

# Upgrading low-quality water by managed aquifer recharge to provide safer groundwater in areas facing water scarcity

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# Managed aquifer recharge (MAR)

Managed aquifer recharge (MAR) is the intentional recharge of water into suitable aquifers for subsequent recovery or to achieve environmental benefits;

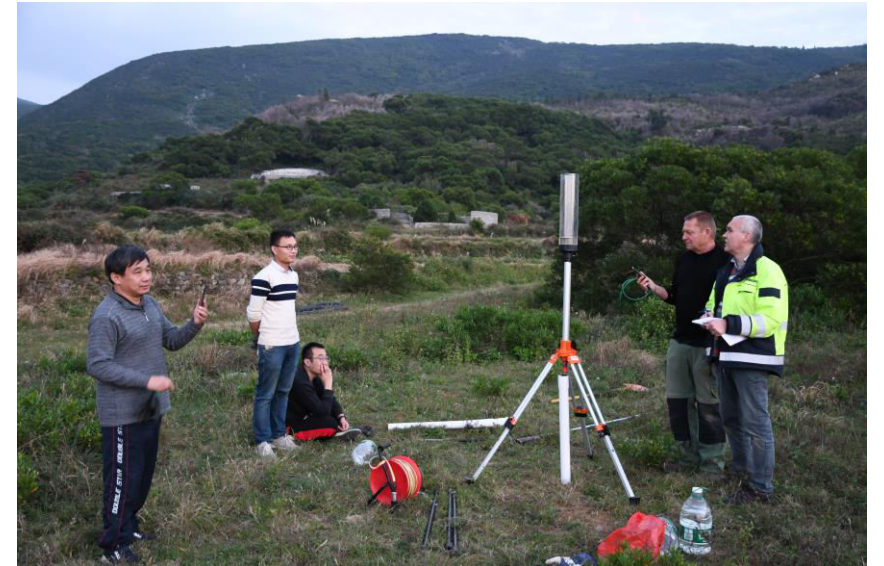
MAR is the only practical way to restore overexploited aquifers

MAR is often used to prevent salt-water intrusion

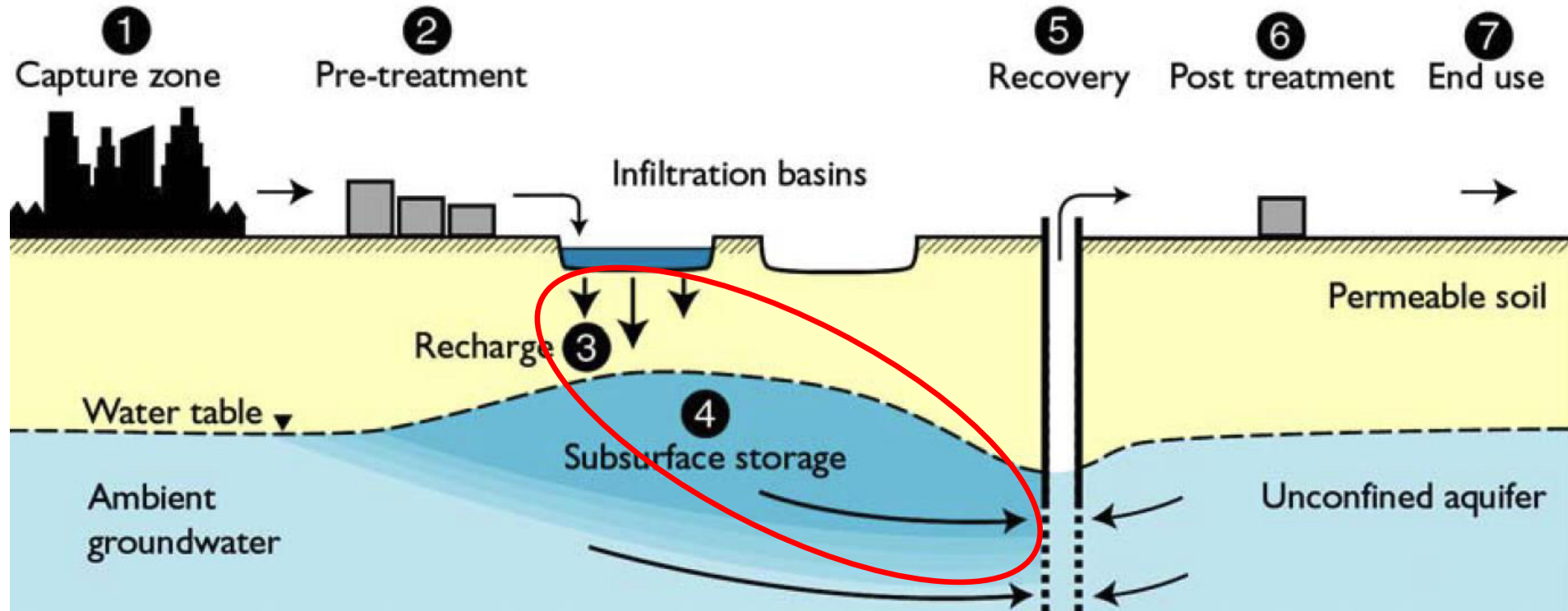
MAR can be used as a tool for adaptation to climate change

## Concerns for contamination of the groundwater resource

- Organic pollutants
- Pathogens
- trace metals
- Nutrient



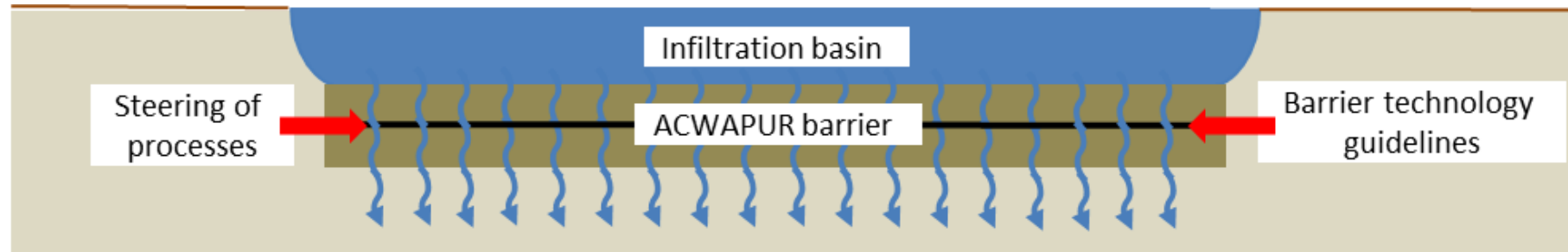
# MAR via infiltration basins



Peter Dillon et al., 2009

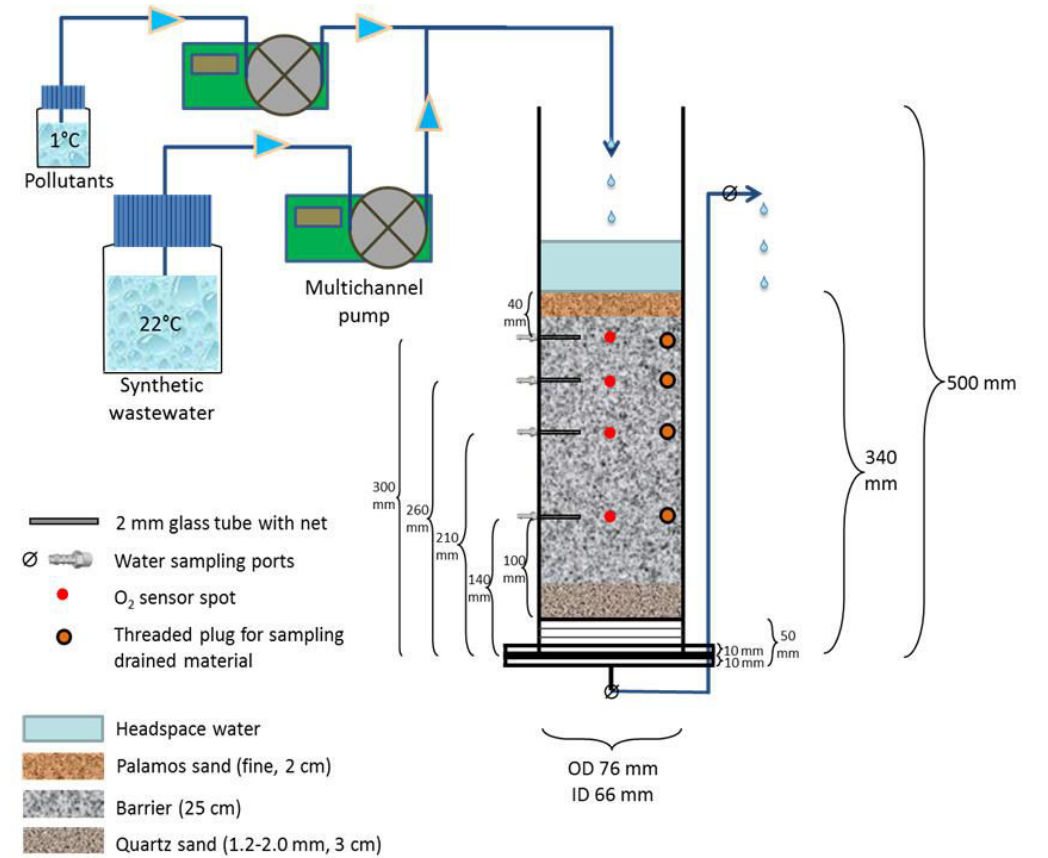
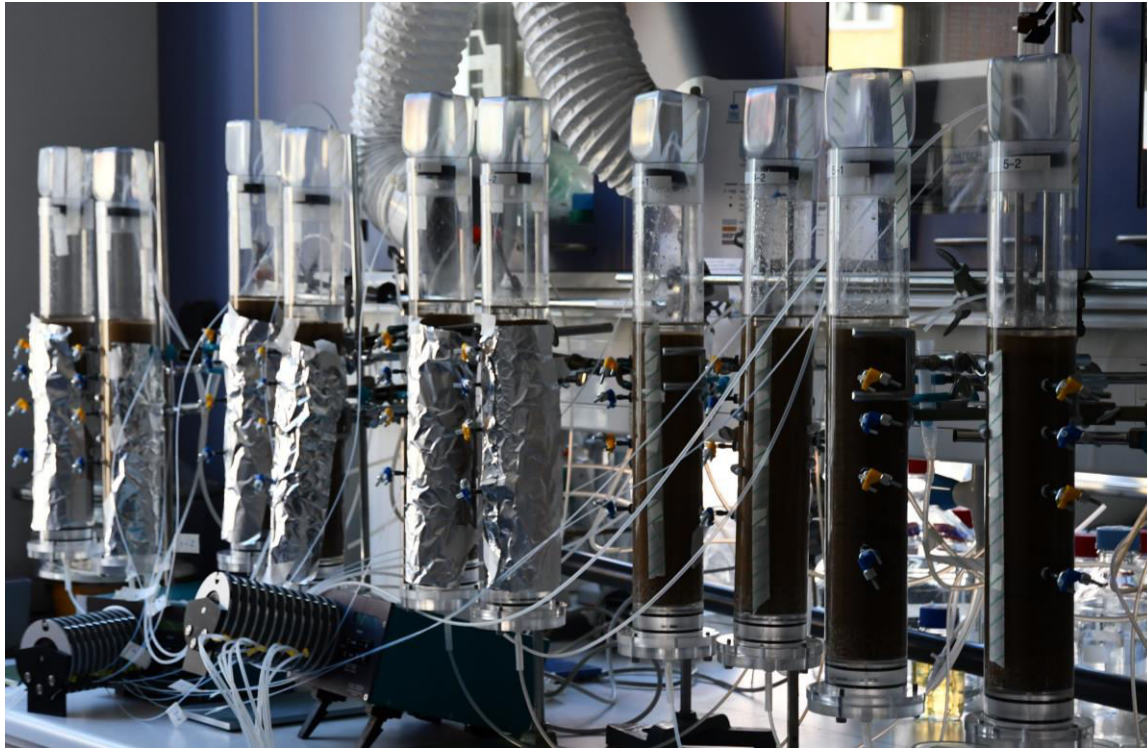
For removal of pollutants MAR rely on physical, chemical, and microbial processes in subsoil and aquifers

# ACWAPUR - Accelerated Water Purification during MAR – A tool to restore drinking water resources

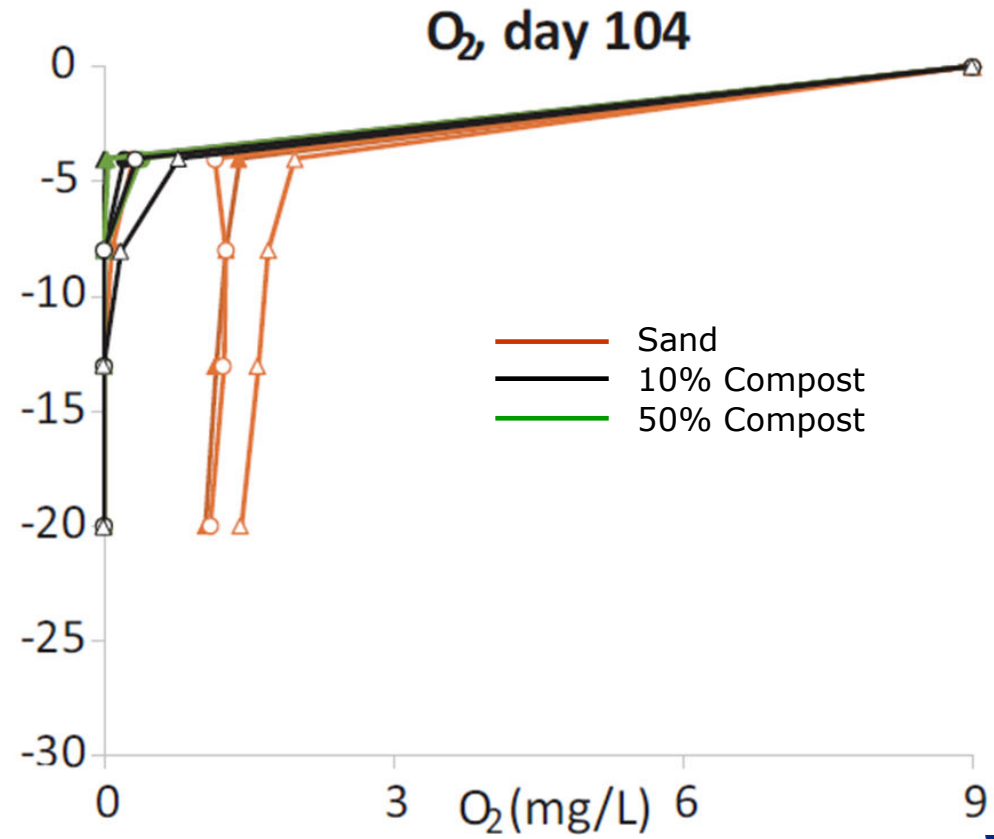


- ACWAPUR aims at constructing barriers preventing leaching of pathogens, nitrogen species, and organic pollutants
- The barriers may consist of compost, wood chips, barley straws, or other organic materials

# Column setup



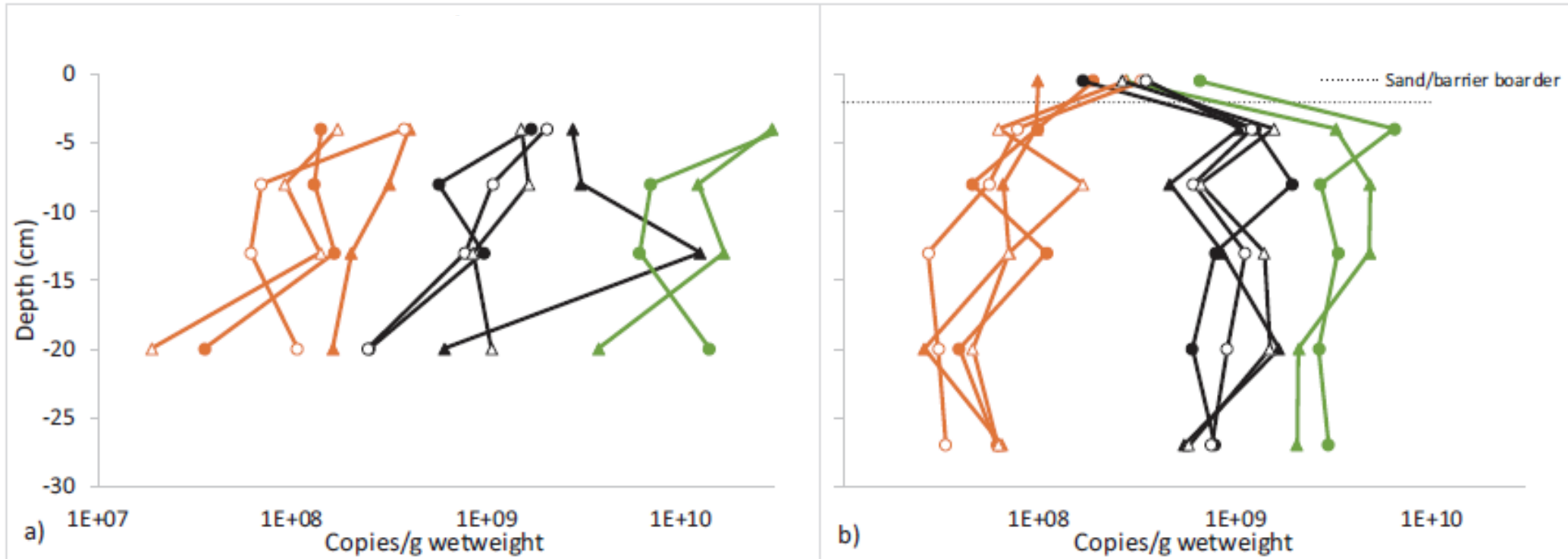
# Oxygen



# Total number of bacteria

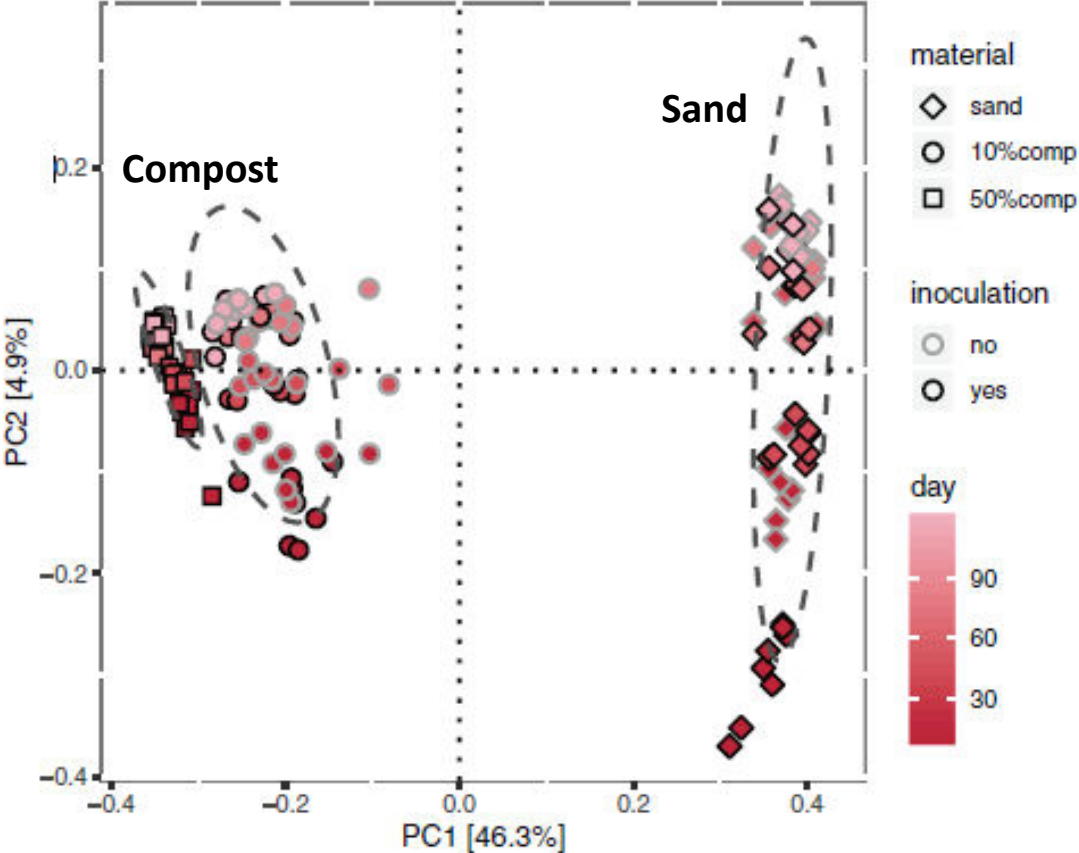
Day 11

Day 119



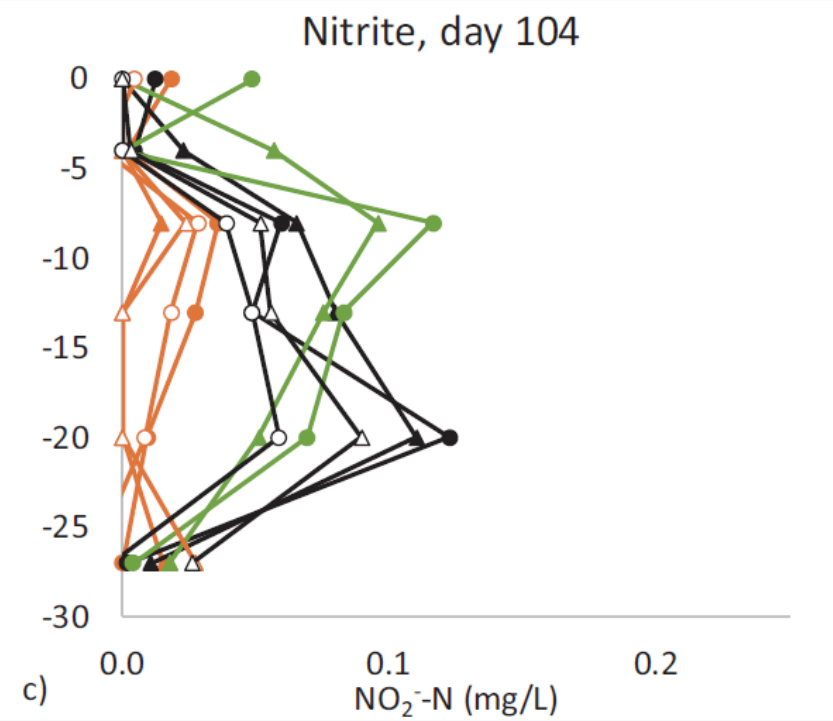
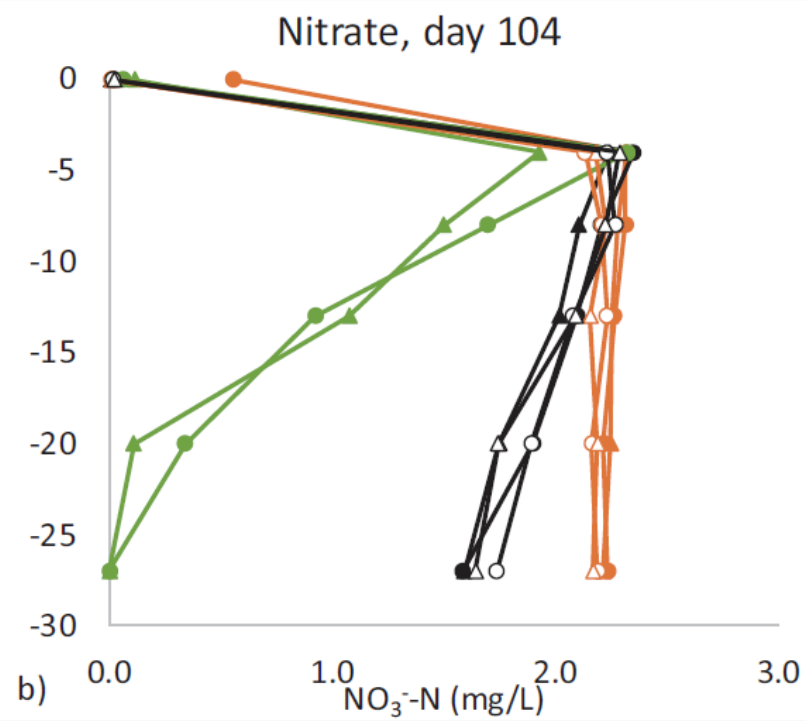
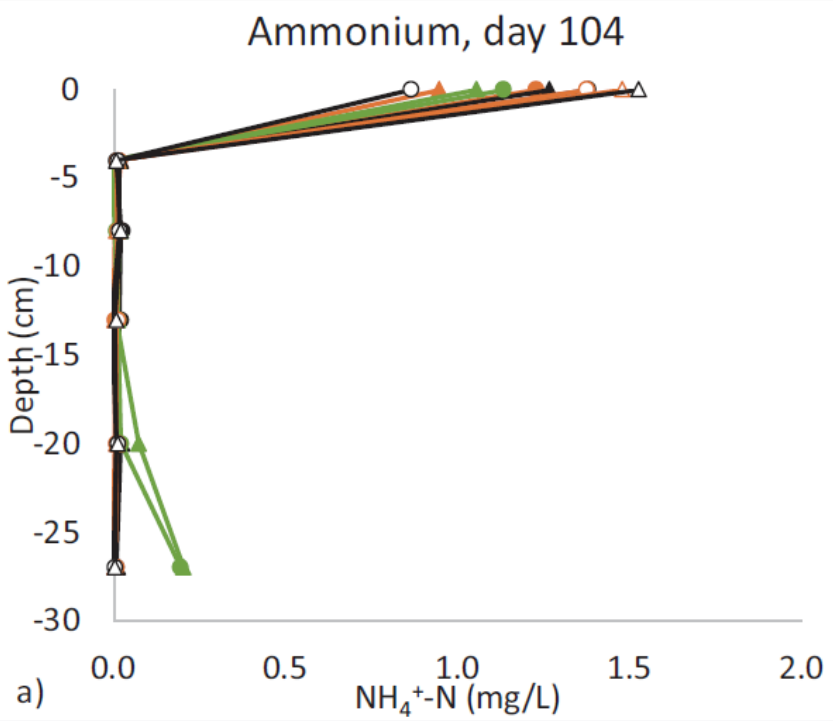
— Sand  
— 10% Compost  
— 50% Compost

# Microbial community composition





# N-species

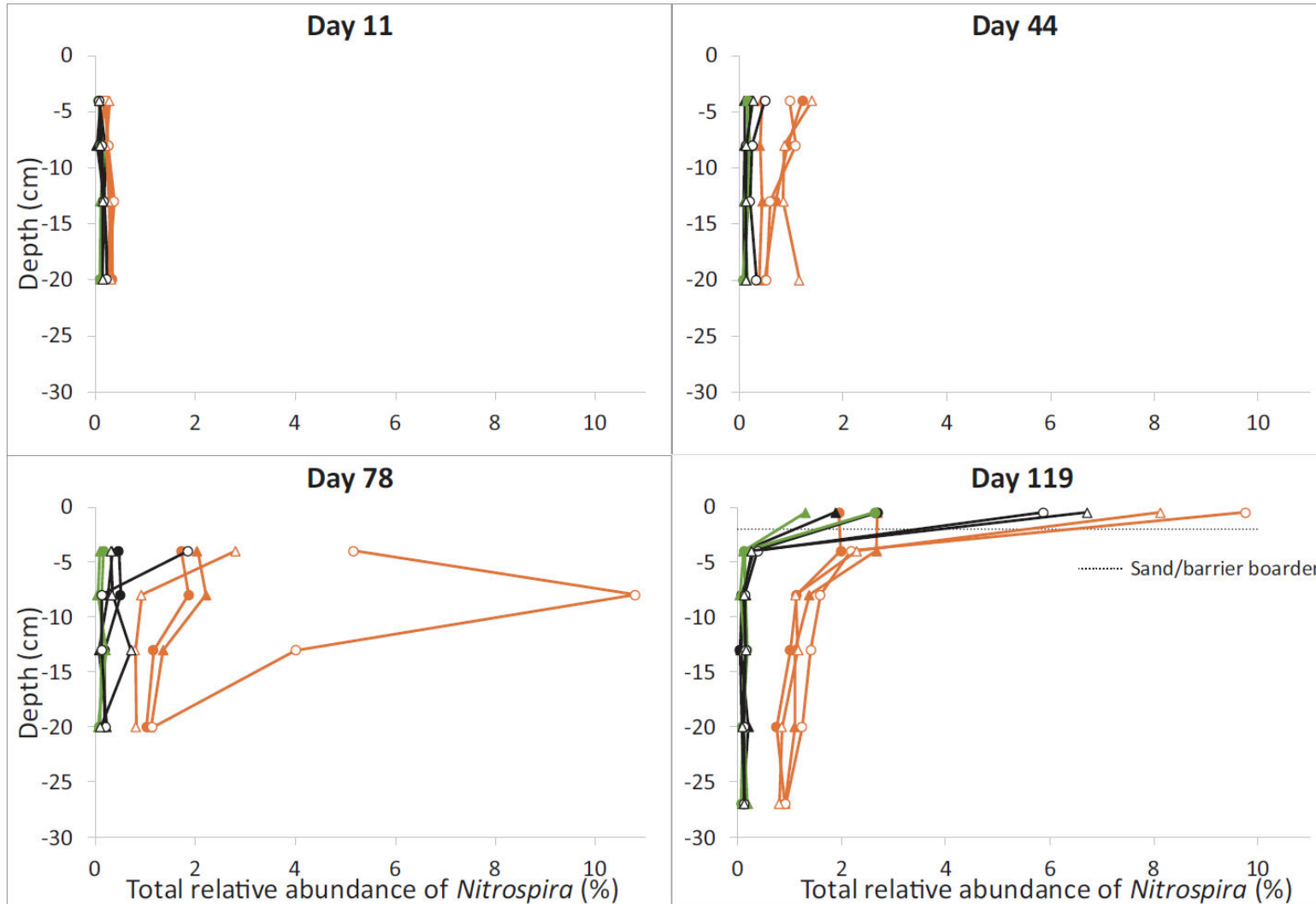


Ammonium oxidation (Nitrification)



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# Nitrospire



Complete ammonium oxidation  
(Nitrification)



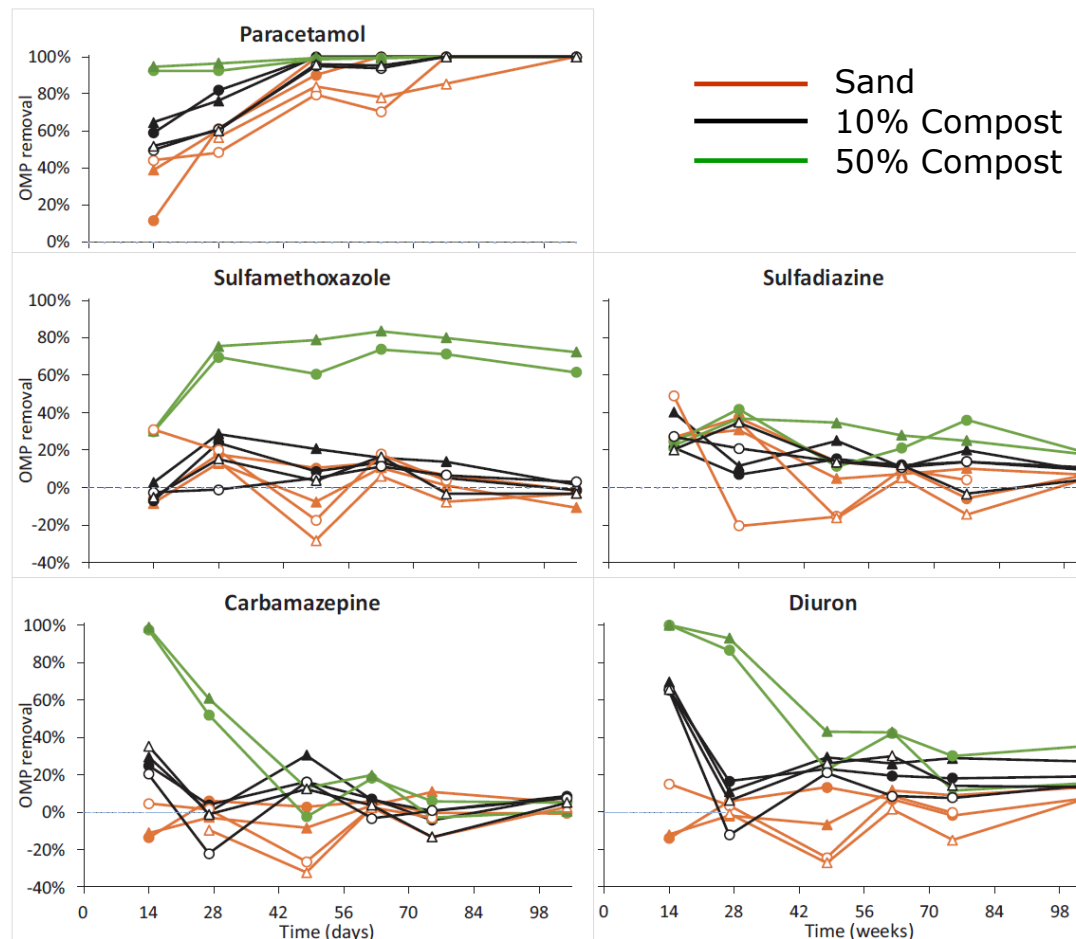
- Sand
- 10% Compost
- 50% Compost



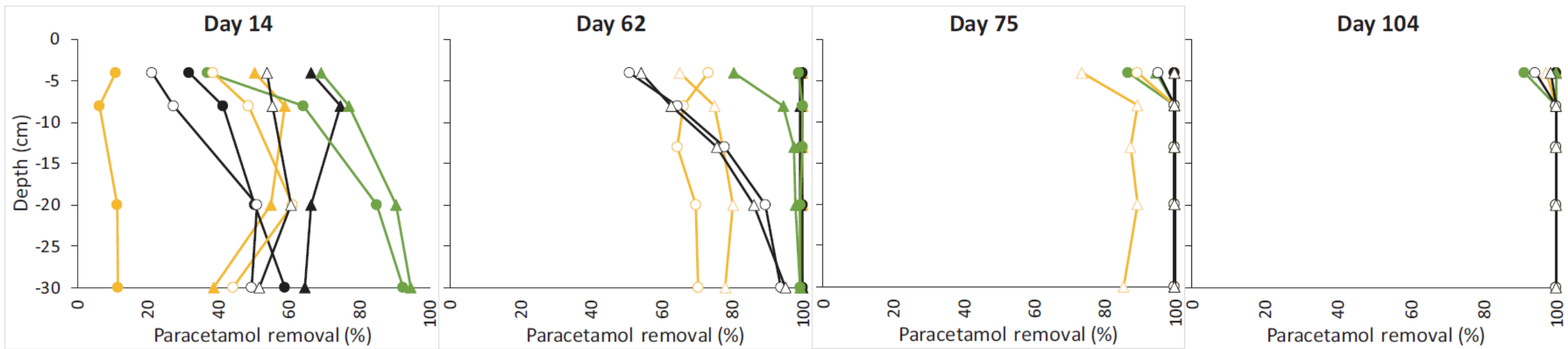
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# Contaminants

| Name                           | Structure                                      | Category                   |
|--------------------------------|--|----------------------------|
| Paracetamol<br>(Acetaminophen) | <chem>CC(=O)Nc1ccc(O)cc1</chem>                | analgesic                  |
| Sulfamethoxazole               | <chem>Cc1cc(N)ccc1S(=O)(=O)Nc2cc(=O)nn2</chem> | antibiotic,<br>sulfonamide |
| Carbamazepine                  | <chem>NC(=O)N1c2ccccc2c3ccccc13</chem>         | psychiatric<br>drug        |
| Diuron                         | <chem>CN(C)C(=O)Nc1ccc(Cl)c(Cl)c1</chem>       | Pesticide and<br>biocide   |



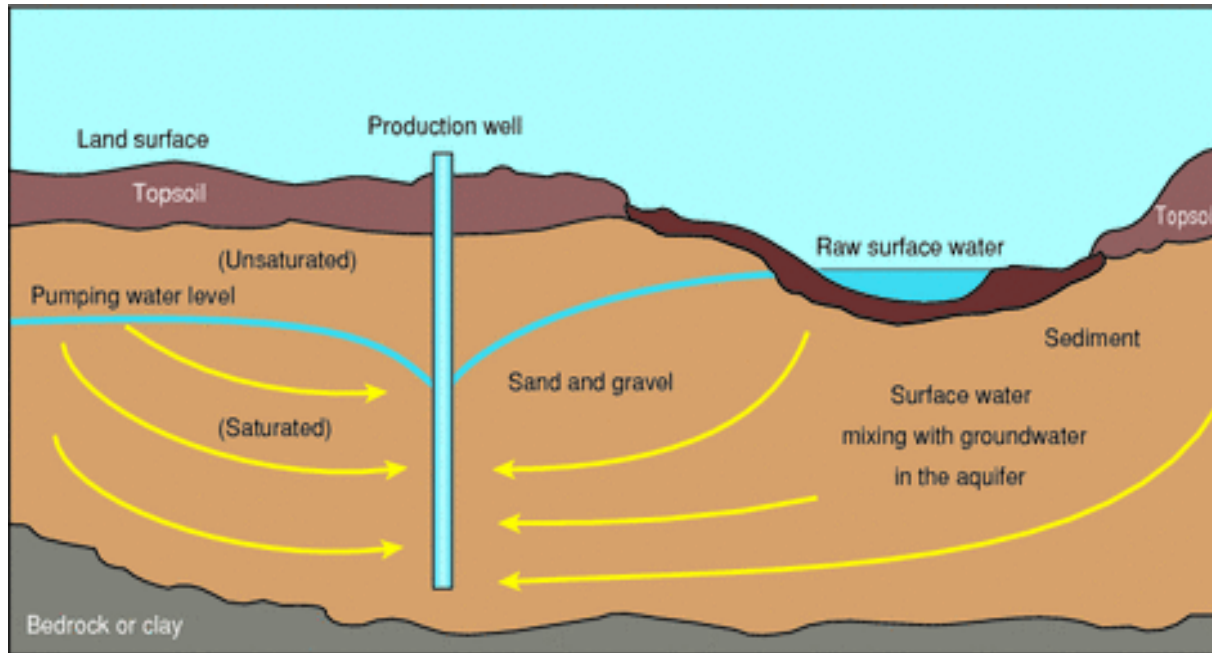
# Contaminants



- Sand
- 10% Compost
- 50% Compost



# Managed and unmanaged aquifer recharge



*Maliva & Missimer (2012)*

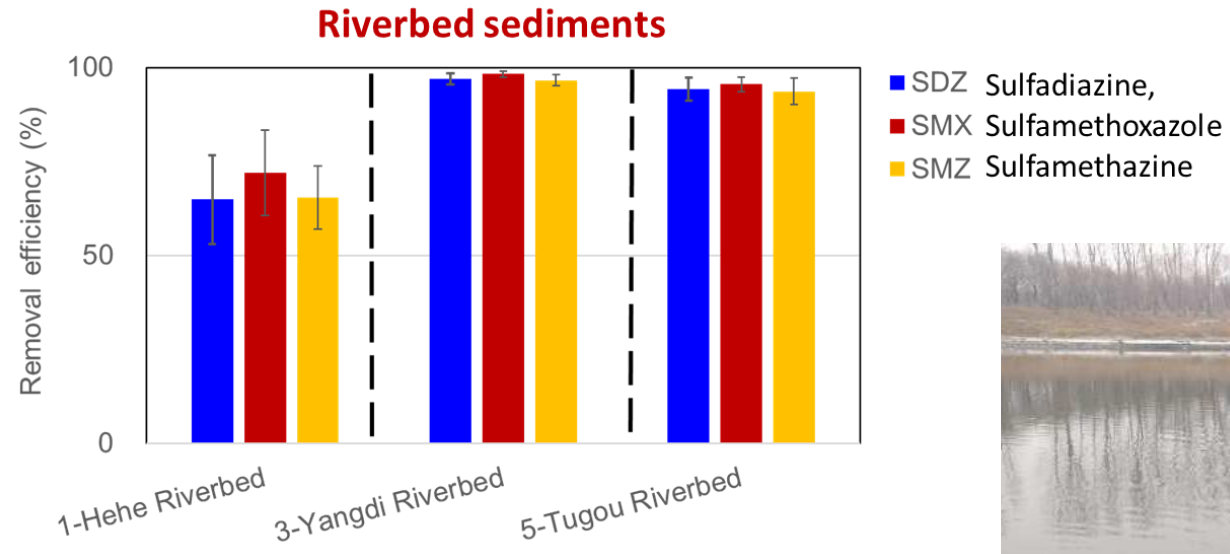
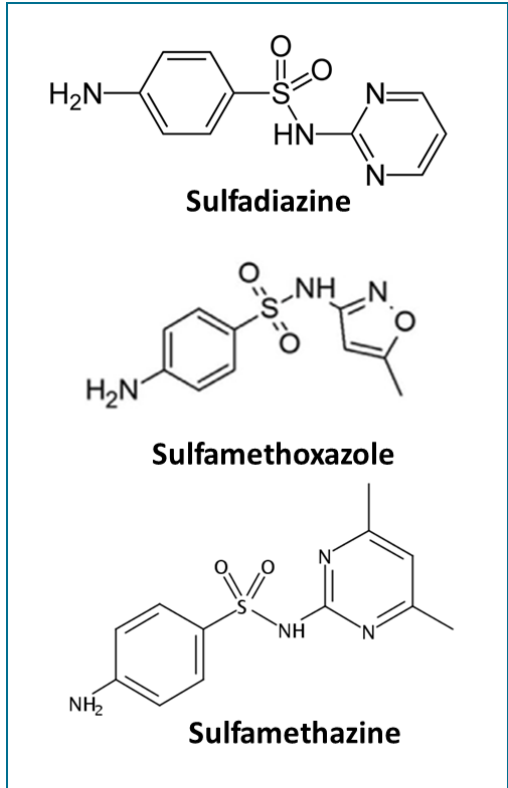


Beiyun river

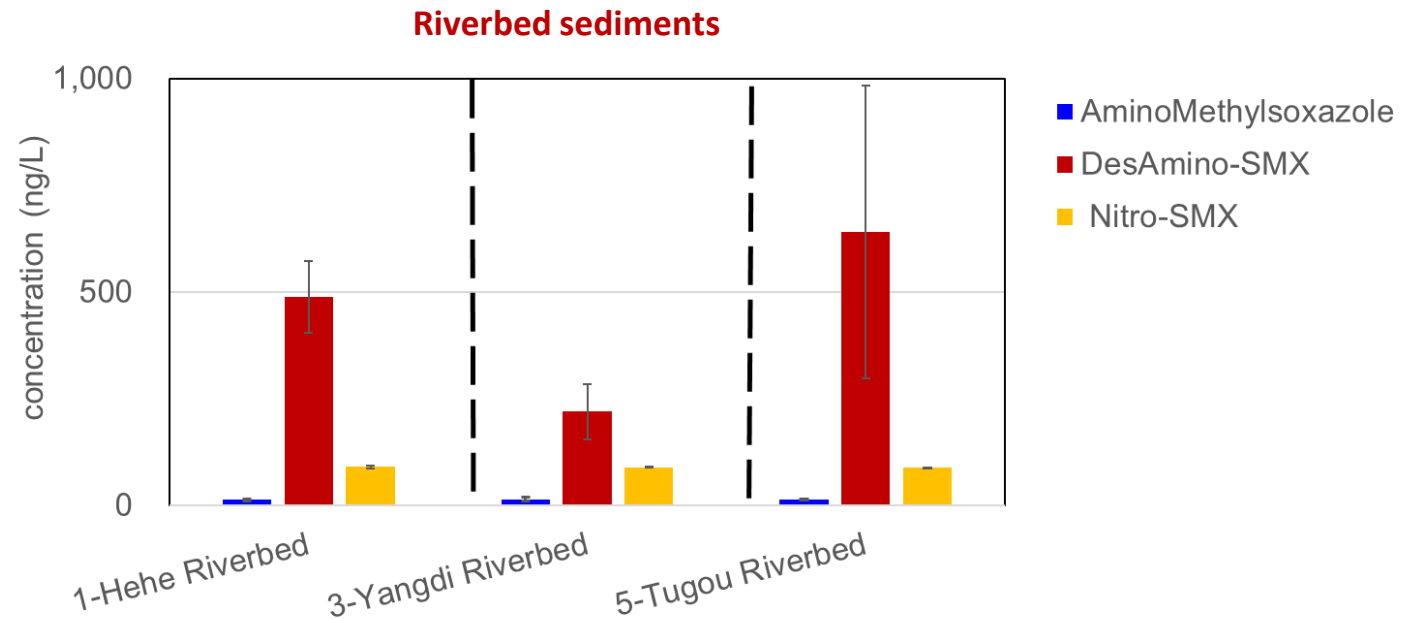
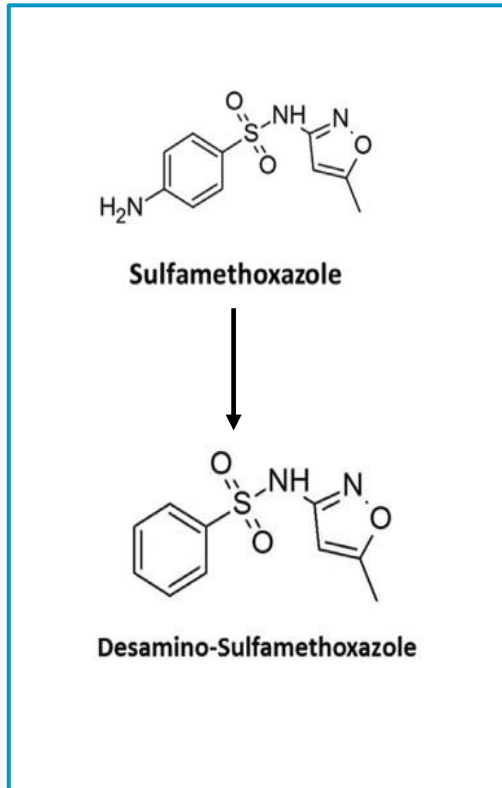


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# Transformation of antibiotics



# Sulfamethoxazole (SMX) - transformation products



# Retrosynthesis of Sulfamethoxazole (SMX)

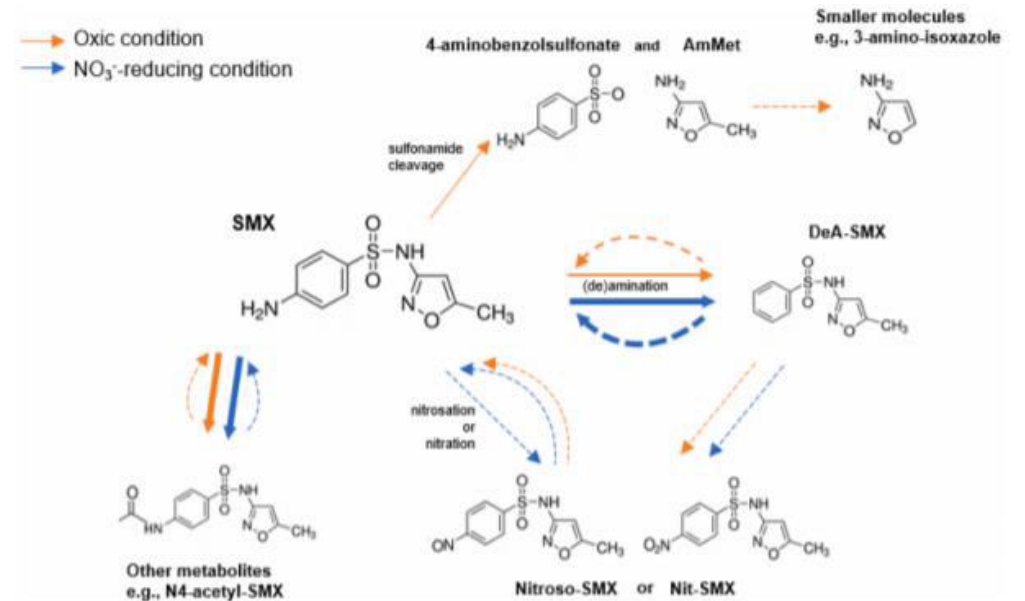
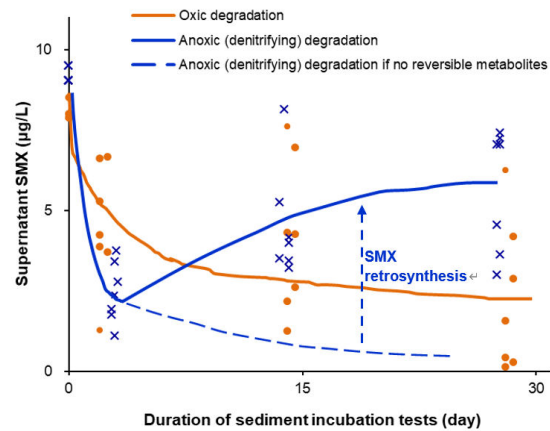
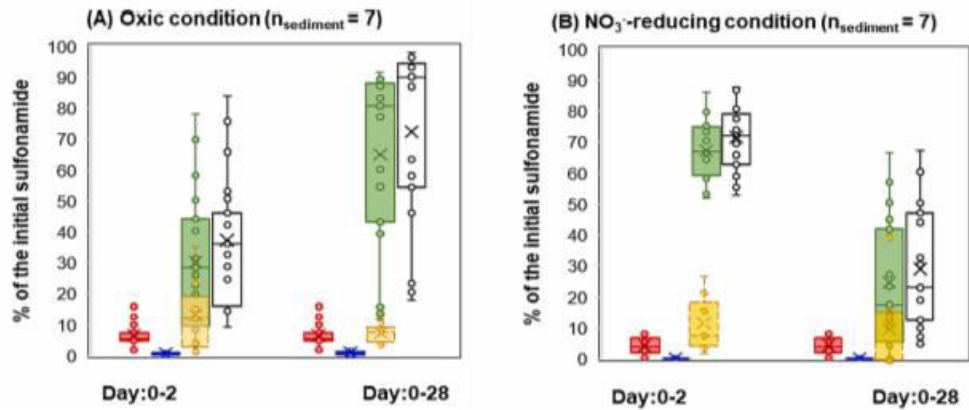


Fig. 4. Proposed transformation processes in SMX biodegradation at oxic and anoxic ( $\text{NO}_3^-$ -reducing) conditions.



# Conclusions

- **Managed aquifer recharge is the only way to replenish overexploited groundwater resources**
- **Barriers creates anaerobic conditions**
- **Barriers may prevent leaching of ammonium and some, but not all organic pollutants**
- **Aquifer sediments and barriers have a great potential to retain pathogenic bacteria**
- **Chinese riverbed sediments have a high potential for degradation of antibiotics, but degradation products may appear**



# Acknowledgement



The MARSA project



Danida Fellowship Centre  
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**Rural Water and Food Security**

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