Chapter 4

Chemical Parameters in Drinking Water

Exposure to chemical contaminants in drinking water has been associated with an array of adverse health effects in human populations, including increased risk of cancer (for example, from exposure to trichloroethylene and trihalomethanes [THM]); adverse effects on neurodevelopment (for instance, from exposure to lead); and adverse effects on reproductive and birth outcomes (for example, from exposure to atrazine).

While in the past the focus on chemical parameters in drinking water was on the potentially toxic effects of contaminants, there is increasing evidence that certain parameters, such as minerals in drinking water, have beneficial effects on public health. There is evidence that low concentrations of magnesium in drinking water is related to an increased risk of cardiovascular disease, and that low calcium content of drinking water is associated with a higher risk of fracture in children, certain neurodegenerative diseases, preterm birth and low birth weight, and some types of cancer(8). It is important to note that excess concentrations of minerals in drinking water may also cause adverse health effects.

Israel's drinking water is unique in that there is a high proportion of desalinated water in the distribution system (over 50%). Desalinated water has been used to supplement severely limited natural sources and to help cope with consecutive drought years. The distribution system includes water from different sources (desalinated, surface, and groundwater), and the mix can fluctuate hourly and monthly. This operational flexibility and the use of a range of drinking water sources allow for a reliable supply system. There is significant geographic variability in the water supply, including in the proportion of desalinated water in the supply system.

Policy and Regulations

Contaminants

The chemical quality of drinking water in Israel is regulated according to standards originally promulgated in 1974 and updated in 2013. The 2013 standards include maximum contaminant levels for over 90 chemical contaminants, including metals, pesticides, radionuclides, and industrial organic pollutants. Drinking water suppliers are required to conduct periodic testing for these contaminants in drinking water sources and to report the results to the Ministry of Health (MoH). Table 1 shows maximum permitted concentrations and potential health effects of selected contaminants highlighted in this chapter.

Potential Health Effects and Maximum Permitted Concentrations of Selected Contaminants in Drinking Water

→ Table 1
Source: United States Environmental Protection Agency(7), Israel Ministry of Health

Contaminant	Maximum Permitted Concentration	Adverse Health Effects
Lead	10 μg/L	Developmental delays and neurocognitive effects in infants and children; effects on kidneys and blood pressure in adults; cardiovascular effects
Simazine	2 μg/L	Endocrine disruption
Atrazine	2 μg/L	Endocrine disruption
Trihalomethanes	100 μg/L (in 90% of samples) Maximum concentration for no more than two weeks is 150 μg/L	Disorders of liver, kidney, central nervous system; increased risk of cancer
Nitrates	70,000 μg/L	Shortness of breath and blue baby syndrome (methemoglobinemia) in infants
Trichloroethylene	20 μg/L	Disorders of kidney, liver and heart; increased risk of cancer
Tetrachloroethylene	10 μg/L	Disorders of kidney, liver and heart; increased risk of cancer

All products in contact with drinking water (pipes, faucets, fixtures, and household drinking water systems) must meet the requirements of Israeli Standard 5452. This standard was updated in 2016 to require that the lead content of products in contact with drinking water not exceed 0.25%. This requirement will enter into force for non-metal products in 2018 and for metal products in 2019.

Israel's drinking water standards require testing for the presence of heavy metals (lead, iron, and copper) and disinfection by-products (THM, chlorite, and chlorate) in distribution systems. The frequency of testing depends on the drinking water source, disinfectant type, season, and population size of the community. The standards state that any individual can request the drinking water supplier to monitor the drinking water in his/her home in order to test for the presence of coliform bacteria, turbidity, lead, iron, and copper. The individual must cover the cost of the test, but the water supplier is required to conduct it and report the results.

The quality of bottled water, like other food products, is under the supervision of the National Food Service at the MoH. Standards set in 1986 define the maximum permissible concentrations of chemicals in the sources of bottled water.

Mineral Content

Israel's drinking water standards require large water suppliers that desalinate seawater to stabilize the water before it is supplied to the public. The required stabilization values include pH level of 7.5-8.3, dissolved calcium level of 80-120 mg/L as $CaCO_3$, alkalinity of above 80 mg/L as $CaCO_3$, Calcium Carbonate Precipitation Potential (CCPP) of 3-10 mg/L as $CaCO_3$, and a positive Langelier Saturation Index. Desalination plants established prior to 2009 are required to stabilize water according to a positive Langelier Index—without requirements regarding CCPP. In 2016, the MoH published less stringent requirements regarding levels of $CaCO_3$ (less than 3 mg/L).

While there is a requirement to add calcium to desalinated water, to date there is no requirement to also add magnesium, fluoride, or iodine. Drinking water fluoridation was discontinued in Israel in 2014. However, in 2016 the Knesset approved a change to the drinking water standards: the requirement of fluoridation at a concentration of 0.7 mg/L is planned to enter into force in 2017.

Data on Chemical Parameters in Drinking Water in Israel

Water Quality in Drinking Water Sources

The MoH publishes quarterly data on the microbial and chemical quality of water in drinking water sources based on data reported by drinking water suppliers. According to data reported for 2015-2016, four main chemical contaminants were detected in drinking water sources in Israel: atrazine (in 8.4% of the sources, concentrations between 0.08-0.67 μg/L), simazine (in 13.4% of the sources, concentrations between 0.08-0.52 μg/L), trichloroethylene (in 13.7% of the sources, concentrations between 0.1-101.6 μg/L), and tetrachloroethylene (in 10.3% of the sources, concentrations between 0.1-176.8 μg/L).

Heavy metals such as arsenic, mercury, lead, and cadmium occur naturally in the environment, and are detected in less than 10% of the drinking water sources, usually at levels below 30% of the maximum permitted concentrations in the drinking water standards. In 2014-2016, 890 drinking water wells were tested for the presence of lead and only 16 (1.8%) had detectable lead concentrations (all less than 5 μg/L).

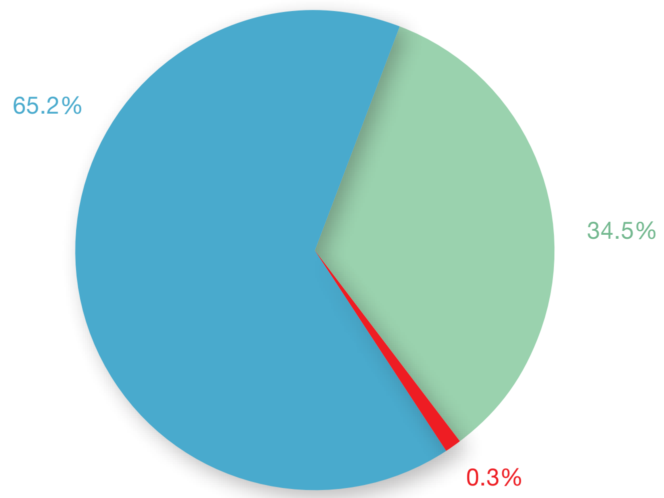
Based on data from 1,250 samples collected in 2016, there are high concentrations of nitrates along the coastal aquifer. Twenty-six percent of the drinking water sources in central Israel, including Ashkelon, had nitrate levels between 50-70 mg/L, and an additional 17% had levels above the maximum permitted concentration in the drinking water standard (70 mg/L). Drinking water sources with nitrate concentrations above 70 mg/L are treated to reduce the concentration in the supplied water. Nitrate concentrations were lower in the northern, southern, and Jerusalem districts. In the scientific literature, high nitrate levels in drinking water have been associated with methemoglobinemia. Therefore, the MoH assessed the methemoglobinemia rates in infants in 2011-2015 and examined the potential association with nitrate concentrations in drinking water. The analysis revealed that methemoglobinemia is rare in Israel and that there is no indication of an association between its incidence and nitrate concentrations in drinking water.

Water Quality in Municipal Water Distribution Systems

The MoH publishes data on water quality in municipal water supply systems, including data on concentrations of heavy metals and chlorination byproducts (THM). Data from 2014-2016 show that lead was detected in 35% of the samples, at concentrations below the standard of 10 μg/L. Lead concentrations exceeded the standard in 0.3% of the samples (Figure 1)[2].

Lead Concentrations in Drinking Water in Municipal Supply Systems, 2014-2016 (n = 5,178)

→ **Figure 1** Source: Israel Ministry of Health[2]



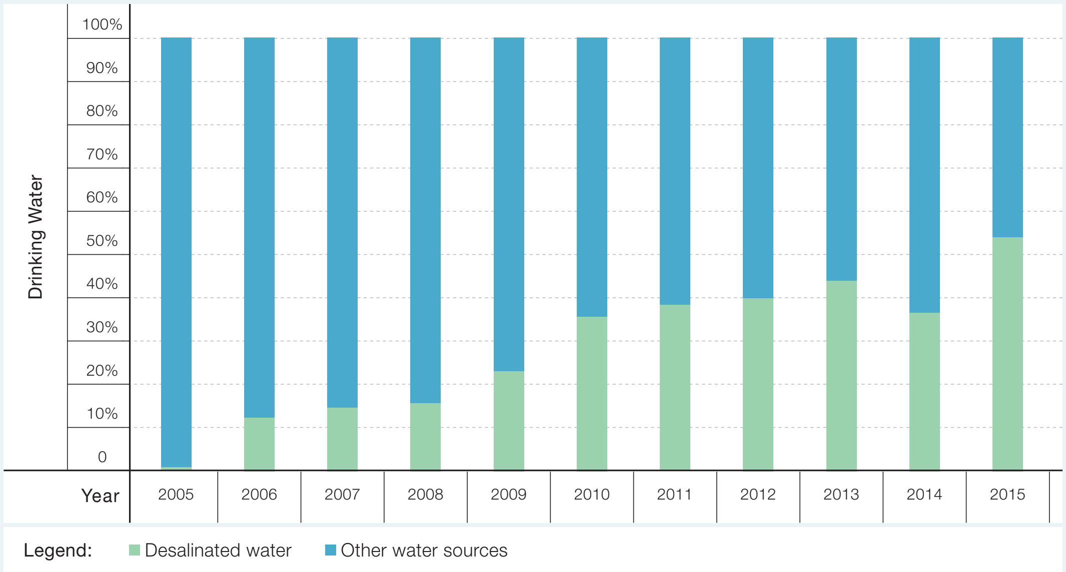
Legend: Above standard Detected, below standard Below level of quantification

In 2015, there were sporadic exceedances in THM levels in communities in northern Israel receiving drinking water from the National Water Carrier. THM levels decreased significantly in 2016 following changes in the disinfectant and supply systems, the dilution of surface water with groundwater or desalinated water, and the aeration of water reservoirs.

Mineral Content

Israel's drinking water supply is highly variable, consisting of desalinated water, surface water, and groundwater. The percentage of desalinated water of the total supplied drinking water has increased drastically from only 2.5% in 2005 to over 50% in 2015 (Figure 2).

Percentage of Desalinated Water out of the Total Drinking Water for Residential and Industrial Uses, 2005-2015



← **Figure 2**
Source: Israel Water Authority

Geographical differences in primary drinking water sources in Israel result in geographic variations in mineral content. Monitoring data from 2015-2016 indicate that the magnesium levels in drinking water sources were 150-190 mg/L in the south (Arava), 3-5 mg/L in the north, and 0 (zero) in desalinated water (compared with the recommended level of 20-30 mg/L). Iodine levels also vary considerably, ranging from 0 (zero) in desalinated water to 250 µg/L in the south (Arava) (Table 2). However, these values do not reflect the magnesium and iodine levels in the water supply system. For example, the general population in the Arava receives desalinated drinking water and not groundwater[1].

Iodine Concentrations in Drinking Water Sources (µg/L), 2016 (n = 260)

North	East Center	West Center	Southwest	Southeast (Arava)	Desalination Plants
2-3	5.5-25	7-95	18-150	250	0

← **Table 2**
Source: Israel Ministry of Health[1]

Research on Adverse Health Effects and Drinking Water in Israel

- Researchers from Bar-Ilan University and the Sheba Medical Center compared 30-day and one-year mortality of acute myocardial infarction patients who participated in the biannual Acute Coronary Syndrome Israeli Survey during 2002-2013. Researchers found higher 30-day and one-year all-cause mortality in acute myocardial infarction patients in regions with desalinated water consumption, possibly attributable to reduced magnesium intake[6].

- Researchers from the Hebrew University of Jerusalem assessed the relationship between iodine intake and thyroid function in a convenience sample of volunteers between 2012 and 2014, and found evidence of prevalent iodine-deficiency disorders in areas reliant on desalination[4,5].

- In 2016, researchers from the Hebrew University of Jerusalem, Ben-Gurion University, and Maccabi Healthcare Services examined iodine levels in a representative national sample of school-age children and of pregnant women. The researchers found that 62% of school-age children and 85% of pregnant women had iodine deficiencies[3].

- The MoH began a study in 2014 to assess the impact of the discontinuation of drinking water fluoridation on dental health in 12-year-old children in several areas in southern Israel.

Progress Since 2014

In the *Environmental Health in Israel 2014* report, the major challenges concerning chemical parameters in drinking water included understanding the potential impact of desalination on mineral intake and public health, understanding the impact of discontinuing fluoridation, and limiting the lead content of materials that come into contact with drinking water. Additional challenges were related to the presence of pesticides in drinking water sources and the lack of a central database of drinking water contaminants that are not included in the standards (such as unregulated chlorination byproducts and pharmaceuticals).

While progress has been made in researching the impact of magnesium and iodine deficiencies due to the consumption of desalinated water, the findings on these adverse health effects have not been translated into policy. A government feasibility study on adding magnesium to desalinated water, mandated by the 2013 drinking water standards, has yet to be completed. The MoH, the Ministry of Agriculture and Rural Development (MoAg), the Water Authority, and the Ministry of Finance are planning a pilot study to examine the feasibility of adding magnesium to drinking water; the study will seek to identify the best technology and estimate the required budget. To date, there is no plan to supplement desalinated water with iodine due to the potential harm of high iodine intake. In light of new findings of the prevalence of iodine insufficiency among children and pregnant women, the MoH published recommendations to add iodine to table salt and to salt used in bread.

There has been significant progress in limiting the lead content of products that come into contact with drinking water (new requirements will enter into force for non-metal products in 2018 and for metal products in 2019). There has also been significant progress in creating a central database of chemicals in drinking water, including unregulated chemicals such as carbamazepine. There is a lack of data on the presence of other unregulated chemicals - for example, per- and polyfluoroalkyl substances (PFASs).

Drinking water fluoridation was discontinued in 2014 and the impact on dental health is unclear, especially among low socioeconomic groups.

Major Challenges

Israel's unique drinking water system, which is characterized by a high proportion of desalinated water and fluctuation among different water sources (desalinated water, groundwater, surface water), faces unique challenges.

Dramatic fluctuations in drinking water sources can lead to consumer complaints about the water's taste. The MoH published recommendations stating that fluctuations should be gradual and accompanied by testing for the presence of heavy metals, but the implementation of these recommendations remains a challenge.

Since heavy metal testing of tap water is not conducted routinely in residences or institutions in Israel, it is unknown whether the increasing amounts of desalinated water in distribution systems have caused leaching of lead and other heavy metals into tap water. In the last MoH survey on the presence of lead in tap water, conducted in 2011, lead was detected in 10% of the samples. The MoH is planning the fourth survey on lead in tap water in residences and institutions, including schools.

While there is abundant data on chemical parameters of drinking water sources and drinking water in the municipal supply system, there is insufficient data about the chemical quality of tap water. Mekorot, the national drinking water supplier, is planning to develop a model for assessing and managing the water mix at central mixing junctions and at points of consumption. This will help the MoH and researchers evaluate the mineral content - for example, iodine and magnesium - in drinking water.

The MoH aims to reinstate drinking water fluoridation in 2017, after having discontinued it for three years. Since the standards require that fluoride levels not exceed 0.7 mg/L, this will require precise monitoring of fluoride in the distribution system.

Israel is becoming increasingly reliant on desalinated water as its primary source of drinking water. In recent years, the Water Authority began planning an additional desalination plant in northern Israel to supply desalinated water to the Galilee region. There is a need for further research on the impact of desalination on the intake of magnesium, iodine, fluoride and other minerals, and the potential impact of decreased mineral intakes on public health. As the percentage of the population consuming desalinated drinking water continues to grow, there is an increasing need for ongoing discourse among policymakers on ways to minimize the potential public health risks associated with desalination and low mineral intake.

References

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