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RECENT PRODUCTS OF THE HOMELAND SECURITY RESEARCH PROGRAM

WATER SECURITY-RELATED EDITION

MANY OF OUR PRODUCTS HAVE MULTIPLE USES, NOT JUST HOMELAND SECURITY APPLICATIONS

Products that Support Distribution System Modeling

EPA's Water Security Modeling and Simulation Research Technical Brief

This brief provides high level summaries and links to the HSRPs modeling and simulation tools

A Software Framework for Assessing the Resilience of Drinking Water Systems to Disasters with an Example Earthquake Case Study Journal Article

Water utilities are vulnerable to a wide variety of human-caused and natural disasters. The Water Network Tool for Resilience (WNTR) is a new open source Python™ package designed to help water utilities investigate resilience of water distribution systems to hazards and evaluate resilience-enhancing actions. In this paper, the WNTR modeling framework is presented and a case study is described that uses WNTR to simulate the effects of an earthquake on a water distribution system. While earthquakes are particularly concerning since buried water distribution pipelines are highly susceptible to damage, the software framework can be applied to other types of hazards, including power outages and contamination incidents. Water Network Tool for Resilience (WNTR) User Manual

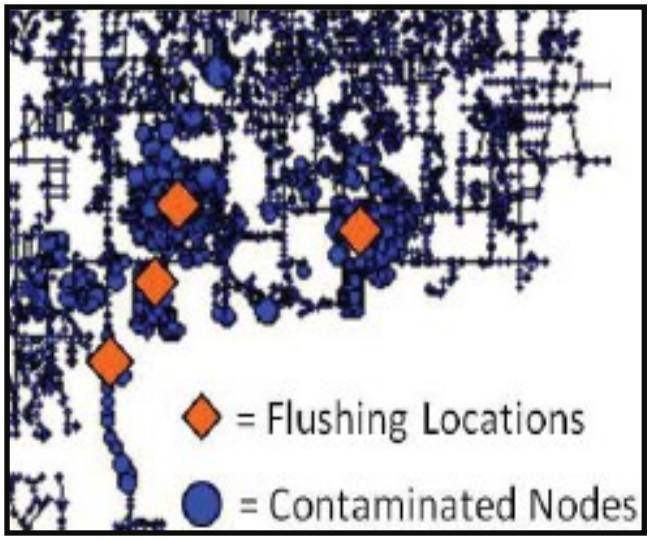
Modeling Fate and Transport of Arsenic in a Chlorinated Distribution System Journal Article

Experimental and modeling studies were conducted to understand the fate and transport properties of arsenic in drinking water distribution systems. Pilot scale experiments were performed in a distribution system simulator by injecting arsenic and measuring both adsorption onto iron pipe material and the oxidation of arsenite by hypochlorite in tap water to form arsenate. A mathematical model describing these processes was developed and simulated using EPANET-MSX, a hydraulic and multi-species water quality software for pipe networks.

Inside this issue

Water Security Toolkit User Manual: Version 1.3

The Water Security Toolkit (WST) is a suite of tools that help provide the information necessary to make good decisions resulting in the minimization of further human exposure to contaminants, and the maximization of the effectiveness of intervention strategies. WST assists in the evaluation of multiple response actions in order to select the most beneficial consequence management strategy. It includes hydraulic and water quality modeling software and optimization methodologies to identify: (1) sensor locations to detect contamination, (2) locations in the network in which the contamination was introduced, (3) hydrants to remove contaminated water from the distribution system, (4) locations in the network to inject decontamination agents to inactivate, remove or destroy contaminants, (5) locations in the network to take grab sample to confirm contamination or cleanup and (6) valves to close in order to isolate contaminated areas of the network.



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U.S. EPA's Homeland Security Research Program

U.S. EPA's Homeland Security Research Program (HSRP) provides scientific solutions that:

Improve water utilities' abilities to prepare for and respond to all hazards incidents that threaten public health.

Advance EPA's capabilities to respond to wide area chemical, biological or radiological contamination incidents, including those resulting from terrorism or natural disasters.

Incorporating a Capability for Estimating Inhalation Doses in TEVA-SPOT Report and data

This report presents the approach to be used to incorporate in the U.S. Environmental Protection Agency's TEVA-SPOT software (U.S.EPA 2014) a capability for estimating inhalation doses that result from the most important sources of contaminated aerosols and volatile contaminants during a contamination event.

Modeling and Experimental Testing of Sediment Resuspension in Water Distribution Storage Tanks Journal Article

Sediments in storage tanks have the potential to accumulate pathogens, metals, and other hazardous materials. This report addresses the potential for sediments in storage tanks to be transported back into water distribution systems. Computational fluid dynamics (CFD) models were developed and three simulation studies were conducted to provide insight into sediment resuspension processes in tanks. In addition, a pilot-scale experiment was conducted to validate the model predictions. The results of this study highlight tank operating conditions which might reduce resuspension and removal of sediments from tanks.

RTX:Link – An EPANET-RTX Application For Water Utilities To Implement Real-Time Analytics Technical Brief

RTX:LINK is an EPANET-RTX-based software tool developed for drinking water utilities, small and large, to harness supervisory control and data acquisition (SCADA) data and the power of real-time analytics. RTX:LINK provides a web browser view - via smart phone, tablet or computer - of all available utility SCADA data through a cloud analytics service to allow the water utility to remotely access and analyze their SCADA data in real-time. RTX:LINK provides remote access to all available hydraulic and operational data (e.g., tank levels, flows and pressures) and a few water quality metrics (e.g., percent tank turnover per day or per week) to help inform and alert operators, engineers or managers to potential problems.

Sediment Resuspension and Transport in Water Distribution Storage Tanks Journal Article

Computational and experimental studies were conducted to better understand conditions that affect particle resuspension and movement in water storage tanks. Parameters that were investigated included inlet/outlet (I/O) line location and diameter, flow rate, particle size, and filling versus draining cycles. Simulation results showed that smaller particle sizes, higher flow rates, and draining cycles yielded the greatest potential for particle resuspension, which was generally limited to regions near the I/O line. Small-scale experiments were also performed using different sizes of glass beads and silica sand; the results generally validated the models. Mitigation methods were also presented to reduce the amount of particle resuspension. A pipe that extended from the I/O line into the tank (slightly above the bottom floor) was found to significantly reduce the potential for particle resuspension in both the computational models and experiments.

Testing Contamination Source Identification Methods for Water Distribution Networks Journal Article

In the event of contamination in a water distribution network source identification (SI) methods that analyze sensor data can be used to identify the source location(s). Knowledge of the source location and characteristics are important to inform contamination control and cleanup operations. Various SI strategies that have been developed by researchers differ in their underlying assumptions and solution techniques.
The manuscript presents a systematic procedure for testing and evaluating SI methods.

Coming in 2018

Ohio River Basin Vulnerability and Emergency Management Decision Support Tool

Application of real-time analytics and modeling at City of Flint water system

Decontamination of chemicals in drinking water infrastructure and premise plumbing

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PRODUCTS RELATED TO DECONTAMINATION OF WATER DISTRIBUTION SYSTEMS

Decontamination of Bacillus spores adhered to iron and cement-mortar drinking water infrastructure in a model system using disinfectants Journal Article

Decontamination of Bacillus spores adhered to common drinking water infrastructure surfaces was evaluated using a variety of disinfectants. Corroded iron and cement-mortar lined iron represented the infrastructure surfaces, and were conditioned in a 23 m long, 15 cm diameter (75 ft long, 6 in diameter) pilot-scale drinking water distribution pipe system. Decontamination was evaluated using increased water velocity (flushing) alone at 0.5 m s (1^{-1}.7 ft s^{-1}), as well as free chlorine (5 and 25 mg L^{-1}), monochloramine (25 mg L^{-1}), chlorine dioxide (5 and 25 mg L^{-1}), ozone (2.0 mg L^{-1}), peracetic acid 25 mg L^{-1}) and acidified nitrite (0.1 mol L^{-1} at pH 2 and 3), all followed by flushing at 0.3 m s^{-1} (1 ft s^{-1}). Flushing alone reduced the adhered spores by 0.5 and 2.0 log10 from iron and cement-mortar, respectively. Log10 reduction on corroded iron pipe wall coupons ranged from 1.0 to 2.9 at respective chlorine dioxide concentrations of 5 and 25 mg L^{-1}, although spores were undetectable on the iron surface during disinfection at 25 mg L^{-1}. Acidified nitrite (pH 2, 0.1 mol L^{-1}) yielded no detectable spores on the iron surface during the flushing phase after disinfection. Chlorine dioxide was the best performing disinfectant with >3.0 log10 removal from cement-mortar at 5 and 25 mg L^{-1}. The data show that free chlorine, monochloramine, ozone and chlorine dioxide followed by flushing can reduce adhered spores by > 3.0 log10 on cement-mortar.

Decontamination of Drinking Water Infrastructure Contaminated with Bacillus Spores on Iron and Cement-mortar Surfaces Technical Brief

This study examines the effectiveness of decontaminating corroded iron and cement-mortar coupons that have been contaminated with spores of Bacillus atrophaeus subsp. globigii (B. globigii), which is often used as a surrogate for pathogenic B. anthracis (anthrax) in disinfection studies. Bacillus spores are persistent on common drinking water material surfaces like corroded iron, requiring physical or chemical methods to decontaminate the infrastructure. In the United States, free chlorine and monochloramine are the primary chemical disinfectants used by the drinking water industry to inactivate microorganisms. Flushing is also a common, easily implemented practice in drinking water distribution systems, although large volumes of contaminated water needing treatment could be generated. Identifying readily available alternative disinfectant formulations for infrastructure decontamination could give water utilities options for responding to specific types of contamination events. In addition to presenting data on flushing alone, which demonstrated the persistence of spores on water infrastructure in the absence of high levels of disinfectants, data on acidified nitrite, chlorine dioxide, free chlorine, monochloramine, ozone, peracetic acid, and followed by flushing are provided

[Radiological Contaminant Persistence and Decontamination in Drinking Water Pipes] Report

The objective of this study was to use the Pipe Decontamination Experimental Design Protocol (PDEDP) to evaluate the persistence of cesium, cobalt, and strontium on concrete and polyvinyl chloride (PVC) and explore possible decontamination approaches. The PDEDP is an approach for evaluating the persistence characteristics of contaminants on drinking water pipe materials and various decontamination approaches.

[EPA's Water Security Test Bed] Technical Brief

Summary of the Test Bed ‘s design and capabilities

[Testing large volume water treatment and crude oil decontamination using the Water Security Test Bed at the Idaho National Laboratory] Report

EPA’s Homeland Security Research Program (HSRP) partnered with the Idaho National Laboratory (INL) to build the Water Security Test Bed (WSTB) at the INL test site outside of Idaho Falls, Idaho. The WSTB was built using an 8-inch (20 cm) diameter cement-mortar lined drinking water pipe that was previously taken out of service. The pipe was exhumed from the INL grounds and oriented in the shape of a small drinking water distribution system. Effluent from the pipe is captured in a lagoon. The WSTB can support drinking water distribution system research on a variety of drinking water treatment topics including biofilms, water quality, sensors, and homeland security related contaminants. Because the WSTB is constructed of real drinking water distribution system pipes, research can be conducted under conditions similar to those in a real drinking water system.

In 2014, WSTB pipe was experimentally contaminated with Bacillus globigii spores, a non-pathogenic surrogate for the pathogenic B. anthracis, and then decontaminated using chlorine dioxide. In 2015, the WSTB was used to perform the following experiments: Four mobile disinfection technologies were tested for their ability to disinfect large volumes of biologically contaminated “dirty” water from the WSTB. B. globigii spores acted as the biological contaminant. The four technologies evaluated included: (1) Hayward Saline C™ 6.0 Chlorination System, (2) Advanced Oxidation Process (AOP) Ultraviolet (UV)-Ozone System, (3) Solstreme™ UV System, and (4) WaterStep Chlorinator. The WSTB pipe was contaminated with Bakken crude oil, and decontamina-

Water Security Test Bed

PRODUCTS RELATED TO WATER TREATMENT

Disinfection of biological agents in the field using a mobile advanced oxidation process Report

The Army's Net Zero Initiative is an energy-conservation program that focuses on energy as well as water and waste usage procedures. All Net Zero projects are geared toward helping the military installation or community become more sustainable and resilient, with an emphasis on taking a systems approach. Net Zero projects must advance the state of the science and are focused on three general topic areas: water, energy, and waste, and the nexuses among them. This project examined the inactivation and/or removal of biological contaminants in dirty wash water using a portable ozone-UV AOP process. The strain of E. coli used in these experiments is not a biological warfare agent, but acts as a surrogate for certain of the vegetative biological agents such as the enterohemorrhagic strain designated E. coli 0157:H7.

Treatment of Perfluorinated Alkyl Substances in Wash Water Using Granular Activated Carbon and Mixed-Media Report

This report summarizes the results from testing conducted to evaluate the treatment of large volumes of water containing perfluorinated alkyl substances (PFAS). Specifically, treatment for water contaminated by aqueous film forming foam (AFFF), which is used to fight very hot hydrocarbon based fires, as may arise from the response to petroleum spills and transportation accidents, was studied. Depending on the manufacturing process for the AFFF, the AFFF contaminated water can contain emerging contaminants such as perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), which are the subject of recent EPA health advisories. The AFFF selected for this study was a product widely used historically, and it contained PFOA and PFOS. The goal of the treatment was to reduce the PFAS concentration before disposal of the water (for example, in a sewer). The goal was not to reduce PFAS concentrations to drinking water advisory levels.

The WSTB pipe was not used for these experiments; instead, the WSTB discharge lagoon was contaminated with AFFF and the contaminated water was pumped through the treatment media then emptied into the bladder tanks. Treatment of the AFFF contaminated water was investigated via granular activated carbon (GAC) and mixed-media. Specifically, the Calgon FiltrasorbÂ® 600 GAC and the Ziltek RemBindâ„¢ mixed-media were selected for evaluation.

Results

- Both GAC and RemBind™ are capable of removing various short-and-long chain PFAS with an efficiency greater than 99.9%, on average, over a 12-hour period
- The removal of shorter chains is of importance because newer AFFF products are formulated to eliminate longer chain PFAS. This suggests that water contaminated with newer AFFF formulations can also be successfully treated with these adsorbents
- GAC media can accommodate a higher flowrate than the RemBind™ media. Up to 6.5 gallons per minute (gpm) (41.7 bed volumes) was achieved in two drums of GAC in series, while a total of 4 gpm (22 bed volumes) was achieved through two RemBind™ drums operated in parallel (2 gpm per drum)
- For some PFAS, the data suggests that the first GAC drum in series (drum 1) was losing its adsorptive capacity, and breakthrough of PFAS was occurring. However, breakthrough was not observed in the second drum in series.

OTHER WATER SECURITY RELATED PRODUCTS

Redesign of Water Distribution Systems for Passive Containment of Contamination Journal Article

Most water distribution systems in the United States are designed as looped systems in order to allow multiple pathways for delivery of water to customers. However, these designs also have the negative consequence that, if the system is contaminated, the contamination may travel widely through the system and have widespread impacts. In this article, an alternative design concept is suggested based on the creation of distribution blocks that subdivide and isolate the system so as to limit contaminant movement. A model-based case study involving a large distribution system was used to evaluate the effectiveness of the distribution block concept. A comparison of the original looped system and the redesigned system also included the following other performance indicators: water age, reliability, and fire flow performance. The analysis showed that for this system, there was a very significant decrease in the water security vulnerability impacts with minimal effects on the other performance indicators.

Detention Outlet Retrofit Improves the Functionality of Existing Detention Basins by Reducing Erosive Flows in Receiving Channels Journal Article

By discharging excess stormwater at rates that more frequently exceed the critical flow for stream erosion, conventional detention basins often contribute to increased channel instability in urban and suburban systems that can be detrimental to aquatic habitat and water quality, as well as adjacent property and infrastructure. However, these ubiquitous assets, valued at approximately $600,000 per km^2 in a representative suburban watershed, are ideal candidates to aid in reversing such cycles of channel degradation because improving their functionality would not necessarily require property acquisition or heavy construction. The objective of this research was to develop a simple, cost-effective device that could be installed in detention basin outlets to reduce the erosive power of the relatively frequent storm events (~ < two-year recurrence) and provide a passive bypass to maintain flood control performance during infrequent storms (such as the 100-year recurrence). .

Evaluation of Exposure to Brevundimonas Diminuta and Pseudomonas Aeruginosa During Showering Journal Article

This study experimentally assessed bacterial water-to-air partitioning coefficients resulting from showerhead aerosolization of water contaminated with *Brevundimonas diminuta* or *Pseudomonas aeruginosa*, and estimated human exposure through inhalation. Dechlorinated tap water was spiked with two cell densities (10^9 and 10^{10} CFU L^{-1}) and cycled at three temperatures (10, 25, and 37 or 40 °C) through a full-scale shower system. For reproducibility, spiked water concentrations were intentionally higher than those found in natural environments. Three types of samplers measured size distribution and viable concentrations throughout the system. Results indicate low levels of respirable bioaerosols were generated. The ratio of bacterial contaminant that was effectively aerosolized (bacterial water-to-air partitioning coefficient, PC_{bwa}) was low – averaging 1.13×10^{-5} L m^{-3} for *B. diminuta* and 8.31×10^{-6} L $m^{-3}$for *P. aeruginosa*. However, the respirable fraction of aerosolized organisms was high, averaging above 94% (in shower) and above 99% (downstream) for both organisms. This study found no significant difference in bioaerosol load for a forward facing versus reverse facing individual. Further, for the average hot shower (33–43 °C) the total number of respirable bioaerosols is higher, but the observed culturability of those aerosolized cells is lower when compared to lower temperatures. Bacterial water to air partitioning coefficients were calculated to predict microbial air concentration and these empirical parameters may be used for assessing inhalation as a route of exposure to pathogens in contaminated waters.