The Use of Calculated Stream Metabolism in Understanding Nutrients and Algal Measures in Agricultural Streams

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National Water-Quality Monitoring Conference
May 7-11, 2006

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Introduction

- Part of the U.S. Geological Survey’s National Water-Quality Assessment (NAWQA) Program’s Nutrient Enrichment Topical Study (NEET)

- Determine interrelations among nutrient conditions/algal measures and stream metabolism

- Focused on small stream sites in areas with significant agricultural influences
Focus on the Western Study Areas

EXPLANATION
Level III Nutrient Ecoregions
- Central Cultivated Great Plains
- Corn Belt and Northern Great Plains
- Great Plains Grass and Shrublands
- Western Forested Mountains
- Xeric West
- Sampling sites
What Is Stream Metabolism?

- Measure of oxygen production and uptake
- Based on photosynthesis
  \[ \text{CO}_2 + \text{Nutrients} + \text{Solar Energy} = \text{Biomass (organic carbon)} + \text{O}_2 \]
- Changes in dissolved oxygen
  - Gross Primary Production (GPP)
  - Community Respiration (CR$_{24}$)
  - Ratio of GPP:CR$_{24}$
Why Measure Stream Metabolism/Primary Production?

- Nutrient and algal biomass relationships often not predictable in altered stream systems
- Identified as a secondary response variable for nutrient criteria
- Few large-scale estimates in disturbed/altered systems
- Indication of instream processing status
  - Ratio of GPP/CR$_{24}$ > 1 = net energy gain
  - Ratio of GPP/CR$_{24}$ < 1 = net energy loss
Why small agricultural streams?

Natural Streams

Nutrient Transport

Nutrient Processing

Dryland Agriculture

Irrigated Agriculture
Were Production Measures Related to Nutrients or Algal Biomass?

- **Combined data sets:**
  - No relationships between productivity and nutrients or algal biomass

- **Individual study areas:**
  - No relationships between productivity and algal biomass
  - GPP and CR$_{24}$ related to some nutrient measures
  - Primary production in these agriculturally dominated areas related more strongly to physical habitat and environmental variables
Data Collection in Each Study Area

- Stream metabolism (10 of the 28 Study Sites)
  - Utilize Data From Large-Scale Sampling Event
    - Water chemistry
    - Reach-scale habitat assessment
  - Continuous Water-Quality Monitors
    - 10 two-station sites
    - Minimum 48-hour deployment
    - Dissolved oxygen, pH, water temperature, specific conductance
  - Continuous Light Measurements (PAR)
  - Reaeration (limited number of sites)
USGS Stream Metabolism Program

Input:
- Load text files of dissolved oxygen and light
- Enter stream-channel characteristics
- Reaeration value

Output
- Spreadsheet format
- GPP and CR$_{24}$
- GPP:CR Ratio
- NEP
Production/Respiration Values

GPP: 0.1 to 8.4, Median = 1.2
CR_{24}: 0.03 to 46.1, Median = 8.2
Gross Primary Productivity to 24-Hour Community Respiration Ratio

Both areas have streams with GPP:CR_{24} >1

Most sites respiration-dominated
Results of Productivity Comparisons --Combined Dataset

- No significant relationships between productivity and nutrients/algal biomass
- Gross production (GPP) values were not strongly related to any environmental or physical variables
- Respiration and net ecosystem values related to local habitat measures:
  - Bank vegetative cover, canopy closure, velocity
Results of Productivity Comparisons
--Washington Dataset

- **CR$_{24}$**: Total and dissolved inorganic nitrogen
- **Environmental Variables**
  - **GPP**: Reach surface area
  - **CR$_{24}$**: Canopy, bank vegetative cover

![Graph showing community respiration vs. total nitrogen](image)
Results of Productivity Comparisons -- Nebraska Dataset

- **GPP:** Total phosphorus, Kjeldahl nitrogen
- **Environmental Variables**
  - **GPP:** Suspended sediment, organic carbon in suspended sediment, precipitation
  - **CR₂₄:** Discharge, grassland
Implications

- The relationship of production and selected nutrient values at regional level supports the use of regional or subregional criteria

- Physical and environmental factors more strongly related to production values

  - Influence of channel/system alterations
    - Altered hydrology
    - Channel modifications

- Small streams with limited oxygen production/nutrient uptake capability
QUESTIONS?

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