Methods of Measuring Nutrient Spiraling in Urban Streams

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Introduction:

Rapid urban development is occurring in many areas of the USA, and is accompanied by dramatic changes in stream ecosystems. Urban development results in alteration of natural waterways by channelization, diversion, or impoundment to meet competing needs of flood protection and water delivery. Furthermore, urban streams are subject to increased nutrient loading via runoff from fertilized areas and impervious surfaces. Given these changes, there is a need to study how urban streams transport and transform nutrients that are delivered to them, and how the efficiency of nutrient retention differs from better-studied, non-urban streams.

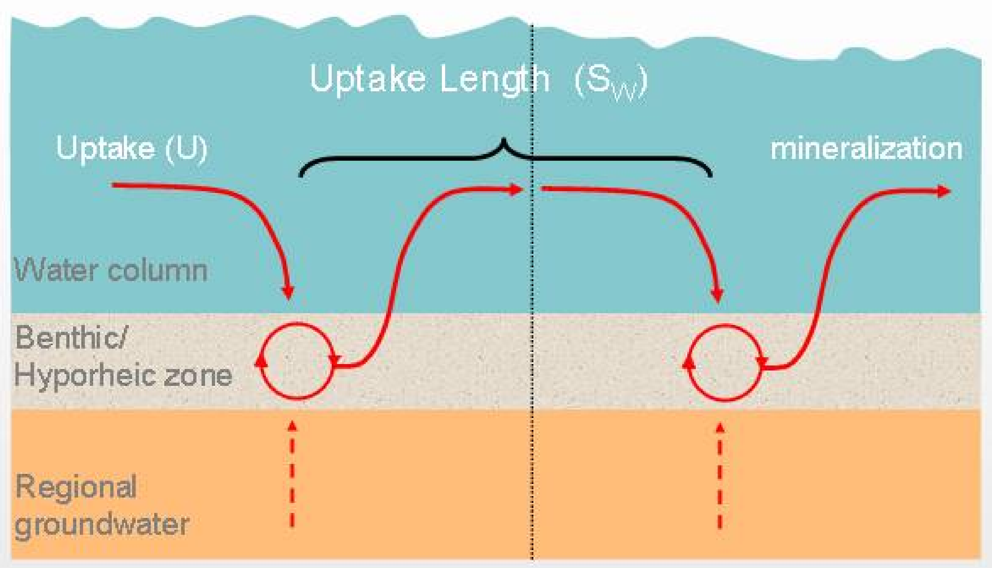
Urbanization is especially rapid in warm desert regions of the Southwest. The Phoenix (AZ) metropolitan area is now the 5th largest in the country and consistently reports high rates of population growth. Albuquerque, NM, also is experiencing intense urbanization. Both cities developed along large, desert rivers that have been highly altered over the past century.

Objectives:

- Examine nitrate uptake in five urban streams of Phoenix, AZ and Albuquerque, NM.
- Determine NO_3^- uptake lengths using 3 different methods.
- Evaluate the three methods to determine which provides the best measure of nutrient uptake in urban streams from the CAP-LTER region.

Nutrient Spiraling Theory:

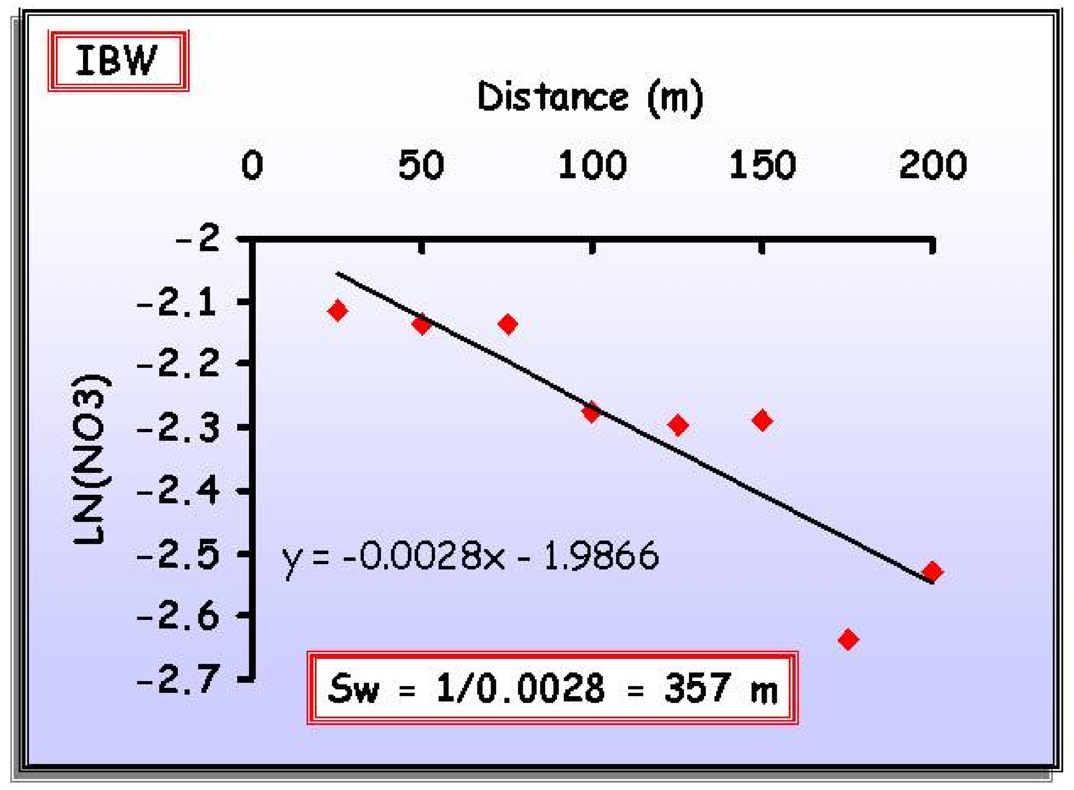
- Spirals are used to describe the cycling and downstream transport of nutrients in streams.



- Uptake length (S_w) is defined as the average distance (in meters) that a nutrient molecule travels downstream before it is taken up, or assimilated by the biota of the stream.
- Sw can be determined graphically by plotting the concentration against downstream distance for a given stream.
- Uptake lengths can be determined from:
  - background changes in nutrient concentration
  - Short-term nutrient enrichment injections
  - Injections using stable isotopes.

Natural changes in background NO_3^-

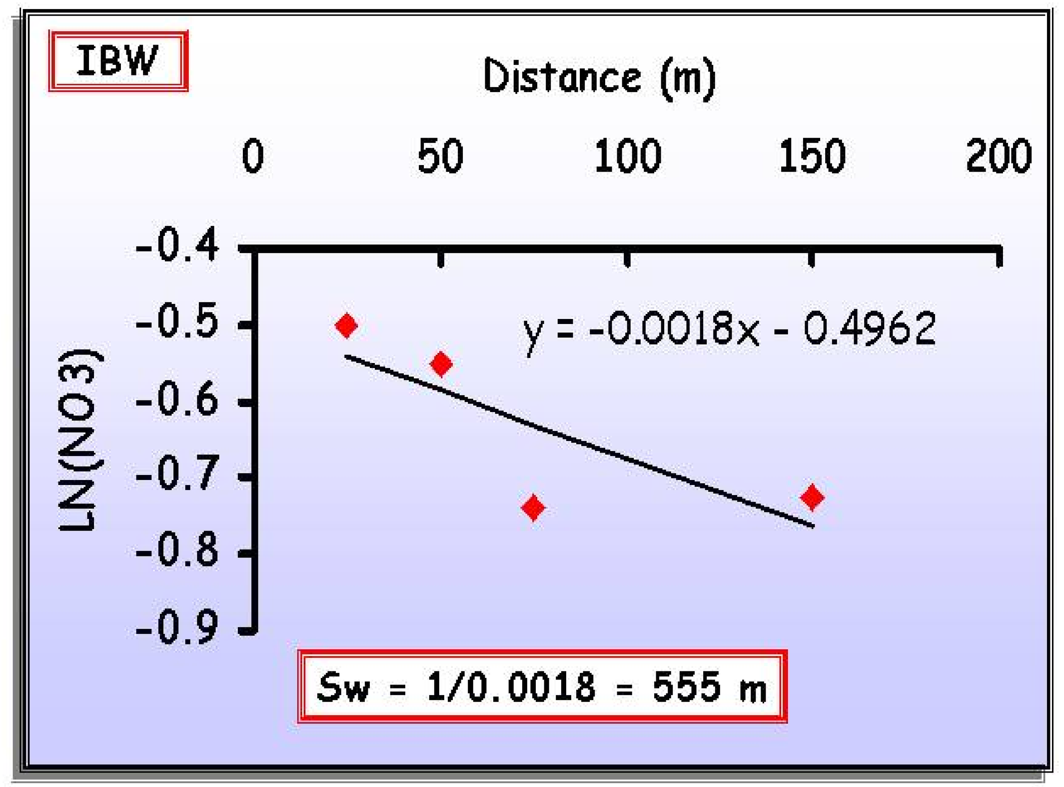
- Natural declines reflect net result of release and uptake processes.
- Ten streams sampled for longitudinal NO_3^- profiles (data only shown for 5).
- Plot of NO_3^- corrected for dilution versus distance.
- Sw from natural declines usually higher than with nutrient additions.



- Sw ranged from 357m to 3333m
- In general, Sw was very large, showing a low retention efficiency for NO_3^-
- Some sites (data not shown) showed increases rather than declines, indicating that uptake was not occurring.

Short-term NO_3^- enrichment

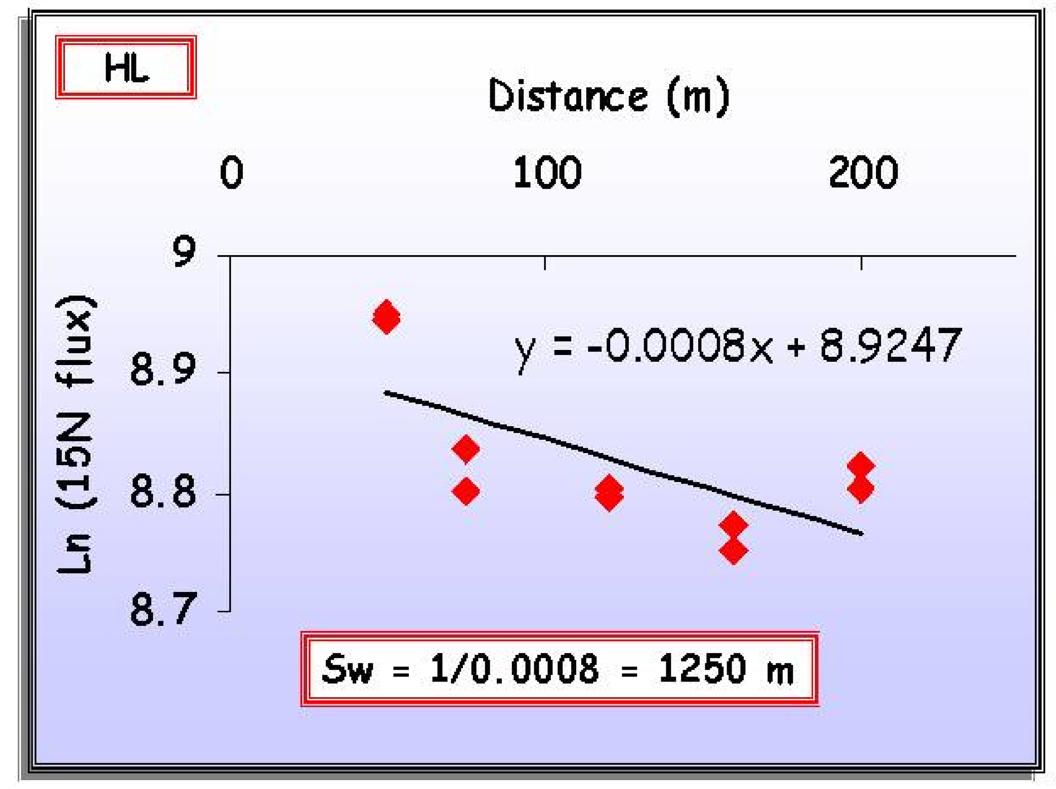
- Short-term enrichment experiments reflect gross uptake.
- Five streams sampled longitudinally for NO_3^- before and after a 2-4 hr injection of KNO_3.
- Plot of NO_3^- corrected for background and dilution versus distance.



- Sw ranged from 294m to 1274m
- Sw in concrete channels was higher than in earthen channels.
- Sw from nutrient additions was shorter than those from natural declines.
- Due to increased NO_3^- levels during additions, ambient uptake conditions may be altered.

Injections with $^{15}NO_3^-$

- $^{15}NO_3^-$ injections represent 'actual' uptake because background NO_3^- is only slightly elevated.
- Three streams sampled for $^{15}NO_3^-$ before and after a 2-4 hr injection of KNO_3.
- Plot of $^{15}NO_3^-$ corrected for background and dilution versus distance.



- Sw ranged from 91m to 1264m
- Sw in concrete channels was higher than in earthen channels.
- Isotope method very expensive, not feasible for use on multiple sites.

Summary of Results

Site	Channel type	NO_3^- (µg-N/L)	S_w(ND) (m)	S_w (NA) (m)	S_w (^{15}N) (m)
RR	Earthen	18	769	294	91
IBW	Earthen	100	357	555	357
HL	Concrete	6100	3164	1274	1264
GD	Earthen	1200	3333	526	N/A
PD	Concrete	5200	1000	833	N/A

ND = natural decline; NA = nutrient addition; ^{15}N = isotope injection

Nutrient addition or ^{15}N?

Site	NO3- (µg-N/L)	Sw (^{15}N) (m)	Sw(NA) (m)	% Change
RR	18	91	357	292%
IBW	100	357	555	55%
HL	6100	1264	1274	0.8%

As background NO_3^- increases, agreement of Sw between Nutrient Additions and 15N decreases.

NA = nutrient addition; ^{15}N = isotope injection

Conclusions:

- Sw may be influenced by channel type in urban streams.
- Using natural declines to determine Sw is not reliable when used over multiple sites.
- Isotope method gives closest 'actual' Sw, but is too costly to use for multiple sites.
- High NO_3^- levels and channel modifications may lead to a condition of saturated uptake kinetics with respect to NO_3^- in urban streams.
- As a result, Sw from nutrient additions may reflect the 'actual' Sw value in urban systems.

Gila Drain (GD)

Price Drain (PD)

Highline Canal (HL)

Indian Bend Wash (IBW)

Rio Rancho (RR)