Israel as a Case Study - Wastewater Reclamation and Reuse - 2008

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22 Israel as a case study

Marcelo Juanicó

22.1 INTRODUCTION

Israel has performed massive irrigation with treated effluents for decades. Today, about 75% of the sewage of the country is reused. This chapter summarizes the developments of this practice in the country, the experience gained and the issues that remain controversial or problematic.

22.1.1 Geography and climate.

The country can be divided into two main regions: Northern-Central Israel with a Mediterranean climate (short temperate rainy winters and long warm-sunny dry summers) and Southern Israel with an arid climate (precipitations below 300 mm *per year*). Droughts are common in the region.

22.1.2 Water resources and demand.

Israel is using all of its conventional water resources and water shortage is a chronic problem. Table 22.1 summarizes the water resources and water demand by the early 2000s. Freshwater supply to agriculture, which constituted almost 70% of the freshwater resources in 1985, diminished to less than 40 percent in 2000. During drought years, freshwater supply to agriculture is severely cut off, while farmers connected to reclaimed wastewater systems continue to receive a full quota.

Table 22.1 Water resources and demand in Israel, the early 2000s, in Mm^3/yr

Water resources		**Water demand**	
Source	**Mm^3/y**	**Sector**	**Mm^3/y**
Freshwater	1350	Urban	700
Brackish water	170	Industrial	85
Reclaimed wastewater	350	International agreements (Jordan, Palestine)	85
		Freshwater irrigation	500
		Wastewater and brackish water irrigation	500
TOTAL	1870	TOTAL	1870

Sources: Water Commission and others.

22.1.3 Sewage as a water resource – the strategic decision

The wastewater reuse practice have emerged as an unavoidable answer to the combination of severe water shortage, a concentrated population with high levels of water consumption and sewage production, and the threat of pollution to diminishing water resources (Shelef 1991; Friedler 2001). Israel has performed massive reuse of effluents for agricultural irrigation since the early seventies and is presently reusing almost 75% of all the sewage produced in the country. The Water Law of 1959 and the policy enacted by the administration until today define sewage as an integral part of the water resources of the country.

22.1. 4 The typical Israeli farmer

Most Israeli farmers are organized into different types of communities and cooperatives. The Jewish Sector is mostly organized into “Kibbutzs” and “Moshavs”. The “Kibbutz” is a socialist community of 200-2000 people that cultivates land and markets the produce as a single organization. The “Moshav” is a cooperative of farmers where land is privately owned but marketing is generally performed as a single organization. In the Arab Sector land is owned privately or by families, but farmers are usually organized into local associations for water management and other purposes. These relatively large organizations are able to provide the professionals (agronomists, water engineers, administrators, *etc*.) that have been essential in leading the wastewater reuse revolution at the farmer level. The Ministry of Agriculture also provides professional guide through an efficient extension service. Part of the success of the wastewater reuse practice in Israel is due to the capacity of the well organized and informed farmers to adapt quickly to the switch from water to wastewater.

22.2 CHRONOLOGY OF DEVELOPMENTS (Table 22.2)

Wastewater reuse has been practiced in the region since historical times. In 1959, a decade after the creation of the State of Israel, parliament approved “The Water Law” that defines sewage a “water resource”. Yet, until the seventies water reuse was irregular in the country, based on isolated small projects without a clear policy on the issue. The potential transmission of diseases via water reuse was also somehow overlooked until 1970 when an outbreak of cholera in Jerusalem (due to irrigation of vegetables with untreated sewage) obliged the Ministry of Health to assume the control of the water reuse practice.

22.2.1 The seventies

In the early ‘70s water scarcity was already a serious problem and the Water Commission started to promote water reuse by giving incentives to the construction of sewage treatment and storage units and funding R&D (Hershkovitz *et al.* 1969; Pano 1975). The development of a textile industry opened a good market for cotton farming and numerous small reuse systems were constructed to provide low-quality effluents for cotton irrigation during the dry summer. It was a multiple win-win situation: the urban sector got rid of sewage at low cost, discharge of sewage to water bodies was drastically reduced, the farmers received the lacking water they needed to grow cotton (enriched with valuable fertilizers) and the textile industry expanded on low-cost cotton produced around the corner. The basic sewage treatment and storage unit was made of two anaerobic ponds in parallel followed by a wastewater seasonal storage reservoir that accumulated wastewater during the winter and released it for irrigation during summer (Juanicó and Shelef 1991 and 1994). The effluents provided by these simple systems were of bad quality, specially by the end of the irrigation season when the reservoirs were almost empty and acted as a simple pipe between the anaerobic ponds and the irrigated fields, but irrigation of cotton did not require any special quality.

22.2.2 The eighties

In the ‘80s cotton market started to decline and farmers had to look for alternative crops. New crops required effluents of better quality and the simple anaerobic pond+reservoir units were not able to provide them. The government invested large sums in R&D looking for feasible ways to improve the performance of wastewater storage reservoirs and supplementary systems (Shelef *et al.* 1987). Drip irrigation was massively introduced in the country during this decade and sub-surface irrigation started to be developed (Oron and DeMalach 1987). The first large water reuse system (Haifa – Kishon Complex) was commissioned in 1984 (activated sludge followed by two reservoirs in series) and an interdisciplinary multi-year monitoring program was run to learn, control and forecast the system’s performance (Rebhun *et al.* 1987 ; Juanicó 1989; Weber and Juanicó 1990; Azov and Juanicó 1991).

22.2.3 The nineties

In the ‘90s two other large projects were commissioned: the Dan Region project based on activated sludge followed by SAT-Soil Aquifer Treatment providing effluents for unrestricted irrigation (Azov *et al.*,1991 and 1992; Icekson-Tal *et al.* 2003) and the Jeezrael Valley Project based on semi-intensive technologies providing high-quality but restricted-irrigation effluents (Friedler 1999; Juanicó and Milstein 2004). The technology to optimize the design and operation of wastewater storage reservoirs was ready (Juanicó and Dor 1999). The agrotechnic aspects of wastewater irrigation were also addressed (Adin and Elimelech 1989; Feigin *et al.* 1991; Teltsch *et al*. 1991; Friedler and Juanicó 1996). The growing demand for the limited freshwater resources and the increasing production of high-quality effluents resulted into several proposals to expand the use of reclaimed effluents to river recovery (Gafni and Bar-Or 1995; Juanicó and Friedler 1999), landscape development and non-potable urban uses (Lahav, 1995). Several monitoring and R&D programs pointed out salination of soils and aquifers as a potential by-product of irrigation with salty wastewater and the Ministry of the Environment started a full campaign to reduce the addition of salts to water during its industrial and urban use (Weber *et al.* 1996; Weber and Juanicó 2004).

22.2.4 Present situation

By 2005, production of sewage in the country is estimated in 500 Mm^3/yr of which about 425 500 Mm^3/yr reach sewage treatment plants and 370 Mm^3/y are reused. Thus, almost 75% of the sewage of the country is reused, mainly in agricultural irrigation. Most treated effluents are of restricted irrigation quality.

Storage of treated wastewater is made in more than 200 open reservoirs (Figures 22.1 and 22.2). The treated wastewater from Metropolitan Tel Aviv is stored in an underground reservoir obtained by isolating an area of the Coastal Aquifer. Both open and underground reservoirs act as storage units and also as equalization and treatment units.

Table 22.2. Chronology of wastewater reuse developments in Israel

Until 1970	'70s	'80s	'90s	2000s
Reuse projects				
Isolated initiatives. Wastewater storage capacity in open reservoirs ~ 20 Mm^3	Multiple new local projects. Wastewater storage capacity in open reservoirs increased by another 50 Mm^3 during the decade.	Multiple new small projects are commissioned. Wastewater storage capacity in open reservoirs increased by another 65 Mm^3 during the decade. Kishon Complex Project – Haifa. First large Interregional project. Good quality restricted irrigation.	Some new medium size projects are commissioned. Wastewater storage capacity in open reservoirs increased by another 30 Mm^3 during the decade. Jeezrael Valley Project. Regional project covers 7 towns. Good quality restricted irrigation. Dan Region Project - Tel Aviv. Second stage for unrestricted irrigation implemented ~ 1989-1990. Largest Interregional Project.	Several new medium size projects are commissioned. Western Jerusalem. Interregional Project. Unrestricted irrigation.
Main events				
Uncontrolled reuse. 1970 Cholera outbreak in Jerusalem due to irrigation of vegetables with untreated sewage; government starts to control wastewater reuse. Government starts to promote wastewater reuse (Hershkovitz *et a.* 1969).	World Bank funds beginning of National WW Project. WW reuse is proclaimed national policy. Starts massive cotton irrigation with low quality wastewater. Start first in-depth surveys on public health effects of wastewater reuse (Fattal *et al.* 1981; Vasl and Kott 1981; Fattal *et al*. 1986)	70% reuse is achieved by the early eighties. Drip irrigation becomes the dominant irrigation technology. Cotton market starts to decline by the middle '80. Better quality effluents widen the spectrum of crops irrigated with wastewater Ministry of Environment is created in 1989 and addresses environ effects of wastewater reuse.	Most efforts oriented to improve quality of treated wastewater towards sustainable reuse. Treated wastewater proposed as a source for recovery of dry rivers and landscape. It is also proposed as a source of non-potable water for the urban sector. First unrestricted irrigation (Dan Region) Agrotechnic effects of wastewater reuse are addressed (mainly soil salination and clogging capacity on drippers). Salination is recognized as a serious potential problem. A full campaign to reduce addition of salts to wastewater is started.	Treated wastewater is proposed as a source of water for future aquaculture development. Reuse reaches 75% of all sewage in the country in spite of quick population growth. Plans to reach almost 100% are set. First results are available from studies on environmental effects of long-term massive Wastewater reuse. Sustainable reuse becomes the main R&D and discussed issue.

Table 22.2 (continuation)

Until 1970	'70s	'80s	'90s	2000s
Legislation, standards, guidelines (sources: Goldman, 1996; and others)				
Drainage and Flood Protection Law (1957). Sets that water projects have priority on other projects. The Water Law (1959) Sets that water resources are public property and controlled by the State. Wastwater is defined as a water resource.	Public Health Law (1973) Minister of Health will define and control treatment for WW irrigation. The Shelef Commission (1977) sets different wastewater quality standards for irrigation of different crops, including unrestricted irrigation.	Public Health Law (1981) restricts wastewater irrigation to list of allowed crops. All reuse projects require a permit.	Public Health Law (1995) All towns with population>10,000 must treat effluents to BOD< 20 mg/L, TSS<30 mg/L The Halperin Commission (1999) derogates Shelef Commis. guidelines. Sets public health requirements for wastewater irrigation following California school. Several rules and standards are applied to reduce addition of salts to WW.	Halperin and Aloni (2003) develop public health guidelines for WW reuse in the urban sector, landscape and industry. Inbar Commission (2003) proposes stricter environment requirements for wastewater reuse including nutrients, salts and other pollutants. Inbar proposal approved in 2005 while this report was being written. Additional rules and standards are applied to reduce addition of salts to wastewater.

The coexistence of projects of different sizes and characteristics (Table 22.3) has proved to be not only possible but also desirable. Large projects have a large-scale effect on economy and development but they are difficult to plan, finance and execute. Small projects have only a limited local effect and generally release effluents of restricted quality, but they are much easier to implement and operate, and the sum of numerous small projects have a total effect comparable to that of large ones. The national policy is to promote all sizes.

The largest systems and some of the medium size ones release effluents of unrestricted irrigation quality. Smaller projects release effluents of lower quality restricted to the irrigation of canned fruits, vegetables for cooking, fruits with non-edible peels, industrial field crops (mainly cotton), fodder crops, forests and pastures (Figure 22.3).

Water availability is the main constrain to maintain and expand an important aquaculture production that exists in the country (Mires 2000). Treated wastewater is now weighted as a potential source of water for aquaculture and the Water Commission is funding the first R&D efforts to develop a wastewater quality standard for this practice (Feldite *et al.* submitted).

Table 22.3. Wastewater reuse projects of different sizes.

Project	Capacity [Mm^3/yr]	Scope
Kibbutz Getaot (old)	0.1	Local single-town
Gedera Council	1.5	Local multi-towns
Jeezrael Valley	10	Regional
Haifa Metropolitan	25	Inter-Regional
Tel Aviv Metropolitan	130	Inter-Regional

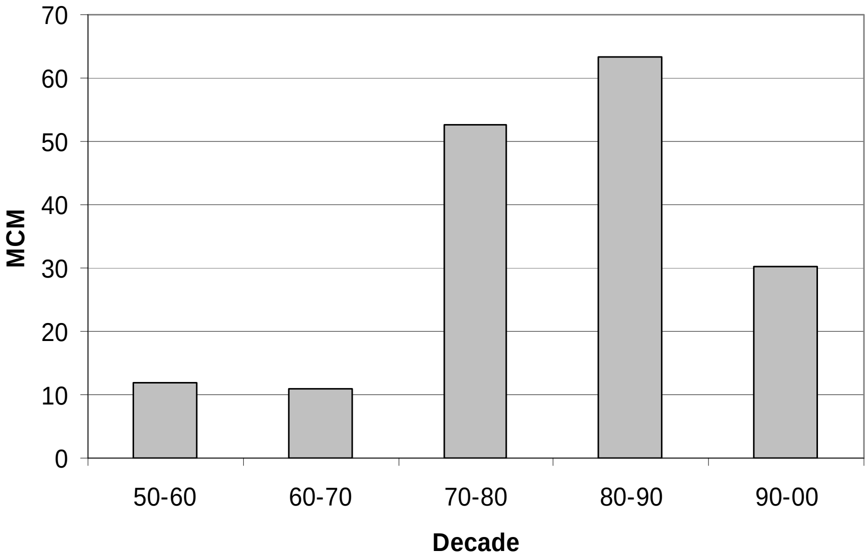

Figure 22.1 Wastewater storage reservoirs constructed in Israel, by decade (as storage volume in MCM-million cubic meter). Data from Dr. Gabi Eitan, personal communication.

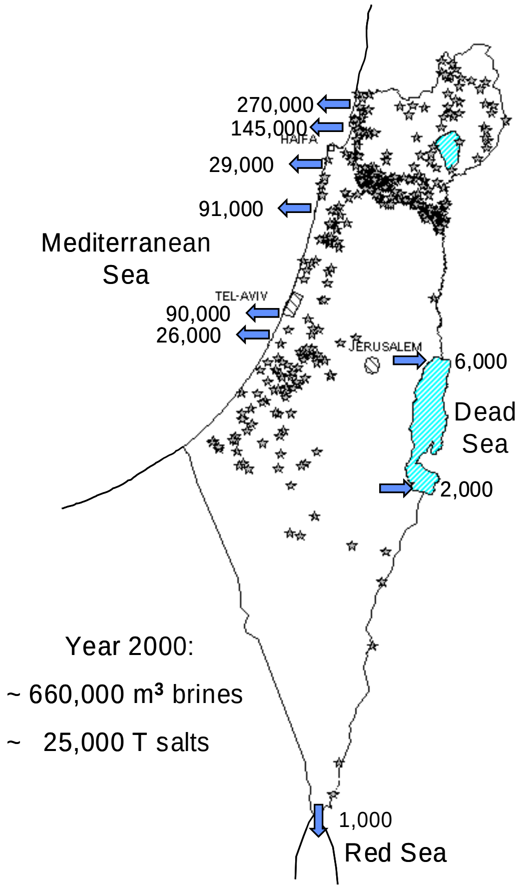

Figure 23.2. Release of brines to the sea during the year 2000, in m^3.
Starts represent open wastewater storage reservoirs.

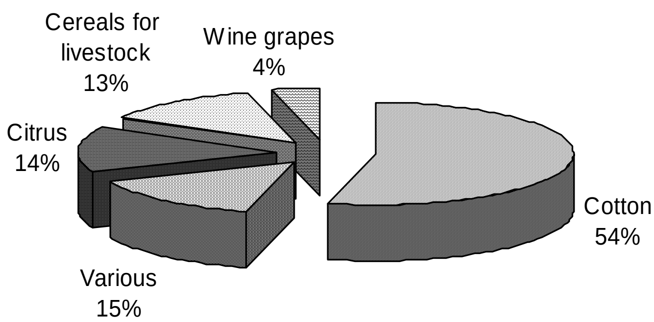

Figure 22.3. Crops irrigated with treated effluents in Central Israel in 1999.
(modified from Leshem 2000)

22.3 CONTROVERSIAL ISSUES

22.3.1 Institutional organization

There are numerous institutions involved with wastewater reuse in Israel. Some of them are:

- Water Commission: it is in charge of the management of water resources such as planning and control of the development of new water resources including treated effluents, economy of the water sector, substitution of water allocations by wastewater allocations, protection of water resources from any kind of pollution, *etc*.
- Ministry of Health: it is the responsible for public health and it develops the guidelines and standards regarding the level of treatment required to irrigate different crops, public parks, *etc.*
- Ministry of the Environment: it takes care of all aspects related to the environment' *e.g.*, toxic compounds in effluents, salts, excess nutrients, *etc.*, as well as the environmental impact to the alternatives to wastewater reuse (discharge of treated effluents to rivers, sea, lakes, *etc*).
- Ministry of Agriculture: it addresses the agrotechnic parameters of the treated effluents (e.g. salts, Boron, clogging capacity, nutrients) and the organization of the rural sector regarding this practice including agronomic guiding to farmers.
- Administration for Water and Sewage (Ministry of Infrastructure): it finances and subsidizes sewage treatment works, and supervises project engineering.
- Ministry of Treasure: sets economical policy and provide the funds for the Administration for Water and Sewage. It also evaluates the economical impact of standards and guidelines on wastewater quality.
- Ministry of Interior: approves physical planning and specific projects.

This division of roles sounds nice in theory, but in practice is rather problematic. Israeli law is not clear enough and there is overlapping of responsibilities. For example, it is not unusual the Ministry of Health to set requirements on the administrative and financial aspects of a project or on the agrotechnic parameters of the treated effluents. There is a conflict between the Ministry of the Environment and the Water Commission on who has the prerogative on soil and/or groundwater protection. There is a foggy overlap between the responsibilities of the central agencies (Ministries) and the local ones (municipalities or local councils). Some inter-ministerial commissions have been created to overcome these problems. But these commissions, while effective for the development of policy and legal instruments, have proved to be too heavy and bureaucratic for giving permits or approving specific projects. The Israel government decided, by late 2005, to create a "Water Agency" that will coordinate all the activities regarding the water sector, but meanwhile this is just a decision not yet implemented. The structure and prerogatives of this "Water Agency" still have to be defined, regulated and tested

22.3.2 75% reuse. Is this the limit?

The percentage of reclaimed water has been close to 70% for more than a decade (75% in 2005) in spite of multiple efforts to increase it. This is due, in part, to quick population growth due to massive immigration: new treatment plants and reuse schemes are constructed but more sewage is produced and the reuse percentage remains the same. A second more serious problem is that it seems difficult to surpass the limit of the 75% reuse. The first commissioned projects were naturally the most promising ones. Now, after more than three decades of treatment and reuse effort, the remaining projects are those much less promising due to high costs, engineering difficulties or lack of demand for reclaimed water in the area. Israel administration has again taken the decision to reach almost 100% reuse but the decision is controversial. The government has also started massive sea-water desalination to supply the increasing freshwater demand, and the relative costs of sea water desalination versus further sewage reclamation are constantly compared and discussed.

22.3.3 Nutrients in wastewater are not accounted by farmers.

It has been long claimed that the nutrients in the treated wastewater are fertilizers for better crop growing and thus it is not necessary to remove them from wastewater: nutrient recycling as a positive by-product of water reuse. This claim has proved to be false. N and P concentration in treated wastewater is in many cases higher than required by crops, leading to problems of vicious crop growth and pollution of soil, aquifers and water bodies. Phosphorus build-up in soil and nitrogen build-up in groundwater have been confirmed. Worse, the characterization and quantification of the nutrients supplied with the effluents is difficult and the farmers take the conservative side by reducing only marginally the dosing of fertilizer. Thus, most of the nutrients supplied with the effluents are not recycled and further burden is added to the already serious problem of overfertilization (Juanicó 1993; Avnimelech 1997). A recently long-term survey by Tarchitzqui *et al.* (2005) confirms that after more than ten years of efforts to solve this problem, most farmers continue to ignore the nutrients in effluents when dosing fertilizers. This sounds strange in a country where most farmers are well informed, but it seems that the sampling and laboratory analyses to determine the variable nutrients content of wastewater is beyond the scope of the farmer’s capabilities. The Inbar Commission is now proposing to require nutrient removal at the sewage treatment plants in order to cope with this problem, while others insist that it is necessary to better train the farmers to calculate and account for the fertilizers in wastewater.

22.3.4 The contractual relationship between urban and rural sectors.

The anaerobic pond+reservoir units of the seventies were a simple and cheap solution for cotton growing. In most cases the reservoirs were constructed by the farmers avid for water of any available quality, with some financial help from the urban sector for the construction of pipes, pumping stations and the anaerobic ponds. In the eighties, with the decline of the market for cotton, many farmers refused to continue to receive low quality sewage and closed the inlet to the reservoir: untreated sewage started to flow again to the rivers. In some cases existed a contractual compromise by the farmers to receive all the sewage produced by the urban sector, but farmers were *de facto* unable to fulfil this obligation.

The lack of a clear separation of responsibilities between the urban and the rural sector regarding the treatment and disposal of sewage led to numerous conflicts and problems during the eighties and early nineties (Juanicó 1993). The regulating agencies found difficult to apply regulations because urban and rural sectors accused each other for the responsibility of pollution and the government found itself acting not as the controller but as the arbitrator between the two parties. Finally the Public Health Protocol of 1995 set the whole responsibility for sewage treatment and disposal on the urban sector (the producer of pollution is now the single responsible for sewage treatment and disposal, and this responsibility can not be transferred to the rural sector or other parties). In the cases where the rural sector is in charge of sewage treatment, storage and reuse, it acts as a subcontractor of the urban sector (as any other private firm) while final responsibility in front of the regulatory agencies remains with the urban sector.

Presently, there are numerous different schemes between the urban and the rural sectors. Large reuse schemes are owned and operated by Mekorot (the National Water Company) that sells treated effluents to the farmers. Some medium-size treatment plants are owned and operated by municipalities or regional councils which also sell the treated wastewater to the rural sector. Other medium size projects are operated as BOT schemes where the municipality pays a private firm or a farmers association to construct and operate the sewage treatment and reuse system, or per cubic meter of treated sewage. Private firms sell treated wastewater to the farmers; water associations also sell it but to their members and at much lower prices. Small rural communities usually have their own sewage treatment and reuse system and treated wastewater is reused in the fields of the community.

22.3.5 The use of wastewater storage reservoirs as treatment units.

Wastewater storage reservoirs have proved to be reliable and efficient units for wastewater treatment when operated in series or in batch mode (Juanicó and Dor 1999; Juanicó and Milstein 2004). However, only a limited number of sewage treatment and reuse systems are using reservoirs in this way. In most cases treatment is completed at the sewage treatment plant and the reservoirs are operated in continuous-flow mode for three purposes:

- Seasonal storage
- Equalization and treatment of potential failures of the sewage treatment plant (role that proved to be very important).
- Limited treatment provided by the continuous-flow mode (only in small systems).

Regulatory agencies are not interested to address these reservoirs as treatment units because most wastewater reservoirs are owned by farmers and sewage treatment is neither under their legal responsibility nor within the scope of their know-how (see above). In order to use the reservoirs as treatment units it would be necessary to transfer their operation to the operator of the sewage treatment plant (that belongs to the urban sector) and this change is difficult to implement. Farmers are not interested either, because the operation of the reservoirs in batch mode reduces the amount of water the reservoir can supply during the irrigation season. They prefer to receive fully-treated wastewater from the municipal sewage treatment plant and use their reservoirs for storage only. Thus, the switch of the reservoirs from “storage units” to “treatment units” is limited no by technical problems but by institutional and administrative ones.

22.3.6 Guidelines on wastewater treatment for agricultural irrigation.

The Shelef Commission (1977) (Ministry of Health) defined four categories of crops with different quality requirements. Cotton and other industrial crops could be irrigated with effluents with BOD<60 mg/L, TSS<50 mg/L and Dissolved Oxygen > 0.5 mg/L. On the opposite side, unrestricted irrigation required BOD<15 mg/L, chlorination with 2 hours contact time, residual chlorine>0.5 mg/L and Coliforms< 12 MPN/100 mL.

The Halperin Commission (1999) (Ministry of Health) adopted the American Title 22 with few modifications, against the opinion of the consulted academics. Regarding the “unrestricted irrigation” category, the guidelines require “mechanical-biological treatment” and filtration in deep granular media followed by chlorination.

The Inbar Commission (2003) (Ministry of Environment) proposed to adopt a single high quality for wastewater irrigation (unrestricted irrigation) without quality categories by crops. The quality requirements are not limited to the protection of public health (enough covered by the Halperin Commission Guidelines) but address the protection of the environment towards sustainable reuse. The introduction of the sustainability concept is considered a landmark. The Inbar guidelines address numerous parameters (organic matter, nutrients, pathogens, salts, heavy metals, detergents, cyanides and others). These guidelines recognize the existence of regions which are less environmentally sensitive, where less strict requirements can be applied. Thus, the Inbar Commission abandoned the previous approach of “different qualities for different crops” and adopts a single unrestricted irrigation level but with “different qualities for different environmental regions”. It does not address the “mechanical-biological treatment” requirement of the Halperin Commission. It does address the requirements for the release of effluents to rivers within the frame of a national plan for river recovery. The proposal of the Inbar Commission was recently approved in May 2005.

The whole issue of quality guidelines is highly controversial. Many professionals consider the requirements of the Halperin and Inbar Commissions as unnecessarily conservative and technically wrong. Other sustain that all the sewage should be treated to an even higher quality including nitrification/denitrification and flocculation/filtration (*e.g.*, Rebhun 2003) or to drinking water standards by membrane technology including desalination *(e.g.*, Zaslavski 2001). The effect that the expected increase in the cost of energy (petroleum, coal) may have on the cost of different levels of wastewater treatment starts to be discussed.

22.3.7 Salination of soils and aquifers - a threat to sustainability.

Sewage is more saline than the supplied freshwater due to the addition of salts during industrial and domestic use (Table 4) and the salts are recycled together with the water. There is a clear salination process of soils and aquifers in Israel and a multi-stage approach is used to fight it (Fig. 4). The main causes of this process are being studied and the issue is controversial. Some hydrologists and soil scientists believe that salination is due mainly to natural processes (primary salination) while others conclude that irrigation with salty wastewater may be the main reason (secondary salination). A review of the whole salination issue is presently underway. It is clear that main salination may be primary in some areas while secondary in others. Even though, almost everybody agrees in that secondary salination due to irrigation with salty wastewater is a threat to sustainability, even in those areas where primary salination dominates.

There are no inexpensive ways to remove the salts once they entered sewage and the prevention of sewage salt enrichment by controlling the sources is the most immediately available solution. The Ministry of the Environment is engaged in a campaign to reduce the addition of salts to sewage since the early nineties. The early stages of this campaign were described by Weber *et al.* (1996) while a list of all main regulations and the first long-term results of the campaign are described by Weber and Juanicó (2004). Meanwhile, desalination of reclaimed wastewater is also weighted (Harussi *et al*, 2001).

Table 22.4 Addition of Sodium to sewage in two cities of Israel in 1994*.

City	Supplied water [Na mg/l]	Sewage [Na mg/l]	Addition [Na mg/l]
Tel Aviv	107	236	129
Haifa	110	256	146

* average values, from Mercado and Banin (1994)

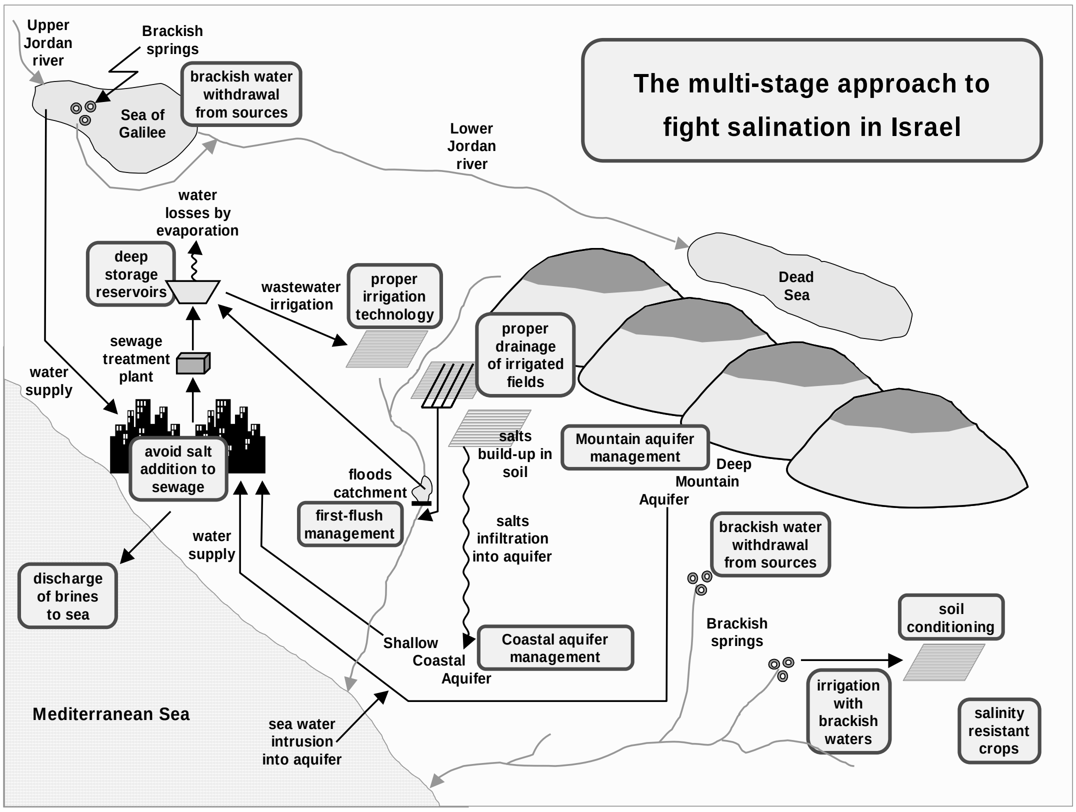

Figure 22.4 The multi-stage approach to fight salination in Israel

Table 22.5. Addition of Sodium to sewage in Tel Aviv, by use, in 1994*.

Use	Na [Tons/yr X 1000]	Na [mg/L]
detergents	18	53
household	9	26
water softening	8	22
other industrial uses	6	17
physiological use	4	11
Total	45	129

* average values, from Mercado and Banin (1994)

Some early surveys indicated detergents as a main source of salts and Boron in sewage in the early nineties (Table 22.5) but not all the detergents had the same salt and Boron contents (Figure 22.5). A regulation on the formulation of industrial and laundry detergents was approved in 1999 and it may be extended to dishwasher detergents in the future. Other important sources were water softening for industry, meat koshering process, and pH neutralization of industrial effluents. The discharge of brines to sewage was first limited and later forbidden, while a system was created to discharge brines to the sea at nine different points of the coast (Figure 22.2). Some of the discharge points are outfalls from large factories or from industrial areas in which numerous small factories are concentrated. Other discharge points are located at the outlet of the cooling system of power stations, where cistern trucks can discharge brines. All the discharges are monitored and controlled by the Ministry of the Environment and comply with the requirements of the Barcelona Convention for the Protection of the Mediterranean Sea. The amount of salts discharged to the sea with the brines reached 35,000 Ton in 2003 (Figure 22.6). The range of pH allowed in industrial effluents discharged to sewers was enlarged. The Ministry of the Environment has encouraged the substitution of Na by K or Ca in industrial processes (softening, neutralization). It has also encouraged the substitution of softening by reverse osmosis or Elgressy EST - Electrolysis Scale Treatment, and of water-based air conditioning by air-based technologies that do not lead to water losses by evaporation and the production of brines. Many other initiatives, regulations and activities to reduce addition of salts to sewage have been implemented during the last decade (Table 22.6). Israeli industry has undergone a radical change in recent years. Many factories have adopted K and Ca for softening and neutralization, while others have shifted to reverse osmosis or Elgressy EST - Electrolysis Scale Treatment, and/or from water-based air conditioning to air-based systems. All hospitals have substituted the softening technology by 2002, thus reducing the discharge of salts to sewage by 1000 T/year. These efforts have positive results: data from different treatment plants indicate a steady decrease in salts and Boron in sewage (Figures.22. 7,22. 8 and 22.9).

22.4 Summary: what can be learned from the Israeli experience.

Sewage can be considered an integral part of the water resources of a region.

The ownership of sewage and the responsibility for sewage treatment and disposal must be clearly stated by law.

The proper integration of sewage to the water resources of the region requires efforts at multiple levels: institutional, financial, engineering, agronomic, legislation, R&D, etc.

Not all the problems must be necessary addressed and solved before starting the reuse practice. It is possible to evolve with time. Starting with small local projects for restricted irrigation is a potential approach. But developments must be monitored, discussed and coordinated in order to constantly adapt the switch from water to wastewater irrigation to changing conditions.

In a country that has practiced massive wastewater reuse for decades and is presently reusing 75 % of its sewage, most treated wastewater is still dedicated to restricted irrigation. Restricted irrigation liberates freshwater resources for unrestricted one. The controversial issue of “unrestricted irrigation with wastewater” is of secondary importance in many cases.

The development of reuse schemes for irrigation with effluents of very low quality (for cotton or similar crops) may lead to unstable situations when the market for these limited number of crops disappears. Effluents of higher quality allow the irrigation of a wider spectrum of crops adding stability to agriculture development.

Professional advice to farmers has been essential in the successful switch from water to wastewater irrigation in Israel. Israel farmers obtain this advice mainly through farmers organizations that can pay for professional advice, and through the Ministry of Agriculture.

Open wastewater reservoirs can be excellent treatment units if operated as required. But, if the reservoirs belong to the farmers, they operate the reservoirs following irrigation needs and not treatment needs. The reservoirs should be under the control of the responsible for sewage treatment in order to be operated as treatment units.

The coexistence of reuse schemes of different sizes and characteristics is not only possible but also desirable. Small systems are less spectacular than large ones, but their effect on the rural sector is conspicuous.

Proper development and execution of the wastewater reuse policy requires the involvement of several institutions in order to cover the numerous aspects of the practice. But, too many institutions and/or a foggy division of roles, may lead to administrative conflicts and execution delays.

First commissioned projects are naturally the most promising ones while the remaining ones are the most difficult. Israel has been stacked around the 70-75% reuse for about two decades in spite of many efforts to reach almost 100% reuse.

Farmers find difficult to account for the nutrient content of effluents when dosing fertilizers. Most farmers just ignore the nutrients, adding to the problem of over-fertilization.

There are many different schemes between the urban and the rural sectors in Israel. The urban sector may treat sewage and sell it to farmers, the farmers may organize to treat the sewage of the urban sector and “sell” it to themselves, third party private firms may act as BOT contractors of the urban sector and sell the wastewater, etc. All the schemes seem to work properly when responsibilities are clearly set.

First concern when starting the reuse practice is the potential transmission of diseases and protection of public health. Agronomic parameters may be also addressed. Later on, sustainable water reuse requires addressing to environmental issues that were neglected at the beginning. There is a consensus regarding some sustainability issues such as salination of soil and aquifers. Other issues are controversial and Israel is still discussing them.

Reduction of the addition of salts and Boron to sewage during industrial and domestic use is a feasible practice.

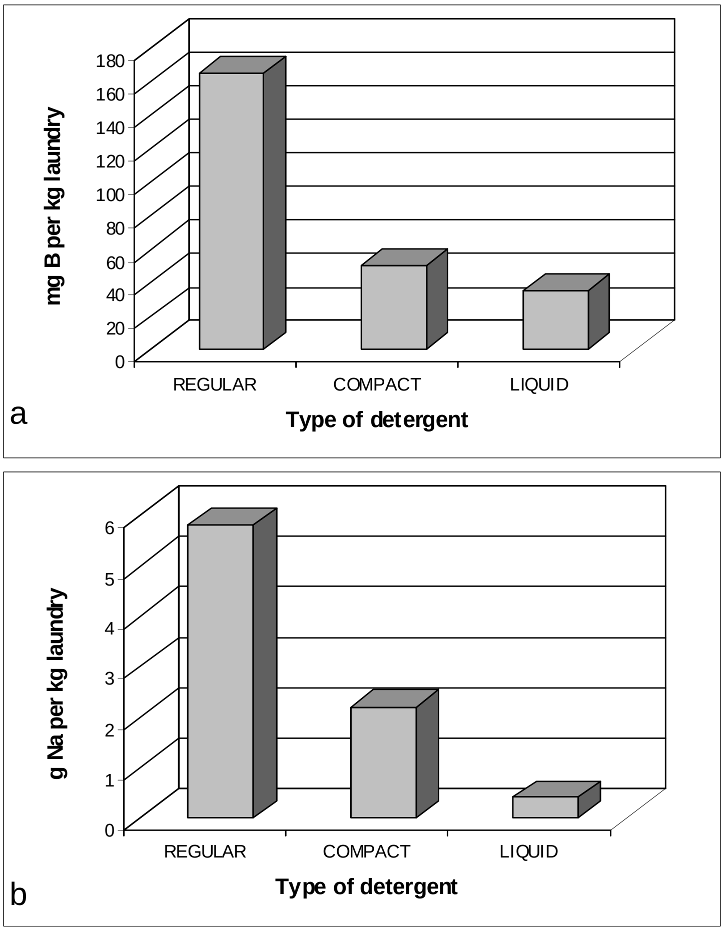

Figure 22.5 Average Boron (a) and Sodium (b) contribution to sewage by different types of laundry detergents used in Israel in the early nineties.

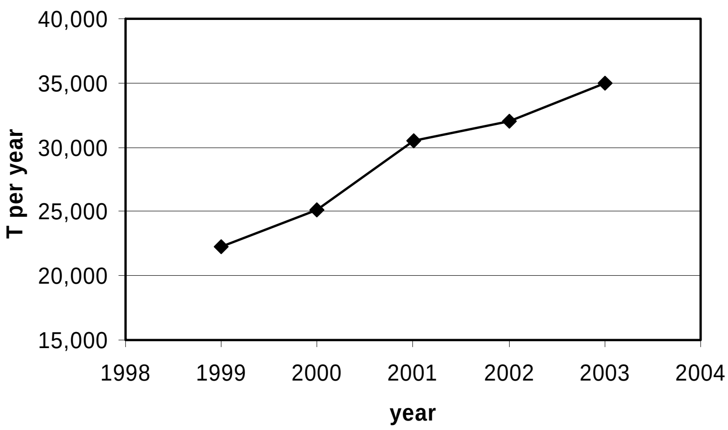

Figure 22.6. Amount of salts discharged to the sea as brines, in Tons per year.

Table 22.6 Development of main regulations and activities against sewage salination in Israel.

Year	Main regulations and activities
1991	Industries which consume above a certain amount of salt for the regeneration of ion exchangers were required to use Potassium salts (mainly Potassium chloride).
1993	Some factories are requested to discharge softening brines to the sea.
1994	Regulations on the use of salts in the regeneration of ion exchangers.
1995	Guidelines for controlling salt discharges from slaughterhouses.
1996	Starts construction of network of sites to discharge brines to the sea. Discharge of brines to sewers is limited (business permit law).
1997	Standards on the proper construction and operation of evaporation ponds.
1998	Prohibition of brine discharge to sewers (water law).
1999	A new standard on the formulation of domestic and industrial detergents: reduced Boron, Sodium and Chloride contents.
2000	Recommendations to switch disinfection of swimming pools from hypochlorite, trichloride and chlorine gas to salt electrolysis.
2002	Within the frame of business permit law: • Protocol on ion exchangers. • Limitations on the use of water based air conditioning and refrigeration. • EC limitations to effluents from pickle factories.
2003	Regulations limiting the concentration of salts in all industrial effluents: • Chloride : no more than 200 mg/L above supply water • Sodium : no more than 130 mg/L above supply water • Fluoride : 6 mg/L • Boron : 1.5 mg/L
Proposed new regulations and activities	Prohibition on the use of domestic ion-exchangers. Further restrictions on the formulation of dishwasher detergents. Public education: • Use of salts in dish-washers • Use of detergents

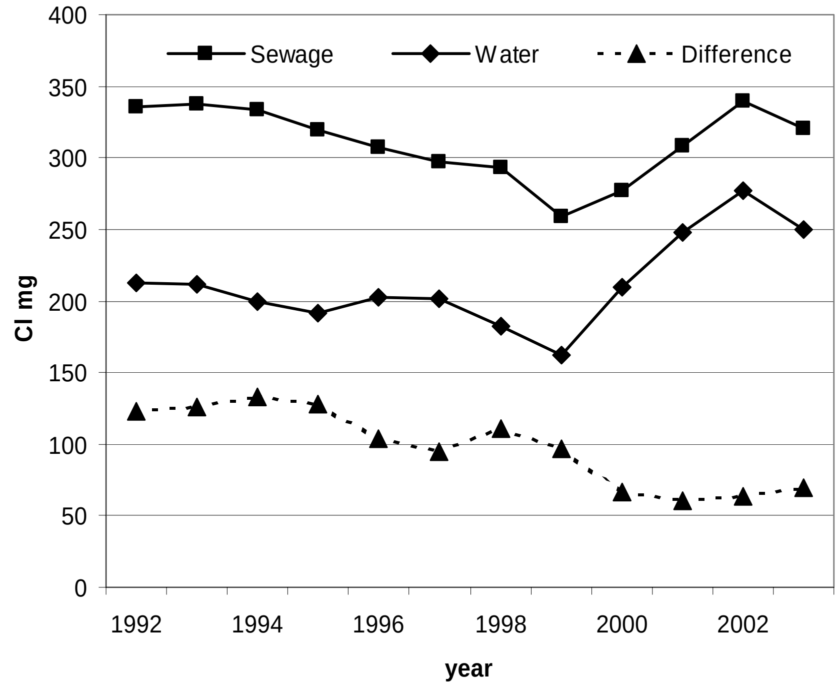

Figure 22. 7. Cl (mg/l) measured in the water supplied to Tel Aviv Metropolitan and the sewage reaching the treatment plant

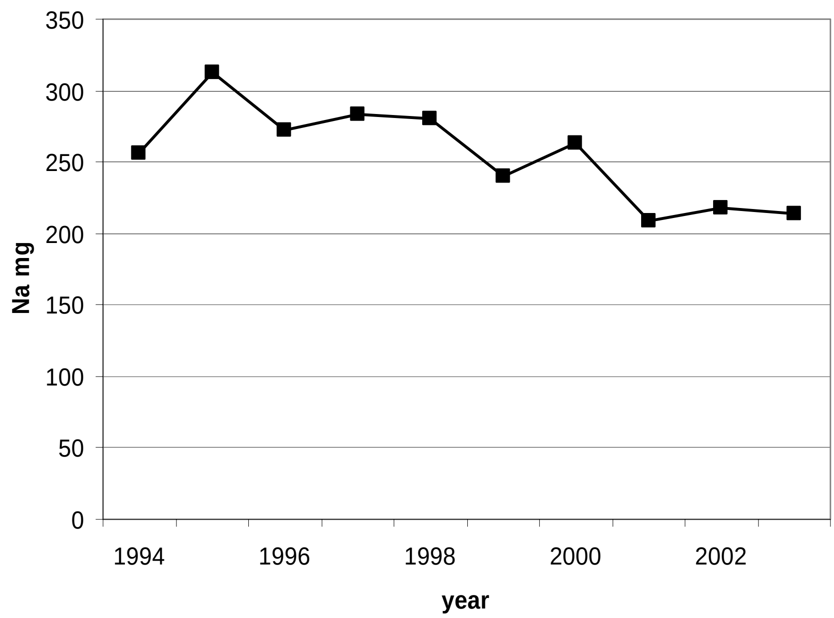

Figure 22.8 Na (mg/l) measured in the sewage of Haifa Metropolitan.

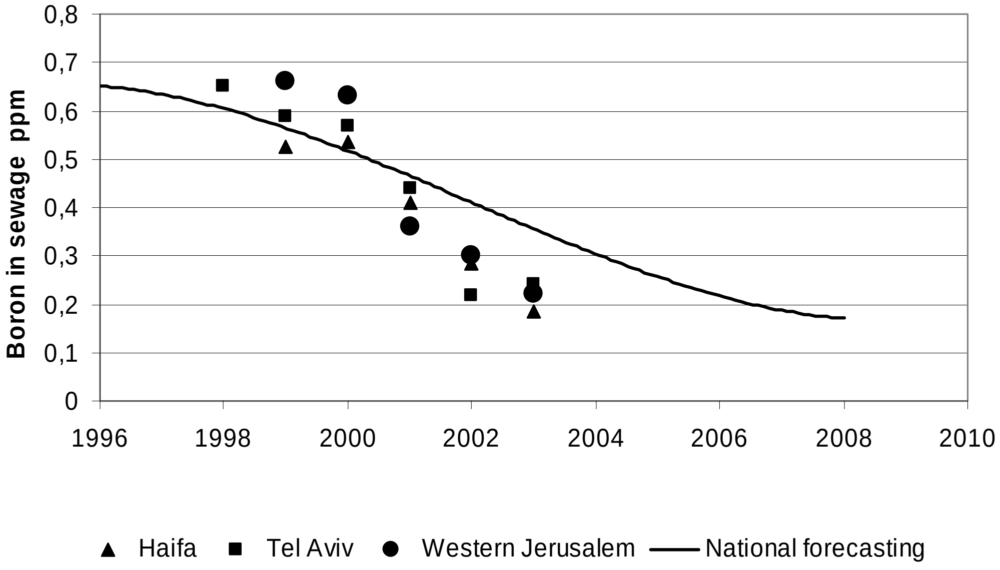

Figure 22.9 Boron measured in the sewage of three main cities and forecasted national average.

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