



Alternative hybrid SAT-membrane treatments: Short SAT-NF treatment to upgrade effluent quality

Prepared by:

A. Aharoni, H. Cikurel, S.K. Sharma, M. Jekel, C. Kazner, T. Wintgens, G. Amy,
M. Ernst, Y. Guttman, N. Tal T. Kreitzer, A. Putschew, K. Vairavamoorthy

Presented by : Avi Aharoni, Mekorot

Lodz – 12-15 October 2010



MEKOROT. Water is a business for leaders

Conventional SAT, problems, and alternative hybrid SAT-NF treatments to upgrade effluent quality

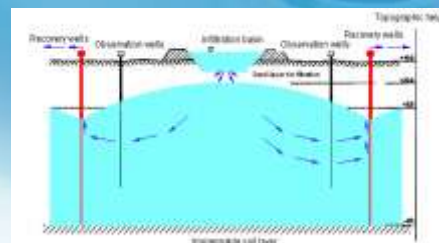
Conventional SAT:

- 140 MCM/year infiltration in 110 ha.
- 1 day flooding, 2 days drying
- Retention time – 6-12 months



Problems in the SAT :

- ✦ 1. Deterioration in Recharge Capacity (OM, Temp, Rain)
- ✦ 2. Bio-fouling of Effluent Pipelines(Before and after SAT)
- ✦ 3. Clogging of irrigation systems due to Mn , Fe release
- ✦ 4. No more new lands are available for infiltration !!



Investigated solutions:

Hybrid systems of short SAT
(1-2 months) and membrane treatment (UF, NF)

Monitored Parameters :

Chemical, Micro biological, Micropollutants

Hybrid UF-short SAT system (RECLAIM):

By this system an infiltration velocity **5-6 times higher**
than the conventional was obtained.

Some persistent micropollutants still prevailed

Hybrid short SAT-NF system (SWITCH)

Detailed in the presentation

MEKOROT. Water is a business for leaders

SWITCH project Shafdan Pilot Plant



OPERATING CONDITIONS

1. Sand filter

6 m³/hr, 6-8 m/hr, backwash every 8hrs, no flocculant and chlorine used

2. SAT system

120 m³/d infiltration (5 m³/hr). 1 day flooding – 2 days drying, actually 3-4 times higher infiltration rate than conventional

3. Reclamation well

15 m³/d reclaimed, 30 - 35 days retention time from infiltration point (15 m)

4. Hydrocyclone + Micron filter

Removal of calcareous and loamy sand from SAT recovered water

5. Nanofilter

DOW NF-270: Polyamide-Thin Film Composite MWCO: 200

Flow rate: 0.5 m³/hr

Recovery ratio: 90%

Salt reduction ratio (as TDS): 15-20%

DOW NF-90: Polyamide-Thin Film Composite MWCO: 100-150

Flow rate: 0.4 m³/hr

Recovery ratio: 70%

Salt reduction ratio (as TDS): 80-85%

SAND FILTER



MEKOROT. Water is a business for leaders.

SAT Infiltration Fields and Reclamation Well



3 (4X5 m²) – Infiltration of 120 m³/d in one field the other two rest



Reclamation well



MEKOROT. Water is a business for leaders.

Hydrocyclon

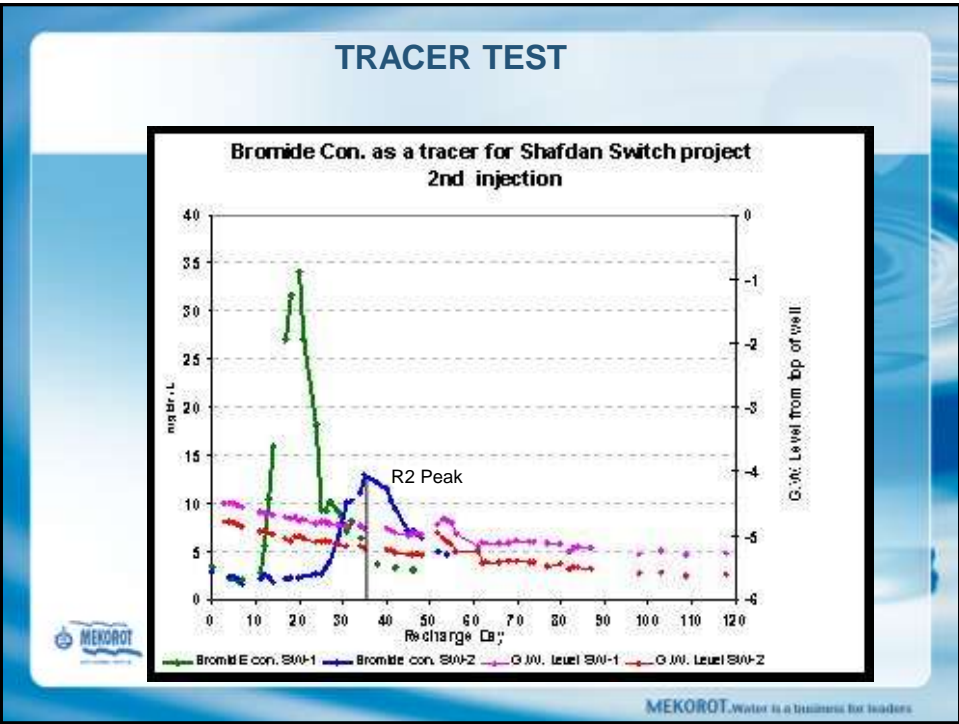
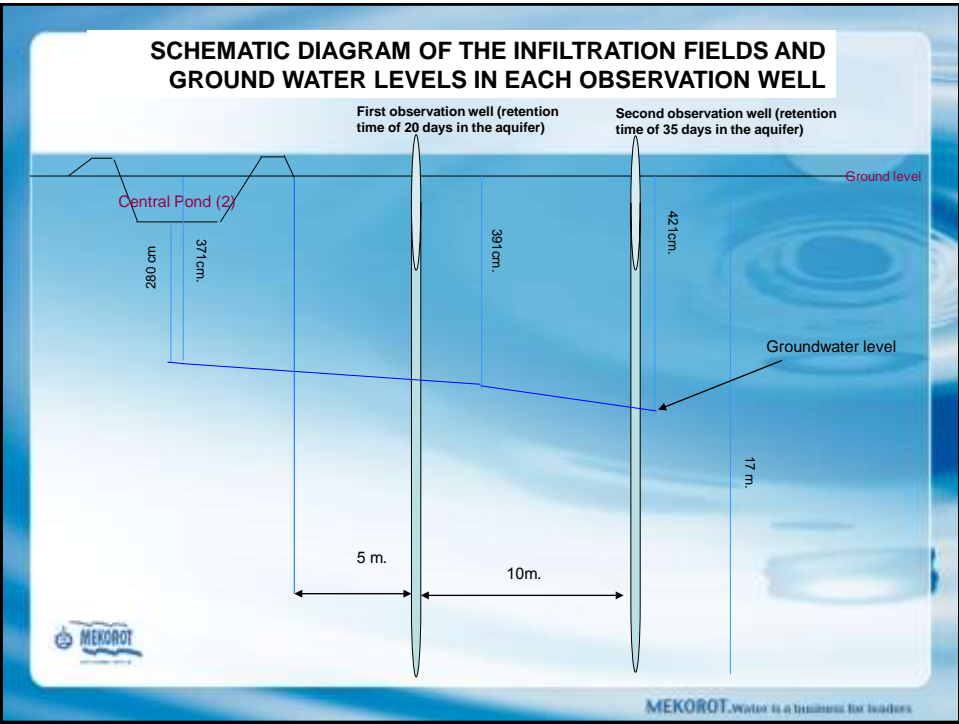


MEKOROT. Water is a business for leaders.

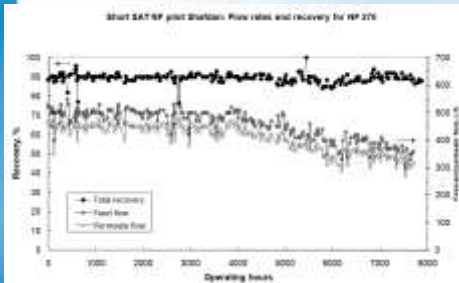
Nano - Filter



MEKOROT. Water is a business for leaders.



Flow Rates and Percent Recovery for the NF Membranes Used in the Process

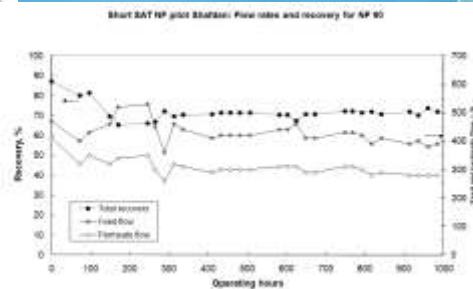


The total water recovery for NF270 was rather high at around 90%. Recovery in the single stages (2 stage system) was around 70%

The total water recovery for NF90 was significantly lower than NF270 (the effect of scaling although some anti-scaling measures were taken).

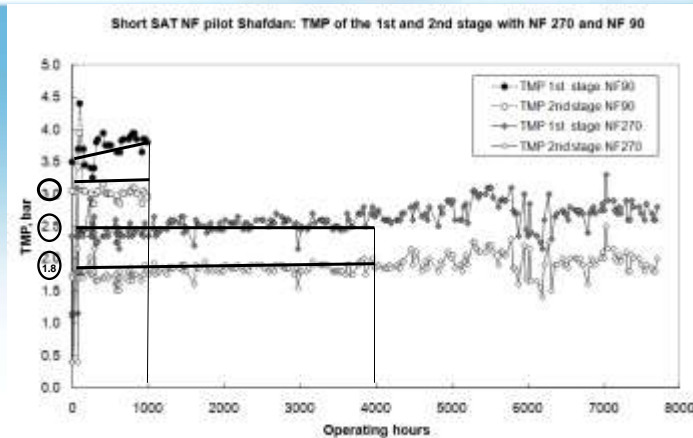
The total recovery was around 70% and in single stage it was around 50%.

Flow rates and percent recovery for NF-90



MEKOROT. Water is a business for leaders

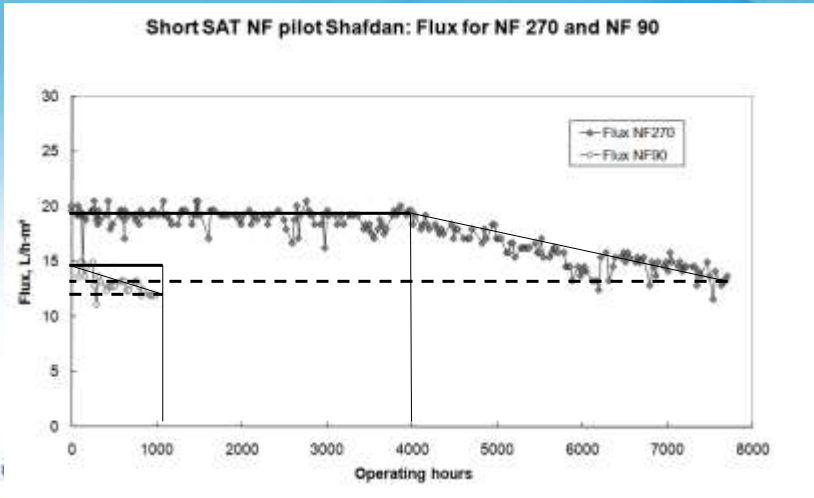
The trans-membrane pressure (TMP) for both membranes:



MEKOROT

MEKOROT. Water is a business for leaders

Flux for NF270 AND NF90 during the experimental period



MEKOROT. Water is a business for leaders

OPERATIONAL PROBLEMS IN SAT (SWITCH):
PUMP IN RECOVERY WELL AT 15 m. DISTANCE FROM THE INFILTRATION FIELDS
(35 days retention time) AFTER ALMOST A YEAR OPERATION

The recovery well pump after 9 months' of operation at 11-12 m. depth



Red -soft loamy sand
(220gr/kg iron as oxide and 155 gr/kg Ca,
20 gr/kg P, 10 gr/kg S)

Clogged filter area

Black and very hard material
(1 g/kg Mn, 340 gr/kg Ca,
8 gr/kg iron, 3 gr/kg S, 1 gr/kg P)



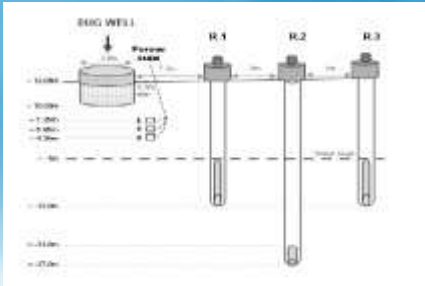
Clogged 50-5 µm prefilter



MEKOROT. Water is a business for leaders

The SHORT SAT advantages

- 1. Shortens the effluents pathway in the saturated zone
- 2. Lowers the possibility to obtain the exceeding low redox conditions that are necessary for manganese dissolution (decrease the manganese dissolution)



MEKOROT. Water is a business for leaders

SWITCH

Chemical parameters:

Parameter	Unit	Sec. Effl.	A.Sh.SAT*	Rem. Eff. % (A.Sh. SAT-Sec. Effl.)	A. Nano Filter	Rem. Eff. % (ANF-A. Sh.SAT)	CAS +LONG SAT**
COD	mg/L	29 - 40	5.0 - 9.0	78-83	2.0 - 3.0	60-67	2-4
DOC	mg/L	9.5 - 10.3	1.8 - 2.3	78-81	0.2 - 0.3	87-89	0.6-0.9
UVabs.	1/cm*	209 - 224	46 - 68	70-78	6.0 - 7.0	87-90	9-13
Ammonia	mg/L	3.17-4.2	0.4-1.0	76-87	0.03-0.1	90-93	0.02-0.05
Phosphorous	mg/L	0.66-1.4	0.03-0.08	94-96	<0.03	>63	<0.03
TDS	mg/L	864 -900	786 - 897	-	687 - 718	13-20	796-852

* After 1 year infiltration. The analyses results relate to 30 days retention time in the aquifer

** After 30 years of infiltration. The analyses results relate to 300 days retention time in the aquifer

All secondary effluent data relate to an average of 2 years and take into account that there are no significant fluctuations in micropollutants concentrations in the Shafdan wastewater

Microorganism removal:

All microorganisms removed by the short SAT: F. Coli (5-6 logs), Enterococci (5 logs), Clostridium (4-5 logs)

MS 2 phage (4-5 logs) and complete removal of Enteroviruses



MEKOROT. Water is a business for leaders

Micropollutants (antibiotics, AOI) concentration in different tertiary treatments of the Shafdan secondary effluents

(Concentrations from all data from Reclaim and Switch)

Micropollutants Process	Unit	CAS (Shafdan)	CAS+long SAT (conventional)**	CAS+ UF +RO (desalination)	CAS+ short SAT +NF (SWITCH)*	CAS+UF + short SAT (RECLAIM)*
Clarithromycin	ng/l	39-500	0-61	0	0	0
Erythromycin +H ₂ O	ng/l	93-594	0-43	0	0	0
Roxythromycin	ng/l	55-787	0-108	0	0	0-118
Sulfamethaxazole	ng/l	173-657	10-363	0	0-43	24-120
Sulfamethazine	ng/l	0	0	0	0	0
Trimethoprim	ng/l	62-349	0-18	0	0	0
AOI	µg/l	13-42	11-12.6	-	0.6-3.5	13-22.7
DOC	mg/l	9.8-13.8	0.5-0.6	0.2-0.3	0.2-0.3	1.6-2.3

CAS: Conventional activated sludge

CAS-UF-short SAT: UF polishing of the CAS effluent and infiltration in a 30 days SAT

CAS-short SAT-NF: CAS effluents infiltrated through short (30 days SAT) and polished by NF

CAS-UF-RO: CAS effluents polished in two stage membranal treatment (ultrafiltration and reverse osmosis)

CAS-long SAT: CAS effluent infiltrated in a 300 days SAT (D9 well)

Note: German recommendation for drinking water values for micropollutants (antibiotics) max. concentration - 100 ng/l.



MEKOROT. Water is a business for leaders.

Interpretation of the micropollutants results and effectiveness of NF-270 membrane

- ✦ Well D9 (conventional SAT) showed in some samples higher than 100 ng concentrations for sulfamethaxazole
- ✦ The UF as pretreatment to SAT and the subsequent short term SAT (RECLAIM WATER) did not effectively removed the sulfamethaxazole
- ✦ NF-270 (more open membrane) was able to remove more effectively the sulfamethaxazole and also AOI and obtaining a very low DOC comparable to UF-RO results
- ✦ Almost no salinity was removed (10-15%) by the NF270
- ✦ NF90 membrane removed all micropollutants that were analyzed more effectively than the NF270 but also removed salinity (80-85%)
- ✦ TMP in each of the two stages of NF90 were higher than NF270
- ✦ Effluent treated by short SAT – NF 270 could be suitable for unrestricted irrigation
- ✦ Water quality obtained by NF90 is very close to UF-RO results

MEKOROT. Water is a business for leaders.

The prospects of the short SAT NF process:

1. Development of hybrid SAT- NF processes as an alternative to more energy consuming and relatively expensive UF-RO processes
2. The foot-print of short SAT-NF processes are indeed much bigger than UF-RO processes but it can save 10-30% energy than the UF-RO process
3. The NF-270 can save more energy, since the operational pressure is low
4. In Mediterranean and African countries, Australia and other Middle Eastern countries where more infiltration areas can be available this process can be effectively applied



MEKOROT. Water is a business for leaders.

Task 3.2.1: Soil Aquifer Treatment (SAT)

1. The demonstration showed that micropollutants can effectively be removed by the short SAT –NF 270 process obtaining a safe and high quality water
2. The short SAT - NF-90 process produced an almost RO quality water



MEKOROT. Water is a business for leaders.

D.3.2.1.c.i. At least one publication (submitted) in a journal or conference proceedings on SAT

One publication in:

- + Rev Environ Sci Biotechnol (2010) 9:193–198

SWITCH project Tel-Aviv Demo City, Mekorot's case: hybrid natural and membranal processes to up-grade effluent quality

A. Aharoni • Y. Guttman • N. Tal • T. Kreitzer • H. Cikurel

- + One paper in the up-coming Regional IWA Membrane conference in Istanbul (22-26 October 2010)

Alternative hybrid SAT-membrane treatments:

Short SAT-NF treatment to upgrade effluent quality

H. Cikurel, S.K. Sharma, M. Jekel, C. Kazner, T. Wintgens, G. Amy, M. Ernst*, Y. Guttman, N. Tal, T. Kreitzer, A. Putschew, K. Vairavamoorthy and A. Aharoni



MEKOROT. Water is a business for leaders.

- + **D3.2.1.f: Demonstration study of SAT (5-years)**
- + **D3.2.1.g: Conceptual model and framework for facilitating technology transfer of SAT to other potential sites (5-years)**
- + **D3.2.1.h: Definition of time/distance relationships required for contaminant elimination in a SAT system (5-years)**
- + **D3.2.1.i: Development of Hybrid SAT-Membrane Systems (5-years)**

ALL WILL ARE INCORPORATED IN THE:

Guidelines for design, operation and maintenance of SAT (and hybrid SAT) systems



MEKOROT. Water is a business for leaders.



Guidelines for design, operation and maintenance of SAT (and hybrid SAT) systems –Table of Contents

1.	Introduction
2.	Types of SAT system and infiltration rates
2.1	SAT for water reclamation and reuse
2.2	Types of SAT
2.3	Infiltration rates in SAT systems
3.	Advantages and limitations of SAT
3.1	Advantages of SAT
3.2	Limitations of SAT
4.	Factors affecting performance of SAT System
5.	Site selection for SAT
6.	Pre-treatment for SAT
7.	Design of production wells (distance from infiltration system, spacing of wells, pumping rates)
8.	Post treatments for SAT (including hybrid SAT systems)
9.	Operation and maintenance of SAT systems
10.	Cost considerations
10.1	Capital costs
10.2	Operation and maintenance costs
11.	Case studies of SAT systems
12.	References

MEKOROT. Water is a business for leaders.

