Summary of discussion of EPC_0 calculations
2020-06-10

Goel et al. were asked to compute equilibrium phosphorus (P) concentrations (EPC_0) as part of revisions to the "Utah Lake Sediment-Water Nutrient Interactions" study report. Below is a summary of discussion about these revisions.

1. Calculation methodology

The calculations referenced in the report and suggested by reviewers use a regression approach that compares water column P concentrations to the amount of sorbed P in sediment (mg P/kg dry sediment). This should result in a positive correlation when plotted. The authors correctly state that any P lost from the water column can be assumed to be sorbed by the sediments, but the calculations conducted use the change in P in the water column (mg P/L) rather than the amount of P taken up by the sediment itself. This led to a negative correlation. Equating water column volume with sediment mass is not appropriate in this case (at least not without a citation demonstrating this approach is appropriate), as the goal of computing EPC_0 is to quantify how much P a unit of sediment can take up. From personal communications with Dr. Goel, the bulk density of sediment is known (600 kg/m^3), which could be used to convert the volumetric P uptake to sediment mass-dependent uptake (sediment core depth and volume is known).

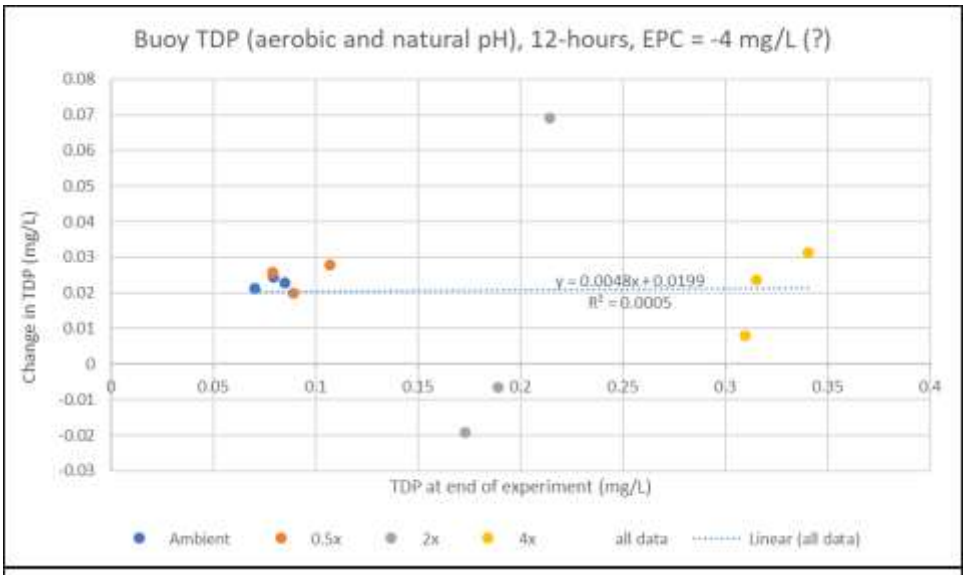
On the x-axis, some analyses use the P concentration at the start of the incubation (e.g., Haggard et al. 2004) and others the P concentration at the end of the incubation (e.g., Pant and Reddy 2001). It is unclear which is appropriate in this case as the authors do not reference an approach they are following.

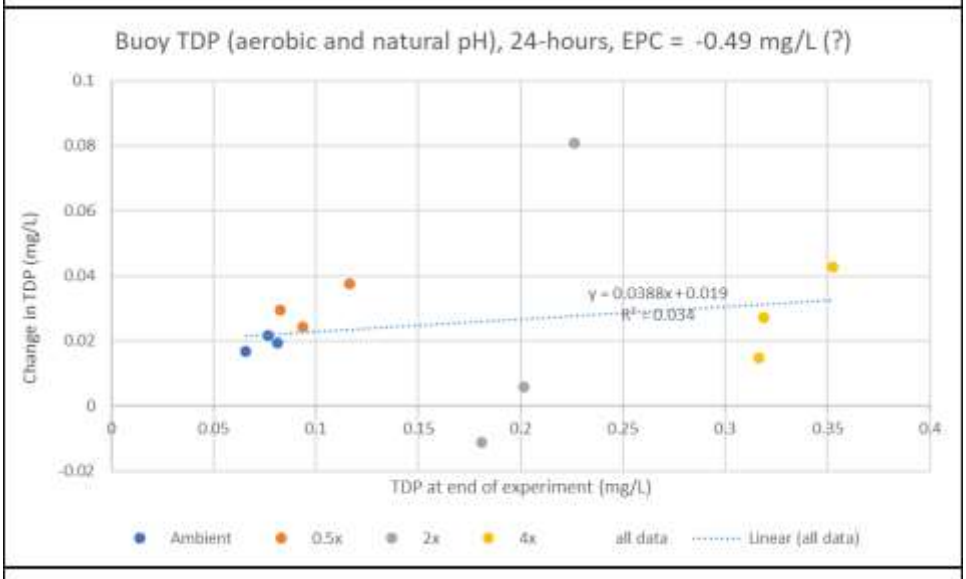
2. Incorporation of replicates and variability

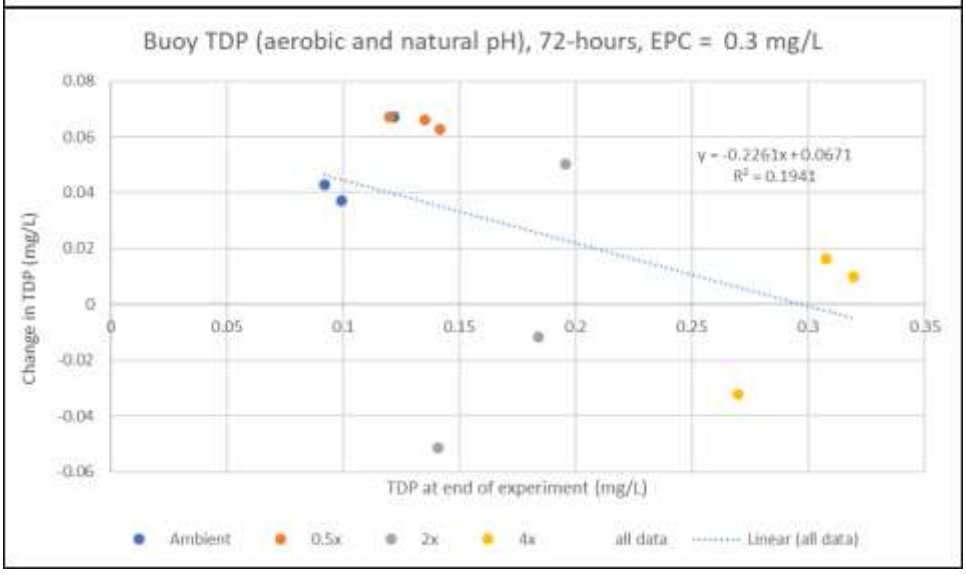
The figures presented in the report have only four data points, but the data points represent an average of several replicates. As reported earlier in the report, the error bars around TDP and SRP fluxes are substantial and in many cases cross zero, pointing to the large degree of variability in observed uptake/release. Reporting these values as a single number is misleading, as it compresses the known variability into single points. Including all replicates in the figure and calculation would enable a more accurate depiction of the variability inherent in these rates and better quantification of uncertainty around computed values.

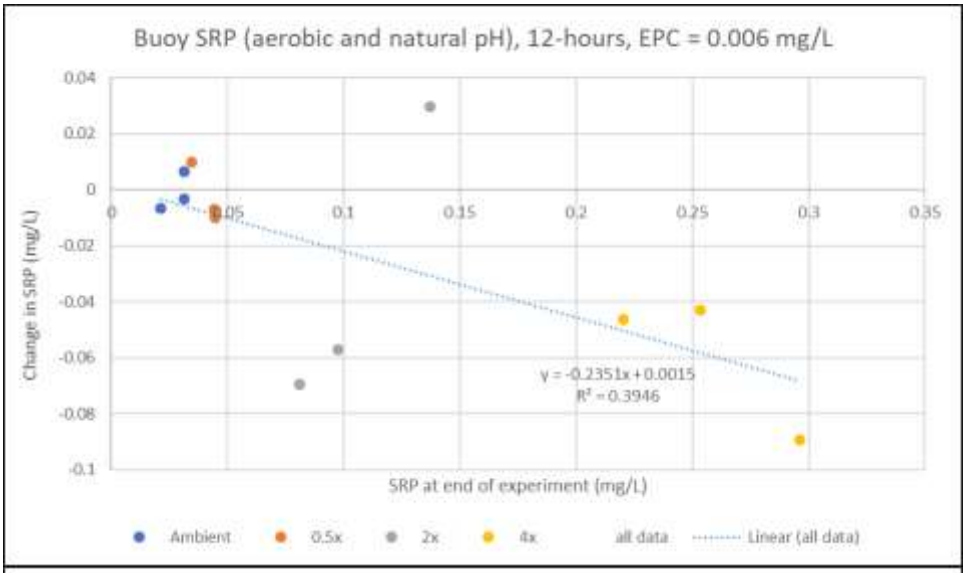
3. Choice of incubation length for calculations

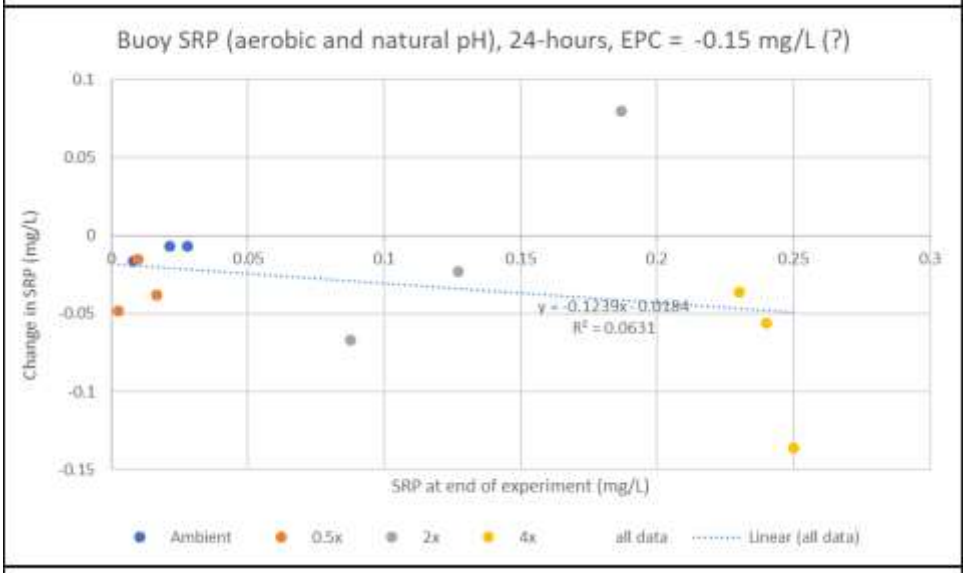
As is shown in the report, the sediments switch between source and sink of P throughout the incubation, so fluxes could be interpreted differently depending on whether 12, 24, or 72 h was used as the endpoint of the incubation. If these endpoints are incorporated into the analyses (via the spreadsheet provided by the authors), the calculated EPC_0 concentrations come out to different values, including some that are negative. The authors have not defended their choice of using 72 h as the endpoint in the analysis. Further, a discussion of the timescale of equilibration of sediments was not provided, potentially hindering the usefulness of these calculations as they relate to the conditions and timescales in Utah Lake.

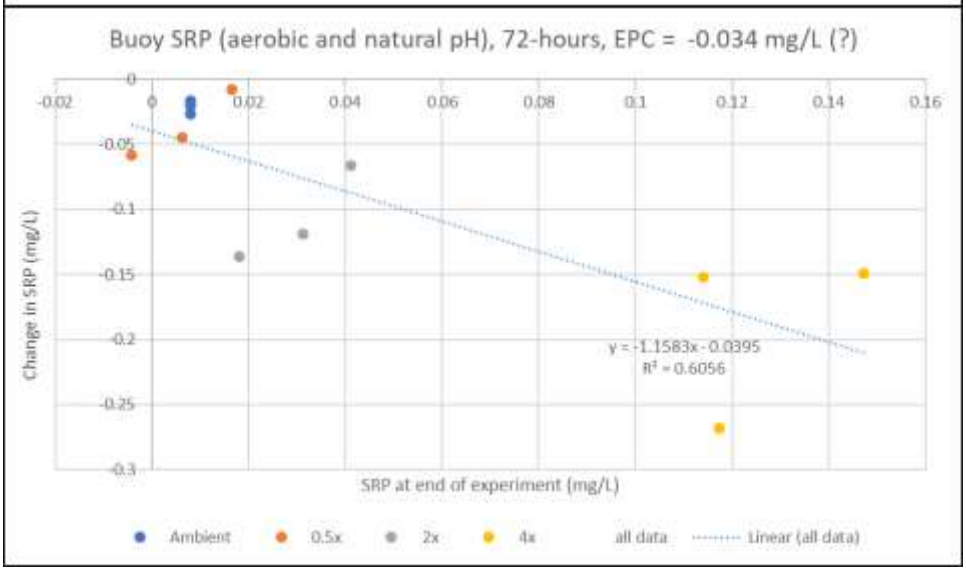

Buoy TDP (aerobic and natural pH), 12-hours, EPC = -4 mg/L (?)
Change in TDP (mg/L)
TDP at end of experiment (mg/L)
y = 0.0048x + 0.0199
R² = 0.0005
Ambient
0.5x
2x
4x
all data
Linear (all data)


Buoy TDP (aerobic and natural pH), 24-hours, EPC = -0.49 mg/L (?)
Change in TDP (mg/L)
TDP at end of experiment (mg/L)
y = 0.0388x + 0.019
R² = 0.034
Ambient
0.5x
2x
4x
all data
Linear (all data)


Buoy TDP (aerobic and natural pH), 72-hours, EPC = 0.3 mg/L
Change in TDP (mg/L)
TDP at end of experiment (mg/L)
y = -0.2261x + 0.0671
R² = 0.1941
Ambient
0.5x
2x
4x
all data
Linear (all data)


Buoy SRP (aerobic and natural pH), 12-hours, EPC = 0.006 mg/L
Change in SRP (mg/L)
SRP at end of experiment (mg/L)
y = -0.2351x + 0.0015
R² = 0.3946
Ambient
0.5x
2x
4x
all data
Linear (all data)


Buoy SRP (aerobic and natural pH), 24-hours, EPC = -0.15 mg/L (?)
Change in SRP (mg/L)
SRP at end of experiment (mg/L)
y = -0.1239x - 0.0184
R² = 0.0631
Ambient
0.5x
2x
4x
all data
Linear (all data)


Buoy SRP (aerobic and natural pH), 72-hours, EPC = -0.034 mg/L (?)
Change in SRP (mg/L)
SRP at end of experiment (mg/L)
y = -1.1583x - 0.0395
R² = 0.6056
Ambient
0.5x
2x
4x
all data
Linear (all data)

4. Confidence in reported EPC_0 concentrations

For the reasons stated in points 1-3, there is likely a low degree of confidence in the reported EPC_0 values. This confidence could be increased and/or better quantified by incorporating the suggestions stated above.

5. Interpretation of future scenarios

In theory, the EPC_0 value represents a fixed concentration based on the present sediment conditions. What processes could impact sediment conditions and likely the EPC_0 values in response to reduced P loading? Including aspects of sediment chemistry that will likely affect their capacity to sorb and/or release P would be a useful addition.