HOW CAN IUVA HELP SMALL WATER SYSTEMS?

JAMES P. MALLEY, JR.

Environmental Research Group, University of New Hampshire, Room 344 Gregg Hall, 5 Colovos Road, Durham, NH 03824-3591; E-Mail: jim.malley@unh.edu.

Note from the Editor: This article comes from the plenary presentation made by Jim Malley at the UV Congress in Whistler, BC, Canada in May 2005.

ABSTRACT

Often our attention is captured by very large environmental challenges such as providing billions of gallons per day of clean, safe drinking water for very large cities. However, the larger global public health challenge often lies with the small systems. Conservative estimates suggest that the lives of 2.5 billion people worldwide (the population of roughly 300 New York Cities) could be dramatically improved if organizations like the IUVA could provide technical knowledge and support to improve the applications of UV disinfection to small and very small water systems around the world.

The article provides an overview of the numbers and types of small systems including Point of Entry and Point of Use systems and reviews the challenges faced by small systems. A successful case study of using UV to improve small system water quality is also presented. The article closes with suggestions for how IUVA can proceed to help Small Systems worldwide with the long term goal of improving the lives of billions of people.

Ultraviolet (UV) disinfection has been applied to small systems for several decades and has attracted scores of small, medium and large companies supplying this market. This article is aimed at defining what is meant by a "small system", how is this market addressed and regulated and where is it going.

SMALL SYSTEMS – WHERE HAVE WE BEEN?

The USEPA (2005) has defined size categories for drinking water treatment systems:

- Very Small Water Systems – serve 25 –500 people
- Small Water Systems – serve 501 –3,300 people
- Medium Water Systems – serve 3,301 –10,000 people
- Large Water Systems – serve 10,001 – 100,000 people
- Very Large Water Systems – serve >100,000 people

Table 1: Analysis of Small and Very Small Water Systems

Region	Number of Systems	Lives Affected (millions)
USA	159,400	122
North America	187,900	175
Globally	1,320,000	2,500

Typical water flow rates for Small Water Systems are 2 – 700 gpm (8 – 2,650 L/min).

As Table 1 shows, Small and Very Small Water Systems affect the lives of about 2.5 billion people annually.

The biggest problem facing small drinking water systems is lack of resources (WHO 2005). There is a scarcity of knowledgeable personnel, time and money (USEPA 2003); furthermore:

- Small System information is plentiful and can be obtained from numerous sources, but the Small System has no personnel to collect or download that information and no time to make sense of it.
- There can be a very high degree of misinformation, ignorance and apathy in small systems ("nothing wrong with our water"; "leave us alone"; "requiring treatment is just a money making scheme and is no benefit").
- Small System infrastructure is heterogeneous, often low quality when purchased and not maintained until total system failure.
- Finally, Small Systems often have severe space constraints for locating any treatment (Klevens 2005).

Figure 1 illustrates that often Small Systems also face space constraints.

Figure 1: Illustration of the tight quarters in a Small Water System in New Hampshire (photo courtesy of Cynthia Klevens, New Hampshire Department of Environmental Services).

WHY MIGHT ULTRAVIOLET TECHNOLOGY BE SO HELPFUL TO SMALL SYSTEMS?

Ultraviolet disinfection systems have many advantages for Small Water Systems:

- Compact
- Chemical free
- Essentially operator free (plug and play)
- Relatively easy to maintain
- Minimal moving parts
- Relatively easy to monitor lamp output
- Relatively inexpensive
- A well developed point-of-entry (POE) and point-of-use (POU) product

The only regulations concerning UV disinfection systems for Small Water Systems are those developed by the National Sanitation Foundation (NSF International) in their NSF Standard 55 (Lubitz 2005). In that standard, Point-of-entry (POE) systems are defined as (See Figure 2):

> *A system used to treat all or part of the water for the facility at the point where drinking water comes into the facility. For Class A systems, a single family shall be considered a facility.*

Point-of-use (POU) systems are defined as:

> *A system used to treat water at a single tap or multi-taps but not for the entire facility.*

SMALL SYSTEM UV PROBLEMS

UV disinfection systems are sometimes manufactured by small companies with little expertise. The buyers of these systems are often given few instructions on how to operate the units and do not understand the need for maintenance. Finally, there is the lack of regulations for small UV systems in most jurisdictions. This has led to many problems:

- Hundreds of small UV systems have been installed without any water quality information; for example, percent transmittances (UVT) values <10% and turbidities >NTU.
- Thousands of UV systems have been installed without any method to control flow; for example, a 2 gpm unit being operated at 10 gpm.
- UV systems have been operated with lamps down to 10% of their new output, completely burned out or just turned off!
- UV Systems have been installed without any sensor or even a means to determine if the UV lamp is on.
- UV reactors have been found operating filled with mud/sediments that are covering the lamps.
- UV sensors have been found reading 100% all the time, even when the lamp is removed from the reactor.

Then there is outright fraud and rip-offs:

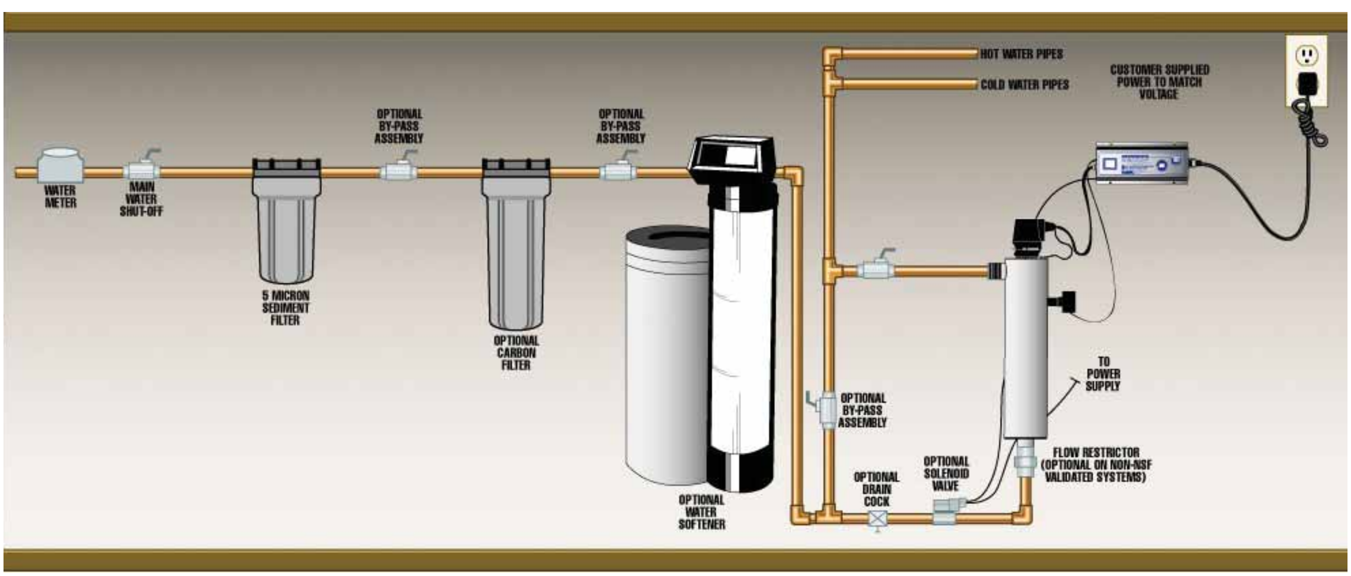

Figure 2: Example of a Point-of-Entry UV systems (diagram courtesy of Melissa Lubitz of R-Can Environmental, Inc. Guelph, ON, Canada).

- No UV lamp in the system at all
- No germicidal lamp "black light" in the system
- No power supply – sometimes not even a plug
- UV Lamps installed without sleeves

HOW CAN IUVA HELP SMALL SYSTEMS?

IUVA has the key resource – dedicated volunteer personnel with large amounts of UV technology experience. IUVA has the ability to provide outreach and help with the education and to answer questions posed by small system personnel. It is true that "no one has the time", but when dedicated volunteers decide the cause is worth doing they make the time.

WHERE DOES IUVA GO FROM HERE?

Plans began in 2004 to establish the "IUVA Small Systems Topical Group". In the past year the group has provided:

- educational seminars to three rural water associations in the US
- an educational seminar at the Water Quality Association (WQA) Annual Meeting in March-April 2005.

The goal should be to double the Group's Activities during this next year. IUVA experts can help Small Systems with the selection, design, and operation of UV disinfection units.

ONE EXAMPLE OF HELPING A SMALL SYSTEM

As reported in a study by Protasowicki and Malley (2002), the town of Norfolk is a semi-rural suburban community located on an upper valley of the Charles River about 20 miles southwest of Boston, MA. Norfolk is supplied by groundwater pumped from two wells – the Gold Street Well and the Spruce Road Well. Both wells draw from the Charles River watershed. Spruce Road is Norfolk's primary water supply and is typically operated at 500 gpm with a maximum flow of 600 gpm and the total annual water production in 2003 was 197 million gallons (~2,800 people served).

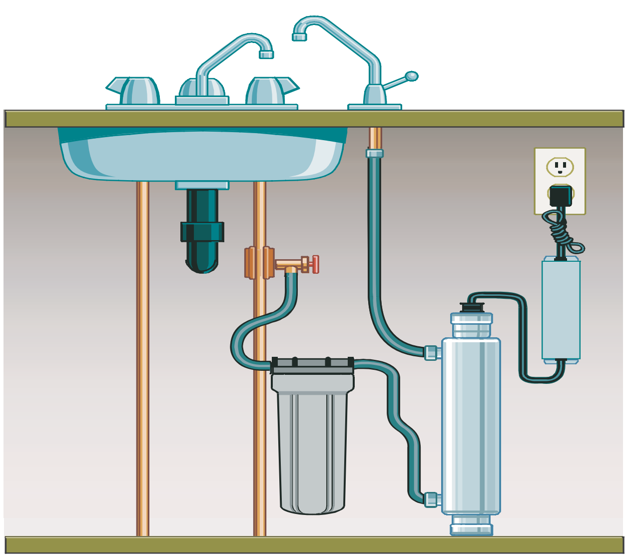

Figure 3: Example of a Point-of-Use (POU) UV System (diagram courtesy of Melissa Lubitz of R-Can Environmental, Inc. Guelph, ON, Canada).

High copper levels in 1999-2000 prompted Massachusetts Department of Environmental Protection (MADEP) to issue a State Administrative Consent Order requiring Norfolk to optimize its corrosion control measures. Norfolk hired Dufresne-Henry to evaluate alternatives and recommend optimization for the Spruce Road Well. Dufresne-Henry recommended venturi aeration to drive off CO_2 and augment the existing KOH feed system. Since aeration represents a break in the hydraulics and potential for microbial contamination, it was also recommended that UV disinfection be implemented following the venturi system.

The MADEP indicated that both venturi aeration and UV disinfection represented innovative technologies and required a pilot study prior to approval to proceed with full scale design. Dufresne-Henry performed the venturi aeration pilot work and worked with the University of New Hampshire (UNH) to perform the UV disinfection pilot study simultaneously. Figure 4 shows the setup for the UNH pilot study.

Pilot Testing

The pilot testing was conducted at 2 to 10 gpm. In the parallel venturi pilot study, the aeration system was monitored for changes in pH and dissolved oxygen of the water as well as mechanical and operational reliability.

The UV system was run at a delivered UV Dose of 60 mJ/cm^2 to be consistent with another state approved groundwater UV disinfection system (Westford, MA). The UV system was monitored for:

- Changes in groundwater quality tastes and odors (TAO), UVT.
- Sensor window and sleeve fouling rate
- UV lamp sensor response
- Bacterial inactivation
- Mechanical and operational reliability
- Delivered UV Dose

The venturi aeration system provided reliable and cost effective removal of CO_2 raising the pH to neutral values while attaining dissolved oxygen saturation of the water. The UV pilot demonstrated:

- Reliable operation with no detectable changes in the taste, odor and color of the water;
- Consistent and stable power and UV lamp output;
- Minimal UV sleeve and quartz window fouling rate;
- Consistently high influent UVT values;
- UV effluent bacterial counts of 0/100 mL throughout;

The Full-scale Facility

Based on the pilot testing results the MADEP approved the full-scale design of venturi aeration and UV disinfection for Norfolk's Spruce Road Well facility. The Spruce Road Treatment Facility was retrofit with dual pressurized Venturi aerators and a Wedeco-Ideal Horizons LPHO Series B300 UV Reactor at maximum flow rate of 600 gpm to deliver a UV dose of 60 mJ/cm^2 at end of lamp life at a minimum %UVT of 95%. Figure 5 shows the installed UV reactor.

The full-scale facility upgrade also included:

- A new generator to provide backup power
- An upgraded instrumentation and control system
- New internal and external facility security systems
- Improved facility piping and access

The MADEP required that the UV System be validated. Thus an onsite full-scale UV system validation, using protocols consistent with the USEPA UV Disinfection Guidance Manual, was performed by UNH using the MS-2 bacteriophage virus. The UV System passed validation and has been in operation since 2003.

Cost and Financing

The Project capital cost was about $1.00 per gallon per day of capacity ($720,000). The Project operation and maintenance costs are $0.04 per 1,000 gallons treated. Finally, financing was achieved through a zero interest loan from the State Safe Drinking Water Act Revolving Loan Fund.

A Real Winner

Norfolk's New Water Treatment Facility using innovative technologies to control corrosion and to provide disinfection received the 2003 American Consulting Engineer's Council – Massachusetts Chapters' Engineering Excellence Platinum Award.

WHERE DOES IUVA GO FROM HERE TO HELP SMALL SYSTEMS?

Many organizations have been concerned with and are attempting to help small systems worldwide. The issue presents very large challenges from among technical, social and geopolitical aspects. Clearly, the issues of assisting small and very small systems in North American and in most of what is commonly referred to as the developed nations is very, very different than addressing issues in third world countries. Here are just a few initial ideas on how IUVA can proceed:

- A Small Systems Hotline or Website?
- Dedicated and motivated volunteers from IUVA to assist small systems directly
- Outreach to colleagues in academia and in businesses in third world nations to promote the development and use of UV systems at the local level
- We have established the beginning of a Small System Topical Group which is open to all IUVA Members – everyone can play if you are interested, and can make the time please contact Jim Malley at **jim.malley@unh.edu**.
- 2.5 billion people are waiting for your help !

Figure 4: Setup for the UV disinfection pilot study at Norfolk, MA .

Figure 5: Wedeco – Ideal Horizons UV reactor installed at the Norfolk Spruce Road Well facility.

ACKNOWLEDGEMENTS

I wish to thank my UNH UV Research Assistants: Jen Wagler, Jim Ropp, Jeff Shaw, Evan Griffiths, Greg Snicer, Annette Doucette, Bryan Townsend, Laurel Passantino, Craig Douglas, Steven Farabaugh, David Gaithuma, Nicola Ballester and James Collins. Rich Protasowicki of Wright-Pierce Engineers, Andover, MA, Melissa Lubitz of RCan Environmental, Guelph, Ontario and Cynthia Klevens of NH Department of Environmental Services, Concord, NH for providing information and illustrations for this article. Funding for this plenary session paper was provided by the UNH Electrotechnology Research Program and the UNH USEPA Water Treatment Technology Assistance Center.

REFERENCES

Klevens, C.M. 2005. Surface Water UV Applications, Proceedings of WQA-Aquatech The International Exhibition and Conference on Water Technology, Las Vegas, Nevada, March 29 – April 2, 2005.

Lubitz, M. 2005. Drinking Water Regulations & Their Impacts on Small Systems. Proceedings of WQA-Aquatech The International Exhibition and Conference on Water Technology, Las Vegas, Nevada, March 29 – April 2, 2005.

Protasowicki, R.G. and Malley, J.P. 2002. UV Treatment of a Groundwater Supply – From Piloting to Start-up Experience in the Town of Norfolk, MA, IUVA News, 4(3): 4-7.

U.S. Environmental Protection Agency. 2005. Small Drinking Water Systems – Small Systems and Capacity Development, **www.epa.gov/safewater/smallsys.html**.

U.S. Environmental Protection Agency. 2003. Small Drinking Water Systems Handbook A Guide to "Packaged" Filtration and Disinfection Technologies, Report No. EPA 600/R-03/041, Cincinnati, OH, May 2003.

World Health Organization. 2005. Health Topics – Drinking Water, **www.who.int/topics/drinking_water/en**.