

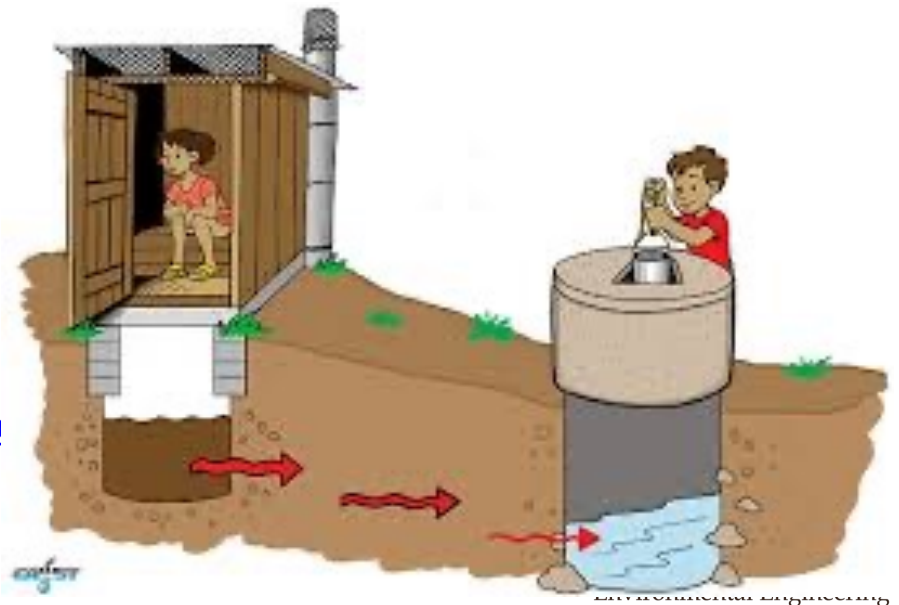
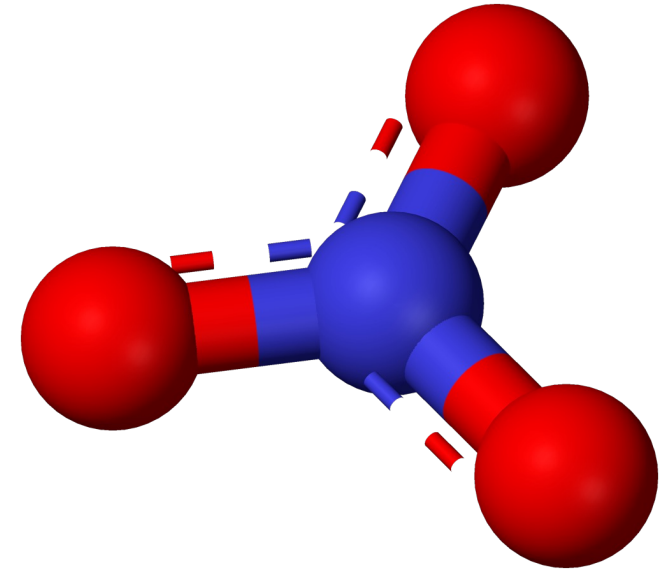
Remediation of Nitrate Polluted Water in Sub-Saharan Africa

May 2023

The Problem

- We estimate several 100 million people suffer from high levels of Nitrate (NO_3^-) in Sub-Saharan Africa.
- Nitrate levels in our water resources have increased in many areas of the world largely due to applications of inorganic fertilizer and animal manure in agricultural areas.
- However, in Sub-Saharan Africa cities the main source is human faeces, from seeping pit latrine toilets. The main reason for this situation is that there have been very little investment in sewage reticulation systems and sewage treatment works since the decolonisation of Africa.

<https://www.mcc.gov/resources/doc/evalbrief-120621-zmb>



Nitrate Levels

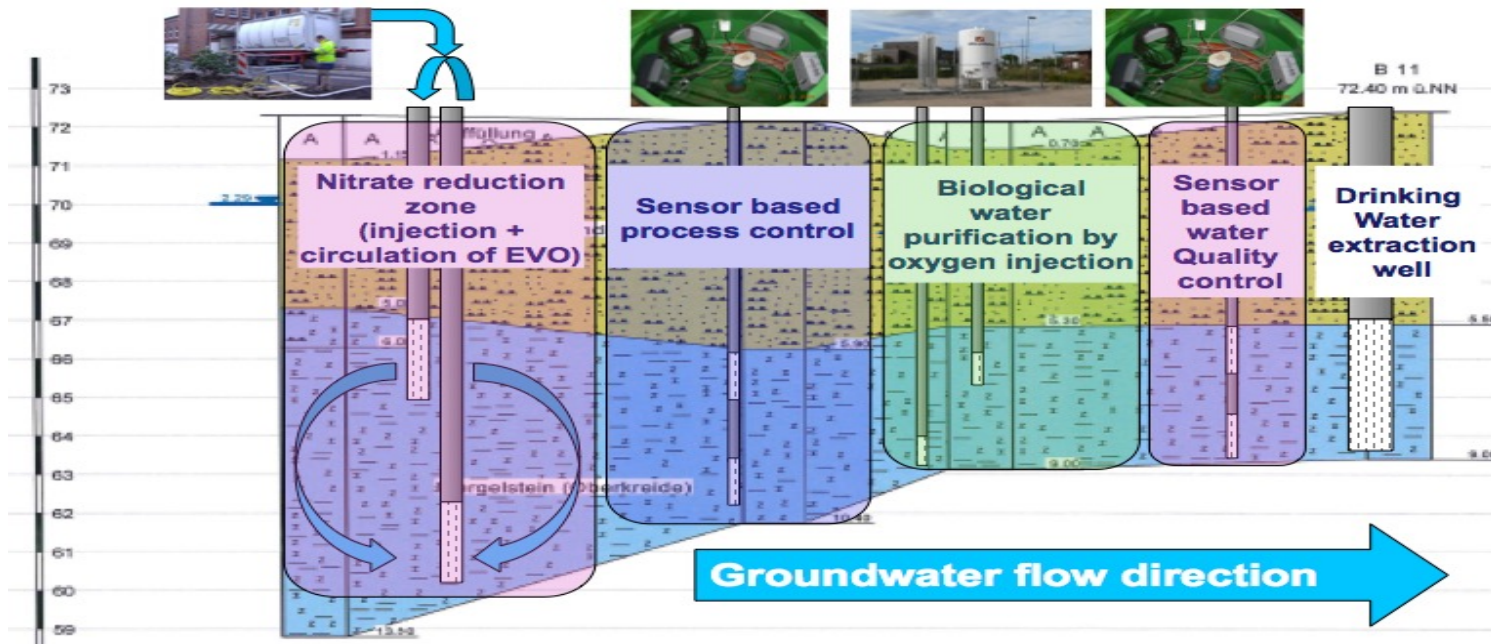
- The maximum contaminant level (MCL) for nitrate in public drinking water supplies in the United States (U.S.) is 10 mg/L as nitrate-nitrogen ($\text{NO}_3\text{-N}$).
- This concentration is approximately equivalent to the World Health Organization (WHO) guideline of 50 mg/L as NO_3 or 11.3 mg/L $\text{NO}_3\text{-N}$ (multiply NO_3 mg/L by 0.225).

Health Effects

- The regulatory limit for nitrate in public drinking water supplies was originally only set to protect against infant methemoglobinemia (blue baby syndrome).
- Later on studies have shown other health effects:
 - colorectal cancer
 - bladder
 - breast cancer
 - thyroid disease

The Solution

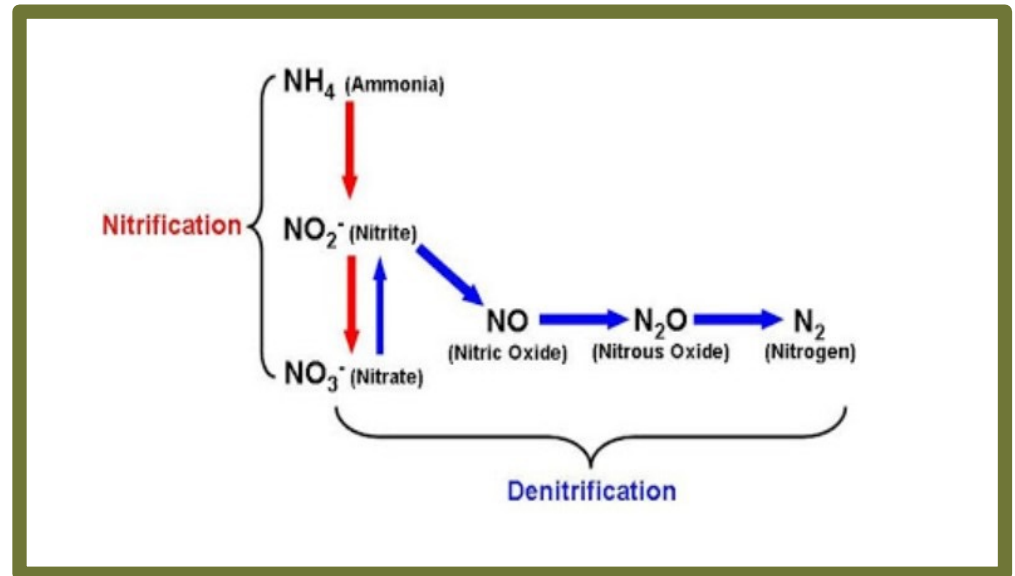
- As the likelihood of making funding available for the enormous investment need for sewage reticulation systems and sewage treatment works is infinite small, we believe the only affordable solution is:
 - 1) In-Situ Remediation of the groundwater in the aquifer
 - 2) In combination with introduction of liners in the pit latrine toilets



Remediation of Nitrate Contaminated Groundwater

The problem:

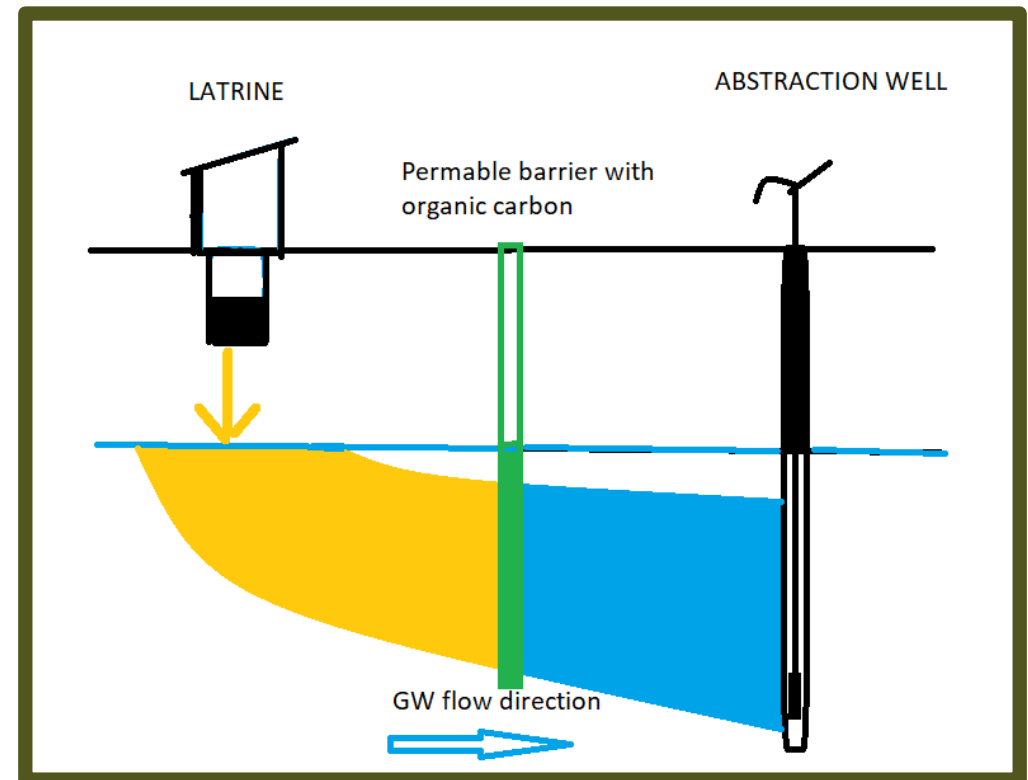
- Disturbance of naturally occurring processes:
 - Under normal low intensity infiltration of urine from humans or animals, naturally occurring bacteria can convert all ammonia to nitrogen gas in a few steps.
 - In high intensive infiltration areas like animal farms or residential areas without waste water treatment system for latrines there may become shortage of key elements, like organic carbon, and nitrate concentration in groundwater will rise.



Remediation of Nitrate Contaminated Groundwater

The solution:

- Restoring environment for natural processes:
 - By introducing a carbon source to the contaminated groundwater the natural processes can handle the elevated nitrate concentrations
 - The carbon source can be applied in different ways depending on circumstances:
 - 1) Barrier between the source and the water abstraction well
 - 2) In and around the source (latrine) for source treatment
 - 3) Barrier around the abstraction well as a well protection approach.

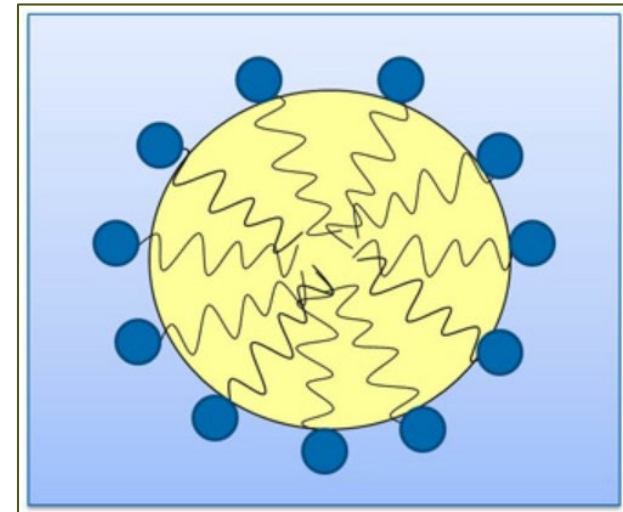


Remediation of Nitrate Contaminated Groundwater

Needed activities :

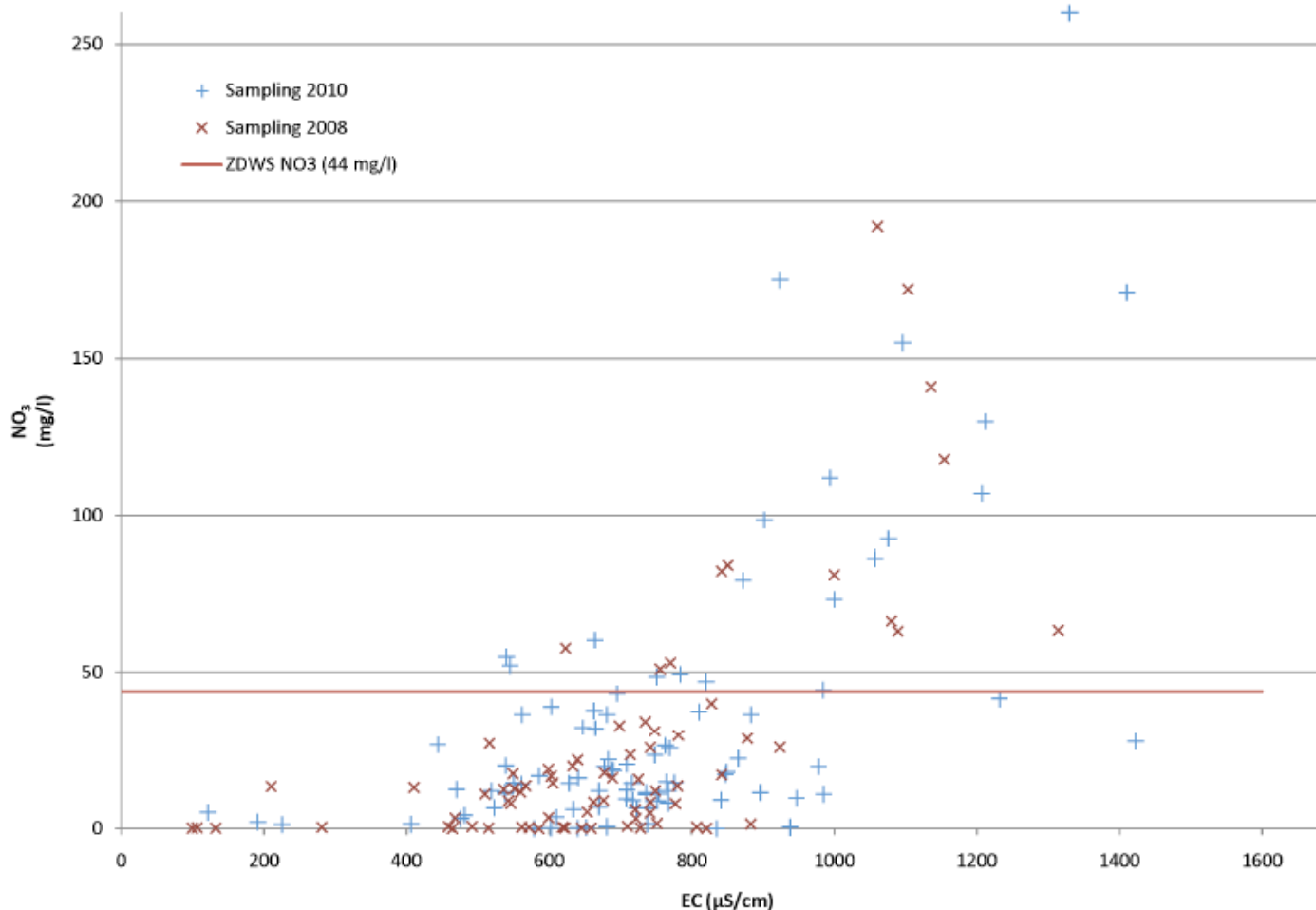
Site specific condition investigation

- Geology and hydrogeology conditions have to be determined.
- Geochemistry conditions have to be determined.
- Bench scale tests with different additives and doses prior to implementation is needed.
- Pilot tests in small scale is advisable to get a final proof of concept
- Emulsified vegetable oil is preliminary the preferred amendment substrate due to:
 - Longevity in the subsurface
 - Cost efficient
 - Can be produced locally



Emulsion = oil droplets surrounded by surfactant emulsifier to keep droplets from coalescing and return back to form an oil layer on water.

Lusaka – a location



Some quite old data gives an indication of the seriousness of the Nitrate issue. A recent study by <https://www.mcc.gov/> shows that 75% of all bore holes tested in Lusaka had a nitrate concentration ≥ 50 mg/L. Only 16% of population is serviced by wastewater works.

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