EFFECT OF BIOFILM GROWTH ON THE FATE OF CONTAMINANTS IN THE SUBSURFACE

A. BIELEFELDT, T. ILLANGASEKARE, & C. MCEACHERN
UNIVERSITY OF COLORADO

ACKNOWLEDGMENTS

- U.S. Air Force
- Rocky Mountain Hazardous Substances Research Center

BACKGROUND

- IN-SITU BIOREMEDIATION
  - JET FUEL : JP-8
  - DE-ICERS : PROPYLENE GLYCOL
- DEGRADE CONTAMINANTS TO CO_2, H_2O, AND INCREASE BIOMASS
  - BIOMASS GROWTH PLUGS PORES IN SOIL
  - CHANGES HYDRAULIC PROPERTIES

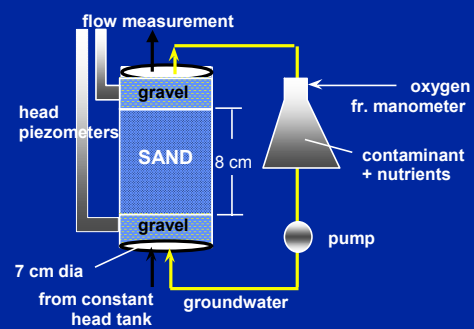
EXPERIMENTS & FINDINGS

- 1-D COLUMN STUDIES
  - HYDRAULIC CONDUCTIVITY & DISPERSIVITY
- 2-D TANK with BIOGROWTH ZONE
  - TRACER BREAKTHROUGH CURVES
- MODFLOW MODEL OF 2-D SYSTEM

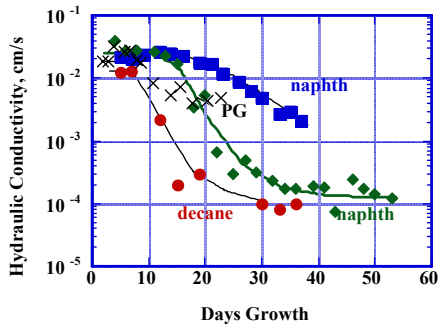
COLUMN EXPERIMENTS

- CONTAMINANT
  - decane, naphthalene
  - propylene glycol
- SAND SIZE (0.19, 0.32, 0.49 mm)
- NUTRIENT LIMITATION (C:N)
- GROUNDWATER FLOW RATE
- BIOGROWTH OVER TIME (<55 d)

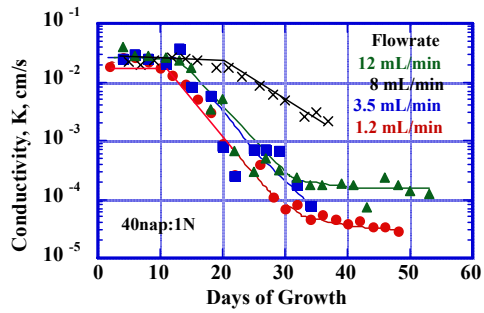
1-D COLUMNS



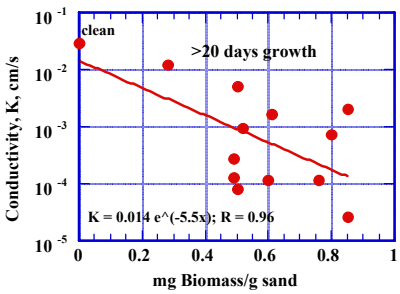
effect of contaminant on K over time

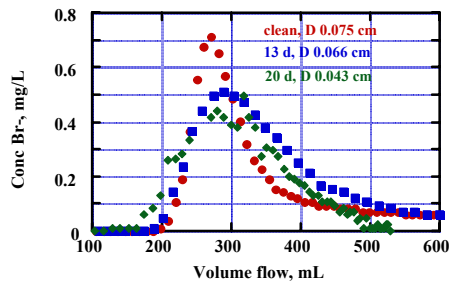


flowrate affects minimum conductivity



poor correlation between biomass and hydraulic conductivity



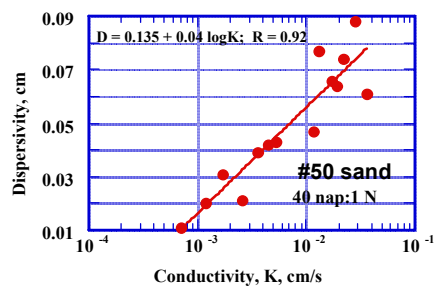


example of breakthrough curves used to calculate dispersivity

Dispersivity Test Observations

- with biogrowth, mass recovery of tracer decreased (controls >90% vs 59% and 41% for examples shown)
- as K decreased, difficult to obtain needed sample volume for analysis
  - cannot relate biomass and dispersivity

relationship between dispersivity and hydraulic conductivity



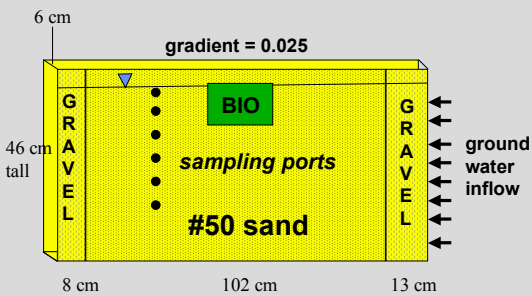
CONTINUING RESEARCH

- Investigate more readily soluble & degradable contaminants (PG) and de-icer mixture with toxic (triazol)
- Further characterize uniformity of biogrowth in column
- Biofilm structure effect on conductivity and dispersivity
- Field soils

TESTS IN 2-D TANK

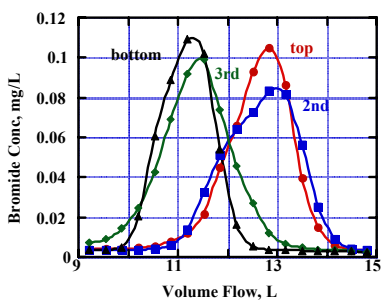
- Desired a controlled zone of biogrowth
  - external "biozone" grown and inserted into tank
- Determine biogrowth effects on groundwater flow via non-reactive tracer tests
- Does a model predict the observed results?

2-D TANK



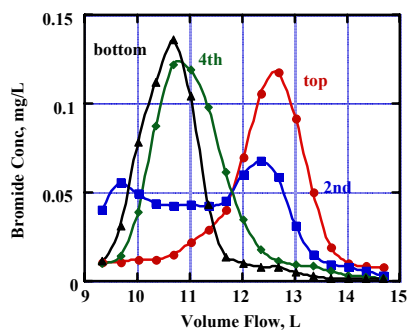
Development of Biozone

- Biozone grown externally in a biobox
- Bioboxes fed similar to columns for 2 to 8 weeks
- Difficulty measuring hydraulic conductivity in the boxes
- Final biomass 0.21 to 0.85 mg/g sand
- Approximately even biomass distribution
- Difficulty inserting biozone into tank



tank with 3 wk biozone

tank with 4 wk biozone



Tank Tracer Test Results

- Clean biozones caused minor disturbances to tracer breakthru
- Biozones caused little change at the lower three sampled depths
- Biozones significantly changed breakthru at the top 2 depths
  - slowed travel caused later peaks
  - double peak from flow around + thru
  - model predicted qualitatively, but poorly matched data

CONCLUSIONS

- biogrowth affects hydraulic conductivity & dispersivity
  - cannot yet quantify these changes
- biogrowth affects groundwater flow in two dimensions
- further experimental work and modeling efforts are needed