Ohio’s Natural Settings & Animal Manure Management

Julie Weatherington-Rice, CSS, CPG
Ph. D. Soil Science & M.S. Geology OSU
OAS Ohio Fracture Flow Working Group
Sr. Scientist, Bennett & Williams
The OFFWG Goal

To CHANGE the way hydrogeology is practiced, reviewed & taught in Ohio.

To PROTECT Ohio’s endangered ground & surface water supplies.
Model Behind the OFFWG Mission

Identification of New Contributors, Ongoing Research, Education, Consensus & Team Building all at the same time

Based on Extension’s Education, Research & Service Model
Livestock
Livestock feedlots, lagoons & manure management systems
Issues to Address

• Manure Nutrients, Pathogens & Pharmaceuticals
• Ohio’s Fractured Soils, Glacial Materials and Bedrock
• Natural Biological Communities in the Soils
• Role of the Water Cycle
• Agricultural Farming Practices & Economics
• Federal & State laws, directives, rules & recommendations
Understanding Ohio’s glacial materials

OSU’s Molly Caren Field Day
(Madison Co.)
Aug, 1997
Subsurface Fractures

- Common in fine-grained (clayey, silty) materials
- More permeable than unfractured parent materials
- Can facilitate rapid water movement and solute transport

(Clermont County, OH)
A simplified cross-section

- Soil
- Glacial drift / till
- Bedrock

(Fractures can be observed in all layers)
Counties in Ohio known to have fractured finer-grained soils (modified from Tornes et al., 2000)
Soil scientists identified fractures

- In 95+ of Ohio’s soil series
- Including 81 “prime farmland” soils
- Covering perhaps 20-25 million acres in the U.S. Midwest and eastern Canada
The shallow Lewisburg silt loam 0-2%

Miamian, Lewisburg, Celina, and Crosby soil association

Represents 1-2 million acres in Ohio and Indiana
How do fractures form?

- Drying
- Freeze/thawing
- Ice sheet pressures
- Till pressure on deposits below
- Unloading of weight when glaciers melted
Fractures in glacial tills

(Franklin County, OH)

(Madison County, OH)
Fracture Ecosystems

- Anaerobic bacteria
- Earthworms
- Fungi
- Rhizomes, stem bases
- Plant roots
- Burrowing Animals
Biological systems

- Can create or expand the network of fractures / macropores
  - Root channels
  - Earthworm burrows
  - Animal holes
  - Biopores

- Can move preferentially through existing fractures
- Can change the biogeochemistry within a fracture
Field observations

• Live roots in streamcut fractures

• Wisconsinan loess over Illinoian glacial till overlying thick paleosol (~50 ft down) formed on pre-Illinoian till

(Clermont County, Ohio)
Extensive root depth

- Fractures traverse multiple stratigraphic layers
- Live tree roots up to 45-65 ft. below associated surface vegetation
Field observations

- Roots in streambed fractures
- 3-5 ft. deep

(Franklin County, Ohio)
Earthworms

- *Lumbricus terrestris*
- Build burrows
- Greater populations under no-till conditions
- Tillage
  - Increases soil porosity
  - Increases runoff
  - Decreases macropore continuity
Earthworm burrows

- Depth to 40 in.
- Length to 50 in.
- Diameter to 0.04 in. (average = 0.03 in.)

(Shipitalo and Butts, 1999)
Earthworm biopores > 0.02 in.

- 727 thousand per acre (long term no till)
- Small fraction of soil volume
- Higher velocity of water and solute movement
- Less contact time

(Shipitalo et al., 2000)
Burrows transmit water

- Directly to shallow groundwater
- To ag. tile drains
- To animal holes
Preferential flow connection

“During dormant season, a direct connection of the macropore flow system in the soil to the preferential flow system in the fractured bedrock below is indicated.” (Shipitalo et al., 2000)
An experiment

- Smoke bomb introduced to agricultural drainage tile main
- Late summer
- Long-term no-till field

(Hancock County, Ohio)
Smoke appeared within minutes
Original Experiment 1997

- Using a blower

( Hancock County, Ohio)
Smoke poured from hundreds of worm burrows & macropores
Macropores in tilled (Sustainable Ag) WET Corn Field

Canfield silt loam, ATI’s Apple Creek Farm, Wayne Co. Sept. 2003

If here – EVERYWHERE?
Measuring hydraulic conductivity with Amoozemeters
Measured Hydraulic Conductivity

- Fractures measured 5.8 to 20.5 ft/year
- Matrix measured 0.6 to 1.8 ft/year
Ground Water Contamination Too?

- Nitrates entering ground water persist for generations
- Current requirements yearly monitoring of farm well for nitrates and coliform bacteria
  - Is well in the same aquifer?
  - Is it down gradient from lagoon?
  - Is data meaningful?
- No ground water monitoring of farm fields with applications
Manure Management Practices Exists in the Real World

• US Clean Water Act, 1972
• NPDES Permits for Point Source Discharges, field tiles?
• Watershed Non-Point Total Maximum Daily Loads (TMDLs)
• Cradle to Grave responsibility for hazardous materials
• Ohio Anti-Degradation – Scenic Rivers
• USDA programs, policies & standards, no-till for sediment reduction, New Standard 633 for manure apps
• US & State level biosurveys & fish kill reports
• Application rates, Agronomic vs. Environmentally Safe
Management Techniques to Control Manure Contamination

- Pathogen Removal & Precision Farming Custom Application Between Tile Lines
Management Techniques to Control Manure Contamination

- Pathogen Removal & Captured Tile Drainage/ Sub-irrigation (WRSIS)
Management Techniques to Control Manure Contamination

- Composting within Animal Housing Units (Daylay, High-rise hog bldg)
- Land application of dry, stabilized material
- Advantages: less volume 1:8-9 vs. volume liquid manure, fewer trips across the field, incorporation of organic material
High-Rise Hog Buildings

- 1st HRHB built 1998
- Darke County
- 960 hogs
Management Techniques to Control Manure Contamination

• Cement Pad Windrow Composting (OARDC - Wooster)
Composting at Wooster
Composting at Wooster
Summary

- Any potentially contaminating land uses (surface or shallow subsurface) may have direct connections via macropores to the ground water below
  - Manure application or lagoons
  - Septic fields
  - Biosolids (sludge) farming
- **Surface water** is also **vulnerable** due to drainage tile outlets and ground water baseflow
For more information...

- www.oardc.ohio-state.edu/fractures
- www.bennettandwilliams.com (Temp home Manure Management Bibliography, 2001) look under “References” Section
- *Ohio Journal of Science*
  June/Sept 2000 special issue
  vol. 100(3/4)
  www.ohiosci.org/Fractures.htm