Consultancy and Engineering

Sustainable Water Integrated Management (SWIM) - Support Mechanism

SUB-REGIONAL WORKSHOP 9-12 July 2012 Israel

Agricultural use of treated wastewater and WHO guidelines

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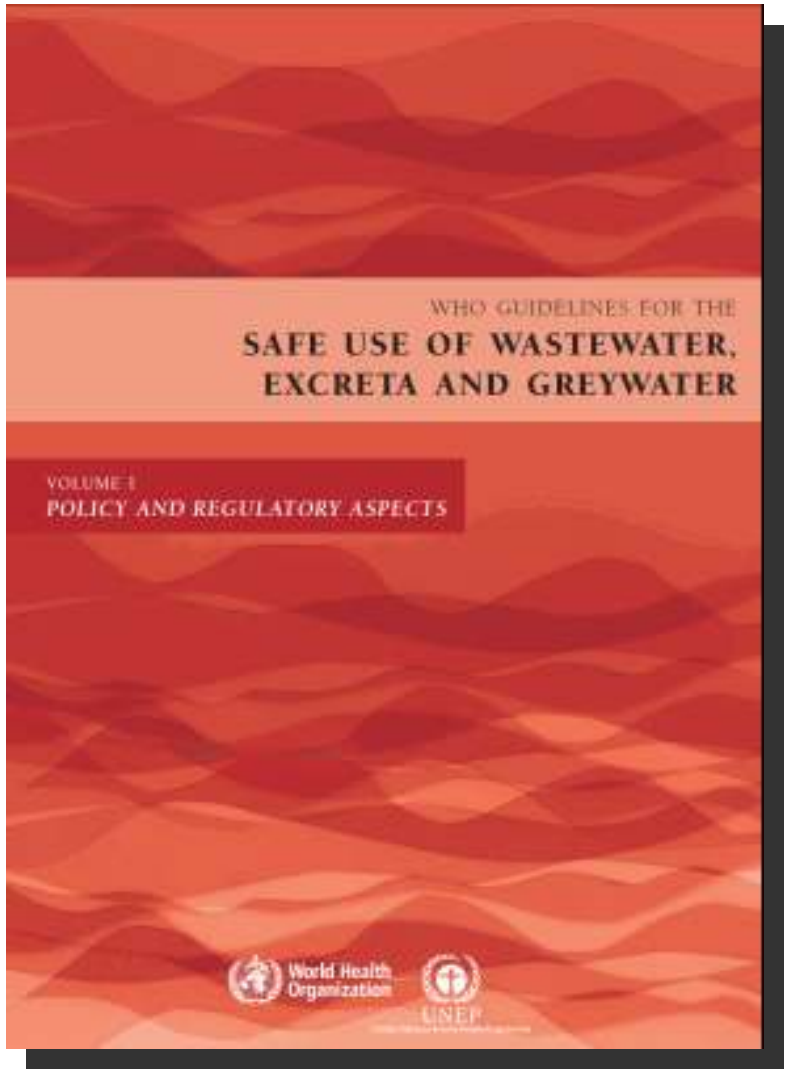
July 2012

WHO Guidelines – an overview

- Health Component
  - Establishes risk level associated with each identified health hazard;
  - Defines a level of health protection as a health-based target for each risk;
  - Identifies health protection measures to achieve health-based targets;
- Implementation Component
  - Establishes monitoring and assessment procedures;
  - Defines institutional responsibilities;
  - Requires system documentation;
  - Requires confirmation by independent surveillance.



WHO Guidelines – an overview

- Health Component
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  - Defines **institutional responsibilities**;
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WHO Guidelines – Hazard

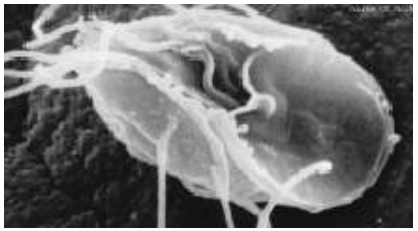
Any agent that is reasonably likely to harm humans, other organisms, or the environment in the absence of its control

Helmints

Ascaris

Parasitic Protozoa

Ameba intestinalis



Giardia Intestinalis

Virus

Enteric Virus

Bacteria

Cholera, typhus, salmonella

Heavey Metals

Others

WHO Guidelines – Risk

Risk = Hazard x Dose (Expos

Groups at risk:

- Consumers
- Farmers
- Close communities

Israeli Experience:

- **Soils**
- **Aquifers**

Table 2.2 Summary of health risks associated with the use of wastewater for irrigation

Group exposed	Health threats		
	Helminths	**Bacteria/viruses**	**Protozoa**
Consumers	Significant risks of helminth infection for both adults and children with untreated wastewater	Cholera, typhoid and shigellosis outbreaks reported from use of untreated wastewater; seropositive responses for *Helicobacter pylori* (untreated); increase in non-specific diarrhoea when water quality exceeds 10^4 thermotolerant coliforms per 100 ml	Evidence of parasitic protozoa found on wastewater-irrigated vegetable surfaces, but no direct evidence of disease transmission
Farm workers and their families	Significant risks of helminth infection for both adults and children in contact with untreated wastewater; increased risk of hookworm infection to workers who do not wear shoes; risks for helminth infection remain, especially for children, even when wastewater is treated to <1 helminth egg per litre; adults are not at increased risk at this helminth concentration	Increased risk of diarrhoeal disease in young children with wastewater contact if water quality exceeds 10^4 thermotolerant coliforms per 100 ml; elevated risk of *Salmonella* infection in children exposed to untreated wastewater; elevated seroresponse to norovirus in adults exposed to partially treated wastewater	Risk of *Giardia intestinalis* infection reported to be insignificant for contact with both untreated and treated wastewater; another study in Pakistan estimated a threefold increase in risk of *Giardia* infection for farmers using raw wastewater compared with irrigation with fresh water; increased risk of amoebiasis observed from contact with untreated wastewater
Nearby communities	Transmission of helminth infections not studied for sprinkler irrigation, but same as above for flood or furrow irrigation with heavy contact	Sprinkler irrigation with poor water quality (10^6–10^8 total coliforms/100 ml) and high aerosol exposure associated with increased rates of infection; use of partially treated water (10^4–10^5 thermotolerant coliforms/100 ml or less) in sprinkler irrigation is not associated with increased viral infection rates	No data for transmission of protozoan infections during sprinkler irrigation with wastewater

WHO Guidelines – Risk Assessment

Table 2.3 Summary of quantitative microbial risk assessment results for rotavirus[a] infection risks for different exposures

Exposure scenario	Water quality[b] (*E. coli*/100 ml of wastewater or 100 g of soil)	Median infection risks per person per year	Notes
Unrestricted irrigation (crop consumers)			
Lettuce	10^3–10^4	10^{-3}	100 g eaten raw per person every 2 days
			10–15 ml wastewater remaining on crop
Onions	10^3–10^4	5×10^{-2}	100 g eaten raw per person per week for 5 months
			1–5 ml wastewater remaining on crop
Restricted irrigation (farmers or other heavily exposed populations)			
Highly mechanized	10^5	10^{-3}	100 days' exposure per year
			1–10 mg soil consumed per exposure
Labour intensive	10^3–10^4	10^{-3}	150–300 days' exposure per year
			10–100 mg soil consumed per exposure

WHO Guidelines
Health Based Targets

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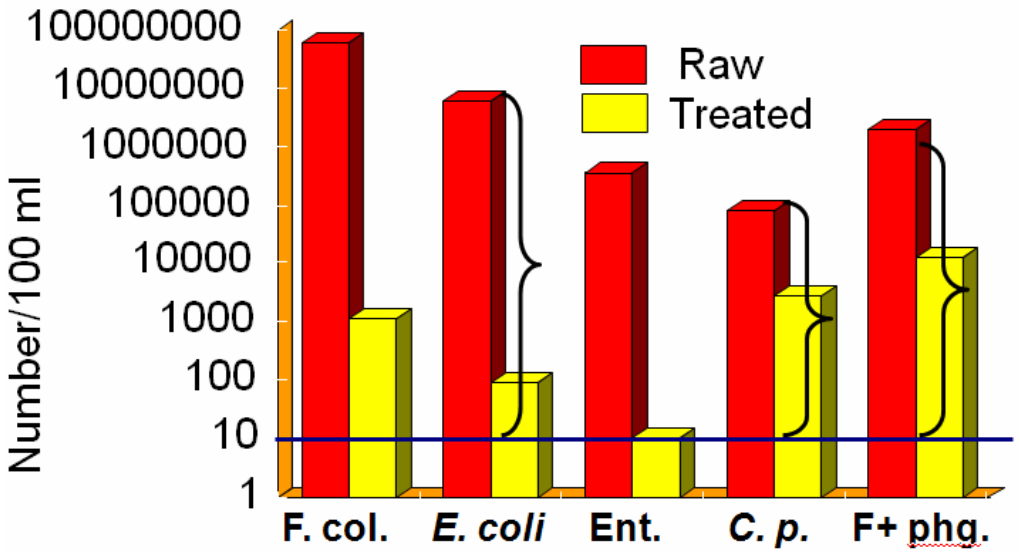
1. Define the tolerable maximum additional burden of disease
2. Define Reduction values for indicator hazards (e.g. Log_{10} reduction for microbes)



Multiple Barriers:

- **Treatment (low cost)**
- **Crop restriction**
- **Irrigation techniques**
- **Produce washing or cooking**

WHO Guidelines
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Consultancy and Engineering

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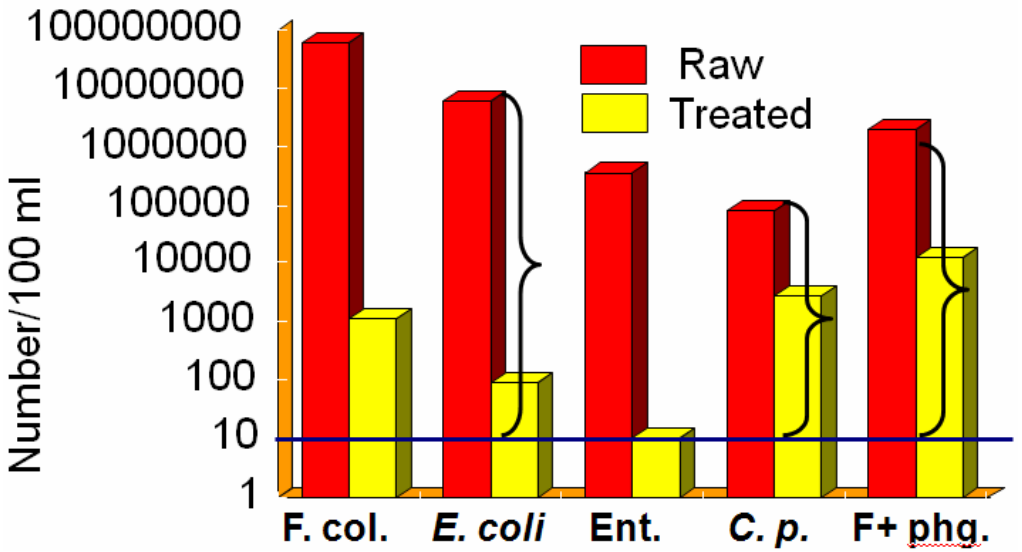


3. Timeline for restricted and unrestricted irrigation

	Implementation phase:	Phase 1 1×10^{-4}	Phase 2 1×10^{-5}	Phase 3 1×10^{-6}
Norovirus	Restricted irrigation Unrestricted irrigation	1 log unit 4 log units	2 log units 5 log units	3 log units 6 log units
Ascaris eggs	Restricted irrigation Unrestricted irrigation	1 log unit 3 log units	2 log units 3 log units	3 log units 4 log units

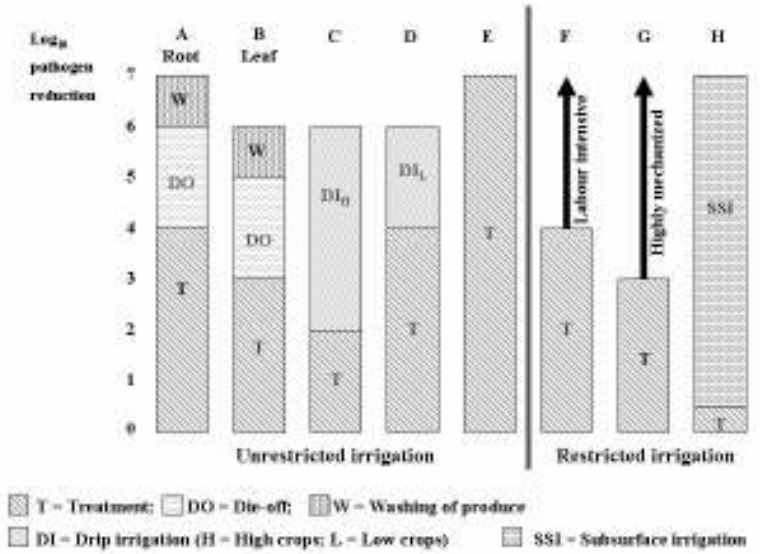
WHO Guidelines – Measures

Reduction targets can be achieved by a combination of

Control measure	Pathogen reduction (log units)	Notes
Excreta storage without fresh additions	6	The required pathogen reduction to be achieved by excreta treatment refers to stated storage times without addition of fresh untreated excreta. Pathogen reductions for different treatment options are presented in chapter 5 of Volume 4.
Greywater treatment	1–>4	Values relate to the relevant treatment options. Generally, the highest exposure reduction is related to subsurface irrigation
Localized (drip) irrigation with urine (high-growing crops)	2–4	C… b…
Materials directly worked into the soil	1	Should be done at the time when faeces or urine is applied as a fertilizer
Pathogen die-off (withholding time one month)	4–>6	A die-off of 0.5–2 log units per day is cited for wastewater irrigation. Reduction values cited are conservative to account for a slower die-off of a fraction of the remaining organisms.
Produce washing with water	1	Washing salad crops, vegetables and fruit with clean water
Produce disinfection	2	Washing salad crops, vegetables and fruit with a weak disinfectant solution and rinsing with clean water
Produce peeling	2	Fruits, root crops
Produce cooking	6–7	Immersion in boiling or close-to-boiling water until the food is cooked ensures pathogen destruction

Choose the best one for you

Hazard → Risk → Targets → Measures



Implementation
Israeli Experience

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Israeli Experience
WW treatment is only the beginning

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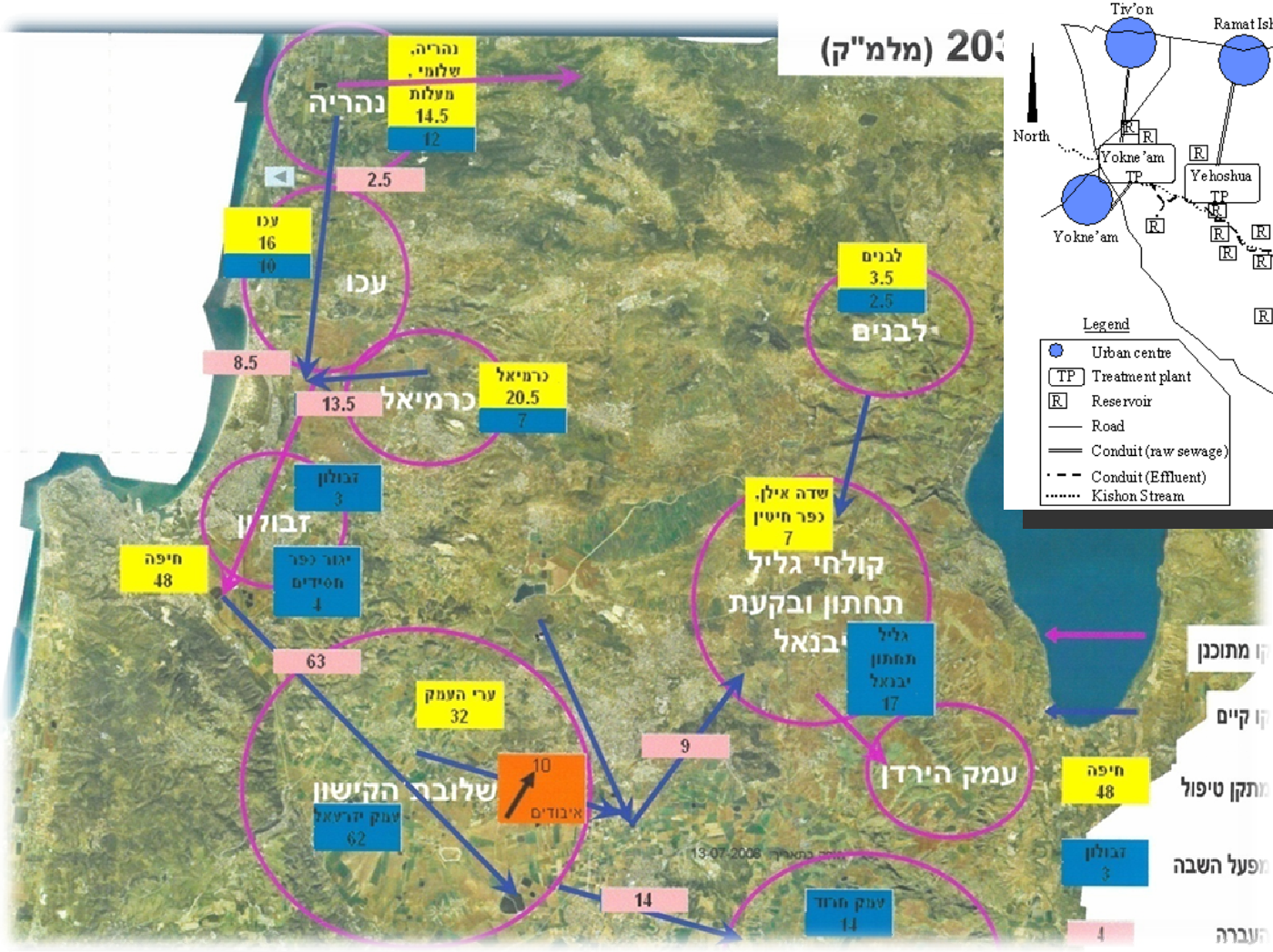

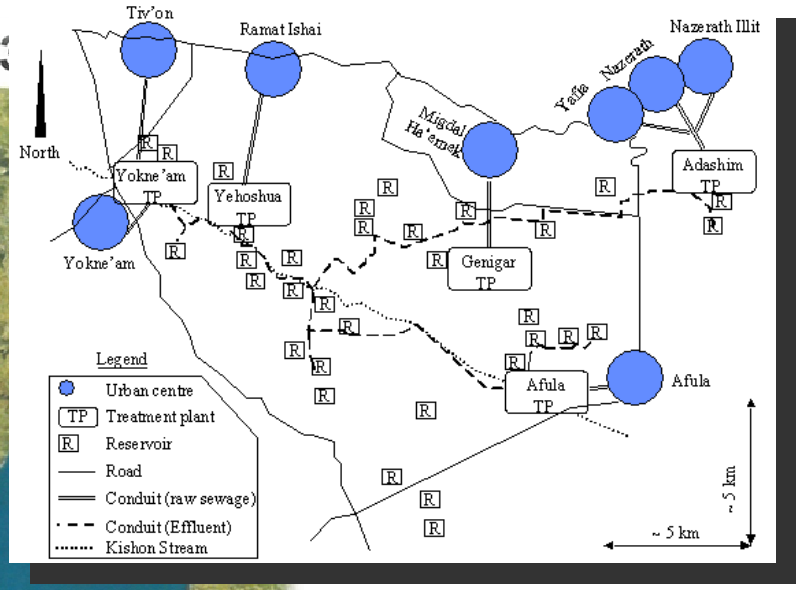

Kishon Concern

- 30 mcm/Yr
- Supplies as far as 40 km from the WWTP

Israeli Experience
Economic Incentives

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Governmental grants of 100 million $ a year for wastewater reclamation projects

Scheme	Freshwater price per m^3	Treated wastewater price per m^3	Percentage
Noirmoutier, FR	€1.54	€0.23-0.30	15-20%
Cyprus	€0.10	€0.10	100%
Israel	$0.31	$0.12	39%
Tunisia	$0.08	$0.02	25%

- ✓ Long distance supply network
- ✓ Long term planning
- ✓ A managing body

Israeli Experience
Emeq Hefer

Consultancy and Engineering

Israeli Experience
Emeq Hefer - reservoirs

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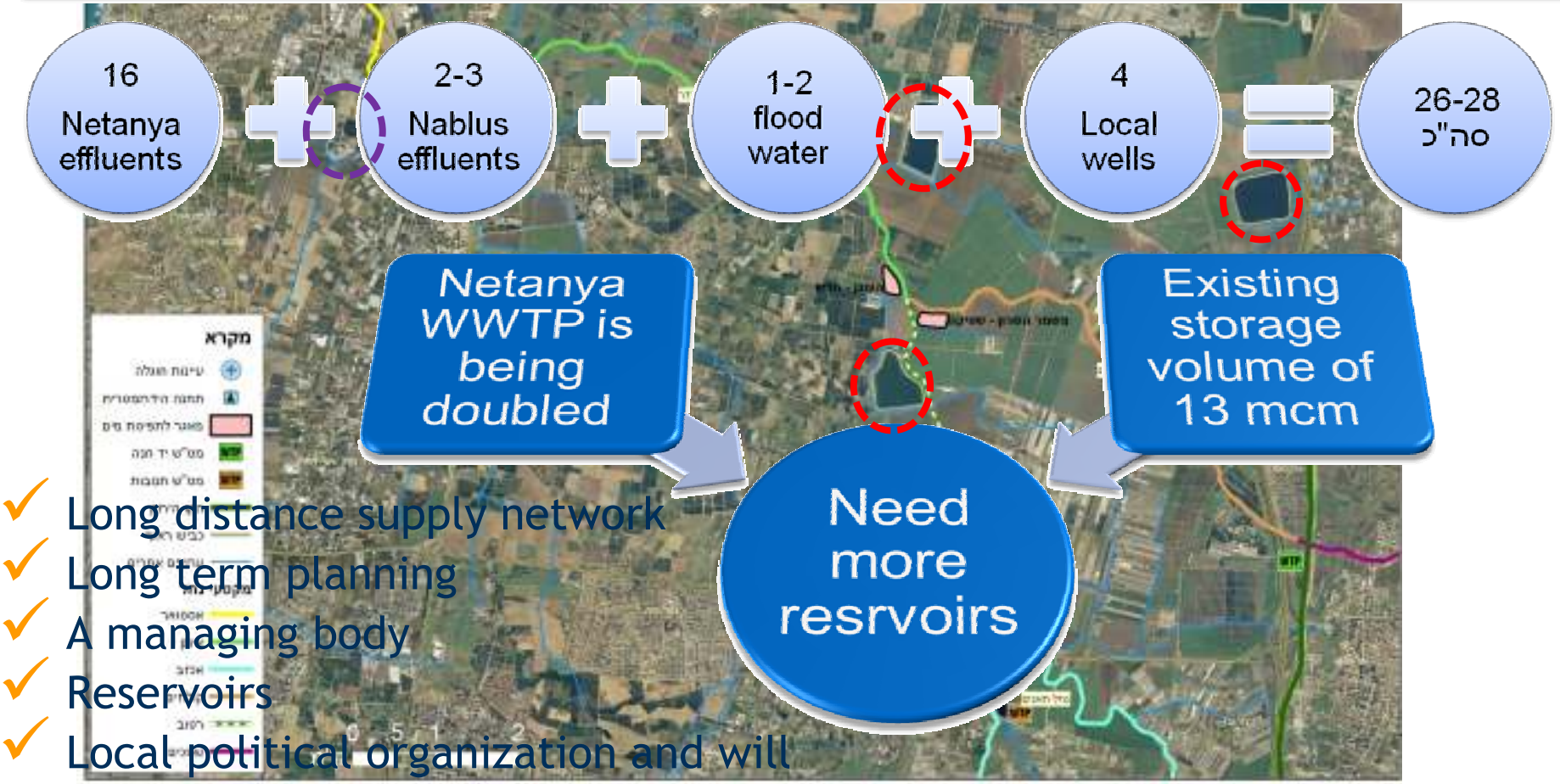
Water sources of the water cooperation (mcm/Yr)



- ✓ Long distance supply network
- ✓ Long term planning
- ✓ A managing body
- ✓ Reservoirs
- ✓ Local political organization and will

Israeli Experience
Affinity of farmers to effluents

Fierce opposition in the beginning

- Why should I give up my inherit water rights?
- Fear of the unknown (what is it going to do to my crops?)
- Initial costs (capital, land)

In retrospect, farmers cannot understand how they lived before

- Constant water supply all year round
- Nutrients in effluents (N,P,K) reduce the usage of fertilizers
- Lower cost of water

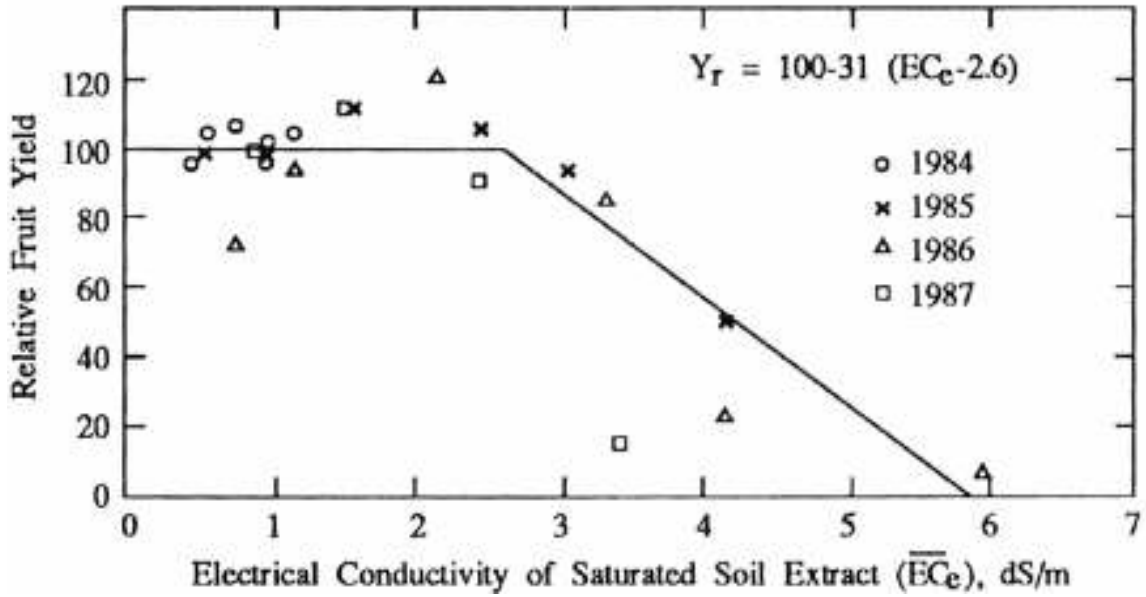
Israeli Experience
Long term effect in soil & aquifers

Consultancy and Engineering

Accumulation of

- Salts – Salification of soil and aquifer
- OM – Flocculation and hydraulic conductivity reduction of soils
- Boron – Soil accumulation until toxic levels to plants
- Sodium – Destroys soil structure

Fruit Yield relation to salt



- Nitrates – lesser concern of groundwater pollution
- Heavy Metals – lesser concern of bioaccumulation and aquifers pollution

Israeli Experience
Long term effect in soil & aquifers

Consultancy and Engineering

Israeli Experience Clogging

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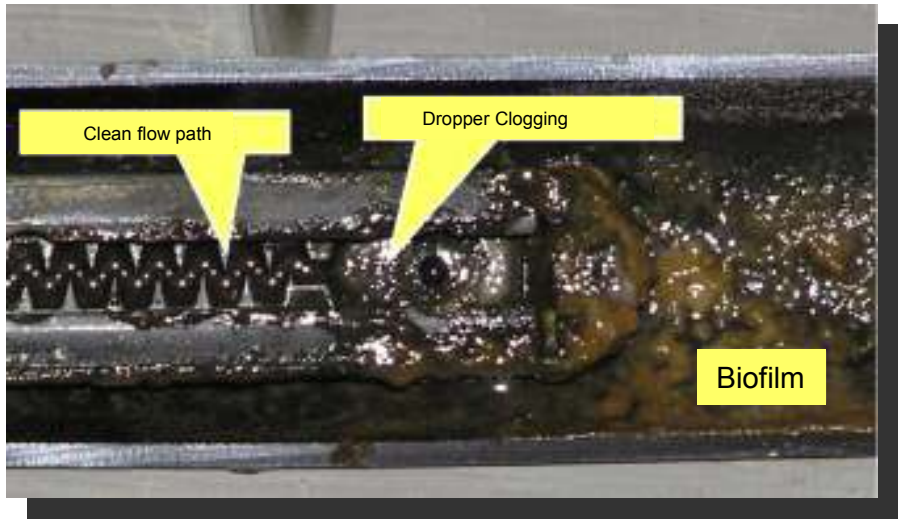
Suspended materials (Particles & colloids)

Inorganic

- Sand
- Clay
- Silt



Organic

- Phytoplankton/algae
- Zooplankton
- Biosolids
- Planktonic bacteria

Israeli Experience
Quality Standards

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Substance	Unit	Unrestricted Irrigation	Disposal at Streams
Aluminum	mg/l	5	
Anionic detergent	mg/l	2	0.5
Arsine	mg/l	0.1	0.1
Beryllium	mg/l	0.1	
BOD_5	mg/l	10	10
Boron	mg/l	0.4	
Cadmium	mg/l	0.01	0.005
Chloride	mg/l	250	400
Chrome	mg/l	0.1	0.05
Cobalt	mg/l	0.05	
COD	mg/l	100	70
Conductivity	dS/m	1.4	
Copper	mg/l	0.2	0.02
Cyanide	mg/l	0.1	0.005
Dissolved Oxygen	mg/l	>0.5	>3
E. Coli	Units per 100 ml	10	200
Fluoride	mg/l	2	
Iron	mg/l	2	
Lead	mg/l	0.1	0.008
Lithium	mg/l	2.5	
Manganese	mg/l	0.2	
Mercury	mg/l	0.002	0.0005
Mineral Oil	mg/l		1
Molybdenum	mg/l	0.01	
Nickel	mg/l	0.2	0.05
Nitrogen (ammonia)	mg/l	10	1.5
pH		6.5–8.5	7.0–8.5
Remaining Chlorine	mg/l	1	0.05
SAR	$(mmol/l)^{0.5}$	5	
Selenium	mg/l	0.02	
Sodium	mg/l	150	200
Total Nitrogen	mg/l	25	10
Total Phosphorus	mg/l	5	1
TSS	mg/l	10	10
Vanadium	mg/l	0.1	
Zinc	mg/l	2	0.2

Inbar Quality Standard

Suggested in 2003

Legally binding since 2010

Regional leniencies in chlorides, electric conductivity, boron, ammonium, total nitrogen an phosphorus

Monitoring requirements for each pollutant sampling method and frequency

Conclusions

- WHO guidelines are a good start, but require local tweaking;
- National and local political organization and will are crucial;
- Economic incentives;
- WWTPs are just the beginning, you need clients, pipes, and reservoirs;
- Consider long term effects on soils and groundwater;
- Adjust quality requirements to region and use.

Thank you for Listening

Consultancy and Engineering

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