Future scenario’s for Soil Aquifer Treatment: Responding to change

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SWITCH Project:
Workshop on Learning Alliance
December 10-11, 2006
Tel - Aviv, Israel
The importance of the Dan Region SAT system as potential source for water reuse in Israel
WATER STRESS:
WATER AVAILABILITY VS. WATER ABSTRACTION IN ISRAEL

290 m³/capita/yr

100%
Water Consumption

(MCMY)

Total Average Annual Consumption (2005) 1,960 MCMY

(Equivalent to the average annual availability)
Water Sources in 2005

- Natural Water: 71%
- Brackish Water Desalination: 15%
- Sea Water Desalination: 8%
- Brackish Water: 5%
- Treated Waste Water: 1%

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Water Sources in 2005 and 2020

2020
- Natural Water: 50%
- Brackish Water Desalination: 22%
- Sea Water Desalination: 3%

2005
- Natural Water: 71%
- Brackish Water Desalination: 15%
- Sea Water Desalination: 8%
- Brackish Water: 5%
- Treated Waste Water: 1%

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The aim is to increase effluent reuse *(by the year 2010)* to minimum 500 million m³ *(210 million M³ new + 290 current uses + natural increase)*.
CHANGES IN EFFLUENT QUALITY STANDARDS IN THE FUTURE

THE FUTURE EFFLUENTS STANDARDS WILL REQUIRE ONLY TWO QUALITIES:

1. UNRESTRICTED IRRIGATION QUALITY EFFLUENTS FOR AGRICULTURE

2. EXCELLENT (BACTERIOLOGICALLY) QUALITY EFFLUENTS FOR MUNICIPAL REUSE (PARK IRRIGATION..)

3. The Accidental drinking water quality of the Dan Region project is an answer for both water qualities
Dan Region Reclamation Scheme

This is the largest reclaimed water installation in Israel.

- It produces “accidental drinking water” quality for agricultural reuse using the soil-aquifer treatment (SAT) polishing process.

- The plant began operating in 1977 and has been expanded in several stages during its 29 years of operation.

- The latest expansion (in 2003) enabled the production of around 140 Mm³/yr of reclaimed water, which is then distributed over more than 100 kilometers (km) to provide water to arid zones of the country.
YEARLY AMOUNTS OF WASTEWATER, EFFLUENT AND RECLAIMED WATER IN THE DAN REGION WWTP AND RECLAMATION PROJECT (2005)

- **Total** treated sewage: 310,000 m³/d
- Recharged to SAT: 114.1 Mm³/Y
- Reclaimed: 135.3 Mm³/Y
- 100% is used for agricultural irrigation
- The investment on such project was done mainly to produce water for irrigation and also to get rid of the produced wastewater in the region
HISTORICAL OVERVIEW OF SAT

- **Late 60’s (last century)** first SAT in Arizona and California USA.

**IN ISRAEL:**

- In the early days of the **Israeli State**, the wastewater from all cities and settlements in Israel was disposed in septic tanks. In the 50’s most of the wastewater flowed to the sea or the rivers.

- In **1955**, an authority for the treatment of liquid and solid waste disposal was founded by 7 cities in the Dan Region (the cities of Tel-Aviv, Ramat Gan, Bat Yam, Holon, Petach Tikva, Givatayim and Bne Brak). The aim of the Dan Region Association of Towns was to prevent sea and rivers pollution by commonly treating the regional wastewater.

- **Mekorot LTD.**, the national water company, joined this project in order to **reuse the quantities of effluent**, resulting from the wastewater treatment, by reclaiming them for irrigation.

- The **innovation** in this project was the conveying of the water from the crowded urban area in the center of the country, a long distance to the south of the country which is a dry area, for the purpose of developing the agriculture there.
The Wastewater Plant was planned to be built south of Tel-Aviv on the sand dunes of Soreq near the town of Rishon – Le Tsion.

The biological treatment mode was chosen to be oxidation ponds.

1972 - The first ponds were ready to receive 20 MMCY wastewater (out of 80 MMCY produced that year).

But since the oxidation ponds required large surface area, the mechanical biological activated sludge (MBAS) treatment mode was preferred for future plans.

1977- In order to reuse the water, the recharge of the effluents to the regional aquifer was started.

The delay in the construction of the first infiltration site at Soreq, was caused by the stiff opposition from the Major of Rishon Le-Tsion (where the project was planned to be constructed).

1987 - An MBAS plant with nitrogen removal was put into operation.

November 1989 - The operation of the “Third Line”, the distribution system for The Soil Aquifer Treated effluent from the Dan Region WWTP, started. Since that time the almost drinking water quality reclaimed water is used for unrestricted agricultural irrigation in the southern part of the country.

1996 - It was expanded to a second stage MBAS

End of 1999 - Until 1999, 7% of the wastewater were treated in the oxidation ponds. The oxidation ponds were closed and all the wastewater are today treated in the mechanical – biological plant.
Groundwater recharge methods

- ASR
- ASTR
- Bank Filtration
- Dune Filtration
- Infiltration Pond
- Percolation Tank
- Rainwater Harvesting
- Soil Aquifer Treatment
- Underground Dam
- Sand Dam
- Recharge releases
The Dan Region WWTP and Recharge Basins

THE DAN REGION WASTEWATER TREATMENT AND RECLAMATION SYSTEM
Soil Aquifer Treatment

SAT basins – Each are divided to sub-basins

View from a sub-basin at the beginning of the filling cycle and a soil treatment machine

Cross Section of the Soil and Aquifer under the Recharge Area

Detention time: 3-12 months
THE DAN REGION PROJECT – BY NUMBERS

Process:
130 – 140 Mm³/yr of effluent recharge in a total area of 80 ha. The effluent percolates vertically through deep vadose zone (15 – 30 m.) and is horizontally spread through the saturated zone. The main operation schedule of the SAT is: 1 – 2 day for surface spreading and 2 - 6 days for drying.

The recharged effluent gradually displaces the native groundwater and is recovered through wells surrounding the recharge basins. The high retention time in the SAT system (6 to 12 months) ensures very high quality water (accidental drinking water quality).

Hydraulic loading to the basins varies according to the infiltration basins: (2004-2005)

For Soreq basins: Between 64 to 130 m/yr. (0.18-0.36) m/d.
For Yavne 1 basins: Between 73 to 122 m/yr. (0.2 – 0.34) m/d
For Yavne 2 basins: Between 88 to 120 m/yr. (0.24 – 0.33) m/d
For Yavne 3 basins: Between 181 to 234 m/yr.(0.5 –0.65) m/d
For Yavne 4 basins: Between 9 to 55 m/yr. (constructed, end 2003)
PROBLEMS IN THE SAT SYSTEM

During the 29 years of operation

1. Deterioration in Recharge Capacity

2. Bio-fouling of Effluent Pipelines

3. Mn and Fe oxides clogging due to anaerobic conditions

As a result not all the produced secondary effluents are reused in the Shafdan Project
In **20-30 years**, around Tel-Aviv a high population growth and advanced urbanization is expected.

As a result there will be more demand for housing construction, energy demand increase..

Also there will be a shift of agricultural land demand from the Tel-Aviv area (where due to population growth there will be changes in land use) to the South of Israel where land is available and if enough water is supplied there would be more and more sustainable agriculture.

Probably more desertization in the southern parts will occur due to climate changes.
In 30 years time the main supply of drinking water will come from:
1. More local sources (desalination, local wells and indirect reuse of effluent)
2. Much improved (filtered – UV disinfected) drinking water supplied from Lake Kinneret.

The effluents that are mainly reused in agriculture will be also reused for municipal and public reuse (street cleaning, fire fighting, park irrigation, recreational) and also for none-food industries (cooling towers..).

Due to mixing of the desalinated water this water will contain less salts and less hardness which will enable more industrial reuses.

The agricultural water consumption which is around 70% of the total consumption will go down to 50% due to the decrease of the agricultural production and due to more advanced agriculture.

But, the effluents from the Dan Region that are supplied to the south of Israel will be still required since the agriculture in this part of the country will still be wide-spread although more sophisticated and less water intensive. Still basic agriculture (potatoes, wheat..) will be practiced.

More local effluent reuse for public irrigation and river replenishment can come from small local treatment plants and not only from central plants like the Dan Region WWTP. These plants could use diversified treatments like advanced technologies (MBR..) or natural systems (wet lands..).
PILOT FOR THE MODIFIED SOIL AQUIFER TREATMENT SYSTEM (SAT) AND DEMONSTRATION OF THE RESULTS IN THE DAN REGION WWTP

THE PURPOSE OF THE RESEARCH:

Looking for alternative technologies that will produce water comparable to the accidental drinking water quality of the Shafdan Water (SW).

THE AIM OF THE RESEARCH AND DEMONSTRATION PARTS OF THE PROJECT:

The work will involve comparing the results of the SAT-NF pilot with the results of the conventional SAT and another process UF-SAT process (part of the Reclaim project).
COMPARISON OF ACTUAL SAT, UF-SAT and SAT-NF

**ACTUAL SAT**
- Secondary effluents
  - SAT system
    - 6 - 12 months retention time
  - Observation well

**RECLAIM**
- Secondary effluents
  - UF
  - Dug well injection
    - 30 - 60 days retention time
  - Observation well

**SWITCH**
- Secondary effluents
  - Short SAT system (spreading)
    - Up to 30 days retention
  - Extraction well and reservoir for NF filt.
  - NF

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PILOT EXPERIMENT

SAT as a pretreatment for membranes, with post-treatment by nanofiltration (NF). This hybrid system can serve as multi-barrier to microbes and chemicals.

The laboratory scale experiments will be done at HUJI and IHE, with IHE using Dutch wastewater effluents.

The pilot scale will be performed by MW. Analyses will be performed at MW, TUB and IHE. MW will perform the standard chemical analyses and the standard microbiological analyses. The emerging pollutants and other chemical analyses will be performed by IHE and TUB who are organized to perform such analyses.

In the demonstration stage a comparison will be performed between the RECLAIM project pilot that studies the SAT improvement by first UF filtration and then infiltration by dug wells and short SAT to obtain the same water quality as the conventional SAT today, and the SWITCH project pilot to show the advantages and disadvantages of each process. Modeling comparison (BRGM as outside contractors)
SWITCH and RECLAIM pilot plant locations
THE PROPOSED PROCESS:

The proposed alternative process consists of:

1. Preliminary treatment before SAT (wire filter) to minimize clogging of the infiltration field

2. Operation of a very short retention time SAT (2-10 days) by surface spreading of the pretreated WWTP effluents to minimize the proteins and polysaccharides that are the main precursors for the NF membrane clogging

3. Polishing of the reclaimed water by Nanofiltration (NF)
   SAT pretreatment before NF will minimize membrane clogging and decrease to a minimum the organic matter
   The polishing and removal of the endocrine disruptors, pharmaceuticals and other micropollutants will be performed by the NF

4. Comparison of the Short retention time SAT – NF treatment with the conventional SAT by analyzing physico-chemical and microbiological parameters

5. Comparison of the 10 days SAT – NF process (SWITCH) to the UF-30 days SAT process (RECLAIM)

(SAT-NF) will serve as multi-barriers to microbes and chemicals
SWITCH PILOT PLANT – SAT fields and the NF membrane set-up

SWITCH PROJECT SCHEME
Details of the UF membranes (5 m³/hr)

SWITCH project NF membrane
Different analyses:

* 3 control points: Secondary effluents, after SAT, after NF

** I. Protocol for routine analyses:**

1. **Basic Wastewater analysis:**
   - Suspended solids, BOD (total and soluble), COD (total and soluble), DOC, ammonia, nitrite, nitrate, total N, phosphorous, alkalinity, pH, turbidity, detergents, mineral oils, phenols

2. **Microbiological analysis:**
   - Total bacteria count, faecal coliform, faecal streptococci, enteroviruses

3. **Trace elements analysis:**
   - Boron, cadmium, chromium, cobalt, copper, fluoride, iron, lead, manganese, molybdenum, nickel, selenium, barium, cyanide

4. **Salinity related analysis:**
   - Chloride, electrical conductivity, sodium, potassium, calcium, magnesium, carbonate/bicarbonate
II. Analyses performed by TUB AND IHE
   (To be collected and posted)

1. Antibiotics analysis – TUB
2. Adsorbable organic iodine (AOI) – TUB
4. DOC characterisation – IHE
5. Boron isotope analysis – (OPTIONAL - If a comparison with RECLAIM to be done, can be performed by BRGM)