Wastewater/contaminated water treatment by HVR Water Purification MD technology

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HVR Water Purification AB,
Scarab Development AB, Sweden, 2025.
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SYNERGY

scarab

Absolutely pure drinking water

HVR

Ultra-Pure Water for the nanoelectronics industry

XZERO

Our vision is to present a solution to the global water pollution

CWT

Circular water system for long term missions in space.

HYDROMARS

type1water

Nanocap is a desktop water purifier that will remove sub-10 nanometre particles better than state-of-the-art equipment.

TYPE1WATER

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COLLABORATIONS

EasyMining

KTH VETENSKAP OCH KONST

KTH Royal Institute of Technology

SLU Swedish University of Agricultural Sciences

ITM Institute on Membrane Technology National Research Council of Italy

esa European Space Agency

Fraunhofer

AIRBUS

imec

SWEDISH GEOTECHNICAL INSTITUTE

ivl Swedish Environmental Research Institute

RI. SE Research Institutes of Sweden

intel

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TEST RESULTS

Type of contamination	Amount	Result	Method	Detection limits	Test by
Bacteria	14 000 (after 7 days)	BDL	Membrane filter count	-	National Bacteriologic Laboratory, Stockholm
Chlorine	3.4 mg/l	BDL	Photometric analysis (Perkin Elmer)	< 0.01 mg/l	Water Protection Ass of South West Finland
Salt water	31 000 ppm	BDL	Ion chromatography	< 1 ppm	VBB Viak Stockholm
Trihalomethanes	1 000 µg/l	BDL	Gas chromatography	< 1 µg/l	University of Turku, Finland
Radon	380 Bq/l	BDL	Alfa detection	< 4 Bq/l	Swedish Radiation Protection Institute
Cesium Strontium Plutonium Radium	2.4 Bq	BDL	Lithium Drifted Germanium Detector	< 0.1 Bq	Radiation Physics Department, Univ of Lund
Arsenic +3	10 mg/l	BDL	AAS Graphite	< 0.003 mg/l	Analytica AB, Stockholm
Arsenic +5	10 mg/l	BDL	AAS Graphite	< 0.003 mg/l	Analytica AB, Stockholm
Ag nanoparticles	3100 µg /l	BDL	HPLC	< 2 µg /l	IVL Swedish Environmental Research Institute
SiO2	10000 µg /l	BDL	AAS	< 5 µg /l	Vattenfall AB, Stockholm
Setralin and 20 other pharmaceutical residuals	4 ng/l	BDL	HPLC	< 0.8 ng/l	IVL Swedish Environmental Research Institute

BDL = Below detection limit

PFAS 26 1664 ng/l (landfill leaches) HPLC 8.96 ng/l SLU lab. limit DW 100 ng/l

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TEST RESULTS

- All non-volatile pollutants including heavy metals,
- nanoparticles, plastics,
- fluoride,
- arsenic,
- pharmaceutical residuals,
- PFAS
- Pesticides,
- pathogenic microbes (bacteria, viruses, protozoans, molds...),
- disinfectant chemicals,
- organic chemicals,
- radioactive compounds

Separation process, the purity of the water (99,9%) is constantly checked by its conductivity level.

Makes the safest drinking water wherever you are, whatever the source

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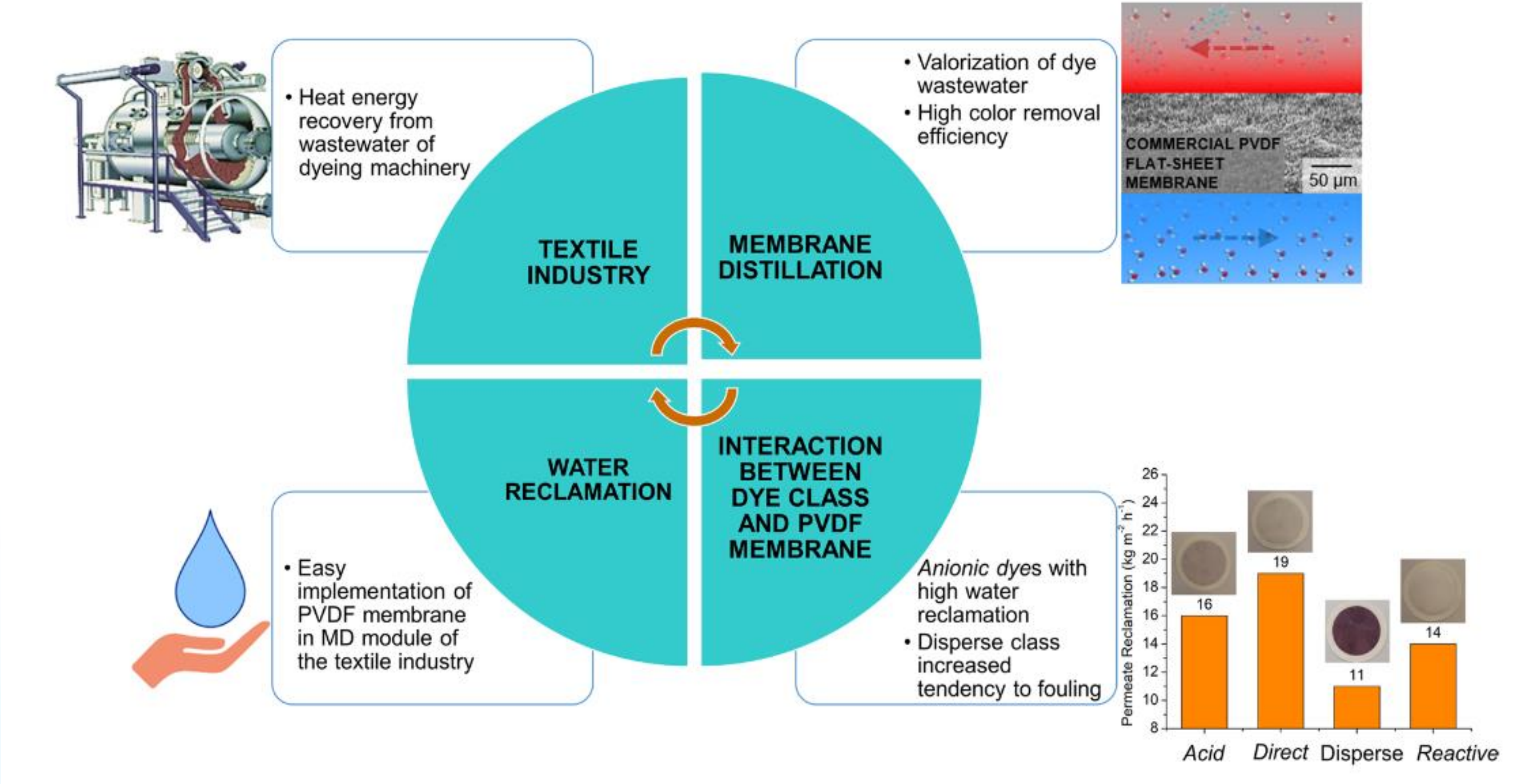
Clean water recovery from textile wastewater



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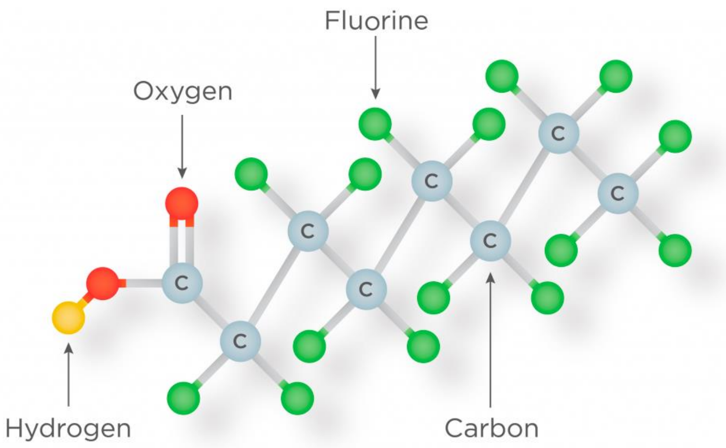
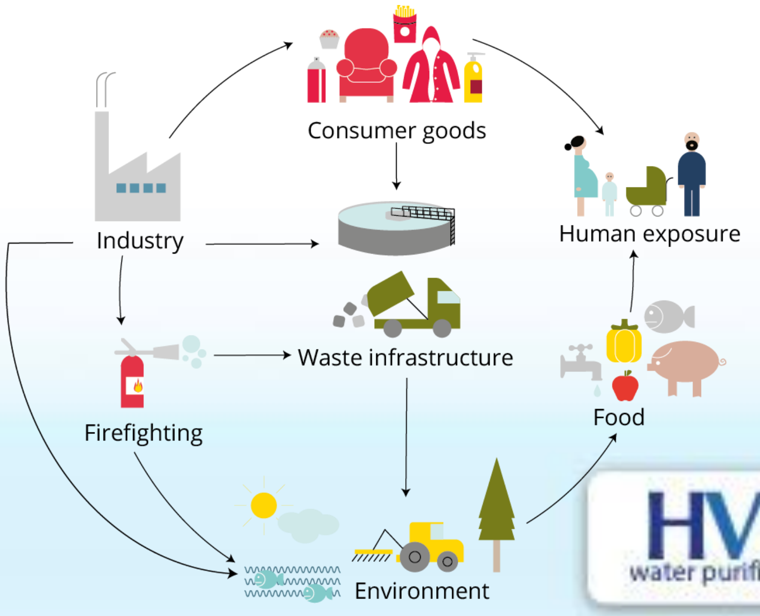
PFAS-Forever Chemicals

- Group of synthesized poly- and perfluoroalkyl substances
  - more than 4,700 PFAS, employed in several chemical industries.
- Characterized by their exceptionally strong carbon and fluorine bonds
  - Their chemistry delivers many distinctive attributes i.e., one part of chemical is hydrophobic (repelled by water), whereas other part are more ionic and water-soluble.
- Due to chemical properties, they are not metabolized rapidly
  - Bio-accumulate in human and animal bodies, eventually
- Developmental effects to fetuses, liver effects, thyroid effects, immunotoxic effects, i.e., decreased response to vaccines and possible increases in COVID-19 severity





Ex. of long and short chain PFAS

Long-Chains	
Perfluorooctanoic acid (PFOA)	Nonstick Surfaces
Perfluorooctane sulfonate (PFOS)	Fabric Protection, Firefighting Foam
Perfluorononanoic acid (PFNA)	Surfactant for Plastic Production
Short-Chains	
Perfluorohexane Sulfonic Acid (PFHxS)	Firefighting Foam
Perfluorohexanoic Acid (PFHxA)	Degradation Product of PFHxS
Perfluorobutyrate Acid (PFBA)	Photographic Film

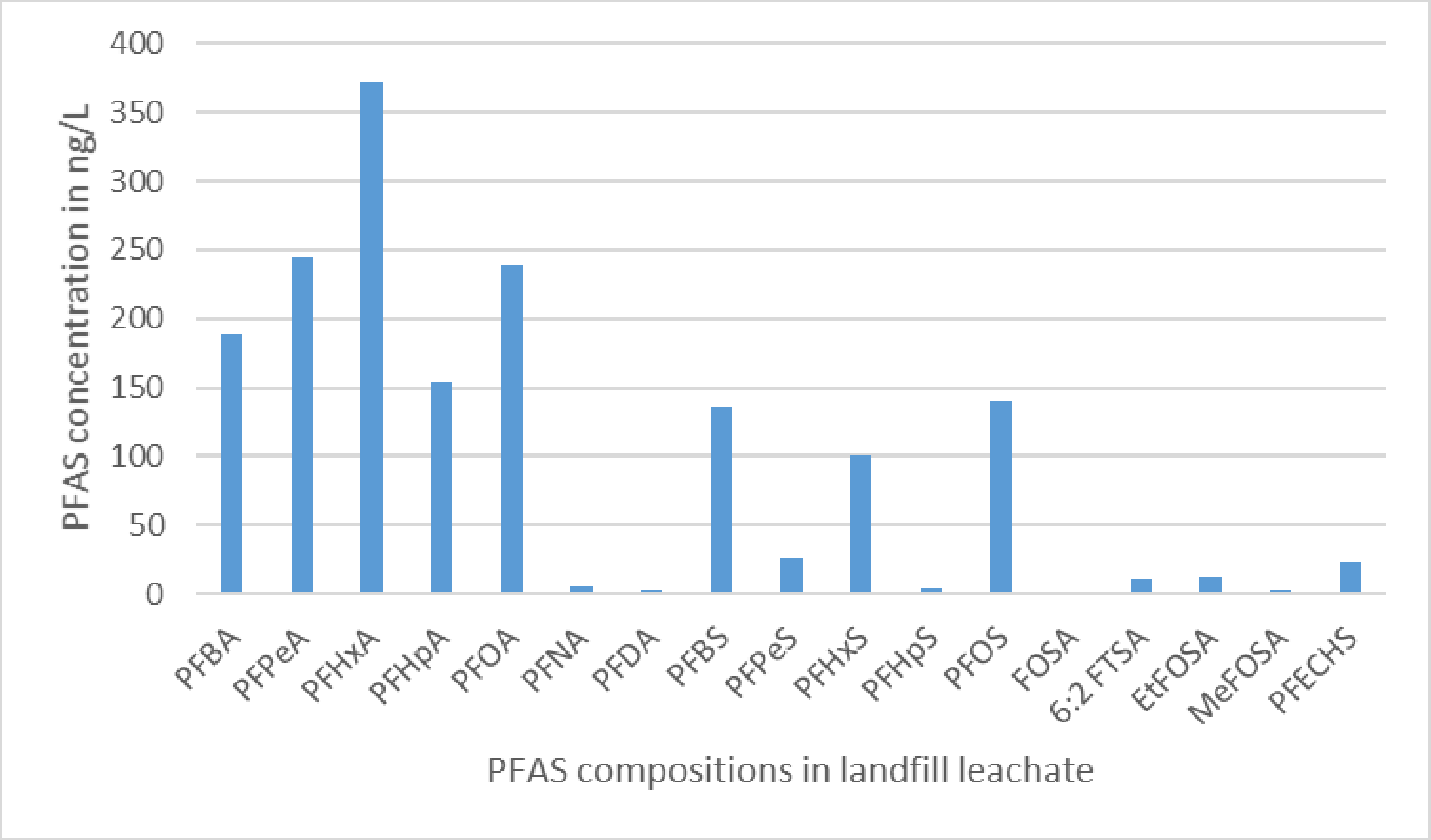
Current technologies for PFAS treatment and major challenges!

Technologies	Challenges
Reverse Osmosis (RO)	Need higher operational pressure (up to 20 bar)! Short-chain PFAS, such as perfluorobutanoic acid (PFBA) and perfluoropentanoic acid (PFPeA), were not found to be much effective separation (up to 80%)! Water recovery rate is low also!
Granulated Activated Carbon (GAC)	PFAS removal efficiency has been shown to be dependent on the PFAS chain length, functional group, pH, and is typically negatively affected by DOC! Moreover, not applicable for direct application!
Anion Ion Xchange (AIX)	PFAS removal efficiency has been shown to be dependent on the PFAS chain length, functional group, pH, and is typically negatively affected by DOC! Moreover, not applicable for direct application!
Nanofiltration (NF)	NF was found to yield over 90% removal efficiency of PFAS! Contaminated feed could not handle directly. NF membrane can not handle raw contaminated water.
Foam Fractionation (FF)	Removal efficiency to be dependent on the PFAS chain length. Moreover, FF-treated retentate would most likely require additional treatment stages for removal of organics, nutrients, metals, or polishing for additional removal of PFAS!

Microplastics treatment challenge

- This study investigated the removal behavior of PS MPs in a simulated drinking water treatment system including coagulation/sedimentation, sand filtration, and UV-based oxidation. The sequential process of coagulation/sedimentation and sand filtration could completely remove MPs > 20 μm, whereas a small portion of the MPs ≤ 20 μm passed through the sand media, suggesting the need for introducing processes, specifically targeted at MPs < 20 μm in the conventional water treatment systems. During the UV-based oxidation process (UV photolysis and UV/H2O2), smaller-sized fragments were generated by photochemical weathering of MPs, which was more evident in the UV/ H2O2-treated sample. Meanwhile, UV/H2O2 treatment substantially promoted the release of a mixture of low molecular weight organic compounds that might stem from radical–facilitated polymer chain scission, leading to an increase in bacterial toxicity in treated water ready for supply.

PFAS concentration in landfill leachate (Total PFAS ca. 1700 ng/L)



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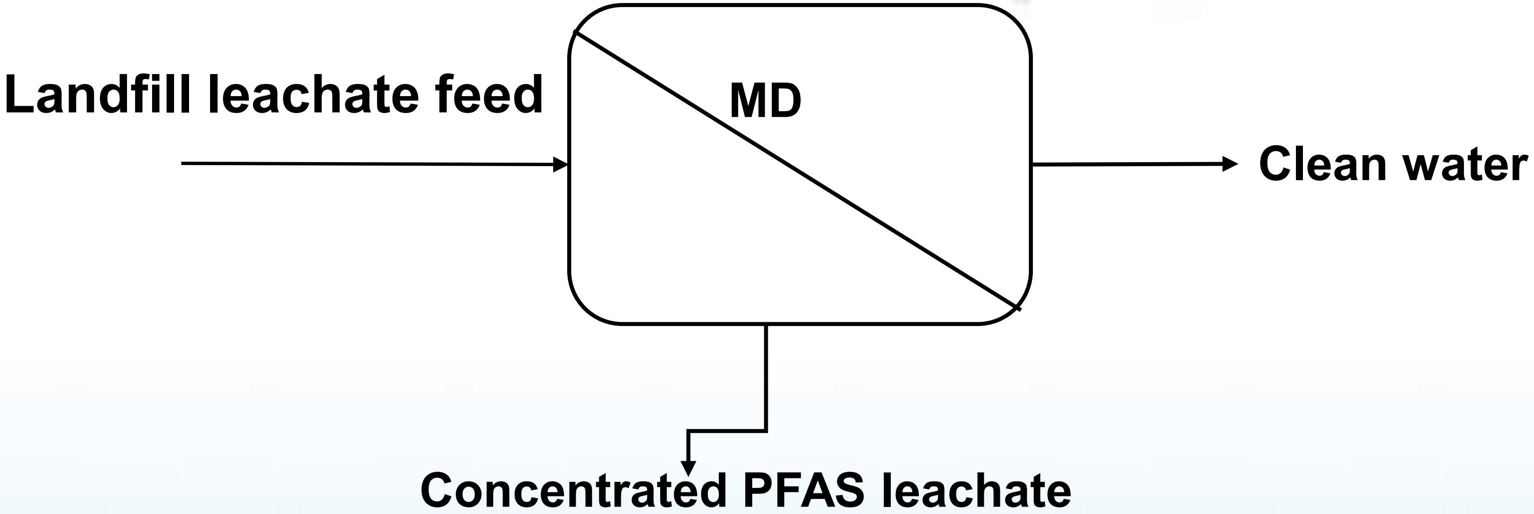
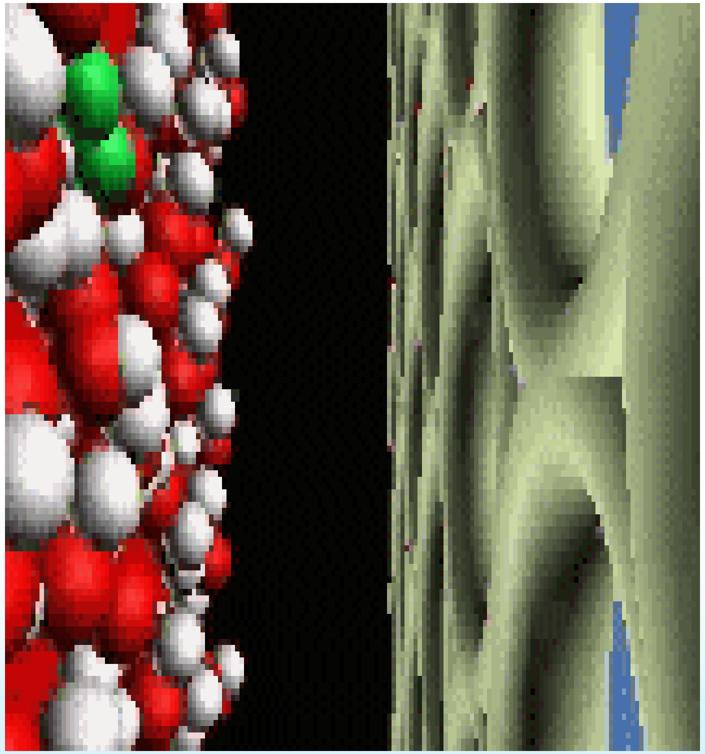
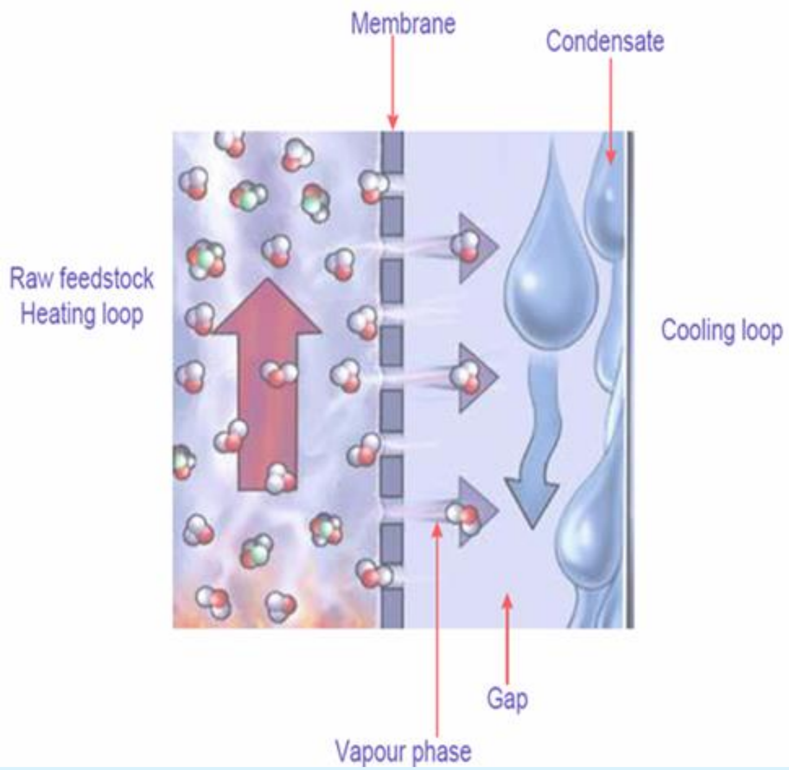
Landfill leachate PFAS sample



HVR Thermal Pervaporation





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Membrane distillation lab unit

Air gap membrane distillation lab unit data

Membrane distillation unit	Parameters
Type of membrane distillation	Air-gap membrane distillation
Membrane materials	Polytetrafluoroethylene (PTFE)
Membrane porosity	80%
Average pore size	0.2 µm
Membrane area	0.32 m^2
Feedwater source	Landfill leachate
Feedwater inlet temperature	50-70°C*
Cooling water (tap water) inlet temperature Feed and coolant flow rate	17-20°C 2.5-3.6 L/m
ΔT_i	30-50°C
Number of cassettes	1

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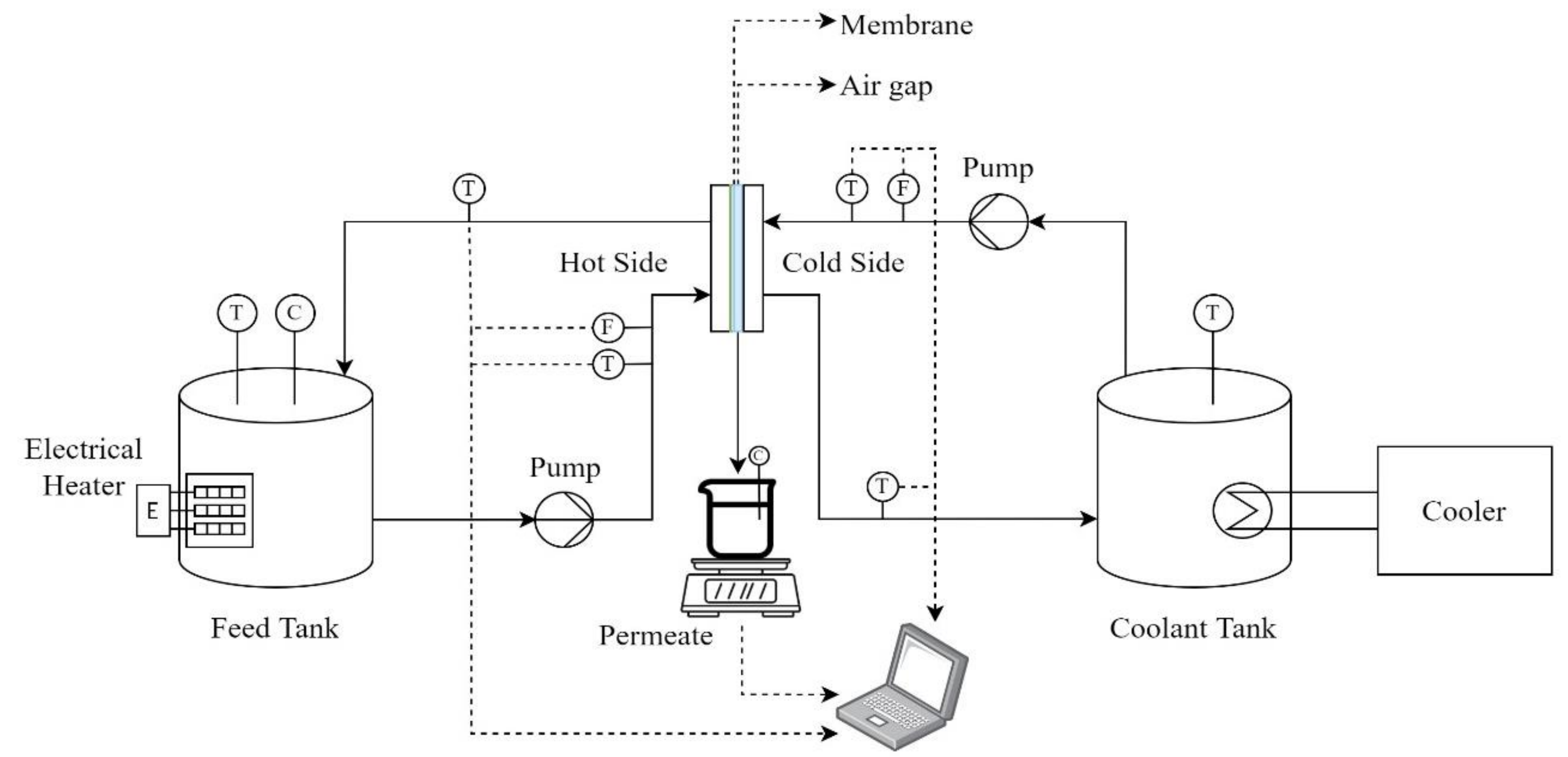
Experimental setup of air gap membrane distillation (AGMD)



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Landfill leachate PFAS 26 and permeate water from MD

- Total PFAS 26 in landfill leachate feed ca. 1700 ng/L
- Total PFAS 26 in MD permeate water 8.96 ng/L (removal efficiency 99.5%)
- PFAS 4 in MD permeate (LOQ)!
- >80% permeate recovery (ca. 42 L permeate and 10 L concentrated leachate!)

MD product water quality analyses

The product water analyses of the three different feeds:

Parameter	Unit	Feedwater 1: As-contaminated groundwater feed (366 µg/L Högsby municipality, Sweden)	Feedwater 2: As-spiked tap water feed (300 µg/L)	Feedwater 3: As-spiked tap water feed (1600 µg/L)
As	µg/L	<0.4*	<0.03*	<0.03*
Ca^{2+}	mg/L	<0.7	<0.7	<0.7
Mg^{2+}	mg/L	0.014*	<0.02	0.002*
Na^{+}	mg/L	0.02*	<0.17	0.012*
K^{+}	mg/L	<0.03*	<0.03*	<0.03*
Conductivity	µS/cm	0.6-0.7	0.6-1.5	0.6-1.5
pH		6	6	6

*below detection limit

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Reject water as feed sample to HVR technology

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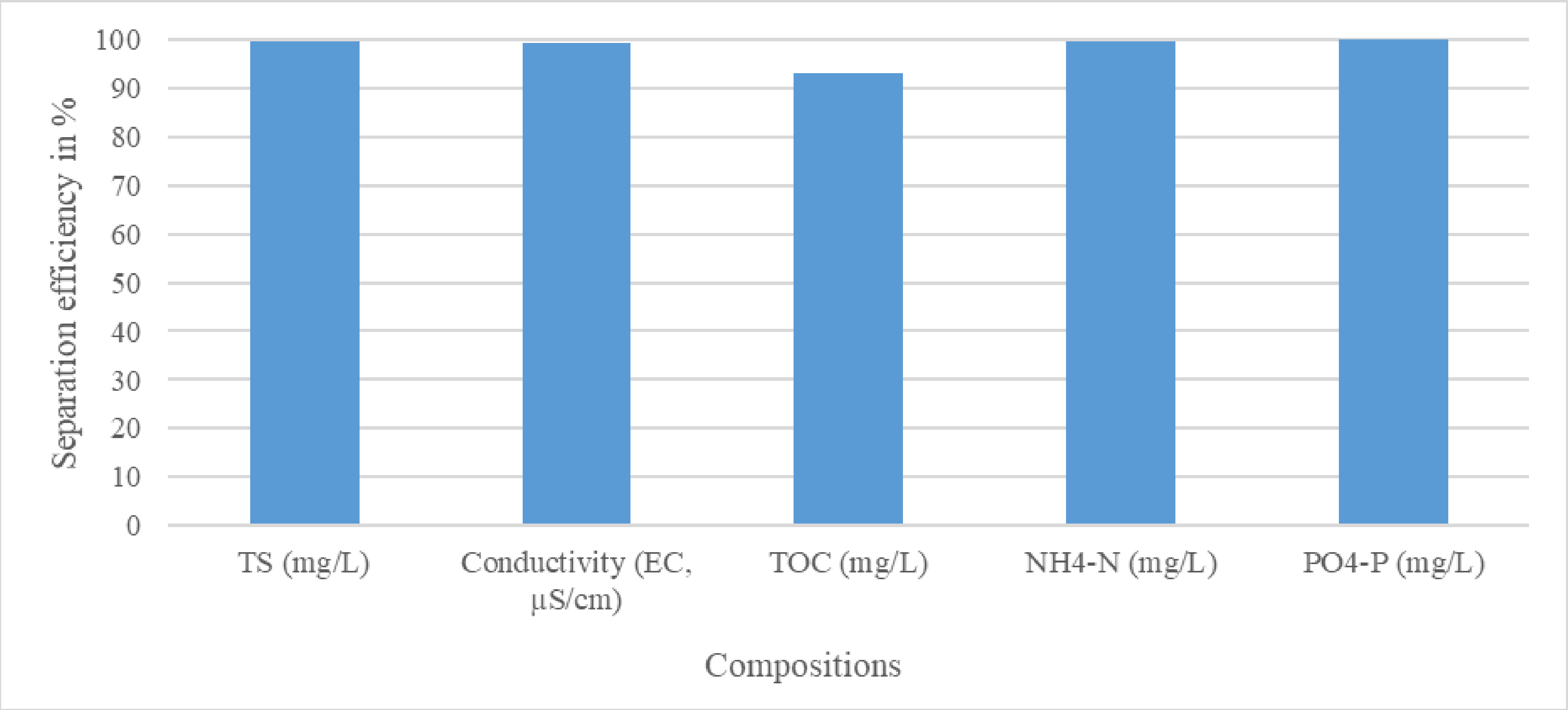
Separation efficiency



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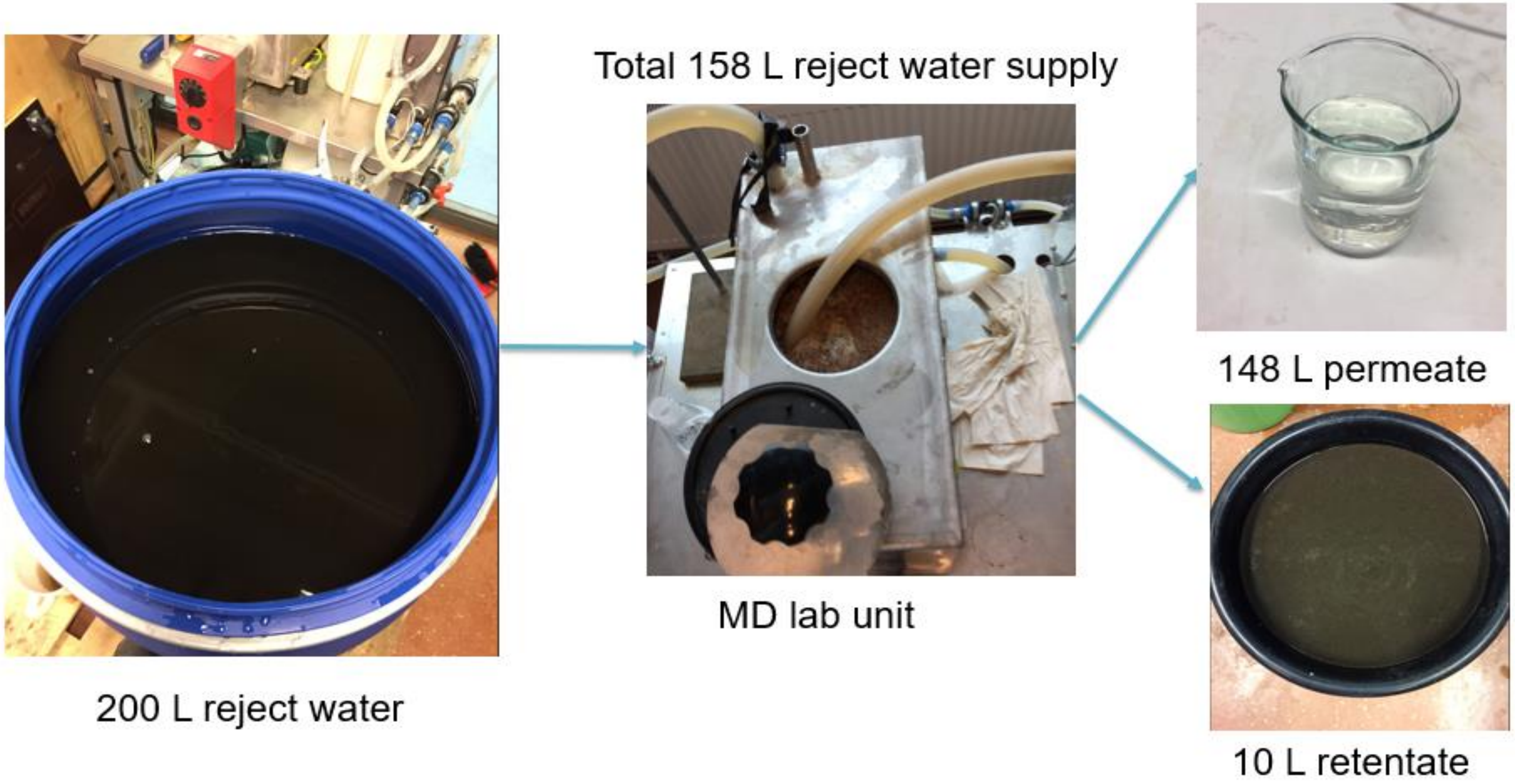
Heavy metals separation (>99% rejection of heavy metals)

Compositions (µg/L)	Linköping Community	MD permeate*
Arsenic (As)	15	<0.2
Chromium (Cr)	15	<0.5
Cadmium (Cd)	0.2	<0.1
Lead (Pb)	10	<0.5
Copper (Cu)	30	1.1
Zink (Zn)	30	<2.0
Nickel (Ni)	30	<0.5
Mercury (Hg)	0.07	<0.1

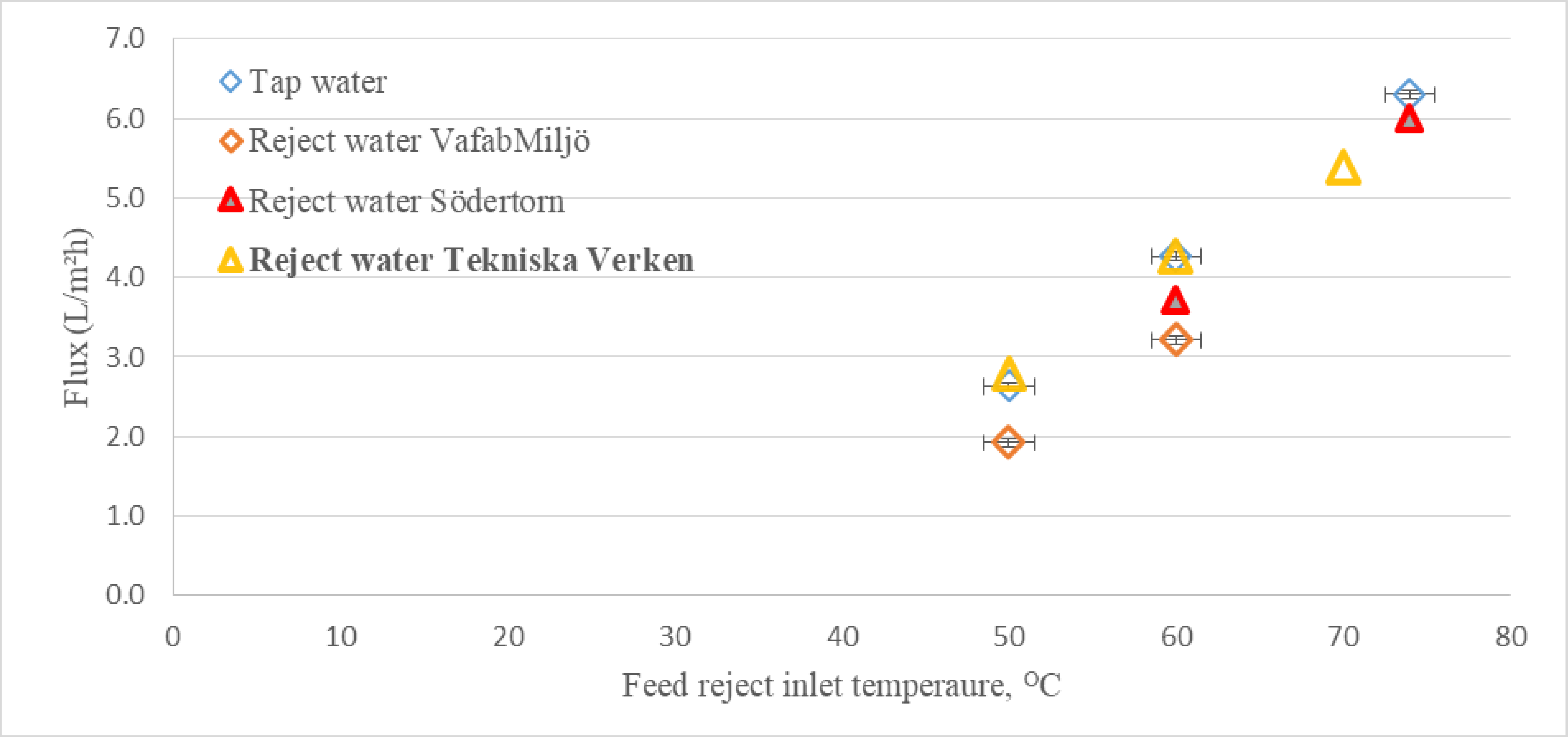
Reject water concentration factor (CF:15.8) in MD retentate



Feed reject water, MD concentrated and product waters analyses

Parameters	Feed reject water	Concentrated rejec	MD-product water-1	MD-product water-2	Reduction (%)
Conductivity (µS/cm)	18500	>20000	22,5	55	99,7027027
pH	2,6	2,64	3,7	3,66	
COD (mg/L)	33000	19700	394	484	98,80606061
PO4-P (mg/L)	240±15	400±10	<0,05	<0,05	99,9875
Total P (mg/L)	290±20	440±10	<0,05	0,09	
NH4-N (mg/L)	1870±10	4100±30	<0,05	<0,05	
Total Sulphur S (mg/L)	370,7	612,5	5,7	1,5	98,46236849
Total potassium K (mg/L)	135,3	246,3	2,1	2,1	98,44789357

Clean water production as a function of feed temperature



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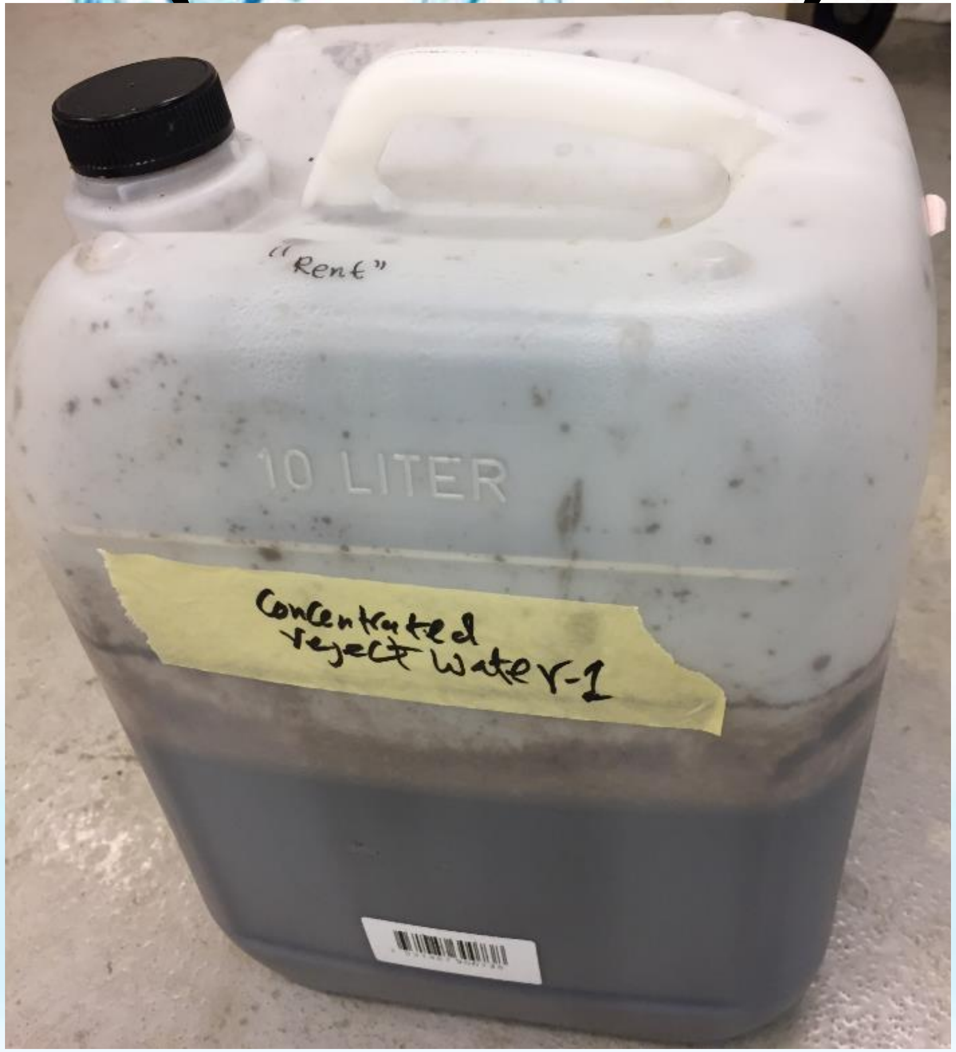
Concentrated MD reject water (about 7 L)



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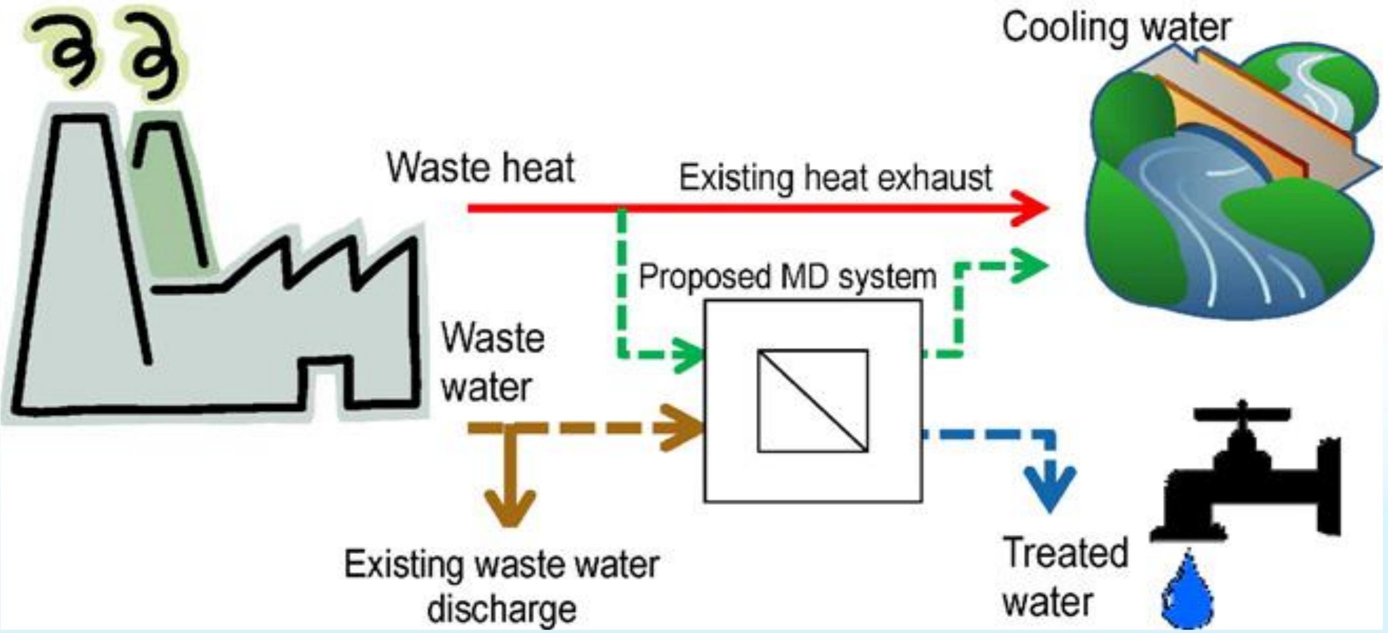
Pilot trial of membrane distillation driven by low grade waste heat: membrane fouling and energy assessment



Biogas digestate reject water and MD permeate

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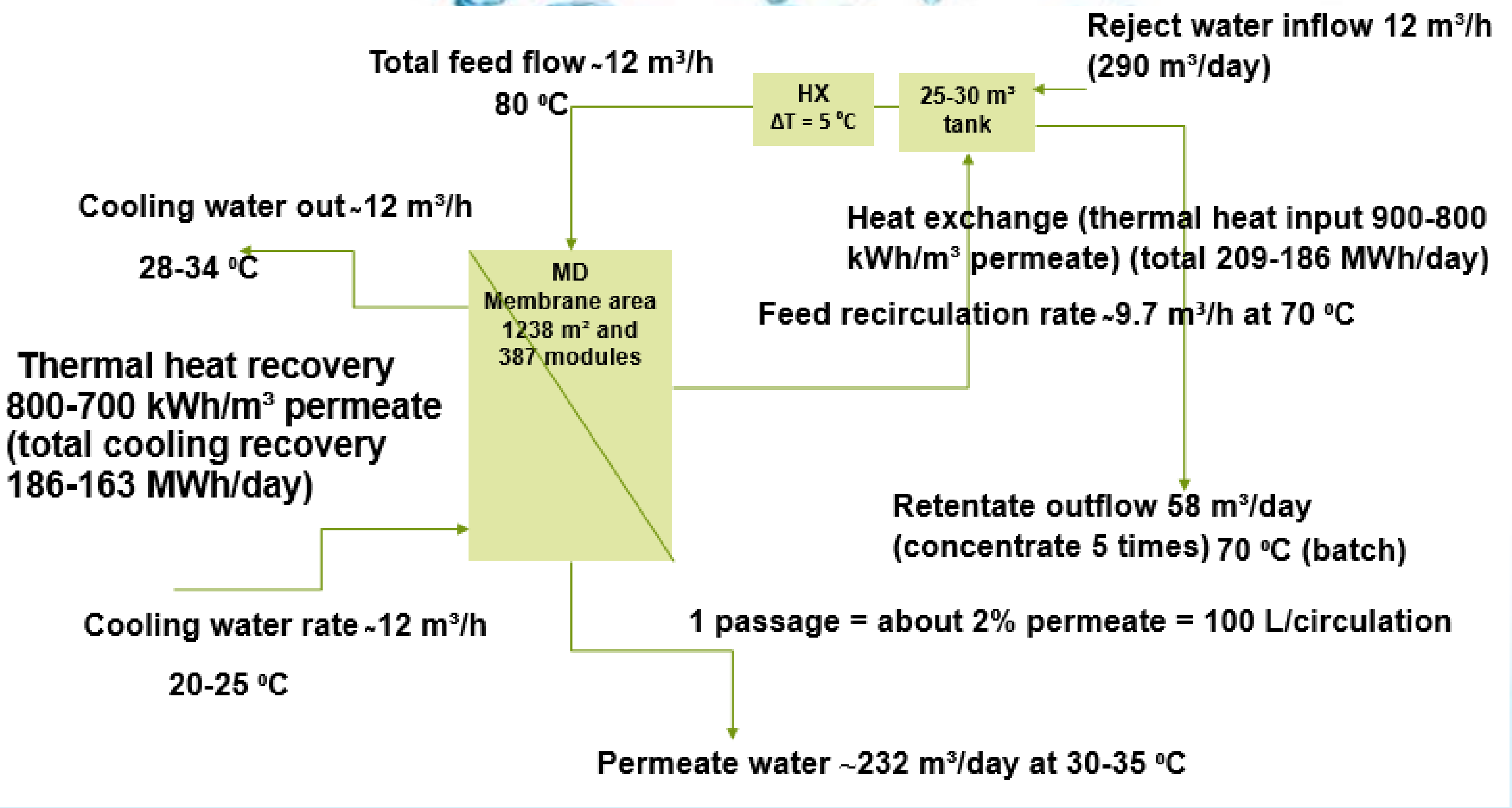
Wastewater treatment by MD at Nodra AB @ 290 m3/day



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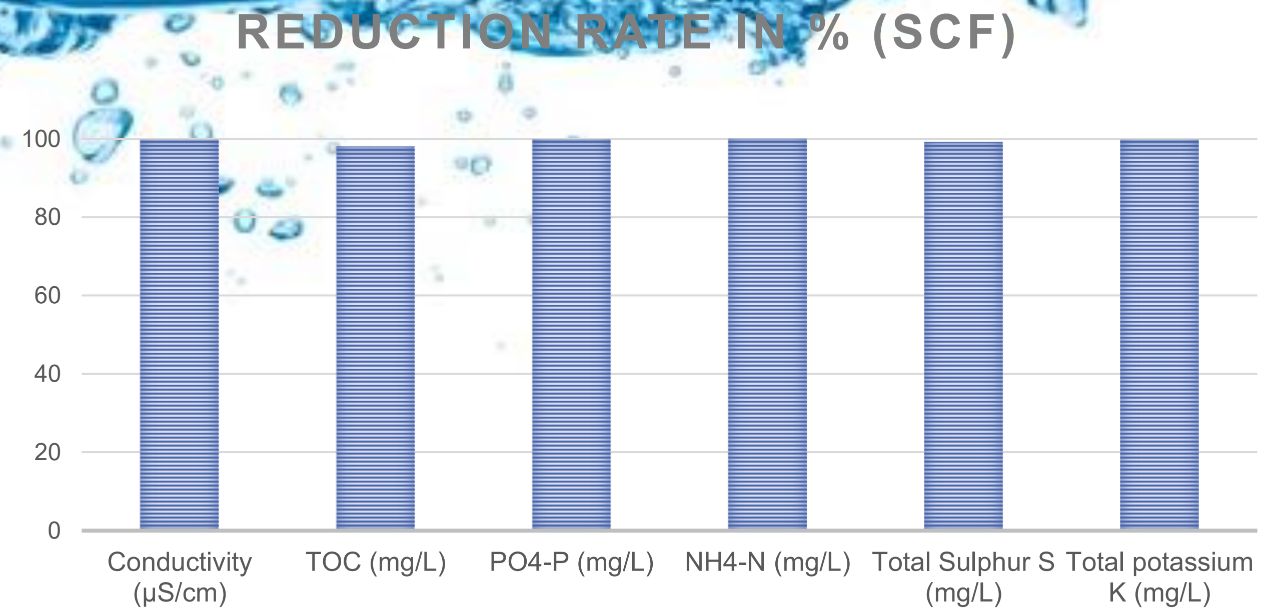
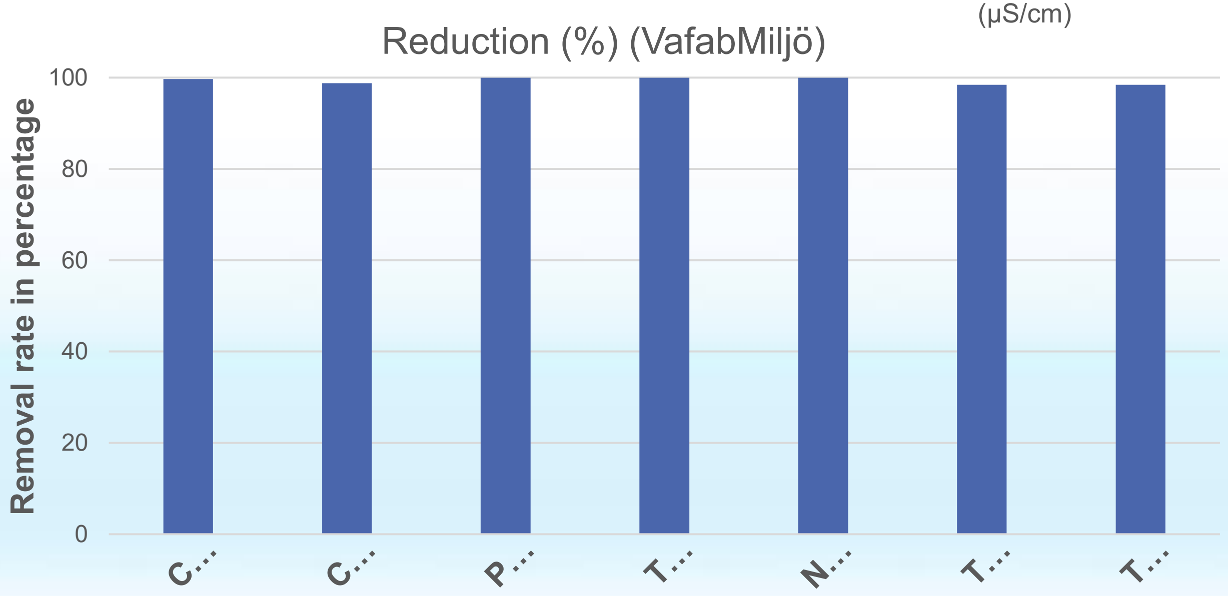
Nutrients removal rate in %





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Pharmaceuticals in sewage treated wastewater

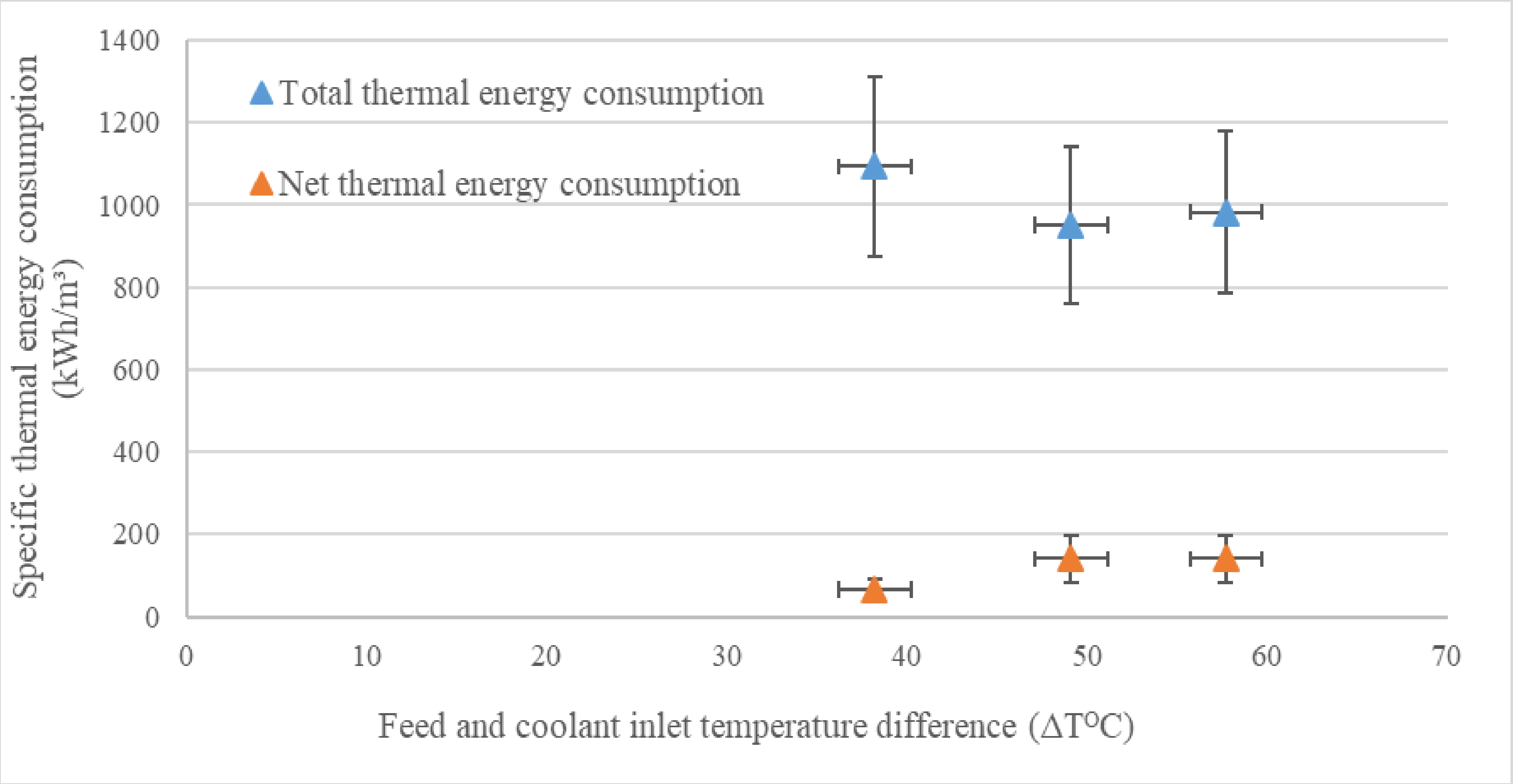
almodipine	20
atenolol	150-500
bisoprolol	40–100
caffeine	200
carbamazepine	300-600
ciprofloxacin	20–100
citalopram	150-450
diclofenac	500
furosemide	600–1 000
hydrocholothiazide	600–1 100
ibuprofen	100
ketoprofen	50–100
metoprolol	1 000–3 500
naproxen	50
oxazepam	150–300
paracetemol	20-50
propranolol	50–200
ranitidine	100–300
sertraline	10
sulfamethoxazole	100–200
terbutaline	10
tetracycline	50
trimetoprim	30
warfarin	10

Product water quality from MD

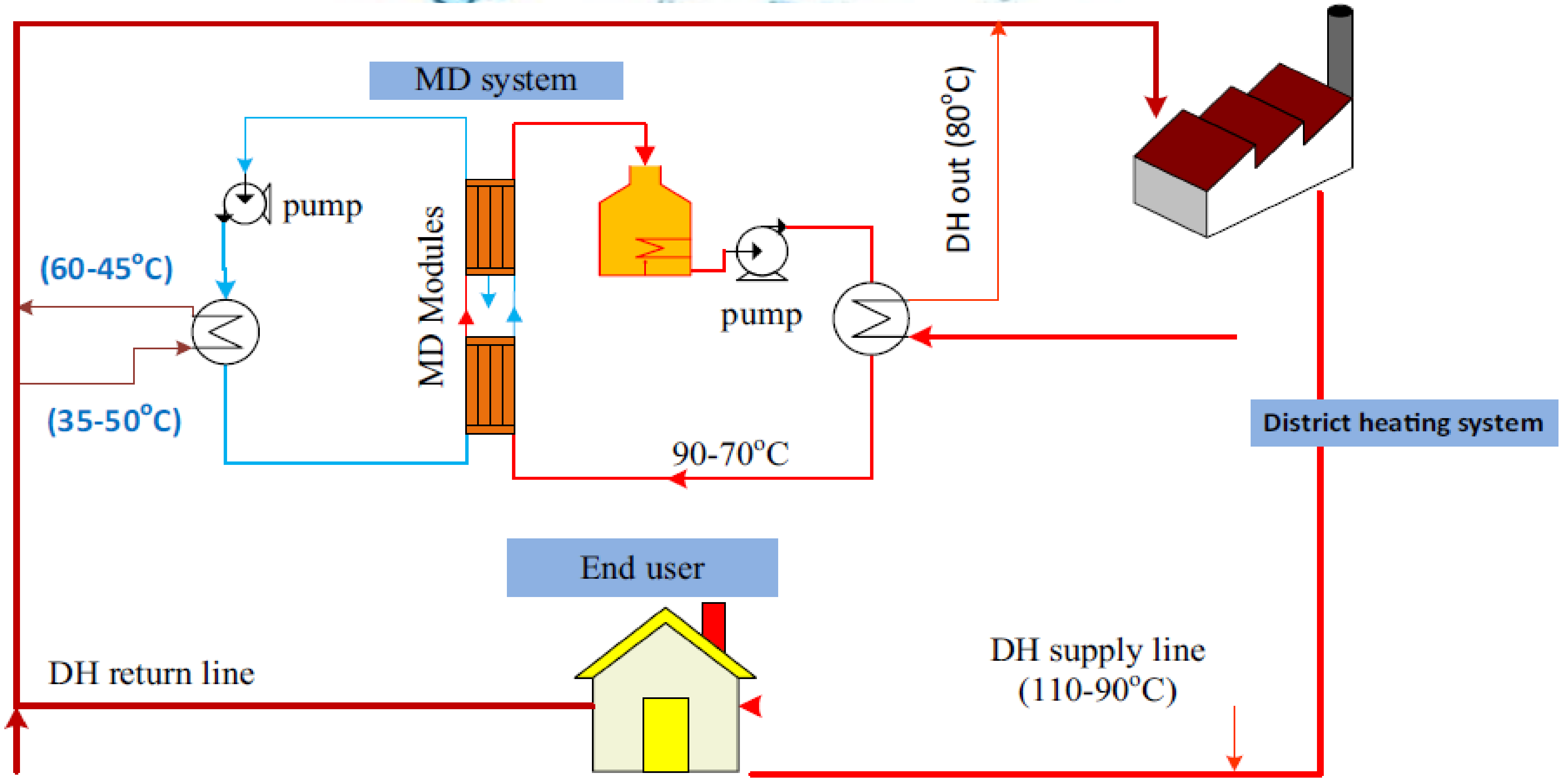
Analysis of raw and treated flue gas condensate.

Parameter	Raw condensate	MD product	Reduction (%)	Unit
Ca	35.0	<0.2	>99%	mg/l
Fe	0.0268	<0.004	>85%	mg/l
K	3.59	<0.5	>86%	mg/l
Mg	4.28	<0.09	>98%	mg/l
Na	902	1.27	99.90%	mg/l
S	60.6	0.274	99.50%	mg/l
Al	89.4	5.98	93.30%	µg/l
As	25.7	<1	>96%	µg/l
Ba	55.3	<0.2	>99.6%	µg/l
Cd	0.910	<0.05	>94.5%	µg/l
Co	0.422	0.105	75.10%	µg/l
Cr	3.21	<0.5	>84%	µg/l
Cu	32.7	<1	>96.9%	µg/l
Hg	5.64	<0.02	>99.6%	µg/l
Mn	28.6	<0.2	>99.9%	µg/l
Ni	7.20	1.62	77.50%	µg/l
Pb	46.0	<0.2	>99.6%	µg/l
Zn	387	<2	>99.5%	µg/l
Chloride	1490	1.5	99.90%	mg/l
Sulfate	168	<0.50	>99.7%	mg/l
Ammonia	115	49	57.40%	mg/l
Alkalinity	225	180	20%	mg HCO_3/l
pH	8.4	8.7		
Conductivity	525	23.3	95.60%	mS/m

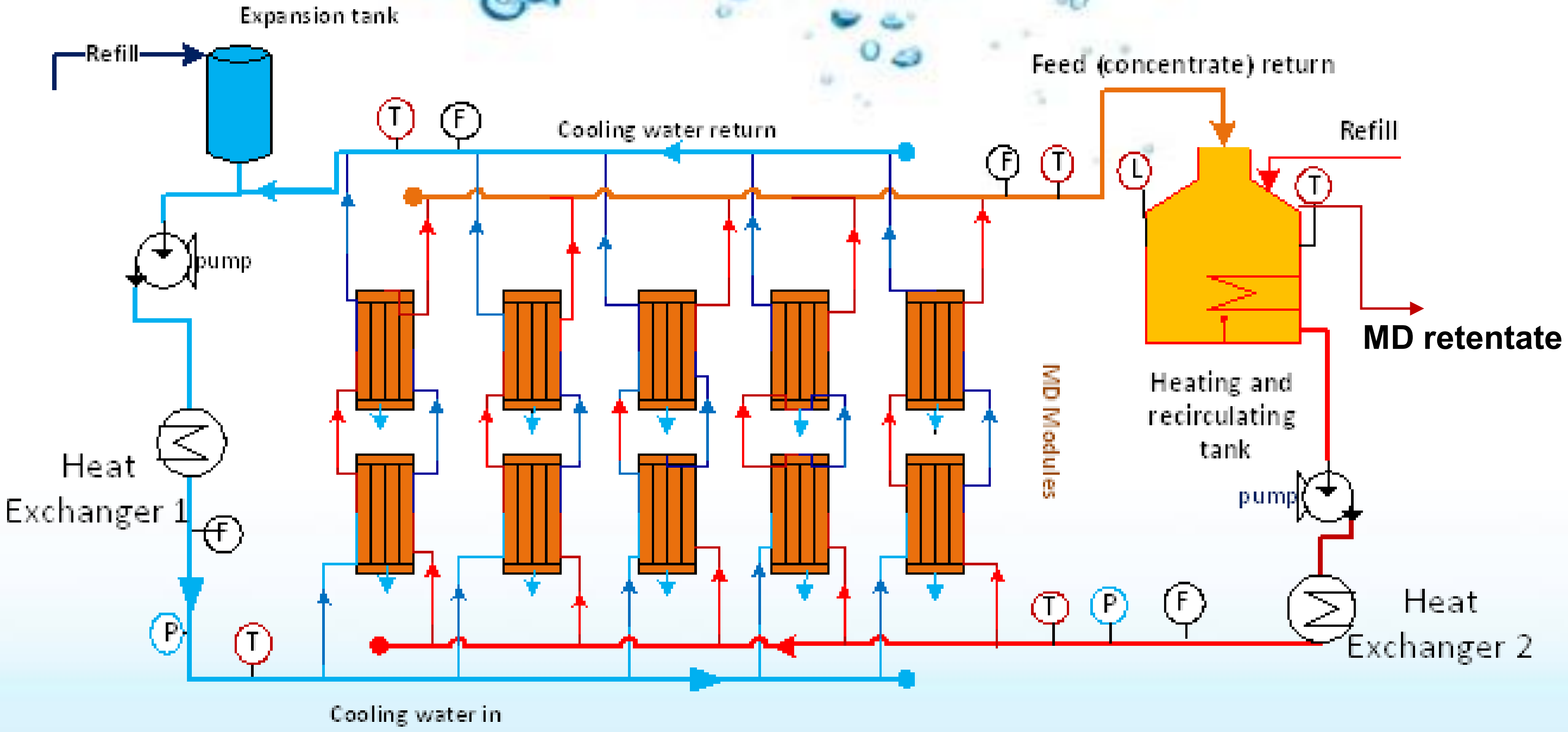
MD thermal energy demand



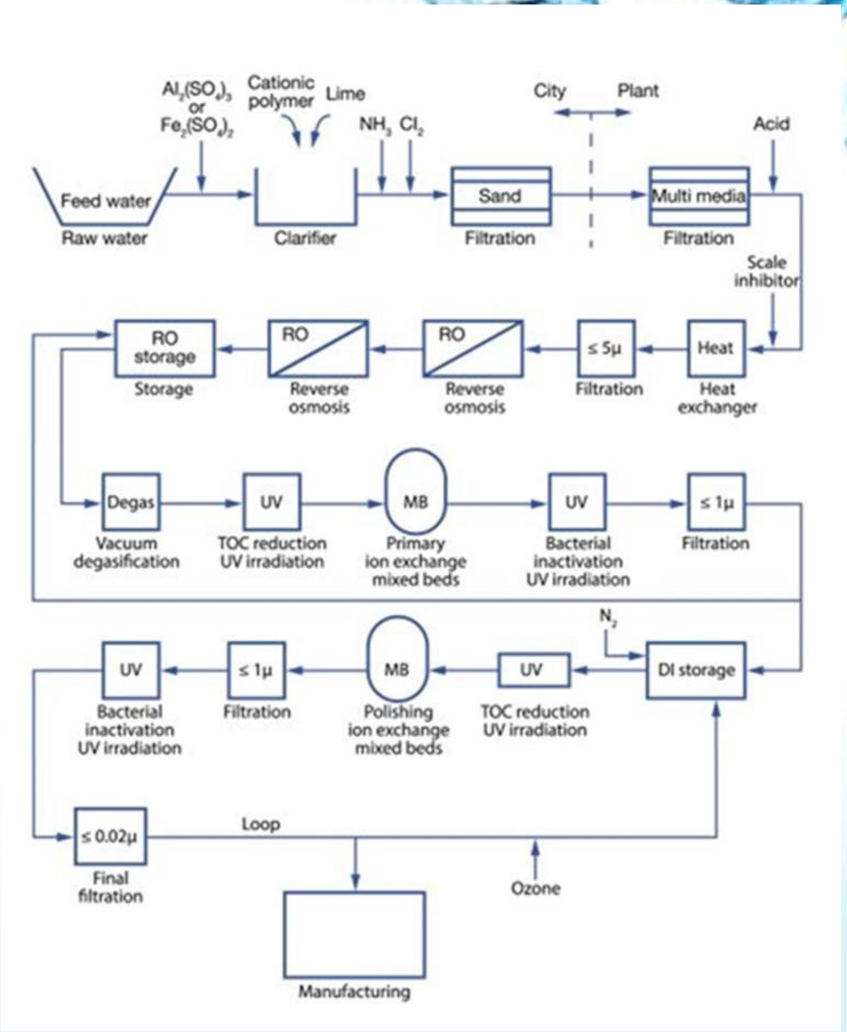
Configuration with the MD system placed between DH supply and return lines



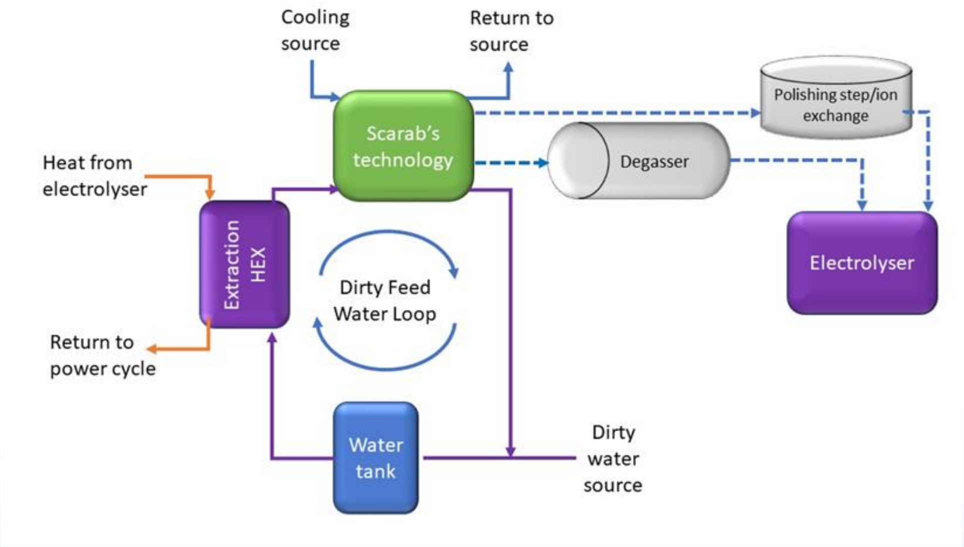
No. of MD modules connection and setup



Steps needed for conventional and MD treatment Technologies

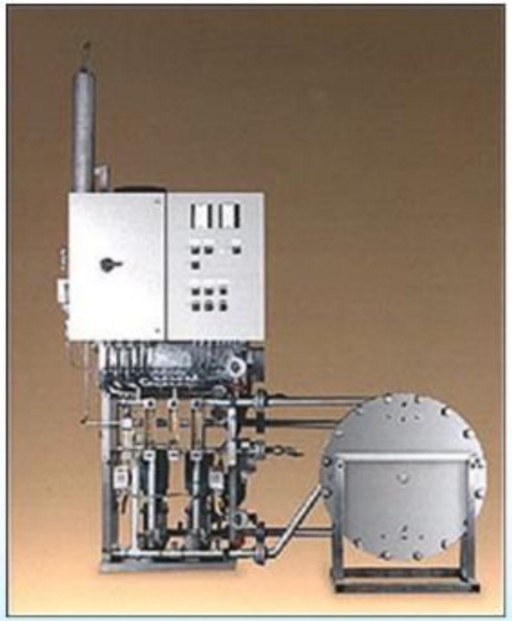


Typical upw plant



Our MD solution

Development of semi-commercial MD unit



Test unit with Sandia National Laboratories in Albuquerque, USA

Test unit in Jeddah, Saudi-Arabien . Brine concentration.

Test unit in Qatar.Treatment of produced water (contaminated water from oil and gas exploration) at the Global Sustainability Center (GWSC) at Qatar Science & Technology Park (QSTP).

Test and demonstration installation at Sjöstadsverket in Stockholm

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MODULAR CAPACITY

- Flat sheet AGMD module manufacturing,
- Product development for semiconductor market (UPW, IPA)
- Nanocap™

Generation 1


Demo – Stockholm, Sweden


Test – Jeddah, Saudi Arabia


Pilot – Doha, Qatar

Generation 2


Tests of LastRinse prototype in Xzero lab, Jan Coenen and Henrik Dolfe


Miriam Åslin shows samples for reference use


Prototype for LastRinse core

Generation 3

SMALL
CHEAP
LIGHT
ABILITY TO MASS PRODUCE

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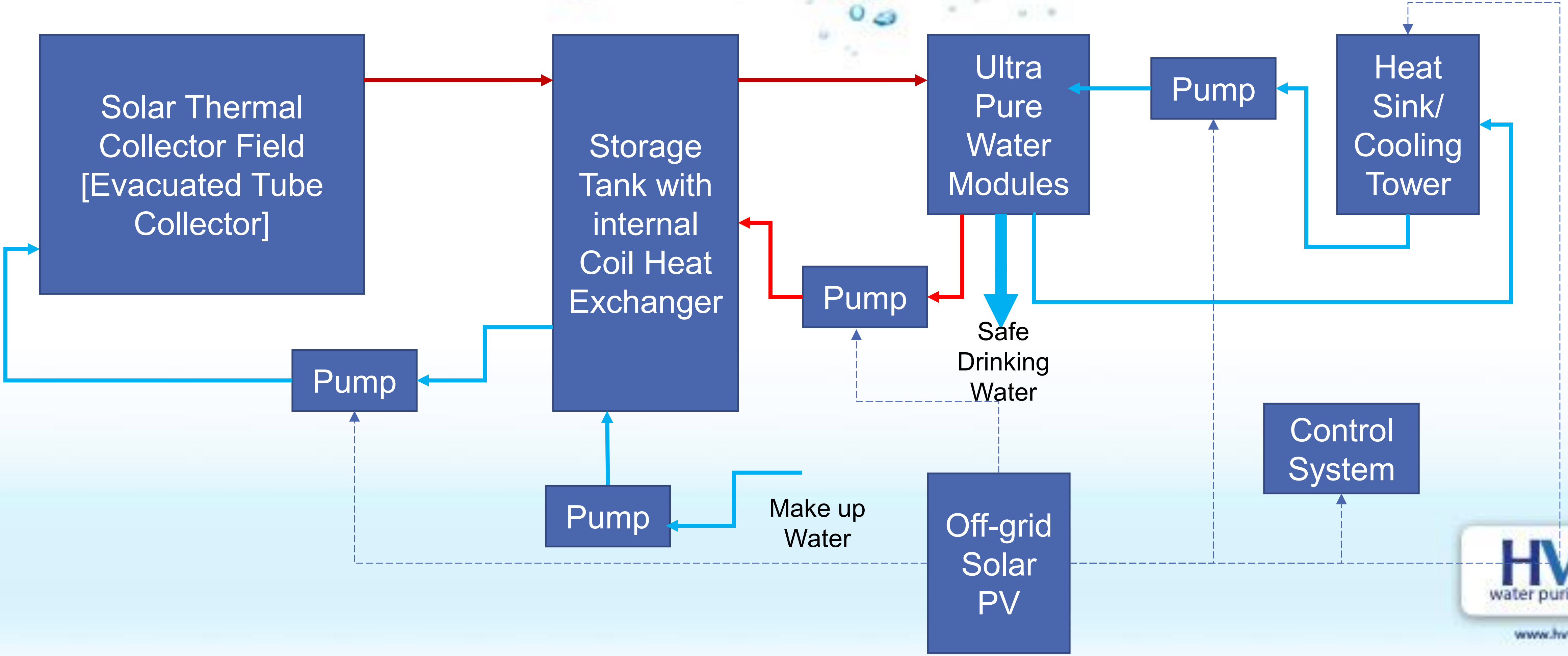
ODISHA PILOT

- Solar powered drinking water supply for a school of more than 200 children
- Removing fluoride from borehole water source
- Fully automated system

ODISHA Schematic



Thank you very much for your attention!