Availability of Phosphorus for Algal Growth in Sediment and Stream Water Inputs to Lake Tahoe

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Rationale

- Phosphorus is limiting biological growth
- Not all P loaded into the lake is available for algal and microbial growth
- Relative importance of sources may differ
- Need more relevant input for Lake Tahoe Clarity Model
- This may provide better information for TMDL limits
Annual Phosphorus Loading to Lake Tahoe

- **Source** – (Total-P, Soluble-P)
  - Atmospheric Deposition – 12.4, 5.6
  - *Stream Loading* – 13.3, 2.4
  - Direct Runoff – 12.3, 2.4
  - Groundwater – 4, 4
  - Shoreline Erosion – 1.6, N/A

(units in $10^3$ kg/year)

(Reuter, et al. 2001)
Historical Work / Literature

- Suspended sediments collected from 5 tributaries to the lower great lakes: 21.8 percent of the total particulate P was bioavailable. (De Pinto, et al. 1981)
- Suspended sediments collected from the Flathead River-Lake ecosystem in Montana: 4-6 % of the total particulate P was bioavailable. (Ellis and Standford, 1988)
Outline

- **Materials and Methods**
  1) Algal Bioassay
  2) Chemical Fractionation

- **Results**
  1) What percentage of Total P is bioavailable?
  2) How do the different sources rank?
  3) Is there a chemical extraction that serves as a surrogate for an algal bioassay?

- **Conclusions**

- **Future Work**
Materials and Methods

- Algal Bioassay (DePinto et al. 1981)
- Chemical Extraction (Hedley et al. 1982)
Materials Sampled

- **Suspended sediments from:**
  1) 5 Major tributary streams
     - EC, GC, IC, UT, and WC.
  2) 5 Direct urban runoff areas
     - RB, SY, OS, SQ, and TC.

- **Dissolved organic P from:**
  3) 2 major tributary streams
     - EC, UT

- **Erodable Streambank Sediments from:**
  4) All LTIMP erodable stream banks
     - IC, GC, WC, UT, EC, ThC, GbC, TrC, and BC
Methods - Bioassay Procedure

Isolate suspended sediments by filtration.

1) Nylon Mesh (20 micron)
2) Filter with Sediment
3) Plastic Disk

3 week incubation with algae in P-free algal growth medium. Put filter into beaker. Isolated algae

Total P (in solution) after incubation – Total P (in solution) before incubation = Total P uptake by algae from sediments
Algal Bioassay Incubation
Algal Bioassay Incubation,
Selenastrum Capricornutum
Algal Bioassay Incubation (21 days)
Algal Bioassay

Total P that appears in solution after incubation is due to 2 mechanisms:
1) Direct uptake of exchangeable PO$_4$
2) Uptake of organic P that is mineralized by phosphatase enzymes.
Methods - Chemical Fractionation Procedure

- Anion Exchange Membrane extract*
- $\text{NaHCO}_3$ extractable inorganic, microbial biomass*, and organic P
- $\text{NaOH}$ extractable inorganic and organic P
- $\text{HCl}$ extractable Total P

*not tested for suspended sediments
Results

- Total P bioavailable from different sources (ug P/mg sed.)
- Percentage of total P that is bioavailable
- Relative rank of sources in ug P/mg sed., and % of TP that is bioavailable.
- Correlation between a chemical extract and bioavailability.
- High molecular weight dissolved organic P not found to be highly bioavailable
Total Bioavailable P (ug/mg sediment) in the Stream Sediments of 5 Tributaries of Lake Tahoe in Spring, Summer, and Fall 2003
Percent Phosphorus Bioavailable in the Stream Sediments of 5 Tributaries of Lake Tahoe in Spring, Summer, and Fall 2003
Total Bioavailable P (ug/mg sediment) in the Stream Bank Sediments of 9 TTIMP Sites of Lake Tahoe

![Bar Chart]

- BC
- ED
- GL
- TC
- TH
- GC
- IN
- WC
- UT

Average Total P Bioavailable (ug/mg Sediment) vs Streambank Source
Percent Phosphorus Bioavailable in the Stream Bank Sediments of 9 Tributaries of Lake Tahoe

![Bar Chart](image-url)

- **Streambank Source**
  - BC
  - ED
  - GL
  - TC
  - TH
  - GC
  - IN
  - WC
  - UT

- **Average % P Bioavailable**
  - BC: 1
  - ED: 4
  - GL: 13
  - TC: 4
  - TH: 2
  - GC: 8
  - IN: 13
  - WC: 7
  - UT: 0
Total Bioavailable P (ug/mg sediment) in the Runoff Samples of 5 Urban Areas of the Lake Tahoe Basin in Summer and Fall 2003
Percent Phosphorus Bioavailable in the Runoff Samples of 5 Urban Areas of the Lake Tahoe Basin in Summer and Fall 2003
Relative Rank of Sources

(ug/mg sediment)

Average P Bioavailable
(ug/mg)


Source
Relative Rank of Sources
(% P Bioavailable)

Source

- Tribut. Sus. Seds.
- Urban Runoff Seds.
- Erod. Bank Seds.
Bioavailable P vs. NaHCO$_3$ Extractable P for Suspended Stream Sediments

\[ y = 1.1378x + 0.7174 \]

\[ R^2 = 0.5184 \]
Bioavailable P vs. Membrane + NaHCO₃ Extractable P for All Stream Bank Sediments

\[ y = 1.455x + 0.0308 \]

\[ R^2 = 0.48 \]
Bioavailable P vs. NaHCO₃ Extractable P for Urban Runoff Sediments

\[ y = 0.995 \times + 0.2 \]

\[ R^2 = 0.90 \]

\[ p<0.001 \]
### DOP Mineralization and Algal Uptake from UT and EC

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<th>Initial (ug/L)</th>
<th>Final (ug/L)</th>
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Conclusions

Less than 50% of suspended sediment P is bioavailable from all sources (average is 22.33%)

% of sediment P bioavailable is highly variable between sources and season
1) Suspended stream seds. (2 – 47%)
2) Streambank seds. (<1 - 16%)
3) Urban runoff seds. (1 – 44%)

NaHCO₃ extractable total P is a fairly good indicator of bioavailable P.

DOP inputs from 2 Tributary Streams not likely highly bioavailable.
Future Work

- More work on the mineralization rate of DOP in the lake
- Particulate P settling in the lake
- Atmospheric deposition inputs
Acknowledgments

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Questions