CARBON DYNAMICS OF URBAN STORMWATER PONDS

Burial, Greenhouse Gas Flux, and DOM Quality

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BACKGROUND

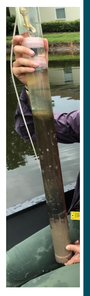
Urban Stormwater ponds are highly productive and under-researched engineered ecosystems that receive complex and high concentrate material from storm runoff. These shallow systems potentially play a large role in regional C cycling. In five ponds aged 14 to 34, this project asks the following questions:

1. At what rate do urban ponds bury C and does this change as they age?
2. At what rate are they emitting greenhouse gases CO_2 and CH_4 to the atmosphere?
3. What is the quality of dissolved organic matter found in these ponds?

METHODS

Carbon Burial

Six cores collected per pond. Deposited sediment is all muck above the sand fill material (time zero point). Muck of a single core is homogenized and analyzed for total organic C and dry weight



$$Burial\ Rate\left(g\ C\ m^{-2}yr^{-1}\right) = \frac{TOC\ \left(\frac{mg}{L}\right) * Dry\ weight\ (g)}{Core\ Sleeve\ Area(m^2) * Pond\ Age(yrs)}$$

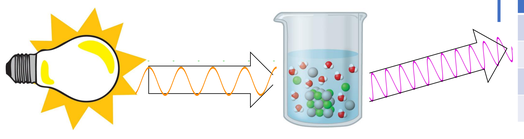
CO_2 and CH_4 Fluxes:

Emission rates are determined using a **floating chamber** and LICOR I-7810 Trace Gas Analyzer. The Analyzer uses **Optical Feedback-Cavity Enhanced Absorption Spectroscopy** to determine concentration. Rates are based on concentration increase over measurement time (200 sec.) in the chamber. Gas flux (µmol or nmol m^{-2} sec^{-1}) is equal to:

$$\left(\frac{dConc.}{dTime}\right)\frac{Pressure\ (atm) * Chamber\ vol.\ (mL)}{gas\ const.\ (mL\ atm\ K^{-1}\ mol^{-1}) * Temp(K) * Chamber\ area(m^2)}$$

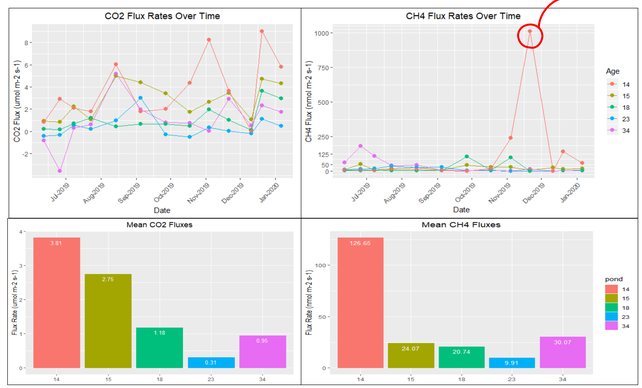
Dissolved Organic Matter:

A Horiba Aqualog spectrofluorometer 'excites' water samples at incremental wavelengths and measures light emitted by fluorophore molecules in the sample. A PARAFAC model was used to identify qualitative groups of organic materials present in our urban ponds. Each group of material is referred to as a 'component'



- C burial rates increase as ponds age. Max rates are higher than most natural ecosystems.
- CO_2 and CH_4 emissions are higher than reported rates of inland waters and show a relationship to pond age, a sign of pond C succession. Stratification and factors of photosynthesis are main influencers of their release.
- Older ponds have accumulated larger proportions of humic substances. Humics increase during wet season and decrease in the dry period while protein-like materials peak during the dry season.

RESULTS: Gas Flux



Mean CO_2 & CH_4 fluxes decrease with age with the exception of the oldest pond. Fluxes may be related to age in that their lack of accumulated material allows new inputs to become mineralized faster than they are stored in sediments.

Source	CH4 mmol m-2 day-1 Max Flux	n	CO2 mmol m-2 day-1 Max Flux	n
Ponds in my study	**16.6 ± 3**	5	**164.2 ± 207.4**	5
Mystery pond	**97.6**	1	**362.9**	1
Open wells	2.3 ± 3	6	146.3 ± 76.2	6
Lakes	4 ± 6.4	7	2.1 ± 23.8	7
Other ponds	17.9 ± 18.5	10	67.1 ± 64	9
Rivers	6.2 ± 12.4	11	20.1 ± 38.5	10
Canals	10.9 ± 17	3	18.1 ± 1.6	1
Reservoirs	3.2 ± 3.5	5	8.4 ± 19.5	5
Springs	4.2 ± 3	3	64.4 ± 13.2	2

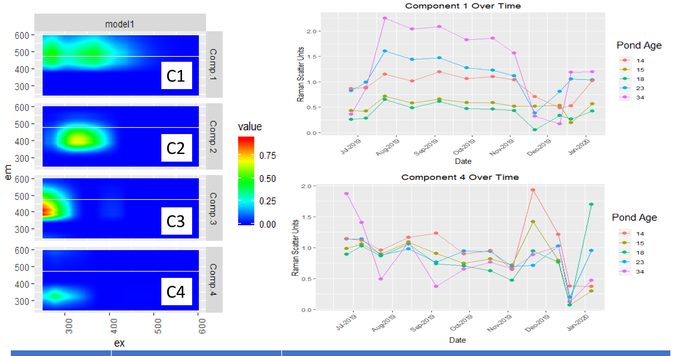
PANNEER SELVAM et al. (2014)
n = number of systems in the study

Mixed Effects Model

	CO2 B	CO2 Std. Err	CO2 p	CH4 B	CH4 Std. Err	CH4 p
Fixed Parts						
(Intercept)	2.9	0.24	2.00E-16			
Surface DO	-0.09	0.04	0.03			
Bottom DO	-0.18	0.06	0.004			
Surface pH	-0.02	0.006	0.0002			
Bottom pH	0.02	0.008	0.001			
(Intercept)				2.2	0.25	1.20E-11
Surface DO				-1.7	0.3	1.60E-06
DO stratification				0.004	0.001	0.0004
Temp stratification				-1.8	0.67	0.01
Random Parts						
Group	Var.	Std. Dev.		Group	Var.	Std. Dev.
Pond (5)	0.0009	0.029		Pond (5)	0.0077	0.087
Residual	0.0033	0.057		Residual	0.2674	0.517

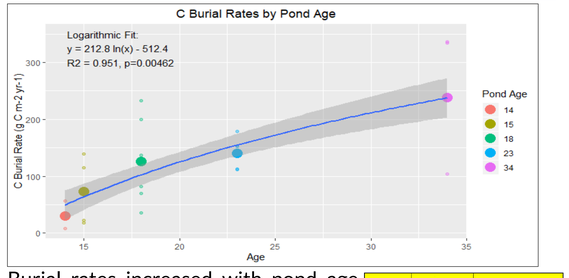
A mixed model shows that factors related to photosynthesis influence CO_2 while pond stratification and DO influence CH_4.

RESULTS: DOM Quality



Component	Excitation, Emission Peaks (nm)	Description
C1	329, 414	Anthropogenic or agricultural humic-like
C2	(<250), 417	Terrestrial UV humic-like, photochemical products
C3	269 (365), 496	Widespread terrestrial humic-like substances
C4	278, 327	Amino acids, proteins, tryptophan-like

RESULTS: Carbon Burial



Burial rates increased with pond age and ranged from 30 to 240 g C m^{-2} yr^{-1}. This relationship fit a logarithmic curve. This fit describes rapid increase in rate change followed by a plateau. It is reported that small ponds can reach a C saturation age where burial rates slow down or cease. The above fit may begin to show this phenomena.

Age	Avg. Sediment Thickness (cm)	Avg. Burial Rate (g C m-2 yr-1)
14	8	30.05 ± 17.48
15	15	73.47 ± 53.96
18	28	125.98 ± 71.07
23	32	140.54 ± 23.86
34	45	238.74 ± 94.76

DISCUSSION

- Our highest burial rate (239 g C $m^{-2}yr^{-1}$) is higher than the mean of most natural ecosystems such as mesoeutrophic lakes (94 g C m^{-2} yr^{-1}), wetlands or peatlands (31 g C $m^{-2}yr^{-1}$), and boreal forests (4.9 g C $m^{-2}yr^{-1}$). This indicates the power urban ponds have to store C for long periods of time.
- Urban ponds emit comparably high rates of C gases and could be related to urban inputs and their physical/chemical characteristics. Their emissions should be accounted for in regional C balances.
- Urban ponds are engineered systems. Using this preliminary data, future studies can focus on how to design ponds for maximum ecological benefits.