Israel’s challenge:
Concept development of a proper and efficient use of recycled water for irrigation
- More than half of the country is defined as arid and semi-arid.
- Since its establishment, Israel had to deal with increased shortages of water and growing demand for water.
- In arid and semi-arid zones, effluent serves as an important water resource and improves the national and regional water reserves.

### Water Demand Per Sectors 2006 (MCM/Year)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Demand (MCM)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>1107.8</td>
<td>56%</td>
</tr>
<tr>
<td>Domestic</td>
<td>737.4</td>
<td>38%</td>
</tr>
<tr>
<td>Industry</td>
<td>113.8</td>
<td>6%</td>
</tr>
<tr>
<td>Other</td>
<td>234.5</td>
<td>21%</td>
</tr>
<tr>
<td>TWW</td>
<td>354</td>
<td>32%</td>
</tr>
</tbody>
</table>

Total: 1959 MCM/Year
During the 90's sequence of drought years depleted water resources.

- Water supply reliability was unsecured.
- "Walking on the edge" water management policy, over extended the water resources to the limits.
- Agricultural allocations were reduced by 50%.
- Promoting saving water in the domestic sector was necessary.
- Israel's challenge: development of concept of a proper and efficient use of recycled water for irrigation.

Water Crisis
Wastewater Use For Irrigation
In Agricultural Sector

- The combination of severe water shortages, contamination of water resources, densely populated urban areas and highly intensive irrigated agriculture, makes it essential that countries put wastewater treatment and reuse high on its list of national priorities.

- Treated Wastewater (TWW) is the most readily available water resource and provides a partial solution to the scarcity problem.

- The main motivation for increased use of TWW for irrigation is: Irrigated agriculture serves as the best solution for human health protection and prevention of environment pollution.

Why Reuse Water?

- Limited New Water Sources
- Improves Potable Water Quality
- Relieves Potable Water Demand
- Restores Potable Water Quality
- Restores River/Lake Levels
- Restores Groundwater Levels
- Offers Reliable Water Supply (Drought-Proof)
- Lowers Cost to Users
- Reduces Pollutants to Rivers and Estuaries

Social/Environmental Benefits
Effluent Use Related to Total Water for Agricultural Use

Wastewater treatment in Israel 2005: Facts and Figures

- Wastewater - ~500 Million M3 WW/year
- 50% treated to secondary level
- 30% treated to tertiary level
- 4% discharged via cesspits
- 16% inadequately treated
- Effluents = 450 Million M3/year
- 65% of effluents (300 M3) reclaimed for irrigation
- 35% discharged to rivers or sea
- By 2010 – Reclaimed Effluents = 50% of all water to Agriculture
New Policy - Sustainable Approach

Reclamation

- Agricultural use will be built and operated by the private sector while the national system will be implemented by the Government.
- Use of treated effluents of adequate quality (Tertiary Treatment) to prevent pollution and damage soil, groundwater and crops.
- The content of salts and Boron will be reduced.

Main Aspects to Take Into Account

- Health considerations: to the people who eat the agricultural product and for the farmers who come in contact with the water
- TWW chemical quality: nutrients content and salinity parameters (total salt content, sodium, chloride, boron, heavy metals and SAR)
- TWW storage and distribution (environmental considerations)
- The irrigation system selected, filtration, monitoring, clogging potential
- Prevention of contamination and salification of land and water sources (surface and underground)
- Prevention damages to the plants.
Regulations For Irrigation

Due to the decision to increase the use of effluents to a total quantity of 500 MCM the Ministers committee for economics (Decision 46, July 2000) decided to nominate an Inter- Ministerial Committee (Inbar) in order to recommend a new regulation for the use of TWW for irrigation in agriculture or for disposal to streams.

Treated Wastewater:
A renewable irrigation water source

- To achieve the threshold values recommended for the regulation parameters, the quality of the TWW must be upgraded.
- The way to reach this objective will differ for any group of parameters.
  - The group of Organics, Nutrients and Pathogens can be treated at the wastewater treatment plants, under the present conditions or with some technical upgrading.
  - The salts and heavy metals, at the present level of wastewater treatment, have to be treated at the source.
Regulation (Inbar Committee)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>UNIT</th>
<th>IRRIGATION</th>
<th>STREAMS</th>
<th>IRRIGATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>EC</td>
<td>dS/m</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>mg/L</td>
<td>100</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>20</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>mg/L</td>
<td>25</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total Phosphates</td>
<td>mg/L</td>
<td>5</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>mg/L</td>
<td>250</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>Fluorine</td>
<td>mg/L</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>mg/L</td>
<td>150</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Fecal Coliforms</td>
<td>U/100ml</td>
<td>10</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>mg/L</td>
<td>&gt;0.5</td>
<td>&gt;3</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.5-8.5</td>
<td>7.0-8.5</td>
<td></td>
</tr>
<tr>
<td>Residual Chlorine</td>
<td>mg/L</td>
<td>1</td>
<td>&lt;0.05</td>
<td></td>
</tr>
<tr>
<td>SAR</td>
<td>(mmol/L)</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td>mg/L</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Regulation-health aspects

It is obligatory for farmers to acquire permits for irrigation with effluent water. The permits are given by the Ministry of Health according to the quality of water and crops irrigated.
Health Limits Using Effluent

**Very high quality effluents suited for unrestricted irrigation**
- Treated at a mechanical- biological treatment plant which produce effluents with 20/30 (BOD/TSS) that is filtrated with a granular filter (or equal filtration)
- Sterilizing at least 30 minutes.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.O.D</td>
<td>Mg/l</td>
<td>10</td>
</tr>
<tr>
<td>T.S.S</td>
<td>Mg/l</td>
<td>10</td>
</tr>
<tr>
<td>C.O.D</td>
<td>Mg/l</td>
<td>100</td>
</tr>
<tr>
<td>Fecal Coli</td>
<td>NO’ IN 100 milliliter</td>
<td>10</td>
</tr>
<tr>
<td>Dissolved Oxygen</td>
<td>Mg/l</td>
<td>&gt; 0.5</td>
</tr>
<tr>
<td>Residual Cl</td>
<td>Mg/l</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**High quality effluents**

Effluents treated at a mechanical-biological treatment plant with a quality of 20/30 (BOD/TSS)

Two “barriers” are needed for irrigation with this quality of water.
Barriers for irrigation with effluents

- According to the quality of effluents, the number of “barriers” needed is decided for irrigation with this water.
- The “barriers” are decided according to the potential health risks in the effluents.
- Such barriers can be:
  - the physical distance between the effluents and the crop
  - non-eatable crops
  - fruits that are treated with very high temperature
  - thick peeling
  - fruit that is eaten cooked, underground irrigation.

The regulations that were based on these aspects were published for all the different crops irrigated, and the water qualities.

- Combination of advanced biological treatment (including nitrification and de-nitrification) filtration and sterilization enable the use of effluents for unrestricted crop irrigation following the most restricted standards that are accepted in the most advanced countries around the world.
Wastewater Treatment - The Shafdan

- The shafdan is the largest wastewater treatment in Israel and is considered to be the largest and most advanced of its type in the Middle East.
- The facility serves a population of about 2 million people and treats about 130 million cubic meters of wastewater annually.
- The water is recharged to confined aquifers through infiltration fields in order to improve their quality, pumped through recovery wells and supplied to the most arid area in Israel “The Negev” at a quality permitting unlimited agricultural crop irrigation.
A Mutual Support System

- Researchers
- Agricultural Related Industries
- Close Cooperation
- Farmers
- Extension Services
According to the national plan of increasing the amount of TWW used for agriculture.

The Ministry of Agriculture has designated a special department to study the short term and long term affects of such irrigation on the crops and the environment.

The professional inputs received from the researchers assist in assimilation and acceptance of farmers the usage of effluents for irrigation and ensuring a safe marketing of agricultural products for overseas markets.

Research - example

Between the years 1998-2005, 120-160 plots of citrus, avocado, and field crops were tested in the soils, leaves and water for 33 different parameters: Mechanical structure, EC, Ph, Cl, Na, Ca, Mg, K, Br, P, N, N-NO3, N-NH4, SAR, BOD, COD, F, Fe, Mn, Cu, TSS
Research

The results of the field trials and the conclusions enable decision makers to decide on regulations and permits for irrigation, taking into account the potential risks and effects, and to identify the best agro-techniques for irrigation with TWW that will minimize damage to the environment and will maximize quality production.
The Extension service

The role of the Governmental Extension service is:
- To transfer the knowledge from the research to the farmer.
- To identify with the farmer the problems that arise when irrigating with TWW and bringing it to the research training courses and seminar on the adequate techniques for irrigating with TWW.

Technologies

- Advanced drip irrigation systems that ensure safe and efficient irrigation with effluents.
- Advanced filters with automatic and manual cleaning mechanisms that protect the irrigation systems from clogging.
- Monitoring devices on the water flow for early detection of clogging.
Use of reclaimed water in irrigation systems often cause blockage of hydraulic systems, clogging of drippers and mini-sprinklers. These may result in economical damages such as: Flow reduction, uneven water distribution, large backwash water volumes, etc.

How can we evaluate the technical quality of the water? Clogging Potential Meter is a field-test simulator, providing immediate numerical data that allow the irrigation system design and the evaluation of periodical changes in the source water quality.
For on-line clogging potential monitoring of reclaimed water we add a small self-cleaning filter, and measure its backwash rate.

- Connections required: 220V and water supply
- PLC unit counts backwashes per hour as the main parameter.
- Data is collected by the PLC and sent via cellular to any desired destination
- Alert message is sent if desired DP is not reached within three backwashes.
Drip System Using Effluents

The Advantages of Drip Irrigation for Effluent Applications

- Sprinklers and center pivots create aerosols that may drift creating health issues.
- Potential contamination of food crops.
- High application rate overloads soil and may leach into underground water resources.
- No effluent drift with drip irrigation.
- Subsurface drip is the ecologically sound solution for using effluents, leaving no effluents on soil surface.
- Drip irrigation allows for precise control of the application rates for maximum environment benefit.
Drip Irrigation for Utilizing Effluents

- Drip is a comprehensive solution for water and food crisis.
- Drip is the only irrigation system, using effluents in very high efficiency for marginal lands and soils.
- Compare to sprinklers, center pivots and flood irrigation drip benefits are:
  - Accurate amount of water: saving water, increasing yield.
  - does not contaminate the soil and underground water resources
  - Low application rate create low movement of water in soil and destruction off all pathogens and viruses.

UNIRAM Drippers Characteristics

- UNIRAM is the new innovation in drip system that gives a good solution for poor effluent quality and marginal field conditions.
- The biggest drippers filter protecting from water contaminates.
- Anti siphon (in subsurface system eliminate contaminates movement from the soil into the drippers labyrinth.
- Avoid root intrusion
Irrigation Efficiency

**Irrigation Methods**

- **Flood**: 40%-60%
- **Furrow**: 50%-70%
- **Sprinkler**: 60%-85%
- **Center Pivot**: 70%-90%
- **Dripper**: 90%-95%

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**Characteristic of the UNIRAM Dripper.**

- UNIRAM is the new innovation in drip system that gives a good solution for poor effluent quality and marginal field conditions.
- The biggest drippers filter protecting from water contaminates
- Anti siphon (in subsurface system eliminate contaminates movement from the soil into the drippers labyrinth)
- Avoid root intrusion
Subsurface drip irrigation

The safest, most efficient way to use wastewater effluents:

- Controlled application rates
- Little chance for cross contamination
- Efficient water utilization
- Proven Technology

UNIRAM Characteristics

Compensated and self-cleaning characteristics for use in bad effluent quality and hilly area
Wide passage and Turbonet (high speed)
Water movement in the dripper. Eliminate of drippers clogging.

Sub Surface Drip Wastewater Disposal System
Traffic Island - Integral dripline - Sub surface fixed spacing
<table>
<thead>
<tr>
<th>Benefits of Subsurface Drip Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>‣ Increased water use efficiency, water is supplied directly to root zone.</td>
</tr>
<tr>
<td>‣ Reduced water percolation through the root zone.</td>
</tr>
<tr>
<td>‣ Reduced runoff from the tail end of a field.</td>
</tr>
<tr>
<td>‣ Reduced evaporation from the soil surface.</td>
</tr>
<tr>
<td>‣ Increased water distribution uniformity throughout a field.</td>
</tr>
<tr>
<td>‣ There is no appearance of effluents on soil surface, no weeds.</td>
</tr>
</tbody>
</table>

Movie – System layout below surface
SDI dosing system

- The Hydro PC and Hydro PCND drippers disperse the wastewater slowly and evenly directly into the root zone of the plants or grass.
- The plant roots use the water and the nutrients and provide the wastewater with natural treatment.
- The slow & precise dosing with HydroPC/ND drippers ensures dispersal of all wastewater into the plant root zone with no water surfacing or leaching to the underground water.

SDI dosing system advantages

- Environmentally friendly
- Easy to install
- Reliable PC/PCND drippers for long term use
- Suitable for many crops from grass and landscape to agricultural uses
- No evaporation or leaching into the underground water
The Arkal automatic disc filtration system has unique qualities facilitating these challenges effectively and efficiently. Spin Klin systems provide excellent solutions when utilizing reused irrigation water:

- Effective, high quality filtration of organic particulates.
- Reliable water filtration not subject to breakthroughs (channeling in media or screen tearing) and penetration of pollutants into the irrigation lines.
- Efficient self-cleaning technology allowing continuous irrigation without manual intervention of the operation system.
- Very low maintenance (direct contact with the water becomes virtually unnecessary).

Spin Klin Technology
Proficiently Protects Low-volume Irrigation Systems Utilizing Wastewater

Kfar Menachem, Israel
source: Jerusalem Wastewater
field crops Irrigation
flow Rate: 420m3/h
filtration grade: 130 micron

Ohad, Israel
water source: Safdan
fruit tree irrigation
flow rate: 130m3/hr,
filtration grade: 100 micron

Faran, Israel
water source: Faran wastewater
vegetable & date irrigation
flow rate: 50m3/hr,
filtration grade: 130 micron
Effluent Uses in Irrigation

Harsh effluents quality

Irrigation with UNIRAM drip system in avocado plantation.

Tool-Karem w.w.t.p

- Simunye Estates, South Africa
  - Source: Mixed sugar plant wastewater and river water. Sugar cane Irrigation
  - Flow rate: 1400 m³/h
  - Filtration grade: 130 micron

- Mekorot, ma‘ale Hakishon, Israel
  - Source: Haifa wastewater field crops irrigation
  - Flow rate: 1400 m³/h
  - Filtration grade: 200 micron

- Ora, Israel
  - Water source: Safdan field crops irrigation
  - Flow rate: 340 m³/hr
  - Filtration grade: 130 micron
Effluent Uses in Irrigation

Anaerobic treatment plant in the Arava desert using dairy and cowshed sewage.

UNIRAM Subsurface drip in palm plantation

Effluent Uses in Irrigation

Mix junction using effluent and saline water.

UNIRAM drip in potatoes.
Case study: Tzafon

- Tzafon, an agricultural village, is located within the Mateh Yehudah region of Israel.
- Tzafon’s major source of income derives from cultivating olive groves, orchards and various vegetables.
- The village’s irrigation water consists of high quality potable water, supplied by the National Water Carrier Company, Mekorot.
- Annual water allocation to the village is 1,100,000 cubic meters.

The Purpose

- To convert 450,000 m³ of effluent water into irrigation water at a cheaper price per m³.
- Jerusalem’s sewage water runs in a 36” pipeline near Tzafon. These waters are at a secondary treatment level and are not suitable for row crop irrigation.
- Most of the village’s income derives from vegetable cultivation. In order to irrigate the crops, it was necessary to upgrade the wastewater to a tertiary treatment level, to achieve "unlimited irrigation" level of water purity to meet standards defined by the Ministry of Health.
The Demand

- Tzalfon, in conjunction with the regional water association, approached Amiad Filtration Systems to set up an effluent upgrading system, for unlimited irrigation, at a flow rate of 250m³ per hour.

The Amiad Solution

System Included:
- Pre-filtration with automatic self-cleaning electric filters.
- A flocculation system for optimal filtration.
- Main filtration by 4 multi-layer media tanks.
- An automatic disinfection system and storage tank for treated water, where water consumption is regulated for irrigation as required by farmers.
- System is computer controlled, which enables control of filtration and disinfection process, including data storage and transmission of alarms to its operator.
Application Of Technology

- The technology used at Tzalfon, and previously applied at dozens of similar water purification projects in Israel and abroad, has been developed and established by Amiad Filtration Systems.
- Amiad Filtration Systems designs and manufactures tertiary sewage treatment systems for various applications: Turf and public gardens, irrigation of vegetables and orchards, etc.

Operation Of System

- Following receipt of certification from the Ministry of Health (District of Jerusalem), the system, which has recently started to operate, supplies water at a price considerably lower than potable water.
- The system which has been operating for a few months, maintains the standards defined by the Ministry of Health to the customers complete satisfaction.
Tzalfon – Tertiary Treatment System

Project Specifications

- Location: Israel
- Flow Rate: 250 m³ per hour
- Water Source: Jerusalem’s secondary effluent (activated sludge).
- Usage: Unlimited irrigation
- Goal:
  - Turbidity of water - Less than 5 NTU.
  - Fecal coliform - Less than 10 p/100 ml.
Process - General Description

- Water enters at a flow rate of 250 m³/hr, aided by in-line pressure (35 meters).
- Alum is injected prior to 80 micron filtration
- Pre-filtration screen 80 micron, reduces load on the main filter. Main filtration with a multi-layer granular filter: Anthracite, sand, quartz and basalt, total granular bed height of 100 cm.
- Disinfection with Sodium Hypochlorite
- Suspension in operative tank with a capacity of 1,000 m³.
- Pump with flow rate of 300 m³/hr supplies the water for irrigation.

Flow Chart
Process Details

- Alum Injection
- Pre Filtration
- Granular Filtration
- Filtration Stage
- Back Wash Stage
- Turbidity Control
- Disinfection
- Operative Tank
- Suspension
- Irrigation Pumps
- Disinfection Control
- Sampling Point
- Data Logger

Process Details - Alum Injection

- Flocculent Injection – Alum Sulphate
  - Alum causes the formation of flocculants composed of the suspended matter in water. These are larger than the suspended matter. Therefore they will be stopped by the granular filter.
  - The Alum dosage injection pump's flow rate will be relative to the water's flow rate going through the filter.
  - The Alum concentration will be determined manually and by the control display by altering the dosage pump's activity.
Process Details - Pre Filtration

- 2 x Screen Filters SAF-6000
- Automatic electric filters at a filtration degree of 80 micron. Their purpose is to reduce the dirt levels from the granular filter.

Process Details – Granular Filtration

4 Granular Filters
- Each filter 2.20 meters in diameter.
- Parallel installation of filters to achieve 15.7m/hr filtration speed
- Each unit has a 3 layer granular bed.
  - 10 cm. Basalt type 1, support layer
  - 55 cm. Quartz sand type 0, main bed
  - 35 cm. Anthracite type 1, pre-filtration layer.
### Granular Filtration – Filtration Stage

- Valves V1 & V2 are open, the rest are closed.
- Filter blocks suspended matter in the granular bed, while a few systems affect the blockage of particles.
- Suspended matter blocked by the media bed affects the filter’s pressure drop.
- When filter is loaded, a back wash is required to clean the filter, prior to the separation of matter caught in filter bed.

### Granular Filtration – Back Wash Stage

- Filtration halted and filter’s water level is reduced.
- Air is inserted into filter causing particles to float & detach from filter bed.
- Containers are filled with water
- Back washing with treated water takes approx. 20 minutes.
- Filter’s back washing occurs under 4 conditions:
  - Time, once every 24 hours (Pre-set)
  - Turbidity of treated water
  - Pressure differential
  - Manual
Process Details – Turbidity Control

- Turbidity control of filtered water occurs past the filter system by a continual turbidity meter.
  - When treated water’s turbidity rises above 4.5 NTU for 5 continuous minutes – filter system enters backwash.
  - 3 back washes, of granular filter within 6 hours, will cause the system to lock down.
  - Turbidity test results are stored in the data logger.

Process Details – Disinfection

- Dosage pump for Sodium Hypochlorite injection.
  - Chlorination of water prior to operative tank
  - Amount of Chlorine addition is relative to flow rate going through filter system.
  - System’s flow rate is achieved by tallying 4 hydrometers combined with each filter’s V1 valve.
After disinfection water flows to an operative tank, at about 1,000 m³ in volume.

- Tank enables continuous operation of system.
- Insuring better operation of filters, by reducing number of shut downs & restarts.
- Used for suspension of water & chlorine for at least 30 minutes prior to irrigation.

Suspension for about 40 minutes, of chlorinated water, is achieved by operative tank.

- Operative tank’s volume is app. 1,000 m³
- Estimated suspension time, for max. 300 m³/hr. flow rate, is between 40 minutes to 3 hours.
- When water demand is low, collection volume can be altered by varying height of buoys in tank.
Process Details – Irrigation Pumps

- Irrigation pumps are located after the operating tank.
- Tally of water meters, after irrigation pumps, ratio to water flow of water delivered to irrigation, is registered by an analogical indicator 4-20 milliamp by data logger.

Process Details – Disinfection Control

- Disinfection control occurs on water supplied for irrigation, past the irrigation pumps.
  - When chlorine level in indicator drops below 1 mg/L, system locks down.
  - System's lock down means an operator has to manually restart system by pressing start button.
  - Dry contact is transferred to shut down irrigation pumps.
  - Chlorine level test results are stored in the data logger.
Process Details – Sampling Point

- Sampling point to test for bacteria
  - Located on water line, after irrigation pumps.
  - Insures water sampling after approximately 40 minutes suspension.

Data Logger

- Data is stored in a data logger, according to 3 parameters.
  - Flow rate
  - Turbidity
  - Chlorine