Source separated wastewater a new resource for producing mineral fertilizer

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Resources in wastewater

Annual discharge from one person

- Nitrogen (N) 4.5 kg
- Phosphorus (P) 0.6 kg
- Potassium (K) 1.0 kg
- Organic matter (BOD) 35 kg

The wastewater resource

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30 million USD

per year

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In Norway 15 - 20 % of thecurrent mineral fertilizer use could be substituted by fertilizer derived from wastewater.

(Jenssen and Vatn 1991)

The wastewater resource

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900 Mio people in rural
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2.5 billion USD

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In developing countries 40 - 50 % of the current mineral fertilizer use could be substituted by fertilizer derived from wastewater.

(Etnier and Jenssen 1997)


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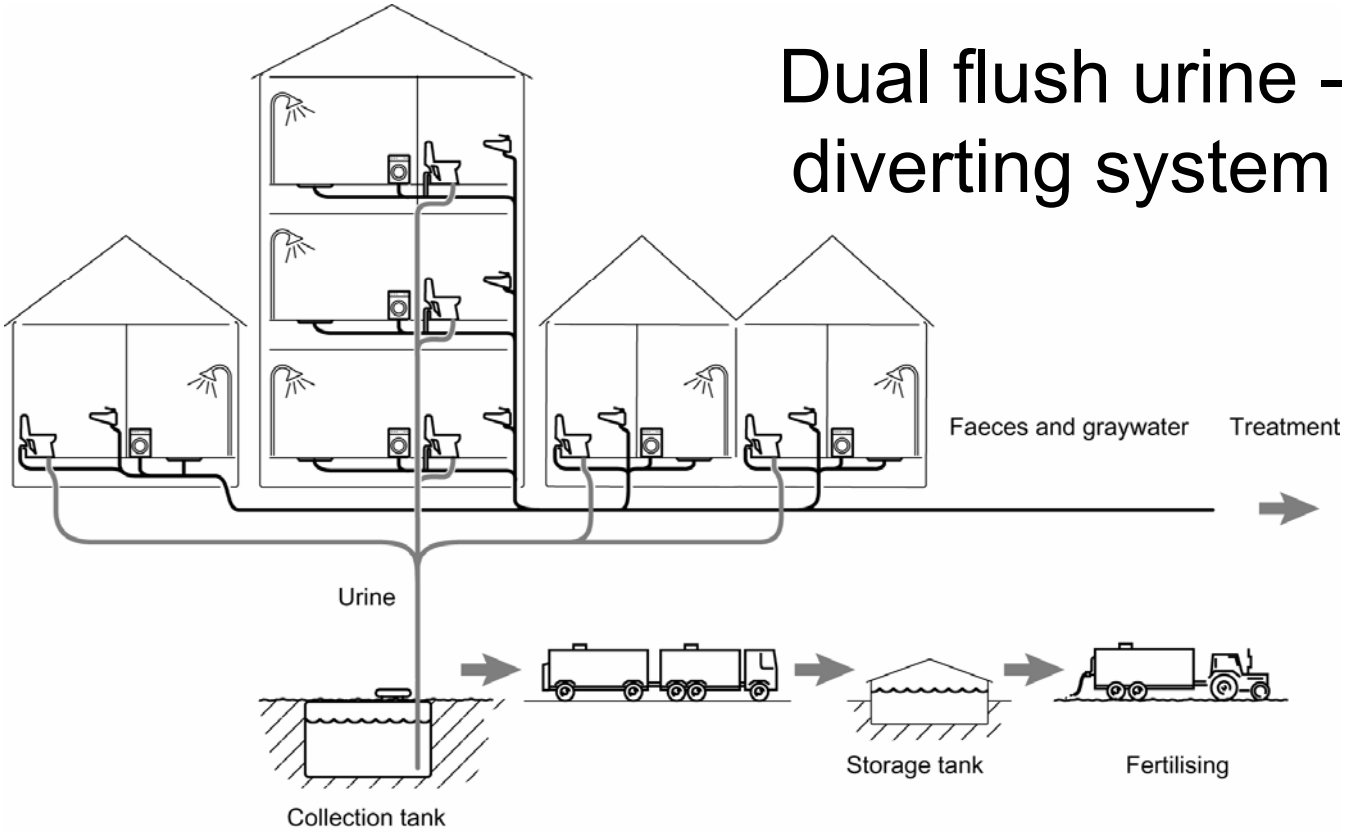
Dual flush urine - diverting system

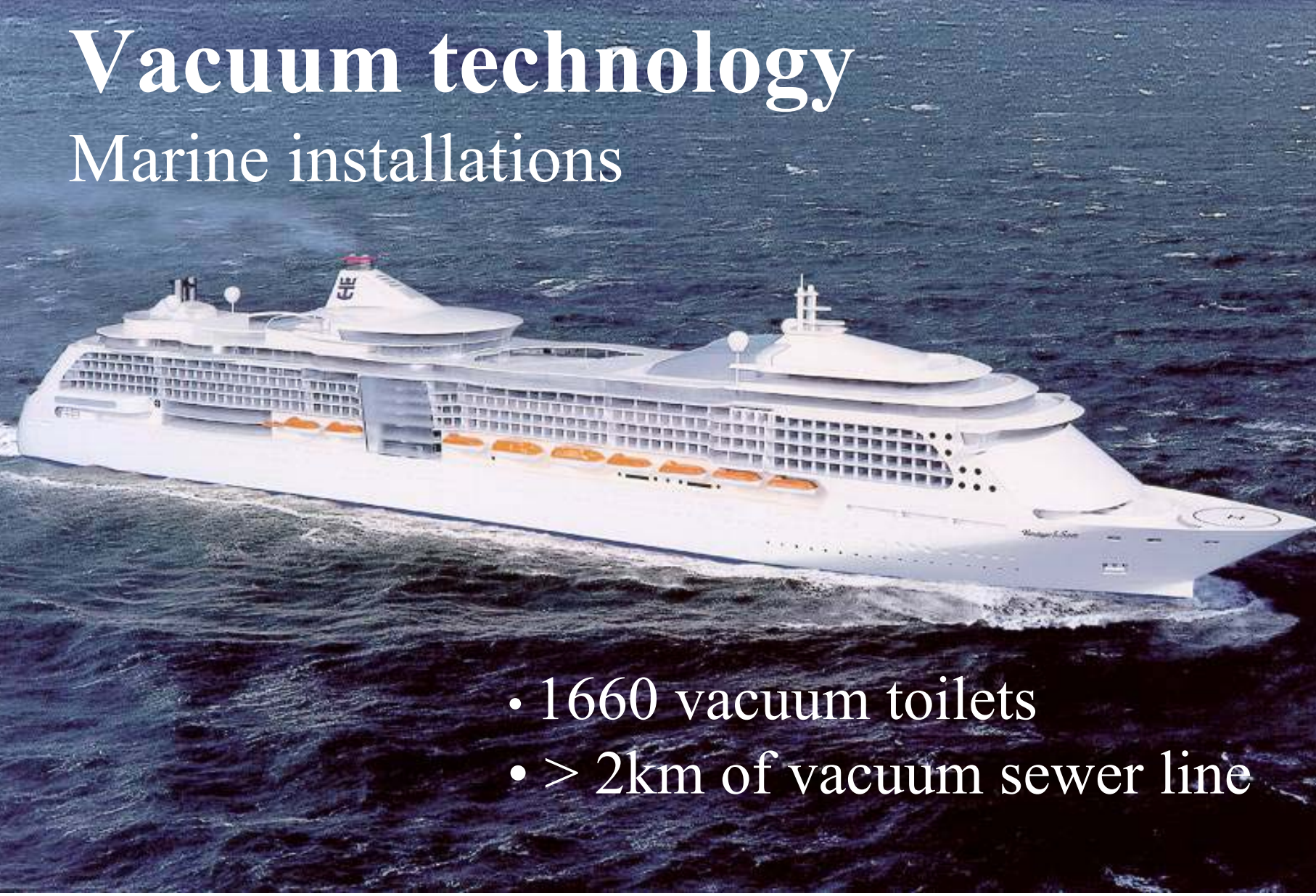


- Urine flushed with 1-2 dl
- Faeces - flushed with 2-4 liters

(Jønsson et al. 1998)

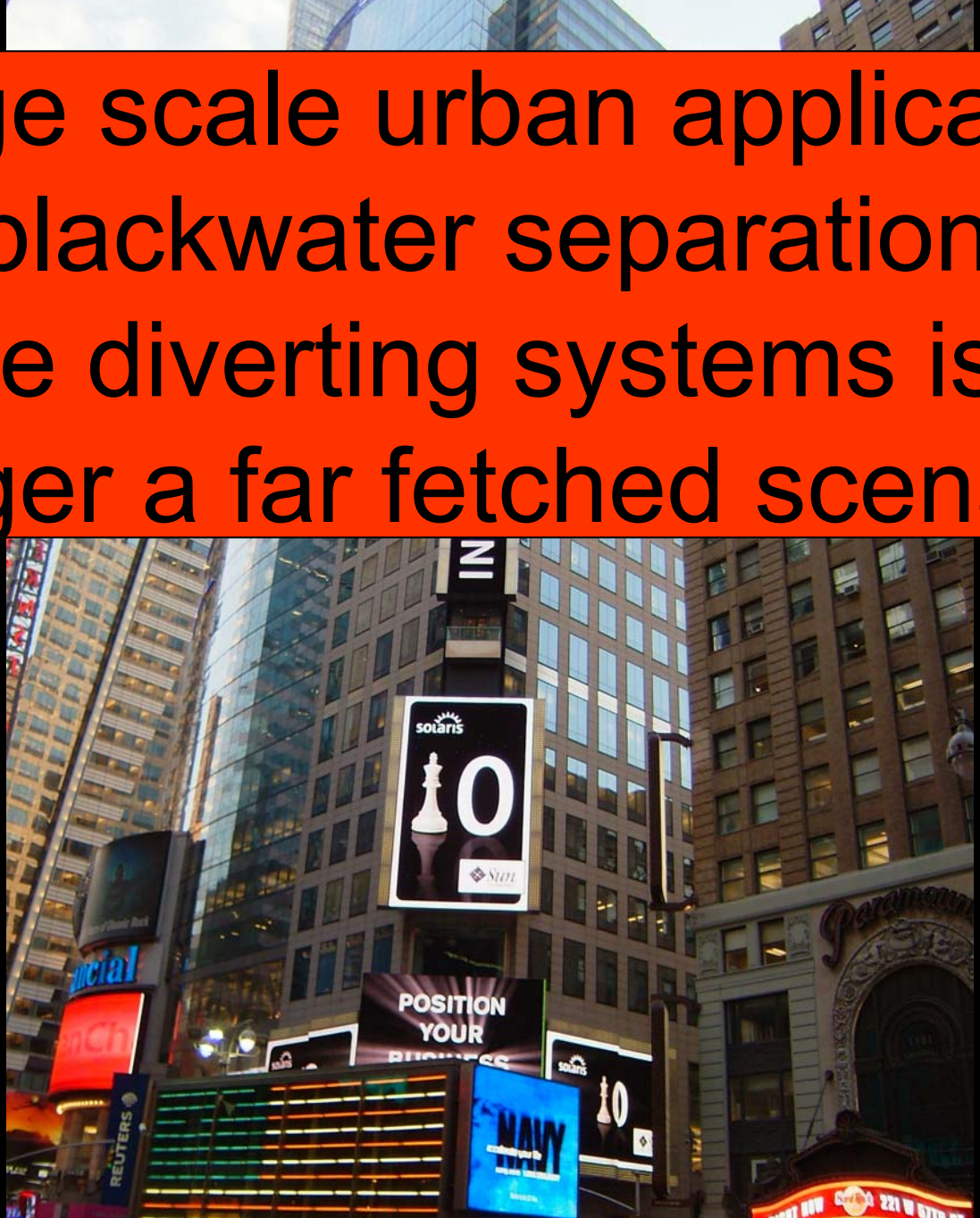
Vacuum technology

Marine installations



- 1660 vacuum toilets
- > 2km of vacuum sewer line

Large scale urban application of blackwater separation or urine diverting systems is no longer a far fetched scenario



Transportation distances - liquid and solid organic fertilizer

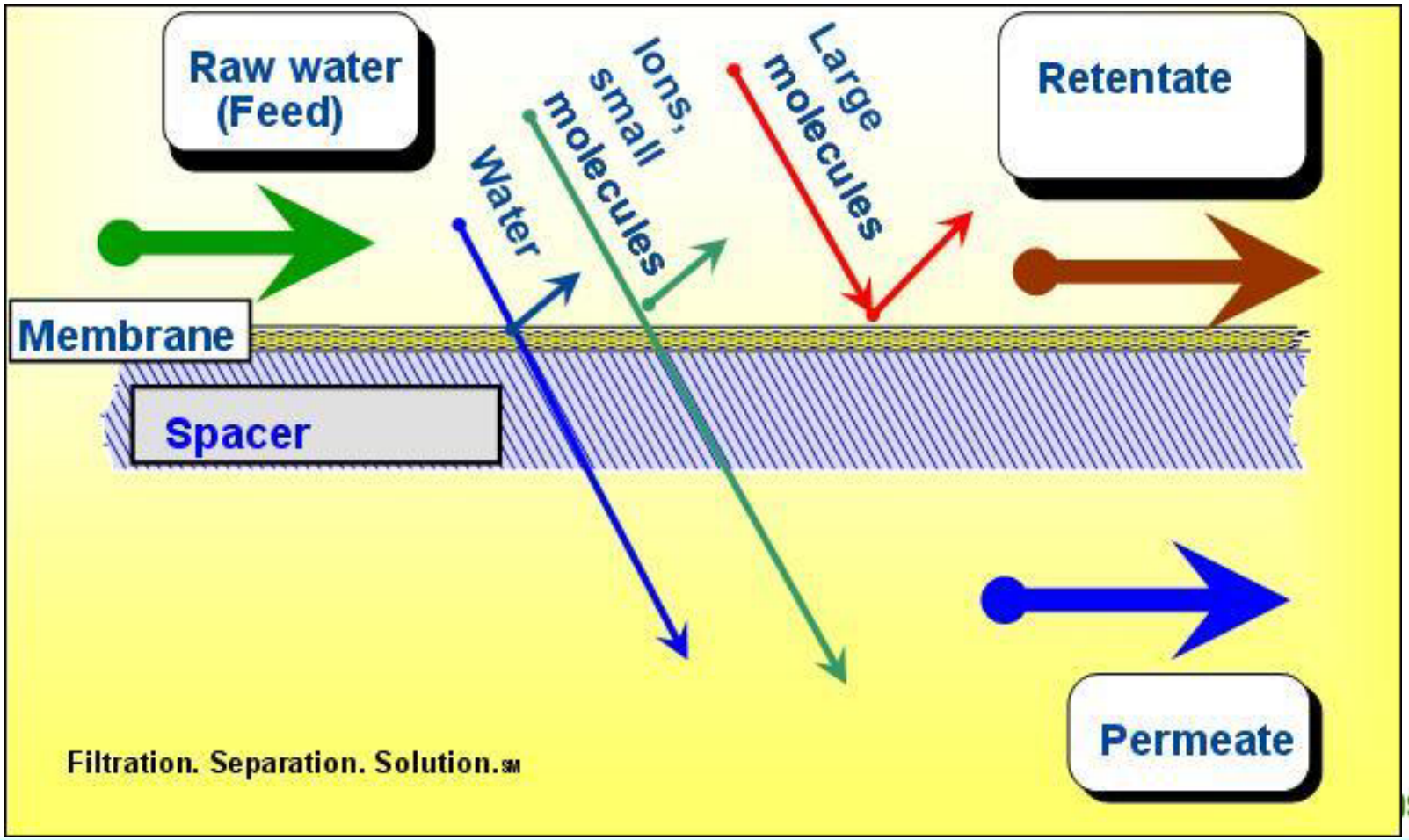
Organic fertilizer resource	Transport distance (km)
Blackwater	25 - 30
Urine	40 - 50
Compost	500 - 1400

(Jenssen and Refsgaard 1997)

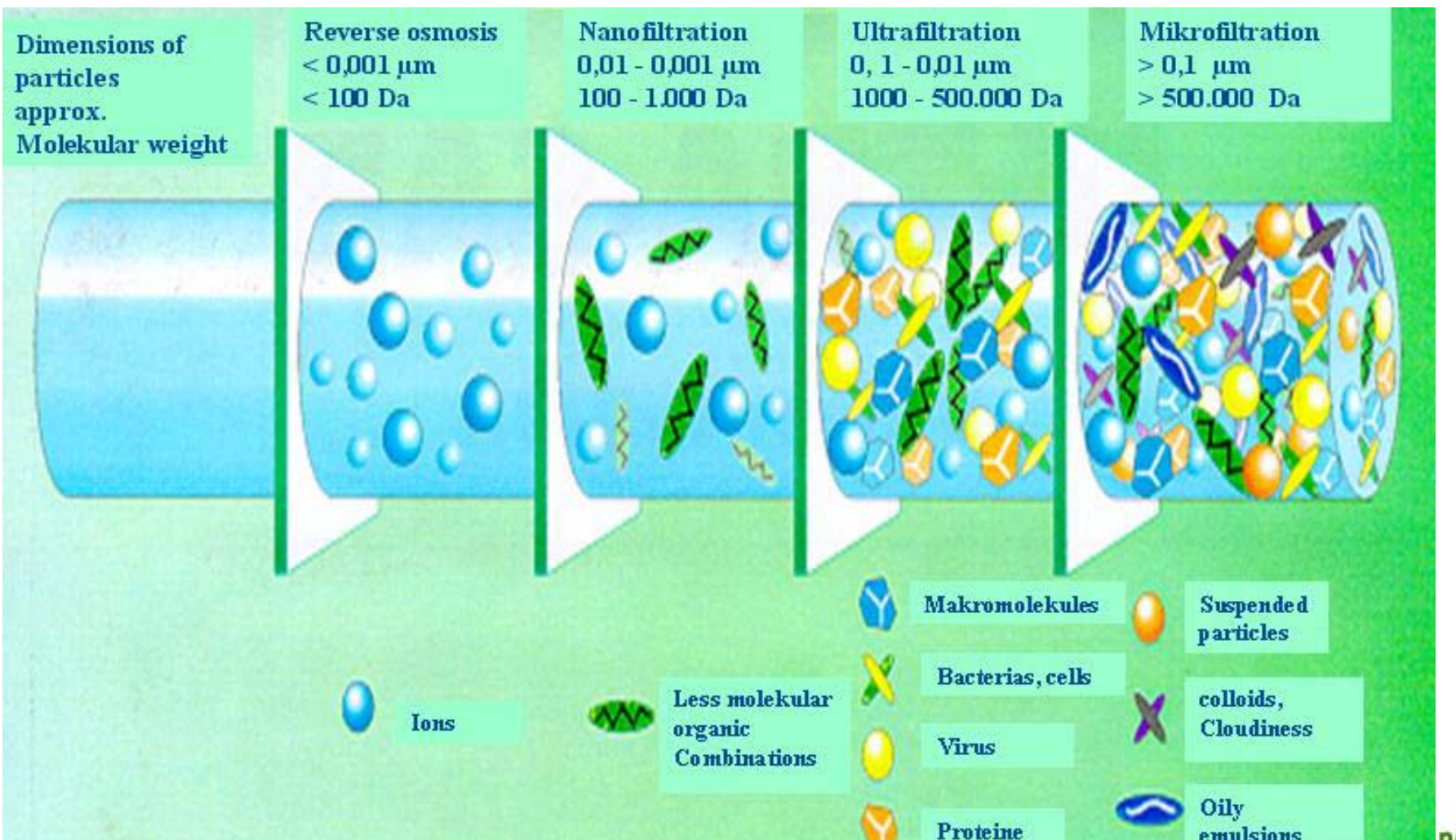
Conventional options for concentration/solidification

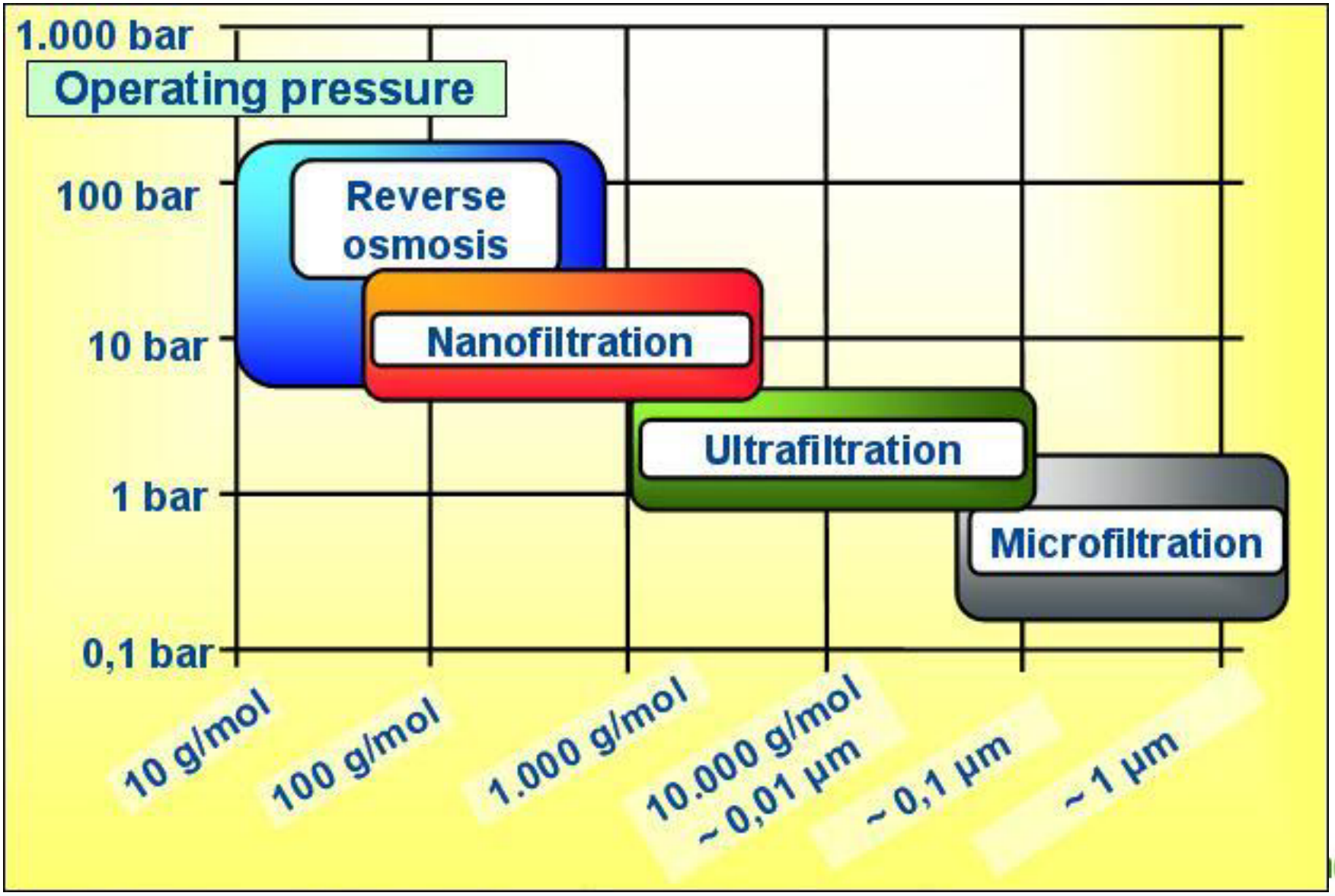
1. **Membrane filtration**
2. Precipitation with iron and aluminum
3. Precipitation and treatment with lime
4. Struvite precipitation.
5. Ammonia stripping in closed loop.
6. Combinations of the above

Membrane filtration - principle



Membrane filtration




1.000 bar
Operating pressure
100 bar
10 bar
1 bar
0,1 bar
Reverse osmosis
Nanofiltration
Ultrafiltration
Microfiltration
10 g/mol
100 g/mol
1.000 g/mol
10.000 g/mol
~ 0,01 µm
~ 0,1 µm
~ 1 µm

1. Membrane filtration of blackwater

- Reverse osmosis retains all major ions (NPK) in the retentate
- Clean water obtained in the permeate.
- Tested in small and larger pilot scale are now undertaken by the city of Gothenburg in Sweden (Skogaberg).
- Challenges are clogging and high energy use.

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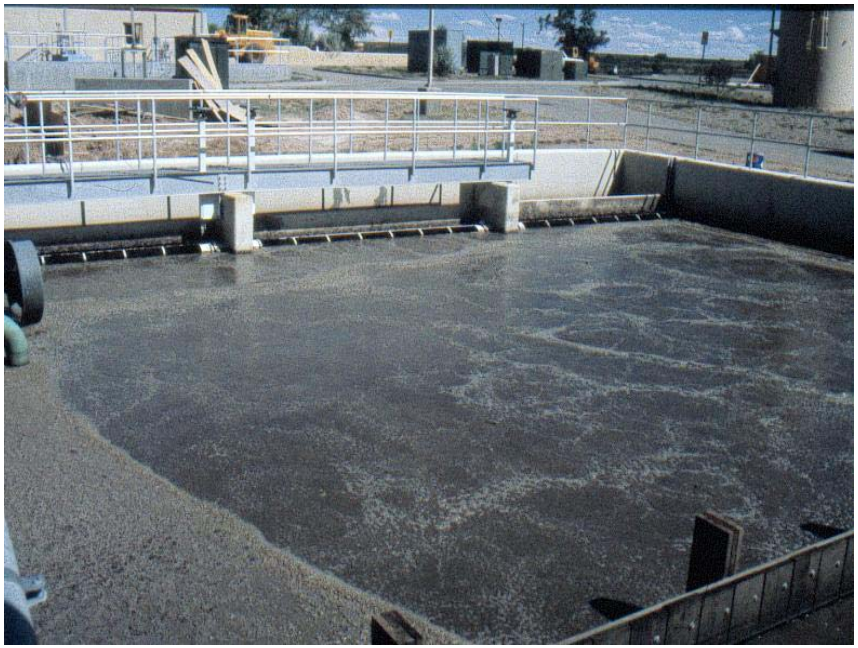
2. Precipitation with iron and aluminum

Fe and Al- phosphates formed



ctivated sludge with chemical precipitation

- Chemical precipitation is common in Nordic countries mainly to remove Phosphorus.
- Phosphorus removed 90-95 % and organic matter 75-80 % from water phase is possible.
- Minor amounts of N and K are removed.
- Fe and Al-P has low solubility under normal soil pH, plants uptake are reduced. (Krogstad et al. 2004)

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3. Precipitation and treatment with lime

- Lime as $Ca(OH)_2$ precipitate phosphorus and organics from wastewater and will be tested on blackwater.
- Combination with magnesium will lower the lime dose. Seawater addition may substitute magnesium and improve results.
- SBR technique simplifies lime dosing.
- Lime treatment will raise pH and hygienization is achieved
- Combination with ammonia stripping for high nitrogen recovery is possible.

Conventional options for concentration/solidification

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4. Struvite production.

Struvite $MgNH_4PO_4$

- Precipitation of magnesium, ammonium and phosphate as MgNH4PO4 as the white mineral struvite also called MAP has been used both in full-scale wastewater treatment tried on several places and with animal manure and initial tests are performed with urine

(Adamson et al 2004).

4. Struvite production.

- Struvite precipitation from urine is enhanced by adding magnesium oxide (MgO) and then more than 90% of the phosphorus is precipitated.
- Due to the surplus nitrogen in the urine/blackwater and the molar ratio of N:P in struvite being 1:1 high nitrogen recovery can only be obtained by either adding phosphoric acid or ammonia adsorbing agents as zeolites (Bán and Dave 2004).

4. Struvite production or MAP-precipitation.

- Due to the very sensitive chemical equilibria when precipitating struvite using phosphoric acid and magnesium oxide commercial attempts to use this process has not been successful.
- A combination of MgO and zeolite for nutrient recovery from urine in laboratory studies seems more promising (Bán and Dave 2004).
- Some potassium may also be recovered through struvite precipitation.

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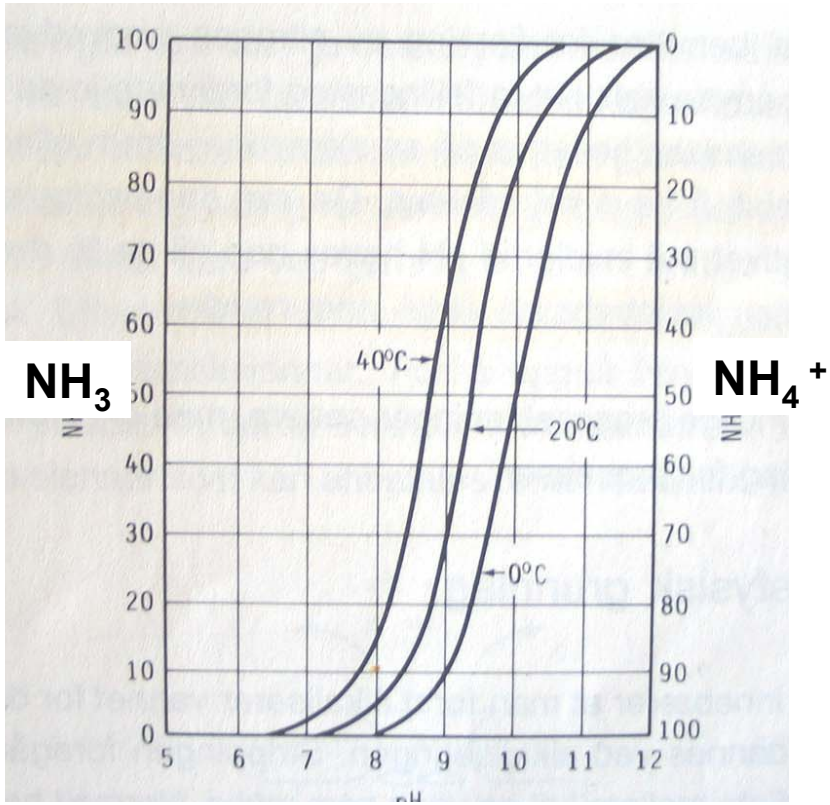
5. **Ammonia stripping**
6. Combinations of the above

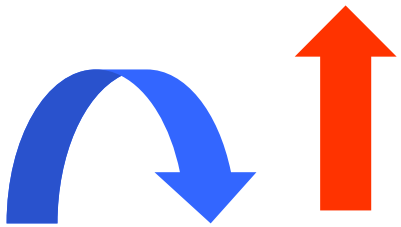
Ammonia volatilization



5. Ammonia stripping

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

ammoniumnitrate



Base or other agent that raise pH

Blackwater/urine

5. Ammonia stripping

- Ammonia stripping is possible both for full-scale wastewater treatment and on nitrogen rich liquids
- The largest WWT plant in Norway VEAS uses a closed loop ammonia stripping process on the filtrate from Chamber presses for sludge with great success and sell the the ammonium-nitrate to a fertilizer manufacturer.

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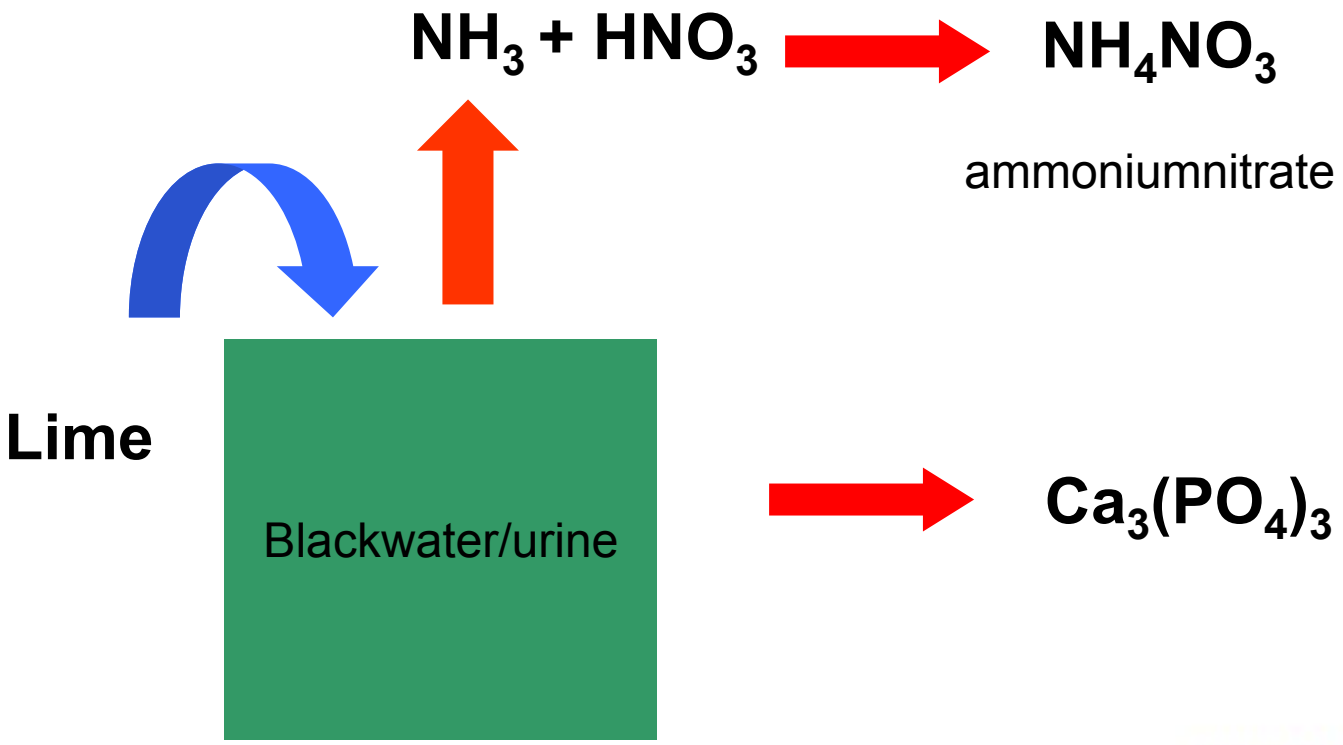
6. Lime and ammonia stripping



Method overview

Method	N	P	K	Energy	O&M	Cost
Membrane filtration	+	+	+	+++	+++	+++
Precipitation with Fe	-	+	-	+	+	+
Precipitation with lime	-	+	-	+	++	++
Struvite precipitation	+	+	(+)	+	+++	+++
Ammonia stripping	+	-	-	+	++	++
Lime + Ammonia stripping	+	+	-	+	++	++

Conclusions

- Mineral fertilizer production from urine or blackwater is feasible
- Membrane filtration or struvite precipitation are the only methods that recover all 3 major fertilizer elements N,P and K
- Lime + Ammonia stripping produces very good N and P fertilizer
- Chemical precipitation with Fe or Al recover only P in a form with low palnt availability

Conclusions

- More R&D should be performed into the possibilities of fertilizer production from source separated urine and blackwater

Thank You!

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