Protecting Wastewater Treatment Plant Operators from Emerging Pathogens

Wednesday, August 24, 2016

1:00 – 3:00 p.m. ET

This Joint Water Environment Federation and Water Environment & Reuse Foundation webcast is presented in collaboration with the National Science Foundation, the National Association of Clean Water Agencies, American Water, and the U.S. Environmental Protection Agency.

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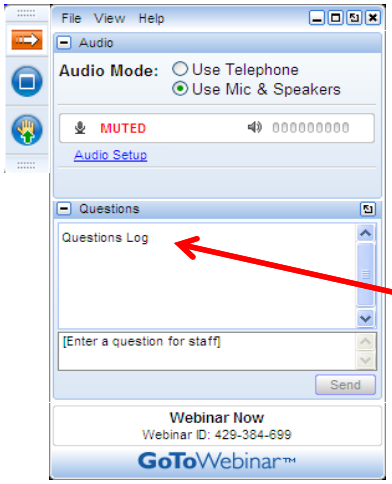
How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this web seminar.**

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Today's Moderator

Lola Olabode, M.P.H
Program Director
Water Environment & Reuse Foundation

Agenda

Introductory Remarks
Lola Olabode – WE&RF & Chris Stacklin – Orange County Sanitation District

Protecting Wastewater Treatment Plant Operators from Emerging Pathogens
Jackie MacDonald-Gibson, University of North Carolina

PPE Practices and Implementation Challenges in Hospitals
Lisa Casanova, Georgia State University

NIOSH Investigations of Workplace Exposure & Employee Health
Nancy Burton, NIOSH/CDC

Worker Health and Safety Culture
Bill Komianos, American Water

Effectiveness of Existing EPA PPE and Decontamination Practices in Protecting Emergency Response Workers from Exposure to Pathogens
John Archer, U.S. EPA

Summary of Workshop on Protecting Wastewater Workers from Infectious Disease Risks
Jackie MacDonald-Gibson, UNC

Q&A and Wrap-Up

Protecting Wastewater Treatment Workers from High Consequence Pathogens

Christopher Stacklin, P.E.

WE&RF Antibiotic Resistance Project Advisory Committee Member
WE&RF Issue Area Team, Resource Recovery
Chair, WEF Water Reuse Committee
Chair, WEF Government Affairs Committee, Regulatory Affairs Subcommittee
WEF House of Delegates
Orange County Sanitation District

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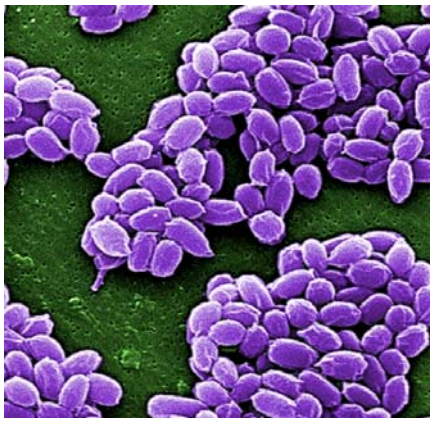
High-Consequence Pathogens

Bacillus. B. anthracis bacterium (etiologic agent of anthrax)



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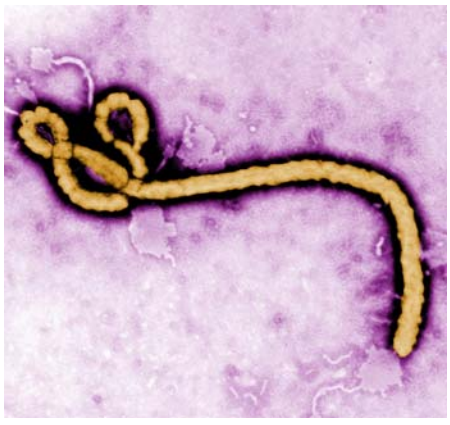
Ebola



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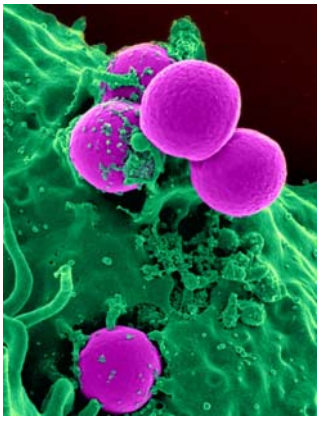
Antibiotic / Antimicrobial Resistance Bacteria

Carbapenem-resistant Enterobacteriaceae (CRE)

CDC / Getty Images

Methicillin-resistant Staphylococcus aureus (MRSA)



National Institute of Allergy and Infectious Diseases (NIAID)

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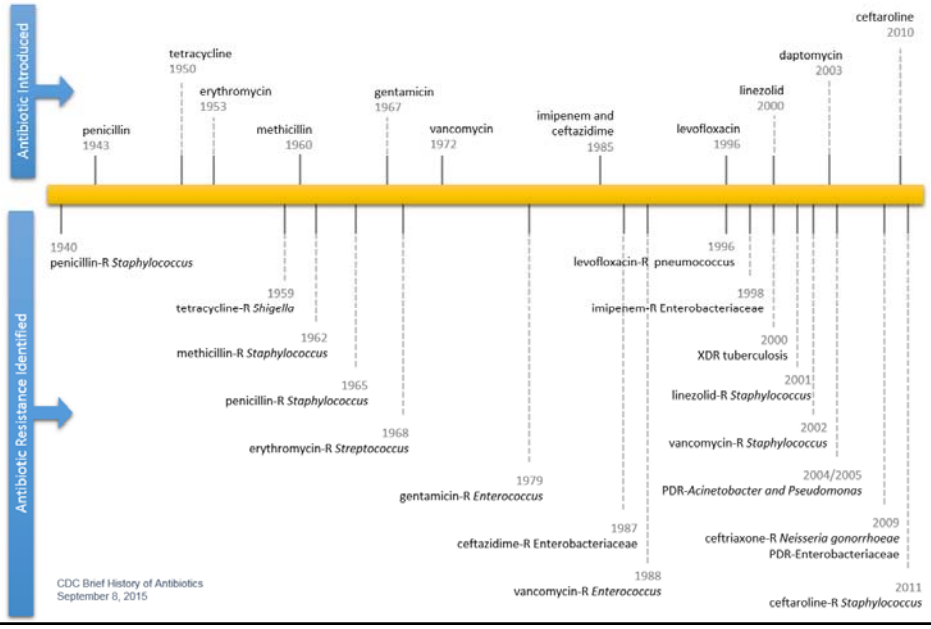
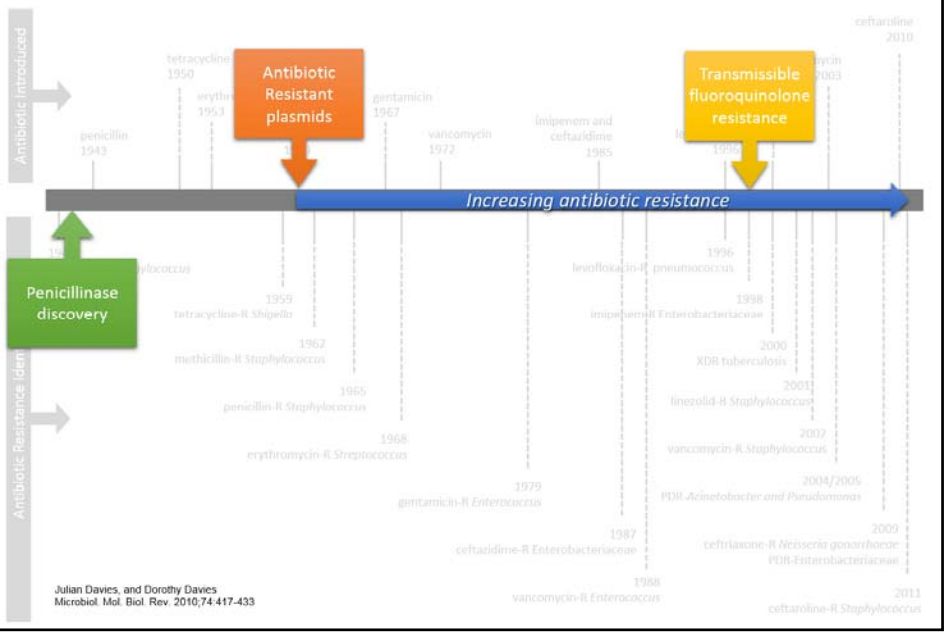
Timeline of Antibiotics



Events in the Age of Antibiotics



Events in the Age of Antibiotics

Alert to U.S. Healthcare Facilities: First *mcr-1* Gene in *E. coli* Bacteria found in a Human in the United States

HAN
HEALTH ALERT NETWORK

Distributed via the CDC Health Alert Network
June 13, 2016, 13:35 EDT (1:35 PM EDT)
CDCHAN-00390

This is an official CDC HEALTH ADVISORY

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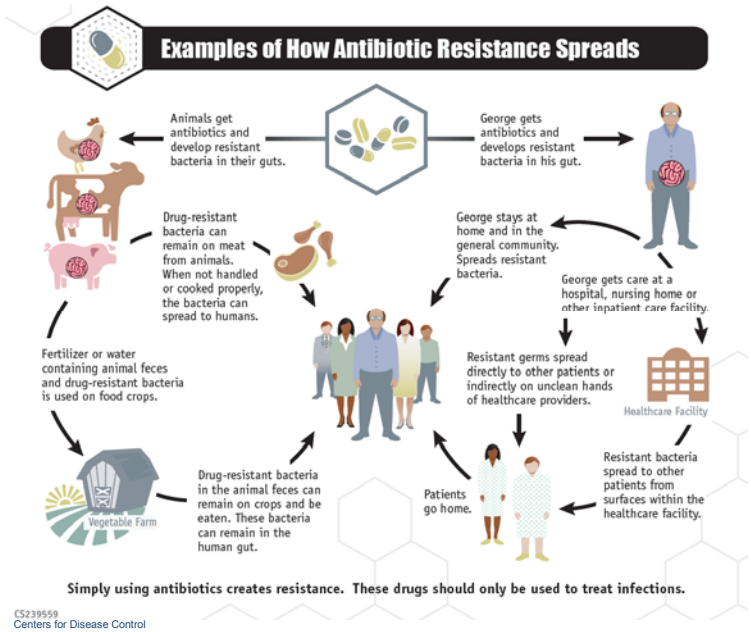

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Potential Wastewater Sources

U.S. Environmental Protection Agency

Li, X., Atwill, E.R., Antaki, E., Applegate, O., Bergamaschi, B., Bond, R.F., Chase, J., Ransom, K.M., Samuels, W., Watanabe, N. and Harter, T., 2015. Fecal indicator and pathogenic bacteria and their antibiotic resistance in alluvial groundwater of an irrigated agricultural region with dairies. Journal of environmental quality, 44(5), pp.1435-1447.

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Potential Wastewater Sources

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Rodriguez-Mozaz, S., Chamorro, S., Marti, E., Huerta, B., Gros, M., Sànchez-Melsió, A., Borrego, C.M., Barceló, D. and Balcázar, J.L., 2015. Occurrence of antibiotics and antibiotic resistance genes in hospital and urban wastewaters and their impact on the receiving river. Water research, 69, pp.234-242.

Varela, A.R., Ferro, G., Vredenburg, J., Yanık, M., Vieira, L., Rizzo, L., Lameiras, C. and Manaia, C.M., 2013. Vancomycin resistant enterococci: from the hospital effluent to the urban wastewater treatment plant. Science of the Total Environment, 450, pp.155-161.

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Sanderson, H., Fricker, C., Brown, R.S., Majury, A. and Liss, S.N., 2016. Antibiotic resistance genes as an emerging environmental contaminant. Environmental Reviews, 24(2), pp.205-218.

Mackuľak, T., Vojs, M., Grabic, R., Golovko, O., Staňová, A.V., Birošová, L., Medveďová, A., Híveš, J., Gál, M., Kromka, A. and Hanusová, A., 2016. Occurrence of pharmaceuticals, illicit drugs, and resistant types of bacteria in hospital effluent and their effective degradation by boron-doped diamond electrodes. Monatshefte für Chemie-Chemical Monthly, 147(1), pp.97-103.

Finley, R.L., Collignon, P., Larsson, D.J., McEwen, S.A., Li, X.Z., Gaze, W.H., Reid-Smith, R., Timinouni, M., Graham, D.W. and Topp, E., 2013. The scourge of antibiotic resistance: the important role of the environment. Clinical Infectious Diseases, p.cit355.

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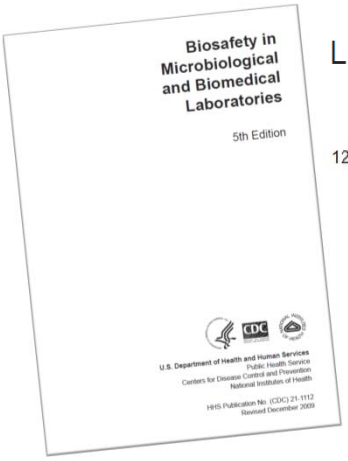
High-Consequence Pathogens



Laboratory Biosafety Level Criteria: BSL-4

12. Liquid effluents from chemical showers, sinks, floor drains, autoclave chambers, and other sources within the laboratory must be decontaminated by a proven method, preferably heat treatment, before being discharged to the sanitary sewer.

Decontamination of all liquid wastes must be documented. The decontamination process for liquid wastes must be validated physically and biologically. Biological validation must be performed annually or more often if required by institutional policy.

Effluents from personal body showers and toilets may be discharged to the sanitary sewer without treatment.

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Thoughts going into the webcast

- Pathogens in the sewer collection system are different than decades ago
- How do we protect the Public and wastewater workers from exposure?
- How do we control sources being discharged into the environment?

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Collaborative Research

- Protecting Wastewater Treatment Plant Operators from Emerging Pathogens (WERF3C15)
- Occurrence, Proliferation, and Persistence of Antibiotics and Antibiotic Resistance During Wastewater Treatment (WERF1C15)
- Risks from Ebola Discharge from Hospitals to Sewer Workers (WERF4C15)
- Collaborative Workshop on Handling, Management, and Treatment of High-Consequence Bio-Contaminated Wastewater by Water Resource Recovery Facilities EPA/600/R-16/054
- Protecting Wastewater Treatment Plant Operators from Emerging Pathogens: A Preparedness Protocol and On-Line Decision Support Tool (WERF3C15)

Today's Speakers

Jackie MacDonald Gibson
University of North Carolina

WERF3C15: Protecting Wastewater Treatment Plant Operators from Emerging Pathogens

Jackie MacDonald Gibson

Department of Environmental Sciences and Engineering
University of North Carolina at Chapel Hill

Motivation for Project

- 2014 Ebola epidemic highlighted need to evaluate risks to wastewater and sewer workers who could be exposed to pathogens discharged in hospital sewage.
- CDC guidelines allow hospitals to flush liquid wastes from infected patients into sewer without disinfection.
- During the Ebola epidemic, utilities expressed concern about lack of disinfection of patient waste.
- WERF commissioned this project to assess adequacy of hospital wastewater treatment guidelines.

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Three Objectives

1. Review existing protocols for the disposal of liquid waste of Ebola patients via sanitary sewers.
2. Develop a consensus protocol for Ebola patient liquid waste disposal.
3. Quantify the probability of Ebola illness for wastewater or sewer workers under different hospital waste management scenarios.

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Review existing protocols for the disposal of liquid waste of Ebola patients via sanitary sewers.

OBJECTIVE 1

WHO and U.S. National Protocols Reviewed

Organization	Protocol or Guideline Document
World Health Organization (WHO)	Interim infection prevention and control guidance for care of patients with . . . Ebola
	Safe management of wastes from health-care activities, 2nd ed.
Centers for Disease Control and Prevention (CDC)	Interim guidance for managers and workers handling untreated sewage from individuals with Ebola in the U.S.
	Biosafety in microbiological and biomedical laboratories, 5th ed.
Occupational Safety and Health Administration (OSHA)	Bloodborne pathogens standard
	Cleaning and decontamination of Ebola on surfaces: Guidance for . . . nonhealth-care/ nonlaboratory settings
	PPE selection matrix for occupational exposure to Ebola virus
U.S. Army Institute of Public Health	Ebola virus disease waste management in the medical treatment facility

State and Local Protocols Reviewed

Organization	Protocol or Guideline Document
Wisconsin Department of Health Services	Interim guidance on the safe disposal of Ebola patient waste in sanitary sewers
Washington State Department of Health	Safe handling of Ebola-contaminated wastewater
Arizona Department of Health Services	Liquid waste management
Florida Department of Health	Interim guidance on the safe disposal of Ebola patient waste
Indiana Department of Health	Ebola waste management guide
Kentucky Department for Public Health	Management and control of Ebola-contaminated waste
California Association of Sanitation Agencies	Revised consensus recommendations for . . . management of wastewater generated by patients infected with . . . Ebola
Portland (OR) Bureau of Environmental Services	Acceptance of Ebola-contaminated waste into the city sanitary system
Kansas Department of Health and Environment	Ebola virus preparedness and response plan

Results: Wide Variation in Patient Waste Management

Organization	Hospitals Notify Utility	No Treatment of Liquid Waste	Pretreatment Before Patient Use		Pretreatment Before Disposal in Sewer			Clean Surfaces After Patient Use
			Toilet	Shower/ Sink	General Disposal	Toilet	Shower/ Sink	
WHO and CDC		x						
Army Institute of Public Health			x	x	x	x	x	x
Emory University					x			
Kansas Department of Health	x		x		x	x		
Nebraska Medical Center					x	x		
New York Department of Health		x						

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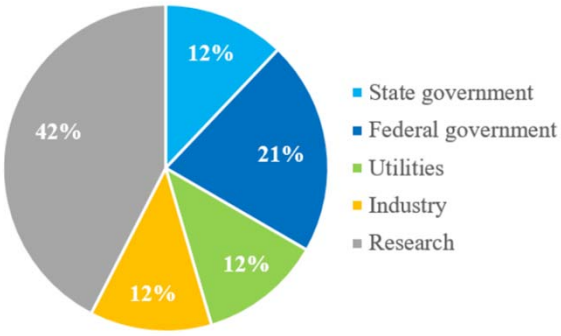
Develop a consensus protocol for Ebola patient liquid waste disposal

OBJECTIVE 2

"Flushing Protocol" Developed via Structured Expert Workshop

- 33 participants
- Water Microbiology Conference, May 2015



Plenary Session
- Overview of existing protocols

Break-Out Groups
- Group 1: Protocol "boundaries" and process
- Group 2: Exposure routes
- Group 3: Existing occupational protections
- Group 4: Logistics of implementation

Plenary Sessions
- Review and critique break-out group reports

Break-out groups
- Review and revise reports

Final plenary
- First draft protocol

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First Draft Protocol Circulated for Review

	Toilet*	Bedpan*	Sink*	Shower*
Waste disinfection	Disconnect toilet auto flush Apply disinfectant around toilet bowl† in same manner as liquid toilet bowl cleaner Add 1 cup of pure bleach (at least 5%) or Quats per manufacturer's guidelines‡ Allow patient to use or dispose of patient waste in toilet Cover toilet bowl with lid or protective barrier Allow 15 minutes of contact time before flushing toilet	Cover and transport patient liquid waste to lavatory	Plug sink Apply disinfectant in sink† Use ½ cup of pure bleach (at least 5%) or Quats per manufacturer's guidelines‡ Allow patient to use or dispose of patient waste in sink Cover sink bowl with protective barrier Allow 15 minutes of contact time before unplugging sink	Prior to use, apply disinfectant in unblocked shower floor drain 3 tablespoons of granular calcium hypochlorite (65%–70% available chlorine) Allow patient to use or dispose of patient waste in shower Apply disinfect in unblocked shower floor drain† 1 cup of pure bleach (at least 5%) or Quats per manufacturer's guidelines‡
Surface disinfection	Apply 1:10 bleach solution to toilet surfaces with a spray bottle Wipe sprayed surfaces and dispose of cloth in Ebola waste container		Apply 1:10 bleach solution to sink surfaces with a spray bottle Wipe sprayed surfaces and dispose of cloth in Ebola waste container	Apply 1:10 bleach solution to shower surfaces with a spray bottle Wipe sprayed surfaces and dispose of cloth in Ebola waste container

*All hospital personnel must be wearing appropriate PPE

†Ensure proper ventilation during disinfection

‡EPA approved disinfectants for use against the Ebola Virus http://www.epa.gov/oppad001/list-1-ebola-virus.html

Modified from U.S. Army Institute of Public Health Ebola Virus Disease Waste Management in the medical treatment facility

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Key Concerns

- Complexity
  - Lower chance of implementation
- Use of bleach
  - Potential risk to hospital workers and patients (fumes)

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Final Protocol

Pretreat waste with peracetic acid

Highly effective against a wide range of pathogens and rapid inactivation[2,3]

Rapid reduction of phages exposed to 1% PAA for 1 hour[3]

[1]Sobsey et al. (1974) *Appl Microbiol.* 28(5), 861-6
[2]Kitis (2004) *Environ. Int. 30(1), 47-55*
[3]Vinneras et al. (2003) *Bioresour. Technol. 89*(2), 155–161.

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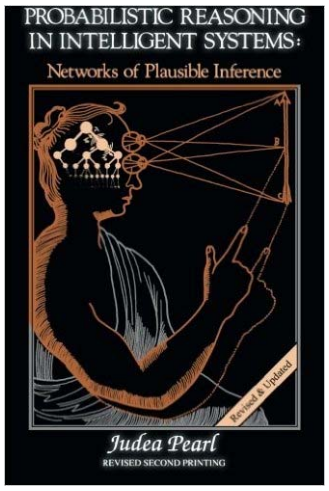
Quantify the probability of Ebola illness for wastewater or sewer workers under different hospital waste management scenarios

OBJECTIVE 3

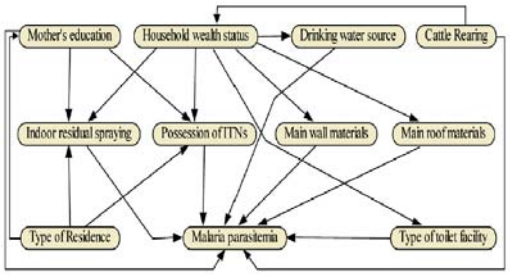
Method:
Bayesian Belief Network (BBNs)

- Developed by Judea Pearl in late 1980s to support causal inference
  - What are the most important underlying causes of risks to human systems?
- Pear awarded A. M. Turing Award in 2011
  - Nobel Prize of computer science



BBNs Have Two Parts

1. Graphical structure representing dependencies



Example BBN for predicting malaria risk in sub-Saharan Africa.

SOURCE: Semakula, H. M.; Song, G.; Achuu, S. P.; Zhang, S. A Bayesian belief network modelling of household factors influencing the risk of malaria: A study of parasitaemia in children under five years of age in sub-Saharan Africa. Environ. Model. Softw. 2016, 75, 59-67.

BBNs Have Two Parts

1. entidependencie
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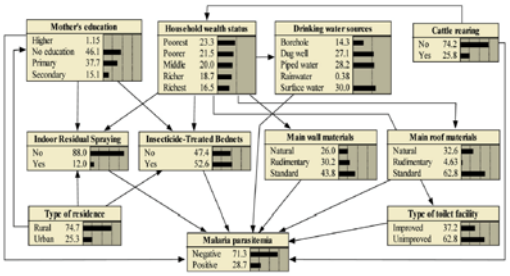
2. Quantitative specification of local probability distributions



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BBN Development Approach

- Step 1: Construct an influence diagram (qualitative)
  - Literature review
  - Expert consultation
- Step 2: Specify all variables and their relationships
  - Literature review
  - Expert elicitation
  - Machine learning algorithms

Influence Diagram Tracks Ebola Viruses Moving from Patient through Sewer

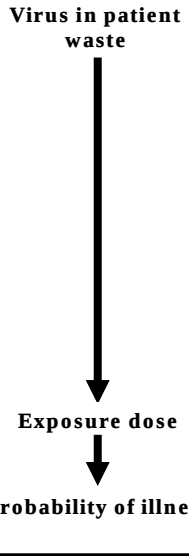
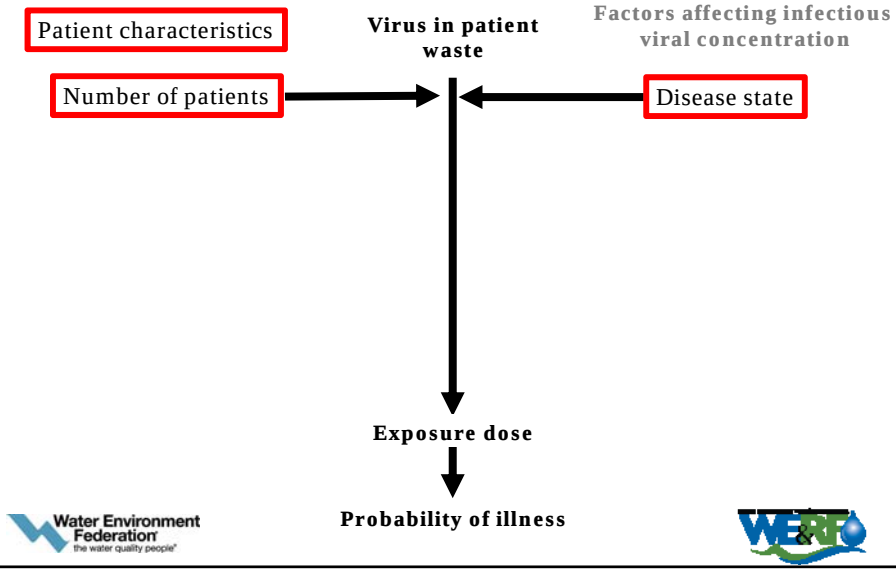


Diagram Represents Multiple Influencing Factors



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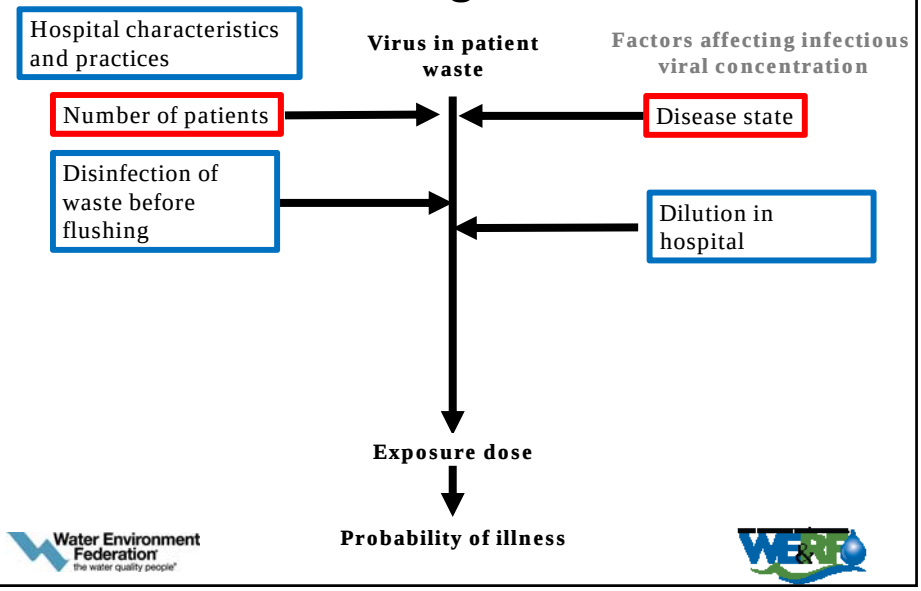

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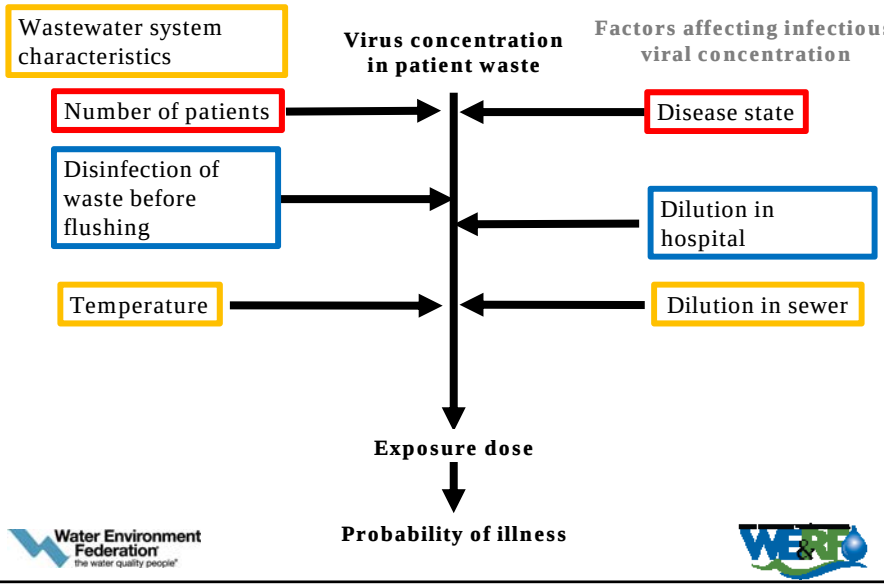

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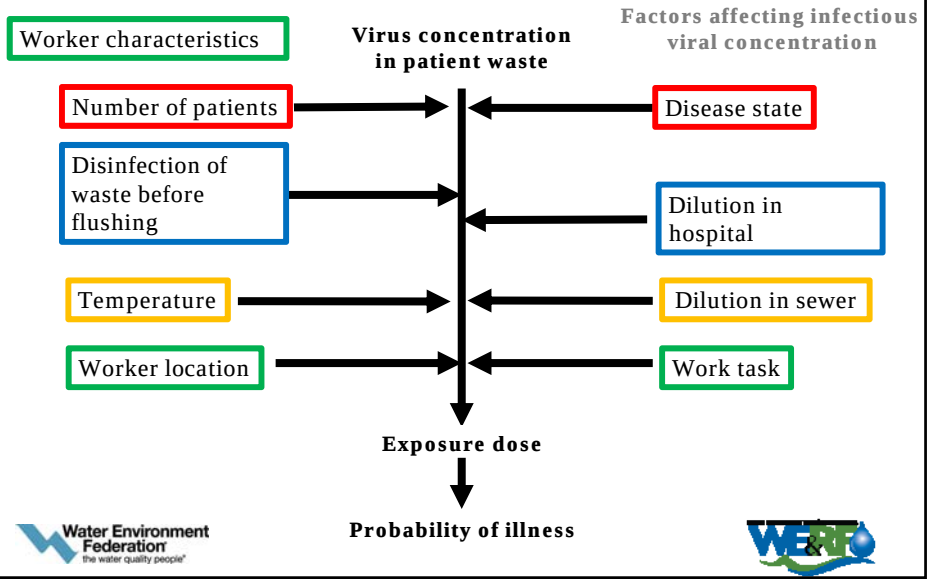
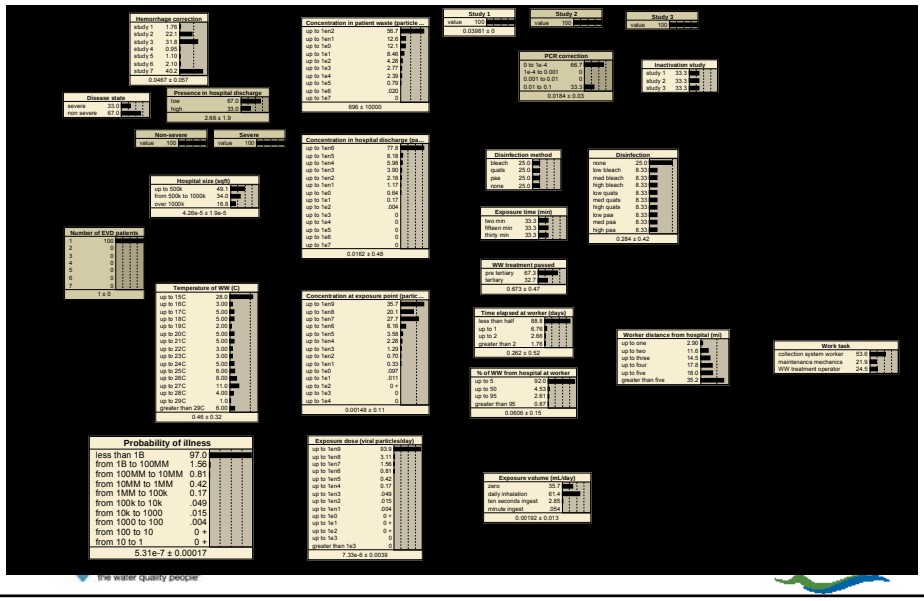
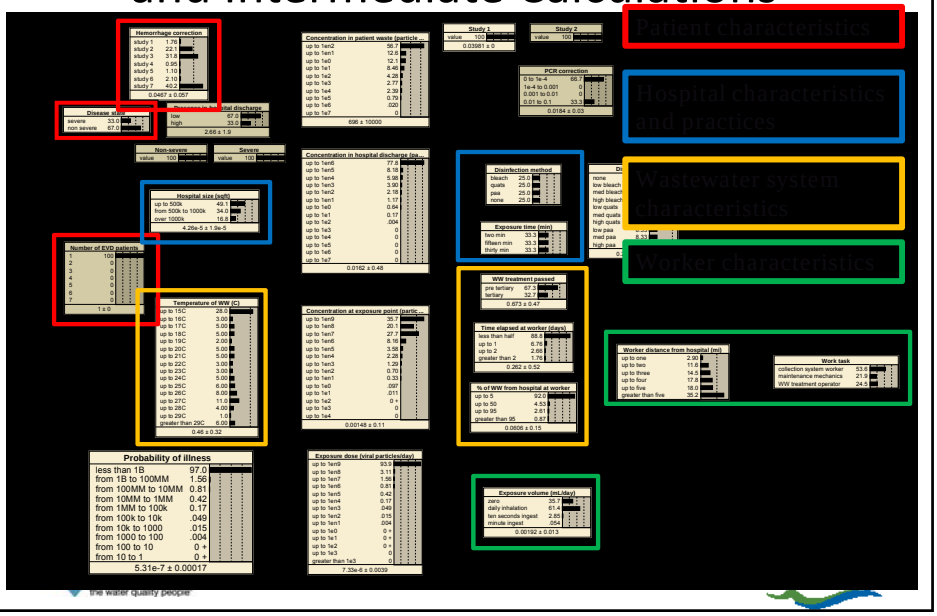


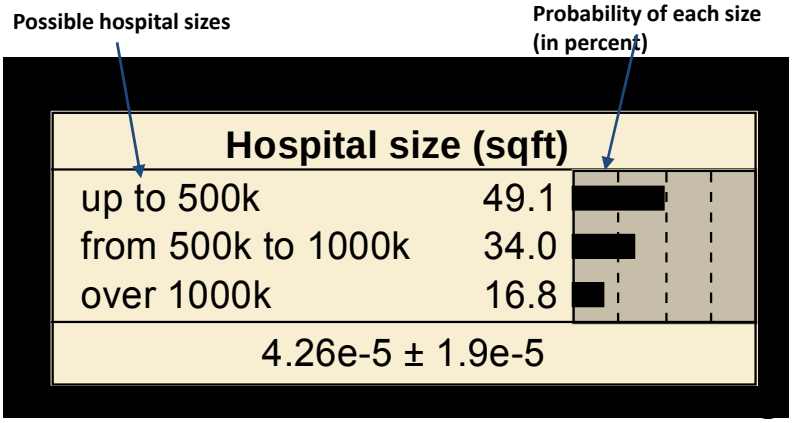
Risk Model as Constructed in *Netica* (Enables Machine Learning)



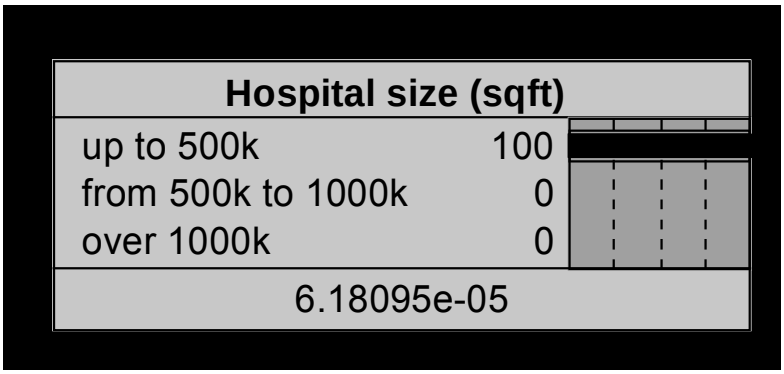
Nodes Represent Influencing Factors and Intermediate Calculations



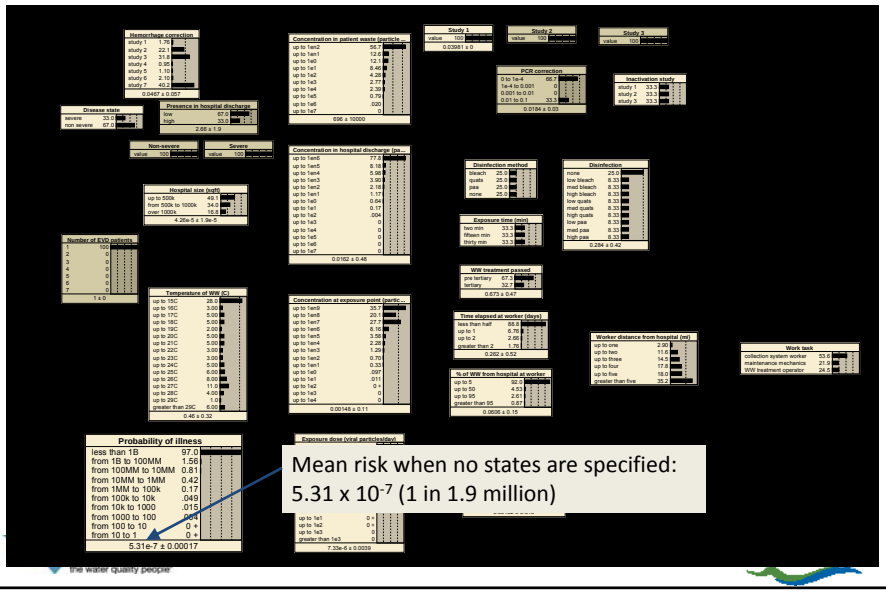
Bars Represent Possible "States" of Each Variable and Their Probabilities



Double-Clicking a Node Specifies Its State

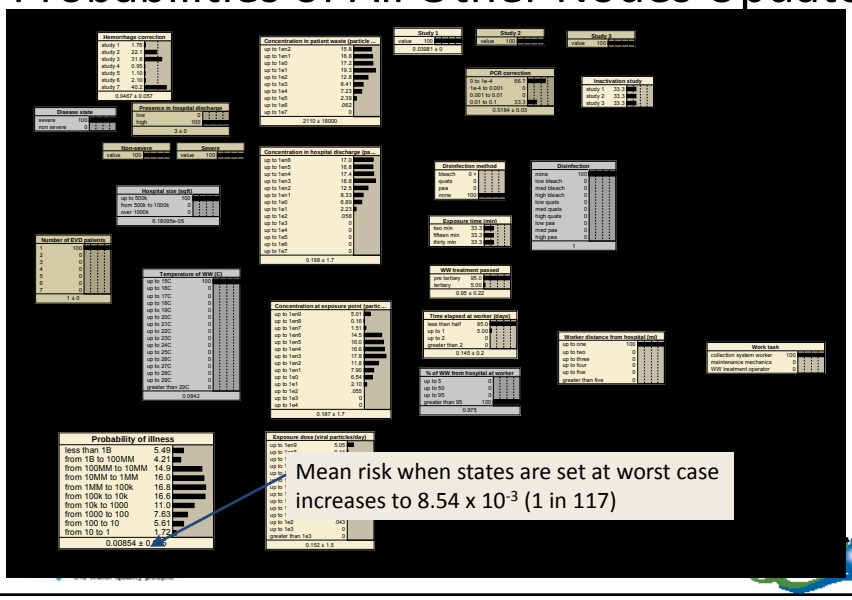


When a Node State is Specified, Probabilities of All Other Nodes Update



Mean risk when no states are specified: 5.31×10^{-7} (1 in 1.9 million)

When a Node State is Specified, Probabilities of All Other Nodes Update



Mean risk when states are set at worst case increases to 8.54×10^{-3} (1 in 117)

Worst-Case Risk

Disease State	Disinfection Method	Disinfection Time (min)	Temp. (°C)	Distance from Hospital (mi)	Hospital Size (ft²)	% of WW from Hospital	Exposure Route	Daily Infection Risk
Severe	None	-	≤15°C	≤1	≤500k	>95%	1 min ingest	1 in 117

Worst-case scenario (one patient):

1. **Patient is in most severe disease state**
2. **Patient waste is not disinfected**
3. **Wastewater temperature is low**
4. **Sewer worker less than 1 mile from hospital**
5. **Hospital is small (less dilution)**
6. **Hospital is major discharger to sewer**
7. **Worker ingests wastewater droplets**

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Risks Decrease Under Alternative Scenarios

Disease State	Disinfection Method	Disinfection Time (min)	Temp. (°C)	Distance from Hospital (mi)	Hospital Size (ft²)	% of WW from Hospital	Exposure Route	Daily Infection Risk
Severe	None	-	≤15°C	≤1	≤500k	>95%	1 min ingest	1 in 117
Severe	None	-	>29°C	≥5	>1,000k	<5%	10s ingest	1 in 2 million

Alternative scenarios:

1. **Warmer temperature**
2. **Larger hospital (more dilution)**
3. **Worker is farther from hospital (more dilution)**
4. **Worker swallows less water**

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Inhalation Risk is Much Lower Than Ingestion Risk

Disease State	Disinfection Method	Disinfection Time (min)	Temp. (°C)	Distance from Hospital (mi)	Hospital Size (ft^2)	% of WW from Hospital	Exposure Route	Daily Infection Risk
Severe	None	-	≤15°C	≤1	≤500k	>95%	1 min ingest	1 in 117
Severe	None	-	≤15°C	≤1	≤500k	>95%	Inhalation	1 in 295,000

Even if all other factors remain unchanged from worst case, preventing ingestion nearly eliminates risk

- **Risk under inhalation decreases by more than a factor of 1,000**

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Disinfection with Peracetic Acid Decreases Risk by 1,000-Fold

Disease State	Disinfection Method	Disinfection Time (min)	Temp. (°C)	Distance from Hospital (mi)	Hospital Size (ft^2)	% of WW from Hospital	Exposure Route	Daily Infection Risk
Severe	None	-	≤15°C	≤1	≤500k	>95%	1 min ingest	1 in 117
Severe	Bleach	15 min	≤15°C	≤1	≤500k	>95%	1 min ingest	1 in 1,220
Severe	Quats	15 min	≤15°C	≤1	≤500k	>95%	1 min ingest	1 in 8,700
Severe	Peracetic acid	15 min	≤15°C	≤1	≤500k	>95%	1 min ingest	1 in 112,000

Under our modeling assumptions, other disinfectants are less effective than peracetic acid.

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Summary

- Existing protocols for managing Ebola patient liquid wastes are inconsistent
- Consensus protocol recommends pretreating liquid patient waste with peracetic acid prior to sewer disposal
- Wastewater and sewer workers could be at risk if ingest wastewater droplets
  - Pretreatment of hospital waste with peracetic acid reduces worst-case risk by a factor of 1,000

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Many thanks!

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  - Mark Sobsey
  - Jamie Bartram
- All those who participated in the May 2015 and June 2016 workshops
- WE&RF
  - Lola Olabode
- NSF
  - Bill Cooper

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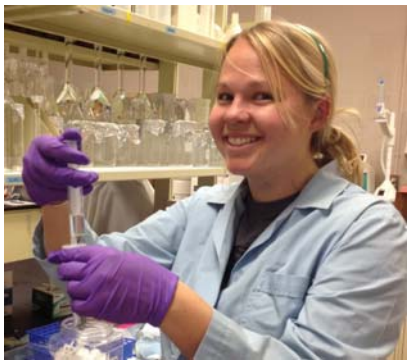
Key Team Members

Dr. Kelsey Pieper



Joe Zabinski

Today's Speakers

Lisa Casanova
Georgia State University

PPE: What can we learn from healthcare?

Lisa M. Casanova
Division of Environmental Health
School of Public Health
Georgia State University

Thinking about transmission

- Respiratory spread (droplets and aerosols)
- HANDS
- Fomites
- Surfaces

Specific challenges

- In healthcare, a dual challenge
- Protecting workers
- Protecting patients

Understanding exposures

- Respiratory exposures
- Body fluid exposures
- Fomite/surface exposures

Levels of protection

- Universal precautions
- Contact precautions
- Droplet precautions
- Airborne precautions
- High level precautions

Universal precautions

- The mindset: everyone is potentially infected
- Focus on body fluid exposures
- Vaccination

Contact precautions

- Thinking about hand transmission
- Gloves
- Gowns
- HAND HYGIENE

Droplet precautions

- Respiratory transmission
- Larger size range
- Close contact
- Masks
- Eye protection
- Isolation

Airborne precautions

- Respiratory transmission
- Larger and smaller size range
- Respirators (not masks!)
- Eye protection
- Isolation
- Respiratory protection programs

High level precautions

- Rare in usual practice
- Dangerous pathogens
- Different combinations, but ultimate goal: no exposed skin or mucous membranes
- Suits
- PAPRs

Other considerations

- Other potential hazards
- Clothing
- Shoes

Choosing precautions

- In healthcare, often organism-specific
- Sometimes task specific (aerosol generating procedures, body fluid splash)
- Challenges of multiple/unknown pathogens

Using precautions

- Compliance: the final frontier
- Healthcare environments are full of sick people and dangerous pathogens
- 100% compliance….right?

Using precautions

- Barriers to compliance
- Workload/cognitive load
- Comfort
- Perception

Using precautions

- Making PPE choices
- Availability
- Task-related comfort

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Some thoughts

- Organism specific or task specific?
- How do we increase compliance?
- How are task and compliance related?
- How does risk perception factor in?

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Today's Speakers

Nancy Burton
NIOSH

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The NIOSH Health Hazard Evaluation (HHE) Program and Worker Protection

Nancy Clark Burton, PhD, MPH, MS, CIH

Protecting Wastewater Treatment Workers from High Consequence Pathogens

August 24, 2016

CDC Workplace Safety and Health ™

NIOSH

SAFER • HEALTHIER • PEOPLE™

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Outline

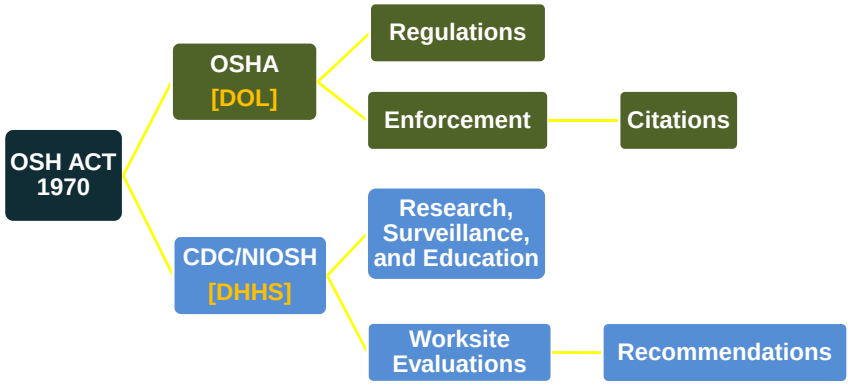
- Overview of HHE Program
- Overview of two HHEs dealing with wastewater treatment workers (WWTWs)
- CDC/NIOSH Resources
- Current Recommendations for Protecting WWTWs from Potential Exposures to Pathogens

Occupational Safety and Health Act of 1970

"…to assure so far as possible healthful working conditions for every man and woman in the nation."

- Occupational Safety and Health Administration (OSHA)
  - Regulatory Agency
- National Institute for Occupational Safety and Health (NIOSH)
  - Research Agency

Differences: OSHA and NIOSH



What is a Health Hazard Evaluation?

- Worksite investigation in response to a request from employees, employers, unions, or government agencies
- Determine whether harmful exposures, processes, or conditions exist and/or cause injuries or illnesses

How Do We Get Requests?

- Who can request an HHE?
  - Three current employees
  - Union
  - Management
- Technical assistance requests
  - Other government agencies
  - Local, state health departments

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HHE Site Visit Activities

- Observe production processes and employee work practices
- Collect air and surface samples
- Privately interview employees
- Conduct medical tests or physical examinations of employees
- Evaluate exposure controls
- Review reports of injury and illness and exposure records

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Health Hazard Evaluations: Examples of Completed Projects Dealing with Wastewater Treatment Workers

HHE Health Hazard Evaluation Program

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Composting Toilets in a National Park

- Management request
- Concerns
  - exposure to untreated and composted human waste
  - appropriate personal protective equipment (PPE) to use while servicing and cleaning the pit and composting toilets
  - heat stress

https://www.cdc.gov/niosh/hhe/reports/pdfs/2009-0100-3135.pdf

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Composting Toilets - Background

- Pit Toilets
  - Used in the back country
  - Flown in and out by helicopter
  - Cleaned out by shoveling material into front end loader
  - Material is dumped into trailer and land-filled
  - Scrubbed out with brushes and rinsed

- Composting Toilets
  - Shovel material into bags
  - Clean out vaults
  - Bags packed out of canyon by mule train
- Servicing for Both Types
  - Stirring the piles
  - General cleaning
  - Removing trash
  - Restocking of supplies

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Composting Toilets - Evaluation

- Observed work processes, work practices and workplace conditions
- Observed PPE usage
- Collected short-term air samples for ammonia and hydrogen sulfide using colorimetric detection tubes
- Collected task-based personal air samples using PTFE filters for culturable enteric bacteria for both types of toilets
- Collected personal and area air samples for culturable thermophilic actinomycetes for composting toilets

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Composting Toilets - Results

- PPE used was appropriate for the potential exposure to human pathogens
- High ammonia levels were detected when opening the pit toilets
- Air Sampling
  - No enteric bacteria detected
  - Thermophilic actinomycetes detected in personal and area air samples
- Use of PPE in the spring and summer could increase risk for heat stress
- Potential exposure to scorpion stings, spider bites, airborne hantavirus, and hepatitis

Composting Toilets - Recommendations

- Engineering Controls
  - Add supports to the tray of the pit toilet and use the front end loader to empty it
- Administrative Controls
  - Open the pit toilets to reduce ammonia exposure
  - Follow heat stress reduction policy
  - Offer voluntary vaccination program for Hepatitis A and B viruses
  - Establish medical follow-up protocols and issue first aid kits for insect bites and scorpion stings
- PPE
  - Provide additional disposable shoe coverings to prevent spread of contamination

Class B Biosolids Land Application

- Management request
- Employees reported headaches, stomach cramps, and diarrhea

https://www.cdc.gov/niosh/hhe/reports/pdfs/1998-0118-2748.pdf

Land Application Process Description

- Transport material to concrete pad for drying
- Loading on truck
- Driving to staging area at field
- Dumping material at staging area
- Loading manure spreader with material using bob cat
- Spreading on field with tractor and manure spreader

Land Application Evaluation

- Collected air samples for
  - Culturable bacteria
  - Endotoxin
  - Volatile organic compounds (VOCs), and
  - Trace metals
- Conducted medical interviews with five employees

Land Application Results

- All five employees reported at least one episode of gastrointestinal illness after working with biosolids
  - One complete work-up by gastroenterologist
- Geometric mean bacterial area air concentrations
  - 412 to 2,356 CFU/m^3
- All bacterial genera identified were associated with outdoor environments or mammals
- Potential human pathogens such as *Mycobacterium*, *Burkholderia,* and *Enterobacter agglomerans, Pseudomonas*, and *Staphylococcus* were identified
- Airborne endotoxin levels
  - 20 to 39 endotoxin EU/m^3
- The air concentrations of various metals detected (aluminum, barium, iron, manganese, nickel, silver, and titanium) and VOCs, including toluene, were low and well below current occupational exposure limits

Recommendations

- Improve personal hygiene practices
  - Provide portable hand-washing stations at fields
- Provide and train workers on type, use, and disposal of PPE
- Add air filtration systems to heavy equipment
- Clean inside of heavy equipment on a regular basis

NIOSH Resources for Workers Exposed to Untreated Sewage

- Interim Guidance for Managers and Workers Handling Untreated Sewage from Individuals with Ebola in the United States (http://www.cdc.gov/vhf/ebola/prevention/handling-sewage.html)
- Frequently Asked Questions (FAQs) on Interim Guidance for Managers and Workers Handling Untreated Sewage from Suspected or Confirmed Individuals with Ebola in the U.S. (http://www.cdc.gov/vhf/ebola/prevention/faq-untreated-sewage.html)
- Guidance for Controlling Potential Risks To Workers Exposed to Class B Biosolids (http://www.cdc.gov/niosh/docs/2002-149/pdfs/2002-149.pdf)

CDC General Recommendations for WWTWs

- **Guidance for Reducing Health Risks to Workers Handling Human Waste or Sewage** (http://www.cdc.gov/healthywater/emergency/sanitation-wastewater/workers_handlingwaste.html)
  - Provides current recommendations on
    - Basic hygiene practices
    - PPE
    - Training
    - Vaccine Recommendations

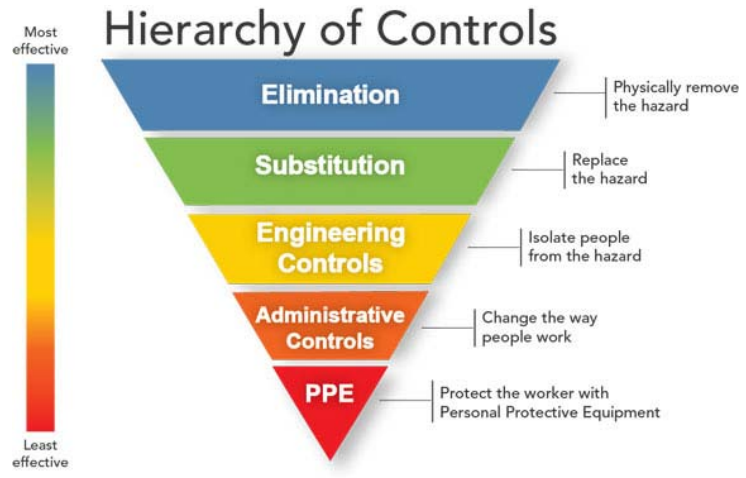

Photo by CDC/NIOSH

Personal Protective Equipment for WWTWs Potentially Exposed to Pathogens

- Why use PPE
  - protect broken skin and mucous membranes
- Other important parts of PPE program
  - Training to properly use the PPE
    - how to put it on and take it off
    - how to store and take care of PPE
  - Hygiene facilities
    - Wash hands with soap and water after removing PPE and eating, drinking, or using tobacco products
    - Use uniforms or laundry services if available

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General PPE Recommendations for WWTWs When Potentially Exposed to Pathogens

- Goggles or face shield: to protect eyes from splashes of untreated sewage
- Face mask (e.g., surgical mask): to protect nose and mouth from splashes of human waste.
- If undertaking cleaning processes that generate aerosols, a NIOSH-approved N-95 respirator should be used.
  - Establish respiratory protection policy (https://www.osha.gov/SLTC/respiratoryprotection/)
- Impermeable or fluid-resistant coveralls: to keep untreated sewage off clothing
- Waterproof gloves (such as heavy-duty rubber outer gloves with nitrile inner gloves) to prevent exposure of hands to untreated sewage
- Rubber boots: to prevent exposure of feet to untreated sewage

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Email:
HHERequestHelp@cdc.gov
Phone:
513-841-4382
Mailing address:
NIOSH HHE Program
1090 Tusculum Avenue
Cincinnati, OH 45226

HHE Health Hazard Evaluation Program

To learn more about the NIOSH HHE Program please visit
www.cdc.gov/niosh/hhe

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Thank you for your attention

- Questions?

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  - Ken Martinez

Disclaimer: "The findings and conclusions in this presentation are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health"

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Today's Speakers

Bill Komianos
American Water

American Water Safety Program

William Komianos, CIH, CSP
Sr. Director, Health and Safety
American Water
August 24, 2016

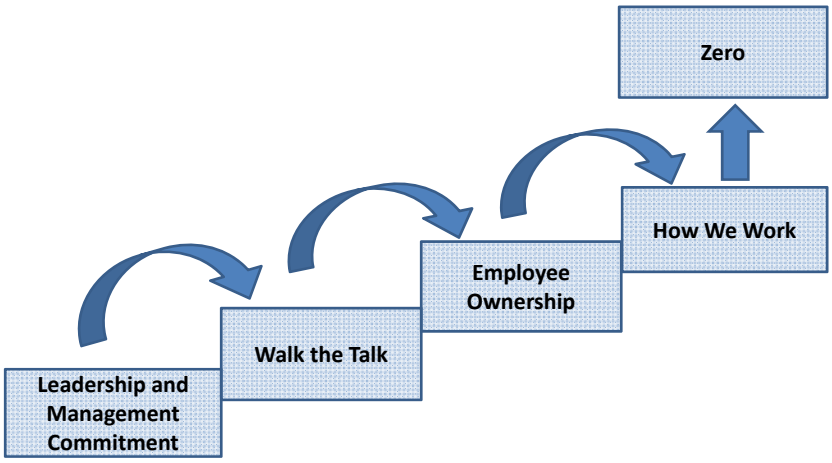
Safety Organization

- Decentralized Model
  - Local control and accountability
  - Safety staff embedded in functional operations
- Corporate Center of Expertise
  - Strategy, policy and practice
  - Technical guidance
  - Support
  - Data, recordkeeping and trending
  - Governance
- "Traditional" Safety Components
  - Training
  - Audits and assessments
  - Compliance

American Water Values and Strategies

- Safety is one of five company Core Values
  - Safety
  - Trust
  - Environmental Leadership
  - Teamwork
  - High Performance
- Safety is also a key Strategy
  - Zero incidents and injuries, live healthy
  - Interdependent with other strategies
    - People
    - Technology and Operational Efficiency
    - Growth

Safety Strategy Road Map



Health and Safety Charter/ Life Saving Rules

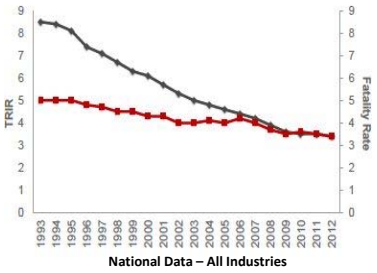
- **Health and Safety Charter**

  Guiding Principles
  - Health and Safety is a core value
  - We choose to work safely in all we do
  - We never compromise safety for speed, convenience or profit
  - We encourage and empower employees to stop unsafe work
  - We continuously improve our skills
  - We follow through on all safety issues.
  - We hold contractors to the same safety standards as our employees

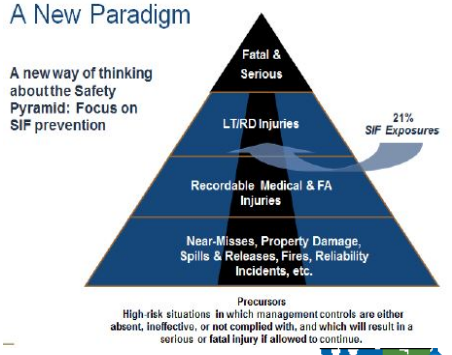
- **Life Saving Rules**
  - Always wear required PPE
  - Work free from influence of alcohol or illegal drugs
  - Always establish work zone safety
  - Always protect excavations against cave in
  - Use approved tools in the manner intended
  - Always Lock out/Tag out when potential for energy release exists
  - Use fall protection
  - Follow confined space entry requirements
  - Safeguard against contact with utility lines
  - All employees are empowered to stop unsafe work

Incident Investigation

- Increased emphasis on Serious injury Fatality (SIF) Potential Incidents.
- Purpose – Identify Root Cause – not blame
- TapRoot Root Cause Analysis method

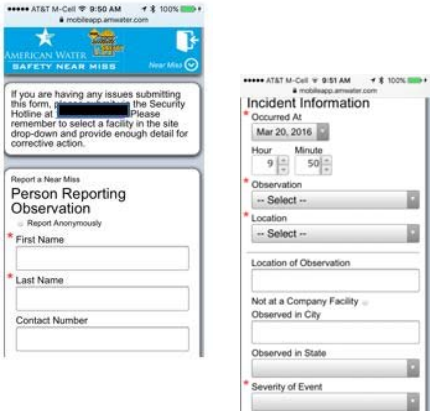


National Data – All Industries



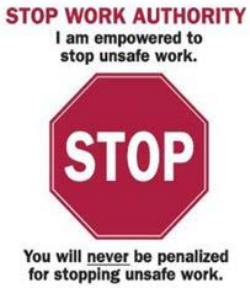
Near Miss Reporting

- Formal Near-Miss Reporting Program
- Employees report near misses via online portal or phone
- Mobile app being piloted
- Can report anonymously
- No discipline associated with near miss reporting.
- Thousands of near misses in last year
- Focus on timely correction



Safety Council

- Active Enterprise Safety Council
  - Union and Management
  - State Level Councils
- Stop work authority
  - Cards distributed to all employees
- Report to Improve
  - Communication
  - Correction
  - Supports Near Miss



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Training – Union Led/Management Supported

- Systems of Safety Training
- Union Led Training for employees and management
- 46 Union Trainers from across the company
- Joint effort with UWUA through Power for America and OSHA Susan Harwood Grant.
- Focus on small group activity method training, communication and application of hierarchy of controls for collaborative problem solving

Major Safety System	Design & Engineering	Maintenance and Inspection	Mitigation Devices	Warning Devices	Training and Procedures	Personal Protective Factors
Level of Protection	Highest – the first line of defense		Middle – The second line of defense			Lowest line of defense
Goal	To eliminate hazards		To further minimize and control hazards			To protect when higher systems fail
	Technical	Inspection and Testing	Enclosures, Barriers and Containment	Monitors	Operating Manuals and Procedures	Personal Decision Making and Actions
	Design and Engineering of Equipment, Processes	Maintenance	Shut down and Isolation Devices	Process Alarms	Process Safety Information	Personal protective Equipment and Devices
	Management of Change (MOC)	Quality Control	Fire and Chemical Suppression Devices	Community Alarms	Process, Job and Other types of Hazard Analysis	Stop Work Authority
	Chemical Selection and Substitution	Turnarounds and Overhauls		Emergency Notification Systems	Permit Programs	
	Organizational (Root cause)	Mechanical Integrity			Training	
	Polices/ Standards				Emergency Preparedness and Response	
	Staffing				Information Resources	
	Skills and Qualifications				Communications	
	Work Organization and Scheduling				Investigations /Lessons Learned	

UWUA/Institute for Sustainable Work and Environment

Hazard Awareness and Emergency Response Training

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Safety Communications/Training

- Use multiple methods to train and communicate on Health and Safety.
  - Balance between communication and overload
  - Timely and relevant
- Formal Safety Training
  - Integration with Job Skills Training
  - Learning and Development Group
  - Specific technical safety training
  - Adult learning methods
- Communications
  - Weekly Near Miss Video
  - Safety Alerts
  - Intranet
  - Tailgate
  - Leverage smartphone technologies

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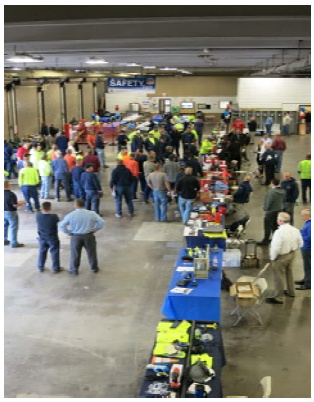
Employee Collaboration and Ownership

- Safety Fairs
- Equipment/Tools and Work Practice development and Review



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Summary

- Culture drives performance and results
- It is a journey, not a project (finite timeline)
- Culture begins with management
- Employee ownership is key to success
- Not a “once and done”
- Not all parts of an organization will move at the same pace
- Adapt and continuously look for new approaches within your “roadmap”

Today’s Speakers

John Archer
U.S. EPA

Decontamination Line Protocol Evaluation for Biological Contamination Events

John Archer, MS, CIH
US EPA Office of Research and Development
National Homeland Security Research Center
Decontamination & Consequence Mgmt Division

Protecting Wastewater Treatment Workers from High Consequence Pathogens - WEBCAST
August 2016

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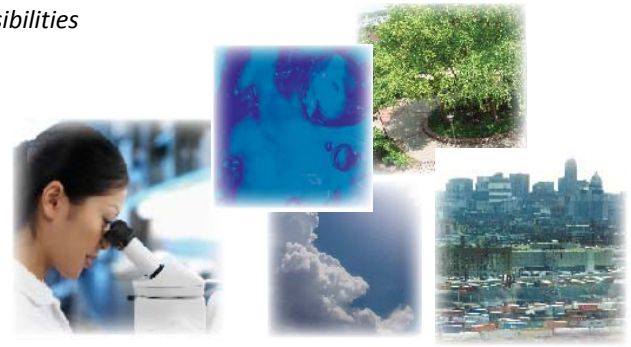
EPA's Homeland Security Research Program (NHSRC)

Mission: to conduct research and develop scientific products that improve the capability of the Agency to carry out its homeland security responsibilities

ADVANCING OUR NATION'S SECURITY THROUGH SCIENCE



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11

EPA's Homeland Security Responsibilities

Water Infrastructure Protection Division

Drivers

Bioterrorism Act
Presidential Directives
Executive Orders
National Response Framework
Elements of:
- Comprehensive Environmental Response, Compensation and Liability Act
- Emergency Planning and Community Right-to-Know Act
- Clean Water Act
- Safe Drinking Water Act
- Oil Pollution Act
- Clean Air Act
- Resource Conservation and Recovery Act

Responsibilities

- **Support water systems to prepare for and recover from attacks and other disasters** by leading efforts to provide States and water utilities guidance, tools and strategies. ***EPA is the federal government Sector Specific Agency (SSA) lead for water infrastructure.***
- **Clean up buildings and outdoor areas** impacted by a terrorist attack or other disaster by leading efforts to establish clearance goals and clean up.
- **Develop a nationwide laboratory network** with the capability and capacity to analyze for chemical, biological and radiological (CBR) agents for routine monitoring and in response to a terrorist attacks.

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Decontamination

What technologies, methods, and strategies are best suited for cleanup of indoor and outdoor areas?

- What clean up technologies are most effective and how are their efficacies changed by real world variations in environmental, process and agent characteristics?

Research Areas:

- Decontamination efficacy
  - CBR agents
  - Porous and non-porous materials, including dirty surfaces
  - Surface and volumetric decontaminants
  - Application methods and parameters
- Material compatibility
  - Sensitive equipment/electronics
  - Historical or high-value materials/items

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Decontamination Research from Bench to Full-Scale

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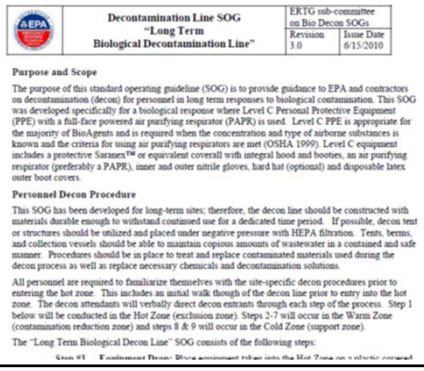
Decon Line Protocol Evaluation

The Question…

Is the existing (6/2010) EPA long term biological decontamination line standard operating guideline (SOG) effective in keeping workers from being contaminated and the exclusion zone free of contaminants?

Ebola Response Questions?



Decontamination Line SOG "Long Term Biological Decontamination Line"	ERTG sub-committee on Bio Decon SOGs
	Revision 3.0 / Issue Date 6/15/2010

Purpose and Scope

The purpose of this standard operating guideline (SOG) is to provide guidance to EPA and contractors on decontamination (decon) for personnel in long term responses to biological contamination. This SOG was developed specifically for a biological response where Level C Personal Protective Equipment (PPE) with a full-face powered air purifying respirator (PAPR) is used. Level C PPE is appropriate for the majority of BioAgents and is required when the concentration and type of airborne substances is known and the criteria for using air purifying respirators are met (OSHA 1999). Level C equipment includes a protective Saranex™ or equivalent coverall with integral hood and booties, an air purifying respirator (preferably a PAPR), inner and outer nitrile gloves, hard hat (optional) and disposable latex outer boot covers.

Personnel Decon Procedure

This SOG has been developed for long-term sites; therefore, the decon line should be constructed with materials durable enough to withstand continued use for a dedicated time period. If possible, decon tent or structures should be utilized and placed under negative pressure with HEPA filtration. Tents, berms, and collection vessels should be able to maintain copious amounts of wastewater in a contained and safe manner. Procedures should be in place to treat and replace contaminated materials used during the decon process as well as replace necessary chemicals and decontamination solutions.

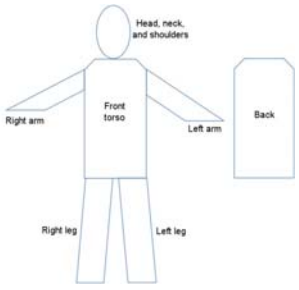
All personnel are required to familiarize themselves with the site-specific decon procedures prior to entering the hot zone. This includes an initial walk though of the decon line prior to entry into the hot zone. The decon attendants will verbally direct decon entrants through each step of the process. Step 1 below will be conducted in the Hot Zone (exclusion zone). Steps 2-7 will occur in the Warm Zone (contamination reduction zone) and steps 8 & 9 will occur in the Cold Zone (support zone).

The "Long Term Biological Decon Line" SOG consists of the following steps:

Step #1 Equipment Drop: Place equipment taken into the Hot Zone on a plastic covered

Evaluation Design
(emphasis on *Bacillus anthracis* response)

- Contaminate response workers with fluorescent dye and non-pathogenic spores[1]
- Have variation in size, sex, experience of test subjects[2]
- Execute the SOG
- Evaluate efficacy of Decon
- Modify as necessary to vary/improve results
- Oversight by OEM and Dynamac



Note:

[1] *Bg*, ultimately not used

[2] IRB, human subjects waiver due to test of existing protocol

Project Constraints

- Indoor, high contamination of workers
- Sampling scenario
- HAZWOPER trained, variability (paid volunteers, fire fighters selected, IRB exemption due to existing procedure)
- Not taking into account decon rinse efficacy to kill microbe of concern

Location	Dosed Locations
1	Outside of face mask
2	Palm of right-hand glove
3	Left shoulder
4	Right hip
5	Inner side of left boot

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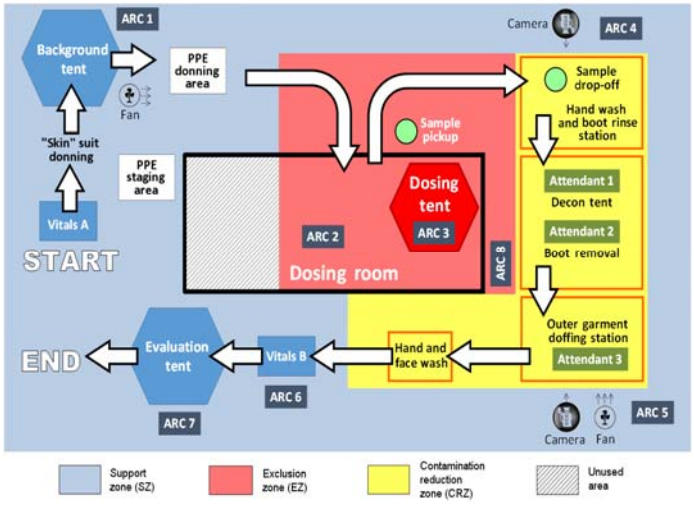
Decon Line Diagram (Indoor)



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Decon Line

Use of OEM field-deployable equipment

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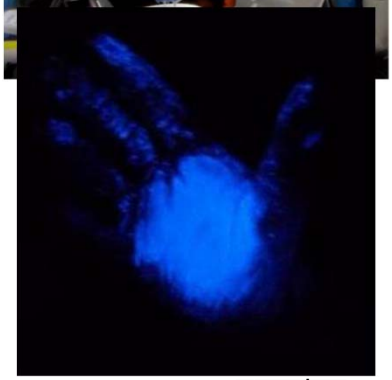
Observation of Subjects



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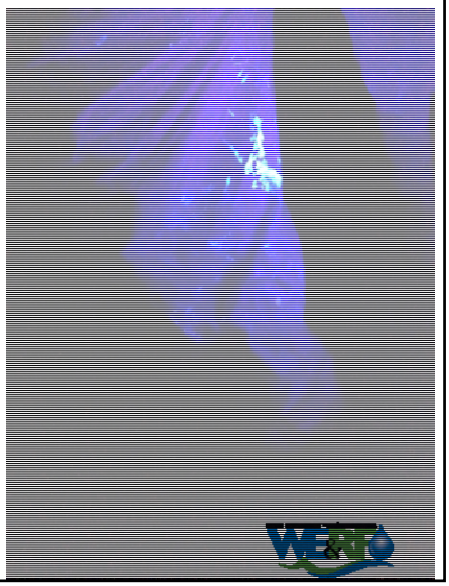
Areas of Contamination



Script 1 – SOG as written (scrub with soap/water, single layer PPE)
Contaminant present (Y/N), area

Contaminant present post decon, Y=1, N=0

Test Subject ID	Head, Neck, and Shoulders	Front	Left Arm	Right Arm	Back	Left Leg	Right Leg
Test 1							
TS31	0	1	1	0	0	0	1
TS00	0	1	0	1	1	0	1
TS02	0	1	1	0	1	1	1
TS79	0	1	1	1	1	1	0
TS62	1	1	1	0	1	1	1
AT10	1	1	1	1	1	1	1
AT32	1	1	1	0	0	0	0
Test Subject Average	20	100	80	40	80	60	80
Test Subject Stdev	45	0	45	55	45	55	45
Attendant Average	100	100	100	50	50	50	50
Attendant Stdev	0	0	0	71	71	71	71
Test 2							
TS10	1	1	1	1	0	0	0
TS79	0	1	0	1	0	0	1
TS02	0	1	1	1	0	1	1
TS26	1	1	1	1	0	0	0
AT62	0	0	0	0	0	0	0
AT00	0	0	1	0	0	0	0
Test Subject Average	50	100	75	100	0	25	50
Test Subject Average	58	0	50	0	0	50	58
Test Subject Stdev	0	0	50	0	0	0	0
Attendant Average	0	0	71	0	0	0	0

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Script 1 – **SOG as written**; contaminant present (Y/N), area

Estimated area of contamination (in²)

Test Subject ID	Head, Neck, and Shoulders	Front	Left Arm	Right Arm	Back	Left Leg	Right Leg	Total
Test 1								
TS31	NO*	21	2	NO	NO	NO	15	38
TS00	NO	32	NO	4	132	NO	36	204
TS02	NO	6	3	NO	2	10	79	100
TS79	NO	1	1	4	1	1	NO	8
TS62	36	1	6	NO	1	1	1	46
AT10	64	1	7	8	4	1	1	86
AT32	16	10	28	30	NO	NO	NO	84
Test 2								
TS10	29	6	4	18	NO	NO	NO	57
TS79	NO	144	NO	120	NO	NO	348	612
TS02	NO	240	16	144	NO	80	16	496
TS26	48	12	3	64	NO	NO	NO	127
AT62	NO	NO	NO	NO	NO	NO	NO	NO
AT00	NO	NO	2	NO	NO	NO	NO	2

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SOG Modifications

- **Script 2**: Added rinse, *No better*, 100% contam; (cumulative >1200 in^2)
- **Script 3**: Added 3rd attendant to help with doffing, no significant improvement
- **Script 4**: Mist from top down, reduced scrubbing*: greatly improved results*
- **Script 5:** Spray cooking oil (particulate containment); *similar to water mist* – messy
- **Script 6:** Added inner Tyvek suit (Tychem outer), almost eliminated contamination (cumulative <5 in^2)
- **Script 7:** Outer Tyvek, inner Tyvek, result like Script 6

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Script 1 (as written) & Script 7 (mist, 2 suit) - Cumulative (in^2)

Test Subject ID, Script 1	Head, Neck, and Shoulders	Front	Left Arm	Right Arm	Back	Left Leg	Right Leg	Total
Test 1								
TS31	NO*	21	2	NO	NO	NO	15	38
TS00	NO	32	NO	4	132	NO	36	204
TS02	NO	6	3	NO	2	10	79	100
TS79	NO	1	1	4	1	1	NO	8
TS62	36	1	6	NO	1	1	1	46
AT10	64	1	7	8	4	1	1	86
AT32	16	10	28	30	NO	NO	NO	84
Test 2								
TS10	29	6	4	18	NO	NO	NO	57
TS79	NO	144	NO	120	NO	NO	348	612
TS02	NO	240	16	144	NO	80	16	496
TS26	48	12	3	64	NO	NO	NO	127
AT62	NO	NO	NO	NO	NO	NO	NO	NO
AT00	NO	NO	2	NO	NO	NO	NO	2

Test Subject ID, Script 7	Head, Neck, and Shoulders	Front	Left Arm	Right Arm	Back	Left Leg	Right Leg	Total
Test 1								
TS61	NO*	NO	NO	NO	NO	NO	NO	NO
TS31	NO	NO	NO	NO	NO	NO	NO	NO
TS00	NO	NO	NO	NO	NO	NO	NO	NO
TS63	NO	NO	NO	NO	NO	NO	NO	NO
TS30	NO	NO	NO	NO	NO	NO	NO	NO
AT77	NO	1	NO	NO	NO	NO	NO	1
AT52	NO	NO	NO	NO	NO	NO	NO	NO
Test 2								
TS61	NO	NO	NO	NO	NO	NO	NO	NO
TS30	NO	NO	NO	NO	NO	NO	NO	NO
TS77	NO	NO	NO	NO	NO	NO	NO	NO
CS52	NO	NO	NO	NO	NO	NO	NO	NO
AT63	NO	NO	NO	NO	NO	NO	NO	NO
AT00	NO	NO	NO	NO	NO	NO	NO	NO

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Conclusion/Recommendations

- SOG as written, **80-100% contamination**
- Modifying to mist, 2 suits - **contamination nearly eliminated**
- Recommend shower
- Sample decon as written is effective

NOTE: Results do not take into account any biocidal impacts of decon rinse

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WASHINGTON, DC 20310-0102

DEC 0 4 2014

DUSA-TE

MEMORANDUM FOR DISTRIBUTION

SUBJECT: Endorsement of Test and Evaluation (T&E) Capabilities and Methodologies Integrated Process Team (TECMIPT) Test Operations Procedure (TTOP) Test for Cross Contamination During Doffing of Personal Protective Equipment (PPE)

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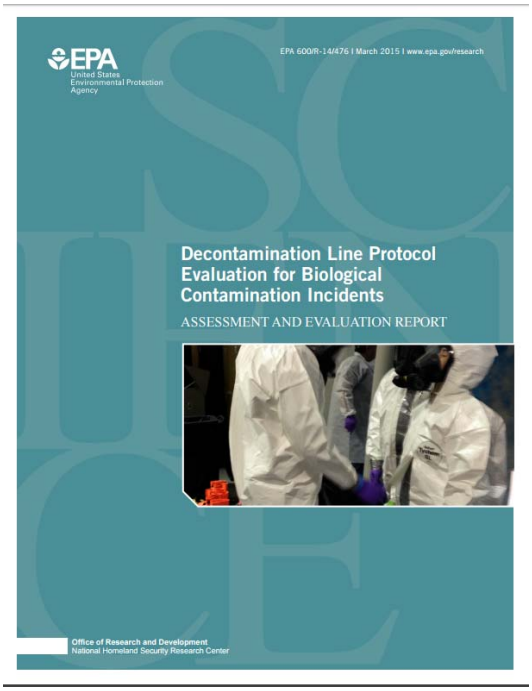
EPA Technical Report
EPA 600/R-14/476
March 2015



Questions???

CAPT Marshall Gray…….Riding off into the sunset!

John Archer
US EPA Office of Research and Development
National Homeland Security Research Center
archer.john@epa.gov
919.541.1151

Today's Speakers

Jackie MacDonald Gibson
University of North Carolina

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NSF CBET 1619958

Managing Health Risks to Wastewater Workers from Ebola and Other Pathogens

Science and Solutions

Jackie MacDonald Gibson

Department of Environmental Sciences and Engineering
University of North Carolina at Chapel Hill

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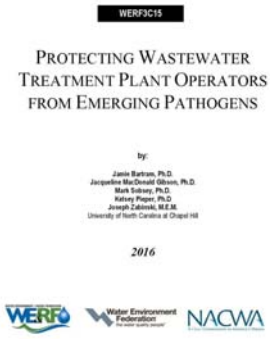
Background: Risk Assessment Project Revealed Need for PPE Guidelines

- Evidence of increased infectious disease risk to wastewater workers
- Lack of guidelines for personal protective equipment (PPE)


WERF3C15

PROTECTING WASTEWATER TREATMENT PLANT OPERATORS FROM EMERGING PATHOGENS

by:

2016

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Workshop Convened to Develop PPE Guidelines for Wastewater Workers

- Objectives:
  - Identify key routes via which wastewater workers could be exposed to infectious agents
  - Establish best PPE practices for decreasing exposure at each key exposure point
  - Identify critical knowledge gaps and a recommended research program to fill the gaps

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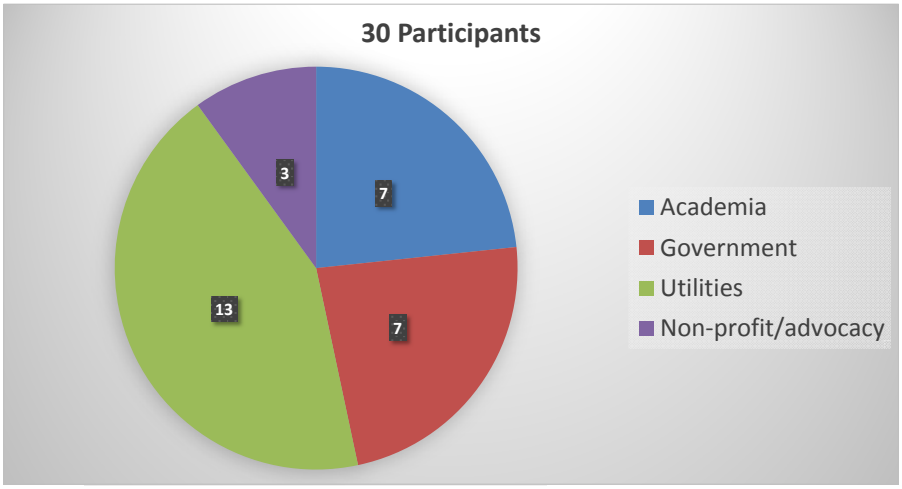
Participants Represented Multiple Viewpoints



Workshop Structure Alternated Between Plenaries and Small Groups

Plenaries:

- **Infectious agents in wastewater**
- **PPE implementation issues**
- **Review and critique small-group products**

Small groups:

1. **Collection system workers**
2. **Routine plant operations**
3. **Plant maintenance**
4. **Biosolids operations**

Preliminary Result 1

Draft PPE selection matrix

Work environment	Job activity	Contact transfer	Splash, eye/face	Whole body contact	Abrasion, cut	Respiratory
Collection System	Lift station inspection	✓				
	Vac/jetter truck operation	✓	✓			✓
	Netting facility/storm drain pretreatment O&M	✓	✓		✓	
	Closed circuit television operation/line cleaning	✓	✓		✓	
	Field wastewater sampling	✓				
	Sewer entry (additional if live sewer)	✓	✓	(✓)	✓	(✓)
	Man-hole Maintenance	✓			✓	
	Sewer pipe repair work (additional if live sewer)	✓	✓	(✓)	✓	(✓)
	Spill response/sewer overflow	✓	✓		✓	
Routine Wastewater Treatment Plant Operation	Visual process/plant inspections/daily rounds[1]	✓				
	Pushbutton equipment operation	✓				
	Manual valve operation	✓			✓	
	Plant wastewater sampling (auto or grab)	✓				
	Field instrument calibration (DO)	✓	✓			
	Sludge judge	✓	✓			
	General housekeeping (e.g., hose down)	✓	✓			
	Dry sweeping, high pressure power wash	✓	✓			✓
	General lab activities[2]	✓			✓	
	Hand held DO	✓	✓			
Wastewater Treatment Plant Maintenance	General facility maintenance	✓				
	Active pump and line maintenance	✓	✓	✓	✓	✓*
	Process/equipment maintenance with sewage contact	✓	✓			
	Maintenance requiring entry into empty tank[3]	✓	✓	✓		✓
Preliminary Equipment	Cleaning bar screens	✓	✓		✓*	✓*
	Screenings handling	✓	✓*		✓*	
	Grit handling	✓	✓*			
UV Disinfection	Routine inspection[4]	✓				
	Routine maintenance[4]	✓				
	Bulb replacement[4]	✓	✓		✓	
	Ballast replacement[4]	✓	✓			
Biosolids Handling	Gravity thickening operation	✓				
	Non-gravity thickening operation	✓	✓			
	Open dewatering equipment operation	✓	✓			
	Enclosed dewatering equipment operation	✓				
	Liquid and cake sampling	✓				
	Septage/waste receiving	✓	✓			✓*
	Compost handling	✓				✓*
	Dewatered class B biosolids handling	✓				✓*
	Dewatered class A biosolids handling	✓				
	Thermally dried biosolids/ash handling	✓				

(✓) Recommended only if in live sewer
[1]Aerosols present around plant would be process specific
[2]Refer to biosafety lab and disposal guidelines
✓* Recommended contingent on other factors
[3]In addition to confined space entry procedures
[4]In addition to minimum PPE requirements

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Matrix Recommends PPE Based on Job Activity

Worker location

Specific tasks

Exposure routes

Work environment	Job activity	Contact transfer	Splash, eye/face	Whole body contact	Abrasion, cut	Respiratory
Collection System	Lift station inspection	✓				
	Vac/jetter truck operation	✓	✓			✓
	Netting facility/storm drain pretreatment O&M	✓	✓		✓	
	Closed circuit television operation/line cleaning	✓	✓		✓	
	Field wastewater sampling	✓				
	Sewer entry (additional if live sewer)	✓	✓	(✓)	✓	(✓)
	Man-hole Maintenance	✓			✓	
	Sewer pipe repair work (additional if live sewer)	✓	✓	(✓)	✓	(✓)
	Spill response/sewer overflow	✓	✓		✓	
Routine Wastewater Treatment Plant Operation	Visual process/plant inspections/daily rounds[1]	✓				
	Pushbutton equipment operation	✓				
	Manual valve operation	✓			✓	
	Plant wastewater sampling (auto or grab)	✓				
	Field instrument calibration (DO)	✓	✓			
	Sludge judge	✓	✓			
	General housekeeping (e.g., hose down)	✓	✓			
	Dry sweeping, high pressure power wash	✓	✓			✓
	General lab activities[2]	✓			✓	
	Hand held DO	✓	✓			
Wastewater Treatment Plant Maintenance	General facility maintenance	✓				
	Active pump and line maintenance	✓	✓	✓	✓	✓*
	Process/equipment maintenance with sewage contact	✓	✓			
	Maintenance requiring entry into empty tank[3]	✓	✓	✓		✓
Preliminary Equipment	Cleaning bar screens	✓	✓		✓*	✓*
	Screenings handling	✓	✓*		✓*	
	Grit handling	✓	✓*			

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Preliminary Result 2

Five research recommendations

1. *Conduct a prospective epidemiological study of wastewater and sewer workers.*
2. *Characterize respiratory exposure for typical tasks performed by workers in wastewater collection and treatment operations.*
3. *Characterize contact exposure for typical tasks performed by workers in wastewater collection and treatment operations.*
4. *Perform cost-benefit analyses of PPE for wastewater and sewer workers.*
5. *Refine guidance and develop best practices for wastewater and sewer worker PPE.*

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Next Steps

1. Workshop participants review current draft PPE selection matrix and research recommendations
2. Workshop organizing committee revises PPE selection matrix and research recommendations
3. External review of final workshop report
4. Final report publication by the National Science Foundation and as journal article

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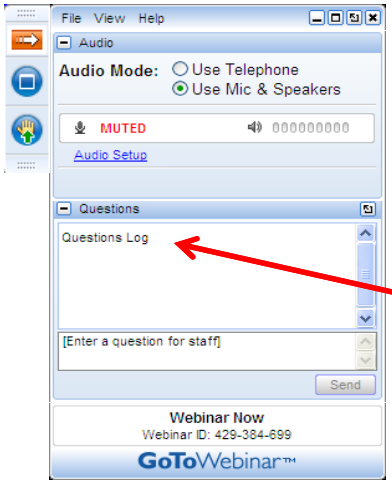
Many thanks!

- Organizing committee
  - Mark LeChevallier, American Water
  - Lisa Casanova, Georgia State University
  - Ted Mansfield, UNC (post doc)
- Workshop participants
- WERF
  - Lola Olabode
- NSF
  - Bill Cooper

Questions for Our Speakers?



- **Submit your questions using the Questions Pane.**