Interreg
Baltic Sea Region

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BORNHOLMS
ENERGI & FORSYNING

SUSTAINABLE WATERS
WaterMan

The WaterMan project
Low-tech filter to purify WWTP effluent for agricultural irrigation

WATER-SMART SOCIETIES

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The Challenge

What was the problem / need / opportunity?

- **Problem:** Increasing pressure on water resources due to climate change.
- **Need:** Explore sustainable alternatives to freshwater use in agriculture.
- **Opportunity:** Reuse treated wastewater from WWTPs for irrigation, especially during dry periods.

Who / what is affected and in what way?

- **Farmers:** Face water scarcity during droughts, impacting crop yields.
- **WWTPs:** Reduce the load on the surrounding waterbodies as nutrients would be kept on land instead of discharged.

Underlying causes

- **Environmental:** Climate variability (e.g. droughts).
- **Systemic:** Lack of national regulation supporting water reuse (EU 2020/741 not applied in DK).
- **Technical:** Existing WWTPs not designed for reuse; need for low-tech, cost-effective treatment solutions.
- **Economic:** Perception that water reuse lacks a viable business case in Denmark.

Objectives of the Pilot Measure

What did the pilot aim to test or prove?

- **Technical Feasibility**
  - Can a low-tech slow sand filter effectively treat WWTP effluent for irrigation?
  - Is the system operationally stable under local conditions (e.g. winter temperatures, flow rates)?
  - Can the system meet basic water quality standards (e.g. E. coli, nutrients, micropollutants)?
  - Determine clogging frequency and maintenance intervals; assess micropollutant removal efficiency.

- **Cost Effectiveness**
  - Is water reuse economically viable for farmers?
  - Can the system be built and operated at low cost?
  - Does it offer a business case strong enough to influence Danish regulation?
  - Estimate Operation & Maintenance (O&M) costs and evaluate ease of use for farmers.

- **Social Acceptance**
  - Will farmers adopt treated wastewater for irrigation?
  - Engage farmers in co-measuring soil moisture and crop yield for long-term adoption.
  - Can stakeholders (e.g. Farmers’ Association, local authorities) support and promote the concept?
  - How can public perception be improved through engagement and education?

Context & Background

➢ Why this specific location/site?

- Bornholm faces droughts that stress the water systems.
- A local farmer, located next to Svaneke WWTP, was interested in using treated water for spinach seed irrigation, providing a real-world test case.

➢ Policy / Industry Background

- EU Regulation 2020/741 on water reuse is not applied in Denmark.
- The Danish Environmental Ministry sees no business case for water reuse.
- <u>The pilot aims to demonstrate feasibility and economic potential to influence future policy.</u>

➢ Conditions

- Economic: Need for cost-effective irrigation solutions; pilot must prove financial viability.
- Environmental: Climate variability, nutrient runoff to the Baltic Sea.
- Institutional: Limited regulatory support; pilot must build a case for change.
- Socio-political: Public perception and farmer acceptance are key; stakeholder engagement is essential.

Stakeholders

- **Key Stakeholders & Their Roles**
  - **Environmental Ministry**
    Regulatory authority; key decision-maker on national water reuse policy.
  - **Local Farmer (Frennegaard)**
    Initial End-user of treated water; Interested in using the treated water.
  - **Bornholms Landbrug & Fødevarer (Farmers' Association)**
    Advocacy and stakeholder engagement; potential lobbying partner.
  - **BEOF – Wastewater Operations Department**
    Technical implementation and operation of the pilot system.
  - **SYMSITES Project Partners**
    Co-organizers of stakeholder workshops and knowledge exchange.
  - **Bornholm Municipality (BRK)**
    - Regulatory authority.
  - **DANVA – Danish Water & Wastewater Association**
    - Wastewater representative - significant advisory and influencing role in shaping water and wastewater policy in Denmark.

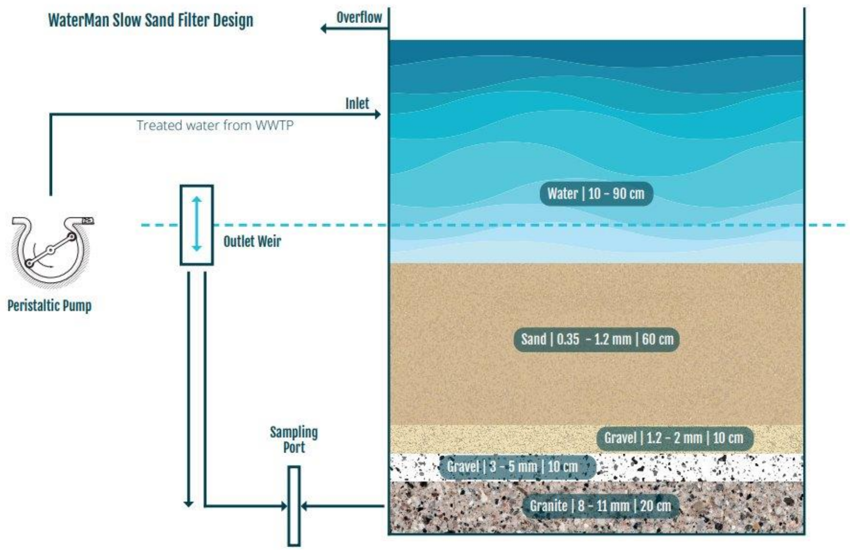
- **Stakeholder Engagement**
  - **Initial Engagement**
    One-on-one meetings with the local farmer and BEOF operations team.
  - **Workshops**
    Joint workshop with SYMSITES (Q1 2025) to:
    - Educate stakeholders
    - Explore challenges and solutions
    - Promote acceptance of wastewater reuse
  - **Visits**
    - Municipality's environmental department pilot visit – regulatory advisory. Promote acceptance.
  - **Strategic Involvement**
    - Environmental ministry engaged to strengthen the case for policy change - email conversations, Teams-meetings and phone calls.
    - Farmers' involvement in monitoring soil moisture and crop yield is recommended for future pilots

The Solution

- **Technical-Organisational Solution Applied**
- **Location:** Svaneke WWTP
- **System:** Low-tech Slow Sand Filter (SSF)
- **Design:**
  - Sand layer (80 cm) + crushed granite drainage layer (20 cm)
  - Peristaltic pump and insulated tank
  - Monitoring operation to manage Schmutzdecke buildup
- **Focus:** Water reuse for agricultural irrigation, not nutrient reduction
- **Startup timeline**: Schmutzdecke formation requires ~10–14 days before stable operation.
- **Maintenance interval**: Surface scraping every 2–3 weeks under normal conditions.
- **Requirements**: WWTP must provide secondary-treated effluent; farmer needs land for filter and access to treated water.

How It Works – Overview

1. **Effluent Collection**
   Treated wastewater from WWTP is pumped into the filter system.
2. **Filtration Process**
   Water passes slowly through sand, forming a Schmutzdecke (biofilm) that removes:
   - Suspended solids
   - Nutrients (N, P)
   - Microorganisms (e.g. E. coli)
3. **Drainage & Collection**
   Filtered water is collected at the effluent end pipe after the outlet weir. Did not make use of the sampling port.
4. **Monitoring & Maintenance**
   - Regular water quality testing
   - Occasional surface scraping to remove clogged biofilm
   - Flow rate adjusted based on Schmutzdecke development



Development & Implementation

➢ Development Process

- **Initial Concept**: Inspired by a 1990s filter on Bornholm
- **Kick-off Activities**:
  - Literature review on slow sand filter (SSF) and Schmutzdecke
  - Hydraulic testing of local sand
- **Design Evolution**:
  - Shift from nutrient reduction to reuse-only focus
  - Downscaled to small-scale feasibility study

➢ Tools, Technologies & Methods

- **Slow Sand Filter (SSF)**:
  - Sand layer + crushed granite drainage
  - Peristaltic pump, insulated tank
- **Monitoring Tools**:
  - E. coli and coliform testing
  - Nutrient and micropollutant analysis
- **Operational Methods**:
  - Harrowing and scraping of Schmutzdecke
    - Manual scraping manageable for small farms but challenging for large-scale use.
  - Monitoring operation to balance biofilm buildup

Micropollutant Removal Performance (SSF Inlet → SSF Outlet)

- **Suspended solids:** 6.44 mg/L → 2.33 mg/L (**~64% reduction**)
- **Turbidity:** 1.6 FNU → 0.3 FNU (**~81% reduction**)
- **E. coli:** 11,400 MPN/100 ml → 410 MPN/100 ml (**~96% reduction**)
- **PFAS compounds:** Most below detection limits; slight reductions observed (e.g., PFBA: 0.66 → 0.26 µg/L).
- **Pharmaceuticals:**
  - **Citalopram + escitalopram:** 0.072 µg/L → <0.010 µg/L (**>86% reduction)**
  - **Clarithromycin:** 0.07 µg/L → <0.01 µg/L (**>85% reduction**)
  - **Diclofenac:** 0.72 µg/L → 0.26 µg/L (**~64% reduction**)
  - **Hydrochlorothiazid:** 0.17 µg/L → <0.01 µg/L (**>94% reduction**)
  - **Venlafaxin:** 0.58 µg/L → 0.09 µg/L (**~84% reduction**)

Phase	Milestone	Status
Phase 1	Feasibility study & lab testing	✓ Completed
Phase 2	Filter construction	✓ Completed
Phase 3	Field testing & monitoring	✓ Completed
Q1 2025	Stakeholder workshop. Promote awareness	✓ Completed
End 2025	Final reporting & evaluation	In Progress

Lessons Learned

➢ What Did Not Go as Planned?

- **Unstable flow** due to initial piping setup
- **Filter overflow** during early operation
- **Fast decline in outflow** linked to Schmutzdecke buildup
  - Unexpected clogging frequency required more frequent maintenance than planned.
- **Winter performance** concerns due to reduced biological activity

➢ Adjustments Made

- **Changed piping system** to stabilize flow
- **Sand selection refined** based on hydraulic testing and clogging resistance
- **Filter design updated**:
  - Polypropylene tank for thermal stability

➢ Key Takeaways for Future Implementations

- **Smaller-scale farms** can benefit from modular, low-tech systems
- Intermittent **operation** is preferable to continuous for managing biofilm
- **Thermal insulation** is critical for year-round performance
- **Stakeholder involvement** (e.g. farmers' associations) strengthens policy impact
- **Economic viability** must be demonstrated early to support regulatory change

- **If starting again**: Include influent pre-treatment (drum filter), real-time monitoring, and automated scraping.
- **Future pilots** (scaling up): Co-measure soil moisture and crop yield with farmers; share results at seasonal workshops.

Scalability

Can the Measure Be Scaled Up?

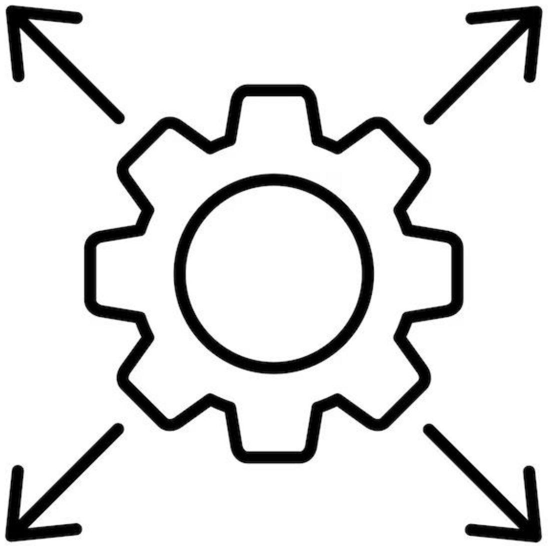
- Technically possible, but with significant limitations
- Scaling within the region would require large land areas and intensive maintenance

Required Adaptations for Larger Scale

- Larger filter surface area to handle higher water volumes
- Scaling requires automation to reduce manual maintenance and improve farmer usability.
- Improved insulation and temperature control for year-round operation
- Efficient sludge and Schmutzdecke management systems

Financial Viability

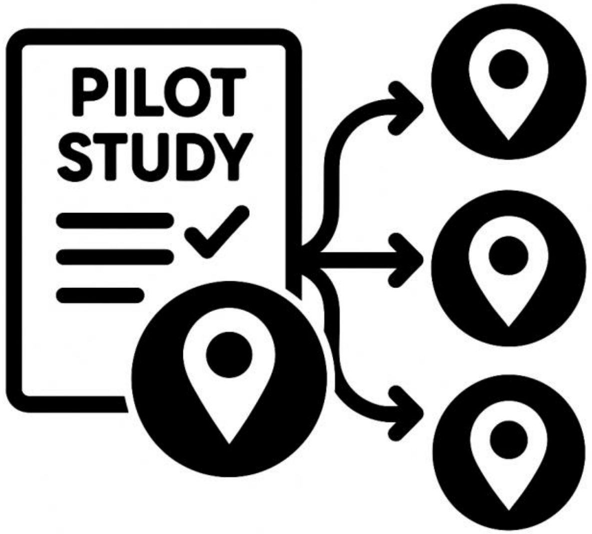
- Not viable in our case due to:
  - High volume of water requiring treatment
  - Large land footprint needed
  - Increased operational complexity and maintenance costs
- More suitable for small-scale farms or modular applications with lower water demand



Transferability

➢ Adaptability to Other Regions or Systems

- Modular design allows scaling up or down based on local needs
- Can be applied in:
  - Rural areas with limited infrastructure
  - Small-scale farms needing alternative irrigation sources
  - Municipal or industrial reuse (e.g. parks, cleaning, process water)
- Suitable for regions with:
  - Seasonal water stress
  - High nutrient runoff
  - Interest in circular water solutions



➢ Preconditions for Successful Replication

- WWTP effluent availability with basic treatment
- Land availability for low-flow filtration systems
- Stakeholder buy-in (farmers, municipalities, regulators)
- Monitoring capacity for water quality and system performance
- Regulatory flexibility or pilot-friendly frameworks
- Economic feasibility: Must demonstrate cost-effectiveness for end-users
- Precondition: Clear O&M cost estimates and farmer-friendly operation protocols.

Final Reflections

- **Biggest Surprise**
  - The impact of cold weather on biological activity was less significant than expected.
  - Schmutzdecke performance dropped during winter, affecting flow and treatment efficiency. But still good removal rates of coliforms.
  - Overall removal rate – Class D

- **“This Might Not Work…” Moment**
  - During early spring, outflow declined rapidly, raising concerns about system viability.
  - Solution: performed regular cleaning/racking to increase flow.

- **Key Tips & Recommendations**
  - Design for seasonal variation – insulation and flexible operation are essential.
  - Start small – modular systems are ideal for pilot testing and small farms.
  - Engage stakeholders early – farmer buy-in and ministry dialogue are critical.
  - Plan for maintenance – biofilm management is a recurring task.

- **Wish List for Future Pilots**
  - Automatic maintenance system for Schmutzdecke management
  - Real-time monitoring sensors for flow and water quality
  - Drum filter at influent to reduce solids load
  - Integrated backwash system (though it may compromise the “low-tech” nature of SSF)
  - Future pilots should include soil moisture and crop yield monitoring, shared at seasonal farmer workshops.
  - Real-time sensors, influent drum filter, automated Schmutzdecke management.

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The „BSR Water Recycling Toolbox" was elaborated as part of the WaterMan project, which is co-financed by the European Union (European Regional Development Fund) and implemented within the Interreg Baltic Sea Region Programme. More information:

eurobalt.org/WaterRecyclingToolbox
interreg-baltic.eu/project/waterman

WaterMan promotes a Baltic Sea Region-specific approach to water recycling, which makes use of the alternation of too much and too little water that has become typical for humid areas in the EU to strengthen the resilience of local water supply. Building on this approach, the project supports municipalities and water companies in adapting their water supply strategies.