Improved SAT processes for all-purpose water production from secondary effluents

Avi Aharoni*, Haim Cikurel*

- *Mekorot Israel National Water Co. Lincoln St. 9, Tel-Aviv, Israel*

Research partners: Saroj Sharma, Gary Amy,(Unesco-IHE, Westwest 7, 2611 AX Delft,, The Netherlands)
Martin Jekel, Mathias Ernst, (TUB, Centre for Water in Urban Areas, Strasse des 17. Juni 135, 10623 Berlin, Germany)

The conventional long-term Shafdan Soil Aquifer Treatment (SAT) is the largest and most efficient tertiary wastewater treatment system in Israel. The system saves 140 million m3/yr of fresh water by supplying an almost drinking water quality to agricultural irrigation. It has been operating for 33 years in a one day flooding – two days drying mode. The infiltered secondary effluents are recovered after 6-12 months retention time (long term SAT). Advantages of this system are: Removal of particulate matter, DOC, microorganisms, P and N. Almost complete removal of micro pollutants (besides carbamazepine, sulfamethoxazole, iodine contrast media..). Due to lack of land for construction of new fields and the gradual decreasing of the infiltration velocity (actually 1 m/d) not all the produced effluents can be infiltrated and reused in the agriculture. Besides the deterioration in the recharge capacity and biofouling of effluent pipelines by organic matter, there is also a manganese precipitation problem (due to anoxic conditions in the soil) causing clogging of the irrigation systems. In order to improve these deficiencies, 3 alternatives to the conventional SAT system were explored in recent years.

1. The EU RECLAIM project: UF- short SAT (2005-2008). Improved infiltration velocity, good microorganism removal, partially improved oxidation conditions in the soil (only till the 10 days retention time R1 observation well area), 80% DOC removal, partial micropollutants removal
2. The EU SWITCH project: Short SAT-NF (2005-2010) Improved infiltration velocity and very good organic matter, microorganism and micropollutants removal (comparable to RO and even better that the long-SAT). But due to still anoxic conditions manganese, calcium and iron dissolution from short – SAT pretreatment caused premature clogging of NF membranes
3. The BMBF ozonation project: Sand filter-H_2O_2/O_3 – short SAT (end 2010-2013). Considering both projects' results it is expected to improve the infiltration, improve the aerobic conditions (area till R3, one month retention time well) and prevent manganese dissolution from the soil and oxidize the micropollutants

The Short SAT technique (1-2 months retention time) used in the (UF-Short SAT) and (Sand filter-H_2O_2/O_3 - Short SAT) pilots has the potential to decrease the manganese dissolution problem, since it shortens the effluent pathway in the saturated zone and lowers the possibility to deplete the oxygen and also much less manganese can dissolve from the soil and reach the reclaimed water due to shorter retention time in the soil. The (short SAT) pretreatment before NF (in SWITCH) removed organic matter, ammonia, phosphates, particles and microorganisms better than the UF pretreatment applied in RO systems in indirect drinking water production.

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Dr. Haim Cikurel
Mekorot, Israel National Water Co

Conventional (long term SAT):

1.140 MCM/year infiltration in 100 ha.
2.1 day flooding. 2 days drying
3.Retention time in aquifer: 6-12 months

Advantages of long – term SAT systems:

1. Removal of particulate matter, DOM, microorganisms
2. Chemical precipitation and immobilization by ion exchange of P, DOC, Cu, UV_{abs} (>70%)
3. N removal by nitrification - denitrification
4. Almost complete removal of micro pollutants (besides carbamazepine, sulfamethoxazole, iodine contrast media..)

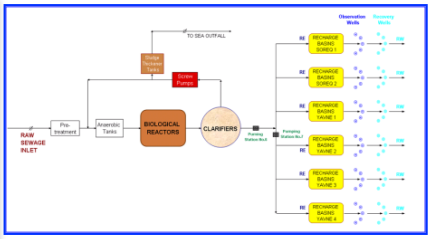

Fig. 1 – Dan Region WWTP and the Soil Aquifer Treatment (SAT)

Problems in the long term -SAT system during 33 years operation:

1. **Deterioration in Recharge Capacity**
2. Bio-fouling of Effluent Pipelines before and after SAT
3. **Mn and Fe dissolution due to anoxic conditions** in part of the SAT system forming oxides afterwards and clogging the irrigation systems
4. **No more new lands are available for infiltration** !!

Suggested solutions:

Hybrid UF- short SAT (1-2 months retention time), short SAT - NF or Sand filter-H_2O_2/O_3 – short SAT treatments

In order to improve the current extensive method (conventional SAT) and be able to **infiltrate more effluents** in a given infiltration area, **minimize manganese dissolution** and **maximize micropollutants removal**, 3 pilot projects have been operated:

1. **The EU RECLAIM project**: UF- short SAT (2005-2008). Improved infiltration velocity, good microorganism removal, partially improved oxidation conditions in the soil (only till the 10 days retention time R1 observation well area), 80% DOC removal, partial micropollutants removal
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3. **The BMBF ozonation project**: Sand filter-H_2O_2/O_3 – short SAT (end 2010-2013). Considering both projects' results it is expected to improve the infiltration, improve the aerobic conditions (area till R3, one month retention time well) and prevent manganese dissolution from the soil and oxidize the micropollutants.

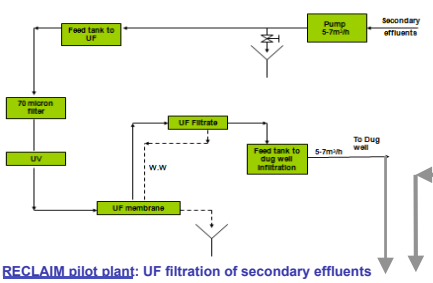


Fig. 2 – RECLAIM pilot plant: UF filtration of secondary effluents

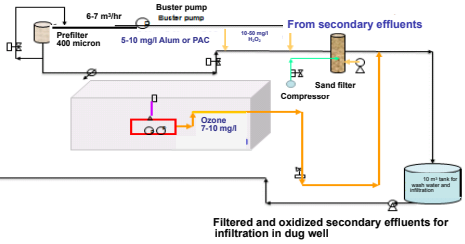
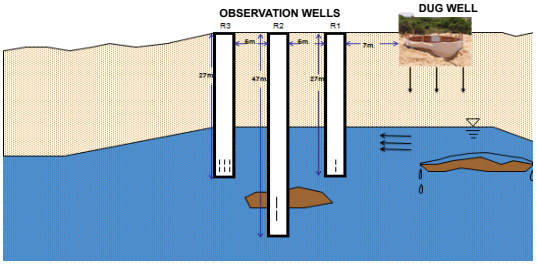


Fig. 3 – OZONATION pilot plant: Improvement of the short SAT anoxic conditions and reduction of manganese dissolution by aeration-sand filtration - ozonation of the secondary effluents (German –Israeli cooperation project)



The advantages of the Short SAT System

The Short SAT technique (1-2 months retention time) used in the (UF-Short SAT) and (Sand filter-H_2O_2/O_3 - Short SAT) pilots has the potential to decrease the manganese dissolution problem, since it shortens the effluent pathway in the saturated zone and lowers the possibility to deplete the oxygen and also much less manganese can dissolve from the soil and reach the reclaimed water due to shorter retention time in the soil.

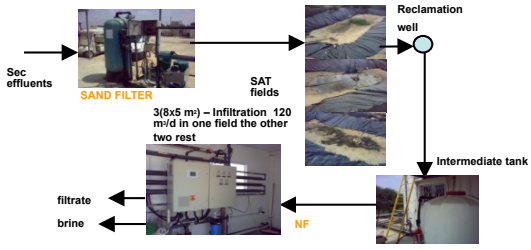


Fig. 4 - SWITCH pilot plant: Sand filter-Short SAT –NF to improve infiltration velocity, organics and micropollutants removal

Table. 1 –Removal efficiency of different chemical parameters during the short SAT-NF and long term SAT

Parameter	Unit	Sec. Effl.	A.Sh.SAT*	Rem. Eff. % (A.Sh. SAT-Sec. Effl.)	After NF	Rem. Eff. % (A.NF-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* 1000	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

Table. 2 –Micropollutants (antibiotics, AOI) concentration in different tertiary treatments (Dan Region WWTP)

(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_2O	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

The (short SAT) pretreatment before NF (in SWITCH) removed organic matter, ammonia, phosphates, particles and microorganisms better than the UF pretreatment applied in RO systems in indirect drinking water production

Mekorot's Research and LA Partners in SWITCH:

- **Research Partners: Gary Amy and Saroj Sharma (UNESCO-IHE), Martin Jekel and Mathias Ernst (Technical University Berlin)**
- **LA Tel-Aviv:** The Water Authority, the Dan Region Association of Towns, T.A. Municipality, Health Ministry, Interior Ministry, Farmers Association, NGOs, Yarkon River Authority, Water workers Association, HUJI.