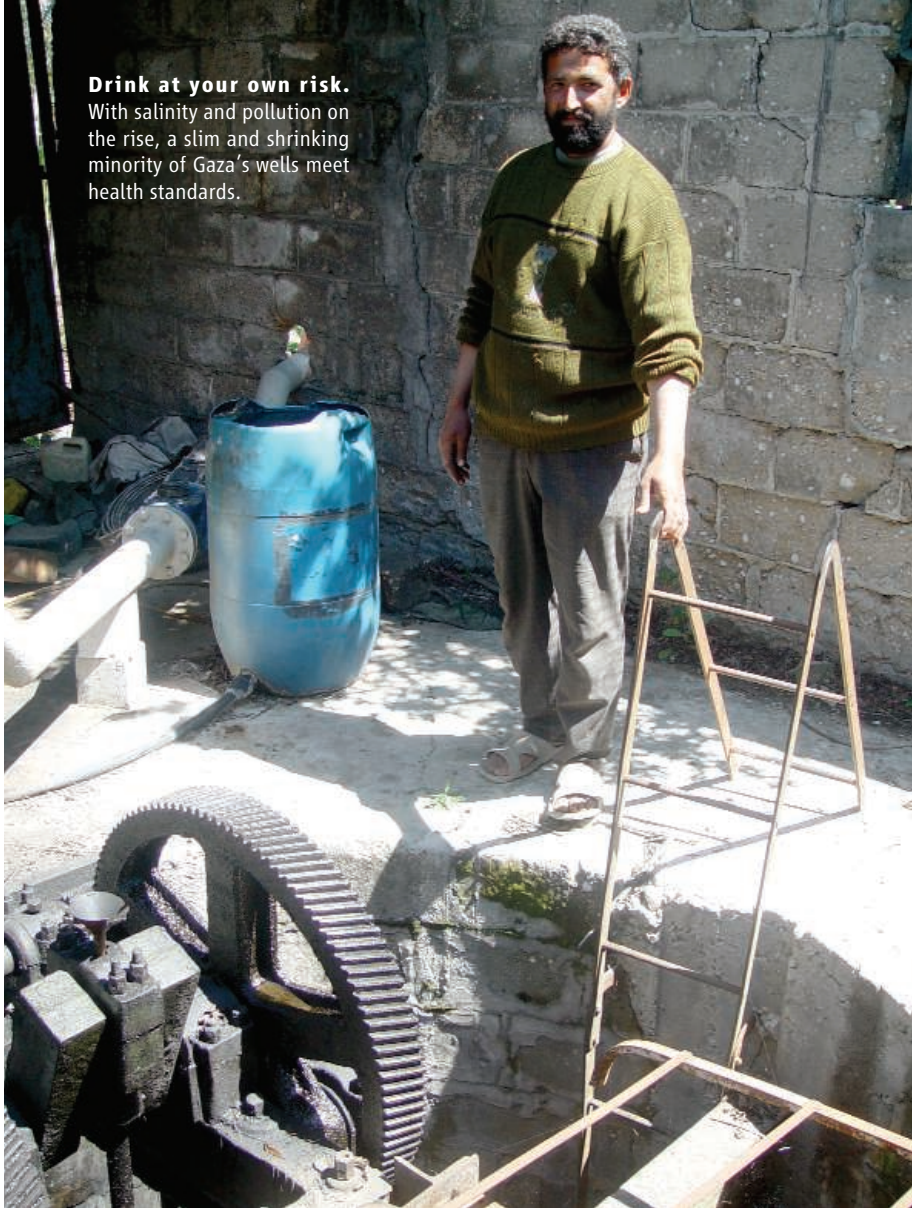


Drink at your own risk.

With salinity and pollution on the rise, a slim and shrinking minority of Gaza's wells meet health standards.



SPECIAL SECTION

Gaza, the worse the water becomes, and Rafah is the end of the line. The Palestinian Authority issues warnings from time to time urging the public to buy bottled water, especially for the very young or elderly. But for the average Gazan—with an annual income of \$600—a \$1 gallon of water is a luxury.

For Abu Taha, who grew up as a Bedouin in the nearby Negev desert, making efficient use of scarce water resources is nothing new. The problem is that the 1.4 million people crammed into the Gaza Strip—most of them the children of refugees who fled their homes in the 1948 and 1967 Arab-Israeli wars—depend on a shallow aquifer for water. But year by year, that source is becoming more contaminated by salt and pollution. Most wells already produce water that is nonpotable by standards set by the World Health Organization.

Water scarcity is a perennial problem in the region, but nowhere is it worse than in Gaza. “It is a microcosm of the entire Middle East,” says Eric Pallant, an environmental scientist at Allegheny College in Meadville, Pennsylvania, who has collaborated with both Israelis and Palestinians on water problems. “If you can figure out how to make water sustainable there, then you can do it anywhere.” Several Gaza water projects have been planned by donor countries in recent years, including state-of-the-art wastewater treatment and desalination plants, but all have fizzled due to security concerns and sanctions slapped onto the new Hamas-led Palestinian government. Israel’s withdrawal of settlers and troops from Gaza last year is a bittersweet victory for the Palestinians. Although they are fully in control of Gaza’s water for the first time, they must now scramble to save it before it becomes irreversibly contaminated.

Water woes

It is a tense first day on the job for Mohammad Al-Agha, the Hamas minister of agriculture. Like a thunderstorm that never quite arrives, Israeli artillery pounds the landscape to the north where Palestinian militants have been launching rockets over the border. After a brief welcome party in his new Gaza City office, Al-Agha, a geologist from nearby Islamic University, and the small group of experts responsible for managing Gaza’s water resources meet with *Science* to discuss their plans. The conversation is interrupted twice when fighter jets scream overhead and strike nearby targets with missiles, causing the building to shudder.

NEWS

Running Out of Water—and Time

Geography, politics, and war combine to make the Gaza Strip a worst-case scenario for water-resource planners

RAFAH—You can almost hear the collective sigh of relief as the angry sun sets over this dusty city on Gaza’s Egyptian border. This is when five of Ali Abu Taha’s sons arrive, unwinding their kaffiyehs and gathering around the charcoal fire where a pot of tea is already boiling. The unprecedented visit of a foreign guest calls for a demonstration of the hospitality for which the Bedouins are famous. The seat of honor is offered, and some of the family’s most valuable possessions are laid out on the carpet for display: a battered old AK-47 rifle and several bottles of home-filtered water. The gun is a family heirloom that rarely sees light, but the water

is indispensable. “The filter cartridges are very expensive and hard to get into Gaza,” says one of the sons, Mohammed, “but this one should hold up for another month, *insha’Allah*.” Not only does it provide the drinking water for Abu Taha’s clan—about 100 people, a third of them his grandchildren—but by enabling them to bottle and sell water to neighbors, it provides one of their few sources of income.

“I don’t recommend drinking too much of this,” says Mohammed as he fills a glass with unfiltered water from the tap. One sip of the pongy brine is enough to understand why. As a general rule, the farther south one goes in

Freshwater Resources

At a glance, the Gazans' water woes seem insurmountable. The only natural fresh source available is the coastal aquifer, a soggy sponge of sediment layers that slopes down to the sea a few dozen meters beneath their feet (see figure). Its most important input is the meager 20 to 40 centimeters of annual rainfall that sprinkles over Gaza's 360-square-kilometer surface—about twice the area of Washington, D.C.—giving between 70 and 140 million cubic meters (MCM) of water per year. Most of that water evaporates, but between 20 and 40 MCM penetrates the sandy sediment to feed the aquifer. Another 15 to 35 MCM, depending on whom you ask, flows in under the border from Israel, while irrigation and leaky pipes are estimated to return 40 to 50 MCM, for a total annual recharge of 75 to 125 MCM.

The aquifer's only natural output is the 8 MCM per year that should exit into the Mediterranean, providing a crucial barrier against the intrusion of seawater. So if no more than about 100 MCM were tapped from the aquifer per year, it could last forever. But Gaza's 4000 wells suck out as much as 160 MCM yearly, says Ahmad Al-Yaqoubi, a hydrologist who directs the Palestinian Water Authority. This estimated 60-MCM annual water deficit is why the water table is dropping rapidly and already reaches 13 meters below sea level in some places. Saltwater from the Mediterranean as well as deeper pockets of brine get sucked in to fill the gap. "The saltwater intrusion is well under way," says Al-Yaqoubi, "especially in the coastal areas and to the south." About 90% of wells already have salinity exceeding the WHO-recommended maximum of 250 parts per million (ppm). The accelerating rate of saltwater intrusion alone could make the Gaza aquifer unusable within 2 or 3 decades, according to a 2003 report by the United Nations Environment Programme.

But there may be far less time on the clock. The aquifer is also mixing with a cocktail of pollutants from Gaza's sewage and agriculture. "Besides salt, our number-one contaminant is nitrate from solid waste and fertilizers," says Yousef Abu Safieh, an environmental scientist based in Gaza City who heads the Palestinian Environmental



Tight spot. Urban pollution, agricultural contamination, and saltwater intrusion from the Mediterranean Sea give Gaza's aquifer a dicey future.

Quality Authority. The maximum safe concentration of nitrate according to WHO is 45 ppm. "In our sampling, we find that most wells have about 200 ppm, and wells close to agricultural runoff can even hit 400," says Abu Safieh. Two Palestinian governmental studies led by Abu Safieh point to patterns of disease matching the distribution of water contamination. The higher the salinity of local water, the higher the incidence of kidney disease, he says, and nitrate concentration correlates with Gaza's high incidence of blue baby syndrome: a loss of available oxygen in the blood that can cause mental retardation or be fatal.

It is the job of a water utility to clean up such contamination and make sure that safe water comes out of the tap, but there is no such unified utility in Gaza. Instead, the strip is covered by a patchwork of fragmented water infrastructure. Gaza's three wastewater treatment plants are far from adequate. The largest, south of Gaza City, was designed to treat 42,000 cubic meters per day—the amount produced by 300,000 people—but now faces a daily inflow of more than 60,000 cubic meters, says Al-Yaqoubi: "This has overwhelmed the biological step of the treatment process." As an emergency measure to prevent sewage from overflowing, barely treated wastewater is now piped to the

coast, where the dark gray liquid can be seen, and smelled, flowing along the beach. Meanwhile, the 40% of Gazans without access to a centralized sewage-disposal system contribute to the burgeoning cesspits. A 40-hectare lake of sewage that has formed in northern Gaza is a menace to people at the surface and the aquifer beneath.

These threats to the water supply are serious, says Al-Yaqoubi, but "water scarcity is of course the problem that will never go away." Considering that crop irrigation gobbles up 70% of Gaza's water and fertilizers contribute most of the nitrate contamination, firmer control of agriculture by Al-Agha's ministry seems like a necessary first step in saving the aquifer from ruin. "The problems continue to spiral," says Mac McKee, a hydrologist at Utah State University in Logan, who has collaborated with Gazans for the past 10 years, because "the

Palestinian Authority has not succeeded in applying effective controls on well-drilling and pumping." About half of Gaza's wells have been dug illegally, mostly by farmers to irrigate small plots of cropland.

"If you try to tell farmers to stop using their wells, they come out with guns," says Ehab Ashour, a water engineer who works for international development agencies in Gaza. And with the struggle for power intensifying between the Hamas and Fatah leaderships, the prospect of better enforcement seems dimmer than ever. For his part, Al-Agha says a crackdown on well-digging isn't even on the table. "We can't do this from an economic standpoint," he says. "Over 60% of people here are farming. We are all locked into this jail, so we have to grow our own food and at the same time try to produce something we can export."

Asking families in Gaza to use less water is also "out of the question," says David Brooks, an environmental scientist who was an adviser during the Israeli-Palestinian water negotiations—a mandate of the Oslo Peace Accords—until they collapsed in 2003 and is now at Friends of the Earth in Ottawa, Canada. Average daily domestic water consumption in Gaza is about 70 liters per person—used not only in homes but also hospitals, schools, businesses, and

public institutions—whereas 100 liters per capita per day is the generally agreed minimum for public health and hygiene. (By comparison, average consumption in Israel is 280 liters per day.) So the only way forward is to secure new sources of fresh water and make existing sources stretch farther, says Abu Safieh. There are several strategies for doing this, he says, “and we are pursuing all of them.”

Making more with less

If you stand on any hill in Gaza and look west, a tantalizing source of water shimmers into view. If only the salts could be efficiently removed, the Mediterranean is a virtually limitless supply for desalination plants. Indeed, this very water is feeding some of the world’s most advanced facilities less than an hour’s drive up the coast in Israel (see Tal, p. 1081).

For any long-term solution in Gaza, “desalination will be absolutely necessary,” says McKee. A desalination plant capable of providing Gaza with 60 MCM of drinking water per year was part of a plan drawn up by the United States Agency for International Development (USAID) in 2000. Money to build the \$70 million plant, along with \$60 million to lay down a carrier system to pipe the water across Gaza, was ready to go from USAID when the second intifada broke out just months later, stalling the project. It was officially frozen in 2003 after a bombing killed three members of a U.S. diplomatic convoy in Gaza.

Besides producing more drinking water, the priority is to deal with Gaza’s sewage, says Al-Yaqoubi, not only to prevent a public health disaster but also to recycle some of the precious water back into the system. A trio of wastewater treatment plants that could handle Gaza’s entire load has been promised by USAID, the World Bank, Germany, Finland, and Japan, but “nothing has happened,” he says, because of the Hamas election victory.

In relation to stretching the current water supply farther, there is one positive legacy of Israeli occupation in Gaza. By working on Israeli farms, “we have become very

comfortable with new technologies,” says Al-Yaqoubi. In spite of the official freeze on international aid to the Palestinian government, projects aiming to improve farming in Gaza “are ongoing by many donors,” he says. The most important is drip irrigation, delivering water directly to roots through a network of tubes. Coupling this with a computerized system that automatically pumps just enough water from a well to meet the plants’ daily needs can make irrigation up to 70% more efficient over the long run.

But for the immediate crisis, the country best placed to help Gaza may be Israel. Before the taps were shut this year after Hamas was elected, 5 MCM per year of

and is to prevent salinity from irreversibly destroying their soil.” Arlosoroff says Israelis and Palestinians working in the water sector have a special relationship. “We understand each other, and we know that these problems require cooperation,” he says, “but the atmosphere between Gaza and Israel is worse now than at any time in our history.”

Across the border, Abu Safieh is similarly disappointed. “There was a time when I could talk with my Israeli counterpart constructively about our environmental problems,” he says, but he has not had any contact in years. Al-Agha says he plans to turn to Egypt for help. For importing and exporting, as well as perhaps for obtaining the abundant



Danger signs. Sewage gushes out onto Gaza’s beaches from a failing wastewater treatment plant. Plans to upgrade the infrastructure remain frozen.

drinking water was being piped into Gaza by Mekorot, the Israeli national water company, and an additional 5 MCM had been agreed. That water does not come free, but it is nevertheless a freshwater source separate from the ailing aquifer.

“We know how serious the situation is in Gaza,” says Saul Arlosoroff, a member of Mekorot’s board of directors and a former Israeli deputy water commissioner. “The first priority is to get these people enough clean drinking water, and the sec-

electricity needed to desalinate water, he says, “our hope is to the south.”

The present turmoil also prevents what Brooks calls “the easiest and best solution” to Gaza’s environmental problems: reducing the number of people living there. “Gaza can’t sustain that population, and any real solution will require people to leave,” he says. Most Gazans “will never give up hope of returning to their homes,” says Abu Safieh, but for now, “we will work to make the best of the bad situation.”

—JOHN BOHANNON