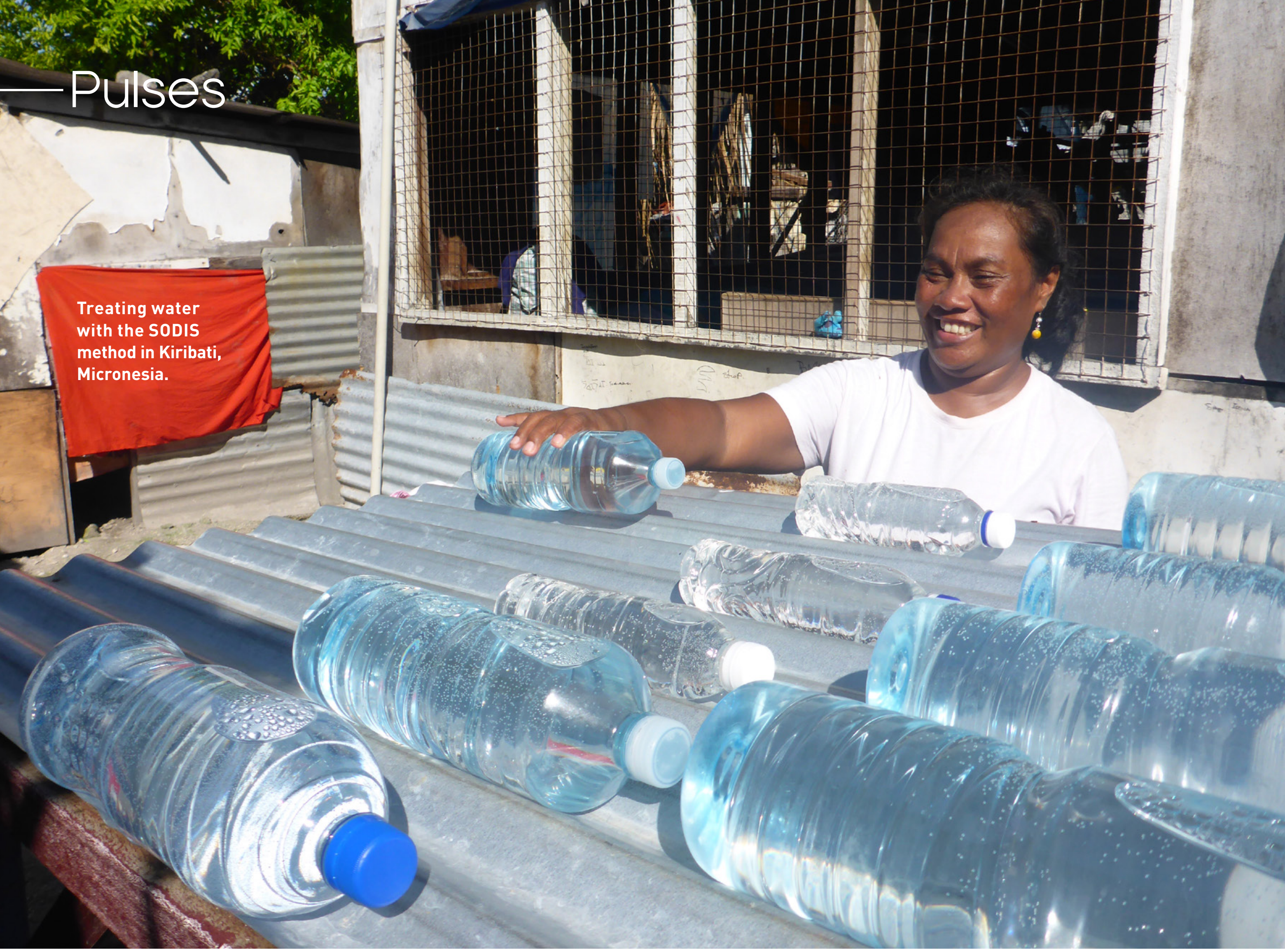

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LIGHT TOUCH

The Best Disinfectant

Stephen R. Wilk explores how sunlight, even absent any bells and whistles, can purify biologically contaminated water.

Two years before he was appointed a justice of the U.S. Supreme Court, Louis Brandeis wrote that "sunlight is said to be the best of disinfectants." Brandeis was speaking metaphorically, on transparency and banking corruption, but the statement derives its force from the centuries-old, commonplace belief that sunlight was, in fact, a readily available, free and effective disinfectant.

The idea of sunlight as a cleansing agent has been around since ancient times, but the effect's validation had to await the germ theory of disease. Immediately after Louis Pasteur's work on the theory came two papers by British scientists Arthur Downes and Thomas P. Blunt. They exposed bacteria growing in Pasteur's solution to sunlight, observing that sunlight could kill and inhibit bacterial development. Experimenting further with colored glass filters, they found that blue and violet light were the most effective, but that red was not ineffective.

The next step came in 1892–93, when H. Marshall Ward at the Royal Indian Engineering College at Cooper's Hill in Surrey, U.K., reproduced these experiments, employing agar as the growth medium, and throwing a continuous spectrum from a prism across the agar to determine the effect of different wavelengths on bacterial growth. He pushed beyond visible wavelengths by using an electric lantern and a quartz prism—confirming for the first time that deeper ultraviolet (UV) rays were much more effective at killing the bacteria than visible light.

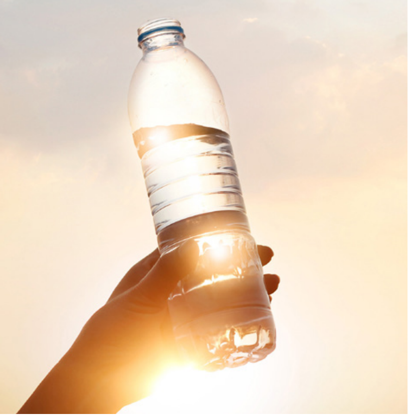
In 1917, H.S. Newcomer at the Henry Phipps Institute, University of Pennsylvania, USA, used an iron arc light to better characterize the useful region of germicidal rays, settling on a peak efficiency of 260 nm. Remarkably, given the limitations of his equipment, this was just 5 nm off of the true peak germicidal value of UV light: 265 nm—the point at which UV light breaks bonds in DNA molecules resulting in the death of the organism.

Insolation revolution

Admittedly, once I learned that deep UV light was responsible for killing bacteria, fungi and even viruses through DNA disruption, I thought I understood the purifying action of sunlight. Yet all of these experiments showed that ambient sunlight throughout the near UV and visible was still an effective germicide. Clearly something else is at work.

The scientific and water supply communities did not abandon the concept of visible-light water purification after finding that UV was more effective. Calling the process insolation, they continued to use it to treat water. However, insolation played second fiddle to the faster and more thorough UV and chemical sterilization treatments. That was the case, at least, until the standard means of purification were not readily available.

In the late 1970s, Aftim Acra, American University of Beirut, Lebanon, was working with the World Health Organization (WHO) to expand treatment of diarrheal disease in the developing world. They were promoting the use of oral rehydration solutions that would replenish the body's supplies of sugars and salts that are depleted by diarrhea. The problem in creating these solutions was finding sources



Getty Images

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of clean water, or even electric power to purify water, in these low-resource areas. The team discovered (some say by accident) that by sealing water in a standard polyethylene terephthalate (PET) water bottle and exposing it to sunlight for a period of six hours or so, the sunlight would destroy the bacteria in the bottle.

This outcome seems counterintuitive—the earth's atmosphere itself blocks the deep UV, and the walls of the plastic PET bottle will further block these. Placing the bottle in the sun will raise its temperature, but not enough to kill bacteria. One would think that in the warm bottle, with any remaining nutrients trapped inside, the bacteria would find a congenial environment to prosper, reproduce and grow. Instead, the opposite occurs.

SODIS

Eventually termed SODIS, for SOlar DISinfection, the method is still widely recommended, and also widely doubted. It seems so unlikely that such a simple, low-tech process using readily available materials can be so effective. Still, SODIS literature shows people scooping up water from the most unlikely of sources, and laying the filled bottles out in rows upon metal or highly reflective surfaces (which let the light pass through multiple times). The main requirements are that the water be as clear as possible (to facilitate passage of the rays) and free of chemical contamination.

Much work has been done on examining the reactions caused by sunlight on water to create activated oxygen compounds. These, it is felt, are what are responsible for killing bacteria in natural waters, and were behind the sterilization experimentally observed in the late 19th and early 20th centuries. The process is still imperfectly understood—and sunlight has also been shown to kill bacteria and fungi under completely dry circumstances.

There have been more advanced variations on the SODIS formula, using special glass reactors with focusing mirrors or devices that use UV LEDs. But these seem fundamentally at odds with the low-tech circumstances that make SODIS most useful—there are no moving parts to break, no chemicals to replenish, no batteries to replace.

Today several organizations are publishing literature on the use of SODIS to provide clean water to parts of the world that still lack it, including the U.S. Centers for Disease Control and Prevention, WHO, UNICEF, the Red Cross and Red Crescent, and the Swiss Federal Institute (EAWAG). OPN

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