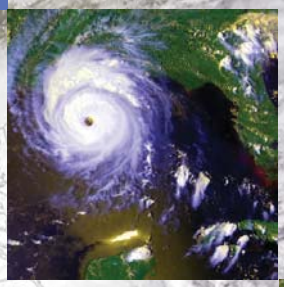
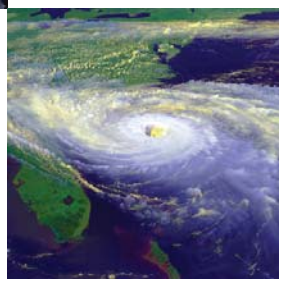


NASA satellite images



Assuring Water Quality in the Eye of a Hurricane

By Kelly A. Reynolds, MSPH, Ph.D.

This year's hurricane season hit hard, resulting in substantial property damage and loss of life. According to the Department of Health and Human Services at the Centers for Disease Control and Prevention (CDC) the vast majority of injuries during a hurricane are caused by flying glass or debris, but hurricanes impact all of life's basic necessities, including food, water and shelter.[1] During such environmental emergencies, many questions circulate in the water treatment industry regarding tap water quality, boil water advisories and the efficacy of point-of-use systems for water treatment.

Toxic floodwaters

During times of heavy rainfall and flooding, such as that experienced by Florida and other U.S. states and cities impacted by this year's hurricane season, water treatment plants may not be operating to their optimal capacity, if at all. Storm damage and flooding can lead to contamination of water distribution lines, groundwater wells, household surfaces and food products. Floodwaters may contain a variety of contaminants from overflowing sewage systems and agricultural or industrial wastes and are generally assumed to be plagued with microbial pathogens and chemical toxins. Therefore, anything that has been in contact with floodwaters needs to be cleaned and sanitized. Non-porous surfaces and children's toys can be disinfected with a dilute bleach solution, however porous materials may have to be discarded if they cannot be effectively decontaminated.

Reducing health risks associated with contaminated drinking water supplies requires consideration of how that water is used not only for drinking (including ice consumption) but also for cooking, produce cleaning and food preparation, dishwashing, hand washing and other personal hygiene uses such as brushing teeth and showering. According to the U.S. Environmental Protection Agency (USEPA), drinking water wells more than 10 years old or less than 50 feet deep are likely to be contaminated during a flood event.[2] Therefore, private drinking water wells should be disinfected followed by bacteriological testing. Swimming pools and hot tubs may also need additional treatment to achieve safe disinfectant residuals.

Boil water advisory and boil water alert

Thousands of boil water advisories are issued each year in the United States. Generally, they are precautionary measures in the event that the water supply might have been contaminated following a known pipe breakage and repair, or a noted pressure drop. Pressure drops in the system are indicative of a compromise in product delivery in the distribution system. A decrease in chlorine residual is also a cause for issuing a boil water advisory. Typically, advisories remain in effect until the water can be tested for bacterial contamination, which generally requires an additional 24 hours.

A boil water notice differs from an advisory in that there is a known contamination event where the water is shown to be microbiologically compromised. Boil water alerts are issued when the monitored water system exceeds national standards for coliform bacteria, used as indicators of treatment efficacy or fecal contamination. Standards may be exceeded either as an acute spike in bacterial populations or as a preponderance of positive samples.

In a potential emergency situation, like the recent hurricanes, a boil water advisory would likely be issued prior to the storm. This is a precautionary measure in case communication channels are

compromised during the storm where public notices would not reach affected individuals. After subsequent testing, the advisory would either be lifted (no evidence of contamination) or changed to a notice (coliform bacteria present at levels above federal or state standards) until treatment could be rendered.

Whether an advisory or an alert is issued, any water used for drinking or cooking should be treated to be sure it is safe. There are a variety of options available for treating contaminated water. Treatment of water found to be biologically contaminated should include the purging of household faucets, coolers and ice from ice machines after the alert is lifted and before resuming use. Likewise, most point-of-use (POU) water treatment devices should be serviced and thoroughly sanitized before resuming use.

Emergency water treatment options

To prepare for the possible event of an emergency, it is advisable to store supplies for treating water, such as equipment for boiling or chlorine or iodine tablets (Table 1). Because the effectiveness of chemical water treatment is related to temperature, pH and turbidity of the water, boiling is often the most foolproof method and recommended under the broadest range of conditions. In addition, boiling is effective against viruses, bacteria and protozoa, but protozoa are not killed by common chemical treatment options (i.e., chlorine or iodine).

But, what if you are unable to boil the water? What if the water is from a highly turbid source, which reduces the efficacy of chemical treatments? In extreme conditions, crude methods of filtration, using common household supplies such as newspaper, filter paper, gauze and cotton cloth, may also help to reduce pathogen transmission. Research shows that this method, along with chlorine treatment can produce an emergency potable water source from snow or rain[3].

POU treatment instead of boiling?

We know that a variety of common events as well as natural disasters can compromise drinking water systems and that boiling water offers a simple and certain means to protect consumers against biologically tainted water. What is less certain is the ability of POU treatment systems to substitute for boiled or chemically treated water.

In the case of minor intrusion events, decreased chlorine residual, or possible low level microbial contamination, POU systems designed for the removal of viruses, bacteria and protozoa are effective safeguards and have been recommended by the EPA and CDC for additional protection for immunocompromised populations. Not all systems, however, are designed for removal of all the aforementioned groups of organisms. In fact, the majority of consumers that opt for additional treatment at the tap utilize equipment designed for improving the taste and odor of the water, not removing microbial pathogens.

Table 1. Procedures for emergency disinfection of drinking water

Boiling	Vigorous boiling for three minutes will kill any waterborne pathogen (most are killed after only one minute).
Chlorine treatment	Check label of common household bleach (5.25 percent sodium hypochlorite) for instructions or add 1/8 teaspoon of household bleach per gallon of clear water. Double amount if water is cloudy. Mix and wait 30 minutes.
Iodine treatment	Common household iodine (2 percent U.S.P.) may be added using five drops per quart of clear water or 10 drops for cloudy water. Mix and wait at least 30 minutes.

NOTE: Commercial chlorine and iodine tablets are also available at drug and sporting goods stores. Follow manufacturer's instructions.

Many systems on the market are not certified for cyst (i.e., protozoan) removal or the elimination of other microbial pathogens.

Knowledge about your POU device capabilities is essential, but even with systems designed for removal of microbes, there are still uncertainties. In emergency situations, it is unlikely that consumers will have knowledge of their source water quality characteristics. Other uncertainties with equipment design, filter life capacity, etc. make it nearly impossible to determine the expected efficacy of the unit in an unusually taxing scenario. During floods, hurricanes or other disasters, the quality of the water may dramatically change, altering the efficacy of POU treatment device.

Recognizing the water purification needs of governmental, industrial and consumer groups, the EPA developed the "Guide Standard and Protocol for Testing Microbiological Water Purifiers."[4] The protocol was designed for determining the ability of POU devices to purify waters of unknown quality, by setting up worse case scenario waters (i.e., high turbidity and variable pH values) and heavy contaminant loads of bacteria, viruses and protozoa. Units were also subjected to a variety of stagnation periods. POU devices that passed the test could be recommended for backpackers and military field personnel and would be useful for some foreign travelers and under emergency flooding events or other natural disasters. The protocol proved to be highly stringent, however, allowing only a few POU units to pass.

Only units claiming to remove pathogens or inhibit growth of microorganisms, that contain regulated contaminants (i.e., iodine, silver, etc.) are required to register the product with the EPA, however, such a registration does not imply EPA approval or the unit's ability to achieve it's stated purpose. Manufacturers can voluntarily seek independent, third-party testing (i.e., from WQA, www.wqa.org; NSF, www.nsf.org; BioVir Laboratories, www.biovir.com) of their product to evaluate performance claims, including EPA Guide Standard and Protocol testing. Products with NSF certification (for a complete list, contact NSF) have met a specific set of standards. However, these standards do not take into account worse case (i.e., emergency) water conditions.

Better safe than sorry

Ultimately, it is best to boil your water in accordance with a boil water alert whether you have a POU system in place or not. Determining the theoretical life of a filter or POU system is difficult given the uncertainties of the source water quality and the characteristics of the water supply. Boiling, on the other hand, provides a simple and certain means for eliminating harmful microbes from the water supply.

References

1. CDC. Hurricanes and Your Health and Safety. Department of Health and Human Services. September 10, 2004.
2. USEPA. What to do after the flood. www.epa/safewater/privatewells/whatdo.html. July 29, 2004.

3. Kozlicic, A., et al. 1994. Improvised purification methods for obtaining individual drinking water supply under war and extreme shortage conditions. Prehospital Disaster Med. 9:S25-8.

4. USEPA. Pesticide Program Guide Standard and Protocol for Testing Microbiological Water Filters. Federal Register, Vol. 52, No. 133, May 26, 1986.

About the author

Dr. Kelly A. Reynolds is a research scientist at the University of Arizona with a focus on development of rapid methods for detecting human pathogenic viruses in drinking water. She holds a master of science degree in public health (MSPH) from the University of South Florida and doctorate in microbiology from the University of Arizona. Reynolds has also been a member of the WC&P Technical Review Committee since 1997.

Since 1995, SANDEC has promoted SODIS in developing countries where boiling water is often not an option. SANDEC is the Department of Water and Sanitation in Developing Countries at the Swiss Federal Institute for Environmental Science and Technology (EAWAG) in Duebendorf, Switzerland. Its activities center on problems of sustainable development in economically less developed countries. Its mandate is to assist in developing appropriate and sustainable water and sanitation concepts and technologies adapted to the different physical and socioeconomic conditions prevailing in developing countries.

Key factors of SODIS application

The Solar Water Disinfection (SODIS) process is a simple technology used to improve the microbiological quality of drinking water. SODIS uses solar radiation to destroy pathogenic microorganisms which cause water borne diseases. Contaminated water is filled into transparent plastic bottles and exposed to full sunlight for six hours.

Weather and Climate

SODIS requires sun radiation and temperature:

- The container needs to be exposed to the sun for 6 hours if the sky is bright or up to 50% cloudy
- The container needs to be exposed to the sun for 2 consecutive days if the sky is 100% cloudy,
- During days of continuous rainfall, SODIS does not perform satisfactorily. Rainwater harvesting is recommended during these days.
- If a water temperature of at least 50°C is reached, an exposure time of 1 hour is sufficient
- The most favourable region for SODIS lies between latitudes 15°N/ S and 35°N/ S. These semi-arid regions are characterized by high solar radiation and limited cloud coverage and rainfall (3000 hours sunshine per year). The second most favourable region lies between the equator and latitude 15°N/ S, the scattered radiation in this region is quite high (2500 hours sunshine per year).

Water Turbidity

- Suspended particles in the water reduce the penetration of solar radiation into the water and protect microorganisms from being irradiated.
- SODIS requires relatively clear water with a turbidity less than 30 NTU.
- In water with higher turbidity than 30 NTU pathogens will have to be inactivated by the temperature rather than radiation (>50°C for at least an hour) or the water has to be filtered before being exposed to the sun.
- Water Turbidity Test: place the bottle, full with water, on the SODIS logo on top of a table in the shade and look through the bottle from top to bottom. Water turbidity is less than 30 NTU, if you can read the letters of the SODIS logo through the water.

Material and Shape of the Containers

- Various types of transparent plastic materials are good transmitters of light in the UV and visible range of the solar spectrum. Bottles made from PET (PolyEthylene Terephtalate) are preferred as they contain less UV-stabilisators than PVC (PolyVinylChloride) bottles.
- Glass: Also glass bottles can be used for SODIS. But it is not possible to construct shallow, large containers using ordinary window glass, as window glass does not transmit UV-radiation adequately.
- Ageing of plastic bottles (due to mechanical scratches and due to photoproducts) leads to a reduction of UV transmittance which will reduce the efficiency of SODIS. Heavily scratched or old, blind bottles should be replaced.
- Photoproducts: Sunlight does not only destroy pathogenic microorganisms found in the water but also transforms the plastic material into photoproducts. Laboratory and field tests showed that these photoproducts are generated at the outer surface of the bottles. No migration of photoproducts or additives (UV-stabilisators) into the water was observed.
- Migration of organic compounds: the migration of organic compounds from reused and new PET bottles into the water was examined by a team of researchers from the EMPA (Swiss Federal Laboratories for Materials Testing and Research). Adipate and phtalate such as DEHA and DEHP were detected in very low concentrations—the level of concentrations found in the water of reused and new PET bottles were in the same magnitude as the concentrations of phtalate and adipate generally found in high quality tap water.

Oxygen

- SODIS is more efficient in water containing high levels of oxygen: Sunlight produces highly reactive forms of oxygen (oxygen free radicals and hydrogen peroxides) in the water. These reactive forms of oxygen kill the microorganisms.
- Aeration of the water can be achieved by shaking the 3/4 filled containers for about 20 seconds before they are filled completely.

Limitations of SODIS

- SODIS does not change the chemical water quality
- SODIS requires relatively clear water (turbidity less than 30 NTU)
- SODIS requires suitable weather conditions
- SODIS is not useful to treat large volumes of water

To view the original chart and for technical notes and additional information, visit www.sodis.ch/Text2002/T-Howdoesitwork.htm