Reclaimed Wastewater

Most raw wastewater (sewage) in Israel is treated in treatment plants. The treatment process includes biological, chemical, and physical methods to lower contaminant concentrations. In Israel, agricultural irrigation is the principal use (85%) of reclaimed wastewater (RWW). Roughly half of all water allocated for irrigation is RWW. Irrigation with RWW that meets the required Israeli quality standards is considered safe, however there is information on pathogens and organic contaminants, such as residues of pharmaceuticals or chemicals not routinely monitored, that may be absorbed by crops or may seep into groundwater. There is also concern that a temporary malfunction at a wastewater treatment plant could contaminate agricultural produce, streams, groundwater, and seawater.

Current RWW quality regulations in Israel address potential risks to public health that may result from transmitting pathogens and other contaminants from RWW to crops, groundwater, streams, and seawater, and ultimately to the public. The regulations also address the potential risks of metal concentrations in RWW to public health, environmental health, and agriculture. The Ministry of Health (MoH) and the Ministry of Environmental Protection (MoEP) jointly set quality standards for irrigation with RWW and discharge of effluents into streams. In addition, guidelines on irrigation with RWW require barriers between the water and the irrigated crops (for example, the use of drip irrigation or a specified minimal time interval between irrigation and harvest). Nevertheless, regulations have not been passed on monitoring and restricting a range of organic contaminants and micro-pollutants, such as pharmaceutical residues in RWW.

Progress since 2017

The *Environmental Health in Israel 2017* report defined challenges related to Reclaimed Wastewater. Progress achieved in this area during the past three years is outlined below.

The challenge: Conduct additional studies on potential exposure to pharmaceuticals and other contaminants via produce irrigated with reclaimed wastewater

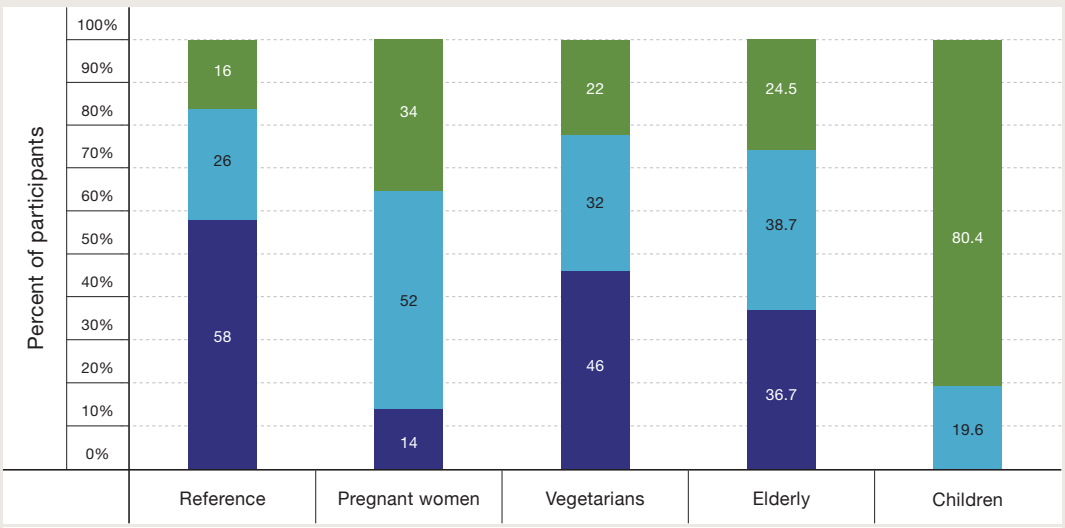
In short: A study conducted found higher urinary concentrations of carbamazepine in populations that consumed more vegetables; recent studies indicate the accumulation of carbamazepine in plants irrigated with RWW.

Challenge for the coming years: Study potential exposure to additional micro-pollutants in crops irrigated with RWW.

Researchers from the Hebrew University Center of Excellence in Agriculture and Environmental Health quantified urinary levels of carbamazepine (CBZ) and their metabolites in a reference group of healthy omnivorous adults and various sub-populations: children, pregnant women, the elderly, and vegetarians and vegans. High levels of CBZ were found among vegetarians, vegans, and other participants who consumed larger quantities of vegetables (Figure 1).[1]

Distribution of CBZ Urinary Concentrations in Sub-Populations in Israel

→ Figure 1
Schapira et al., 2020[1]



Researchers from the Hebrew University of Jerusalem studied the uptake, transport, and metabolism of CBZ in various agricultural crops, in different parts of the plant, and compared crops irrigated with freshwater and fertilized with biosolids with those irrigated with RWW. They showed that the crops irrigated with RWW tended to accumulate higher concentrations of CBZ.[2]

Legend: Significant progress | Some progress | Little or no progress

The challenge: Create a database that integrates chemical and microbial monitoring in sewage, reclaimed wastewater, in the field, and in agricultural produce

In short: The database, with monitoring data on sewage and RWW, was created and is expected to be launched soon.	**Challenge for the coming years**: Expand information in the database on chemical monitoring in the field and in agricultural produce; consider data collection on antibiotic resistance from these sources and from hospitals.

MoH, MoEP and the Water Authority have created an integrated database that includes monitoring data on various contaminants in sewage, RWW, and sludge. The database, in advanced stages of development, allows direct data feed from accredited labs. The system includes a portal for online input of data from control procedures conducted by plant operators and allows for data analysis. At the present writing, the database contains tens of thousands of entries from some 400 wastewater treatment plants nationwide.

In addition to the information collected in the database, it may be useful to collect data on antibiotic resistant bacteria and antibiotic resistant genes in sewage, RWW, fields, and agricultural produce, and to cross reference them with data on antibiotic resistance from hospitals.

The challenge: Conduct a risk assessment of chemical contaminants in reclaimed wastewater

In short: No risk assessment on chemical contaminants in RWW, other than CBZ, has been conducted.

Research thus far has focused on CBZ. Studies on CBZ concentrations in plants irrigated with RWW have not shown that these concentrations pose a risk to public health. It is presumed, however, that RWW contains many other chemicals (micro-pollutants and pharmaceutical residues) that are not routinely monitored. Despite the widespread use of RWW to irrigate agricultural crops in Israel, no comprehensive risk assessment on the effects of these contaminants has been conducted. The regulations for RWW quality for agricultural irrigation in Israel comport with the World Health Organization's (WHO) 2006 risk assessment, which focused primarily on heavy metals and pathogens. Risk assessments dealing with chemical micro-pollutants in RWW are very few in number.

Research on Reclaimed Wastewater in Israel

- Researchers from the Hebrew University of Jerusalem exposed chicken eggs to low environmental concentrations of CBZ (0.02–0.2 pg/mg), resembling concentrations measured in RWW, and found that exposure to even low environmental concentrations induced increased embryonic mortality and teratogenic effects.[3]

- Researchers from the Hebrew University Center of Excellence in Agriculture and Environmental Health quantified urinary levels of CBZ and their metabolites in children, pregnant women, the elderly, vegetarians, and vegans. High levels of CBZ were found among vegetarians, vegans, and participants who consumed larger quantities of vegetables.[1]

- Researchers from the Hebrew University of Jerusalem studied the uptake, transport, and metabolism of CBZ in various agricultural crops, in different parts of the plant, and compared crops irrigated with freshwater and fertilized with biosolids with those irrigated with RWW. They showed that the crops irrigated with RWW tended to accumulate higher concentrations of CBZ.[2]

- Researchers from the Hebrew University of Jerusalem, in collaboration with colleagues from the University of Leeds and Al-Quds University in eastern Jerusalem, conducted a holistic analysis that included an assessment and examination of the transfer pathways of pharmaceuticals found in RWW used in agricultural irrigation. Attempting to assess the impact of these pollutants on human health and on ecological systems, the researchers concluded that broad research is needed to understand these effects.[4]

- Researchers from Tel Aviv University analyzed regulation in various countries for monitoring and removing pharmaceuticals from various water sources—regulation that does not exist in Israel. Focusing on Switzerland, Austria, Singapore, and the U.S., where RWW is also used as a source of drinking water, the researchers offered several proposals for monitoring and treating these pollutants in Israel's water systems, with emphasis on RWW, in order to reduce potential exposure of the public.[5] Notably, no regulation exists anywhere in the world for monitoring and removing pharmaceuticals in RWW used for agricultural irrigation.

- Researchers from Tel Aviv University showed that the use of ethanol-activated granular aerogel was effective in adsorbing persistent organic pollutants (POPs) in hospital raw wastewater.[6]

- Researchers from the Hebrew University of Jerusalem, in collaboration with colleagues at the University of Chicago, studied the impact of RWW irrigation on a microbial community of soil and roots and on the growth of agricultural crops (tomato and lettuce). They found that in comparison with freshwater irrigation, RWW irrigation raised the level of soil acidity (pH) and increased the concentrations of various elements, such as potassium and sodium, in the soil. They also found that irrigation with RWW resulted in lower plant fruit and shoot weight and altered the plant's soil and root microbiome.[7]

- Researchers from the Agricultural Research Organization's Volcani Center and the Hebrew University of Jerusalem found no correlation between the presence of certain antibiotic resistant genes (intl1) in RWW and their presence in soil irrigated with this wastewater, with the exception of sandy soils. They also found no evidence that antibiotic resistant genes were transferred from the RWW to the soil or to the plant.[8]

- Researchers from Ben-Gurion University in the Negev, in collaboration with colleagues from the Volcani Center, the Newe Ya'ar Research Center, and from the Environmental Protection and Research Institute – Gaza, studied the role of physical barriers (drip irrigation or plastic mulch) in preventing bacterial transmission from irrigation water (with an emphasis on treated wastewater) to agricultural crops. The researchers quantified the concentrations of fecal bacteria in cucumber and melon plants irrigated with treated wastewater or potable water, with and without these barriers. No association was found between the type of barrier or water source and the concentrations of fecal bacteria in the soil or the crops.[9]

Future Challenges

Raw wastewater in Israel is treated regularly and, for the most part, efficiently. The existing wastewater treatment infrastructure, however, is insufficient for dealing with increasing loads, and with events involving exceptionally large quantities of raw wastewater, for example, during heavy rain. In such cases, excess untreated wastewater from the treatment plants is discharged to the environment, potentially exposing the population in Israel to a broad range of contaminants. In addition, the capacity of wastewater storage systems is inadequate (particularly during the winter, when there is no agricultural consumption of RWW). In these cases, wastewater is discharged into streams, posing a potential risk to public health. Consequently, it is necessary to improve the infrastructure for sewage treatment and RWW storage in Israel, and to adapt it to the steadily increasing volume of sewage and RWW.

In 2020, the Water Authority (via Mekorot, the national drinking water supplier, and in coordination with MoH and MoEP), launched a pilot facility for advanced treatment of RWW at the Shafdan plant—a preliminary step toward building an industrial facility for treating some RWW (5,000 m^3/h) without soil aquifer treatment (SAT). The facility will utilize advanced technologies such as membrane bioreactor (MBR), ozonation, biological activated carbon filtration, and UV to remove a large range of micro-pollutants known as "contaminants of emerging concern" (CECs), including pharmaceuticals, per- and polyfluoroalkyl substances (PFAS), and other industrial pollutants. The facility is expected to treat about a quarter of the secondary treated effluent at the Shafdan site and to remove more than 80% of these contaminants. MoH, MoEP and the Water Authority are working to enhance control of micro-pollutant concentrations in industrial sewage, especially in the pharmaceutical industry.

Risk assessments are needed, as are holistic analyses that integrate data collected in the new database, monitoring of data from the field (soil and agricultural produce), and monitoring of biological data (for example, CBZ in urine). It is important that the risk assessments address exposure to a large number of chemicals and pharmaceuticals in RWW (by using, for example, additive or synergistic models). In light of growing evidence that municipal wastewater is a source of PFAS[10] and POPs including flame retardants and organochlorine pesticides, it would also be worthwhile to consider monitoring other contaminants, such as PFAS, and POPs in RWW and sludge.

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