MEMBRANES TECHNOLOGIES FOR WASTEWATER TREATMENT AND UNRESTRICTED REUSE

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- **What kind of problems are we facing to days:**
- Pollution
- Clean Water crisis
- Wastewater Discharge
- Food Deficiency
- Famine
- Diseases resulted from contaminated drinking water and poor sanitation.

Deficiency of clean drinking Water OR any water

Collecting non-potable drinking water

Poverty, Famine and Deficiency of Food Supply

Hungry children searching for food in the garbage

Hungry children searching for food in the garbage

Hungry Child eating the waste

Poverty, Famine and Deficiency of medical care (absence of clean drinking water)

Dehydrated child in Africa, without any means of treatment

Dehydrated child in Africa

Death due to Hunger

Dehydrated Child

Pulitzer1994 KevinCarter

The PHOTO in the mail is the "Pulitzer prize" winning photo taken in 1994 during the Sudan famine. The picture depicts a famine stricken child crawling towards an United Nations food camp, located a kilometer away.

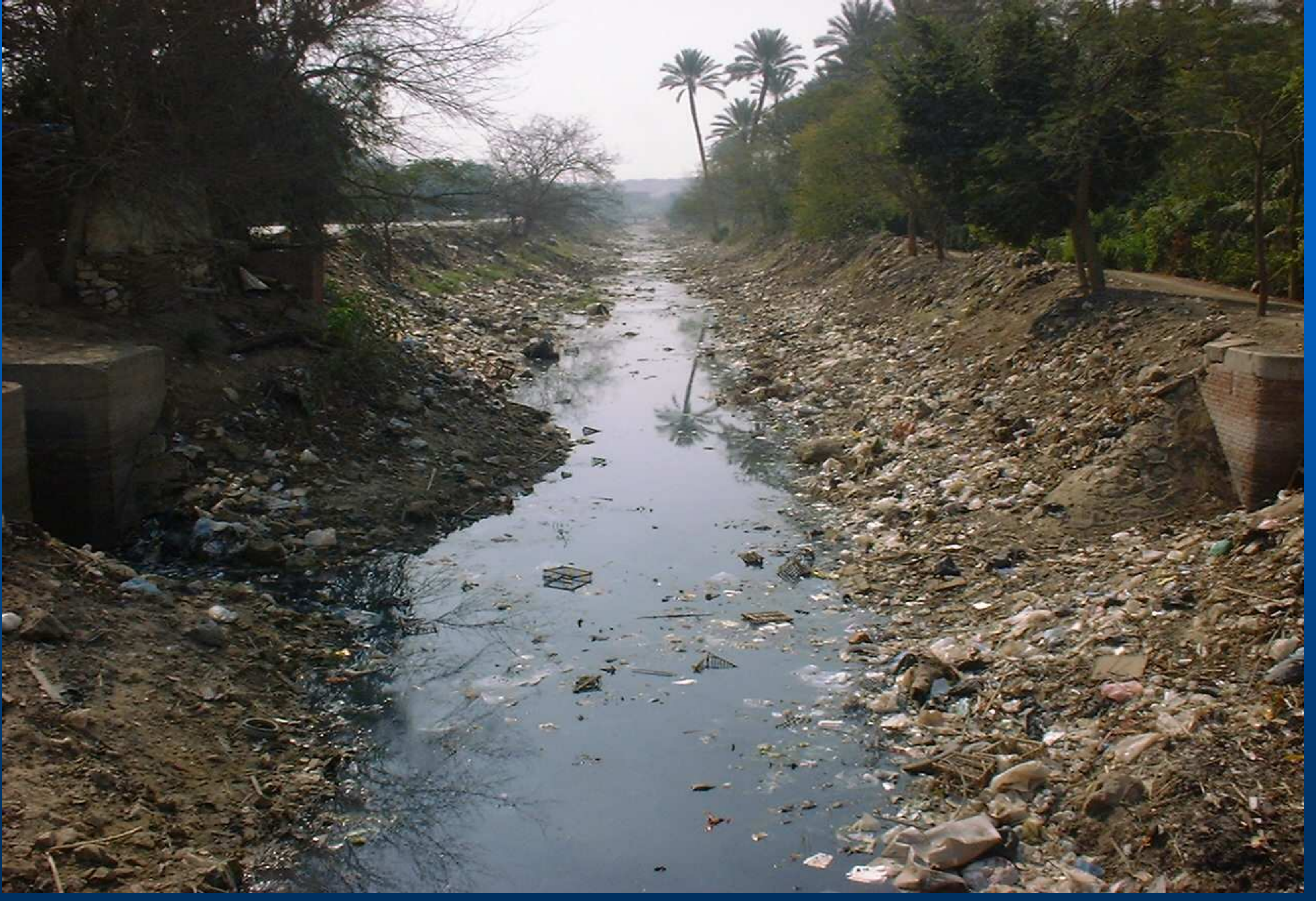
>The vulture is waiting for the child to die so that it can eat it. This picture shocked the whole world. No one knows what happened to the child, including the photographer Kevin Carter who left the place as soon as the photograph was taken.

>Three months later he committed suicide due to depression.

Where are going now

Innocent very sad child with no hope for any future

Deficiency of water for irrigation



Membrane Technologies for Wastewater Treatment

- MUNICIPAL WASTEWATER TREATMENT
- INDUSTRIAL WASTEWATER TREATMENT
- BRACKISH WATER TREATMENT
- DESALINATION
- MEMBRANE FOR FOOD PROCESSING

Global Water Resources

- ***Global fresh water consumption is doubling each 20 years, more than twice rate of human population growth.***

- **However, this vital resource is polluted and depleted at an astonishing rate.**
- **In order to avoid major world water crisis, alternative solution must be thought and implemented using water resources up to the maximum potential.**

- **Meanwhile, wastewater should be wisely treated and reused up the maximum possibility.**

- ***Employing reliable treatment technique is the major solution that must be considered and implemented to avoid water scarcity.***

- ***Membrane Technology is among the major solution that must be considered and implemented for the treatment of both water and wastewater.***

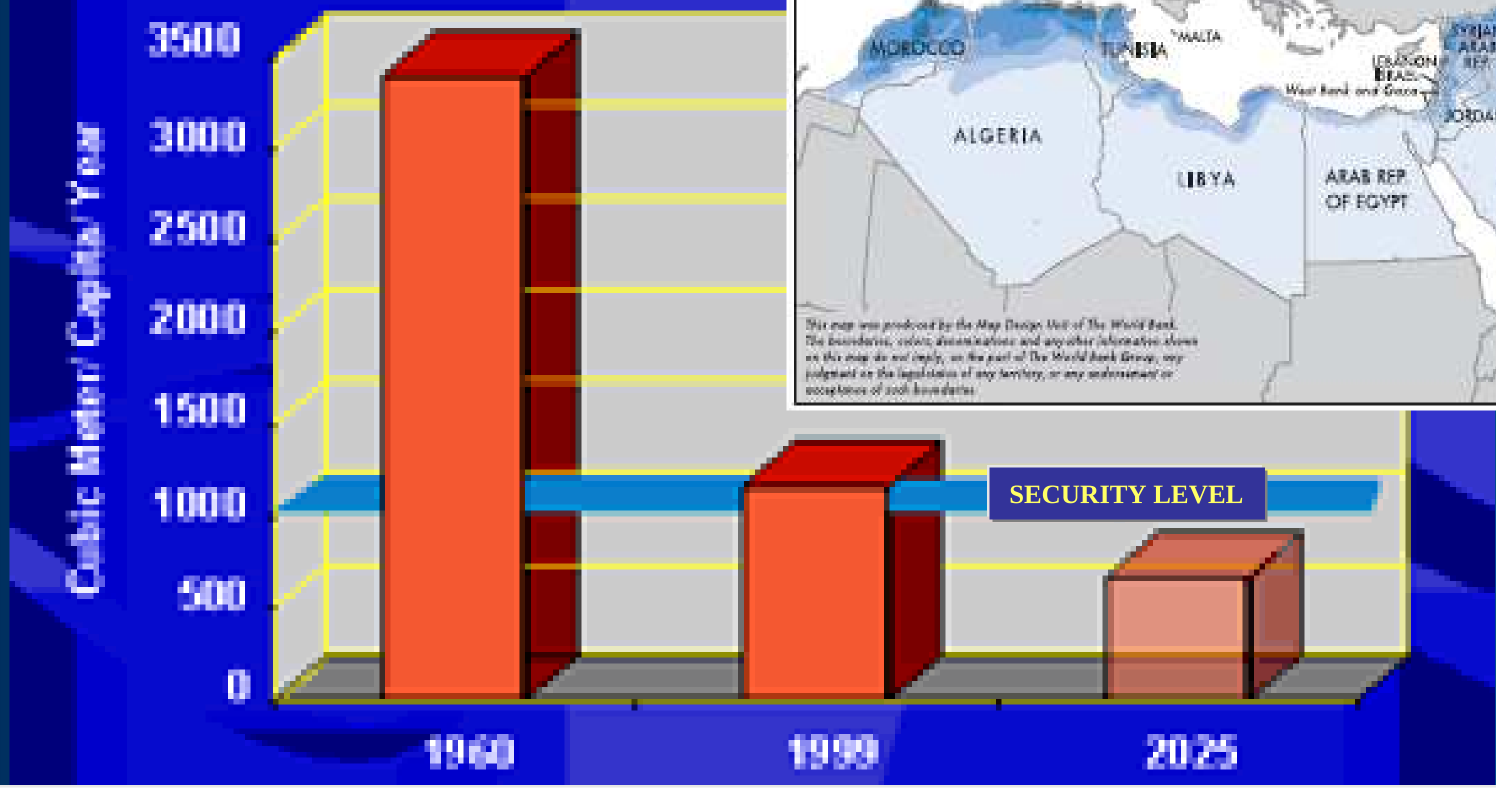
World water and <u>sanitation</u> crisis

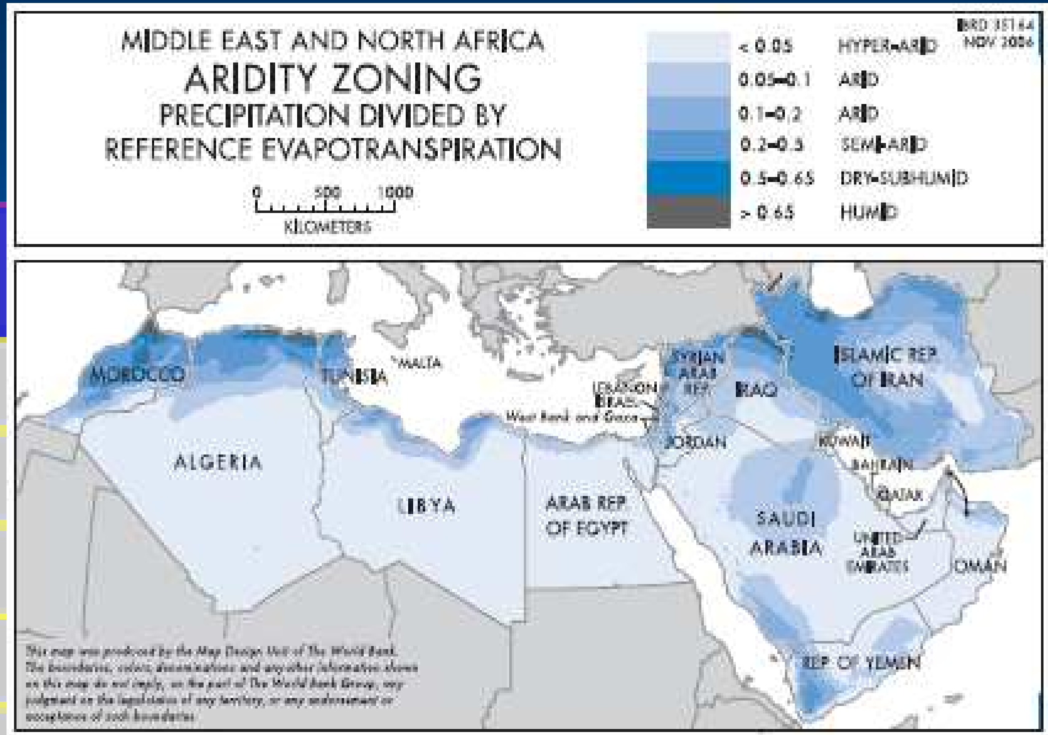
- **1.1 billion people around the world have no access to safe drinking water.**
- **2.4 billion people have inadequate sanitation and/or no means of wastewater disposal.**
- **Expected growth of the global population by another 2 billion people within the next 25 years needing clean water and sanitation (most of them are in the developing countries).**

World water and <u>sanitation</u> crisis

- **90 %** of **wastewater** worldwide is either **poorly treated or not treated** at all before discharge.
- 80 % of all diseases and 25 % of all deaths in developing countries can be attributed to polluted water (WHO).
- However, reuse of well treated WW has great advantages to avoid water scarcity.

Per Capita Water Availability in MENA Countries

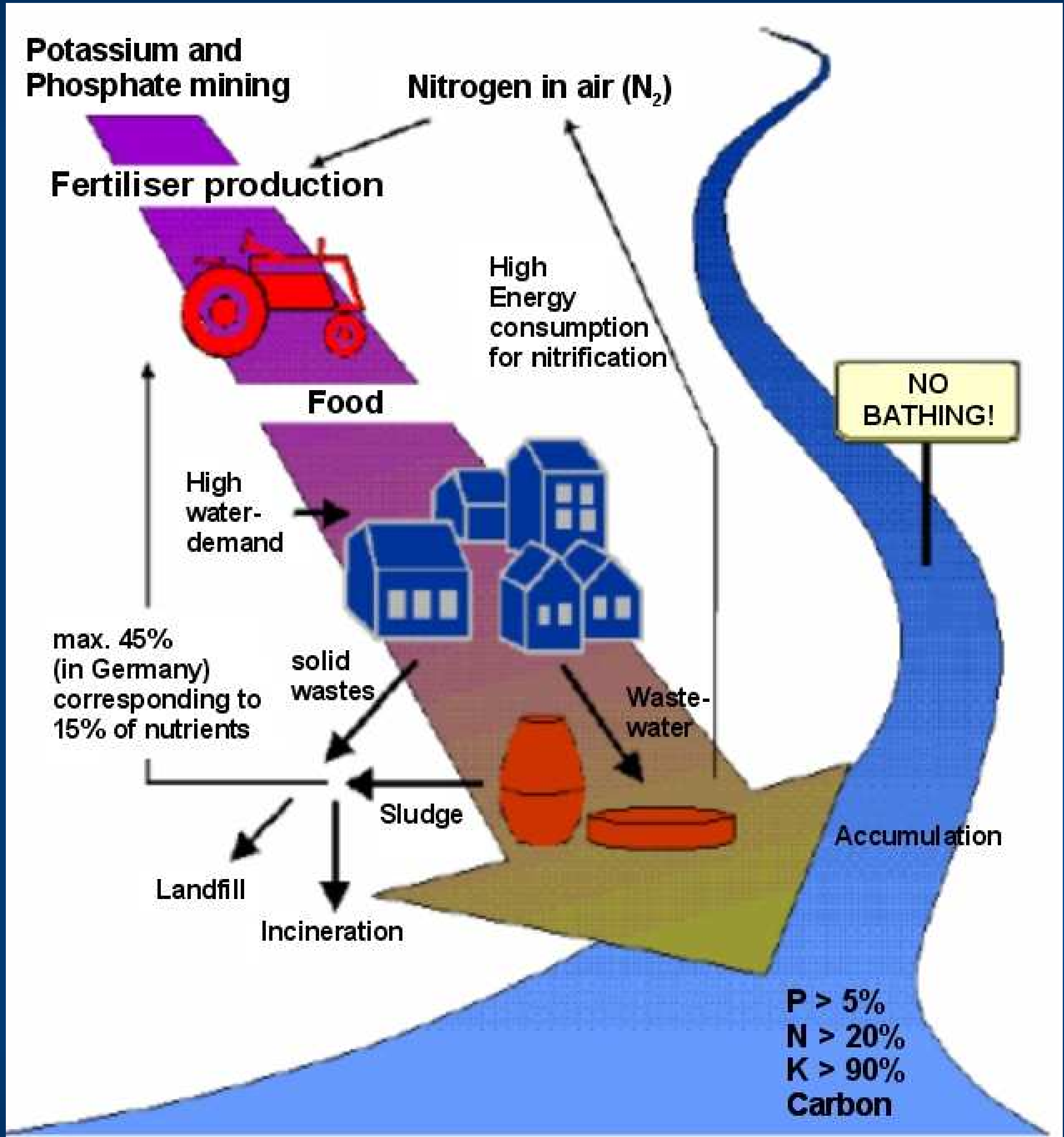




Today, average per capita water availability in MENA regions is ≈ 1,200 m³ per year (world average ≈ 7,000).

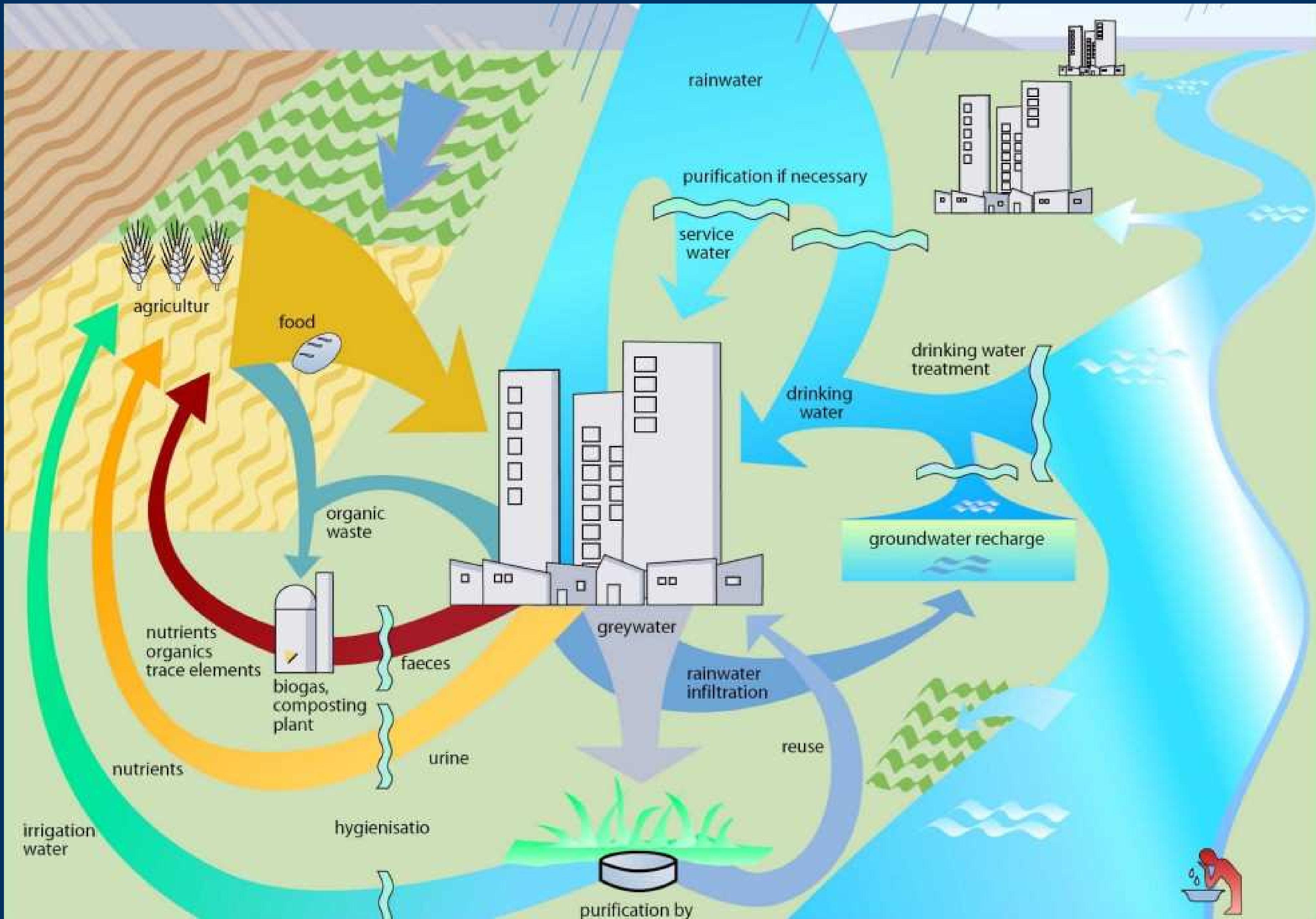
The annual water availability in these regions ranges from about 1,800 m³ per person in Iran to less than 200 m³ per person in Jordan, West Bank/Gaza, and Yemen. By 2025, the regional average water availability is projected ≈ 500 cubic meters/person/year (WHO, 2004).

http://www.promembrane.info/48.0.html



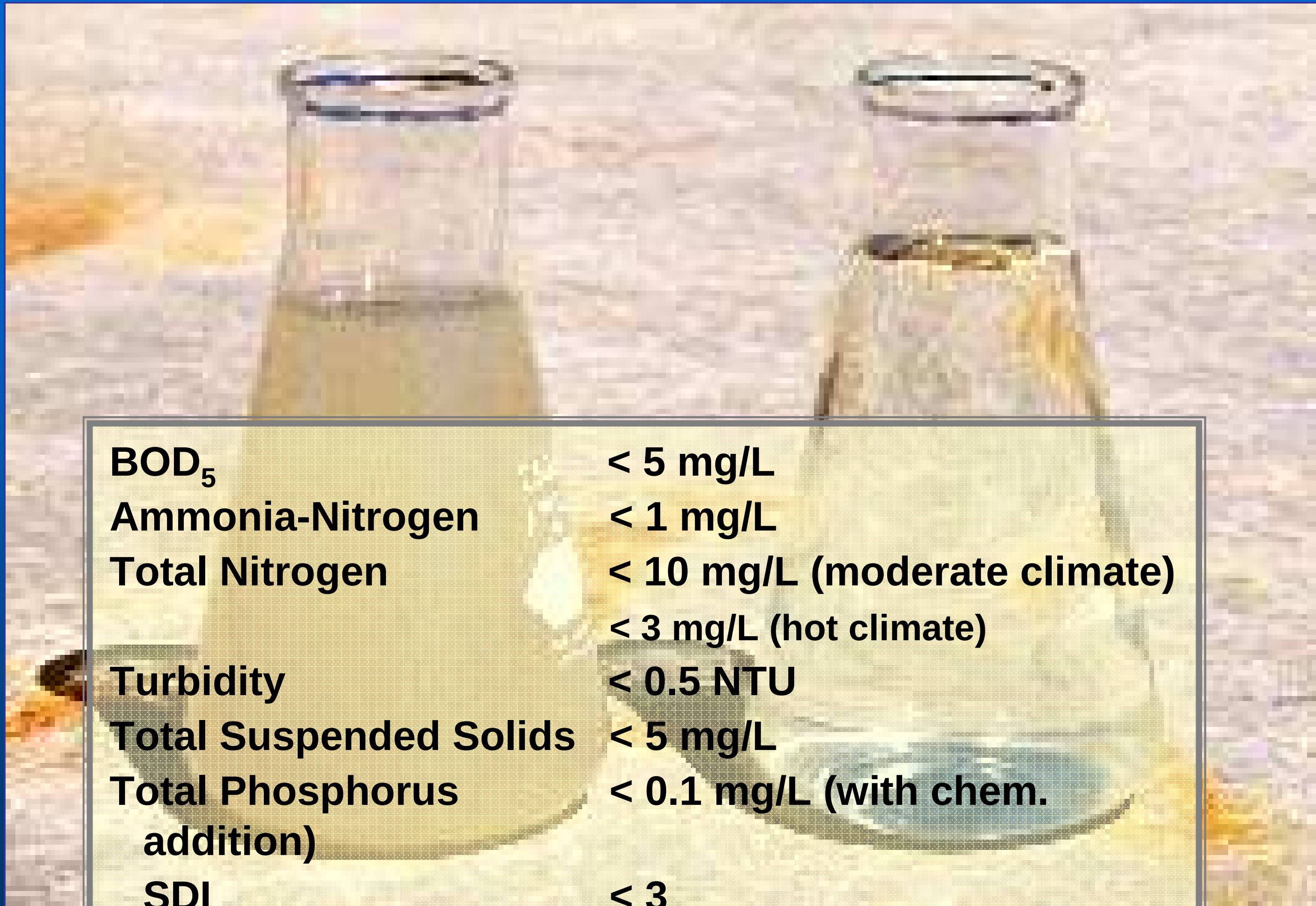
Potassium and
Phosphate mining
Nitrogen in air (N_2)
Fertiliser production
High
Energy
consumption
for nitrification
Food
NO
BATHING!
High
water-
demand
max. 45%
(in Germany)
corresponding to
15% of nutrients
solid
wastes
Waste-
water
Sludge
Accumulation
Landfill
Incineration
P > 5%
N > 20%
K > 90%
Carbon

Source GTZ



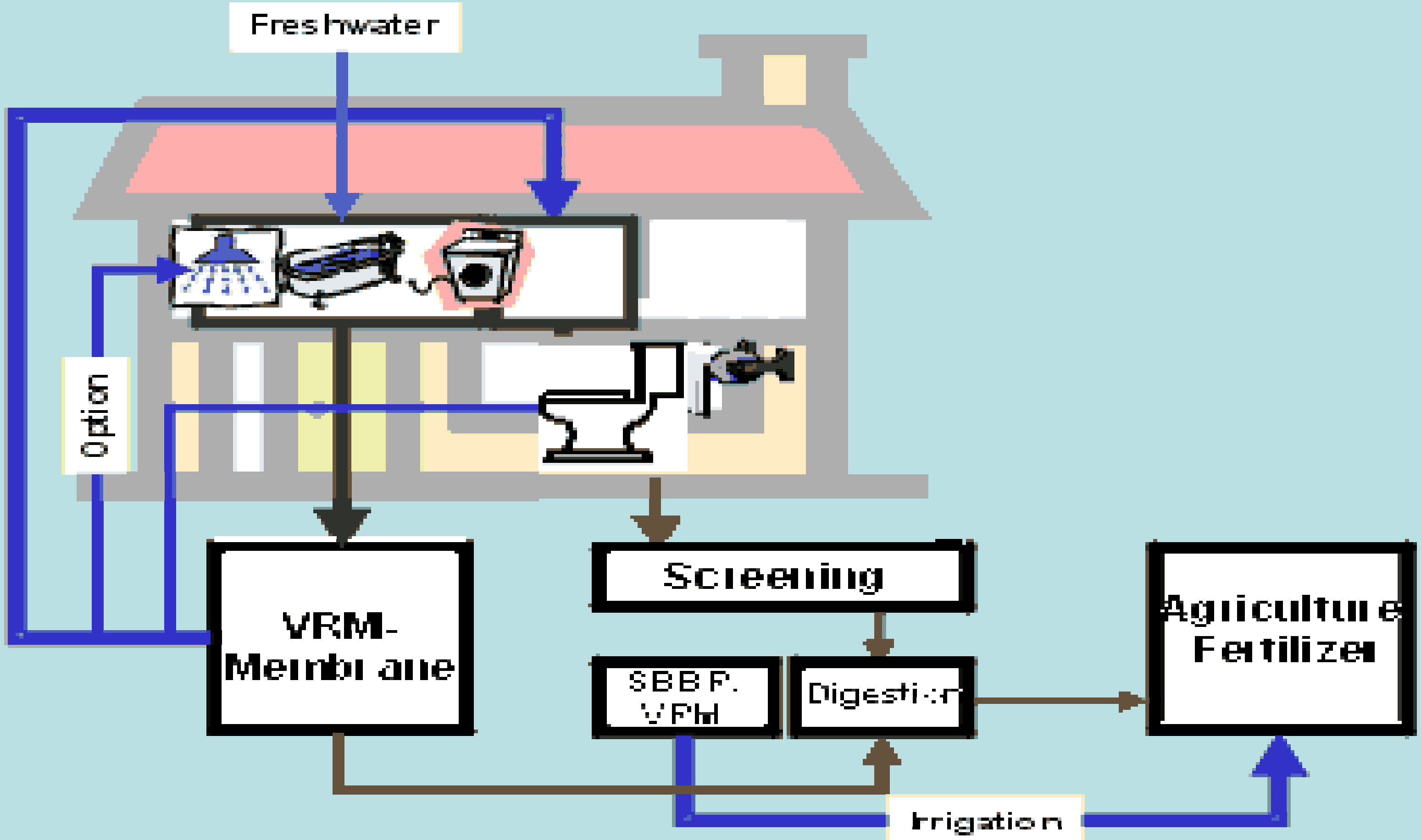
rainwater
purification if necessary
service water
agricultur
food
drinking water treatment
drinking water
organic waste
groundwater recharge
greywater
nutrients organics trace elements
faeces
rainwater infiltration
biogas, composting plant
urine
reuse
nutrients
irrigation water
hygienisatio
purification by

This is the Objective ! Effluent Quality



BOD_5	< 5 mg/L
Ammonia-Nitrogen	< 1 mg/L
Total Nitrogen	< 10 mg/L (moderate climate)
	< 3 mg/L (hot climate)
Turbidity	< 0.5 NTU
Total Suspended Solids	< 5 mg/L
Total Phosphorus	< 0.1 mg/L (with chem. addition)
SDI	< 3
Fecal Coliform	< 10 CFU/100 mL

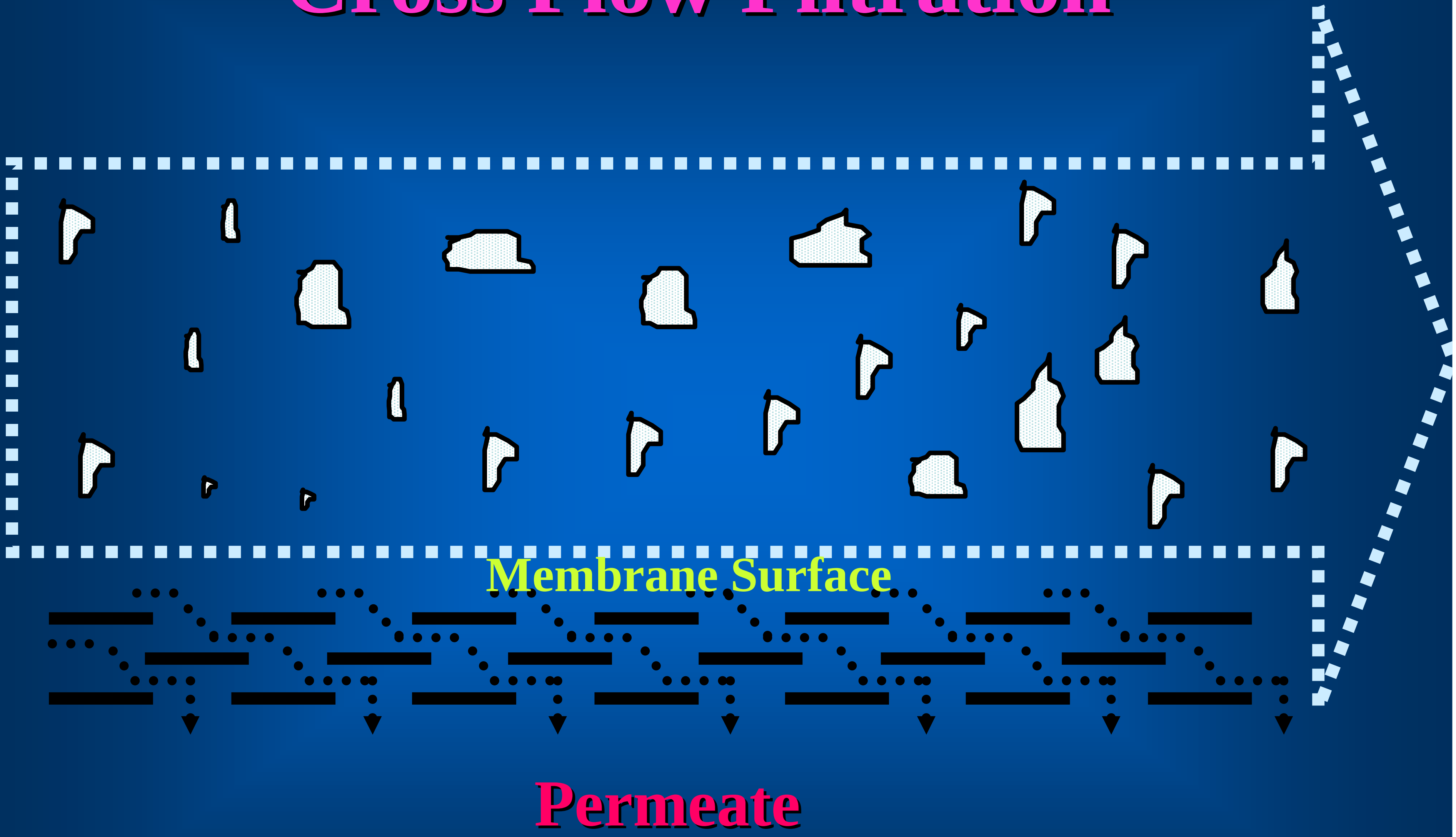
Membrane Technology represent a very promising process for clean and hygienic treated water



Definition

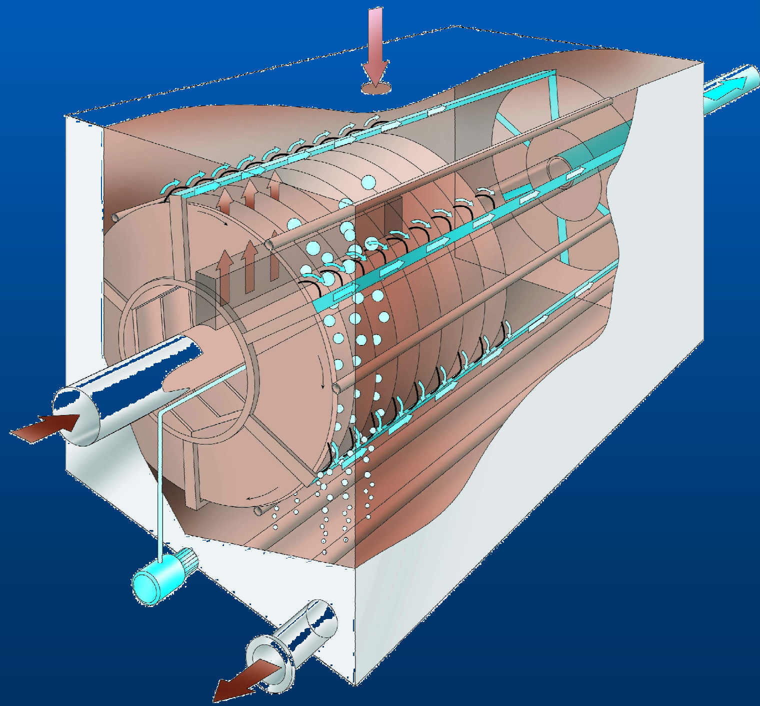
Membrane is a thin layer of material capable of separating substances when a driving force is applied across the membrane.

Cross Flow Filtration



Membrane technology

- Highly effective removal of soluble and biodegradable materials in wastewater stream.
- ***Selective permeable membrane (pore sizes < bacteria).***
- Treated water recycle potential for non-potable application.
- Compact, flexible system.

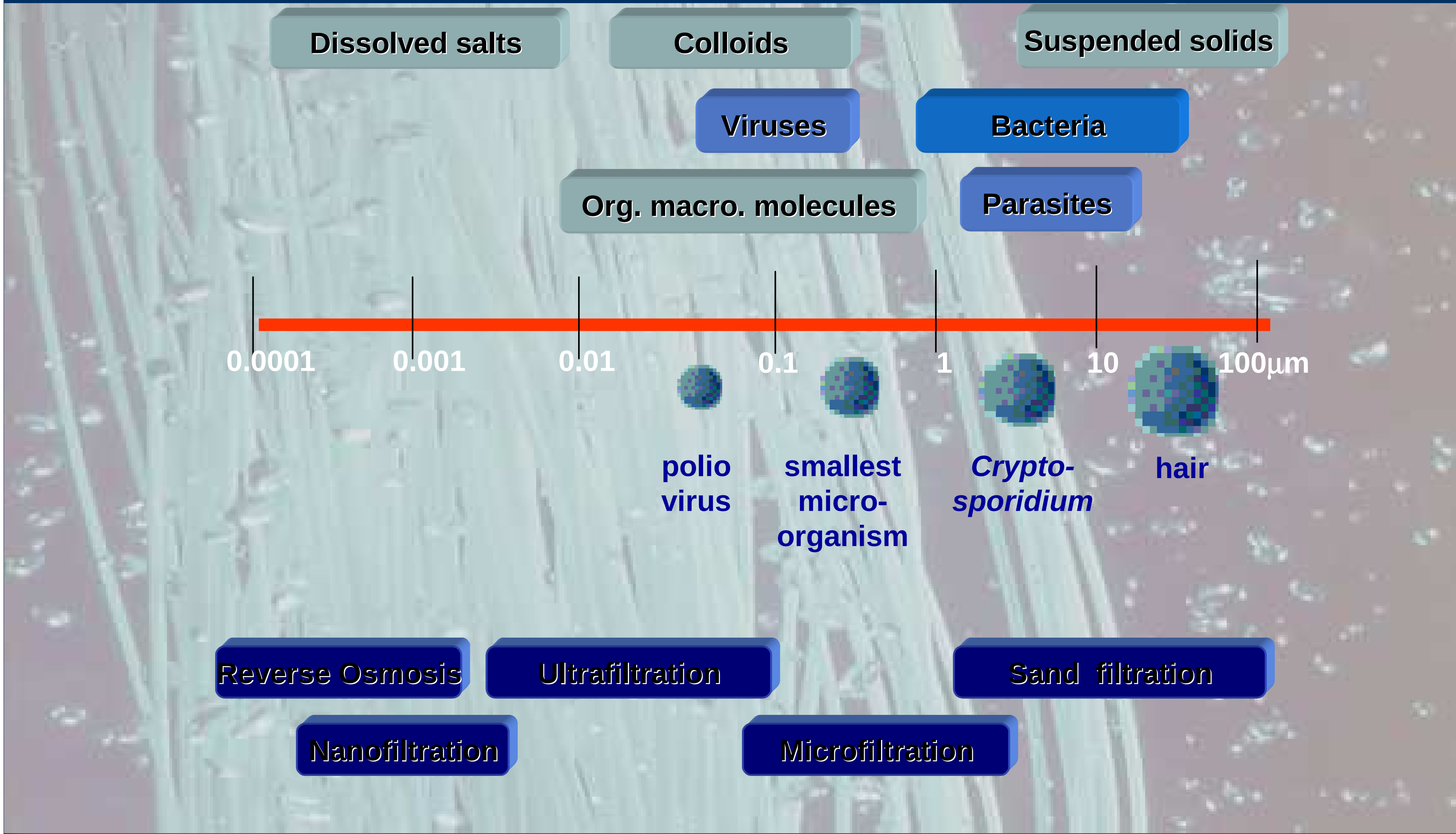


pathogens can be removed by MT
The Need for Membrane Filtration

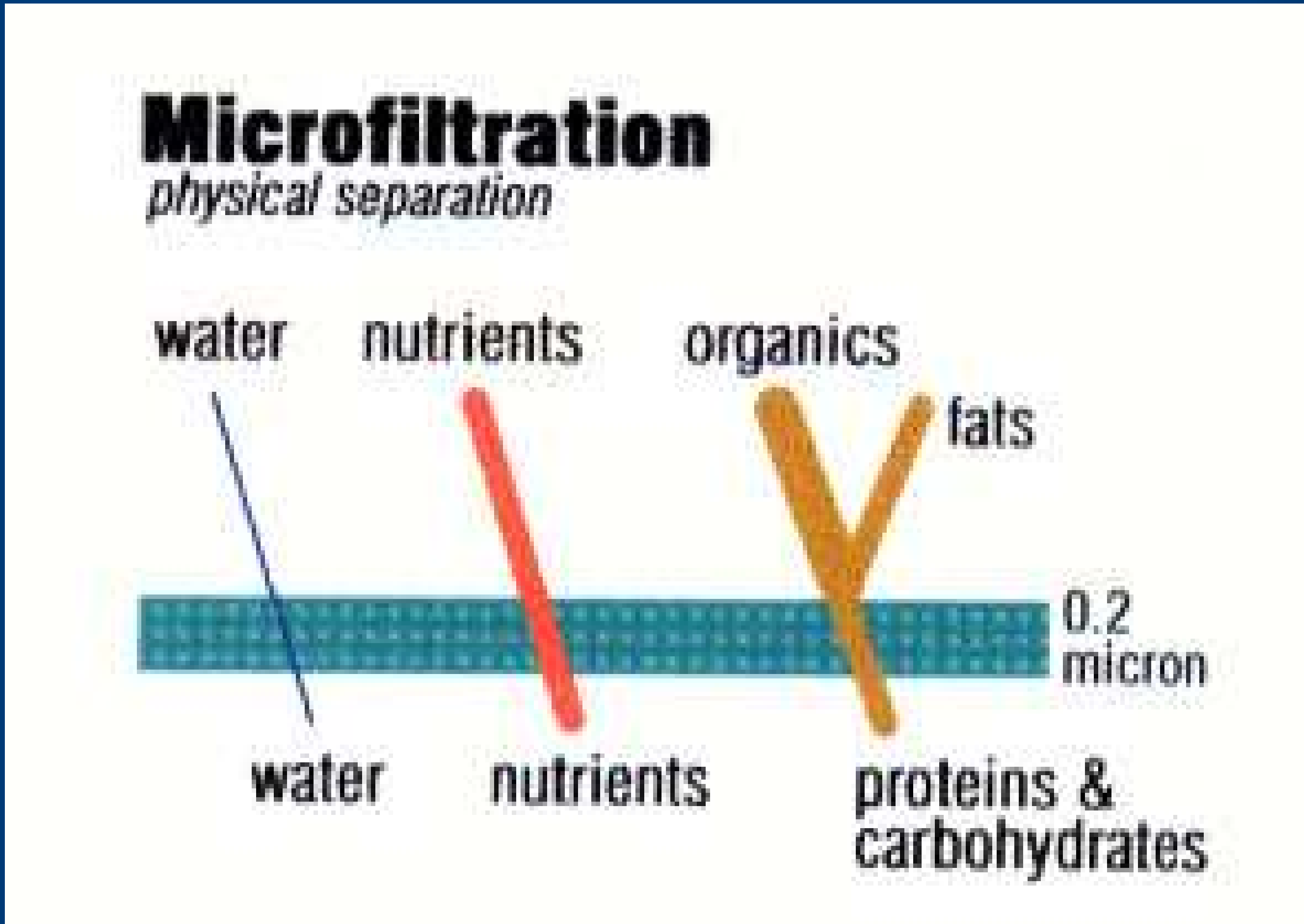
Cryptosporidium Parvum (2-5 µm)

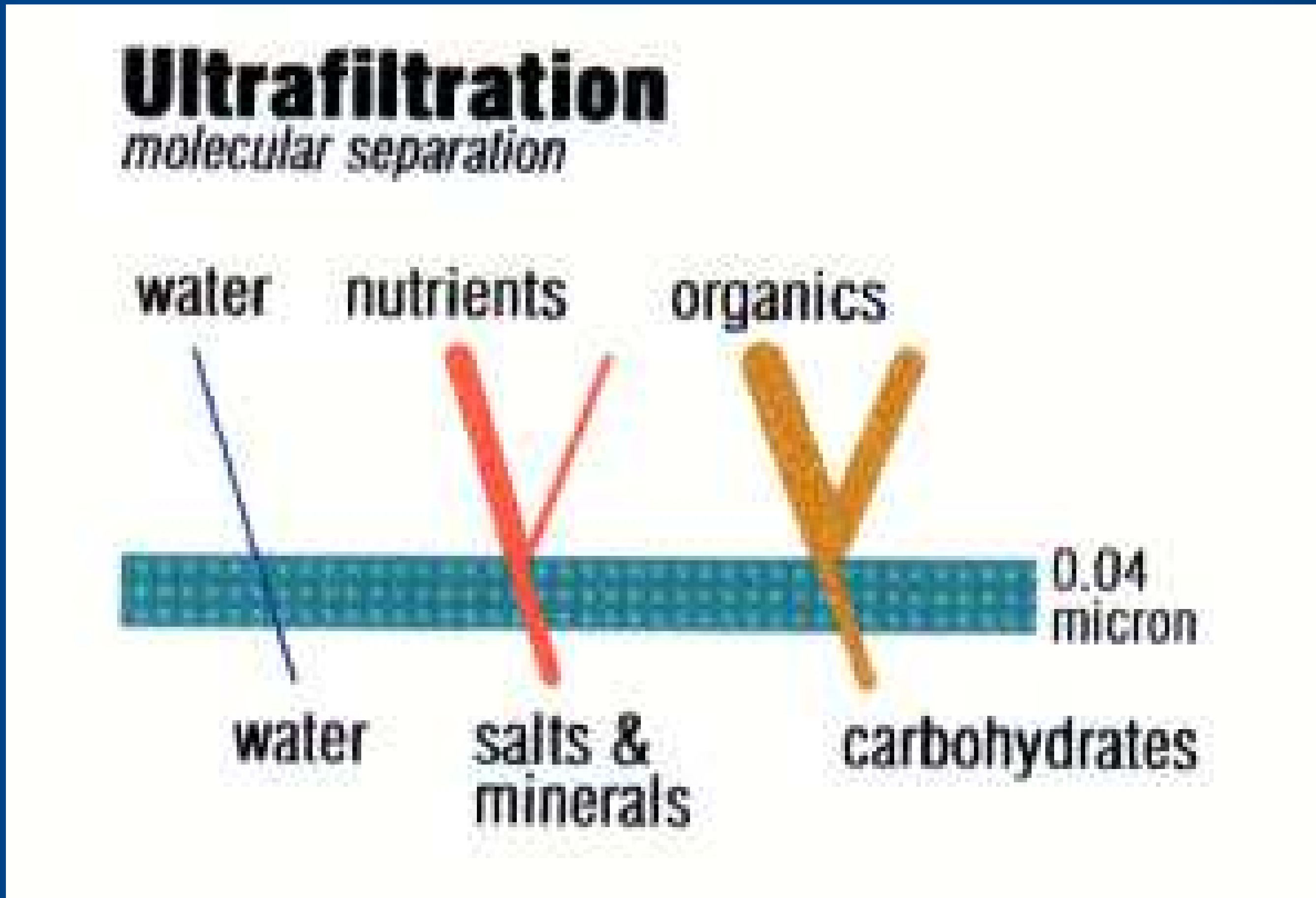
Giardia Lamblia (10-12 µm)

- **UF/MF removes pathogens**

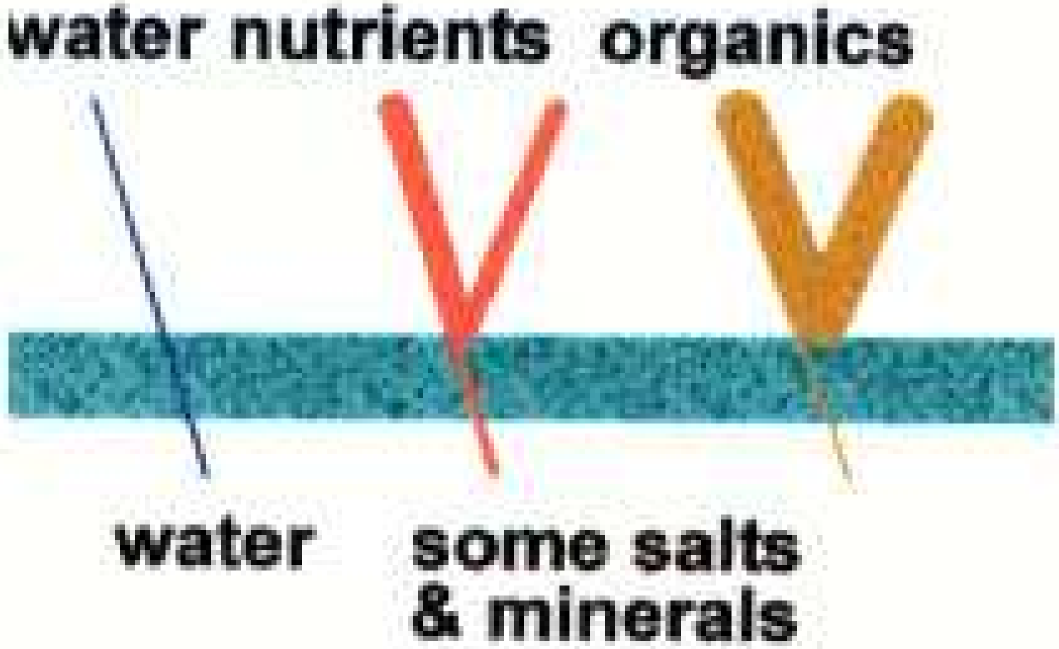


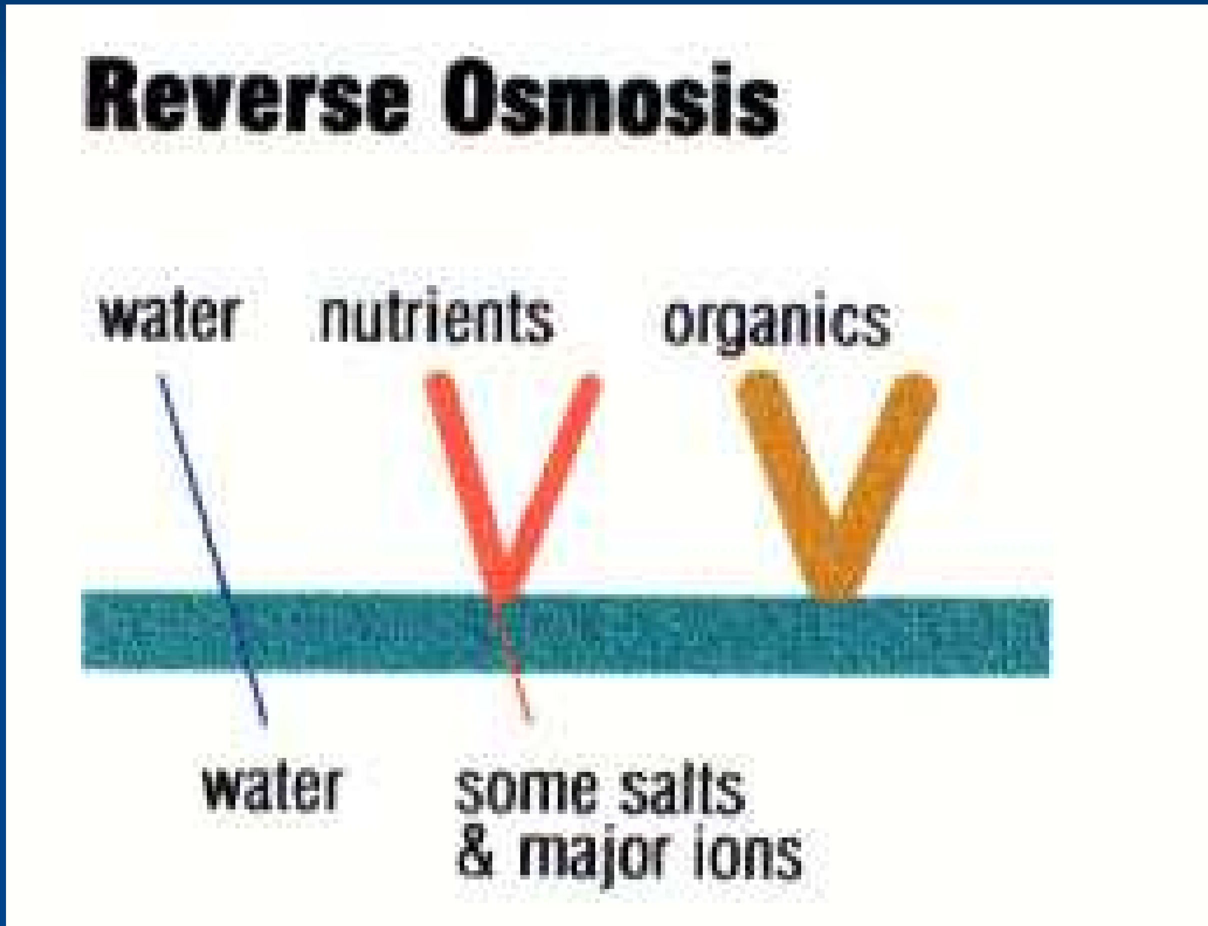
Membranes for Water Treatment


Microfiltration
physical separation
water
nutrients
organics
fats
0.2 micron
water
nutrients
proteins & carbohydrates

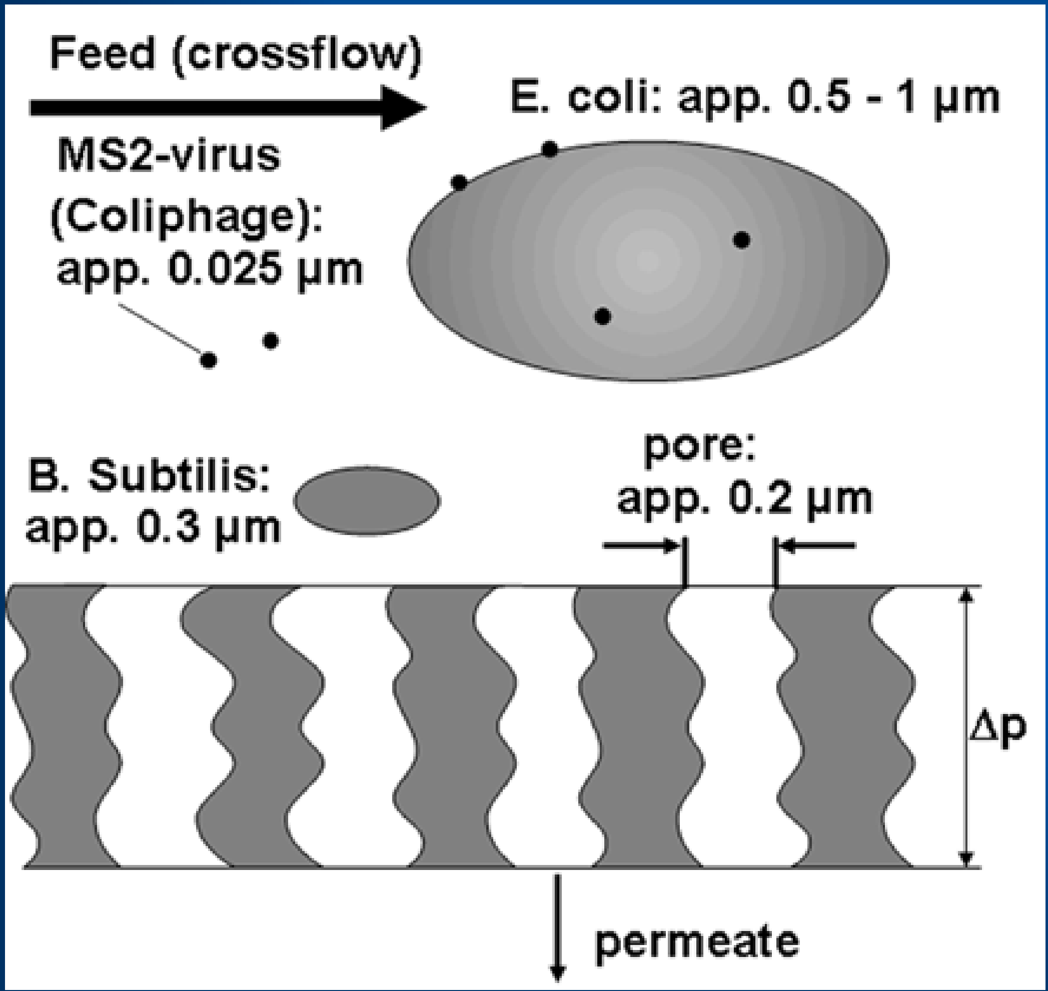

Ultrafiltration
molecular separation
water
nutrients
organics
0.04
micron
water
salts &
minerals
carbohydrates

Nanofiltration




Reverse Osmosis
water
nutrients
organics
water
some salts
& major ions

Membrane selection



Membranes:

Micro- or ultrafiltration

hydrophilic material

Typical pore sizes:

0,02 - 0,4 µm

Operation:

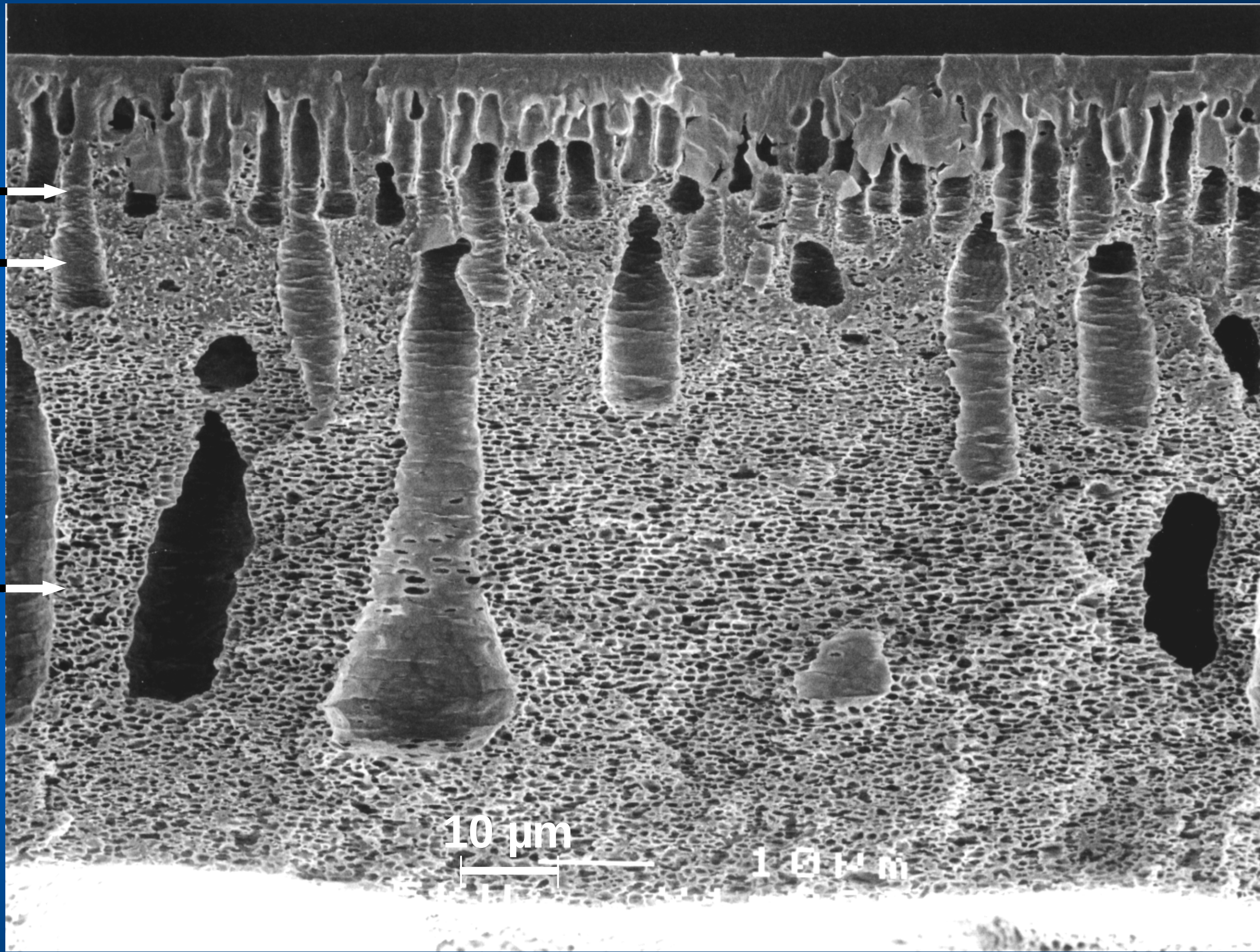
Parallel flow to membrane surface (**crossflow**) necessary to remove particles

Nanofiltration membrane

top layer 0,5 - 1 µm

narrow pores

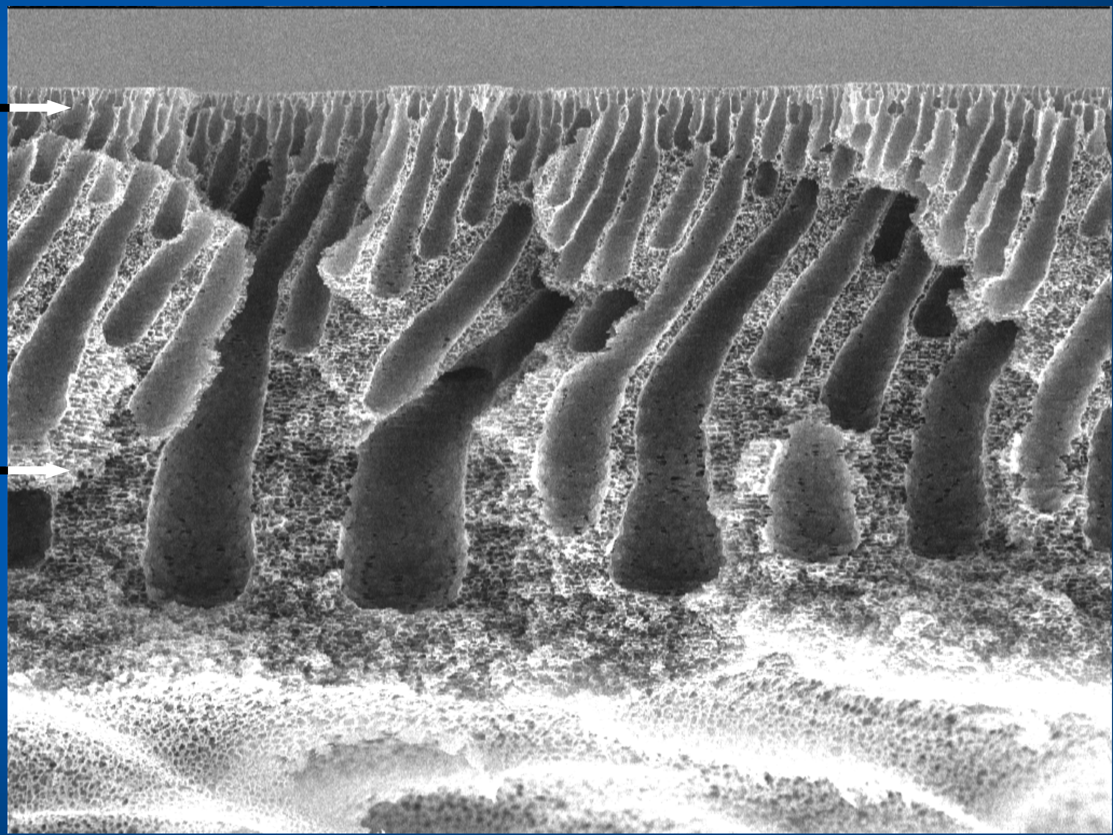
wide pores



Ultrafiltration membrane

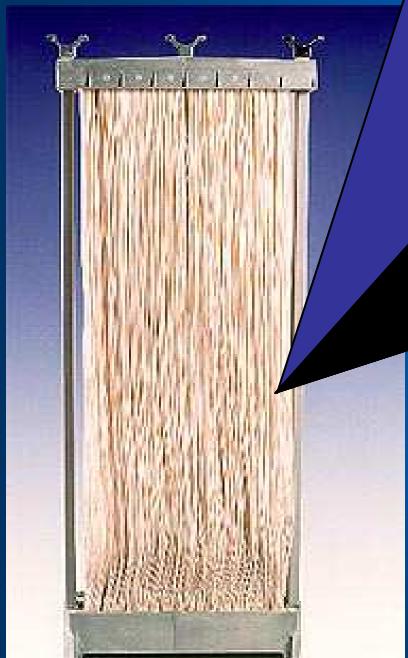
narrow pores

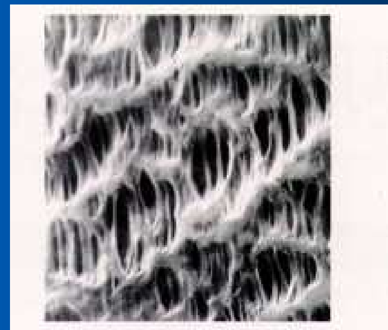
wide pores



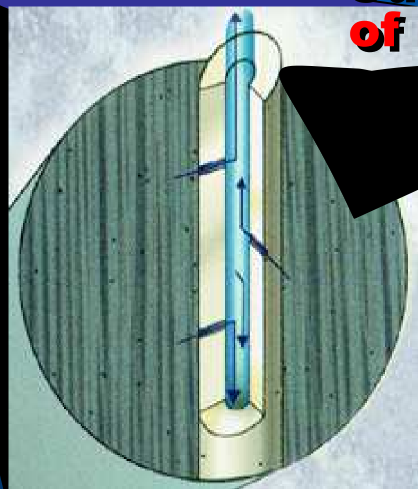
A membrane separates water from wastewater by filtration

Hollow fiber shape



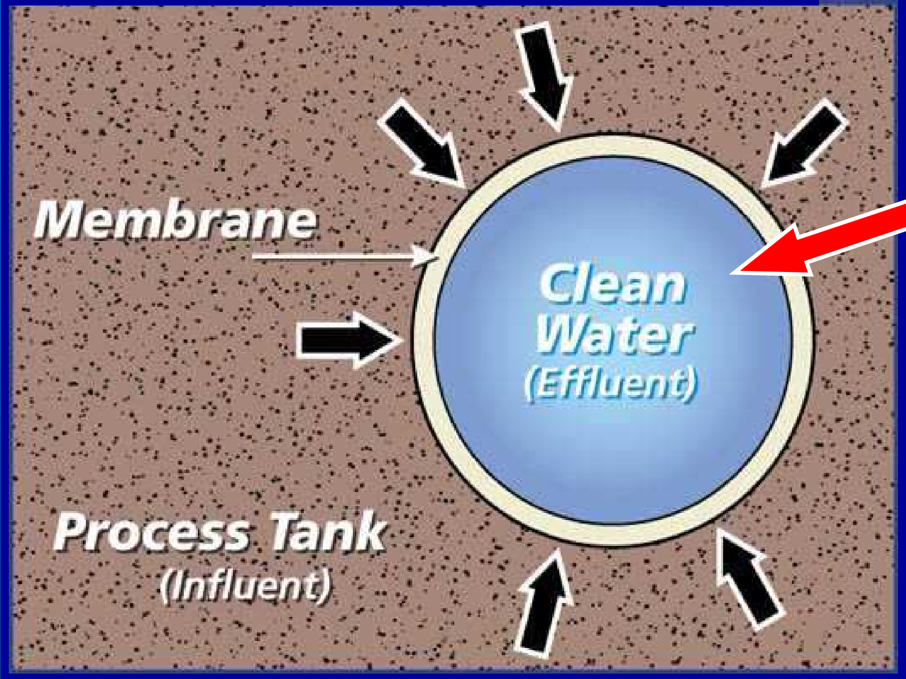


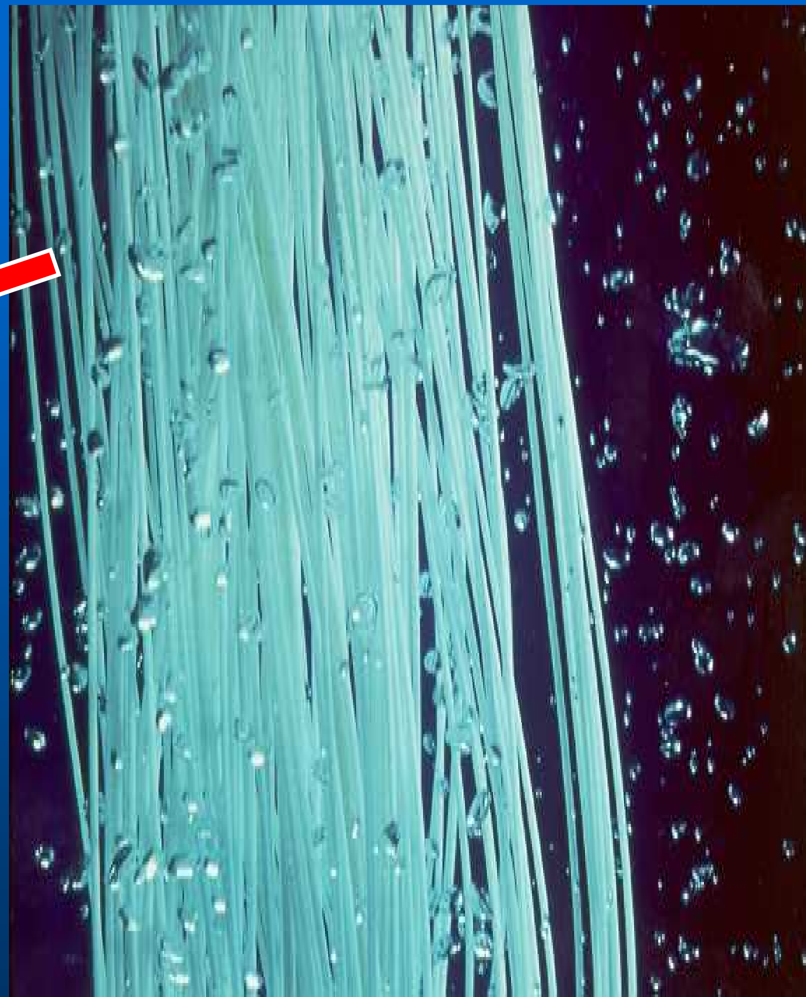
Outer surface of membrane



The Immersed Hollow Fibre

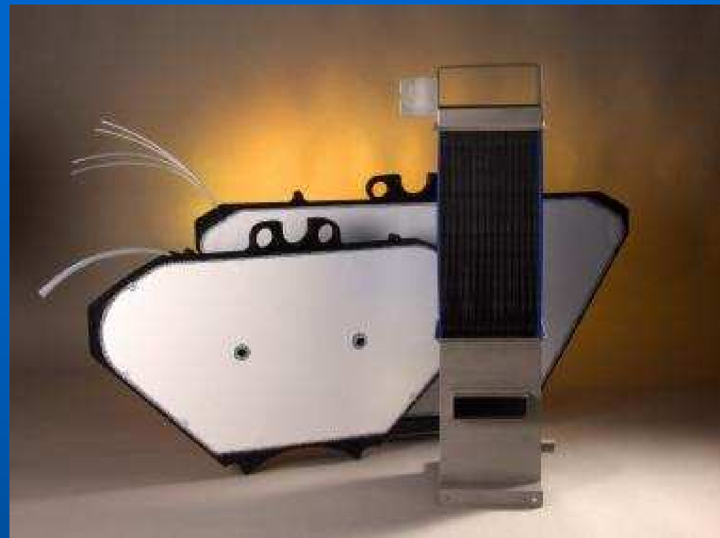
Membrane Fibre Cross-Section





Main Fields of Application for Membrane Technology

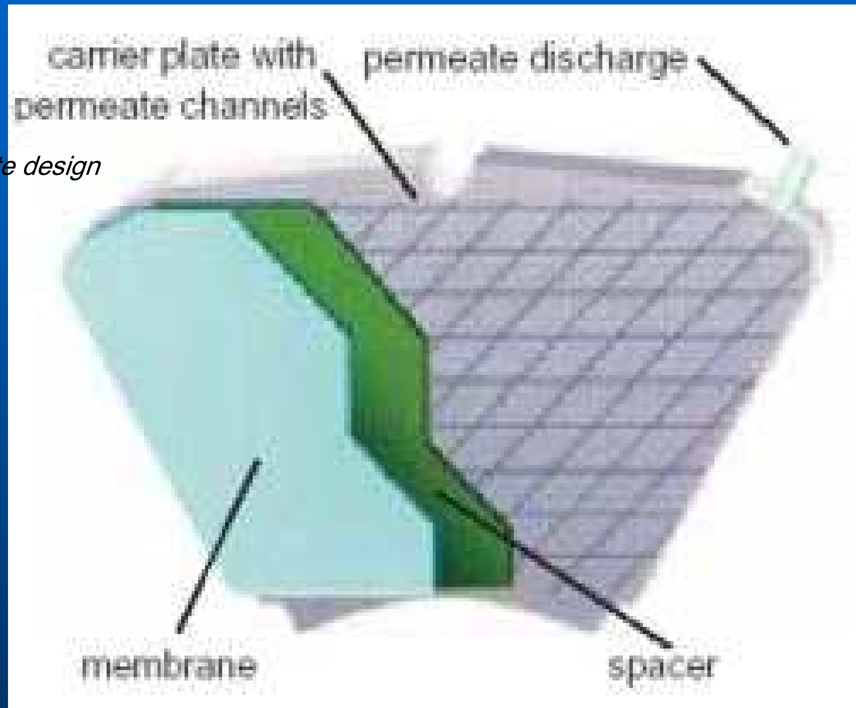
- Wastewater treatment
- Potable water treatment
- Exhaust air treatment
- Fuel cell
- Industrial applications:
  - Pharmaceuticals industry
  - Chemical industry
  - Food industry
  - etc.



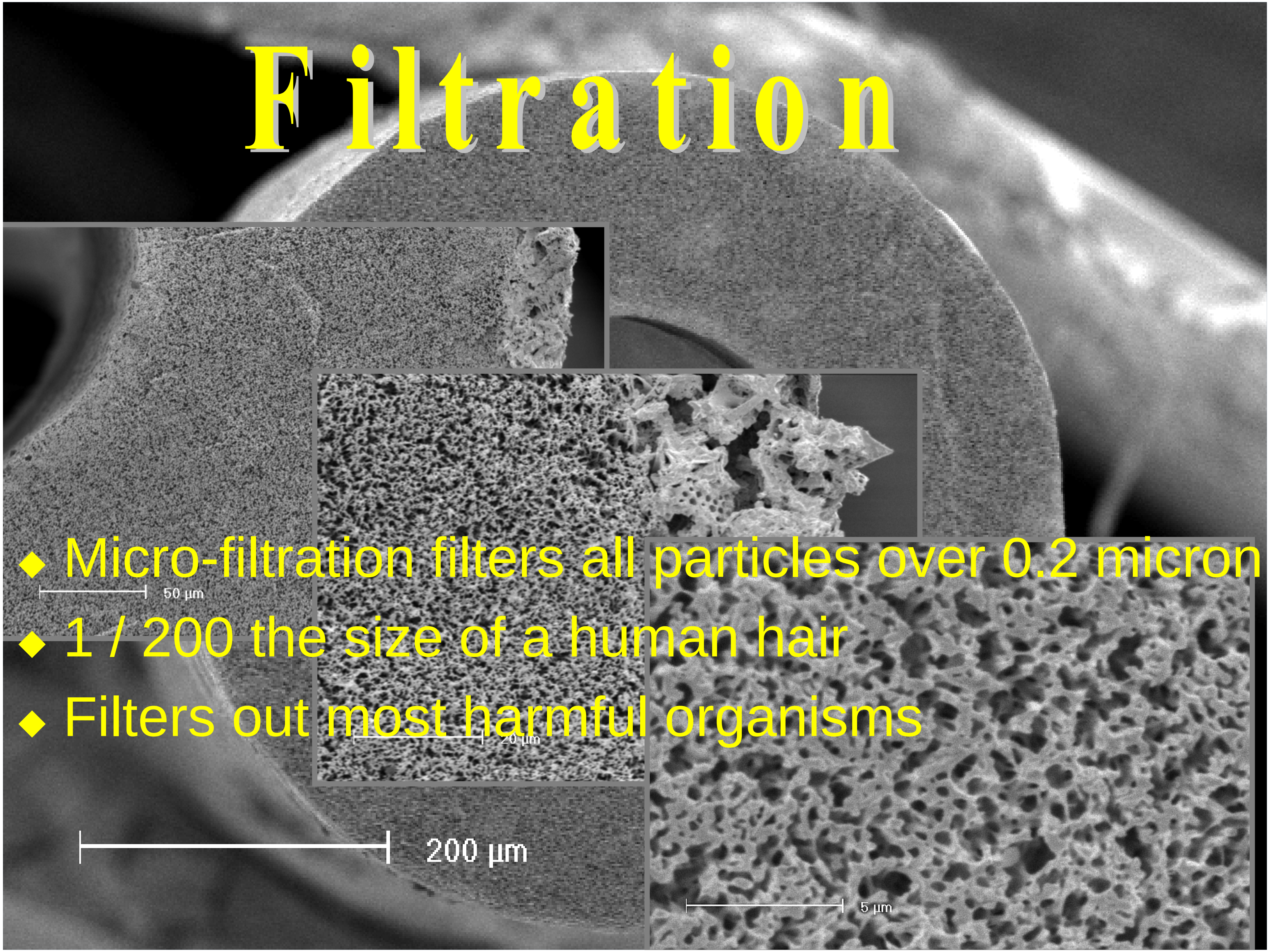
The MBR Unit can be integrated into existing concrete tanks, steel tanks or container units.

MBR 20 module with 3 m² filter surface Membrane plate design

Membrane plate design



Filtration



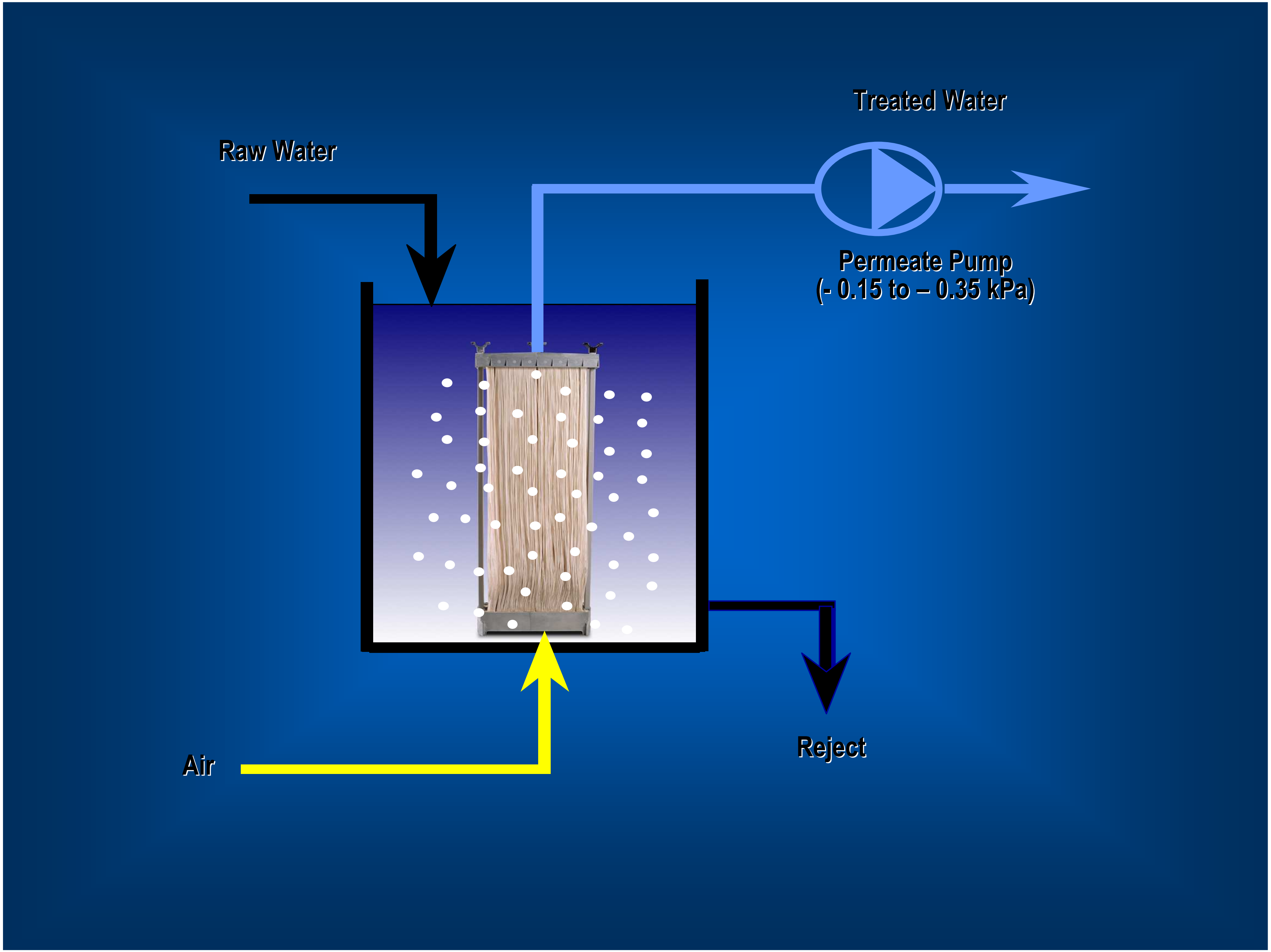
- Micro-filtration filters all particles over 0.2 micron
- 1 / 200 the size of a human hair
- Filters out most harmful organisms

Competitive Equipment is available

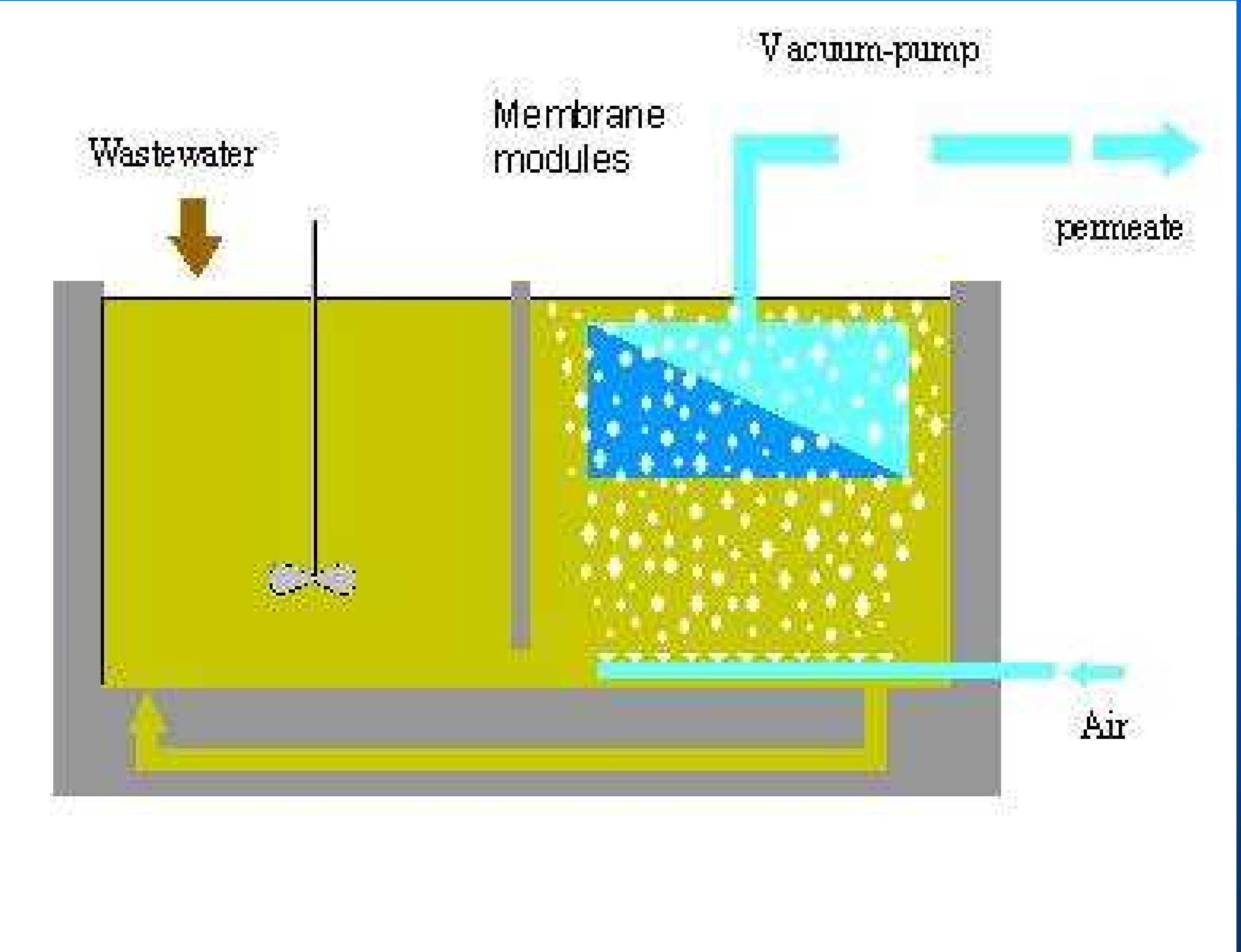
- Zenon
- U.S. Filter
- Kubota
- Mitsubishi-Rayon
- China
- India

The areas of competition are:

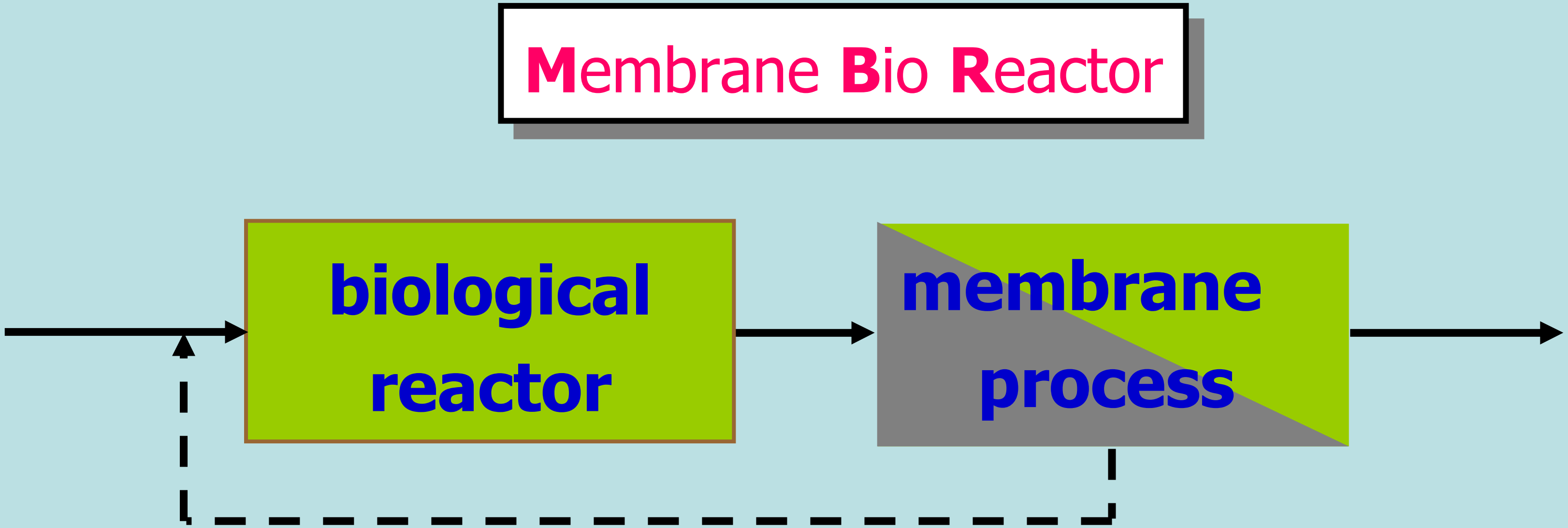
- Capital, operating, and life-cycle cost
- Configuration and size
- Cleaning systems
- History and projected life of the membrane equipment
- Experience with using the equipment in comparable applications


Treated Water
Raw Water
Permeate Pump
(- 0.15 to – 0.35 kPa)
Air
Reject

Membrane bioreactor with submerged modules



What is an MBR?



combination of a biological reactor and a membrane process to retain the biomass

- keep biomass in the biological reactor (reactor performance)
- mechanical disinfection (effluent hygienic quality)

The advantages and disadvantages of MBRs

Advantages

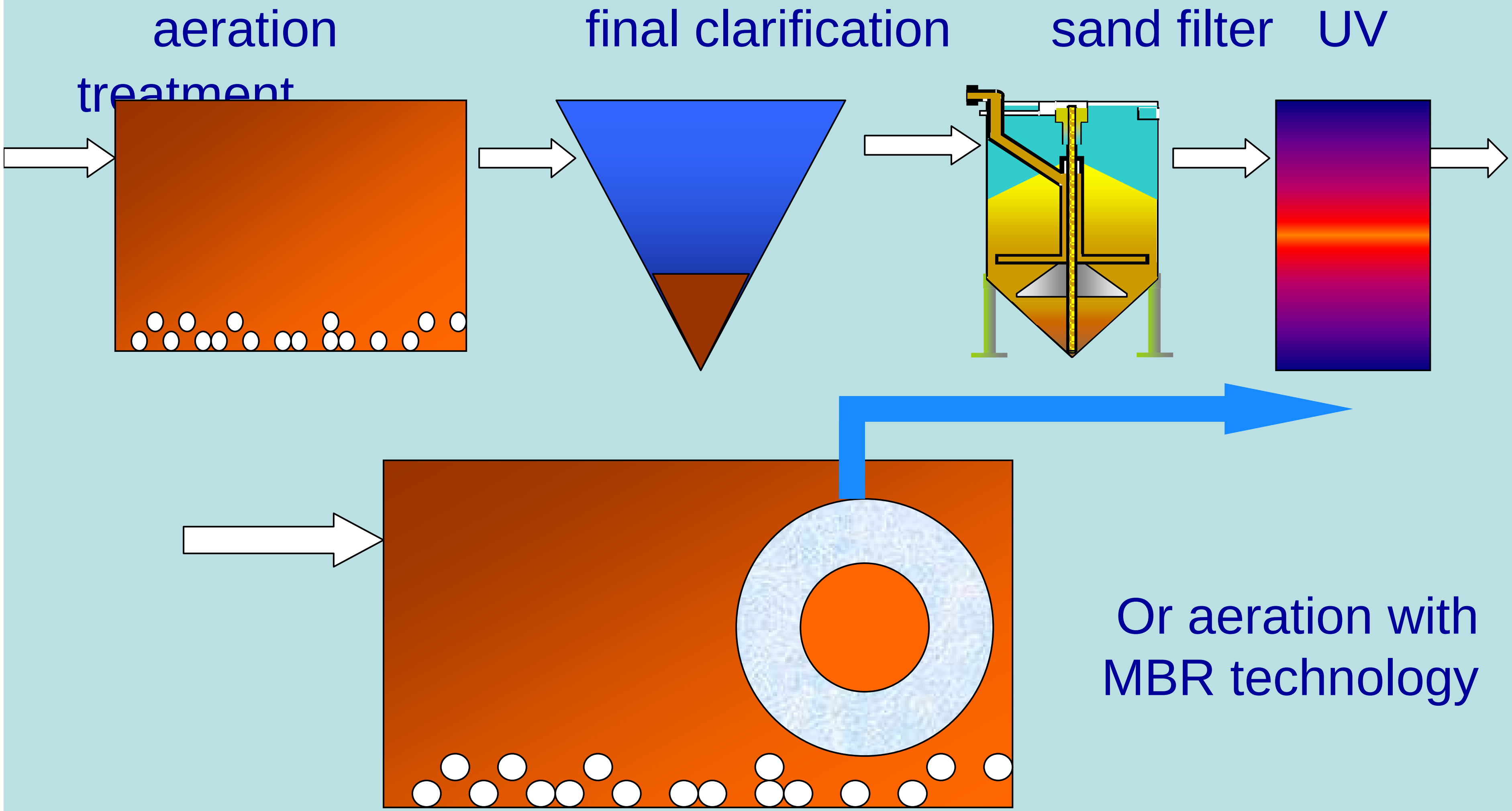
- Good effluent quality with high hygienic standards
- High possible biomass concentration (10-25 g MLSS/L)
- Reduced reactor volume and footprint
- Reduced net sludge production

Disadvantages

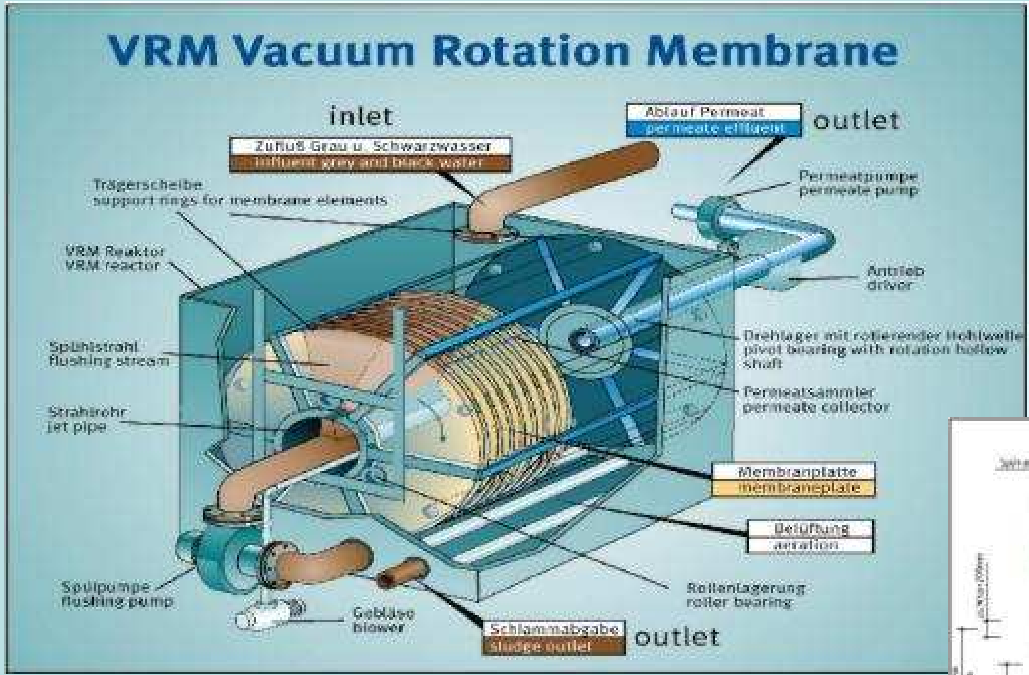
- High investment costs of membrane modules
- Membrane integrity (failure detection, lifetime)
- High operating costs (energy consumption)

Process Design

Process chain for a customary municipal water purification plant with disinfection's unit



Flow Diagram of MBR Unit

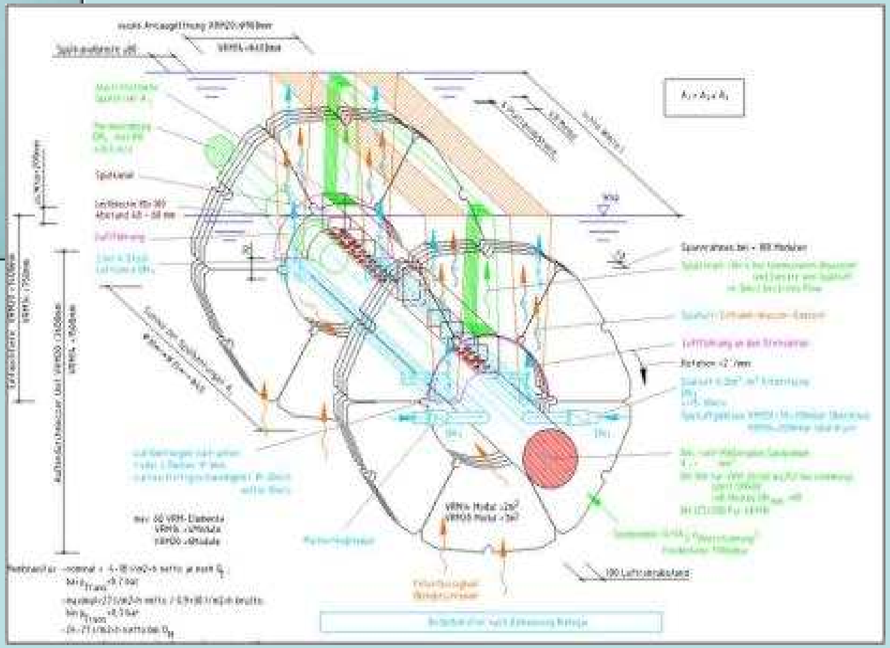


Installation

➲Concrete

➲Container

➲Stainless steel tank



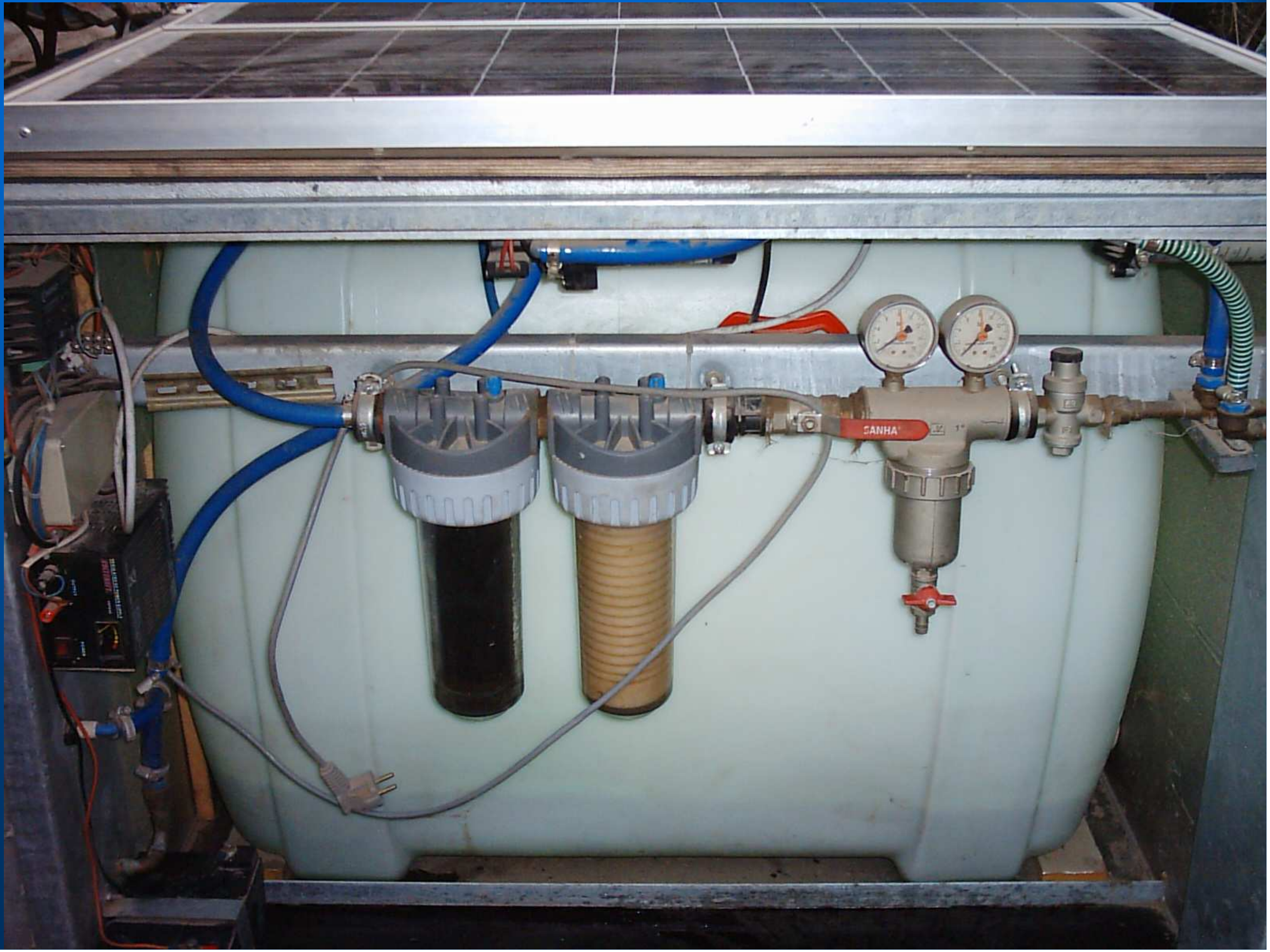
Cleaning devices

➲Rotation

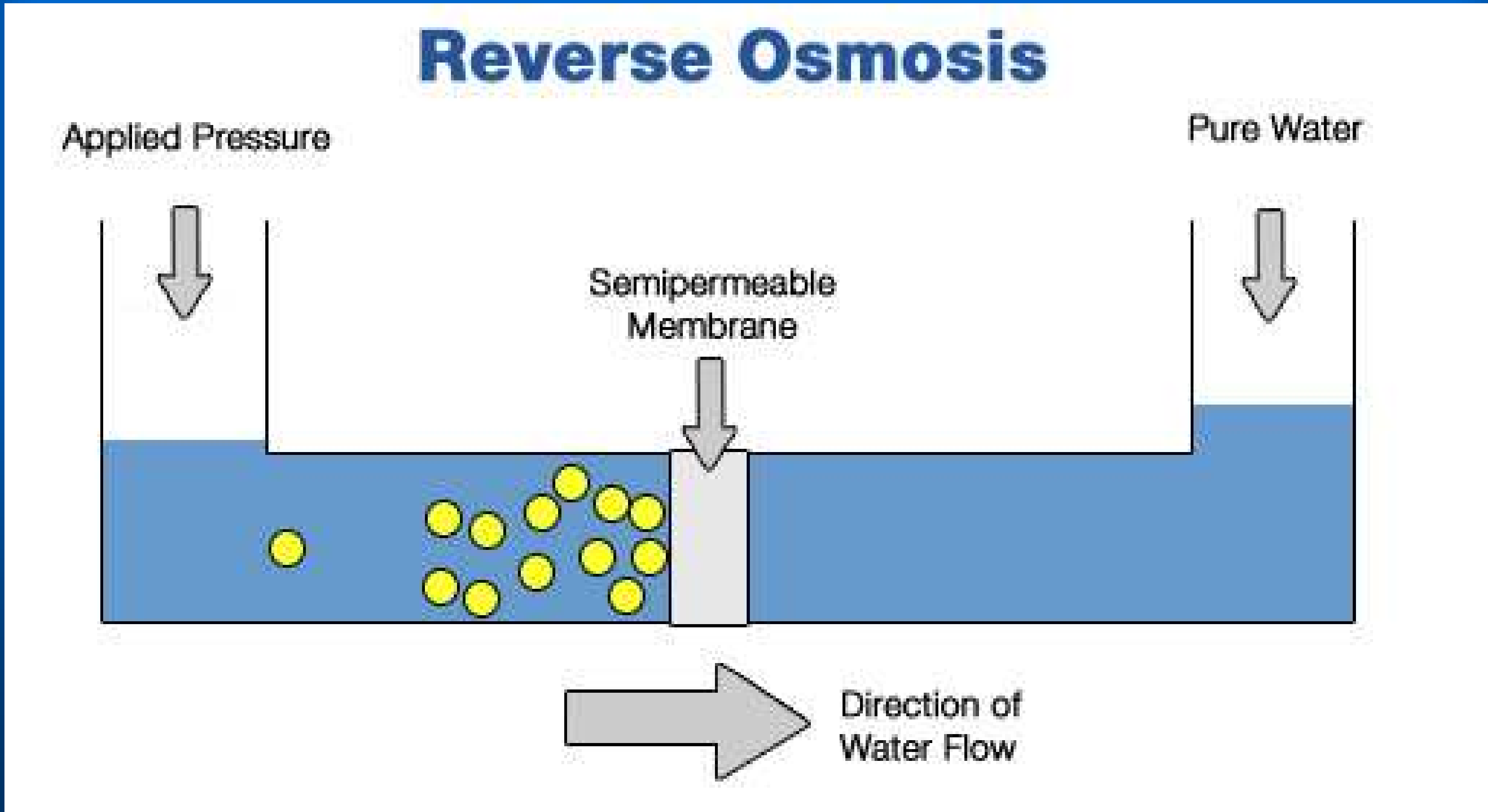
➲Jet flushing

➲Air injection

Membranes for river or brackish water treatment supplied with solar energy



Simple Diagram for the Process Description Of Reverse Osmosis



Membranes for Drinking Water (RO)

Estimating the costs and benefits of Membrane Technology

<u>The following elements are important for calculating the financial and economic analyses</u>

- **Investment / capital costs**: cover all cost (membrane), energy and labour, etc..
- **Running costs**: refer to all materials, energy and labour expenses
- **Opportunity costs (of capital)** and alternative investments
- **Revenues**: (if there is any)

RESEARCH & DEVELOPMENT

- Two compact pilot plants component of MBR were studied in both Germany (Technical University of Berlin TU-B, Department of Sanitary Engineering) and Egypt (National Research Centre).
- The component consists of the Membrane Bio-Reactor (MBR) with a fully computer-control system.
- The MBR is a submerged rotating and aerated type of a maximum 1,200 l/h plant capacity.
- The operated MBR was of the type Vacuum Rotating Membrane (VRM).

The aim of the study

- to investigate the efficiency of MBR for the treatment of sewage water according to the warm and/or cold climate (like Egypt and/or Germany).

- The treatment efficiency is studied in terms of the physical, chemical and biological characteristics in the influent and effluent of the MBR.

- The fate of heavy metals was also investigated; for the first time; in both the influent and the effluent of MBR for the first time.

The component system was erected in Zenien wastewater treatment plant. It was fed with primary treated wastewater. The system was operated continuously for 24 hours/d for a period of time 120 days.

The specification of the component is as follows:

- Type VRM 14*/24**
- (vacuum rotation membrane)
- * unit diameter (1.4m)
- ** number of membrane modules
- flow rate Max 1,200 l/h
- L * W * H 2700 * 2000 * 2320 mm
- Weight 2,800 kg
- Filtrate surface per module 2 m2
- Max flux (gross) 30 l/m2 * h at ≤ 0.3 bar
- Trans membrane pressure
- Membrane polyacrylonitrile (PAN)
- Water permeability at 1 bar 1800 Um2.h
- Pore size 37.7 nm

RESULTS AND DISCUSSION

The overall results reveal

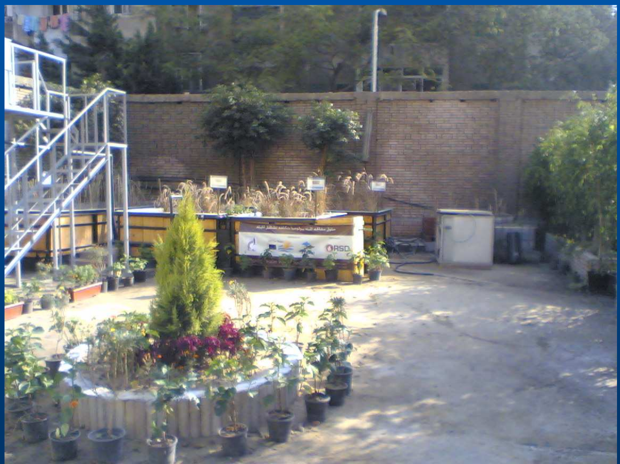
- the use of MBR under the Egyptian condition proved to be efficient for improving the wastewater effluent in terms of the physical, chemical and biological characteristics.
- The final effluent exhibited reasonable low concentration of BOD, COD, TSS, ammonium compounds, nitrites and E.C.
- Complete elimination of viruses, and bacteria.
- Remarkable decrease in the level of trace elements was obtained.

APPLICATION OF MEMBRANE TECHNOLOGIES FOR WASTEWATER RECLAMATION & REUSE

SBR Pilot Plant

MMBR for BlackWater

Zer0-M Project



Kobota membrane, installation & treatment

3. Municipal and household-like wastewater

Construction of the mobile treatment plant





Treatment quality

Treatment performance five times better than designed!

4. Wastewater from agroindustry
(olive oil production)

Example: MOWOM

CRAFT Project funded by the EC in the frame of the programme "Energy, environment and sustainable development, EVK1-CT-2002-30018"

MOWOM - Development of a mobile wastewater treatment system for small olive mills

Goals:

- Characterisation of olive mill wastewater
- Physico-chemical pretreatment
- membrane separation for water recovery
- composting of residues

Typical wastewater compositions

Influence of the **olive oil** production mode on the wastewater composition

	Traditional press	3-phase	2-phase
Solid residues (kg/t olives)	330	500	800
OMW (L/t olives)	600	1200	250
Fruit water of wastewater (%)	94	90	99
BOD_5 wastewater (g/L)	100	80	10
Polyphenols in wastewater (mg/L)	203	164	200

Pilot plant as a whole

Singapore Reuse Membrane Plant
Drinking water from sewage

Bedok, Singapore

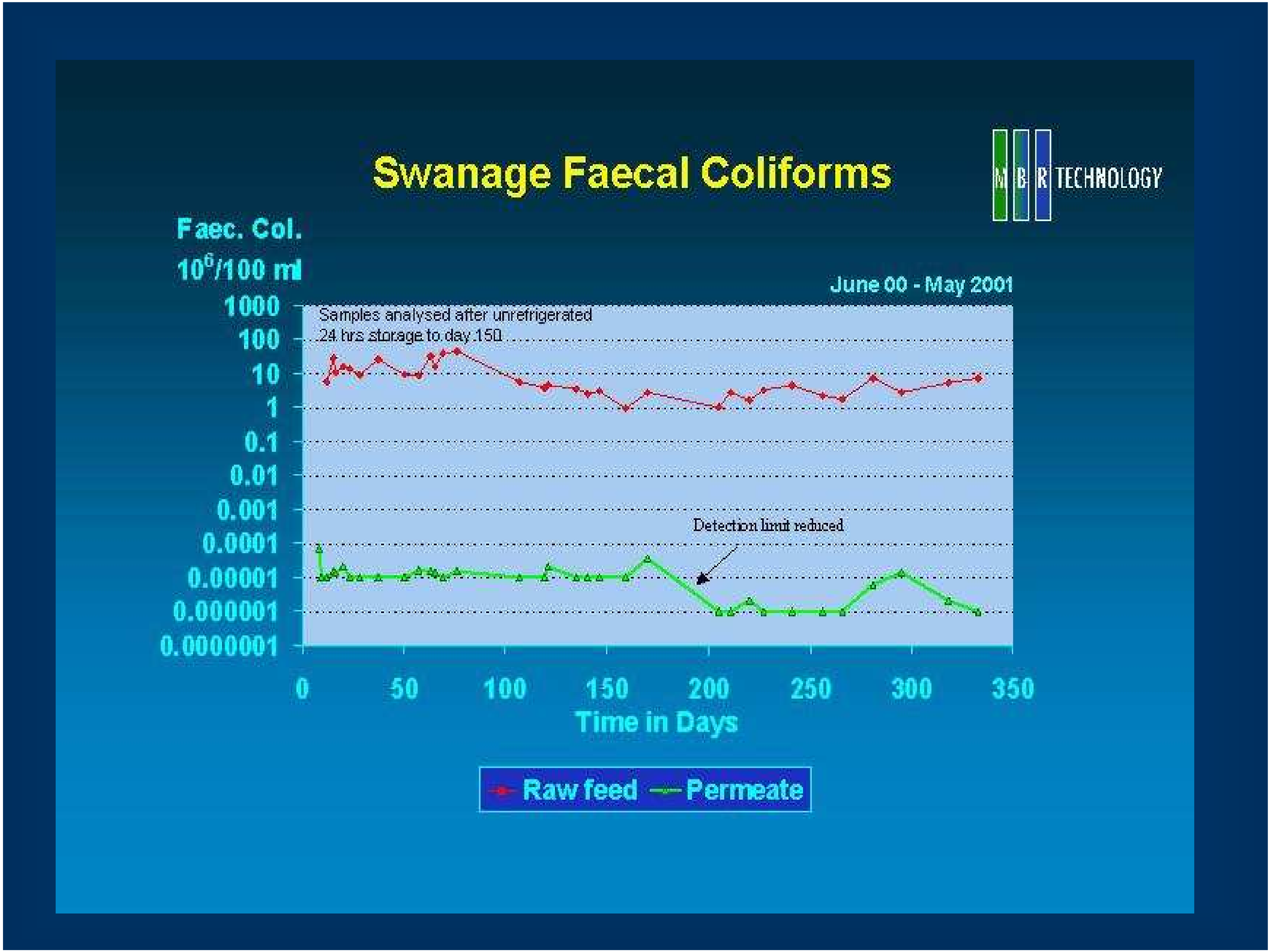
- ZW-500c/RO
- 42 MLD

Kranji

- CMFs/RO
- 42 MLD

TOWN of MILTON WPCP , Milton, Canada

- New construction: 1,000 m^3/d - Modular design - Online: 1997
- Effluent criteria: cBOD < 2.1 - $(NH_3)N$ < 0.8 - TP < 0.07


Swanage Faecal Coliforms
MBR TECHNOLOGY
Faec. Col.
10^6/100 ml
June 00 - May 2001
Samples analysed after unrefrigerated
24 hrs storage to day 150
Detection limit reduced
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
0.0000001
0
50
100
150
200
250
300
350
Time in Days
Raw feed
Permeate

On-site recycling
“Sewer Mining”

WASTEWATER TREATMENT & REUSE
Membrane BioReactor

Scaling on membrane

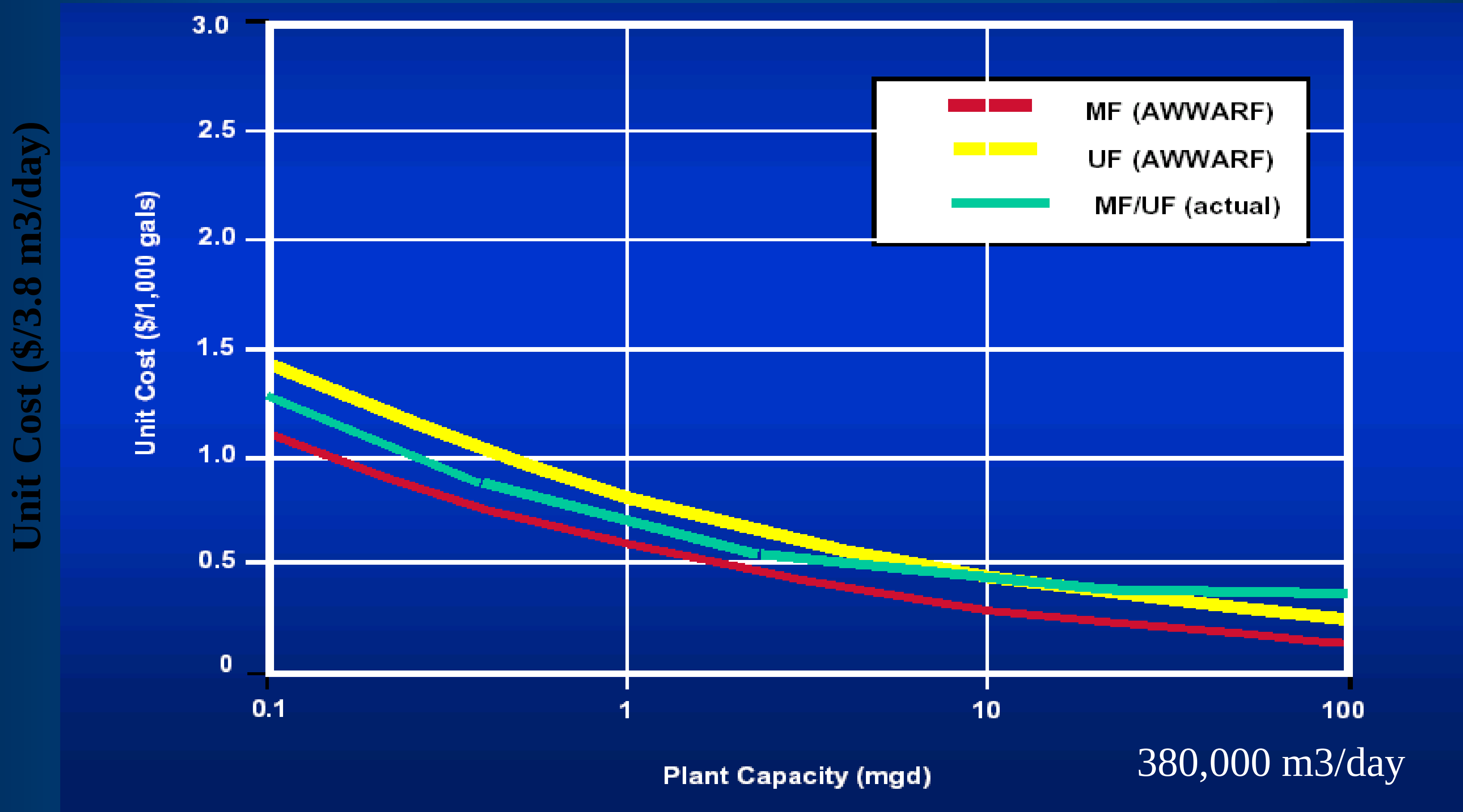
After sometime the performance of the membrane declines and the quality of permeate decreases. Meanwhile, the operating pressure increases. This is mainly due to scale formation on membranes .

Membrane Bioreactor Technology

MBR TECHNOLOGY

Revenue costs 1992 - 2001

Decreasing Membrane Treatment Cost



Courtesy CH2M Hill

Conclusion

- Reclamation and reuse of seawater and wastewater represent an important water supply and was able to solve the increasing municipal, industrial, and agricultural demands for water.

- Membrane technology has led to significant innovation in processes and products over the last few decades offering new opportunities in the design, rationalization and optimization of innovative productions.

- Water production, water treatments and water distributions, might be completely redesigned based on the concept of Integrated Membrane Operations, as nature has being doing for already many years, in a modern and advanced city planning.

KEY-FACTORS FOR FURTHER IMPROVEMENT OF RO DESALINATION SYSTEMS

Enhancement of water recovery factor

Costs reduction

Improvement of water quality

New brine disposal strategy

INTEGRATED MEMBRANE SYSTEMS

Relative risk

Relative Risk

- 960,000 Americans Die from Cardiovascular Disease (Eating Fatty Foods), Each Year
- 430,000 Americans Die from Smoking-Related Causes, Each Year
- 42,000 Americans Die in Car Accidents, Each Year
- 22,000 Americans Are Killed with Guns, Each Year
- 3,160 Americans Die from Coal Lung Disease Each Year
- 0 (Zero) Americans Have Ever Died From Exposure to Recycled Water


Thank you for your kind Attention
hshafywater@yahoo.com