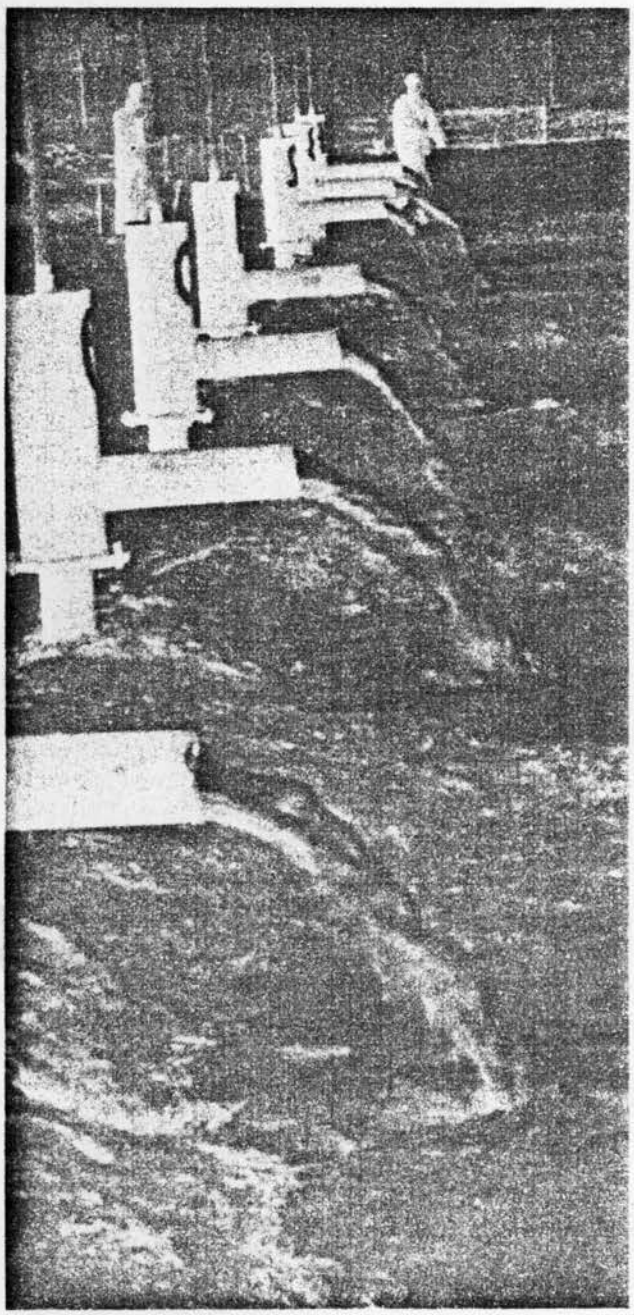
MAN AND THE BIOSPHERE

WATER-QUALITY RESEARCH AND DEVELOPMENT IN ISRAEL



By MIRIAM WALDMAN and YEHUDA SHEVAH

EDITOR'S NOTE: The authors explain why research and development activities concerning the quality of water are, in Israel's case, no luxury but an absolute necessity: the interests of public health and the country's development require R & D. To cite just one reason: renovated water which in 1980 contributed 50 million cubic metres (MCM) to the nation's water supply, is expected to increase five-fold — to 250 MCM — by 1990, i.e. by the end of the present decade...

Israel's water resources and water balance

Israeli research and development (R & D) activities concerning the quality of water are directly traceable to the country's unique water economy which puts a premium on the exploitation of most of the known water resources, fully aware of the fact that much of its water will have to be treated for re-use, in the near future. Moreover, known water resources are affected by human activities and are thus continuously exposed to the threat of cumulative pollution processes.

Generally speaking, rainfall occurs only during the four-months period from December to March and is, moreover, unevenly distributed geographically, ranging from about 1000 mm in the north to about 200 mm in the south — less than 100 mm in the extreme south of the country. Natural precipitation results in an annual water potential of about 1750 million cubic metres (MCM) of which 950 MCM take the form of groundwater, the rest being surface water. The former is provided by two main aquifers, one consisting of coastal sandstone, the other, further inland, of foothill limestone. The surface water originates mostly in the Jordan River basin area. Other aquifers are marginal, con-

tributing about 200 MCM of brackish water. Annual water demand, currently estimated at about 1880 MCM and rising to an anticipated 2000 MCM by 1990, is in excess of the available water. This indicates that *future demand can be met only by making use of renovated water.* Indeed, some 50 MCM of treated effluents are already in use, and the quantity is expected to increase fivefold, to about 250 MCM by 1990 (Table 1)

Table One
ISRAEL'S WATER BALANCE
1980 AND 1990 (FORECAST)
(In MCM/Year — millions of cubic metres per annum)

SUPPLY	1980	1990
Groundwater	950	950
Surface Water	600	600
Brackish Water	200	200
Renovated Water	50	250
Total	1800	2000
DEMAND		
Domestic & Industrial	430	650
Agriculture		
Fresh	1120	900
Brackish	200	200
Renovated	50	250
Total	1800	2000

The excessive use of the available water necessitates the strong backup of a comprehensive R & D programme to facilitate the continuation of the current use of water without adversely affecting either the country's resources or the health of its population.

R & D in water quality is essentially an inter-disciplinary matter, covering a wide range of subjects and skills. Above all, it requires considerable funds, not — alas! — always available. The present article seeks to outline some of the pressing problems and aspects of water renovation now being investigated under Israel's current R & D programme.

Water renovation research

To make possible the extensive use of renovated water, an integrated research programme is under way with the objective of developing and adopting a water treatment technology to facilitate the re-use of water for non-potable purposes. The programme includes:

- operation of a pilot plant for the removal of non-degradable organic ingredients from wastewater and for the inactivation of micro-organisms by treatment with ozone and chlorine;
- epidemiological and toxological studies *in vitro* and *in vivo* to monitor residual effects of micro-pollutants; and
- diversification and direct use (for agricultural irrigation) of secondary effluents, without advanced treatment.

(a) **The pilot plant for the removal of non-degradable organics** is designed for the study of the following:

- Removal efficiency of DOC and TOC (Dissolved and Total Organic Carbon pollutants, respectively).
- Removal mechanism of GAC (Granulated Active Carbon), with or without ozone treatment, as compared with slow filtration through sand.
- Efficiency and economic aspects of the ozonation process.
- Testing of various treatment schemes and combinations of biological and chemical processes.

Current work consists of several stages, including:

* Biological Treatment
* Lime Treatment
* Ammonia Stripping
* Re-carbonation
* Filtration
* Ozonation
* Treatment with Activated Carbon
* Slow Sand Filtration

To date, several studies have been conducted, yielding relevant information about the following:

- Operation of Advanced Treatment Schemes
- Optimal Doses of Lime and Ozone
- GAC (Granulated Active Carbon) Absorption Mechanism
- Consumption and Ozone Recovery Studies

(b) **Epidemiological and toxological studies**

Untreated wastewater contains pathogenic agents injurious to health, either directly or indirectly. Such agents therefore require painstaking epidemiological and toxological studies and monitoring — a fact fully reflected in Israel's on-going research on the quality of water, as may be judged from the following examples: Safety evaluation of effluents after disinfection with ozone or chlorine is being investigated both by *in vitro* techniques, using bacterial cultures and standard tests, and by *in vivo* methods, using large numbers of mice.

Preliminary results of these experiments indicate that chlorinated secondary and tertiary effluents cause morphological damage to 50–100% of BGM cells, while ozonated effluents cause damage to only 25% or no damage at all (0%) (*Yannai, 1980*; see Table 2).

Table Two
SAFETY EVALUATION OF TREATED EFFLUENTS
***IN VITRO* EXPERIMENT**
Morphological Damage to BGM Cells

Agent		Per Cent
Tap Water		0
Distilled Water		0
Secondary Chlorinated Effluents	200mg/l	50–75
Secondary Ozonated Effluents	200mg/l	0
Lime & Chlorinated Effluents	200mg/l	100
Lime & Ozonated Effluents	200mg/l	0–25

(Source: Yannai, 1980)

With *in vivo* experiments, fifth-litter ICR mice receiving secondary effluents showed no significant differences in the number weaned and in the mean weaning weight as compared to those of the control group *(Meshorer, 1980;* see Table 3).

Table Three
***IN VIVO* EXPERIMENTS**
Mean Data of ICR Mice Receiving Purified Effluents
Fifth Litter

	Number Born		Number Weaned		Mean Weight (gms)	
	Male	Female	Male	Female	Male	Female
Control	5.3	4.3	4.7	4.3	7.2	7.0
Experimental (P.Eff.)	5.3	5.0	5.0	3.7	13.3	11.0

(Source: Meshorer, 1980)

Trace organics have become a matter of concern in wastewater schemes involving groundwater recharge, making both quantitative and qualitative determination of organic compounds in effluents a subject of great importance. This explains why trace organics too are being investigated in contemporary Israeli research *(Michail, 1981).*

(c) Direct use of secondary effluents

Secondary effluents can be used without further treatment for irrigation *in clearly defined systems* for the irrigation of *industrial* crops (such as cotton, for example). Effluents can be used directly or after storage in impoundments during the rainy season, as follows: The *impoundment of primary effluents* was found to improve the quality of the effluents rather markedly as measured by such indicators as reduced biological oxygen demand (BOD), suspended solids, and ammonium nitrogen *(Abeliovitch, 1980; Dor, 1980;* see Table 4).

Table Four
CHANGES IN QUALITY OF EFFLUENTS IMPOUNDED IN SEASONAL RESERVOIRS

Item/ Activity	Soluble BOD	Ammonium	Total Suspended Solids	Dissolved Oxygen (noon)
Raw Sewage	110	38	215	0
Primary Treatment	105	47	127	0.6
Seasonal Storage	47	25	147	7.8

(Source: Abeliovitch, 1980)

Similarly, storage of secondary effluents for two months caused a ten-fold reduction and practically complete disappearance of viruses. At the same time, there was a decrease in the number of coliforms and fecal coliforms as well as in fecal streptococci by two to three orders of magnitude (ten to a hundred-fold). Disinfection of the effluents at the end of the storage period ensured virus-free effluents *(Kott, 1974).* In a more recent experiment, in which ozone was applied in a dosage of 25 mg for fifteen minutes to secondary effluents, the number of fecal coliform was reduced to 8×10^2 per 100 ml, while the number of entero-viruses *fell to zero (Kott, 1980;* Table 5).

Table Five
OZONE INACTIVATION OF MICRO-ORGANISMS
OZONATION OF SECONDARY EFFLUENTS

Application Rate	Fecal Coliform (in 100 ml)	Enteroviruses (in 100 ml)
Control	1.5×10^6	5.1×10^3
15.3 mg	4.4×10^3	4.5×10
25 mg	8.0×10^2	0

Note: Ozone applied for 15 minutes
(Source: Kott, 1980)

Irrigation with Effluents

The major aspects of irrigation with low-grade effluents are concerned with effluents and soil properties; hydrological, climatic, and environmental factors; crop characteristics; and long term effects on soils. All these factors are being dealt with in a variety of studies. Preliminary results indicate that soil management practices play a key role in the inter-action of effluents with soil and crops. But much more research is needed to determine effects on soil ecosystems. At the same time, advanced technology and improvements are incorporated under practical

conditions in large-scale water reclamation projects, including —

- new irrigation techniques (drip irrigation);
- slow-release and controlled use of fertilisers;
- slow-release fertilisers; and
- cultivation of new crop varieties with high nutrient uptake.

Photo-oxydation

Natural conditions can help to reduce the risk of bacterial contamination from aerosols emanating from sewage treatment plants and effluent irrigation systems. Thus preliminary results *(Acher, 1980)* have indicated that bacteria and viruses in aerosols are *totally* inactivated by solar radiation.

Major water renovation projects

Brief as it is, this survey would be entirely inadequate without at least a passing reference to such major enterprises in the field of water renovation as the Dan Region Project serving several cities including Tel Aviv, with a total population of more than a million souls and an annual water consumption of about 120 MCM.* Also to be noted in this connection is the Kishon Reclamation Scheme for the renovation of wastewater generated in the Haifa metropolitan area: the wastewater concerned is to be conveyed to, and impounded during the winter in, a reservoir with a planned capacity of 12 MCM, located in the Yezreel Valley, some 30 km east of Haifa, then pumped for irrigation to nearby industrial crops.

* For a history of the Dan Region Project, see article by Hillel I. SHUVAL in this issue (p. 19). — Ed.

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growing role of BIO TECHNO LOGIES in world energy

By JOSEPH VARDI

EDITOR'S NOTE: Formerly director-general of Israel's Ministry of Energy and Infrastructure and today President, International Technologies (Holding) Ltd., the author foresees a greatly expanding importance of biotechnologies in all parts of the world. According to Vardi, the field is still wide open to any nation wishing to stake out a claim to a share of the export market in innovative biotechnological products and know-how. He believes that Israel is well placed to compete for such a share. But as the knowledgeable author sees it, time is of the essence, and a determined beginning must be made now...

1.
Evolution of Non-conventional and Renewable Energy Sources

Until recently, developments in the field of non-conventional energy resources and technologies were few and far between. The picture began to change significantly only after the 1973 petroleum embargo, but most of the activities developed since then amounted to little more than studies, both economic and technical, with very little immediate practical consequences. This is understandable enough, given the almost absolute lack of interest in the subject during the pre-1973 period, and the lack of adequate knowledge of what should be done by the decision-makers, as well as of an institutionalised framework for making such decisions and executing and managing relevant programmes during the 1973/1978 period. But in spite of the fact that during that five-year period not much happened in terms of actual developments, the time-span was essential in developing the capabilities, understanding and

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