IUVANews

Vol. 18, Issue 2 · Summer 2016

UV Treatment of Ballast Water

Status of EPA Development of Water Quality Criteria

UV's Role in Meeting Pathogen, Pollutant Targets

Official Publication of the International Ultraviolet Association


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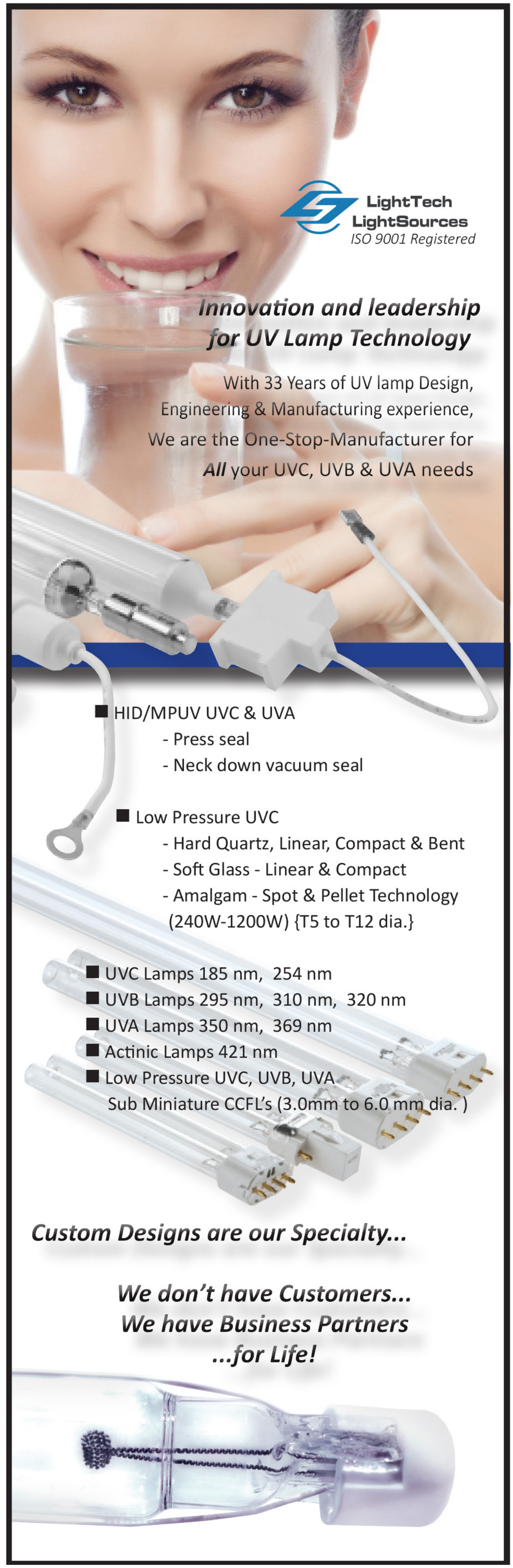
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Kati Bell

A Message
from the IUVA President

Summer has arrived, and since our last *IUVA News*, our members have organized and executed some very exciting activities. First, a special thanks to Dr. Kumiko Ogama, the IUVA Japan vice president, and Dr. Karl Linden, immediate past-president, for organizing our first-ever event in Japan on April 22. With the theme of *UV Innovations: Towards Sustainable Water Use*, the full-day symposium drew an impressive crowd to the University of Tokyo, expanding the geographic reach of the IUVA. Read the rest of *IUVA News* for more information on this successful event. In May, IUVA supported and organized a half-day workshop on "All You Ever Wanted to Know (and More) About UV-C LEDs and Applications," in conjunction with the RadTech Global Conference & Exhibition for UV+EB Curing Technology, held in Chicago, Illinois, May 15-18. The RadTech event boasted over 30 presentations on UV-LEDs, which is a topic of growing interest with recent advances in technology. We would like to offer a big thanks to Oliver Lawal for his leadership in organizing this event and for broadening our scope and helping the IUVA stretch into new areas.

Coming up later this year, Dr. Jamal Awad has organized a special workshop in conjunction with the WateReuse Association at its annual event with the theme of UV applications in reuse. More information on the event is available at https://watereuse.org/news-events/conferences/annual-watereuse-symposium/. In September, IUVA will have a booth at the Water Environment Federation Technical Exhibition & Conference (WEFTEC) in New Orleans, Louisiana, and we are looking for volunteers to help man the booth. If you are interested in volunteering a few hours to increase IUVA's visibility in the wastewater industry, please contact Gary Cohen or Jamal Awad (gcohen@iuva.org or jamal.awad@ghd.com) with your contact information and dates and times of availability.

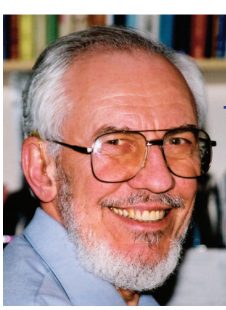
We also have set the date for a 2017 Americas conference for Feb. 5-7 in Austin, Texas. The call for abstracts will be out around the time of this issue of *IUVA News*, so mark your calendars. More details will be provided on the IUVA website in the coming weeks.

While there are always fun and exciting things happening in IUVA, there are also technical issues and regulatory challenges that arise in the UV industry. One of the important functions of our organization is to provide a forum to address issues that potentially have a significant impact on the application of UV. One such example is the EPA's ongoing development of a new ambient water quality criteria for viruses, based on bacteriophage. I have contributed an article in this issue of *IUVA News* with an update of the project progress and anticipated schedule for publication.

It was recently brought forward that now is the time for the scientific community to come together and help promote a data-driven approach based on good science. We, as an organization, have an opportunity to participate with the broader wastewater community to support a meaningful scientific approach to addressing the concerns that have been brought forward by the UV community. Please contact either myself at kati.bell@mwhglobal.com or Dr. Linda Gowman, the rechnical committee chair, at lgowman@trojantechnologies.com to discuss opportunities for providing input into the broader industry effort.

In the meantime, go enjoy the summer – and be sure to protect yourself from those UV-A and UV-B rays!

Kati Bell, IUVA President
Water Reuse Practice Leader at MWH Global



Jim Bolton

A Message
from the Editor-In-Chief

The articles in this issue come from the very successful Sunday workshop, "Proposed Changes in International Regulations and their Potential Impacts on Disinfection Practices," which was held at the World Congress in Vancouver earlier this year. I know you will enjoy the articles.

Looking ahead, the fall 2016 issue will feature an update of the 2006 review of the UV sensitivities of microorganisms, a look at the UV AOT treatment of taste and odor compounds, as well as a customer's account of experiences in installing and monitoring a UV wastewater treatment system. Additionally, the fall issue will explore minimizing collimated beam errors.

IUVA News is your quarterly ultraviolet magazine, so please take some time to read it through, and don't forget the ads. The ads make it possible to publish *IUVA News*, so please support our advertisers by clicking through to their websites or contacting them for further information. If you are a marketing manager in a UV company, I encourage you to advertise in *IUVA News*. You will not only attract direct sales but also enhance your image in the UV community. Send me an email at editorinchief@iuva.org, and I'll send you the *IUVA News* Media Kit. Also note that *IUVA News* publishes short Application Notes highlighting novel and ground-breaking applications of a UV company's technology.

WateReuse, Sept. 11-14, Tampa, Fla.
An IUVA workshop has been scheduled. To learn more, visit www.watereuse.org.

WEFTEC, Sept. 25-28, New Orleans
Visit IUVA at booth 1209. For more, go to www.weftec.org.

Confluence, Nov. 9, Cincinnati area
Details on this event are being finalized. To learn more about Confluence, visit www.watercluster.org/wordpress.

IUVA Americas, early 2017
The call for papers is available. Visit www.iuva.org.

World Congress Regulatory Workshop: An Introduction

Linda Gowman[1, 4], Bertrand Dussert[2, 4] and Scott Alpert[3, 4]
[1]Trojan Technologies; [2]Xylem Inc.; [3]Hazen and Sawyer; and
[4]IUVA Regulatory Workshop Organizing Committee

Editor's Note: A workshop titled "Proposed Changes in International Regulations and their Potential Impacts on Disinfection Practices" was held at the IUVA World Congress in Vancouver (Jan. 31, 2016). The information that follows is from that workshop.

Regulations abound in the water space, which is appropriate given the impact of water and water quality on public health and environmental sustainability. Understanding, interpreting and implementing these regulations can be difficult. Requirements and interpretations can vary from one jurisdiction to the next and even from one person to another. The uncertainties can result in challenges with installation, product designs, product testing and demonstrated compliance.

The IUVA has long undertaken efforts to aid interested parties in understanding the many regulations and guidance impacting the appropriate usage of UV technologies. The workshop conducted at the January 2016 World Congress in Vancouver continued that approach.

Titled "Proposed Changes in International Regulations and their Potential Impacts on Disinfection Practices," the workshop covered an overview of the critical nature of international regulations in drinking water, water reuse, the consequences of the potential use of new microbial standards, such as bacteriophage indicators and the opportunities and challenges of bringing UV disinfection to the treatment of ships' ballast water.

The sold-out workshop was well attended by stakeholders across the UV industry, which led to good discussion among participants. The response confirms that the whole UV sector is seeking to find more comprehensive and informed ways of continuing to lead responsibly, in terms of public and environmental health protection while honoring good science, robust technology development and optimal business practices to meet those imperatives.

The audience was in agreement that, through its technical committee and other member-associated activities, the IUVA should continue its role in facilitating technical discussions and educating stakeholders both inside and outside the UV community.

On behalf of IUVA, the organizing committee wishes to thank all of those who attended the workshop and, especially, the speakers for their time and effort in preparing the presentations and the abstracts presented in this issue of *IUVA News*. ■

UV Treatment of Ballast Water: Market, Regulations, Validation Test Methods

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Background

When cargo is unloaded from a ship, ballast water is pumped into onboard ballast tanks in order to keep the ship stable for the journey to another port to take on more cargo. The ballast water that then is discharged as the new cargo is loaded has been implicated in a number of harmful invasions by foreign aquatic species on indigenous ecosystems (aquatic nuisance species).

Two regulations have been promulgated to prevent the transfer of non-indigenous species between marine habitats of the world: the 2004 IMO Ballast Water Management Convention and the 2012 US Coast Guard Standards for Living Organisms in Ships' Ballast Water Discharged in US Waters. When enforced, these regulations will apply to more than 60,000 vessels that carry ballast water between various worldwide ports.

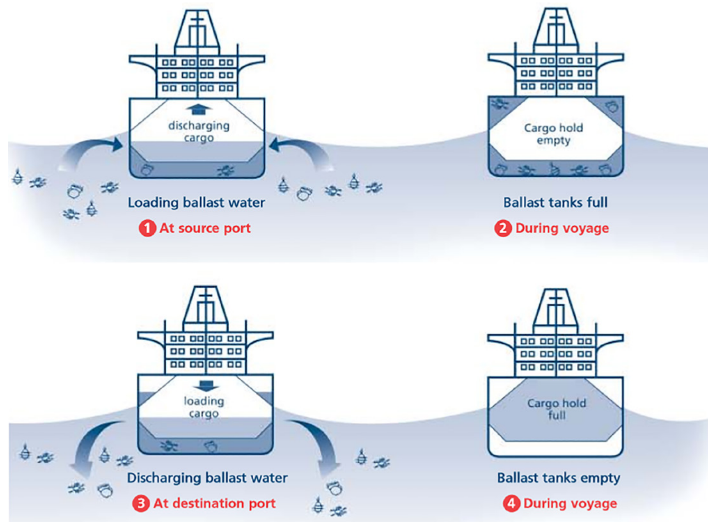

Image 1. Schematic showing potential transfer of aquatic nuisance species from one location to another via ballast water

Regulations

In 2004 the International Maritime Organization (IMO) published the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWMC). The convention is awaiting ratification by the required 30 countries representing at least 35% of the world's shipping gross tonnage in order for it to come into force. Currently there are 51 countries signatory to the convention representing about 34.87% of world tonnage, leaving it 0.13% short of the required tonnage for ratification. The convention will enter into force one year after the tonnage requirement is satisfied.

The United States Coast Guard (USCG) also published its own Final Rule in 2012 for ballast water discharges. The USCG regulations are largely in concert with the IMO BWMC 2004; however, a key difference is the inclusion of specific requirements that any ballast water management system used to treat ballast under the USCG Final Rule is required to be specifically type-approved by the USCG.

The discharge standard

Both the IMO and USCG regulations utilize the same numeric limits for organisms discharged via treated ballast water:

1. Less than 10 organisms per cubic meter greater than 50 microns
2. Less than 10 organisms per mL smaller than 50 microns but greater than 10 microns
3. Sampling of three indicator organisms to prove discharge of no more than:
   - 1 cfu per 100 mL of *Vibrio cholera*
   - 250 cfu per 100 mL of *Escherichia coli*
   - 100 cfu per 100 mL of intestinal enterococci

US ballast water treatment regulations are further complicated by the Environmental Protection Agency's (EPA) Clean Water Act, which is administered via the Vessel General Permit. The USCG and EPA have worked together under a Memorandum of Understanding to develop consistent rules for the discharge of ballast water; however, there are in fact two separate standards to which ship owners must comply.

Disinfection technologies

Ballast Water Management Systems (BWMS) use multiple processes to meet the disinfection standard. Most ballast water treatment technologies utilize a liquid-solid separation technique as a first stage treatment process to remove sediments and larger organisms. Fine mesh screen and disc filters, as well as hydrocyclone separators, typically are employed for this purpose. Coagulation/flocculation also has been used for solids separation.

The second stage of the treatment process can occur by one of several chemical or physical disinfection methods. Chemical disinfection technologies include direct chemical injection, electrochlorination, electrolysis, ozone or any kind of advanced oxidation process. Physical disinfection technologies include UV irradiation, deoxygenation, ultrasonic treatment and cavitation.

Chemical treatment
Chemical treatment technologies can be very effective for ballast water treatment. Chlorine is a well-known disinfectant that can be introduced directly in chemical form or generated on board from sea water.

Some advantages of these treatment systems include generally lower power consumption and residual disinfectants being carried in the ballast tank after initial treatment. Disadvantages of chemical treatment include the handling, storage and cost of replacing toxic chemicals on board and the need to maintain neutralization compounds to ensure discharges are not toxic to the receiving water body.

Other systems generate powerful, but short-lived, disinfecting agents to kill organisms in the ballast water. Electrolysis and AOP systems create short-lived hydroxyl radicals, which are a powerful oxidizing agent. However, many of the same concerns apply as with electrochlorination related to safety and the creation of disinfection by-products. Ozone is another powerful oxidizing agent that has been employed for ballast water treatment.

Physical treatment
Physical treatment processes like cavitation and ultrasound have been used in combination with other treatment technologies but have not yet been employed as standalone technologies. Deoxygenation is an available technology for large tankers where an existing inert gas generator services the ballast tanks in addition to the cargo tanks. Deoxygenation often requires a constant feed of inert gas to the ballast tanks which has the advantage of providing some corrosion protection, but it is expensive to install the piping and PV valves on each ballast tank for existing vessels.

Ultraviolet irradiation
Ultraviolet (UV) irradiation has become the most common treatment technology used for ballast water treatment to date. UV treatment does not create any toxic compounds or change the chemistry of the ballast water, which makes it environmentally neutral and eliminates safety and corrosion risks associated with some chemical treatment technologies.

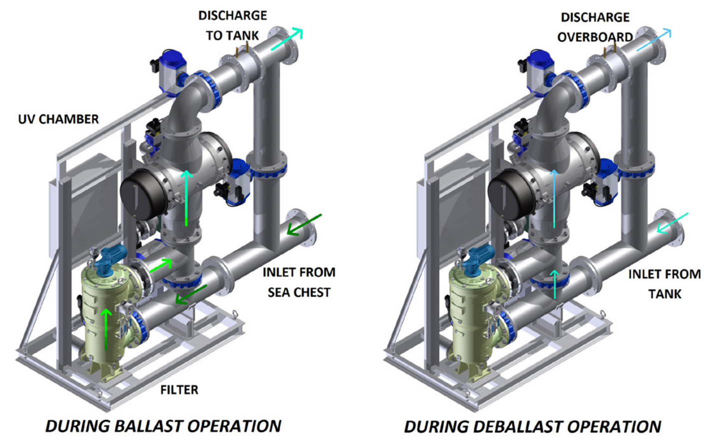

Image 2. Typical UV-based ballast water treatment system

The market
In all, approximately 60,000 vessels will need to be fitted with BWMS over the next 10 years. UV treatment systems make up about 46% of the global sales of ballast water treatment systems to date (roughly 3,000 systems) while electrochlorination and electrolysis systems make up the bulk of the remaining 54%. For retrofit installations, UV treatment systems make up an even larger percentage of global sales to date due to their modular nature and relatively small footprint.

Testing of ballast water treatment systems
Ballast water treatment systems (BWTS) are required to be tested to show they perform to the regulatory requirements. Testing of any equipment for suitability on a ship is called "type approval."

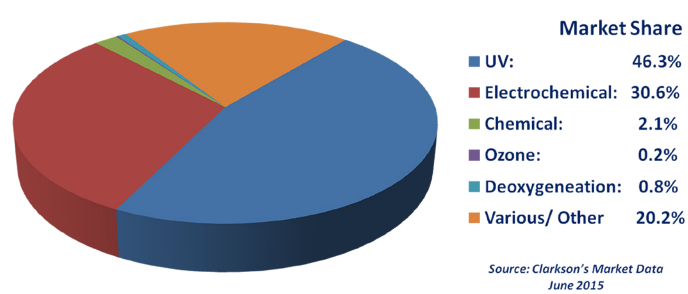

Image 3. Ballast water treatment market share by technology

Type approval
In type approval, representative equipment is tested against a set of standards to demonstrate that it is compliant by design. Typically, the type approval process involves rigorous testing of an example piece of equipment against a set approval standard. In the case of BWTS, this involves the shore-based and shipboard testing of equipment to demonstrate seaworthiness

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and its capability to achieve the discharge standard. In principle, the IMO, USCG and the United States Environmental Protection Agency (EPA) regulations stipulate the same type approval approach to the certification of BWTS.

The main difference between the USCG and IMO regulations is that the USCG requirements for testing are more clearly defined than for the IMO. All testing of BWTS for USCG must be done in accordance with a strict EPA test protocol. Under this protocol the allowed methods for all aspects of the testing are defined – unlike the IMO regulations, where the testing laboratory has some discretion in the test methods used.

The testing of equipment to satisfy the requirements of the US regulations must be conducted by an independent laboratory (IL) that has been approved by the USCG. The IL's responsibility differs significantly from that of a class society in a "traditional" type approval arrangement.

Typically, type approval testing can be combined to conform to both IMO and USCG regulations and consists of:

1. land-based testing
   - five tests at each of three salinities
2. shipboard testing
   - five consecutive successful shipboard runs
3. seaworthiness testing
   - so-called "shake and bake" or environmental testing
   - pressure vessel compliance
   - explosion-proof where necessary (tankers)

Land-based testing

For land-based testing, the natural water is often augmented to ensure it has sufficient organisms of each size class.

Table 1. Inlet and outlet requirements for land-based tests

Size class	Required inlet	Disch. standard
> 50 µm (predominantly zooplankton)	> 100,000 org/m³	< 10 org/m³
10 to 50 µm (predominantly phytoplankton)	> 10,000 org/mL	< 10 org/mL

In addition, suspended solids, dissolved organics and a UV absorber may be added.

The testing consists of five consecutive successful tests at each of three salinities (fresh, brackish and salt) for a total of 15 tests with the treatment requirements shown in Table 1.

For a typical test, water is first pumped into an influent tank where it is augmented as required to meet requirements (the larger tank in Image 4 below). From there it is pumped through the treatment system to a smaller (250 m³) holding tank, where it is held for up to five days to simulate the hold in the ballast tank during a voyage. For UV systems, it then is pumped back through the treatment system bypassing the filter for a second dose of UV before discharge. Samples are taken before treatment.

Image 4. DHI land-based test facility in Denmark

Test methods

The test methods vary by size class.

> 50 µm (zooplankton) test method

The larger (> 50 µm zooplankton) do not reproduce fast enough to be able to practically use a reproductive test. A poke and prod method that tests for mobility is commonly used. Since UV-inactivated heterotrophs are generally motile for up to 72 hours but ultimately die off due to the inability to reproduce, this method is very conservative for UV treatment systems. Large sample incubation where the sample is held for up to five days under ideal growth conditions and the sample monitored over time have been proposed, but this technique would need further research and validation to be accepted by the USCG and most international authorities.

10 to 50 µm (phytoplankton) test method

The US Coast Guard Rule and associated ETV protocol incorporates a vital stain method that tests for the presence of enzymatic activity for phytoplankton. Since UV does not directly impact such cellular activity, this method is not effective in determining inactivation by UV.

A grow-out method employing Most Probable Number (MPN) is being used internationally and has been proposed for use to the USCG.

Most probable number test method
The Most Probable Number Dilution-Culture Method (MPN method) measures the number of viable phytoplankton cells in a sample via their ability to reproduce.

- A ballast water sample is serially diluted.
- The dilutions are incubated at favorable light and temperature levels together with nutrients and purified water constituents from the ambient (source) water.
- After 14 days, dilutions are monitored for chlorophyll fluorescence with a standard laboratory fluorometer. If one or more viable cells are present in any dilution, they will reproduce and increase the chlorophyll fluorescence.
- Dilutions are simply scored for growth or no growth, based on changes in chlorophyll fluorescence over the incubation period.
- Scores at each dilution are used in an MPN calculator to determine the probable number of viable cells that were present in the original sample.

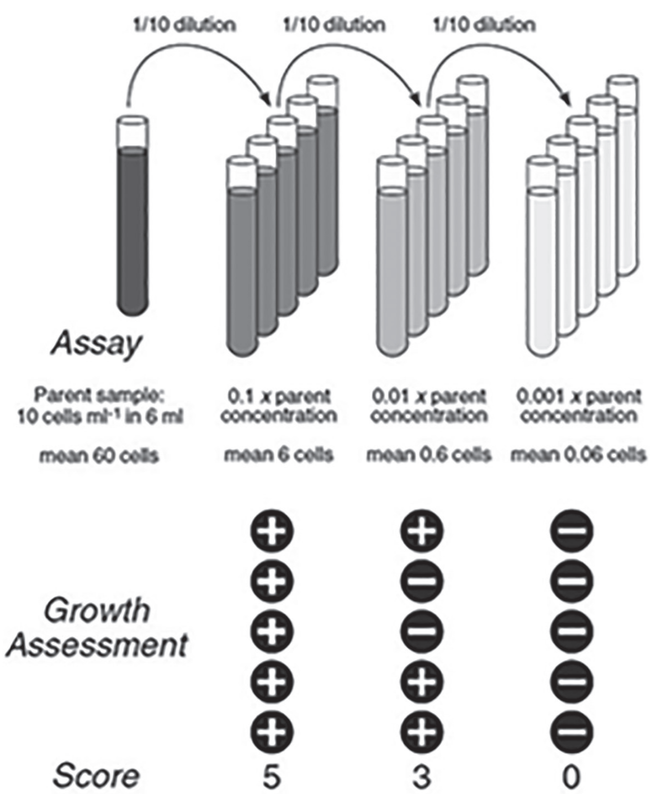

Image 5. Depiction of MPN Method. Cullen, J.J. and H.L. MacIntyre (2015). J. Appl. Phycol. DOI 10.1007/s10811-015-0601-

MPN method and the US Coast Guard
The US Coast Guard Rule and associated ETV protocol incorporates a vital stain method that tests for the presence of enzymatic activity for phytoplankton that is incompatible with UV since after exposure to UV the enzymatic activity can continue but, due to DNA damage, the organism cannot reproduce and hence populate a foreign environment. However, the rule does allow for alternate methods to be approved.

Meetings with the USCG indicated that any alternate method needed to be fully "validated" (backed up with testing and data). For example, the percent of organisms that do not grow out in an MPN needed to be quantified. The Coast Guard asked EPA ETV to convene a UV technical panel to investigate alternatives that suit UV.

This ETV UV tech panel met in 2013 and decided that the MPN grow-out method was the most suitable approach. An MPN Subgroup was formed with representatives from the Coast Guard, EPA, marine biology experts, testing laboratories and UV manufacturers. The UV manufacturers banded together to fund research by three testing laboratories that practiced MPN (DHI and NIVA in Europe and Moss Landing in the US) to obtain data needed to prove the validity of the method – under guidance of MPN Subgroup.

Taxonomic studies showed that a majority of the organisms in an MPN do grow-out. The small proportion of organisms that may not grow-out is analogous to the fact that not all organisms stain sufficiently to be counted in a vital dye test. Testing was done to standardize the incubation conditions, such as temperature, time and nutrient media.

It was postulated that grazers (zooplankton) may impact the result by consuming all the phytoplankton in a given test cell. It was determined that the ratio of phytoplankton to zooplankton at >1,000:1 makes this statistically insignificant. This work resulted in harmonized protocol of the methods employed by the three laboratories that was finalized early in 2015 as an MPN Method Document suitable for approval by the EPA for incorporation into the ETV protocol as an alternate test method and was submitted to the US Coast Guard by four UV manufacturers for approval.

US Coast Guard Decision
On Dec. 14, 2015, the USCG announced a preliminary decision not to approve MPN. Specifically, the decision found that the MPN method is not equivalent to the vital stain method in measuring the efficacy of ballast water management systems. This preliminary decision essentially prohibits the practical and efficient use of ultraviolet (UV) light-based systems in spite of the fact that the MPN method is a well-established,

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sound, scientific measurement method that is being employed internationally to test UV systems for type approval. This decision is being appealed by the four UV manufacturers directly impacted. For information, visit http://mpnballast-waterfacts.com.

The recent decision by the US Coast Guard to consider the MPN method as not being an equivalent method to measure the effectiveness of BWMS in treating the 10-50 µm organism class is unfortunate and wrong since:

- Ultraviolet (UV) technologies render organisms nonre-productive and therefore harmless in the context of preventing invasions.
- The MPN method is a well-established and sound scientific measurement method.
- The MPN method consistently induces organisms to grow. There is no evidence to support the rhetoric that most phytoplankton species are unculturable.
- The MPN method is more accurate, more conservative and more protective of the environment than the ETV stain method.

The UV dosage required to damage esterase systems as measured by the ETV stain method is approximately 10 times greater than the dose used to prevent the infestation of aquatic nuisance species by rendering organisms incapable of reproduction as determined by MPN. Therefore, holding UV-based systems to this method puts them at a decided disadvantage and is a disservice to the maritime industry in general, limiting its choice of BWM systems and increasing the cost and size of the resulting treatment system whether it be a larger UV system or forcing the use of an alternate technology.

Conclusion

New regulations from the IMO and USCG soon will govern ballast water discharges throughout the world and require the installation of BWMS on most vessels. Treatment by filtration followed by UV is very effective in preventing the transfer aquatic nuisance species via ballast water. Methods that are used to test the efficacy of all BWTS should be tailored to their effect on the organism in preventing reproduction and therefore the possibility of a harmful invasion.

For UV-based systems, the only effective means for measuring the inactivation of phytoplankton is via grow-out to show their incapability of reproduction. A proven and reli-able method for this exists and is being used internationally in determining the efficacy of UV systems. It is important that the US Coast Guard rescind its decision and approve this method and other reproductive measures that may be devel-oped in the future for the benefit of the environment and the maritime industry in general. ■

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Status of EPA Development of New Ambient Water Quality Criteria for Bacteriophage

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Allegra da Silva, Ph.D., P.E. MWH, Denver, CO
Contact: Katherine Y. Bell (615-340-6514 or kati.bell@mwhglobal.com)

Background

Human pathogenic enteric viruses, such as adenovirus, enterovirus and norovirus, are found in human wastewater and have been implicated as important causative agents of gastroenteritis (GE) in humans from exposure to contaminated recreational waters and consumption of contaminated shellfish. Human pathogenic enteric viruses have very low infectious doses as low as one to 10 virus particles, are highly transmissible and have biochemical characteristics that permit them to persist in bathing waters and in shellfish (EPA 2015). There is some previous work that suggests the current US Environmental Protection Agency (EPA) Ambient Water Quality Criteria, based on fecal indicator bacteria, such as *E. coli* and *enterococci*, do not adequately predict the presence of human viral pathogens in receiving waters. However, there is also no clear-cut epidemiological evidence linking viral GE outbreaks from exposure to bathing waters that do meet criteria based on fecal indicator bacteria (Dorevitch 2016). Thus, while FIB may not predict viral pathogen concentrations, it is difficult to conclude that FIB are entirely inadequate at their intended purpose – protecting public health.

Though it would be ideal to monitor concentrations of specific viral pathogen concentrations that cause GE, the primary reason that viral pathogens of concern are not used is because there are methodological limitations that make monitoring viral pathogens challenging. Human viral pathogens are not easily quantified in wastewater effluent, storm water or coastal receiving waters. Thus, similar to using bacterial indicators, viral indicators are being explored as indicators of the actual viral pathogens. Coliphage (viruses that infect *E. coli* bacteria, but not humans) have potential to be used as fecal indicator viruses as a surrogate for human pathogenic viruses. Coliphage benefit from being quantifiable in a range of water types, and specific subgroups of coliphage (e.g., somatic or F+ coliphage) have been proposed to show relationships with human health outcomes in recent epidemiological studies. As a result, a number of federal agencies and groups including US EPA, US Food and Drug Administration (FDA), and the Interstate Shellfish Sanitation Conference (ISSC) have been investigating the possibility of using coliphage in water quality and shellfish harvesting water quality management plans. EPA is considering developing new ambient water criteria under the Clean Water Act (CWA) based around viral indicators rather than the existing recommended criteria for *E. coli* and *enterococci* (EPA 2015).

EPA bacteriophage criteria development

In the US, water quality standards are the foundation of the water quality-based pollution control program mandated by the CWA. As such, water quality standards define goals for a waterbody by designating its uses, setting criteria to protect those uses and establishing provisions such as anti-degradation. Section 304(a)(1) of the CWA also requires EPA to develop criteria for water quality that accurately reflects the latest scientific knowledge. These criteria are based solely on data and scientific judgments of pollutant concentrations and environmental or human health effects; no considerations are made for cost or other implementation requirements. And, interestingly, unlike drinking water, where standards are developed by first establishing an acceptable human health risks, for ambient water quality, EPA develops a dose-response relationship and then makes a policy decision to establish acceptable risk to set the criteria.

As a first step in this criteria development process, the EPA conducted a literature review of the scientific information that will be evaluated to develop coliphage-based ambient water quality criteria for the protection of swimmers (EPA 2015). This literature review establishes that coliphages are equally good indicators of fecal contamination as EPA's currently recommended criteria for *E. coli* and *enterococci* (EPA 2015). The review also indicates that coliphages may be better indicators of viruses in some treated wastewater than bacteria, although there are a limited number of published studies, and many of these studies show that conclusions are site-specific. This is probably one of the most important limitations in development of such a criteria. A secondary limitation is that while it is anticipated that the literature review would establish that there is a public health issue associated with viruses in surface water, CDC data indicate that the relative issue associated with viruses appears to be of lesser concern than agents such as algal toxins with respect to human health (CDC 2014).

With respect to the additional activities in criteria developing, a recent presentation by EPA staff indicated that that several activities have been conducted and the EPA has proposed a schedule for the criteria development, as outlined in Table 1.

Table 1. Proposed schedule for bacteriophage criteria (Nappier 2016)

Date	Milestone
4/17/15	Review of coliphages as possible viral indicators of fecal contamination for ambient water quality
10/15/15	EPA webinar for stakeholders
3/1/16	Coliphage expert workshop. Fact sheet anticipated in summer 2016; proceedings anticipated in winter 2017.
2016	Listening sessions/webinars • Conferences (New Orleans and Chapel Hill) • States • Other stakeholders (industry/environmental groups)
Summer 2016	Analytical method multilaboratory validation
Late 2017	Draft criteria released for public view

The Coliphage Expert Workshop, held in March 2016, had the purpose of having internationally recognized experts who could engage on the topic of how best to protect public health from viral contamination of water, given currently available information. The specific goals of the workshop included obtaining input on science questions from experts in the fields of environmental microbiology, microbial risk assessment and environmental epidemiology. Additionally, the experts were to support EPA in gathering scientific insight into determination of the best coliphage type (male specific and/or somatic) for use on CWA 304(a) criteria. This included a discussion on identifying situations where these coliphage types may be most useful for preventing illness and identifying impaired waters.

Moving forward, the EPA proposes to conduct additional meta-analysis of National Epidemiological and Environmental Assessment of Recreational Water (NEEAR) and Southern California Coastal Water Research Project (SCCWRP) data. The NEEAR study data was derived from an investigation of human health effects associated with recreational water use. It was a collaborative research study between two laboratories of the EPA and the Centers for Disease Control and Prevention to investigate human health effects and rapid water quality methods associated with recreational water use. This study provided near real-time water quality measurements to better define the link between water pollution, swimming at the beach and public health. A main goal of the NEEAR study is to determine how new ways of measuring water pollution can be used effectively to protect swimmers' health. The SCCWRP data was derived from several epidemiology studies at beaches with varying characteristics between 2007 and 2014 (SCCWRP 2016).

Concurrent with the ongoing criteria derivation process, the EPA continues to work on validation of two culturable methods for bacteriophage that were used in the four Great Lakes beaches study that was conducted during summer 2015. With this background information, EPA anticipates that a draft 304(a) AWQC for viruses (coliphage) will be published for peer-review and public comment in late 2017.

Implications of bacteriophage criteria on design of municipal UV disinfection systems

Disinfection is at the heart of the sanitary and public health aspects of wastewater treatment and even secondary treated wastewater contains large numbers of pathogenic (disease causing) organisms. The purpose of wastewater disinfection is to inactivate pathogens that have not been removed in the upstream treatment process to the extent necessary to protect the public health, at some acceptable risk. This should be clearly distinguished from sterilization, which is the elimination of all microbial life from the water – which is not an objective of wastewater disinfection.

To achieve the end goal of protecting human health, UV irradiation often is used for wastewater disinfection. In order to understand how wastewater treatment plants (WWTPs) would be impacted considering a new bacteriophage criteria, it is also important to evaluate the treatment performance of UV disinfection with respect to both indicators and pathogens. This has huge potential impacts on the economics of UV disinfection and while the development of EPA criteria do not need to consider economic factors, the implementation of such a criteria could significantly impact current practices that have been demonstrated to be protective of human health for decades.

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UV irradiation impacts on indicators and pathogens

The germicidal action of UV irradiation is a result of photochemical reactions. When UV photons (polychromatic) are absorbed by a microbe, in bacteria, viruses or protozoans, most of the germicidal action of UV light is due to nucleic acid absorption. This is because nucleic acids absorb in the range of 240-280 nm, 10-20 times higher per weight compared to protein; although proteins, can also be involved in inactivation of microorganisms by UV (Jagger 1967). Various proteins and enzymes have been found to absorb UVB and UVC, resulting in further damage to the organisms (Harm 1980; Oguma et al. 2002; Sinha and Häder 2002).

Because most disinfection using UV irradiation is a result of disruption of nucleic acids, it is of note that although the absorption spectra of different nucleic acids are similar, nucleotide bases of DNA are adenine, guanine, thymine and cytosine, whereas RNA contains uracil instead of thymine. Nucleic acids are heterocyclic aromatic compounds that show significant absorption of UV photons; in DNA, UV absorption results in dimerization of adjacent thymine molecules, inhibiting transcription of the microbe's genetic code and reproduction. Dimers in DNA that can be formed from thymine (T) and cytosine (C) include T<>T, C<>T and C<>C, and in RNA dimers can be formed from uracil and cytosine. Cytosine dimers absorb less than thymine in the germicidal range (Harm 1980) and the quantum yield of T<>T formation is greater than for the other dimers C<>C and C<>T (Patrick and Rahn 1976). Thus, organisms rich in thymine (found only in DNA) tend to be more sensitive to UV irradiation; conversely, microbes such as MS2 bacteriophage that is a single stranded RNA virus is less sensitive to UV radiation; although, adenovirus is a DNA virus that requires very high doses of UV to achieve inactivation.

Because the nucleotide composition of genetic material varies from one organism to another, so does the sensitivity to UV disinfection. A graphical summary of low-pressure UV doses required to achieve 4-log inactivation of various bacteria, protozoans and viruses are shown in Figure 1. It is of note that there are additional confounding issues associated with interpretation of virus inactivation using medium pressure UV, which has been at the center of a significant body of recent research; and that information is not presented here.

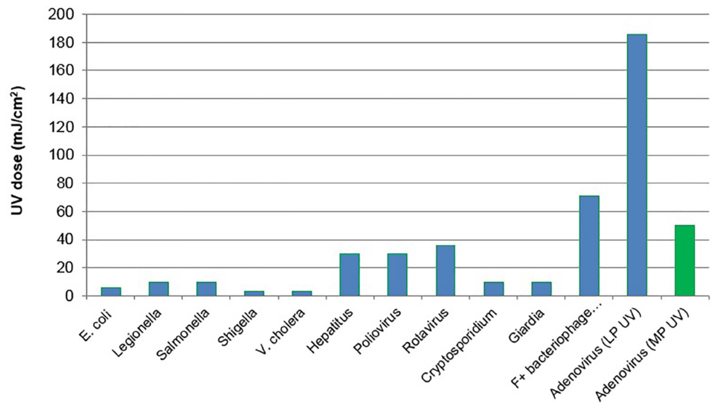

Figure 1. Low-pressure UV dose requirements for meeting 4-log inactivation of various microorganisms (EPA 2006)

Implications for NPDES permitting at wastewater treatment facilities

In the US, limits for microbial indicators are typically enforced at the "end-of-pipe," meaning that the ambient water quality criteria must be met at the end of the treatment process, before it is discharged to the receiving water body. This issue is somewhat murky in the US wastewater community because, while the EPA, in documents such as the Ephraim King Letter (EPA 2008), has indicated that there is a prohibition on the use of mixing zones for bacteria in primary contact recreation waters, individual primacy states may in fact, use mixing zones to calculate the effluent limits for bacteria. While the mixing zone calculation should be allowable, most states typically implement bacteria criteria at the end-of-pipe and utilize the criteria directly in National Pollutant Discharge Elimination System (NPDES) permits as discharge limits. However, if the ambient water quality criteria are updated to reflect coliphages, many utilities may initiate more site specific investigations to leverage the benefits of mixing zones to provide dilution factors that could be used in permitting because methods of wastewater disinfection that are most commonly employed, are not adequate to provide high levels of coliphage inactivation, although these practices already provide protection of human health (Dorevitch 2016).

Summary

The EPA develops criteria for determining when water has become unsafe for people and wildlife, using the latest scientific knowledge. Ambient water quality criteria for human health are intended to establish guidance for how much of a specific pollutant can be present in surface water before it is likely to cause harm. The EPA's commitment to develop new bacteriophage criteria by 2017 for public review should strengthen public health protection compared to the existing 2012 criteria and provide a mechanism for the various Clean Water Act needs to be met. While the EPA has conducted work toward a bacteriophage criteria, there are additional policy decisions that will establish numeric criteria that support derivation of effluent limits in NPDES permits. It is this information that is critical in understanding how new criteria could impact the design of UV systems for WWTPs. As a result, it will be important for the UV community to participate in EPA stakeholder events and provide new information to the EPA during this process if it emerges during the ongoing criteria development process. ■

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The Critical Role of UV in Meeting Pathogen and Pollutant Targets for IPR and DPR Applications

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Introduction

With increasing uncertainty in regional water supplies and the prolonged drought in the West, it is important for communities to diversify their water portfolios. Wastewater is a reliable supply that can be repurposed to provide another option for a community's water source. Non-potable and potable wastewater reuses are two means of repurposing treated wastewater. Non-potable water reuse is valuable but has limitations, including the seasonal demand for non-potable water, the costs and complexity of extensive "purple pipe" systems and the common lack of irrigation or industrial customers to maximize water reuse. Indirect potable reuse (IPR) and direct potable reuse (DPR) provide an additional category in a municipal water treatment source portfolio, allowing the capture and use of all treated water through every season.

In IPR scenarios, secondary treated wastewater undergoes further treatment through an advanced water purification facility (AWPF) before being supplied to a groundwater basin or surface water supply, providing an environmental buffer. The environmental buffer is able to provide additional treatment through filtration, photolysis, etc. and provides "response retention time," which is a set time value that allows for water quality monitoring and response. Currently in California, Title 22 regulatory requirements set by the California Division of Drinking Water (DDW) allow for groundwater recharge via surface spreading or groundwater injection of treated water (CDPH 2014). For groundwater injection, full advanced treatment (FAT) through an AWPF must be employed. FAT includes microfiltration/ultrafiltration (MF/UF), reverse osmosis (RO) and UV advanced oxidation (UV AOP).

DPR projects do not use the environmental buffer, instead relying upon advanced treatment and advanced monitoring systems to provide confidence in water quality. Engineered storage buffers provide an added measure of safety to the final water quality. DPR treats secondary wastewater effluent with an AWPF, and the purified water is either delivered straight to the consumer or first blended into a drinking water treatment plant for delivery (Figure 1). There are no current regulations for DPR in California or nationally. However, the state of Texas is approving DPR projects on a case by case basis, and the Colorado River Municipal Water District's facility in Big Spring, Texas, has been successfully producing potable water through DPR for three years.

Meeting treatment requirements with UV processes

Treatment technologies and monitoring techniques are used to protect public health in potable reuse scenarios. Risk mitigation is the foundation for public health protection and setting technology treatment target limits. Research studies have shown the goal of potable reuse systems should be to eliminate the acute risk and mitigate the chronic risk through potable reuse treatment (WRRF 2014). Pathogens are the main, but not only, concern in acute risk scenarios, NDMA and other emerging contaminants represent the chronic risk. The UV process is beneficial for (1) disinfecting virus, protozoa and bacteria, (2) NDMA removal and (3) removal of a wide-range of emerging contaminants through advanced oxidation.

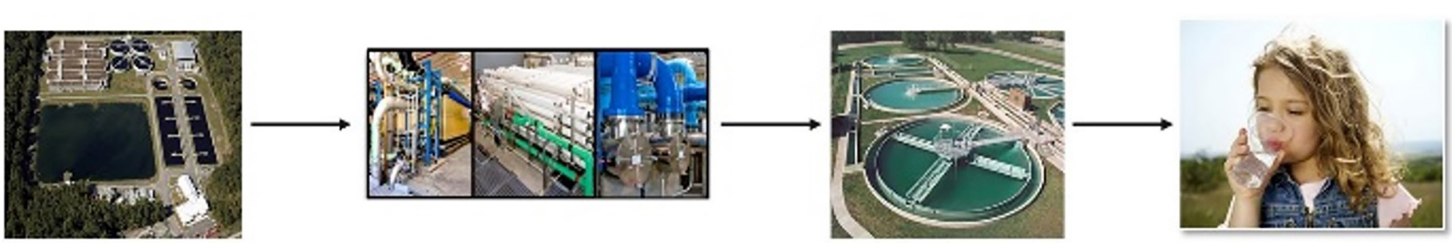

Figure 1. Direct potable reuse graphic depicting treated wastewater effluent entering an AWPF, including FAT, blending effluent water with a drinking water facility, then delivered to the consumer.

Details of how UV processes provide treatment to meet these regulatory requirements are detailed below, with supporting data from a study conducted by Carollo Engineers at the Silicon Valley Advanced Water Purification Center (SVAWPC) with the Santa Clara Valley Water District (SCVWD) in Santa Clara, California.

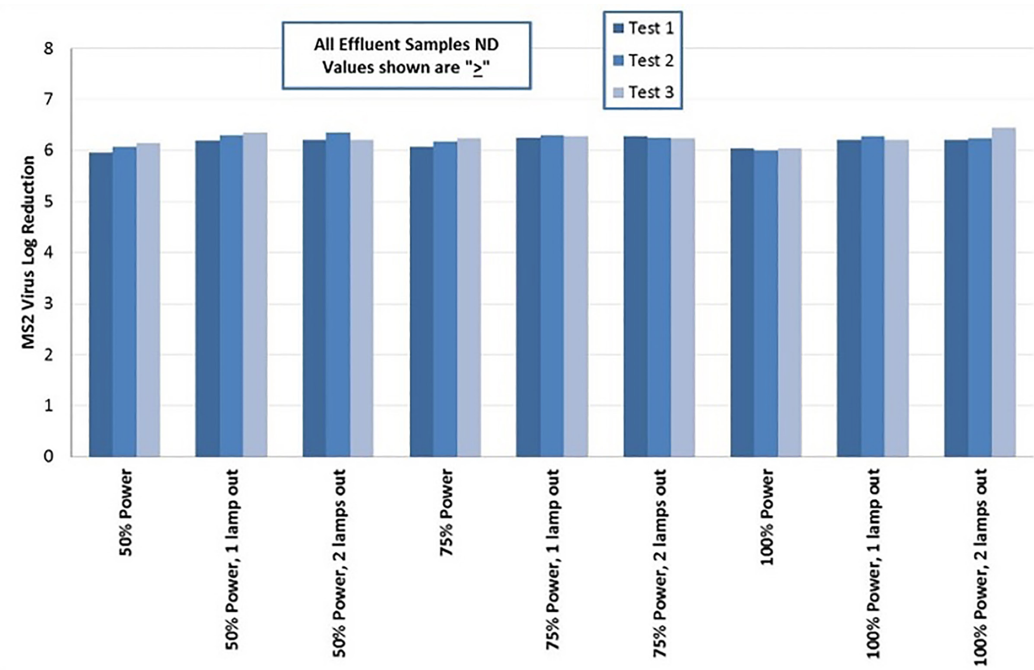

Figure 2. Impact of lamp power modulation and lamp outages on MS-2 virus removal in RO permeate at SCVWD.

Pathogen disinfection

Title 22 recycled water regulations require an IPR facility to demonstrate and meet 12-log virus, 10-log *Giardia* and 10-log *Cryptosporidium* (12/10/10) removal across the facility (CDPH 2014). Each individual treatment process in the facility cannot be granted with a removal credit greater than 6-log for each virus, *Giardia* and *Cryptosporidium* (6/6/6). Therefore, multiple processes must be used (MF/RO/UV AOP) to receive the necessary log removal credits. The UV process provides, by far, the most significant pathogen barrier, being the only process in the treatment train capable of being awarded all 6/6/6 log removal credits.

No measurable concentrations of these pathogens are typically found in RO permeate (UV influent); however, an additional barrier is necessary in the event of off-spec water passing through the RO system and for meeting the 12/10/10 requirements. For UV disinfection, the most resistant known pathogen to low-pressure (LP) UV inactivation is Adenovirus. The UV dose response of Adenovirus type 2 (Ad2) shows a 6-log reduction of Ad2 can be obtained at a UV dose of 235 mJ/cm^2 (Gerba et al. 2002). This provides a conservative UV dose setpoint for pathogen inactivation in potable reuse systems.

A typical UV dose for UV AOP systems following RO in potable reuse facilities is >800 mJ/cm^2. This provides a much higher dose than necessary to achieve the 6/6/6 log-removal requirement for pathogen disinfection. Demonstration of pathogen disinfection via seeded MS-2 removal, with simulated UV process failures was conducted at the SVAWPC. Simulated failures included modulating power settings (50%, 75% and 100%) in parallel with intentional lamp outages (1 and 2 lamps out), with the MS-2 log-removal response being measured. Results from this challenge testing show even with lamp outages and significant power reduction (50%), the UV system was able to provide 6-log removal of MS-2 virus (Figure 2). This challenge testing demonstrates the robust nature of the UV process to provide a high level of performance in RO permeate, even in failure scenarios.

NDMA removal

N-Nitrosodimethylamine (NDMA) is a disinfection byproduct formed in water and wastewater treatment. The US Environmental Protection Agency (EPA) defines NDMA as a human carcinogen with a carcinogenic risk level of 0.69 ng/L in drinking water (EPA 2016). NDMA is poorly removed by RO membranes (Plumlee et al. 2008). UV is proven to destroy NDMA through photolysis, with 90% removal based on a UV dose of ~900 mJ/cm^2 (Sharpless and Linden 2003). Title 22 regulations require potable reuse facilities to meet a limit of 10 ng/L following the UV process, which is achieved in FAT facilities using a high UV dose, typically between 700 and 1,100 mJ/cm^2. New methods of tracking NDMA removal through UV treatment are needed, as the analytical turn-around time for the samples does not allow for online monitoring. During the study performed at the SVAWPC, NDMA removal and total chlorine destruction were measured simultaneously with

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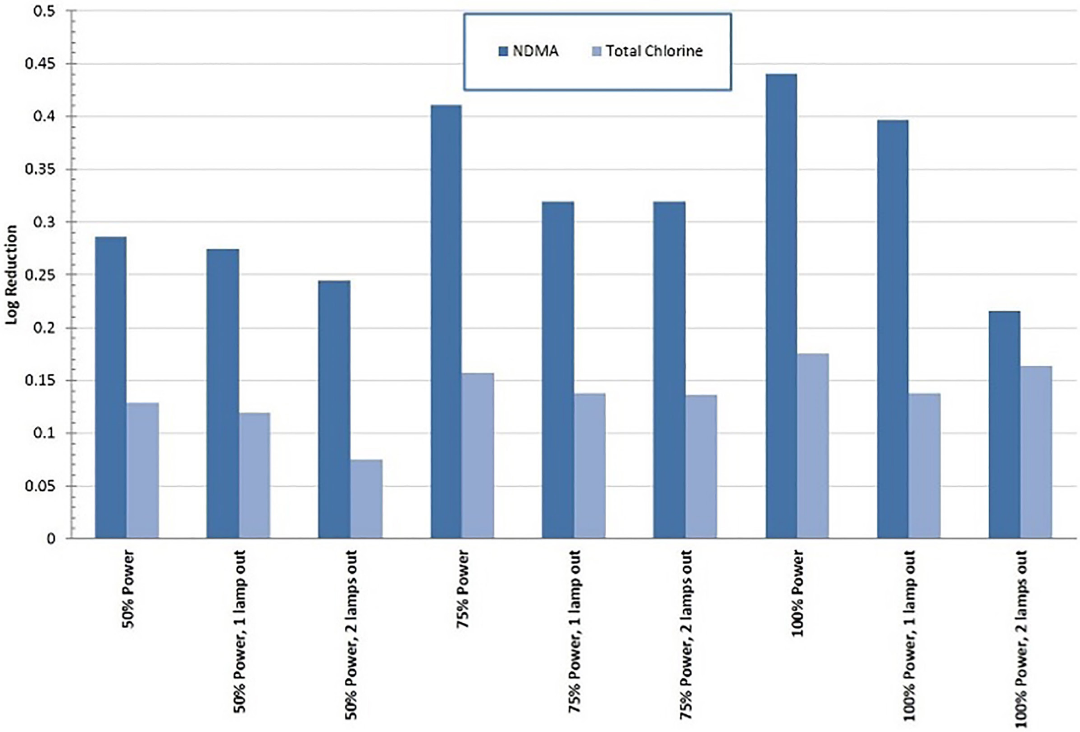

Figure 3. Impact of lamp power modulation and lamp outages on NDMA and total chlorine destruction in RO permeate at the SVAWPC.

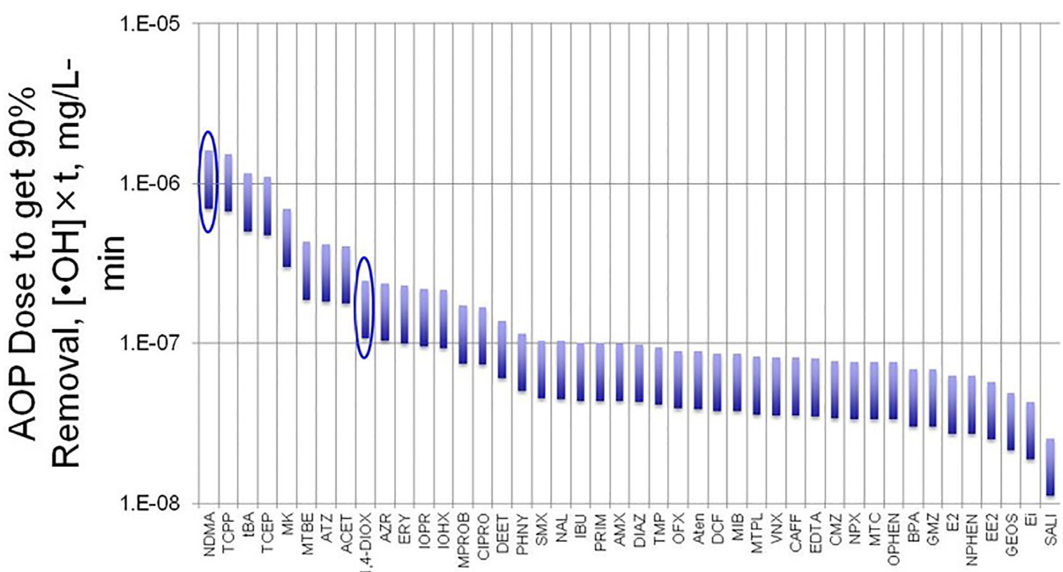

Figure 4. Destruction of Trace Pollutants by UV AOP (Hokanson et al. 2011)

the lamp failures from the MS-2 removal study in the previous section (Figure 2). Results from the study are shown in Figure 3. NDMA removal was impacted by UV lamp and power failures, with the total chlorine destruction corresponding to the NDMA removal changes. Thus the UV process provides both NDMA destruction and the ability to indirectly monitor final effluent quality through periodic chloramine destruction testing. Note: Work from this same study indicates that hydrogen peroxide will interfere with the accuracy of chloramine monitoring.

Emerging contaminant removal

Emerging contaminants not only pose a potential risk to human health, but are also an integral part of public perception and acceptance of potable reuse projects. RO removes most emerging contaminants found in secondary treated wastewater effluent, leaving few contaminants to be treated by UV processes, aside from NDMA. An additional barrier is needed following RO, in case of passage of contaminants through RO. UV with the addition of an oxidant ($NaOCl/H_2O_2$) generates non-selective hydroxyl radicals that are fast-acting and effective for a wide-array of emerging contaminant destruction.

To validate UV AOP systems for emerging contaminant removal, Title 22 regulations require the demonstration of 0.5-log removal of 1,4-dioxane through an advanced oxidation system. This requirement is based on 1,4-dioxane being a conservative surrogate for AOP performance, as it is not amenable to UV degradation. Figure 4 shows the hydroxyl radical reaction rate for NDMA and 1,4-dioxane relative to several other emerging contaminants commonly found in secondary treated wastewater effluent (Hokanson et. al. 2011). 1,4-dioxane is shown to be a conservative indicator for the removal of many other pollutants. Demonstrating 0.5-log removal of 1,4 dioxane provides confidence in the UV AOP system functionally destroying emerging contaminants from RO permeate.

UV monitoring and control strategies

The success of potable reuse systems is crucially dependent on reliable treatment and monitoring tools, with the definition of reliable in potable reuse systems meeting the four "Rs": Reliable, Robust, Redundant and Resilient (Pecson et al. 2015).

Monitoring techniques, such as a peroxide weighted dose, are being explored due to the ability to monitor these parameters online. Hydrogen peroxide dose, UV sensor and UVT monitoring allows for a correlation between UV dose and peroxide to be found, and for a given system with 1,4-dioxane removal demonstration, the optimized UV and hydrogen peroxide dose can be determined, providing confidence and potential cost savings for the facility. Figure 5 shows an example of data demonstrating the effectiveness of a peroxide weighted dose and correlation of 1,4-dioxane at the SCVWD during pilot testing. A peroxide weighted dose correlated well with the measured removal of 1,4-dioxane.

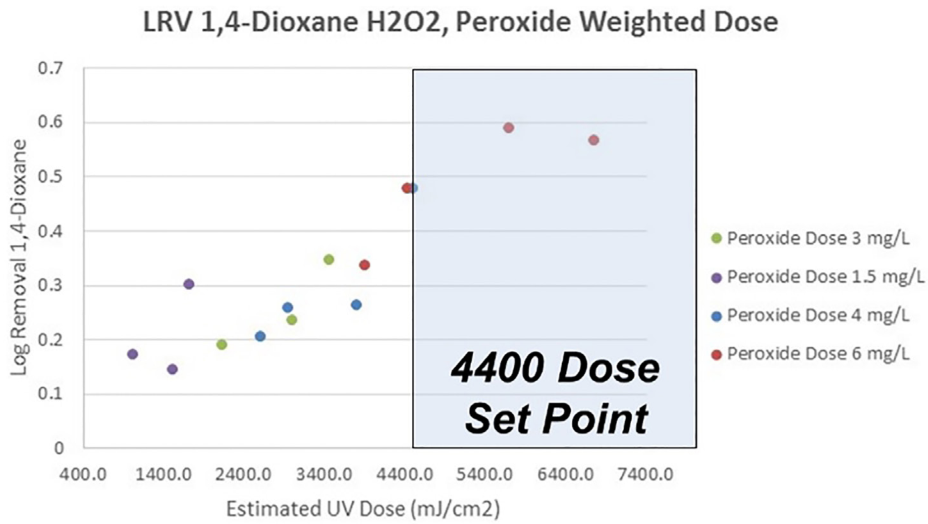

Figure 5. Removal of 1,4-dioxane correlated to UV Dose via a peroxide weighted dose in RO permeate at the SVAWPC.

Future of UV and UV AOP in potable reuse

Monitoring and sensor technologies are important for the viability of UV processes for potable reuse in the future. Providing reliable sensor technologies that are designed for high UVT water (>99%) from RO permeate is paramount for future system design. Additionally, optimizing oxidant and UV dose for a given AOP system and a given oxidant will provide utilities with reliable operation and potential cost savings. This optimization is leading to further pilot testing, and more importantly data collection, across the industry.

Large data sets from several municipalities are aiding in driving the industry forward for setting baseline performance of treatment technologies in potable reuse. A baseline performance will allow for online monitoring tools developed for UV processes to more accurately detect when normal operation is not being met. This information will provide further confidence in public health protection via UV processes in potable reuse applications. ■

Acknowledgements

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Expansion to Asia: A Summary of the 2016 IUVA Symposium in Tokyo

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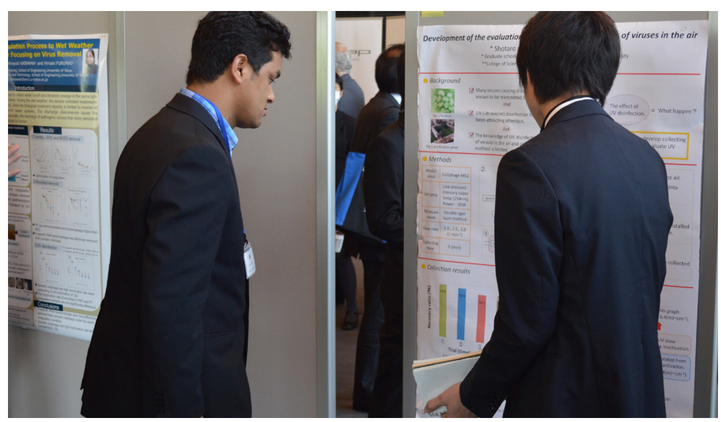
The IUVA symposium “UV Innovations: Towards Sustainable Water Use” was held April 22, 2016, at the University of Tokyo. It’s been 12 years since the first IUVA conference in Tokyo, so the mission of this event was to update the things happening around UV applications in Japan and to think of UV innovations for the future.

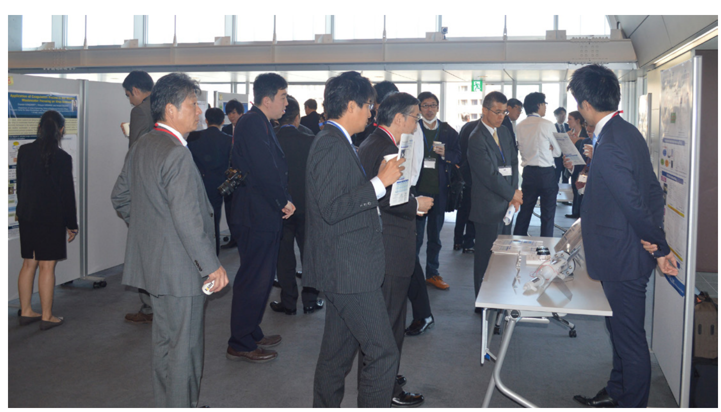
The event was officially supported by Japan Water Research Center (JWRC), Japan Water Works Association (JWWA), Japan Society on Water Environment (JSWE), Research Center for Advanced Science and Technology (RCAST) at the University of Tokyo, and Research Center for Water Environment Technology (RECWET) at the University of Tokyo, in cooperation with National Institute of Public Health (NIPH), Japan. Moreover, industrial sponsors included AquiSense Technologies, Nikkiso Giken Co. Ltd, Swing Corporation, Hanovia Ltd, Nedap Light Controls, Trojan Technologies and Carollo Engineers. Thanks to those strong supporters and sponsors! Approximately 120 attendees from industry, municipalities, water utilities and academia attended the symposium. Two water industry newspapers joined the event and wrote articles in their latest issues. The event featured simultaneous translation to and from English and Japanese so all participants could get the most out of the presentations.

Figure 1. Invited speakers in Tokyo included, from left, Zhimin Qiang, Mengkai Li, Harold Wright, Karl Linden, Kumiko Oguma, Jiangyong Hu, Madjid Mohseni and Ron Hofmann.

The symposium was originally motivated to focus on these key questions:

- For drinking water treatment in Japan, UV is approved as a measure against *Cryptosporidium* for systems sourcing groundwater and river-bed water. Why not for surface water systems? How do we expand the range of applications in a scientifically correct manner?
- For wastewater treatment in Japan, UV has been used mostly in special cases with reasons to avoid chlorination (ex. Discharge area is a habitat of rare species of fish). Moreover, for water reclamation and reuse, UV has never been adopted in practice. Why not? What about the cases in other countries?
- Innovative light sources, such as UV light-emitting diodes (UV-LEDs), have been growing in the market. What will the future hold for these UV innovations?





Figures 2 and 3. Poster sessions and exhibitions were a vital part of the Tokyo symposium.

Based on the issues above, the program was developed as shown in Table 1. The event opened with a remote video welcome from Dr. Jim Bolton. The following technical session provided an excellent overview the UV status in leading countries (US and Canada) and in the context of Asia (China and Singapore). In contrast to those countries, it was highlighted that Japanese UV guidelines are unique and UV applications in Japan are growing but still limited in number compared to the others.

Table 1. Technical program for IUVA Tokyo 2016

UV Applications and Trends in Drinking Water
Karl Linden, University of Colorado-Boulder, USA
Drinking Water UV Disinfection in North America
Harold Wright, Carollo Engineers, USA
Small Water Systems and UV Applications in Canada
Madjid Mohseni, University of British Columbia, Canada
UV Applications in Water Treatment Industry in China
Mengkai Li, Chinese Academy of Science, Beijing, China
UV Applications for Water Treatment and Reclamation in Singapore
Jiangyong Hu, National University of Singapore, Singapore
UV Guidelines for Drinking Water Treatment in Japan
Shioko Kurihara, Japan Water Research Center, Japan
UV Applications in Japan
Dai Shimazaki, National Institute of Public Health, Japan
UV-LED as a Potential Solution for Water Treatment
Kumiko Oguma, University of Tokyo, Japan

During coffee and lunch breaks, active networking and discussions were carried out at the poster session and exhibitions.

To wrap up the symposium, a panel discussion was opened. Sponsors were invited to the panel to give short presentations on their UV innovations, followed by open discussion.

Questions from the floor focused on presumed bottlenecks that are currently hindering the expansion of UV applications in Japan. Major concerns were as follows.

1. UV has NOT been considered as the best available measure against *Cryptosporidium*, because UV-inactivated *Crypto* is still detected by staining-microscopic observation. This fact makes it hard to convince people of the safety of UV-treated water, and that's how the physical removal of *Crypto* by intensive turbidity control is more accepted in Japan. To be "*Crypto*-free" sounds better for officers and citizens.
2. Many people believe UV treatment is expensive and not economically feasible for mid- or small-scale systems with limited finances. UV manufacturers and engineers should appeal more toward the cost effectiveness and small footprint of UV systems.

Figure 4. Sponsors were invited to give short presentations on their UV innovations.

Figure 5. Open discussions with people on the panel and members of the audience took place.

The IUVA Symposium in Tokyo was a great success to gather a broad range of people, not just from academia, and to let practitioners know the facts about UV applications. The event organizers believe this event was a great kickoff toward a renewed discussion of UV applications in Asia. Dr. Oguma, IUVA VP of Asia, is working to plan the next IUVA activity in Asia. We hope you can join us next time! ■

UV Industry News

New low-cost UVO-cleaner debuts – Jelight Company Inc., Irvine, California, has announced the UVO-Cleaner®, a photo-sensitized oxidation process in which the contaminant molecules of photo resists, resins, human skin oils, cleaning solvent residues, silicone oils and flux are excited and/or dissociated by the absorption of short-wavelength UV radiation. Atomic oxygen is simultaneously generated when molecular oxygen is dissociated by 184.9 nm and ozone by 253.7 nm UV. The 253.7 nm UV radiation is absorbed by most hydrocarbons and also by ozone. The products of this excitation of contaminant molecules react with atomic oxygen to form simpler, volatile molecules that desorb from the surface. Therefore, when both UV wavelengths are present, atomic oxygen is continuously generated and ozone is continually formed and destroyed.

AquiSense announces operations expansion – AquiSense Technologies LLC is planning a major expansion of its greater Cincinnati operations that will boost its workforce and expand its capabilities. The Florence, Kentucky-based manufacturer of UV-LED-based water disinfection and wastewater treatment systems will continue with its $4 million investment plan to create a new 15,000-square-foot headquarters and manufacturing facility in Erlanger, Kentucky. The new building will allow for full-scale production and will be vertically integrated from incoming UV-LED inspection, injection molding, electronic assembly to final product assembly and test. In the future, the facility will expand to wet lab and prototype production. In addition, AquiSense has a 2,000-square-foot research and development center in Charlotte, North Carolina, which includes a state-of-art UV-LED benchmarking laboratory. The new development will result in a doubling of the existing workforce to 30 new jobs, according to CEO Oliver Lawal.

Philips separates lighting business – "Philips, Amsterdam, Netherlands, is reviewing all strategic options for Philips Lighting, including an initial public offering and a private sale. Philips is on track to be able to announce the separation of the lighting business in the first half of 2016, subject to market conditions and other relevant circumstances. To this end, Philips is currently working with its advisors on the preparations for an IPO and a private sale. Each option is governed by its own processes and follows its own timeline. The important point to note here is that there is no preferred option and a final decision will be made in the second quarter of 2016." From a letter from Steve Klink, head of Philips Group Press Office. Reproduced with permission.

New handbook available – The American Water Works Association, Denver, Colorado, has announced that a new book, "Advanced Oxidation Handbook," by James Collins and James R. Bolton, can be ordered from its website. For more information, visit http://www.awwa.org/store/productdetail.aspx?productid=38748919.

SurePure technology instrumental in clinical trial – SurePure, Inc. a global leader in liquid photopurification, announced today that the company's patented photopurification technology has been used to produce key research samples for an upcoming clinical trial. This trial is expected to demonstrate that SurePure's technology, which enables immune active proteins to remain undamaged, will stimulate greater vaccine response in the elderly. Tamarack Biotics and UC Davis are jointly conducting the clinical trial in California. Bob Comstock, CEO of Tamarack Biotics, said, "SurePure technology has analytically proven to retain key immune active proteins, and we are now eager to test the real-world application of this technology. We expect this double-blinded, placebo-controlled clinical trial will help lead to improved overall health in the elderly and reduce illness-related health care costs. This is vitally important research given our rapidly aging population." Guy Kebble, CEO of SurePure, said, "This application and the clinical trial reflect the value of the SurePure technology in achieving microbial cleanliness while simultaneously retaining the inherent qualities of the product. We are pleased to be partnering with Tamarack Biotics in this important research."

Electrode technology meets AOP requirements – Neptune Benson, Coventry, Rhode Island, announced that its newly developed electrode technology has exceeded expectation during potable water reuse demonstration testing in California. Neptune Benson, in collaboration with Carollo Engineers, took part in the nine-month VenturaWaterPure project, which is aimed to increase recycled water supply to meet long-term demands in this California community. The objective of the overall study is to draw attention to the value of potable reuse as a renewable resource that can provide a cost-effective and sustainable source of high quality water. The state of California Division of Drinking Water (DDW) has established detailed regulations for potable water reuse. These regulations require that all indirect potable reuse plants

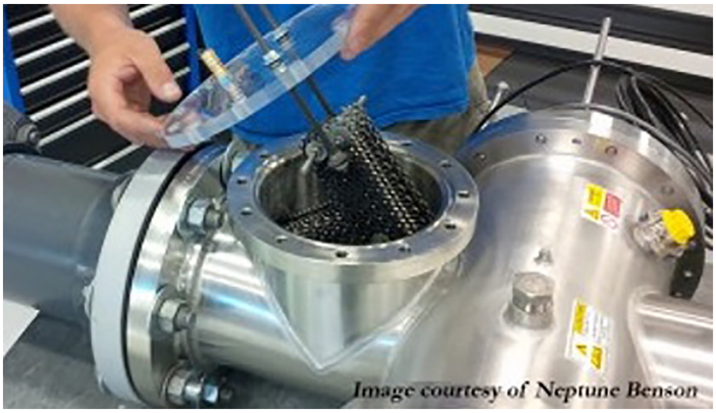


Image courtesy of Neptune Benson

(IPR), which inject treated water into the groundwater basin, have a UV advanced oxidation process (UV AOP) within the treatment train. The AOP process works to remove micro-contaminants, contaminants of emerging concern and (CECs) and pharmaceutical and personal care products (PPCPs). Per regulation, the AOP must provide a minimum of 0.5-log reduction of 1,4-dioxane, which is a conservative surrogate for a wide range of trace pollutants. The typical AOP utilizes UV with either hydrogen peroxide (H_2O_2) or sodium hypochlorite (NaOCl), with chemical dosing values of 3 to 6 mg/L. The Neptune Benson electrode has been designed to work with the ETS-UV system to provide AOP without the use of any chemical additives (hydrogen peroxide or sodium hypochlorite).

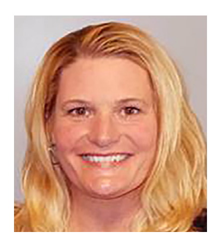
Fresh-Aire appoints development manager – Fresh-Aire UV, a division of Triatomic Environmental Inc., Jupiter, Florida, the largest manufacturer of UVC and PCO-activated carbon indoor air quality (IAQ) products in North America, has named UV industry expert Stuart Engel as its international business development manager. Engel will help Fresh-Aire UV penetrate the European and Middle East/North Africa (MENA) HVAC industry and solidify the 30-year-old firm as a market leader. He also will help Fresh-Aire UV further develop its U.S. commercial business and expand its specification manufacturer's representative network domestically. For information, contact Chris Willette (chris@freshaireuv.com).

Stuart Engel

American Ultraviolet announces mobile units – American Ultraviolet has introduced two mobile UV disinfection units, Models MRS 33-8 and MRS45-12. The Model MRS 33-8 unit uses 360 degree motion sensors as a safety precaution and features eight 33" slimline UVC lamps optically centered around a highly polished reflector for maximum intensity. System controls are located directly on the unit, which allows utilization of a touchscreen with three preprogrammed disinfection cycle times and the option to manually set disinfection cycles times. The Model MRS 44-12 is designed for larger applications not requiring data logging or a touchscreen tablet controller. This unit uses a 360-degree motion sensor for safety shut off and 12 45" slimline UVC lamps mounted around a central reflector to maximize reflected UVC energy within any given space. System controls are located directly on the unit and utilize a touchscreen with three preprogrammed disinfection cycle times and the option to manually set disinfection cycles times outside the three default options.

Glasco advances product line – Glasco UV, Mahwah, New Jersey, has continued to advance its NONCON IL-FEP COIL product line. Introduced in 2006, the original systems were designed to test UV-254 nm's effectiveness in targeting certain biological agents like anthrax. Today's systems take advantage of improvements in fluoropolymer technologies, which allow them to offer solutions for many difficult to treat liquids. The NONCON IL-FEP systems are designed to treat low-transmission liquids, such as juice, milk, wine and coconut water, and thick and viscous liquids like sugars and coolants. Systems also provide a mechanism for disinfection without using quartz or mercury-based lamps in the actual flow. The FEP coils keep the liquids separated from the UV lamps. For information, visit http://www.glascouv.com/noncon-uv.html.

Aquionics appoints sales administrator – UV disinfection specialist Aquionics Inc., Erlanger, Kentucky, has named Michelle Buckman as its new sales administrator. In her position, Buckman will provide vital support to the sales team to ensure customers continue to receive on-time sales and service. Buckman has 10 years of experience in sales support and customer service from previous positions with St. Elizabeth Healthcare (Edgewood, Kentucky), MAG Industrial Automation (Cincinnati, Ohio) and Pomeroy IT Solutions (Hebron, Kentucky). ■



Michelle Buckman

Calendar

September

WateReuse, Sept. 11-14
Tampa, Fla.
watereuse.org

WEFTEC, Sept. 25-28
New Orleans, La.
weftec.org

November

Confluence, Nov. 9
Cincinnati, Ohio, area
watercluster.org/wordpress

Ad Index

IUVA Corporate Members

Large organization

Aquionics Incorporated
Calgon Carbon UV Technologies
Carollo Engineers, Inc.
CDM Smith Inc.
CH2M Hill Engineers, Inc.
Crystal IS
Evoqua Water Technologies
Fujian Newland EnTech Co. Ltd.
Hazen & Sawyer
HDR, Inc.
Heraeus Noblelight GmbH
Light Sources, Inc.
LIT Ultraviolet Technology
NYC Dept. of Environmental Protection
Philips Lighting BV
Trojan Technologies
Xylem Inc.

Medium organization

Alpha Cure
American Ultraviolet Company
atg UV Technology
Atlantic Ultraviolet Corporation
Berson UV-techniek
Bio-UV SA
eta plus electronic GmbH
Funatech Co., Ltd.
GHP Group Inc.
Hanovia Ltd.
MWH
Neptune Benson
Phoseon Technology
Real Tech Inc.
SUEZ Treatment Solutions
Surepure
Ushio America, Inc.
UV-technik Speziallampen GmbH
ZED Ziegler electronic Devices GmbH

Small organization

ABIOTEC Technologie UV
Advanced UV Inc.
Allanson Lighting Technologies, Inc.
American Air & Water, Inc.
AquiSense Technologies
Atlantium Technologies Ltd.
Australian Ultra Violet Services (Operations) Pty Ltd.
Bolton Photosciences Inc.
E. Vila Projects & Supplies, SL
Foshan Comwin Light & Electricity Co., Ltd.
Gigahertz-Optik Inc.
Glasco UV LLC
HaiNing YaGuang Lighting Electrical Co. Ltd.
JenAct Ltd.
Light Progress
NEDAP Light Controls
NPO-ENT
OFI Technologie & Innovation
Opsytec Dr. Gröbel GmbH
PWN
SA Water
S.I.T.A. SRL
ULTRAAQUA
Ultra Violet Products (AUST) Pty. Ltd.
UV Dynamics
UV Guard
VGE International B.V.
Wonder Light Industry, Machinery, Electronic Products (Zheng Shan) Co. Ltd.

Find out more at
www.philips.com/uvpurification

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