

Nutrient limitation and carbon dioxide fluxes from urban lakes supplied with groundwater and surface water in Tempe, Arizona

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Background

- Urban lakes are often subject to increased nutrient loads from fertilizer application or nitrogen deposition.
- Urban lakes in Arizona are supplied with either groundwater or surface water which can have different concentrations and ratios of inorganic nitrogen and phosphorus.

Objectives

- Determine if water source impacts nutrient limitation of primary production.
- Determine if water source impacts CO₂ flux.

Study Sites

- Selected six urban lakes in Tempe, AZ.
- 3 supplied with groundwater and 3 supplied with surface water.

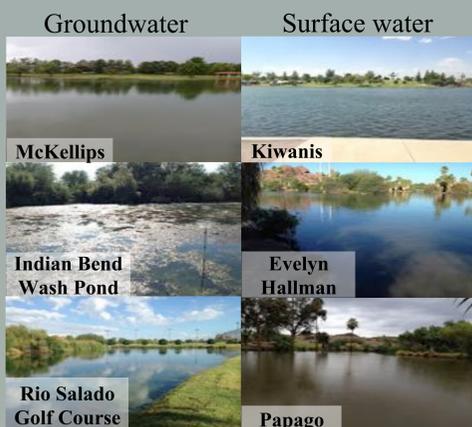


Figure 1: Picture of field sites

Methods

Water Chemistry

- Measured pH / conductivity with stick meter.
- Measured nitrate, ammonia, and phosphate using colorimetric analysis.

Objective 1: Bioassays

- Incubations and nutrient diffusing substrata (NDS) had four treatments: control, +nitrogen, +phosphorus, and +nitrogen and phosphorus.
- Incubations and NDS deployed for one and three weeks respectively (Figure 5).
- Chlorophyll was extracted and measured to quantify phytoplankton and benthic algal growth.

Objective 2: CO₂ Flux

- Gases collected in floating chambers.
- Samples injected into an EGM-4 infrared gas analyzer (Figure 5).

Results

Lake	Phytoplankton limiting nutrient (incubations)	Benthic algae limiting nutrient (NDS)
McKellips	Phosphorus	NA (samples stolen)
Indian Bend Wash Pond	No limitation and phosphorus*	No clear result
Rio Salado Golf Course Pond	Phosphorus	No clear result
Kiwanis	Co-limitation and phosphorus*	Nitrogen
Evelyn Hallman	Co-limitation	No clear result
Papago	Sequential co-limitation (N)	No clear result

Legend: █ = Groundwater █ = Surface water

Table 1: Summary of limiting nutrients in each study lake based on bioassay results.

*Water samples collected on two different days resulted in incubations with different results.

What is RR?

The response ratio allows us to compare the standardized effect of treatments.

$$\text{Response ratio (RR)} = \frac{\text{chl-a "x" treatment}}{\text{chl-a Control}}$$

Objective 1: Bioassays

Incubations suggest groundwater supplied lakes may be P limited

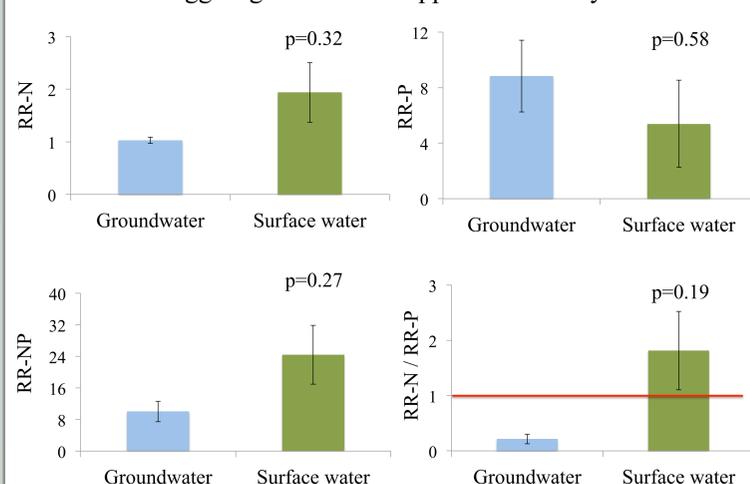


Figure 3: Response ratio for +N, +P and +NP. For the relative response (RR-N/RR-P) a value >1 indicate stronger N limitation while a value <1 indicate stronger P limitation. Bars represent +/- 1 standard error; n = 6

Water Chemistry

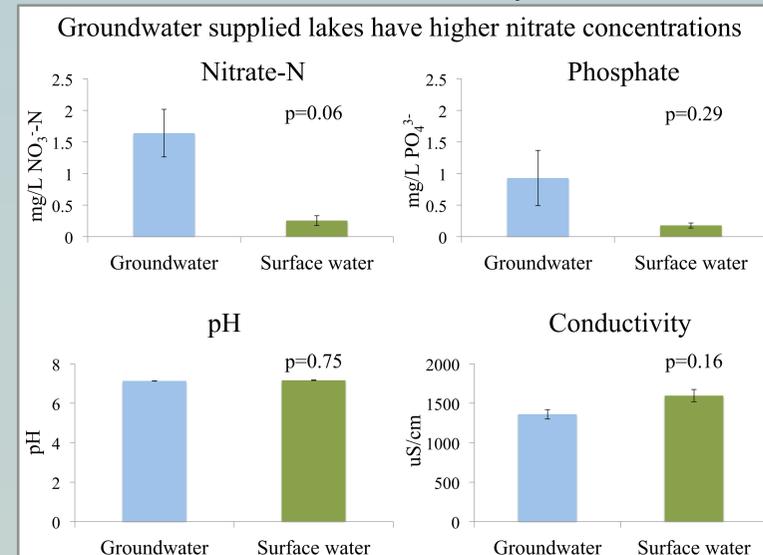


Figure 2: Mean nitrate-N, phosphate pH and conductivity for groundwater and surface water supplied lakes. Bars represent +/- 1 standard error; n = 6.

NDS show no clear trends

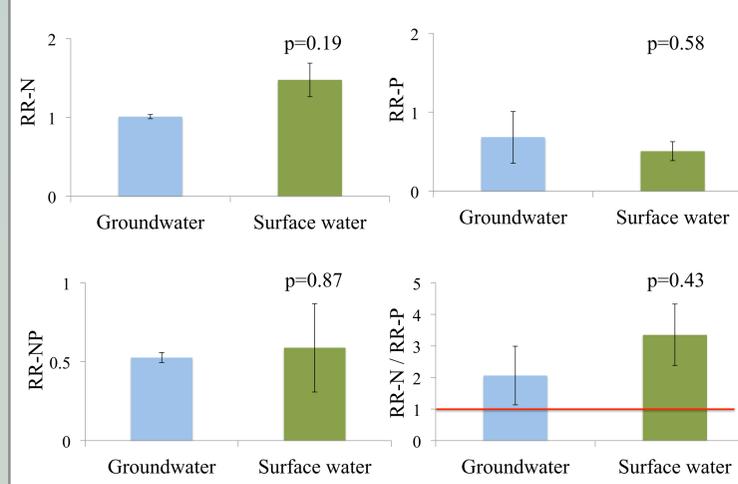


Figure 4: Response ratio for +N, +P and +NP. For the relative response (RR-N/RR-P) a value >1 indicate stronger N limitation while a value <1 indicate stronger P limitation. Bars represent +/- 1 standard error; n = 5

Objective 2

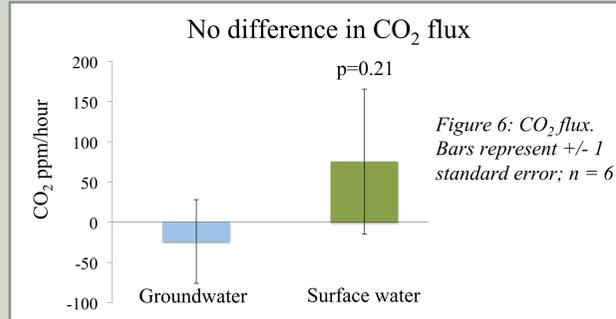


Figure 6: CO₂ flux. Bars represent +/- 1 standard error; n = 6

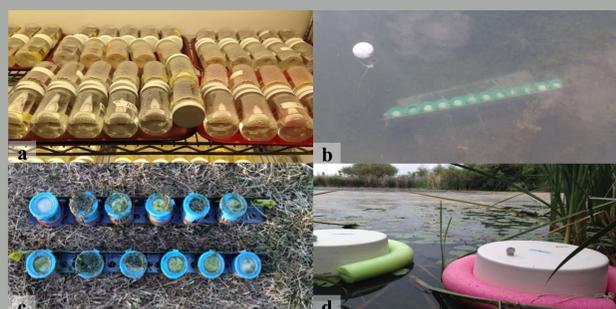


Figure 5: (a) Water samples in incubation; (b) NDS submerged in Rio Salado Golf Pond; (c) NDS after 3 week incubation; (d) CO₂ flux method.

Results/Conclusions

Water Chemistry:

- Lakes supplied with groundwater tend to have higher nutrient concentrations and have marginally significantly higher levels of nitrate which may impact algal growth (Figure 2).

Objective 1: Bioassays

- Results suggest that the decision to supply a lake with groundwater or surface water can affect nutrient limitation regimes in urban lakes (Table 1; Figure 3).
- Timing of sampling: indications that results may vary due to discrete natural events such as rain (Kiwanis), or management actions such as refilling a lake (Indian Bend Wash Pond; Table 1).
- It is important to look beyond the "usual suspects" (e.g. fertilizer application) for what may affect ecosystem processes in urban lakes.

Objective 2: CO₂ Flux

- In contrast to many natural lakes, we observed small CO₂ fluxes, suggesting that these urban lakes do not contribute to our community's CO₂ emissions (Figure 6).

Next Steps

- Our small sample size and sampling area of urban lakes limits our ability to draw conclusions and generalize our findings.
- Future efforts will increase the number of lakes in both water sources sampled and extend the sampling effort beyond Tempe, AZ.
- NDS experiment was complicated by sedimentation and human disruption of samples. Future iterations of this experiment will need a modified method.
- These experiments were completed as part of an undergraduate biology lab and will be continued in future semesters.

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