Toward Sustainable Groundwater in Agriculture

An International Conference Linking Science and Policy

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http://ag-groundwater.org

Unedited Personal Conference Notes
taken by

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No guarantee of accuracy!

Abstracts, presentations, and video-recordings of the plenary session and select special sessions will be posted on the conference website by August 2010.

Leon Kauffman - USGS: Factors contributing to the susceptibility of Public-supply Wells to Agricultural Contaminants

- Redox classification: oxic vs. anoxic vs. mixed
- CA – high loading, oxic, longer travel times
  - In CA nitrate is "more persistent" (oxic)
- Cone of depression etc. → draws high nitrate levels deeper into the aquifer; this could drawdown redox conditions as well.

Klaus Hinsby – Geological Survey of DK and Greenland: Groundwater Chemical Status in Denmark Based Environmental Objectives for Ecosystems and European Water Directives and Guidelines

- Hypoxia of coastal waters (oxygen depletion)
  - Sea floor→ sulfur bacteria (no O_2)
- Algal blooms and eutrophication
- EU water framework and directives
  - Requires "good water status" by 2015
- Nitrate is at the top of the list of the main contaminants for EU waters
- Nitrogen reductions of 50 – 75% are needed
  - See Rockstrom et al, Nature, Ecol.+Society
  - Horsens Fjord – greater than 50% of N is from agriculture
  - The necessary reduction of N is more difficult in oxic waters due to persistence of nitrate
- For the protection of ecological systems, the desired reduction in nitrate levels will be difficult to achieve .

Chris Green – USGS: Trends in Nitrate Concentrations in Agricultural Areas of the US: Implications for Aquifers and Streams

- NWQAP – National Water Quality Assessment Program
- Chemical fertilizer use has increased 20X
- Transects from upland to stream – 20 sites across the US
- Age dating GW using CFCs and SF_6 to determine recharge date
- More and more fertilizer = more and more N
- Higher concentration of nitrate in "newer" water
  - Newer water has recharge w/higher fertilizer use
- Legacy effects
  - Re. reactivity, there is a time lag for denitrification (O_2 gets used up first)
    - Possibly a decade for denitrification to begin

Frank Chapelle – USGS: Bioavailability of Dissolved Organic Carbon and Ambient Redox Processes in GW Associated with Agricultural Land Use

- $O_2 + CH_2O \rightarrow CO_2 + H_2O$
- K=kinetic constant=$([CO_2][H_2O])/[O_2][CH_2O]$
- Bioavailability of DOC in South Carolina (SC)> that in San Joaquin Valley(SJV), CA
- SC-corn, soybeans, alfalfa
- Modesto – Ag/urban
- Indicators of DOC bioavailability
  - DOC concentration

- Carbon content of DOC
- Amino acid content of DOC
- Microbial abundance
- Microbial growth
- Specific UV absorption (254-aromaticity of DOC)→more aromatic=less bioavail
- Bioassays of CO_2 production/consumption

- SC has more DOC than SJV, SC DOC is more bioavailable than SJV

Cathy Ryan – University of Calgary: Can Groundwater Protection and Agricultural Production Co-exist over Vulnerable Aquifers?

- Abbotsford/Sumas Aquifer → gravel, sand, unconfined
  - Considered to be "importing nitrate" to the US
  - Poultry manure used on berry crops
  - ~1 m of recharge/yr
  - Only manure storage was regulated
    - Suggested/voluntary N fact sheets, end of season test
- GW>10 yr old → no trend in nitrate change
- GW<5 yr old→ increasing nitrate trend
- Goal is to optimize berry production without nitrate contamination→BMPs
- Need to be aware of seasonal (and other) variations in nitrate leaching
- 366 kg N/ha applied with estimated leaching losses of 206 kg N/ha→15mg N/L?
- Voluntary BMP approach is not effective → need to link management with GW quality.

William Robertson – University of Waterloo: In-stream Bioreactor for Agricultural Nitrate Treatment

- Treat agricultural drainage by promoting and controlling redox
- Stream bed was replaced with a 2 layer reactor; base of woodchips to provide C for denitrification, top layer of gravel in first section followed by top layer of silt in second section
- Lift up outlet pipe to control redox→ controls detention time
  - With a long enough detention time (effluent pipe more vertical), nitrate can be exhausted leading to sulfate reduction and the generation of hydrogen sulfide.
- Year round operation – reaction rate decreases in winter, but continual nitrate removal at the lower rate
- Hg and TSS is lower in the effluent – reactor acts as a filter
- How long will the media last?
  - Fresh pine is better than hardwood
  - 10 mg/L nitrate removal/day?
  - Lose 50% of removal capacity in the 1st year, but can be used consistently thereafter (15 years?).
  - Removal rate is not dependent on nitrate concentration (zero order)
- Problems
  - Incomplete denitrification in winter due to lower temps→ N_2O production
  - Methane production in summer (much more than N_2O)
    - reduced detention time could decrease methane production
  - Methylation of mercury – occurs under sulfate reducing conditions
    - Higher flow would minimize sulfate reducing conditions
  - Effluent is anaerobic

David Randolph – Department of Earth and Environmental Sciences, University of Waterloo: Quantifying performance of regional scale reductions in nutrient applications for source water protection through vadose zone monitoring

- BMPs and municipal well water quality – Southern Ontario, Thornton well field
- Increased nitrate since 1975, blending began in late '90s
- What to do?
  - 1-Bought agricultural land within a 2 year time of travel ('02/'03)
  - 2-Rent the land and reduced the N loading
- How to find out if BMPs are helping
  - Unsaturated zone 3-30 m (monitoring implications)
  - 23 lb/ac excess N
  - Modified N application→decrease application to levels less than what plants need (to decrease the N)
- BMP monitoring
  - (1) Measure nitrate→ quantity changes in vadose zone
  - (2) Annual mass load of nitrate
  - Br tracer, measure cores: how far and moisture content
  - Total stored N decreased with BMPs 17 mg/L → 7 mg/L over 3 yrs with BMP = 60% reduction
  - (3) Simulate/Predict magnitude and timing of impacts on municipal wells using regional scale GW flow model
- Method has potential but delayed impact due to lag time
- Small piece of land to improve GW
- 30 wells, 15 stations, $200,000

Carolina Balazs – UC Berkeley: Just Water? Environmental Justice and Drinking Water Quality in California's Central Valley

- Public health and nitrate contamination: focus on impacted populations
  - Vulnerable groups re. class and race in the San Joaquin Valley (SJV), CA to determine if there is higher nitrate exposure in lower income communities and communities of color
- High cost of nitrate treatment
- SJV
  - 10% of the CA population lives in SJV and 20% of SJV population lives below the poverty level
  - Agriculture → fertilizer→nitrate problem
  - 95% of the population requires GW for DW
- Concern of cumulative exposure
- ½ of MCL = 22.5 mg/L = "At risk" according to CDPH
- 327 systems/communities
- CDPH, 2008, water quality monitoring database, PICME
  - Average nitrate concentrations:
    - 3% are above MCL
    - 10% are at risk (these were mostly small systems – 1 or 2 wells)
- As you increase the % Latino you increase the risk of exposure
- 5% served at risk, <1% served above the MCL
  - This is the low estimate, because small water systems were underrepresented
- Considerations: cost of increased monitoring, cost of mixing/treatment/alt. sources

- ?What about domestic wells: 3.3 million people in SJV? 200,000 of them using domestic wells

Michael Goss – University of Guelph, Kemptville Campus: Microbial Contamination of GW under Agriculture Fields, Sources and Pathways

- Bacteria are moving where water is moving quickly
- Factors that constrain movement of bacteria through soil
  - Convection, sedimentation, adsorption, diffusion, straining, filtration
- Subsoil characteristics: silt vs. sand
- Comparison of liquid swine manure vs. solid cow manure
  - Liquid manure→ greater opportunity to contaminate both SW and GW
- Microbial sensitivity to environmental factors
  - UV, pH, temp, moisture, indigenous soil organisms (competitive interaction), ammonia
- Note: by adding manure, a carbon source is also added
- Microbes survive longer with liquid manure. In liquid manure, microbes move faster than in plain water, because they have something to stick to.
- Report of the Walkerton Inquiry → 7? deaths due to bacterial contamination
  - Raised the question of which is the bigger issue: nitrate or bacterial contamination?
  - Suggestion that if you drink water with 150 mg/L N you wouldn't even know it, but with just one microbe…!!

Jens Christian Refsgaard – Geological Survey of DK and Greenland: Nitrate Reduction in GW Dominated Catchment: How Good Are Our Models?

- Odense Fjord catchment N balance
- Nitrate loads must be decreased by 50%
- Nitrate is being reduced naturally, but we don't know where (2/3 nitrate naturally attenuated)
  - Heterogeneous subsurface
- Modeling: DAISY root zone, MIKE SHE/MIKE II
- Inverse modeling techniques, descriptions of hydrograph
- Issue of scaling because of the geological heterogeneity
  - Could not do it at hectare scale
  - The main issue with characterizing land BMPs for nitrate is the lack of data on the heterogeneity.
- SkyTEM – electromagnetic mapping 300m down
- For smaller scale heterogeneity – stochastic geology