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NUTRIENTS IN WATERSHEDS: DEVELOPING ENHANCED MODELS

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Year of Water: Thirty Years of Progress Through Partnering

Environmental Issue:

Excessive nutrients, especially nitrogen and phosphorus, contaminate more US waters than any other single contaminant.

High nitrogen in drinking water is a health risk, especially for infants in that it can cause the potentially lethal blue-baby syndrome (Nolan et al., 2002).

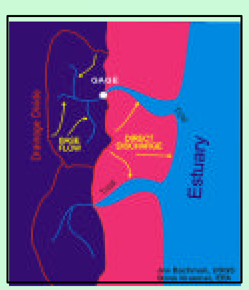
Excessive nitrogen and phosphorus in fresh and coastal waters can degrade ecosystems by causing eutrophication and hypoxia, making these waters dead zones for aquatic life, and degrading fishing and recreation industries.

Scientific Approach:

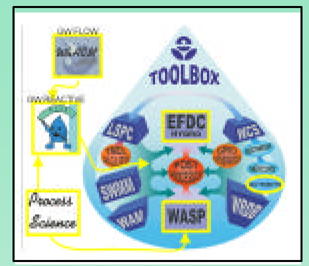
We plan to update and interface proven public-domain models, most of which are in the current toolboxes of EPA offices including Office of Water and Region 4.

Starting with these models, we identified major sources of uncertainty in the models regarding nutrient fate and transport, in terms of both modeling limitations and process understanding.

We are addressing these uncertainties.



The Model Toolbox:



Our team includes co-developers and nationally recognized users of several of the models in Region 4 and Office of Water toolboxes. We will prototype with the Region 4 Toolbox and transition to OW Basins.

WASP: the Water quality Analysis Simulation Program is a general surface water quality model. It is used by EPA and the states for simulating the fate of toxic and conventional pollutants, including nutrients and eutrophication. Linkage is provided to EFDC hydrodynamics.

EFDC: the Environmental Fluid Dynamics Code is a surface water model that solves the multidimensional equations of flow and sediment transport. It is used by EPA for simulating contaminated sediments and for driving WASP-based nutrient simulations.

WhAEM: the Wellhead Analytic Element Model is a general purpose groundwater flow modeling system that is being adapted to the watershed problem. The system has access to single aquifer (GFLOW) and multi-aquifer (Tim) solvers. It is used by EPA to simulate water-table elevations, and the direction and rate of groundwater movement, and will be linked to the reactive-transport module.

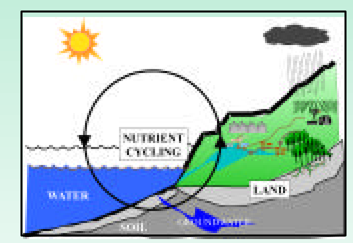
RT3D: the Reactive Transport in 3 Dimensions code simulates three-dimensional, multi-species, reactive transport of chemical compounds in groundwater. This widely used public domain reactive transport code includes predefined modules for standard kinetic reaction mechanisms. In order to simulate the fate of nitrogen species in groundwater, additional modules will be needed to simulate the effects of equilibrium reactions.

The Uncertainties Being Addressed:

Process Understanding:

Much of the uncertainty regarding nutrient fate rests at the level of process understanding. We are seeking to improve our understanding of several of these issues:

1) What determines the effect of given land uses on stream-water quality?
2) What are the best measures of incipient stream-water degradation?
3) What controls the degradation of organic nitrogen in streams?
4) What specific processes control nitrogen transformations in sediments?



Modeling Limitations:

The currently linked modeling systems will be expanded to include a more representative subsurface component. The linkage will be developed and tested using field data from the Piedmont Province (Watkinsville, GA) and the Coastal Plain (Neuse River Estuary, NC). The model components include:

1) Surface-water flow (EFDC);
2) Surface-water quality (WASP);
3) Subsurface flow (WhAEM/GFLOW/Tim);
4) Subsurface transport/reactions (RT3D);
5) Land drainage (HSPF).

Collaborators:

We are working with several partners, both inside and outside of EPA:

1) WASP is being updated and augmented with Tim Wool of Region 4;
2) Nitrogen transport is being studied with Ross Lunetta and Richard Green of EPA at RTP, Jim Tesoriero of USGS, and Ted Mew of North Carolina DENR;
3) Nitrogen processes are being studied with Dinku Endale and colleagues at USDA, ARS in Watkinsville, GA;
4) Exploratory nitrogen process work is being carried out with B.T. Nolan of the USGS's NAWQA survey.

Impacts:

We anticipate that the enhanced tools and knowledge that we produce ultimately will improve TMDL (Total Maximum Daily Loads) implementation in our Nation's watersheds. Substantive impacts to date include:

1) We have evidence that nitrous oxide and methane are highly sensitive indicators of nutrient and organic waste contamination in stream systems and consequently might be sensitive diagnostic parameters; and
2) We have identified that nitrate in sediments and aquifers can be reduced in oxic waters by reaction with ferrous iron, a process that previously has not been identified.

Reference:
Nolan, Hitt, Ruddy. 2002. ES&T. 36. 2138-2146.

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