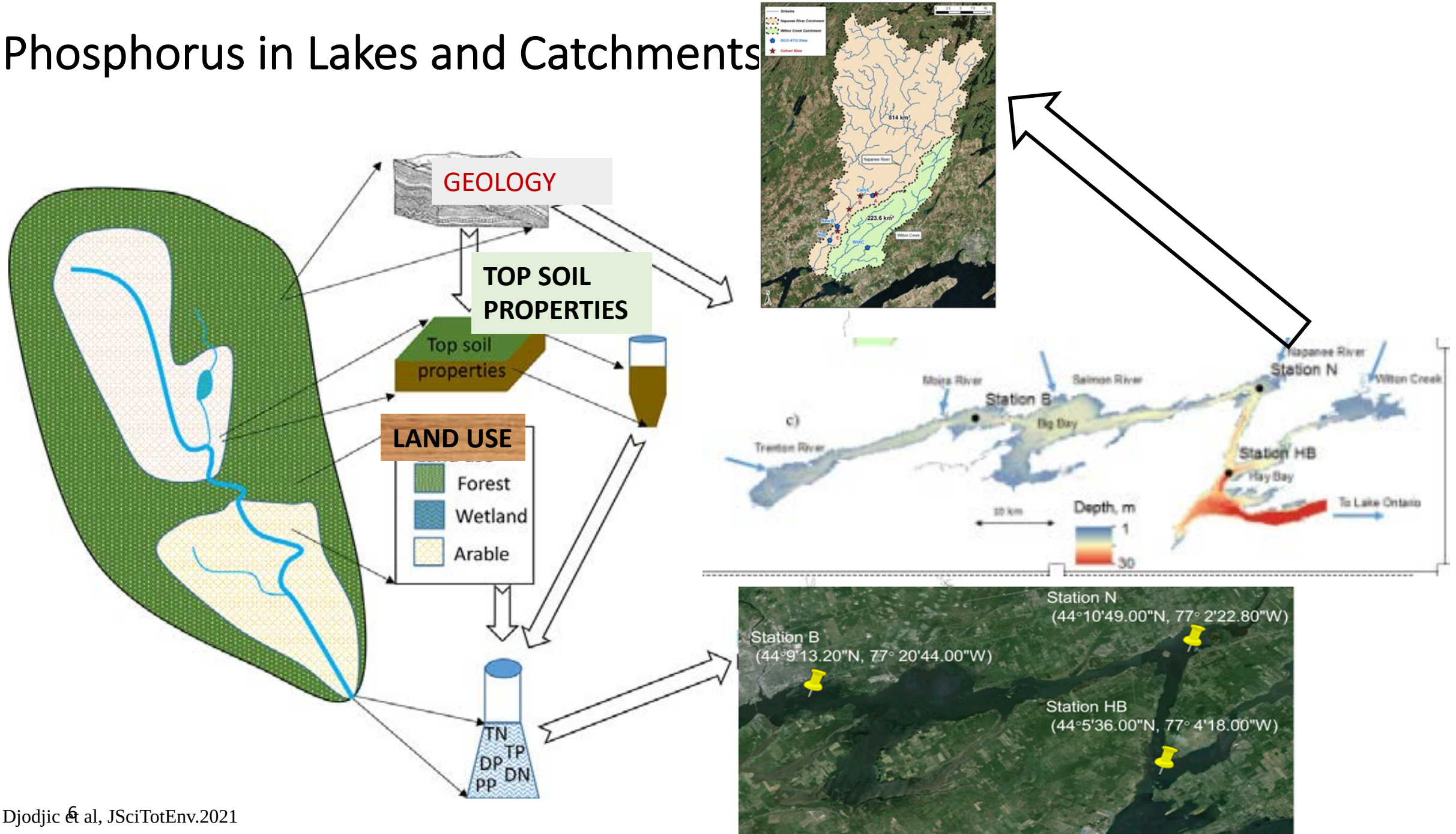
BUI #8 – Eutrophication or Undesirable Algae

BUI #13 – Phytoplankton & Zooplankton

https://www.bqrap.ca/

Phosphorus in Lakes and Catchments



Djodjic et al, JSciTotEnv.2021

Rationale

- Temporal and spatial dynamics of bioavailable P (rain events, seasons, catchment areas/sources)
- Identification of sources and transport of phosphorus (P) as well as an estimation P fractions, in particular bioavailable P
- Developing of farm-based T trapping reactors
- Estimation of P internal loading in Bay of Quinte

Non-point Loading of Bioavailable Particulate P

Bioavailable P is the sum of **immediately available P** and **forms P that can be transformed** into a bioavailable form by naturally occurring processes

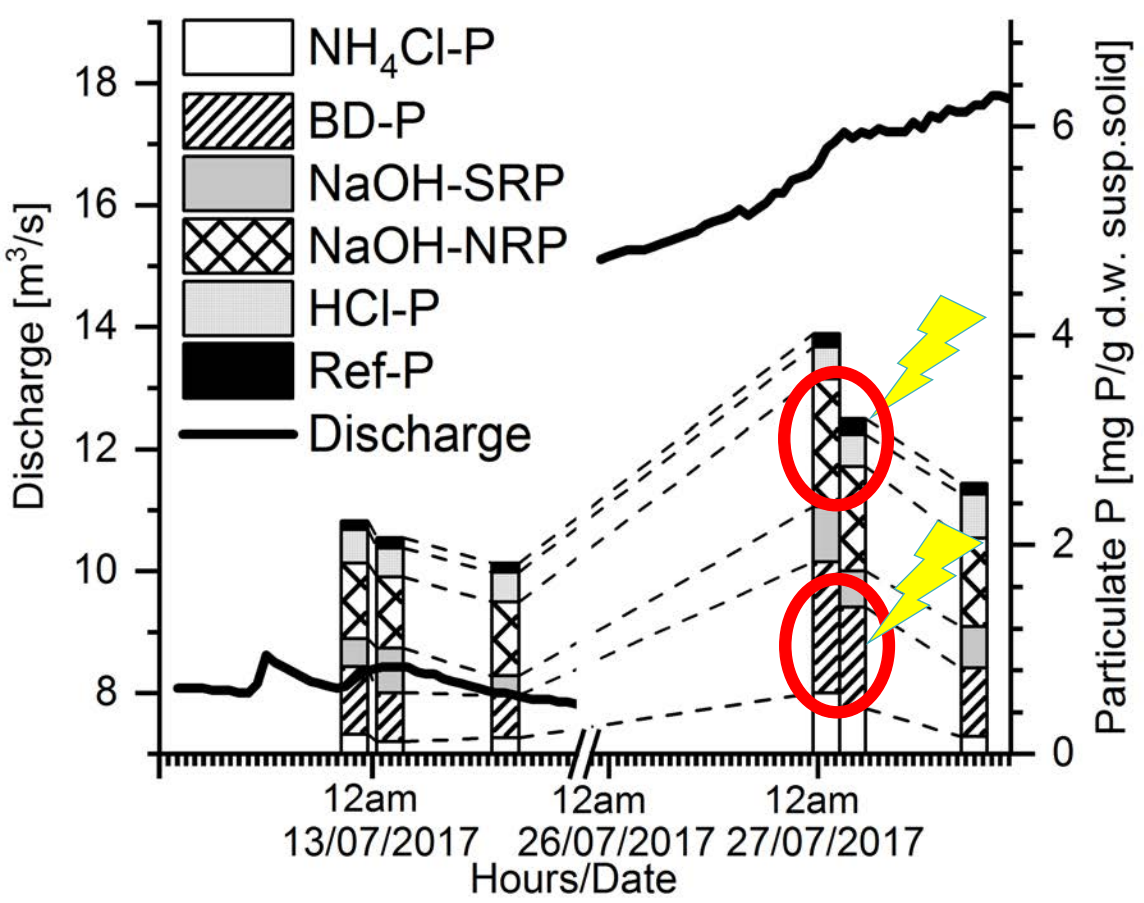
- Riverine P: dissolved/colloidal phase and particulate P forms (PP)
- Dissolved P (SRP) : **immediately bioavailable**
- PP = mineral + organic particles; it dominates P transport in rivers
- What is a portion of **bioavailable PP forms**?

→P fractionation techniques

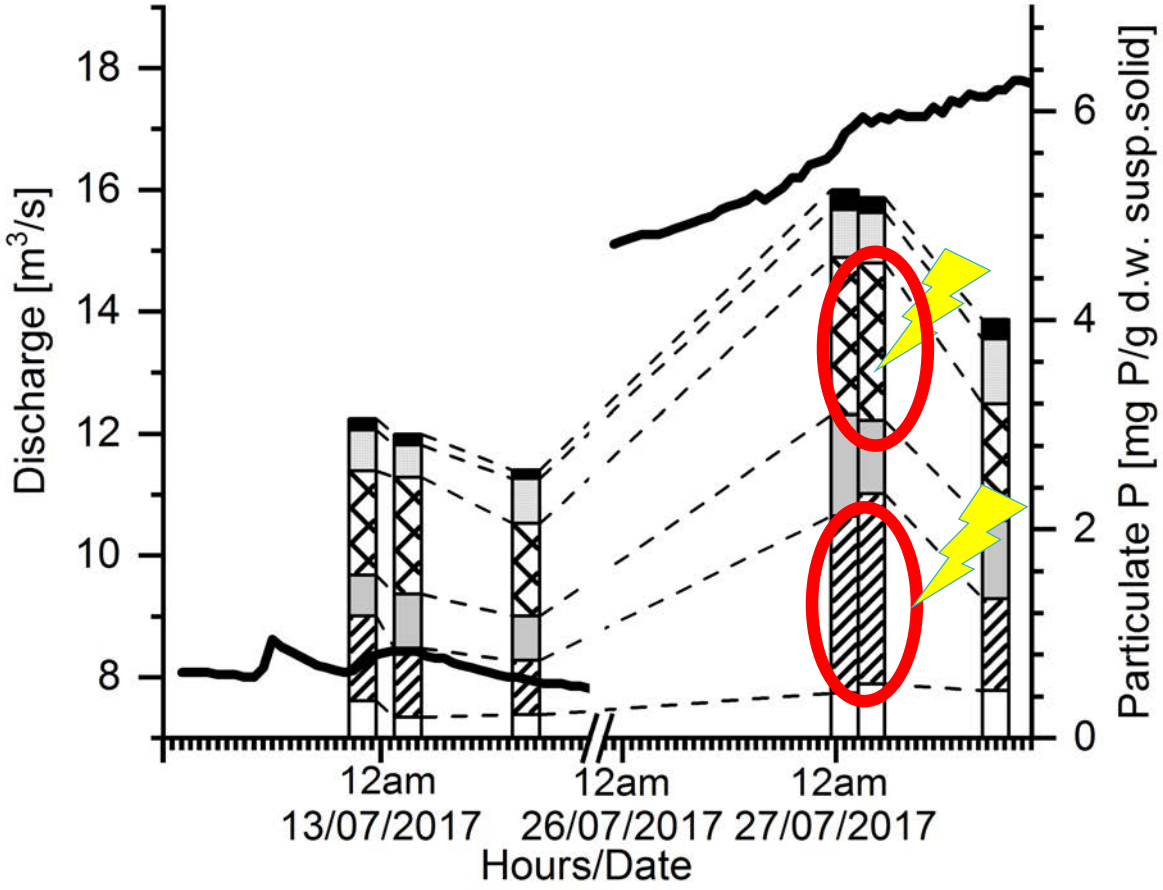
Same study sites as in the previous talk

PP binding forms: low and high flow rain event

The rain event: the bioavailable P is increasing absolutely values in the total P



Camden East station

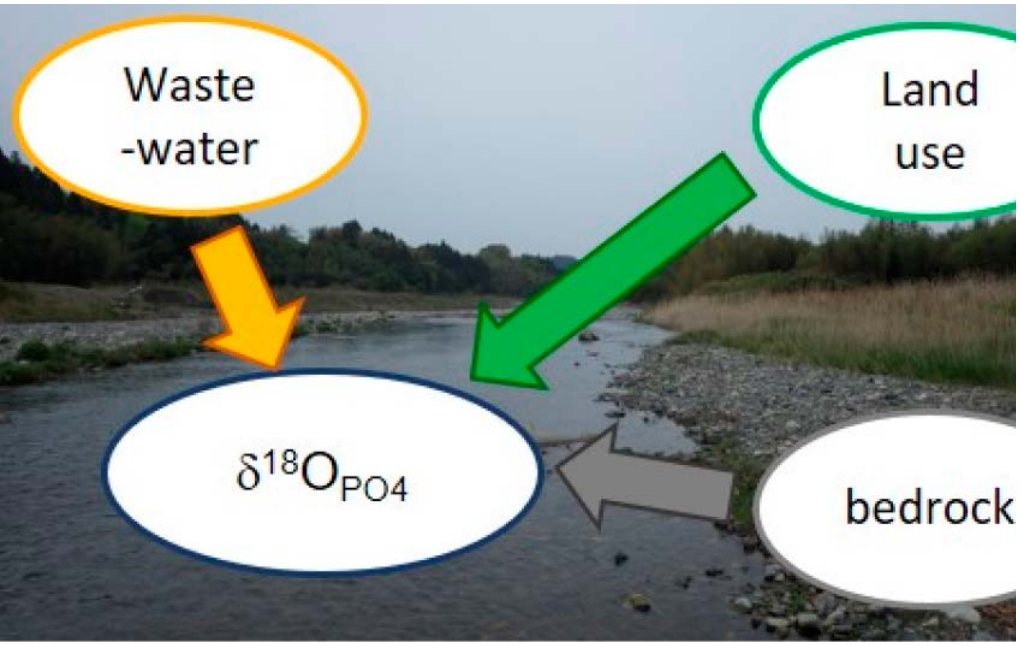


Napanee station

Extreme events: Annualized particulate P export

Hydrological conditions	Wilton Creek			Napanee River		
	TPP export	Bioavailable PP export	HCl-P	TPP export	Bioavailable PP export	HCl-P
	Net P export kg P/km^2/yr					
Baseflow	4.48	2.99	0.54	1.63	1.02	0.20
High flow	42.91	29.43	5.59	16.83	11.08	2.09

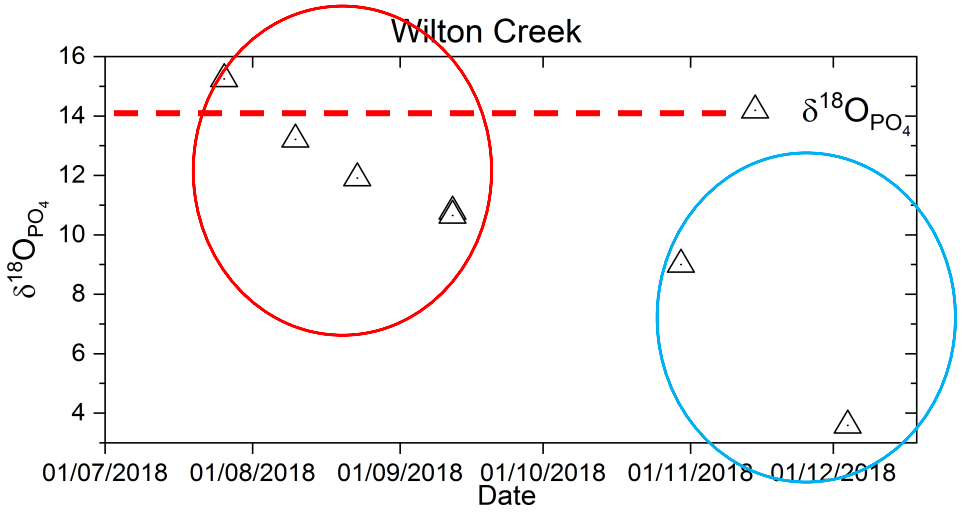
Tracking P sources: is it possible?

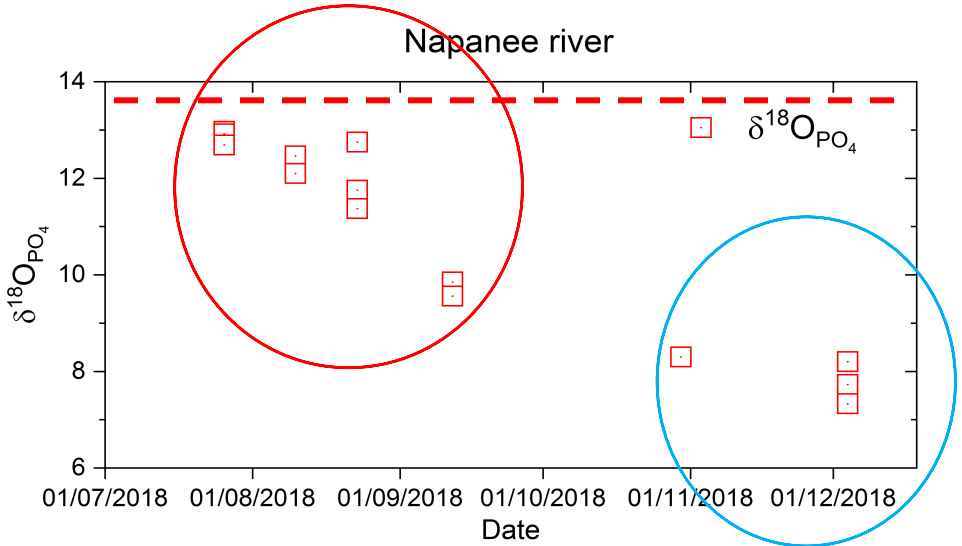


- Stable isotopes are used to identify **biogeochemical and physical processes** and trace **sources**. They also allow to study **long-term** evolution of signals and are not dangerous for the environment.
- P has only **one stable isotope** (^{31}P)…
- But phosphate has **4 oxygen atoms**. This is the only stable isotope approach to study P cycling.
- Different sources have **distinctive** $\delta^{18}O\text{-}PO_4$ signatures (e.g. mineral fertilizer vs manure).
- At conditions found in soils, **only biologically-driven processes** can change the $\delta^{18}O\text{-}PO_4$ signature.

Modified from F. Tamburini, SM. Bernasconi, V. Pfahler, E. Frossard; Ishida et al., 2020, ES&T

The $\delta^{18}O_P$ values in Wilton Creek and Napanee River



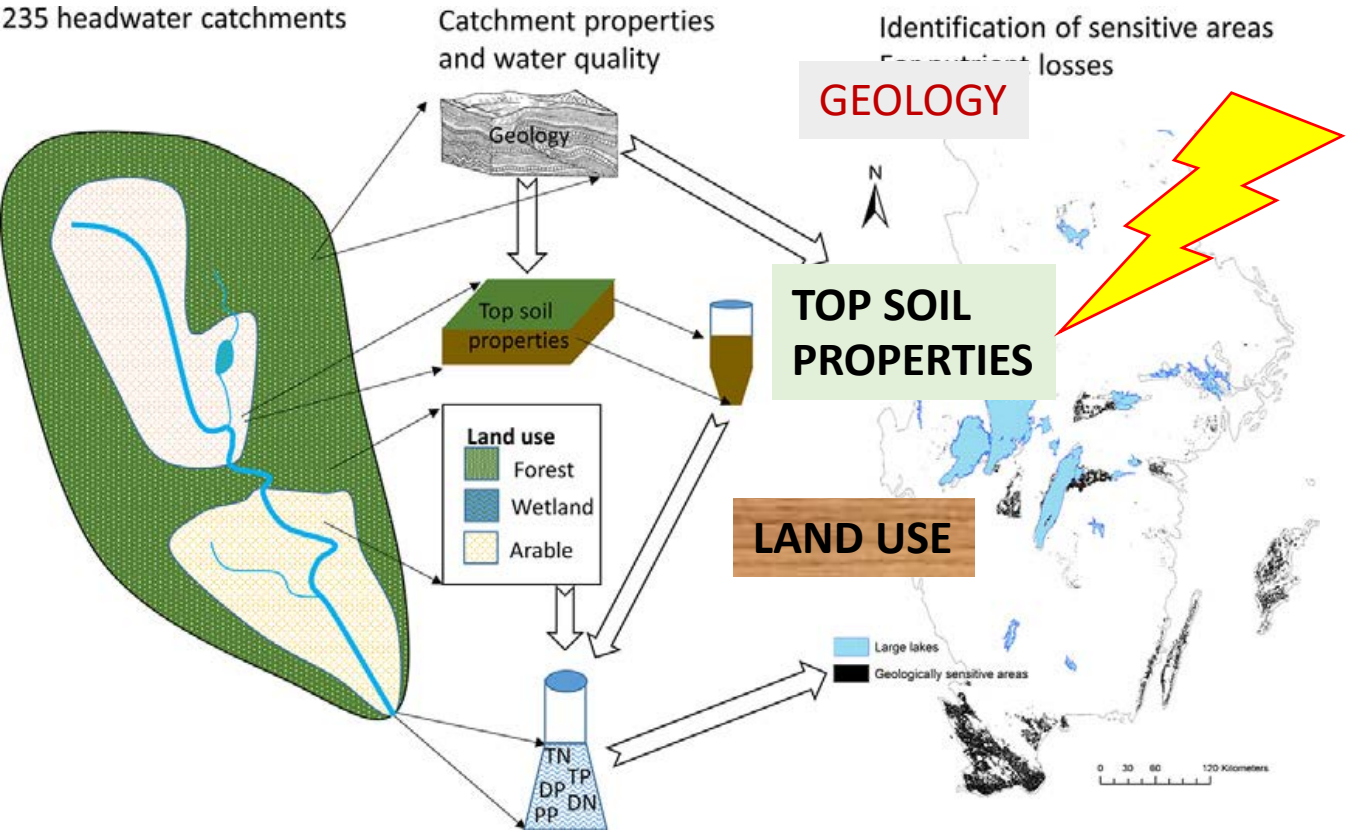


δO_{PO4} in August-September 2018:

- Wilton Creek: 13‰ -10‰ VSMOW at Napanee river sites: 13‰ -9‰
- The signature are most probable from the stream bed, drainage ditches and field tiles since manure signatures are rather higher
- In Fall-December 2019
- Wilton Creek : 20-30 ‰ VSMOW
- Napanee River 25-20 ‰ VSMOW
- Manure 16.01 ‰ VSMOW

Kaiser's Lake Farm, small catchments and laboratory experiments with soils

Phosphorus Cycle in Lakes and Catchments

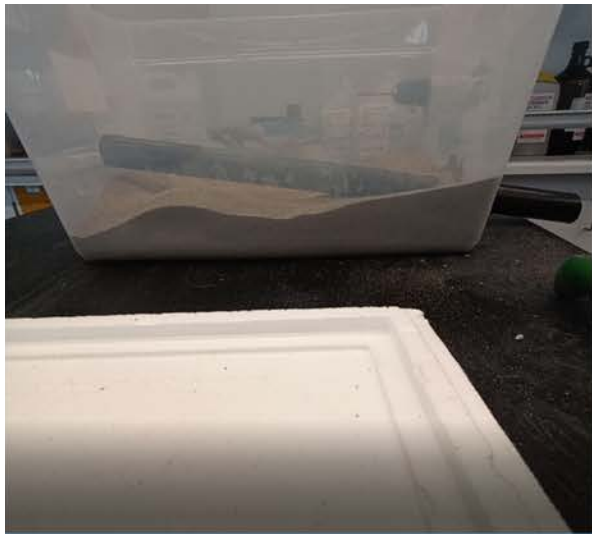


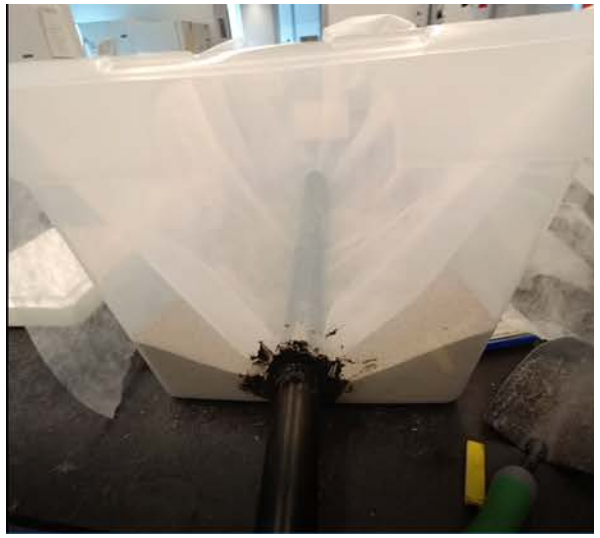
Djodjic et al, JSciTotEnv.2021

Efficiency of P trapping bioreactors

Sample	Time (hours)	PO4 (mg/L)	pH	Removal
Control Buffer		3.03 ± 0.1	7.1	
Calcinated eggshell (2wt%) and Non-calcinated eggshell	4	2.44 ± 0.30	7.93	19 %
Calcinated eggshell (5wt%) and Non-calcinated eggshell	4	0.78 ± 0.1	7.9	74 %
Calcinated eggshell (2wt%) and Woodchips	4	1.01 ± 0.05	8.5	67 %
Calcinated eggshell (5wt %) and Woodchips	4	0.63 ± 0.1	8.75	**79 %**
Pure calcinated eggshell	4	0.49 ± 0.1	8.9	84 %

P trapping bioreactors





Next steps: Long-term monitoring

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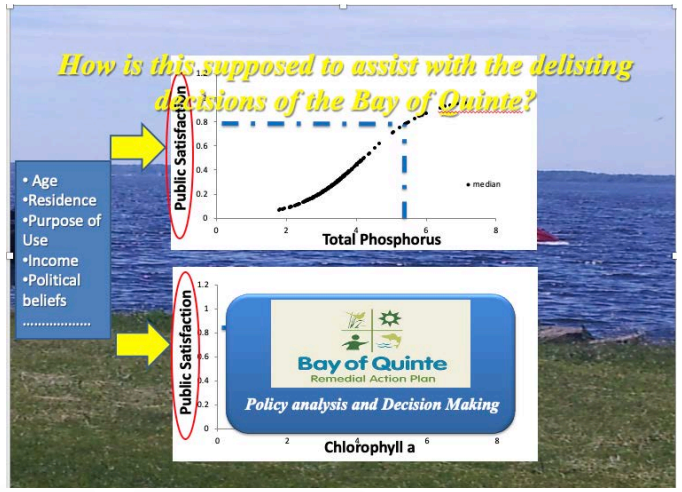
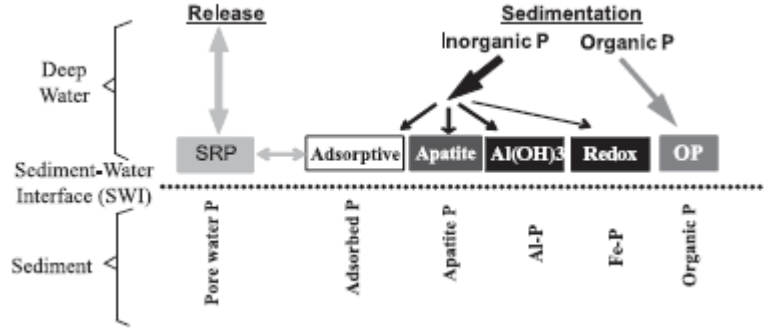
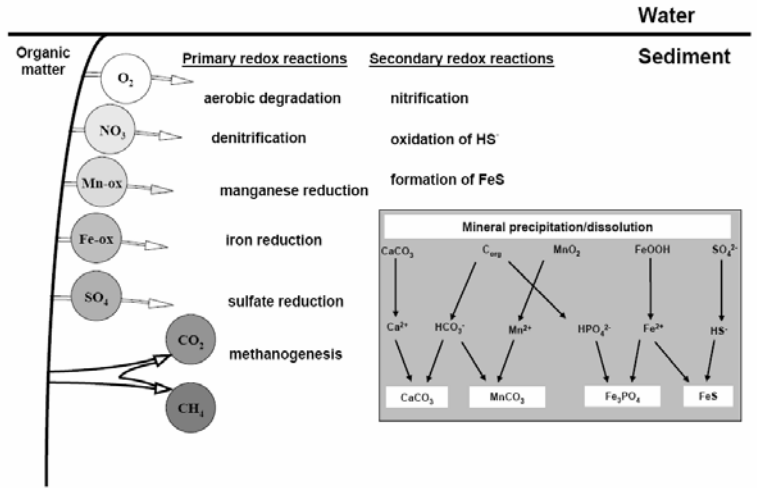
P internal loading: field observations and modelling







Chemical Geology 354 (2013) 216–232

Contents lists available at SciVerse ScienceDirect

Chemical Geology

journal homepage: www.elsevier.com/locate/chemgeo

Dynamics of P-binding forms in sediments of a mesotrophic hard-water lake: Insights from non-steady state reactive-transport modeling, sensitivity and identifiability analysis

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ABSTRACT

Sediments can act both as a source or sink of contaminants and nutrients in lakes. In this study, we developed a non-steady state reactive transport diagenetic model to gain insights into the dynamics of phosphorus binding forms in the sediments of Lake Simcoe, a mesotrophic hard-water lake located in Southern Ontario, Canada. We investigate three basins of the lake with differences in their phosphorus binding forms, reflecting the distinct spatiotemporal patterns of land use and urbanization levels in the watershed. In the model, total phosphorus is divided into loosely adsorbed phosphorus, phosphorus bound with aluminum, organic phosphorus, redox sensitive and apatite phosphorus, and dissolved phosphorus in pore water. Using the ... of organic and inorganic matter along with the concentrations of dissolved substances as dy... conditions, we simulated the depth profiles of sixteen solute and solid compon... reproduced the fractionation data of phosphorus binding forms. The impa... mentation fluxes and geochemical conditions on phosphorus dia... anthropogenic disturbances and natural variability in La... that pinpointed the most influential processes ... non-steady state diagenesis model rev... been overwhelmingly influenc... 100 years. In contrast, ... depletion in ... when ...

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Invited research article

Biogeochemical mechanisms controlling phosphorus diagenesis and internal loading in a remediated hard water eutrophic embayment

Stefan Markovic [a], Anqi Liang [a], Sue B. Watson [c], Jay Guo [c], Shan Mugalingam [d], George Arhonditsis [b], Andrew Morley [e], Maria Dittrich [a,*]

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Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

...phorus retention and internal loading in the Bay of Quinte, L... using diagenetic modelling

...Doan [a,d,*], Sue B. Watson [b], Stefan Markovic [a], Anqi Liang [a], Jay Guo [b], Shan ...okes [a], Andrew Morley [e], Weitao Zhang [f], George B. Arhonditsis [a], Maria Ditt...

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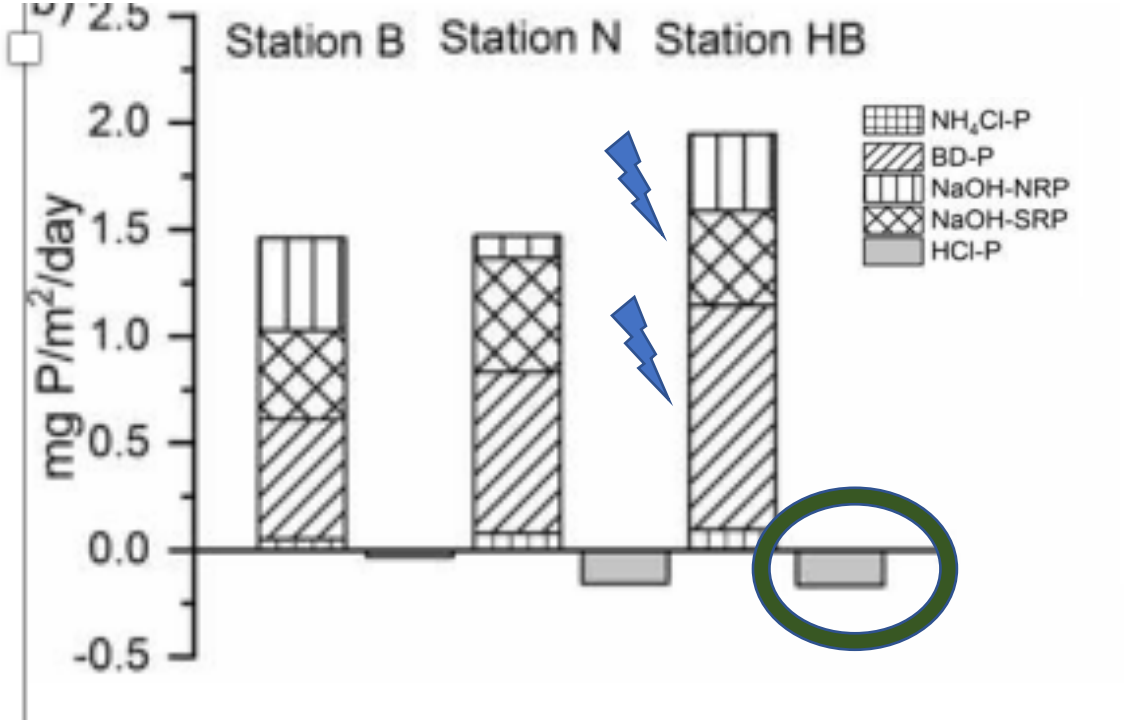
...over Trent Conservation Authority, 714 Murray Street, Trenton, ON K8V 5P4, Canada
... The University of Danang-University of Science and Technology, 54 Nguyen Luong Bang, Danang, Viet Nam
... Ontario Ministry of the Environment and Climate Change, Eastern Region, 1259 Gardiners Road, Unit 3, P.O. Box 22032, Kingston, ON K7M 8S5, Canada
... AEML Associates LTD, Canada

Table 2
Estimation of surface area weighted average P fluxes at the three stations over the 2002–2009 period. Note that inputs (F_{input}) are taken from (Kim et al., 2013).

Flux/station	F_{input}	$F_{release}$	$F_{release}/F_{input}$
	mg TP m^{-2} d^{-1}	mg SRP m^{-2} d^{-1}	
Station B	5.6	1.8	32.1%
Station N	25.1	1.9	7.6%
Station HB	23.5	1.4	6.0%

Potentially mobile P from sediment

P fluxes from sediments
120 kg P/day - Belleville
25 kg P/day - Napanee
44 kg P/day - Hay Bay



P internal loading: The mobilization of organic P moderated by sorption/desorption processes coupled with redox-sensitive Fe cycling

P immobilization was driven by the precipitation of apatite.

Sediment retention of deposited P was fairly low (~60% of the total P) and even lower for labile P forms (35%-40%), indicative of intensive diagenetic P recycling.

Markovic et al., 2016, Kim et al. (2013)

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In the Bay of Quinte

- To monitor P Internal loading from sediment

Thanks for your attention

Questions?