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Alternative Hybrid SAT treatments to upgrade effluent quality

A. Aharoni[*(1)], M. Ernst[**], G. Amy[+], S. Sharma[+], Y. Guttman[*], N. Tal[*], T. Kreitzer[*], A. Putschew[**], M. Jekel[**], C. Kazner[#], T. Wintgens[##], K. Vairavamoorthy[+] and H. Cikurel[*(1)]

[*]Mekorot Israel National Water Co. Lincoln St. 9, Tel-Aviv, Israel
[**]TUB, Centre for Water in Urban Areas, Strasse des 17. Juni 135, 10623 Berlin
[+]Unesco-IHE, Westwest 7, 2611 AX Delft,, The Netherlands
[#] Dept. of Chem. Eng., RWTH Aachen Univ., Turmstr. 46, D-52056, Aachen
[##]Hochschule fur Life Sciences Institut fur Ecopreneurship, Grundenstrasse 40, Muttenz, CH-4132
(1) Mails to be addressed to: hchikurel@mekorot.co.il and aaharoni@mekorot.co.il

The field site that is used in demonstration activities in SWITCH is located in Tel Aviv and operated by Mekorot (SHAFDAN), and is the largest existing SAT demonstration site in the Mediterranean and European region. The conventional SAT system used as tertiary treatment saves 140 million cubic meters per year (MCMY) of fresh water by supplying an almost drinking water quality to agricultural irrigation.
The system has been operated for more than 30 years in a one day flooding – 2 days drying mode.
Due to lack of land for construction of new fields and some gradual clogging of the actual fields the SAT capacity is decreasing (actually 1 m/d infiltration velocity). Besides the deterioration in the recharge capacity and biofouling of effluent pipelines by organic matter, there is also a manganese oxide precipitation problem causing the clogging of irrigation systems. This is due to anaerobic conditions prevailing in the groundwater since organic matter depletes the oxygen and redox conditions cause manganese to be dissolved which then, in the presence of oxygen, forms manganese oxides in the pipelines and distribution systems.
In addition, in an alternative Hybrid SAT treatment studied in the context of an EU project (RECLAIM WATER project) it was found that some micropollutants (sulfamethaxazole, carbamazepine) although in small concentrations, prevail after SAT systems (Hein et. al., 2009).
The technique based on UF and short term SAT only (RECLAIM WATER), produced very good chemical and microbiological quality water but did not remove all micro-pollutants effectively due to the short retention time in the aquifer before the water is pumped out.
Nevertheless, the water is still suitable for unrestricted irrigation according to all regulations as of today in Israel and other parts of the modern world. But since the regulations are being tighter in the prospect of future regulations the SWITCH research in Shafdan is looking to obtain a more effective removal of micropollutants.
Both RECLAIM WATER and Switch processes save infiltration space by effective pretreatments before SAT (sand filtration, UF).

In the actual demonstration activity in Switch, new concepts are tested at the demonstration scale. Travel distance/time relationships required for elimination of different contaminants are being checked, pretreatment to reduce infiltration basin clogging is also addressed.
The different stages are:

1. Pretreatment (sand filtration) of 6 m^3/hr of secondary effluents without flocculant addition at 8 m/hr, the filter is backwashed every 8 hrs. No chlorine is used during the air-water backwash.
2. 5m^3/hr filtered secondary effluents are intermittently infiltered in 3 SAT fields, operated at a 1 day infiltration - 2 days relaxation mode and at 3-4 times higher infiltration rate than conventional.
3. Observation well (5 m from the SAT fields) and a recovery well (located 15 m from the SAT fields and reclaiming water after 30 days retention time in the aquifer) which extracts only 15 m^3/d of water.. The recovered water is sent to a hydrocyclone and micron filter before a polishing step by NF. The hydrocyclone and micron filter remove most of the loamy sand (calcareous and iron containing).
4. A DOW NF 200-400 polyamide-Thin film composite NF membrane is operated at 500 l/hr with 90% recovery (2 stages). The TMP for the 2 stages is 1.2-1.5 Atm. The membrane has been operated for 8 months with no special problems. The NF is backwashed only with acid water (inorganic problems mainly) every 4-6 hours and once a week with alkali. The salt reduction is only 15-20% since no desalination is necessary for agricultural irrigation.

Analyses are performed at Mekorot, TUB and IHE. Mekorot is performing the standard chemical analyses and the standard microbiological analyses. The emerging pollutants and other chemical analyses are performed by TUB and IHE who are organized to perform such analyses.

RESULTS

In early 2008 the first tracer tests were run to determine the retention time of the infiltrated effluents in the aquifer, before being sampled at the observation and reclamation wells. The tests were run with water recovered from conventional SAT (third Line water) with Bromide (Br) addition as tracer. Two tracer tests were run while the first was static (no recovered water), in that case 120 m^3/d of third line water was infiltered intermittently to each field while letting the others rest for 2 days. A retention time of 20 days to the observation well (5m away from the SAT) and 35 days retention to the reclamation well (15 m. away from the SAT) were obtained.
After the completion of these tests and due to late installation of the sand filter and NF, the first infiltration tests with sand filtered secondary effluents started in September 2008 and the first samples after SAT were sent to analyses to TUB and UNESCO IHE end October 2008. The purpose was to see if the polysaccharides and other clogging material had been retained by the sand filter and the short SAT.
The results of two campaigns (November and December 2008) showed that there was a complete removal of clogging material by the sand filter and the short (30-35 days retention time) SAT. Also dissolved organic matter was reduced to levels similar to the conventional SAT (decrease from around 10-11 mg/l before SAT to 1.7-2 mg/l after SAT). Most of the micropollutants that were analyzed (macrolide antibiotics and pharmaceuticals) were effectively removed.
At this stage in January 2009 the NF was operated and four campaign results have been obtain till now.
Table1 shows the chemical parameters results. It can be seen that after the NF polishing the organic matter removal is comparable and even better than the long SAT results while N and P are removed efficiently.

Table 1 – Organic matter, ammonia, phosphates and salt removal efficiencies at different stages of the pilot.

Parameter	Unit	Sec. Effl.	After Short SAT*	Rem. Eff. % Aftr.shrt SAT	Aftr. Nano Filter	Rem. Eff.% (from short SAT to NF)	CAS +LONG SAT**
COD	mg/L	29 - 40	5.0 - 9.0	78-83	2.0 - 3.0	60-67	-
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

The microorganisms are effectively removed at the short SAT stage. 5-6 logs of F.Coli, 5 logs of Enterococci, 4-5 logs of Clostridium, 4-5 logs of MS2 phages and complete removal of enteroviruses were obtained.

Micropollutants

Table 2 compares the different macrolide and sulfanamide antibiotics and organic iodine (AOI) removal efficiencies for the following tertiary treatment systems:

a. Conventional SAT
b. UF-short SAT (Reclaim Water)
c. Short SAT-NF (Switch)
d. UF-RO

All secondary effluent data relate to 2 years' average taking into account no significant fluctuations in micropollutants concentrations in the Shafdan wastewater.

Table 2 – Comparison of antibiotic and AOI concentrations in different tertiary treatments in Shafdan

(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	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 infiltered 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 infiltred in a 300 days SAT (D9 well)

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

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

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

The results obtained within the framework of RECLAIM WATER that included analysis at a specific well D9 in the 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. In Switch demo experiment the NF polishing step was able to remove more effectively the sulfamethaxazole and also AOI obtaining a very low DOC comparable to UF-RO results. This was obtained with no significant clogging of the NF due to the short SAT pre bio-filtration.
The interpretation of these results should take into account that the conventional SAT water is only used for unrestricted agricultural irrigation and not for drinking purposes and the Table 2 results are based on a specific well (D9).

Innovative features/science:

The importance of micropollutants in drinking water and reclaimed unrestricted irrigation water is more and more increasing as new detection methods decrease the limits of detection.
Of major concern are the endocrine disruptors, antibiotics and pharmaceuticals.
The Switch research and Demo is part of recently checked hybrid SAT treatments (membranes and SAT combination) to give an answer to these problems and at the same time reduce the GHG emissions (smaller carbon footprint) as compared to the UF-RO systems

REFERENCES:

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