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Security Nexus Perspectives

BUILDING WATER SECURITY ON SMALL PACIFIC ISLANDS

By Dr. Ethan Allen*

The approximately 10,000 small Pacific islands (*i.e*., Oceania, exclusive of Australia and the large islands of New Zealand, Papua New Guinea, and Hawaii) are home to about two million residents. Despite marked cultural, linguistic, and societal differences, the peoples of these tiny protuberances from the vast ocean share a set of common challenges related to their vital freshwater resources[1]: small land area, limited groundwater and aquifer capacities, and high dependence on rainfall.

Across most small Pacific islands, municipal water sources are unreliable, of limited availability, and/or contaminated due to leaks and/or illegal 'bootlegged' connections, both of which allow untreated water to mix with treated. Water from such systems may be available for a few hours per day, a few days per week, and is commonly unpotable without further treatment. Only a fortunate few residents can expect to turn a tap in their homes and receive a flow of water ready to drink. Many in the region routinely buy bottled water for drinking and food preparation; but for many others, that luxury is not an option due to lack of funds and/or local availability of bottled water, especially on the smaller, more remote islands.

Islands vary in their freshwater resources. Atoll islands – narrow, low-lying strips of coral rubble marking remnants of the rims of long-submerged volcanoes – are particularly freshwater stressed. Their hydrogeology limits their fresh groundwater to thin, shallow 'lenses' that can be easily contaminated by wastes and/or salinized by oceanic over-wash. Surface freshwater sources are virtually non-existent on these islands whose highest elevations are usually just a few meters. Especially in the face of rising sea levels, residents of atoll islands are heavily dependent on rainwater catchment systems (RWCSs).

Residents of high islands – where remnants of a volcanic cone rises hundreds or even a few thousands of meters from the sea – in contrast, often have surface freshwater sources such as ponds, rivers, streams, or springs, in addition to more substantial groundwater in thicker lenses and aquifers. Even in these better-supplied locales, however, fresh water for drinking is a limited resource, with river or stream flow often varying in synchrony with rainfall (whose patterns are increasingly erratic, with more extensive droughts becoming ever-more common), coastal freshwater lenses subject to contamination and salinization, and limited surface water sources easily polluted. On these islands, many residents rely on RWCSs and/or surface water.

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So for many residents of small Pacific islands, collecting and storing drinking water from rain or local surface sources is an ongoing individual, family, and/or community task. Both surface water and rainwater are subject to microbial (viral, bacterial, fungal, protozoan, etc.) contamination if in contact with organic debris. Besides salt, such microorganisms are the major contaminants of freshwater in Pacific islands, while metal, mineral, pesticide, or other chemical contamination are generally much less of an issue. Many such microbes can induce illness. Processes for ridding water of such 'bugs,' therefore, are critically important for maintaining the health of residents across the region.

Both geographic isolation and limited technical support capacities constrain the use of reverse osmosis and ultraviolet (UV) light decontamination systems on small remote islands. These technologically sophisticated systems are appropriate only where and when replacement parts can be obtained reasonably quickly and trained, knowledgeable personnel are available; neither circumstance is common across much of the Pacific Ocean expanse.

Various less technologically sophisticated options for decontamination, all coming with certain costs and benefits, are well known. Boiling water, for example, is not particularly technologically challenging but entails investments of time and considerable energy resources, rendering this a somewhat costly method. Simply placing a bottle of water in direct sunlight for a number of hours will, though heating and UV exposure, kill the vast majority of microbes; this method is difficult to scale up, and its efficacy depends heavily on strong, direct sunlight.

The use of iodine crystals, on the other hand, is relatively simple and not time or energy-intensive, but (a) such crystals are not always available, (b) this method is unsuitable for pregnant women due to potential maternal-fetal health issues, and (c) the aftertaste of iodine is unpalatable to many. Chlorine tends to be more readily available than iodine, but brings with it issues of taste; furthermore, as chlorine volatilizes readily, its protection is transient and thus achieving the proper dosage (enough to kill microbes but not enough to taste) and timing (enough time for it to take effect, but not so much that the antimicrobial effects wane) is problematic.

The antimicrobial use of silver has been long recognized. Recently, however, a broadly practical decontamination process based on silver's lethality to microbes has been developed. MadiDrops are silver-infused, porous ceramic cakes that, placed in a five-gallon water dispenser, will knock out virtually all microbes overnight. A single MadiDrop[2] can be used daily for a year, decontaminating more than 1,500 gallons of water. This technology hits a 'sweet spot' for isolated small Pacific islands, inexpensive and requiring neither replacement parts nor technological sophistication nor electrical power.

Filtering is another traditional option for microbial decontamination. The technologies for filtering out microbes are changing rapidly, with rising effectiveness and decreasing costs. Examples of three relatively new simple microbial filters suitable for application on small Pacific islands follow:

1) Folia Water[3] makes coffee-filter type filters infused with silver nanoparticles that come with a screw-on filter holder, enabling simple decontamination and filtering of a half-gallon of water in about 10 minutes. Each filter can provide a week of germ-free water for a family.
2) Aqus filters[4]. are an inexpensive, multi-layered filter based on progressively finer and finer nanofibers. These small, simple devices can filter up >300 gallons per day and remove bacteria, fungi, and most other microbes (except viruses).
3) Life Straw[5] - is a straw containing filters, along with decontaminating iodine crystals and carbon.

Emulating the natural water cycle of evaporation to condensation and back, various distillation technologies enable the extraction of freshwater from seawater. While basic passive solar distillation is a very simple, low technology process, it is typically quite inefficient, limiting its usefulness. Many commercial distillation devices, on the other hand, are technologically complex, requiring specific replacement parts, and so are unsuitable for use in remote small islands. One notable exception is a new company, Sunny Clean Water[6], that has recently developed an extremely efficient process to obtain about five gallons of fresh water per day from a one-square-meter device; these stills are being field-tested, and show considerable promise for availability in the near future. Their relative simplicity suggests ready application in remote island locales.

Finally, technologies are being developed to extract and condense water vapor directly from the air. A company called Zero Mass Water has already commercialized a system melding state-of-the-art nano-structured materials together with a solar panel to produce a device that extracts and condenses water from the humidity in the air. However, the sophistication and need for special parts makes this option less useful for remote small-island sites. On the emerging front in this realm, however, a group of researchers at Penn State University have recently developed a "slippery rough surface"[7] whose nano-scaled textured surface is particularly efficient at passively condensing water vapor from air; prototype devices harvest 30 gallons per day per square meter of surface. At some point in the not-too distant future, this might well lead to a broadly usable simple system requiring little technological sophistication that could meet drinking water needs on small Pacific islands.

Particularly with rising sea levels and the more frequent and extended droughts that accompany climate change, accessing adequate quantities of potable water on small Pacific islands is an increasing challenge. However, appropriate innovative technologies are helping meet this challenge, and are offering new ways for residents of these remote sites to enhance their drinking water security, resiliency, and self-sufficiency.

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