Gravity Driven Membrane Disinfection for household drinking water treatment

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Principle of membrane filtration

Feed water

Membrane

Permeate

H₂O

Permeate
Membrane filtration processes

Desalination

- Reverse Osmosis (RO)
- Nanofiltration (NF)
- Ultrafiltration (UF)
- Microfiltration (MF)

Disinfection

- dissolved ions
- hormones
- humics
- macromolecules
- colloids
- viruses
- bacteria
- emulsions
Disinfection → Ultrafiltration

Operation of Ultrafiltration on any scale requires:

- ✓ Regular backflushing
- ✓ Disinfection
- ✓ Chemical cleaning
- ✓ Pre-treatment
- ✓ Pressure of 1-10 m water column
Concept of Gravity-Driven Membrane (GDM) filtration

Surface water
Spring
...

Storage tank

Membrane Module (Ultrafiltration)

Bucket
Existing distribution system
...

0.4 – 1.5 m hydrostatic pressure

Clean water storage tank

permeate
to the tap

Membrane fouling and clogging is expected but does not occur
Due to the phenomenon of flux stabilization
The phenomenon of flux stabilization

Flux stabilizes on a level of 4-10 (L h\(^{-1}\) m\(^{-2}\)) for at least 2 years

48 - 120 L/day with 0.5 m\(^{2}\) membrane
- Particulate and dissolved material deposits on membrane

- Thickness of the layer increases in time
Layer formed during 40 days of filtration of river water
Fouling layer visualized by laser microscopy

Day 12

Day 28

- All bacterial cells (SYBR® Gold)
- Particles and the membrane (Reflection)
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
Structural changes within the fouling layer are caused by biological and physical processes in the layer.
Advantages of GDM-filtration

- **Effective**: Parasites, Viruses, Bacteria
- **Easy**: no energy, almost no maintenance
- **Robust**: even highly turbid water can be used, not fragile
- **Long life span**: expected life span 5-8 years → therefore, low costs for the expected life span
- **No recurring costs** (e.g. chemicals)
GDMD project in Kenya

**Goal:** development, design, production and sustainable implementation of a novel GDM household water filter

**Technical**
- Challenge testing
- Membrane module optimization
- Design

**Commercial**
- Production
- Distribution
- Marketing
- After-sale service

**Consumer**
- Willingness to pay
- Health Impact
- Behavior change

**Health Impact**
- Consumer
Technical evaluation in the field

First prototype of a GDM-filter

Membrane:
- Micodyn-Nadir, (Germany)
- 150 kDa cut-off (about 20nm pore size)
- 0.6 m² surface area

Clean water tank, 10L

Capacity: New: 10L in 2 h, Fouled: 10L in about 4 h
Challenging waters:

25 filters

**Kajiado:** 16 filters
Pond water, borehole, open shallow wells
(organic matter, turbidity, Fe)

**Thika:** 5 filters
Thika river
(organic matter, turbidity)

**Nairobi:** 4 filters
Distribution network
(chlorine)
Monitoring

- Frequency of use and flow rate → Level sensors
- Water quality →
  - E.coli and Coliforms: Nissui Compact Dry Plates
  - Biological activity: ATP pens
  - Conductivity, Oxygen, pH
  - Relevant ions: Fe

End-user perception
Survey: feedback from households
First results (after 1 month)

- Good pathogen removal
- Sufficient flow rate inspite of thick fouling layer
- High acceptance by households mostly due to removal of turbidity
- Filter used regularly, mostly once a day

- Re-contamination at the tap and in the clean water tank
- Interpretation of microbial tests
Next steps

Technology and design
- Design of the system by professional designers
- Optimization and design of the membrane module
- New microbiological methods adapted for the field studies

Business chain

Business planning and production
- Planning large scale production
- Business plan development

Reaching low-income market
- Assessment of distribution chains for low-income households, promotion
- Alternative financial mechanisms
- Willingness to pay, acceptance
Thank you for your attention!

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Further information  [www.eawag.ch/membranefilter](http://www.eawag.ch/membranefilter)