

ENVIRONMENTAL SYSTEMS DIVISION NEWSLETTER

The ESD Newsletter is a monthly newsletter involving ALL members of ESD. Members are encouraged to forward materials, authored papers on Environmental and Environmental Systems topics, and comments on newsletter topics or current events to the Editor. Your participation is greatly appreciated.

The ESD newsletter features **Five** Sections:

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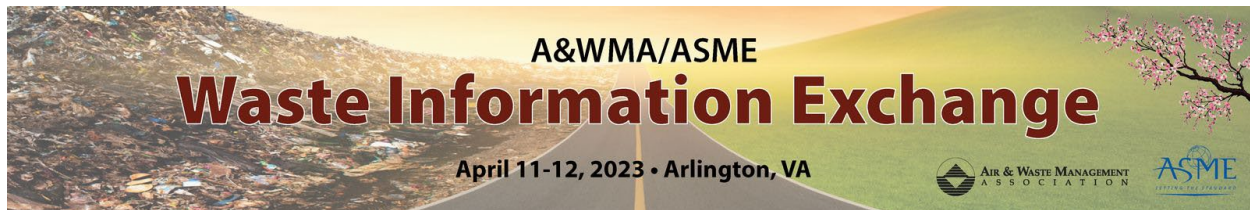
5. READER COMMENTS TO THE EDITOR

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1. ESD DIVISION NEWS

A&WMA/ASME - Waste Information Exchange

This collaborative A&WMA/ASME conference will cover the latest information on a broad range of waste-related topics including regulations and research in an interactive, discussion-focused format. Hear directly from experts who are working together to develop solutions for creating a cleaner and healthier environment. Presenters include experts from EPA's Office of Resource Conservation and Recovery (ORCR), other agencies, NGOs, and industry, and will focus on policy updates, regulatory changes, and current and late-breaking research on hot topics such as: Solid Waste, Bio solids, Landfill Issues and Greenhouse Gas Emissions Monitoring, Reuse/Recycling, Resource Management, Waste-to-Energy, PFAS Emissions and Controls, Environmental Justice, RCRA Requirements for Open Burning. Managers, practitioners, policymakers, and researchers involved in waste management, public works, operations, maintenance, manufacturing, transportation, technology, compliance, collections, and other environmental roles will benefit from the technical content and networking available. Find more details at www.awma.org/waste and stay tuned for the full technical program. **[Back to Newsletter's Page 1](#)**



2. ENVIRONMENTAL TECHNOLOGIES

Licorice leaf extract is a promising plant protectant for conventional and organic agriculture

Pesticides have proven effective in protecting crop yield against plant pathogens, but the environmental detriment to nontarget organisms has prompted a tug-of-war between organic and conventional agriculture practices. This poses the question: How can growers and farmers sustain their business in the safest, most responsible way? While copper, a naturally occurring pesticide, has been widely implemented in response to this question, finding additional biocontrol methods will reduce copper use and further contribute to

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sustainable solutions. A study recently published in Plant Disease, reveals another promising biocontrol alternative. Since the licorice plant has broadly benefitted other industries, the researchers tested its impact as a pesticide -- discovering that the licorice leaf extract is a potent bactericide and fungicide. "In the pharmaceutical, cosmetic, and food industries, the interest focuses primarily on roots of the licorice plant. The leaves and upper parts of the plant are byproducts and often neglected. However, we show their potential as a base for plant protection products, which may be utilized in both conventional and organic agriculture systems."

Using plant efficacy trials, the researchers tested the impact of licorice leaf extract on the virulence of common, highly pathogenic bacteria in the model plant Arabidopsis and in tomato. Their results demonstrate that licorice leaf extract modulates plant immune responses to pathogens, involving both salicylic acid and ethylene-based responses. The extract also acts against a particular late blight-causing oomycete that is resistant to metalaxyl, the active ingredient in several synthetic fungicides. Altogether, these exciting results offer a potential way to naturally control plant diseases caused by a vast range of pathogens, including bacteria and oomycetes. "The possibility to develop biological alternatives for plant protection that are sustainable and employ otherwise unused materials will not only help in our agricultural approaches, but also support local, circular economies." Further studies can help extract every bit of potential that licorice leaf extract holds as an alternative plant protection measure in the production of economically important crops. (Ref.1) [Back to Newsletter's Page 1](#)

The gene-editing technology in your store-bought tomatoes that could eat agriculture

The small tomatoes on shelves of supermarkets in Japan may look like normal fruit, but they are actually genetic pioneers. In late 2021, Japanese company Sanatech Seed began selling special tomatoes that had been genetically modified to produce high levels of gamma-aminobutyric acid (GABA), a compound naturally found in the brain. GABA has been linked to stress reduction and is touted as a treatment for high blood pressure and insomnia. Sanatech used a revolutionary gene-editing technology called CRISPR to modify a tomato genome to reduce the production of enzymes that naturally break down GABA. Now a decade old, CRISPR is widely acknowledged as one of the most important technological breakthroughs in human history. It makes editing genetic material far simpler and more affordable. The tomatoes are part of a pending onslaught of CRISPR-modified foodstuffs hitting the markets. Kale that lacks the bitter aftertaste, drought-resistant cattle and rice, and bananas that can better withstand viruses are all heading toward fields and shelves at a

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breakneck pace because of CRISPR. The technology is moving quickly, at times outpacing regulatory efforts. Many nations are setting up expedited approval processes for CRISPR products because the technique allows researchers to go from lab to field to shelf many times faster than by previous genetic-modification methods.

How to label and describe CRISPR products is also controversial. They often entail no introduction of genetic material from other organisms, instead replicating or switching existing genes. However, the speed and power of the modifications have some scientists concerned that CRISPR may have the potential to be a Pandora's Box of unintended consequences let loose on the fields just when the world can poorly withstand shocks to the food system. CRISPR is here to stay—but are we ready to manage the risks? Short for Clustered Regularly Interspaced Short Palindromic Repeats, CRISPR repurposes an ancient bacterial defense mechanism to simplify the editing of DNA and RNA. CRISPR lets researchers edit genes much as writers cut and paste words on a computer. That is an oversimplification, as CRISPR does require knowledge of genetics as well as laboratory infrastructure—but CRISPR is significantly faster, cheaper, and more flexible than previous types of genetic modifications.

CRISPR supporters claim that editing genes without inserting foreign DNA makes it less inherently risky than older forms of genetic engineering that involved moving DNA from one species to another. Thus, they say, CRISPR works just like traditional cross-hybridization agriculture methods. The key difference is that CRISPR methods can accomplish in a year or less what formerly required a decade or longer, and at a lower cost. CRISPR crops present the world with both unprecedented opportunities and genuine risks. On the one hand, CRISPR can reset the balance of power in agricultural biotech. It is relatively cheap and relatively easy to learn. The types of modifications possible in CRISPR might allow countries and regions to take greater control of their food futures by modifying crops and animals specifically to try to meet regional and national conditions or tastes rather than pay steep fees to global agribusiness concerns for seeds and a steady stream of pesticides. As one of the most powerful technological developments of the past century, CRISPR presents a remarkable opportunity for the world to reset the global balance of power in food and to futureproof the food supply by making it more productive and more resilient. That said, failing to scrutinize CRISPR processes and products could be a recipe for ecosystem collapse and—considering that food is truly life and the most critical resource in the world alongside water—rapid extinction. Private industry could play a role in this regard, creating failsafe tools for managing CRISPR crops. Moreover, governments should consider CRISPR what it is: a novel, remarkable, but still unproven technology. (Ref. 2) **[Back to Newsletter's Page 1](#)**

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3. ENVIRONMENTAL REGULATIONS**White House Climate and Environmental Justice Screening Tool**

The White House Council on Environmental Quality (“CEQ”) recently released Version 1.0 of its Climate and Economic Justice Screening Tool (“CEJST”), an interactive geospatial mapping tool identifying communities burdened by various socioeconomic and environmental factors. According to the White House, CEJST is key in the implementation of President Biden’s Justice40 Initiative, which is the administration’s effort to ensure that disadvantaged communities receive 40% of the overall benefits of federal climate, clean energy, clean water, and other investments. As the White House’s recent Executive Order on Further Advancing Racial Equity and Support for Underserved Communities Through the Federal Government demonstrates, environmental justice continues to be a key focus of the administration. CEJST will help the federal government identify disadvantaged communities that would benefit from federal investments in climate, clean energy and energy efficiency, clean transit, affordable and sustainable housing, remediation efforts and clean water infrastructure, among other areas. To date, CEJST has identified 27,251 communities as disadvantaged or partially disadvantaged, defined as either (1) belonging in a census tract that satisfies the requirements of at least one of CEJST’s categories of burden and their corresponding economic indicators, or (2) are on the lands of a federally recognized Tribe.

CEJST is easy to use. A search field on the upper-left corner of the interactive map allows the user to input a location. The map then navigates to the requested area, identifying the surrounding census tracts. Tracts that are designated as disadvantaged communities are shaded gray. Clicking on the gray area further isolates the map into individual census tracts with unique data sets. The text to the right of the map displays factors like climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development. Each of the factors can be expanded to reveal statistics that are more specific relevant to the selected census tract. Notably, CEJST should not be confused with EJScreen 2.1, which is an existing environmental justice mapping and screening tool that provides the U.S. Environmental Protection Agency with a consistent dataset and approach for analyzing environmental and demographic indicators side by side. There is considerable crossover in the datasets underlying CEJST and EJScreen; however, the tools are intended to serve different purposes. While CEJST primarily helps federal agencies to identify funding opportunities pursuant to the Justice40 Initiative, the EJScreen is designed to help the agencies when conducting environmental reviews and making permitting and

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enforcement decisions. The two tools overlap and can be used together not just by government agencies, but also by industries, and individuals, to help inform decisions about environmental matters with a lens of EJ concerns. (Ref. 3) [Back to Newsletter's Page 1](#)

EPA Releases Proposed Approach for Considering Cumulative Risks under TSCA

On February 27, 2023, the U.S. Environmental Protection Agency (EPA) announced the availability of and solicited public comment on two draft documents that are being submitted to the Science Advisory Committee on Chemicals (SACC) for peer review: “Draft Proposed Principles of Cumulative Risk Assessment under the Toxic Substances Control Act” (draft proposed principles) and “Draft Proposed Approach for Cumulative Risk Assessment of High-Priority Phthalates and a Manufacturer-Requested Phthalate under the Toxic Substances Control Act” (draft proposed approach). 88 Fed. Reg. 12354. In its February 24, 2023, press release, EPA states, until now, it has generally approached Toxic Substances Control Act (TSCA) risk assessments by looking at the risk posed by a single chemical. In many cases, people are exposed to multiple chemicals with similar effects at the same time, however, and in some of these cases, EPA “believes that the best approach to evaluate risk to human health may be to look at the combined risk to health from these chemicals.”

In the draft proposed principles, EPA outlines the proposed principles of CRA as potentially conducted in support of TSCA risk evaluations. EPA notes that it is not explicitly required to conduct CRAs under TSCA, but states that “TSCA does require EPA to consider reasonably available information and to use the best available science to ensure that decisions are based on the weight of the scientific evidence.” According to the draft proposed principles, EPA “recognizes that for some chemical substances, the best available science may indicate that the development of a CRA is appropriate to ensure that risk is adequately characterized.” In the draft proposed approach, EPA proposes a methodology for evaluating cumulative risk for the phthalate chemicals currently under review. EPA proposes that di-ethylhexyl phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP), di-isobutyl phthalate (DIBP), dicyclohexyl phthalate (DCHP), and di-isononyl phthalate (DINP) (but not di-isodecyl phthalate (DIDP)) are toxicologically similar (and pose an additive hazard) and that the U.S. population is co-exposed to these phthalates. Therefore, EPA proposes to group these phthalates for CRA under TSCA.

EPA states in its press release that the proposed approach “is not itself a cumulative risk assessment nor does it make a finding of risk, but rather is a methodology that EPA proposes to use and seeks public input about and peer review on.” Additionally, since EPA has not yet

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developed risk estimates for the individual chemicals, EPA “cannot predetermine the results of that work in this cumulative risk assessment approach.” EPA is conducting the CRA for phthalates and individual risk evaluations in parallel, and EPA notes that those risk evaluations will undergo their own public comment and peer review, as appropriate. By releasing the draft proposed approach for public comment and peer review now, EPA “is assuring that the methods used to conduct the cumulative risk assessment will be based on the best available science.” According to EPA, the results of the phthalate CRA may help inform its individual phthalate risk evaluations and ultimately the unreasonable risk determinations.” (Ref. 4) [Back to Newsletter’s Page 1](#)

4. EDITORIAL BOARD SELECTIONS**pH Testing and the pH Meter for Food Analysis**

pH is a measurable parameter between the values of 0 and 14, defining the acidity or alkalinity of a solution. Solutions with a $\text{pH} = 7$ are considered neutral, $\text{pH} < 7$ are considered acidic and $\text{pH} > 7$ are considered basic, or alkaline. The term pH can be defined as the “potential of the hydrogen ions” and its value determines many factors in the chemical environment of molecules, affecting properties such as the solubility of compounds, chemical reactions, and availability of nutrients, biological functions and microbial activity among many others. pH testing is the process by which the acidity or alkalinity of a substance is determined. Expressing the acidity of a solution imposes challenges as it involves a single ion species quantification, over a broad range of concentrations. Therefore, a more convenient way to express this property was established based on a logarithmic measure of the concentration of hydrogen ions in a solution. A pH meter is an electric device used to measure hydrogen ion activity in water-based solutions. The pH meter is used in many applications such as for laboratory experimentation, in testing food and beverages, in the oil and gas industry, for testing pharmaceuticals, verifying water treatments and in agriculture among others.

The pH values largely affect bioprocesses driven by enzymatic or microbial activity, impacting process yields and specificity. Taste is radically influenced by pH, since pH levels can help to regulate sweetness and sourness perception. In addition, the texture is pH dependent and many foods rely on accurate pH levels to create and control the desired texture. pH level also affects food appearance, by stabilizing or destabilizing colloidal mixtures and thus leading to the formation of a hazy appearance or precipitates in clear

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mixtures. Many food constituents are also natural pH indicators, changing color according to the pH. This is the case of anthocyanins in wine, fruits and vegetables. In food safety, pH plays a crucial role in inhibiting the growth of spoilage microorganisms. For these reasons, most regulatory agencies impose rules for the pH levels of certain commercial foods, since generally acidic foods ($\text{pH} < 4.6$) are considered safer and allow longer shelf lives.

Foods may have low pH because of naturally occurring acids, and as a result, most foods are considered acidic. Through scientific criteria, any food with a pH lower than 7 is considered acidic, however there are sub classifications according to the acidity level. Food products with a pH between 4.6 and 7 are considered low acid foods and are more susceptible to microbial growth. For this reason, common production standards and regulatory legislation often requires the use of severe preservation processes in such products. High acid foods, such as most fruits and fermented foods have a pH naturally below 4.6, ensuring higher safety and demanding lower protection concerns. Similarly, safety criteria are applied to acidified foods, achieving a pH value below 4.6 by the addition of edible acids. To ensure adequate pH levels, increase shelf life and prevent spoilage, manufactures often include ingredients to regulate acidity, such citric or acetic acid either in their pure forms or as lemon juice and vinegar.

An alkaline diet has been popularized, claiming to improve health, fight disease and reduce cancer risk. The basic claim is that such a diet improves the acid–base balance and raises the urinary pH. Some advocates of this diet argue that the classification is not related with the food’s actual pH but their effects on the body or on the abundance of alkali-generating ash or mineral content in such foods. This does not change the fact that the classification of acidic and alkaline foods promoted by this current trend is not really related with their actual pH values. Thus, the common tables and charts categorizing foods according to the alkaline diet criteria are fundamentally erroneous. Furthermore, the claim that the alkaline diet can change the body’s pH is dubious, as there are no studies proving it so and the human body has several mechanisms to maintain a stable pH level. Yet, and regardless of the scientific inaccuracies and little dependence on the food pH, the “alkaline diet” does encourage healthy eating patterns, focusing in fresh fruits, vegetables and plant-based alternatives. The limitation of animal protein intake, associated with the guidelines of the alkaline diet may also lead to the reduction of acidic compound accumulation in the body and possibly improve renal function. Regardless of the diet’s effectivity or eventual health benefits, its classification as well as the pH values of foods included on its lists should be approached with caution and with awareness that it does not follow the scientific criteria for pH determinations and classification. (Ref. 5)

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ENVIRONMENTAL SYSTEMS DIVISION NEWSLETTER**Tasteless Strawberries? Pesticides Could Be the Reason**

Have you ever bitten into a plump, red strawberry, only to find it bland and watery? Certain pesticides might be responsible. A team reporting in ACS' Journal of Agricultural and Food Chemistry has found that two common strawberry fungicides can affect cellular mechanisms, creating berries with subdued flavor and sweetness, as well as a lower nutritional value. The flavor profile of any produce, including berries, is a result of its taste and smell — sweetness often arises from the amount of dissolved glucose or fructose, and a unique aroma comes from volatile compounds, such as esters and terpenes. In addition, many fruits are also full of nutrients, including vitamin C, folic acid and antioxidants. However, because fungicides are designed to disrupt the cellular processes of detrimental fungi, they could accidentally interfere with these processes in crops, inhibiting production of these important flavor and nutritional compounds.

The researchers grew three groups of strawberries (*Fragaria x ananassa* Duch) in identical conditions, applying BOS or DIF to two of the groups when the berries were still green. Even after treatment, the fully-grown berries were identical in size and color to those grown without pesticide. Yet, under the surface, the team found a number of chemical changes caused by both of the fungicides:

- The levels of soluble sugars and nutrients, such as sucrose and vitamin C, were reduced.
- Sugars were converted into acids, further reducing sweetness.
- The amount of volatile compounds changed, subduing the berry's taste and aroma.

Looking more closely, the team found that BOS had a direct effect on the regulation of genes involved in cellular pathways related to producing sugars, volatile compounds, nutrients and amino acids. Finally, in a blind taste test, people consistently preferred the untreated strawberries. The researchers say that this work could provide guidance to farmers about the use of pesticides. (Ref. 6)

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Catalyst Purifies Herbicide-Tainted Water and Produces Hydrogen as a Bonus

Researchers in the Oregon State University College of Science have developed a dual-purpose catalyst that purifies herbicide-tainted water while also producing hydrogen. The project, which included researchers from the OSU College of Engineering and HP Inc. is important because water pollution is a major global challenge, and hydrogen is a clean, renewable fuel. Findings of the study, which explored photoactive catalysts, were published in the journal ACS Catalysis. "It is possible to combine oxidation and reduction into a single process to achieve an efficient photocatalytic system,". "Oxidation happens via a photodegradation reaction, and reduction through a hydrogen evolution reaction." A catalyst is a substance that

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increases the rate of a chemical reaction without itself undergoing any permanent chemical change. Photocatalysts are materials that absorb light to reach a higher energy level and can use that energy to break down organic contaminants through oxidation. Among photocatalysts' many applications are self-cleaning coatings for stain- and odor-resistant walls, floors, ceilings and furniture.

Made up of positively charged metal ions surrounded by organic "linker" molecules, MOFs are crystalline, porous materials with tunable structural properties and nanosized pores. They can be designed with a variety of components that determine the MOF's properties. Upon MOFs' calcination – high heating without melting – semiconducting materials like titanium dioxide can be generated. Titanium dioxide is the most commonly used photocatalyst, and it is found in the minerals anatase, rutile and brookite. The team discovered that anatase doped with nitrogen and sulfur was the best "two birds, one stone" photocatalyst for simultaneously producing hydrogen and degrading the heavily used herbicide glyphosate. Glyphosate, also known as N-phosphonomethyl glycine or PMG, has been widely sprayed on agricultural fields over the last 50 years since first appearing on the market under the trade name Roundup. "Only a small percentage of the total amount of PMG applied is taken up by crops, and the rest reaches the environment,". "That causes concerns regarding the leaching of PMG into soil and groundwater, as well it should – contaminated water can be detrimental to the health of every living thing on the planet. And herbicides leaching into water channels are a primary cause of water pollution." Among an array of compounds in which hydrogen is found, water is the most common, and producing hydrogen by splitting water via photocatalysis is cleaner and more sustainable than the conventional method of deriving hydrogen – from natural gas via a carbon-dioxide-producing process known as methane-steam reforming. Hydrogen serves many scientific and industrial purposes in addition to its energy-related roles. It is used in fuel cells for cars, in the manufacture of many chemicals including ammonia, in the refining of metals and in the production of plastics. "Water is a rich hydrogen source, and photocatalysis is a way of tapping into the Earth's abundant solar energy for hydrogen production and environmental remediation." (Ref. 7)

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Toilet Paper an Unexpected Source of PFAS Pollutants

Wastewater can provide clues about a community's infectious disease status, and even its prescription and illicit drug use. Nevertheless, looking at sewage also provides information on persistent and potentially harmful compounds, such as per- and polyfluoroalkyl substances (PFAS), that are released into the environment. Now, researchers in ACS'

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Environmental Science & Technology Letters report an unexpected source of these substances in wastewater systems — toilet paper. PFAS have been detected in many personal care products, such as cosmetics and cleansers that people use every day and then wash down the drain. However, not many researchers have considered whether toilet paper, which also ends up in wastewater, could be a source of the chemicals. Some paper manufacturers add PFAS when converting wood into pulp, which can be left behind and contaminate the final paper product. In addition, recycled toilet paper could be made with fibers that come from materials containing PFAS. Therefore, Timothy Townsend and colleagues wanted to assess this potential input to wastewater systems, and test toilet paper and sewage for these compounds.

The researchers gathered toilet paper rolls sold in North, South and Central America; Africa; and Western Europe and collected sewage sludge samples from U.S. wastewater treatment plants. Then they extracted PFAS from the paper and sludge solids and analyzed them for 34 compounds. The primary PFAS detected were disubstituted polyfluoroalkyl phosphates (diPAPs) — compounds that can convert to more stable PFAS such as perfluorooctanoic acid, which is potentially carcinogenic. Specifically, 6:2 diPAP was the most abundant in both types of samples but was present at low levels, in the parts-per-billion range. Then, the team combined their results with data from other studies that included measurements of PFAS levels in sewage and per capita toilet paper use in various countries. They calculated that toilet paper contributed about 4% of the 6:2 diPAP in sewage in the U.S. and Canada, 35% in Sweden and up to 89% in France. Despite the fact that North Americans use more toilet paper than people living in many other countries, the calculated percentages suggest that most PFAS enter the U.S. wastewater systems from cosmetics, textiles, food packaging or other sources, the researchers say. This study identifies toilet paper as a source of PFAS to wastewater treatment systems. (Ref. 8)

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Quantum Dots Offer Efficient Drinking Water Disinfection

Water contaminated with bacteria is a large threat to global health. A Chinese research team has described a simple new method of disinfection in the journal *Angewandte Chemie*. It is based on tiny biocompatible assemblies of atoms, known as quantum dots, made of silver sulfide with caps made of a silver-binding peptide. When irradiated with near-infrared light, they kill bacteria in water with high efficiency through synergistic effects. Particularly in developing nations and remote regions of the world, it can be very difficult to access clean drinking water. Pathogenic bacteria, such as *E. coli*, enterococci, salmonella, or cholera pathogens, can cause serious infections. A single swallow can sometimes have fatal consequences. Traditional disinfection methods widely implemented in recent decades, such as UV light, chlorination, and ozone, have disadvantages, including high costs, poor efficiency,

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poor biocompatibility, and carcinogenic by-products. An alternative is needed. The research team has now introduced a new method that is based on quantum dots made of silver sulfide (Ag₂S). Quantum dots are nanoscopic structures made of about one-to-ten thousand atoms that are “confined” in space. Their quantum-mechanical properties correspond more to those of molecules than macroscopic solids, which can lead to interesting opto-electronic effects.

Silver sulfide quantum dots are already used in photodynamic and photothermic therapy, including for the treatment of certain tumors and skin diseases. They can be used as contrast agents and as fluorescence thermometers. So far, they have not been used much for disinfecting water, partly because previous methods for preparing them have been complicated and expensive. The team from Nanjing University and the Nanchuang (Jiangsu) Institute of Chemistry and Health has now developed a simple, inexpensive production method, in which the quantum dots are enclosed by caps made from a specially developed biomimetic silver-binding peptide (AgBP2). When irradiated with near infrared (NIR) light, the new AgBP2-Ag₂S quantum dots effectively kill bacteria in water. They are chemically stable, photostable, and biocompatible. Their strong activity is due to a synergistic combination of two effects. First, irradiation causes them to produce highly reactive oxygen species, and second, they cause strong local heating. Neither of the two effects alone leads to success, but their synergistic combination destroys bacterial cell membranes. They are able to kill over 99 % of E. coli bacteria within 25 minutes of NIR irradiation—a promising strategy for antibacterial disinfection of water. (Ref. 9) [Back to Newsletter’s Page 1](#)

5. ESD NEWSLETTER READER COMMENTS

None received this month.

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NEWSLETTER ARTICLE SOURCES

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3. <https://www.natlawreview.com/article/white-house-climate-and-environmental-justice-screening-tool>
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ABOUT NEWSLETTER

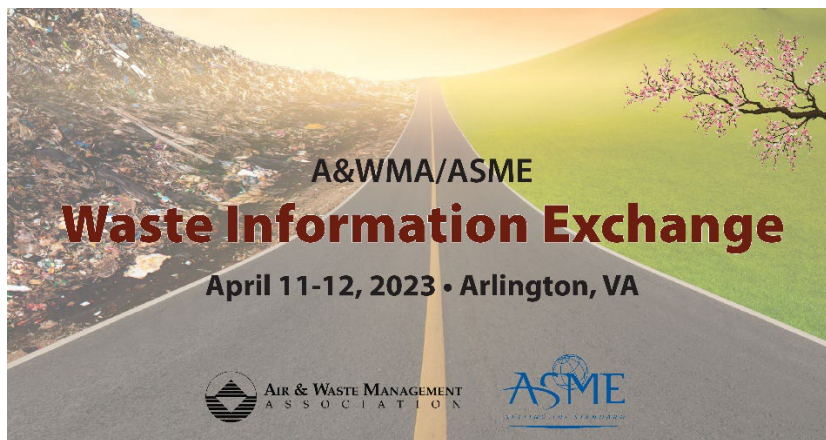
ENVIRONMENTAL ENGINEERING features the application of environmental technologies to engineering systems to attain optimal performance according to established standards. The Newsletter of the Environmental Systems Division (ESD) will attempt to highlight a variety of environmental technology applications aimed at enhancing engineering systems performances in accordance with the latest standards by presenting excerpts of and links to selected articles from a variety of websites.

DISCLAIMER

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Upcoming Webinars (Live or Recorded Access) / Conferences



[Joint Rail Conference](#)

Sheraton Inner Harbor Hotel, Baltimore, MD
April 11-13, 2023

[30th International Conference on Nuclear Engineering](#)

Kyoto International Conference Center, Kyoto, Japan
May 21-26, 2023

[42nd International Conference on Ocean, Offshore & Arctic Engineering](#)

Melbourne Convention and Exhibition Centre, Melbourne, Australia
June 11-16, 2023

[Turbo Expo 2023](#)

Hynes Convention Center, Boston, MA, USA
June 26-30, 2023