Gravity Driven Membrane (GDM) disinfection

A novel household water treatment system

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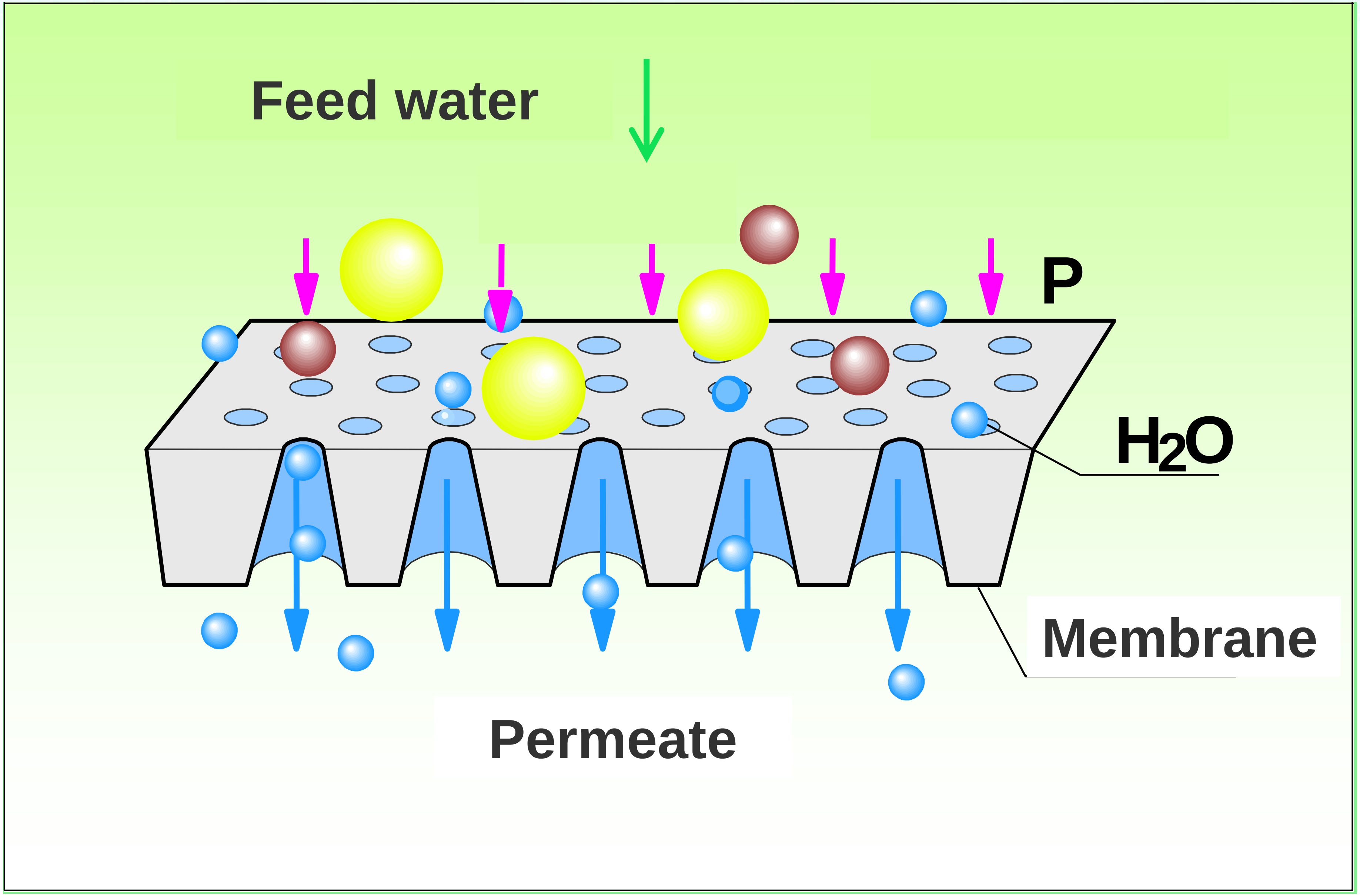
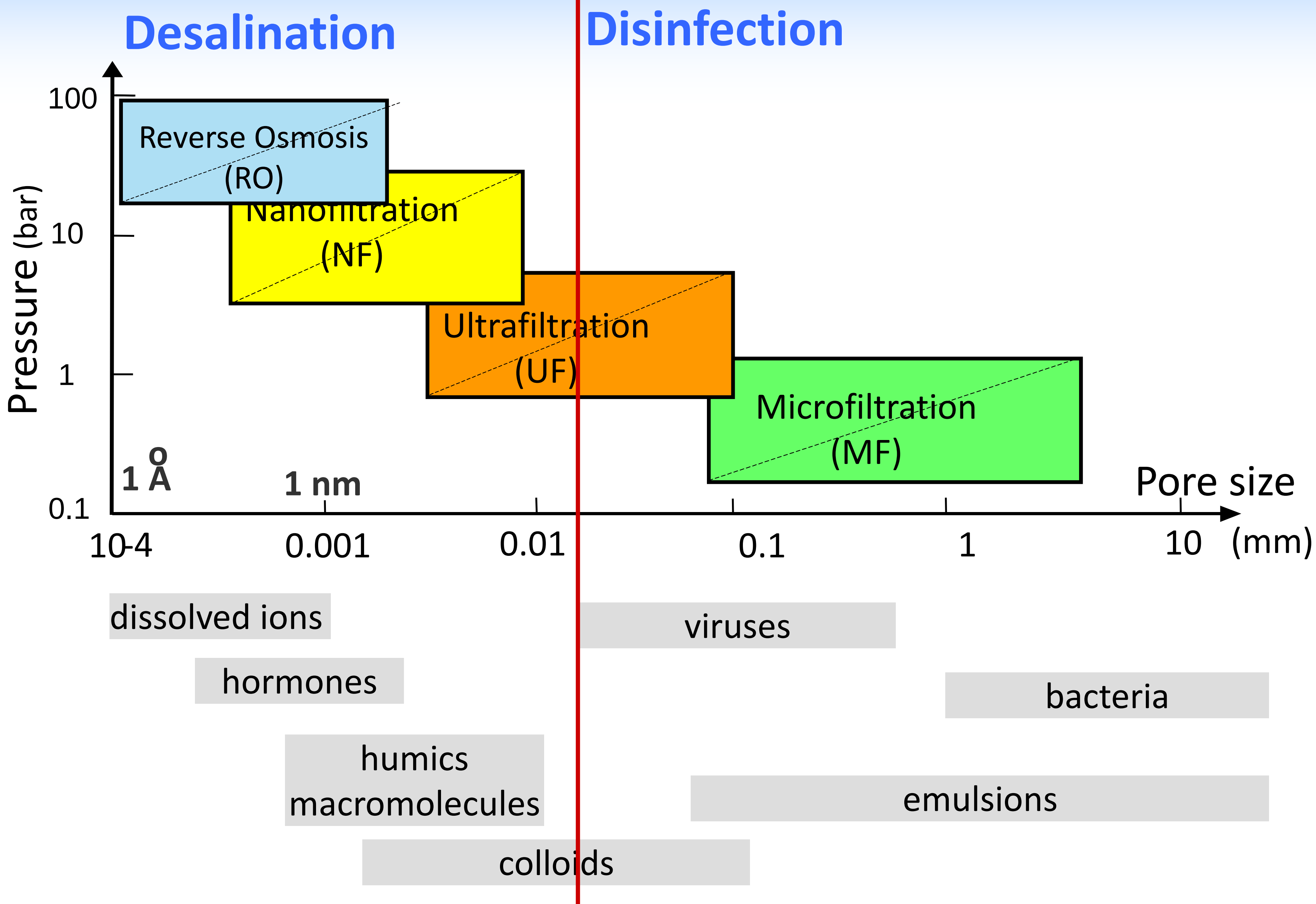
Principle of membrane filtration



Membrane filtration processes

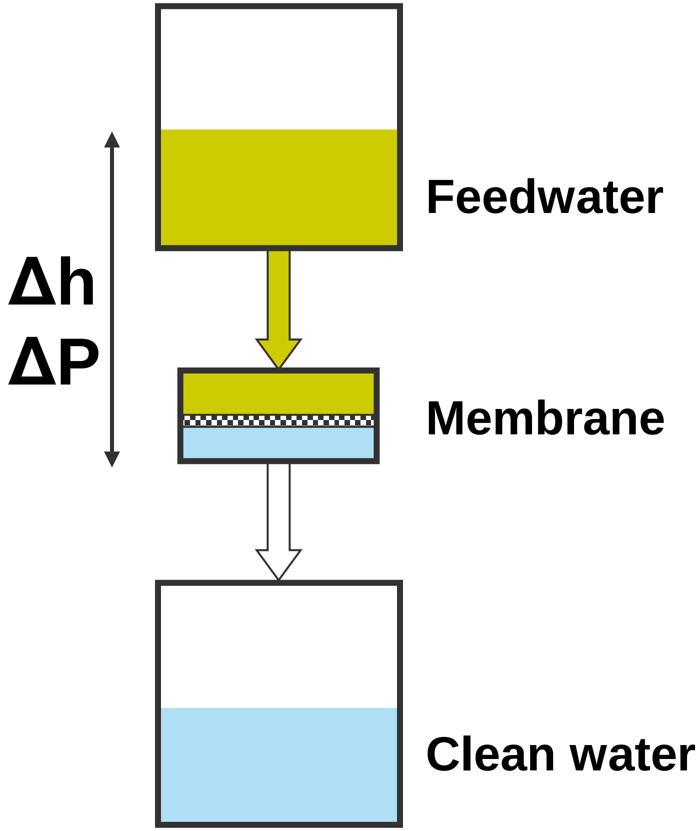


Ultrafiltration

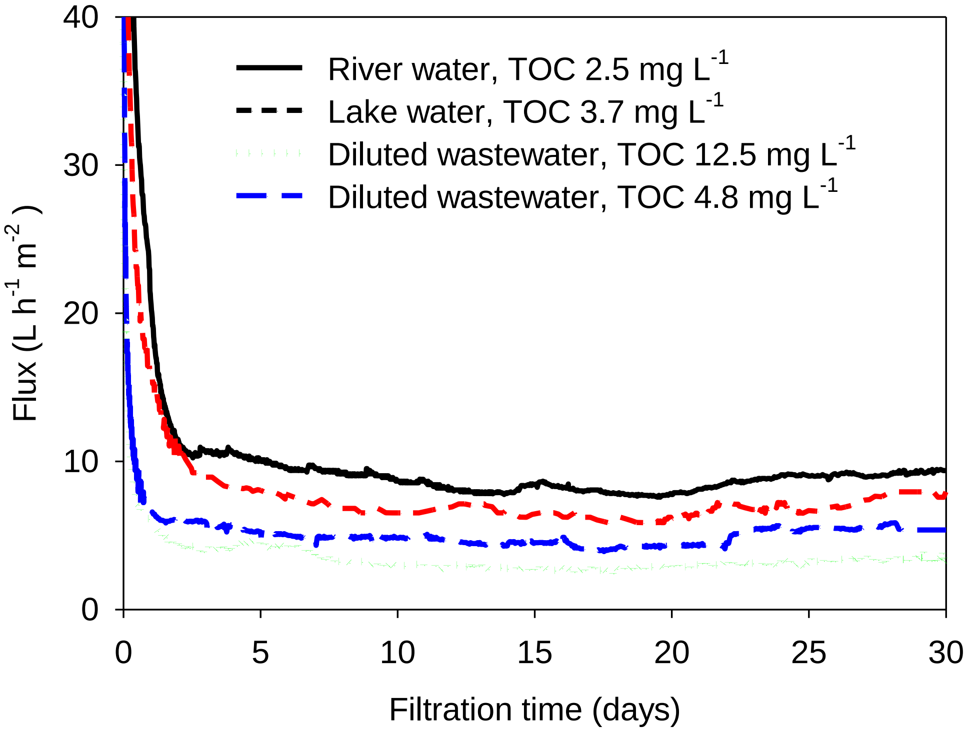
Operation on any scale requires:

- ✓ Regular backflushing
- ✓ Disinfection
- ✓ Chemical cleaning
- ✓ Pre-treatment
- ✓ Pressure of 1-10 m water column

Gravity-driven Ultrafiltration

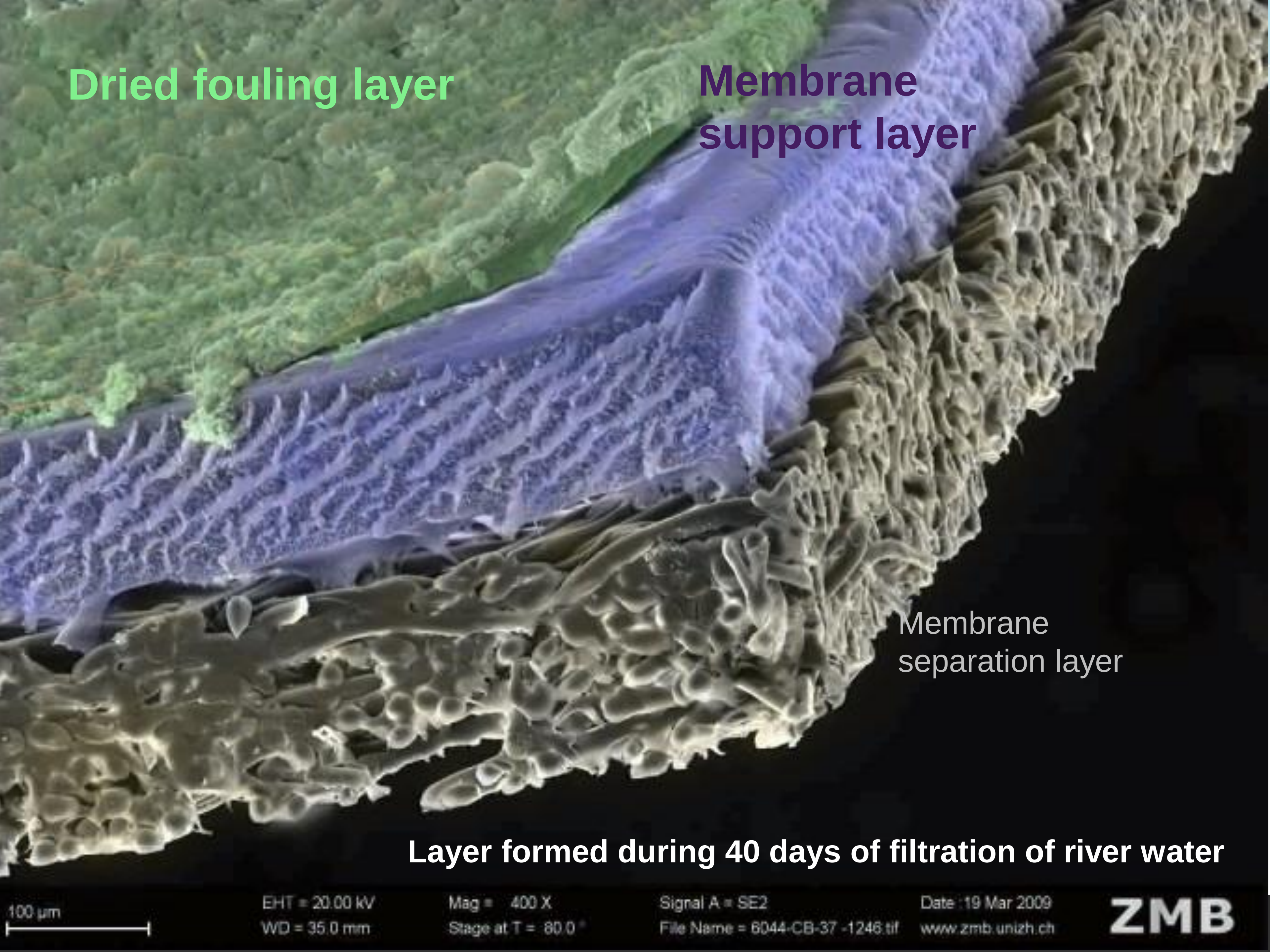


- Dead-end, no cross-flow
- No backflush
- No chemical cleaning



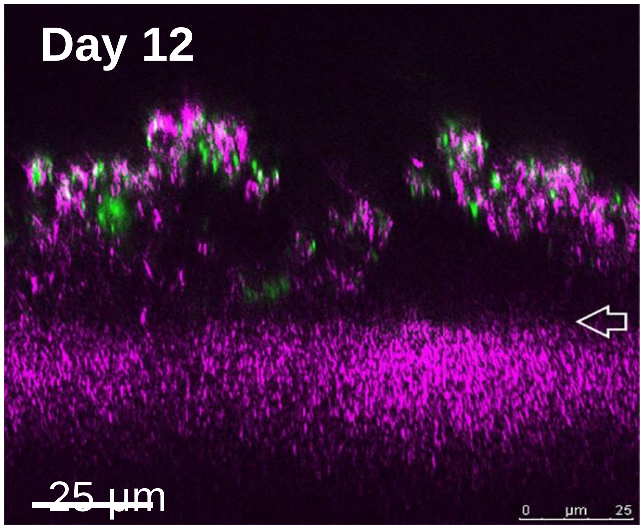
- **Stable flux: 4-10 L/h/m²**

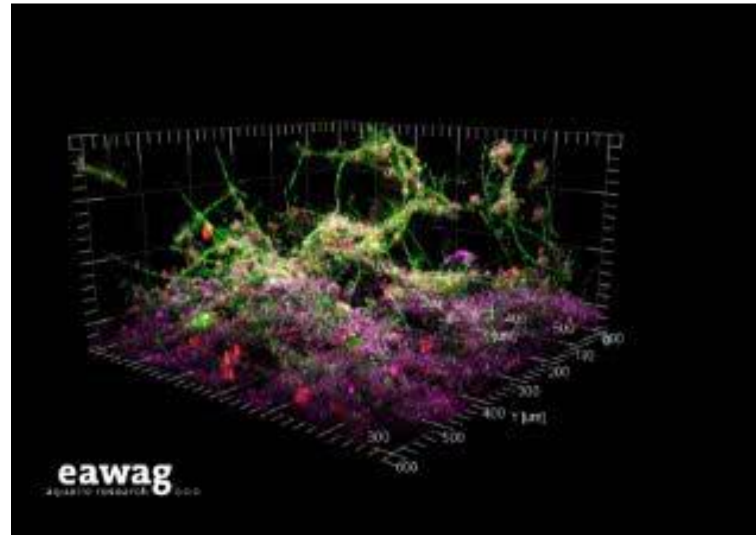
Peter-Varbanets, M., et al (2010). "Stabilization of flux during dead-end ultra-low pressure ultrafiltration." *Water Res., 44(12), 3607-3616.*
Peter-Varbanets, M., et al (2011). "Mechanisms of membrane fouling during ultra-low pressure ultrafiltration." *J. Membr. Sci., 377(1-2), 42-53.*



Dried fouling layer
Membrane support layer
Membrane separation layer
Layer formed during 40 days of filtration of river water
100 µm
EHT = 20.00 kV
WD = 35.0 mm
Mag = 400 X
Stage at T = 80.0 °
Signal A = SE2
File Name = 6044-CB-37 -1246.tif
Date :19 Mar 2009
www.zmb.unizh.ch
ZMB

Fouling layer visualized by CLSM





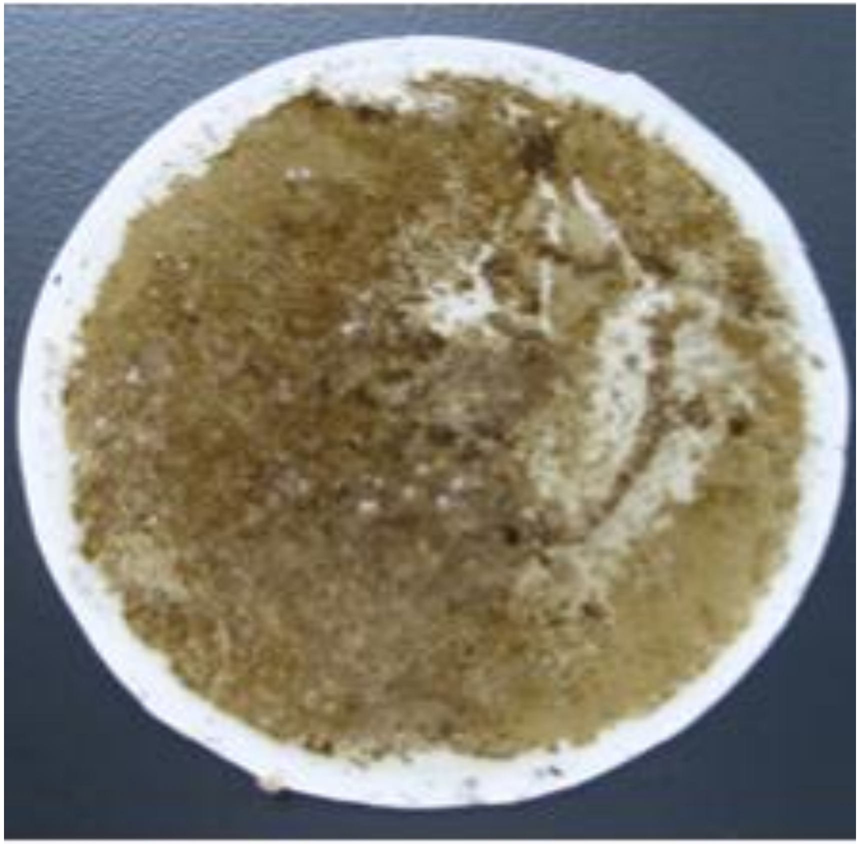
- All bacterial cells (SYBR® Gold)
-Particles and the membrane (Reflection)

- Porous and heterogeneous fouling layer
  → reason of flux stabilization

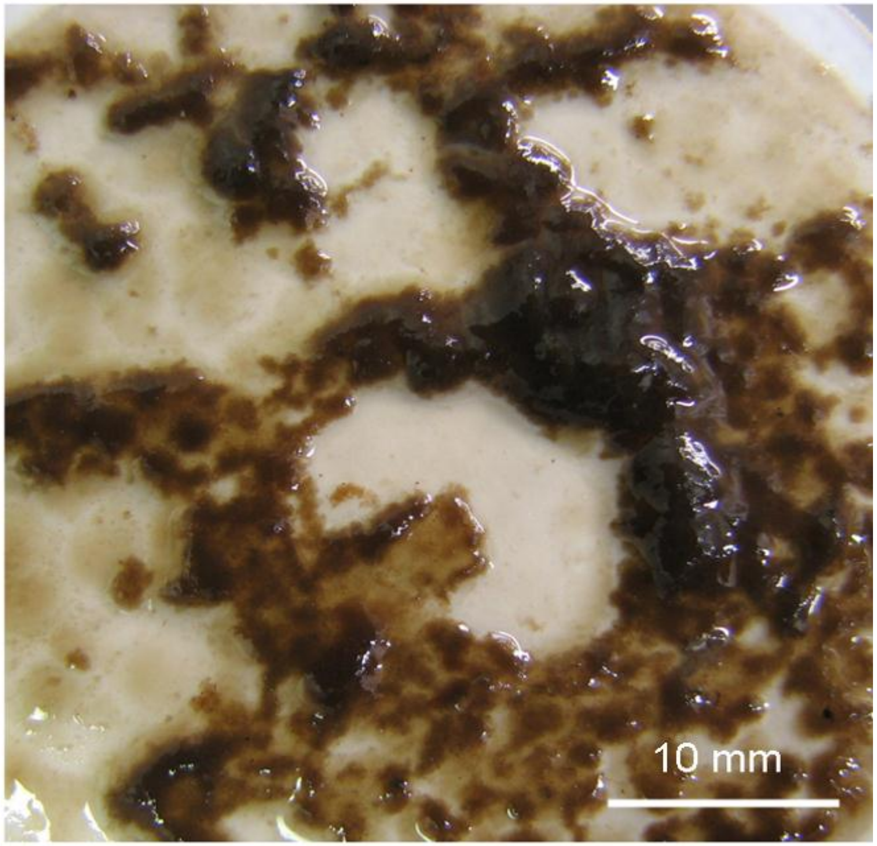
- High presence of bacteria
  → importance of biological activity

Fouling layer structure on macro-scale

1 month, river water

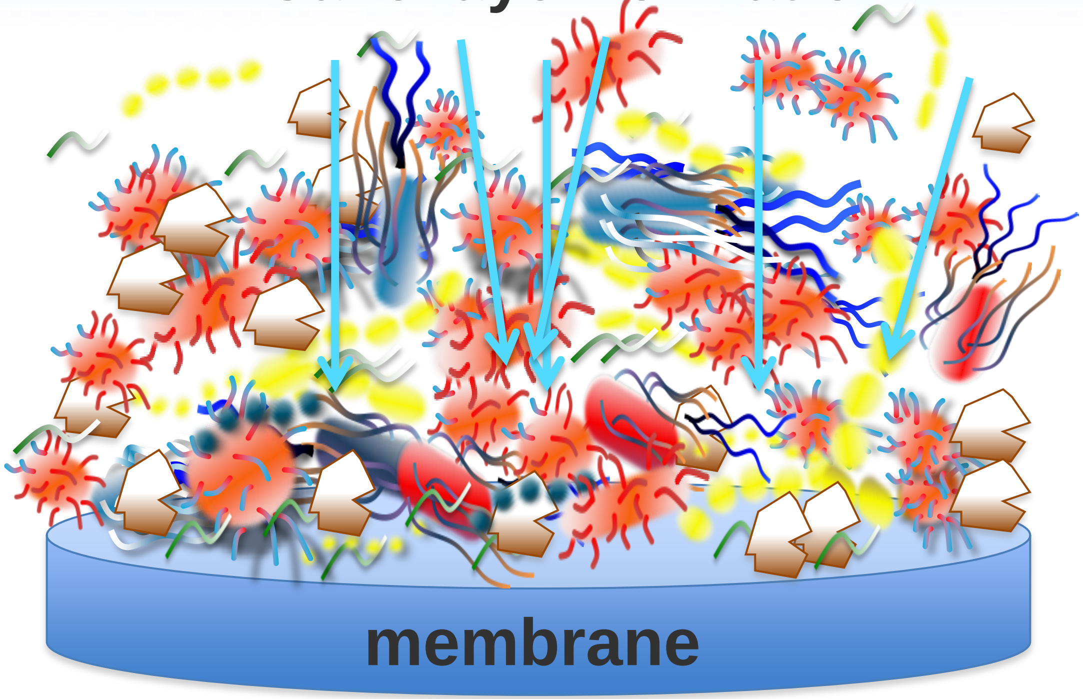


3 month, diluted wastewater



The changes of the fouling layer structure lead to the stabilization of flux

Cake layer formation



Structural changes within the fouling layer are caused by biological and physical processes in the layer

Lab studies, field trials, commercialization

Field evaluation

Kenya: 25 prototypes

Optimization and design

Virus removal efficiency

Membrane module optimization

Industrial design

Commercialization

Entrepreneurs, NGOs, membrane producers

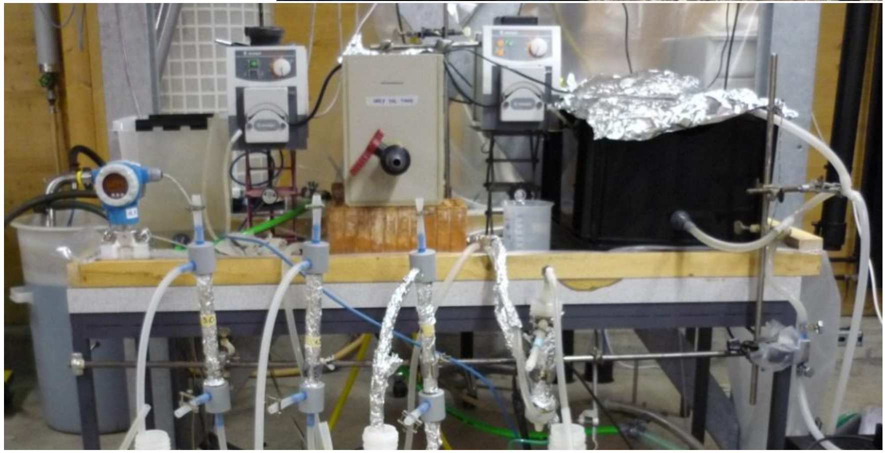
Carbon credits

Long term planning

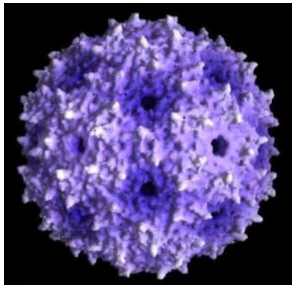
Development of long term strategies

Discussions with private sector

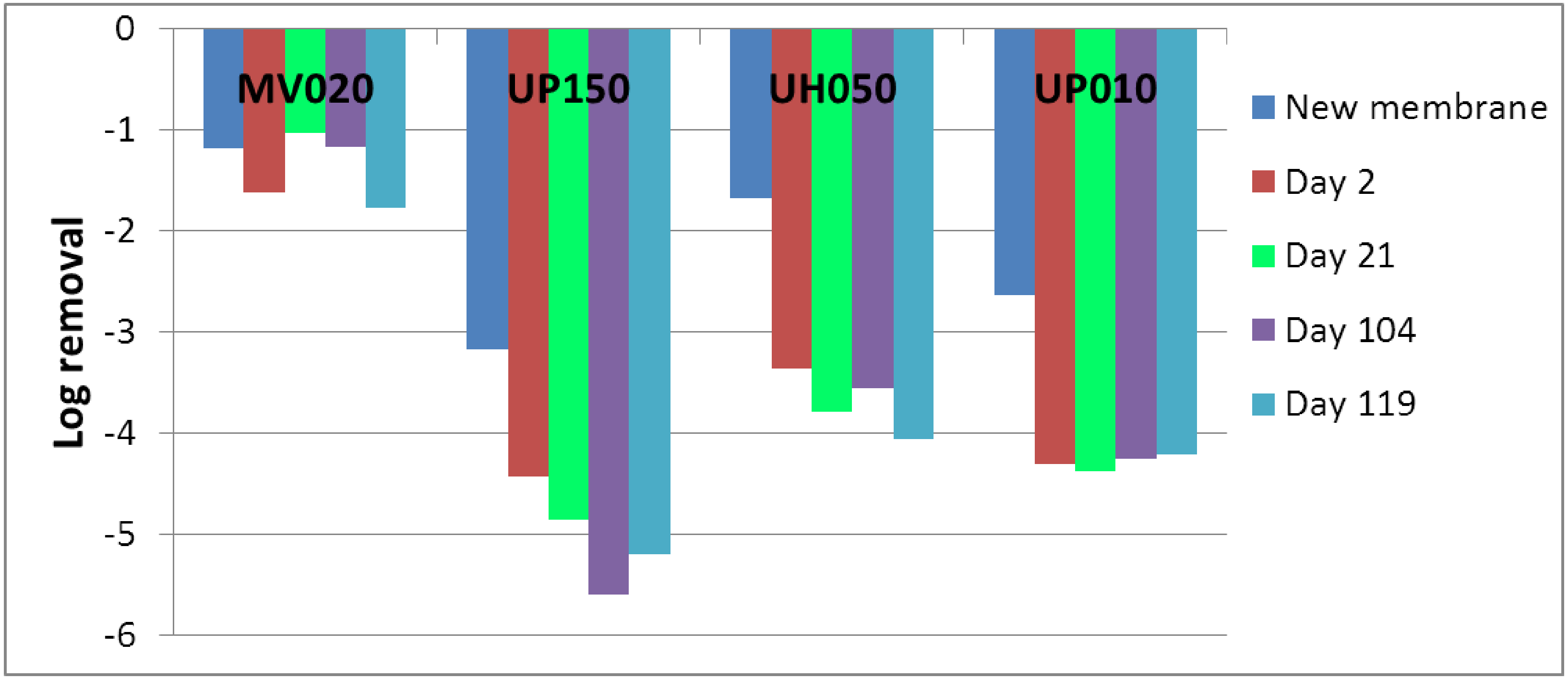
Private donor



Virus removal



Challenge tests: MS2 bacteriophage



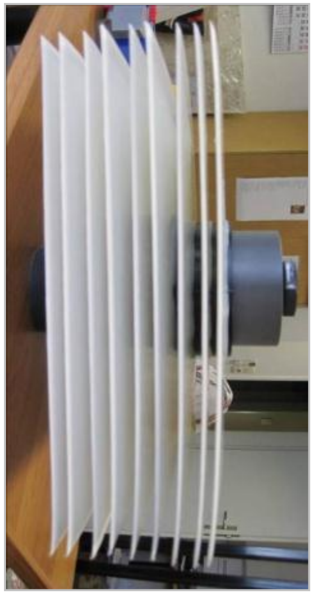
GDM Field trials in Kenya

Alpha prototype GDM filter

Pre-filter (cloth)

UF membrane:

- Microdyn-Nadir
- 150 kDa cut-off
  (about 40nm pore size)
- 0.6 m^2 surface area (full)



Clean water tank, 10L


National Park
Kijabe
Gatamaiyo Forest
Nature Reserve
Oloombokoshi
B 3
A 2
Githunguri
Thika
Ntulelei
B3
A 104
Ruiru
A3
Nduma
Kiambu
Mt Suswa
Conservancy
Ruaka Town
Githurai
Kikuyu
Nairobi
Nguluni
Silanga
Kangundo
Mwala
Nairobi
National Park
Ngong
Myondoni
Ongata
Rongai
Kiserian
Athi River
Kathiani
Lema
Machakos
Oltepesi
A 109
A104
Konza
Kinyunyini
Kajiado
Elangata
Waus
Salama
Magadi
Koora
A 109
Lake
Magadi
Shampole
Kenya Marble
Quarry
Entonika
Mashuru
Olokia
Shompole
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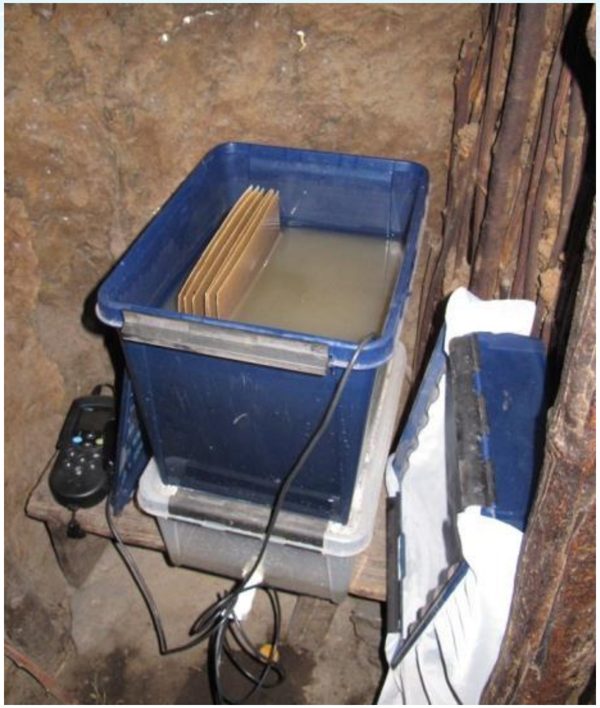
25 filters: diverse water sources



Kajiado (n=16)

Pond water, borehole, open shallow wells

organic matter, turbidity, Fe

Thika (n=5)

Thika river

organic matter, turbidity

Nairobi (n=4)

Distribution network

chlorine

Monitoring

Frequency of use and flux

- Submersible dataloggers

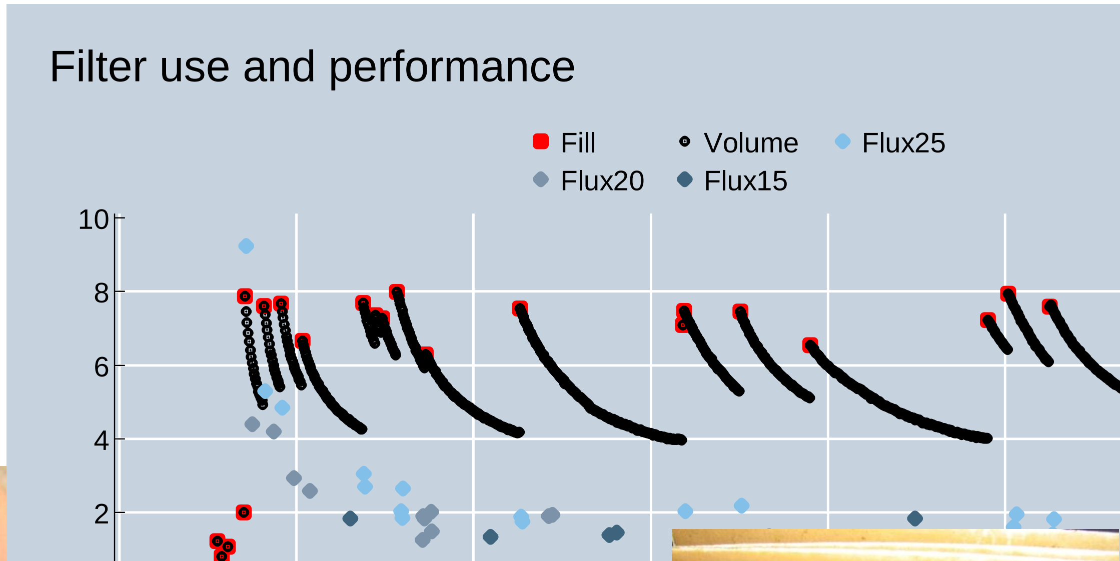
Water quality

- Microbial: Nissui Compact Dry Plates, ATP
- Conductivity, Oxygen, pH, Fe

End-user perception

- Observation, Household surveys

Frequency of use and flux



Preliminary results (3 months)

- ✓ Good pathogen removal
  - ✓ Low *E. coli* inputs
- ✓ Stable flux in spite of thick fouling layer
- ✓ Regular use
  - ✓ 100% functioning
- ✓ Relatively high acceptance

- Re-contamination and/or re-growth
  - Total coliforms, ATP
- Flux lower than in lab

→ Design improvements

Next steps: September 2011- June 2012

Technology

- Temperature
- Microbial re-growth

Business models

- Distribution channels, supply chain
- Social Marketing
- Pricing and subsidy (including carbon credits)
- Business plan for Foundation

Design

- User interface
- Membrane module

Foundation

- Private donor
- Research support
- Product commercialization, investment

Field evaluation

- Monitoring
- Second generation of prototypes
- Re-growth/recontamination, viruses

Many thanks to

- Kenya Water for Health Organization
- Workshop staff of Kenya Water Institute
- Public Health Officer of Kajiado
- The people of Kajiado, Thika, and Woodley

Further information

www.eawag.ch/membranefilter