The Use of Anhydrous Ammonia for Bioventing

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Overview

- Bioventing
- Challenges
- Objective
- Method
- Results and Discussion
- Conclusions

Bioventing

- Popular in-situ remediation technology for hydrocarbon contamination
- Application
  - nutrients
  - oxygen
  - water
- Stimulates growth of hydrocarbons degraders

Challenges

- Nutrient requirements
  - type of nutrient
  - concentration
- Means of supplying nutrients

Objective

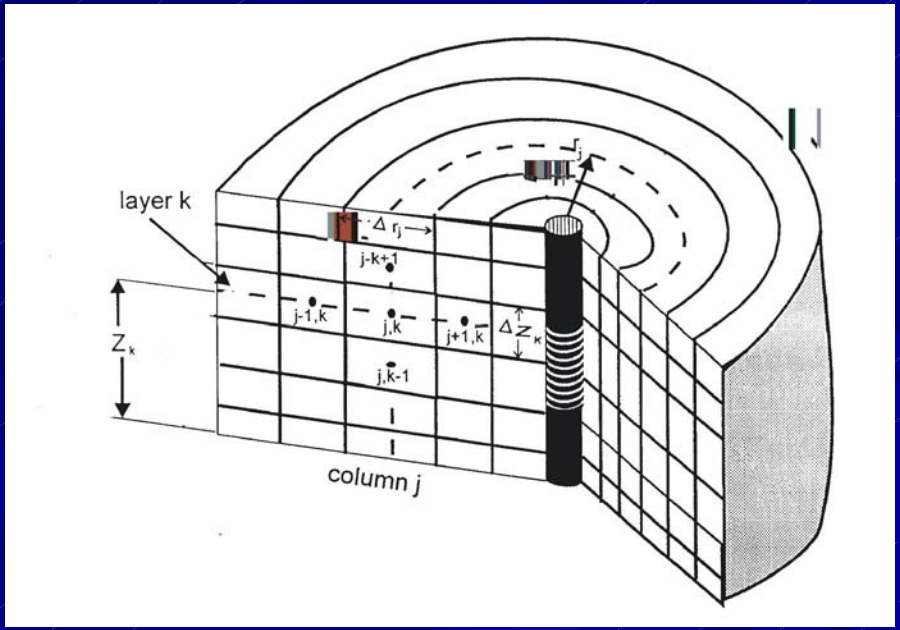
- Investigate the possibility of injecting anhydrous ammonia into subsurface to satisfy nutrient requirements
  - popular agricultural amendment
  - gaseous form

Method

- Modelling
  - 2-D finite difference
  - application approach
- Laboratory
  - respirometry
  - comparison of two ammonium sources
  - microbial counts

Method - Modelling

- Determine plausibility of easily and safely dispersing AA into the subsurface
- Model written to describe radial flow of AA



Method – Modelling – cont.

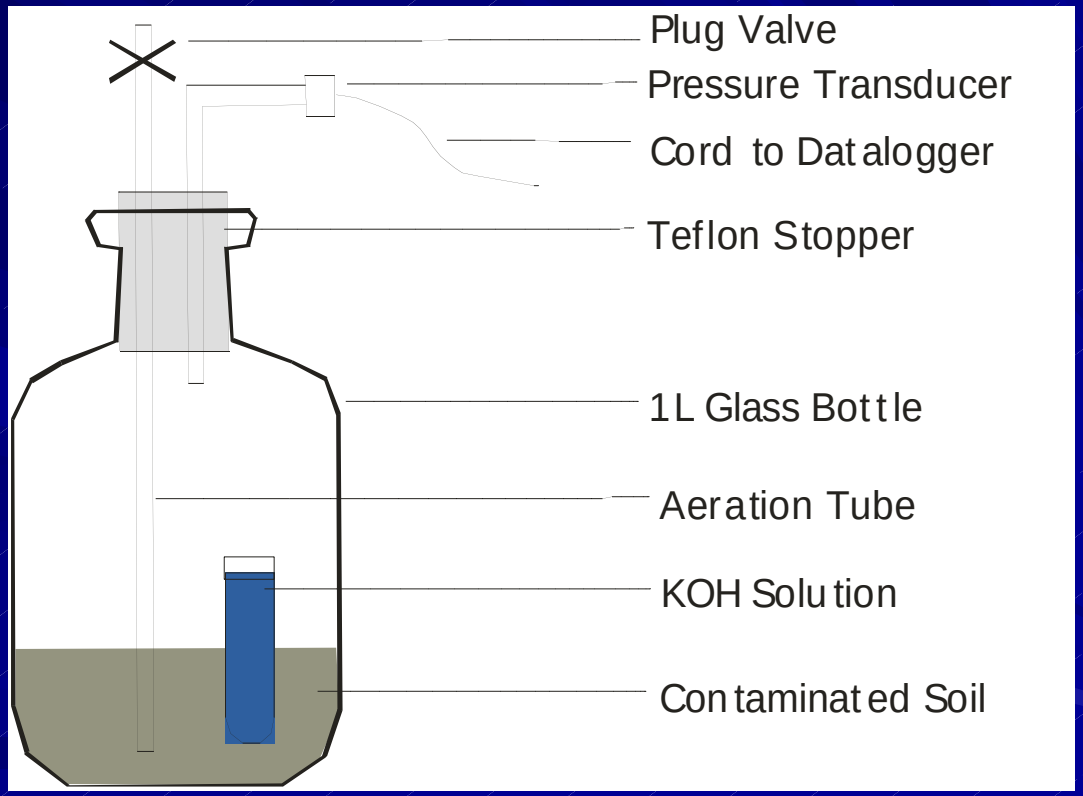
- Assumptions
  - AA behaves as ideal gas
  - aqueous and organic phases stagnant
  - biological and chemical degradation of AA during injection negligible
  - gas flow according to Darcy's law

Method - Modelling – cont.

- Boundary Conditions
  - Depth of contamination 2.5 m
  - Well screened for 2 m
  - Radius of influence 7.5 m

Method - Laboratory

- Respirometer



Method - Laboratory – cont.

- Soil tested
  - gasoline contaminated soil
  - fine sand
  - TPH @ 2300 mg/kg
  - water content @ 10 wt%
- Nutrients added to attain C:N of 10:1
  - NH_4Cl powder
  - Anhydrous Ammonia gas
- Incubator temperature @ 25 C

Method - Laboratory – cont.

Experiments Completed

Run No.	C:N	Nutrient	H_20 (wt%)	Incubation Period (d)
1	10:1	NH_4Cl	15	2,5,10,15,30
2	10:1	AA	15	2,5,10,15,30

Method - Laboratory – cont.

- Tests completed
  - TPH levels over time
  - microbial counts

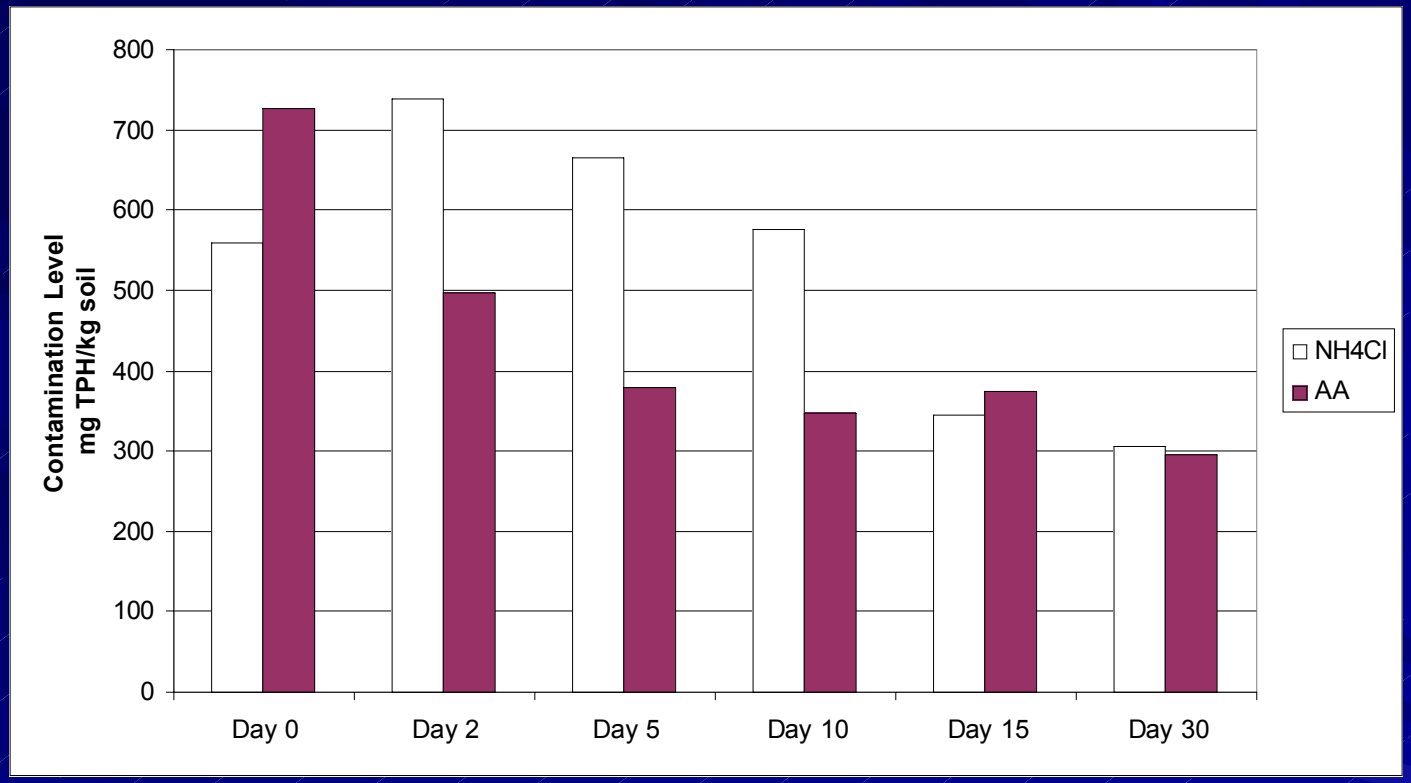
Results - Modelling

- AA could easily be injected into subsurface
  - sparge time of 30 min @ 2 atm
  - resulting concentration 0.15 kg/m^3
- Safety
  - handling protocol available
  - application concentrations should be less than 0.15 kg/m^3
- Behavior
  - satisfactory degradation of hydrocarbons
  - replenish AA every 30 d

Results - Laboratory

- pH
  - NH_4Cl: 7.7 to 8.2
  - AA: 9.1 to 9.2
- Microbial counts
  - NH_4Cl: 10^5 to 10^6 for hydrocarbon degraders
  - AA: 10^4 for hydrocarbon degraders
- Degradation Rate
  - NH_4Cl: 0.028 d^{-1}
  - AA: 0.023 d^{-1}

Results - Laboratory



TPH Concentrations over Time

Conclusions

- Modelling showed that AA easily and safely injected
  - sparge time of 30 minutes
  - AA would reduce by 80% over 30 d
- AA effective in degrading gasoline
- AA inhibits the growth of microorganisms

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