Universiteit Utrecht

Smart Water, Smart Soils:

Thinking outside the (water) box!

Prof Dr Ruud J. Schotting

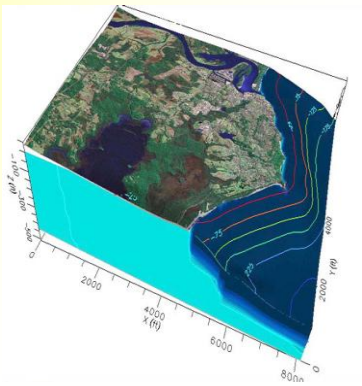
Sultan Qaboos Chair of
Quantitative Water Management

Universiteit Utrecht

Water Management

Highly inter-disciplinary

- Physics (fluid flow)
- (Geo) Chemistry
- (Micro) Biology
- Mathematics
- Numerical methods
- GIS/Graphics



Universiteit Utrecht

Challenges in history of agriculture

- Settling down after nomadic life
- Growing population
- Intensive land use
- Need for food → Guaranteed production
- Resistance against diseases

Universiteit Utrecht

Smart Solutions in Agriculture

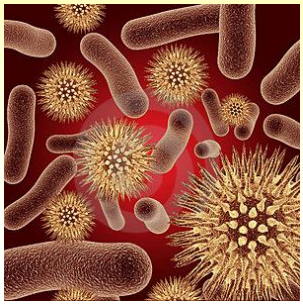
In agriculture farmers found Solutions in adapting soil properties:

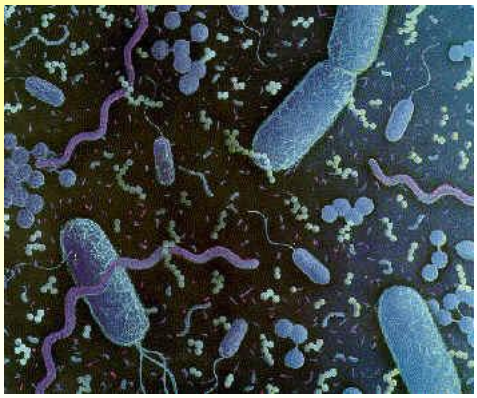
- **Burning of vegetation**
- **Crop alteration**
- **Ploughing the fields**
- **Use of (natural) manure**
- **Addition of organic materials (lupines)**

Result: optimization of soil properties to maximize yields

Universiteit Utrecht

Changing the hydrogeological properties of soils with …..





BACTERIA?

Universiteit Utrecht

Water Availability Management Yunnan

Universiteit Utrecht

Water Availability Management Yunnan

Study mission June 9 – 13, 2010

Ultimate goal:

Yunnan Drought Preparedness Plan

Combination of a variety of traditional and innovative techniques to mitigate the consequences of future droughts

Universiteit Utrecht

Water Availability Management Yunnan

Study mission June 9 – 13, 2010

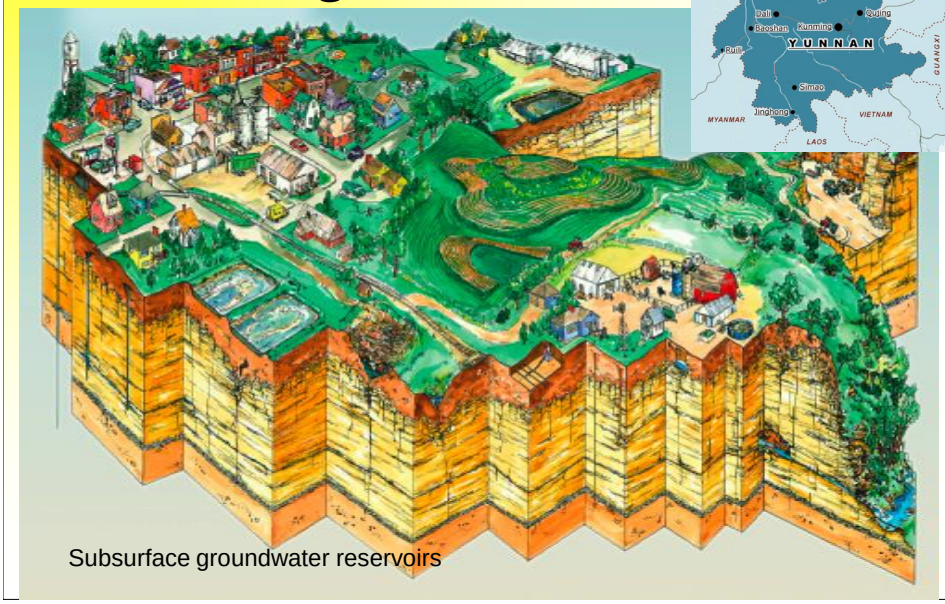
Ultimate goal:

Yunnan Drought Preparedness Plan

-Man-made aquifers to store water
-Bamboo instead of corn (erosion reduction)
-Local bamboo-based industry: food, furniture, building materials, etc

Universiteit Utrecht

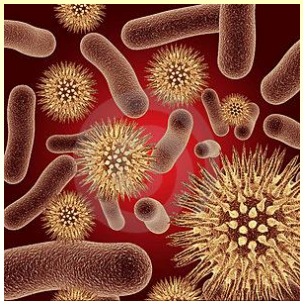
BioSealing of fractures?

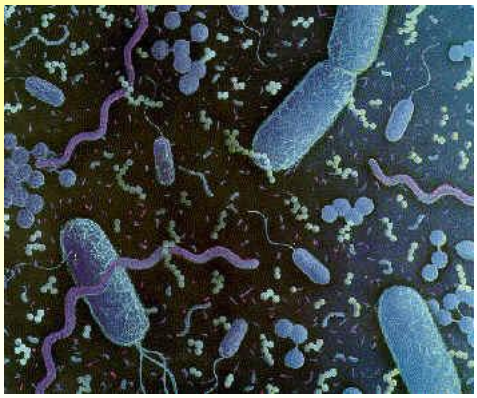


Subsurface groundwater reservoirs

Universiteit Utrecht

Changing the hydrogeological properties of soils with …..



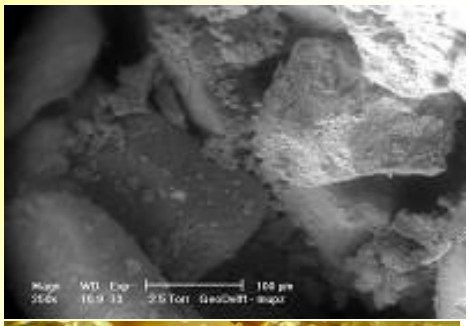


BACTERIA!

Universiteit Utrecht

Applications of 'Smart Soils'

- BioSealing
- BioGrout



Universiteit Utrecht

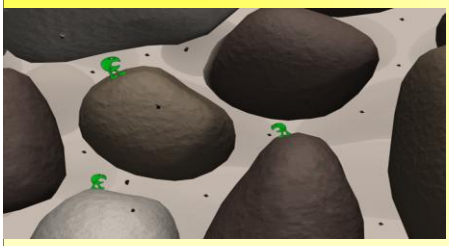
BioSealing

BioSealing is a method to clog subsurface leaking water retaining constructions

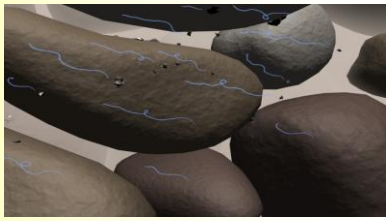
- **Micro-organisms are available everywhere**
- **Injection of nutritients in existing flow paths**
- **Fast growth of micro-organisms: biomass**
- **Transport of fine particles (clay minerals)**
- **Catchment of fines in bioslime: clogging!**
- **Desintegration of bioslime: clogging persists**

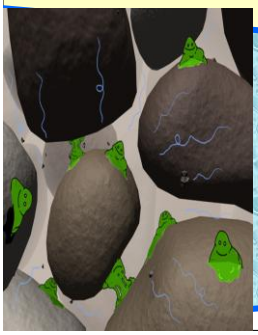
Universiteit Utrecht

nutrients are injected

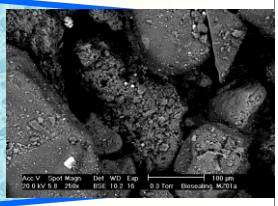


groundwater flow
directed towards the leak





Biomass growth is stimulated at the position of the leak



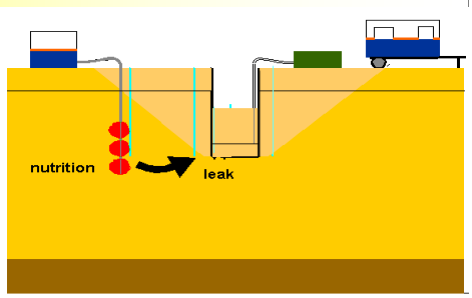
Universiteit Utrecht

Applications of biosealing

Leakage control in groundwater retaining constructions

Seepage control in recharge dams and other dikes/dunes/dams

Reduction of piping phenomena!

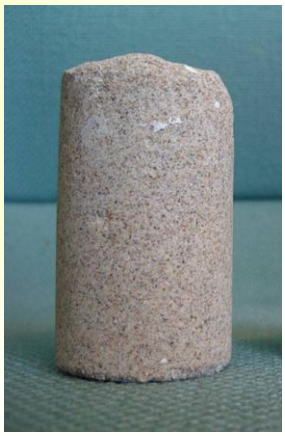


Universiteit Utrecht

BioClogging = BioGrout

From loose sand

to ➔



sandstone!!!

Universiteit Utrecht

Scale-up in 5 years

5 cm 1 m 1 m^3 43 m^3

1D 2D 3D

Universiteit Utrecht

Principles

General: strengthening of sand by producing calcite ***in situ***

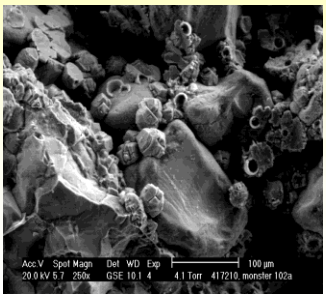
First Generation process: urea hydrolysis

urea

$CO(NH_2)_2 + 2H_2O \rightarrow CO_3^{2-} + 2NH_4^+$

$Ca^{2+} + 2\ Cl^- + CO_3^{2-} \rightarrow CaCO_3 \downarrow + 2\ NH_4^+\ 2Cl^-$

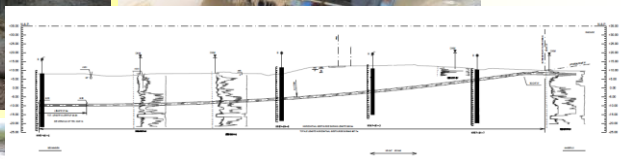
calcite



Urease containing *Sporocarcina pasteurii* (Bacillus)

Universiteit Utrecht

BioGrout: Application in gravel



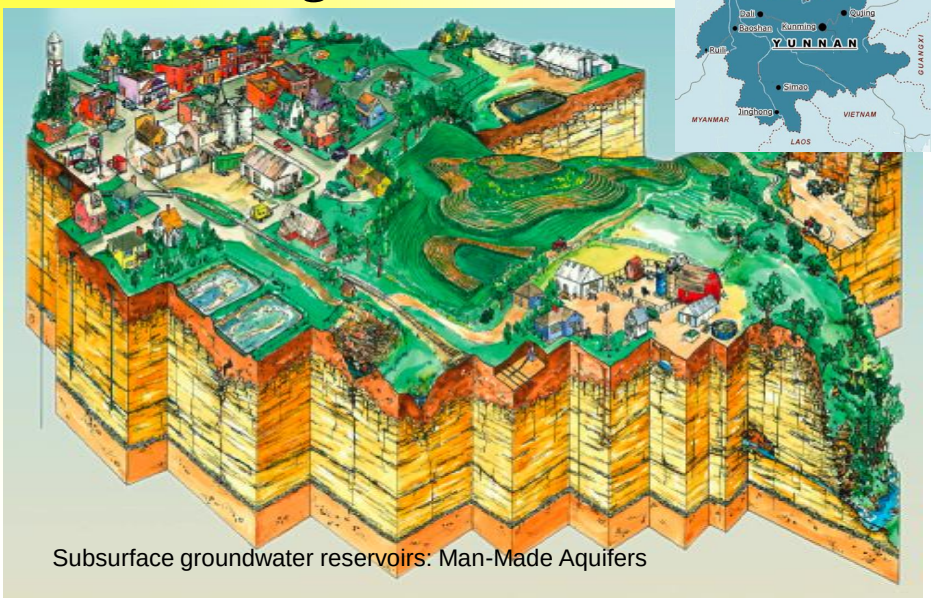
9 februari 2012

Universiteit Utrecht

SmartSoils Biosealing

Universiteit Utrecht

BioSealing of fractures!



Subsurface groundwater reservoirs: Man-Made Aquifers

Universiteit Utrecht

BioSealing: man-made aquifers

- Storage of fresh water
- Availability of fresh water in periods of drought: drought preparedness!
- Environmentally friendly: only natural processes
- Simple technique
- Pilot project needed to demonstrate the potential of biosealing

Universiteit Utrecht

Thank you for your attention!

‘Water, fresh water, every where…
Enough for all’

Ruud Schotting 2012