



Chemical Agents of Opportunity for Terrorism: TICs & TIMs

Chemical Contamination of Food, Water, and Medication

Training Support Package

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Chemical Agents of Opportunity for Terrorism: TICs & TIMs

### Learning Objectives

- Describe how U.S. drinking water is produced as a prototype for the water, food, and medication systems
- Use past incidents of water, food, and drug contamination to identify system vulnerabilities and potential agents of concern
- Describe system-wide changes or legislation resulting from past accidental or terrorist events
- Identify resources detailing measures used to protect the US water, food, and drug supplies

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Chemical Agents of Opportunity for Terrorism: TICs & TIMs

### Water Treatment

- State / federal EPAs regulate public drinking water safety (Safe Drinking Water Act) in US
- Common treatment steps:
  - Coagulation / Flocculation
  - Sedimentation
  - Filtration
  - Disinfection

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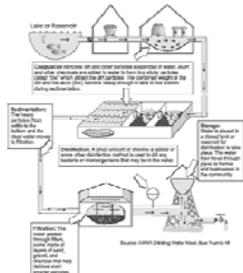
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### Typical Public Drinking Water System



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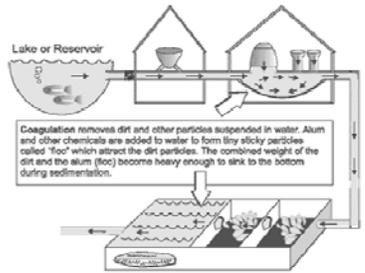
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### Coagulation/Flocculation



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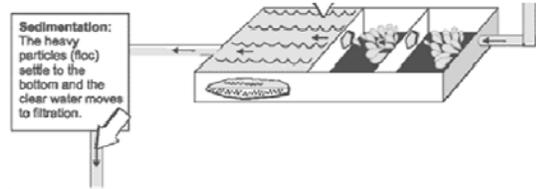
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### Sedimentation



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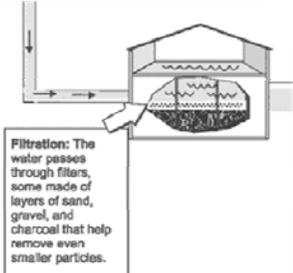
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### Filtration



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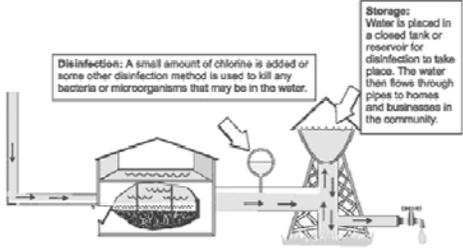
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### Disinfection



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### Water System Vulnerabilities

- The Water System,
- Is essential for health & safety
  - Comprises spatially diverse elements
  - Is susceptible to intrusion
  - Provides numerous attack sites
  - Is difficult to protect against backflow attacks
  - Contamination is difficult to trace

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## Maple Leaf Reservoir (Seattle, WA)

- Sept 10th, 2002
- Breach of fence around 60,000,000 gal finished water reservoir reported.
- 15 foot garden hose found near cut in fence.
- First noted 2 days earlier but not reported to supervisors.



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## Questions

- When water supply adulteration is suspected,
- What chemicals should we test for?
  - Who can run STAT tests for significant chemical contaminants?
  - What criteria do you use to say the water is safe to drink?

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## Maple Leaf Reservoir (Seattle, WA)

- Tests on hose and reservoir water negative
- No claims of responsibility
- No clusters of illness identified
- Reservoir water disinfected and reprocessed

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## The Ideal Drinking Water Contaminant

- Resists water treatment
- Is difficult to detect
- Is difficult to clean
  - Pipes, reservoirs, etc
- Causes illness:
  - Delayed onset
  - Difficult to diagnose
- Readily available
- No odor & taste
- Colorless
- Water soluble
- Stable in water (i.e., resistant to hydrolysis)
- Unexpected
- Low LD50

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## Relative Water Toxicity

$$R = \text{Solubility/Lethal Dose} \times 1000$$

Compound	R
Botulinum Toxin	10,000
VX	300
Sarin	100
Nicotine	20
Cyanide	9
Amiton (OP)	5
Na Fluoroacetate	1
Arsenite, arsenate	1

Clark: J Contingencies Crisis Management 2000

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## Cyanide Calculations

Cyanide salts as potential contaminants:

- Individual:
  - 250 mg Lethal Human Dose (oral)
  - (250 mg/0.5 L = 500 mg/L = 0.5 g/L)
- Water System:
  - 0.0005 kg/L x 200,000,000 L = 100,000 kg = 220,000 lb = 110 tons

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### Botulism Calculations

- 0.00003 µg/kg LD50 Mice
- 70 µg Lethal Human Dose
- 70 µg/0.5 L = 140 µg/L
- 140 µg/L x 200,000,000 L = 28,000 g
- 28 kg for 200,000,000 L Reservoir!

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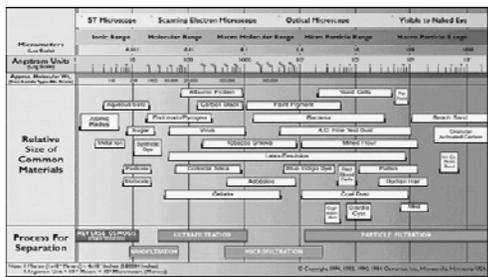
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### Filtration Spectrum



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## Cross-Connections

- Mix of non potable with potable water
  - Distribution system pressure  $\geq$  20 psi
  - Backpressure: external > system pressure
  - 1970-01: 459 events, 12,093 illnesses
    - Avg 1 line break/yr 1,000 person system
- (Potential Contamination Due to Cross-connections and Backflow and Associated Health Risks. Issue Paper US EPA OGW & DW Aug 2002)

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## Cross Connection / Backflow Threats

*One sociopath who understands hydraulics and has access to a drum of toxic chemicals could inflict serious damage pretty quickly to a water supply system in a neighborhood or a pressure zone without detection in most communities. - Denileon: JAWWA 2001*

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## Cross Connection Example

- North Carolina (1997)
- 60 gal. retardant foam pumped into hydrant
  - No local labs for testing
  - Water use ban on 40,000 households
  - 90 million gallons used to flush system
  - No drinking water for 39 hrs

Krouse: Opflow 2001

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## Drinking Water: Terrorism Detection

Detection Scenarios:

- Caught in the act  
(cameras, security, or eye witness reports)
- Online/Field detection & monitoring
- Water quality observations (odor, color,...)
- Mass Illnesses (often nonspecific)
  - ED/Public Health Surveillance Systems

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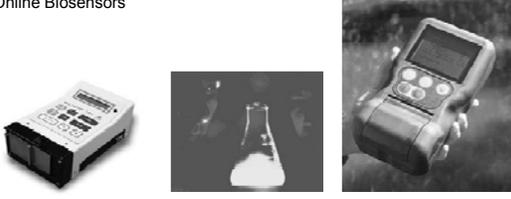
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## Early Detection

- Online Phys/Chem Monitors
  - Chlorine, pH, Turbidity, Total Organic Carbon, Pressure, Radioactivity
- Rapid Field Testing Kits
- Online Biosensors



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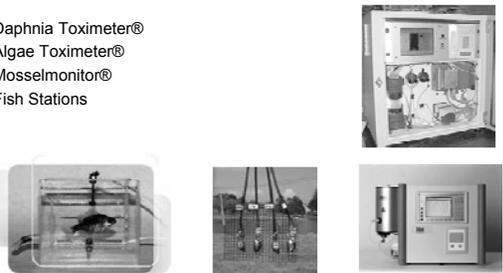
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## Online Biosensors

- Daphnia Toximeter®
- Algae Toximeter®
- Mosselmonitor®
- Fish Stations



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Which of the following statements regarding US drinking water standards is correct?

1. FDA enforces standards set by the EPA
2. EPA sets and enforces standards either
3. USDA enforces standards set by the
4. EPA specifies the methods used to
5. EPA enforces standards set by the FDA
- 6.
- 7.
- 8.
- 9.
- 10.

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Chemical Agents of Opportunity for Terrorism:  
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### Protecting Food: FDA vs USDA Roles

- USDA regulates meat, poultry, eggs, & processed egg products
- FDA regulates all other foods (~ 80% of US food supply)
- FDA & USDA, high risk foods:
  - large batches
  - uniform mixing
  - short shelf life
  - ease of access

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Chemical Agents of Opportunity for Terrorism:  
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### Factors Enhancing Food System Vulnerability

- Concentration of primary production in large, monoculture farms/stockyards
- Raw goods from small suppliers combined
- Concentration of commodity food-processing in large centralized facilities
- Quality control not designed to detect unanticipated contaminants/poisons

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## Botulism Threat

- Potency: "Most Lethal Substance"
  - 70 ug Lethal Oral Dose
  - 70 gm Could Kill 1,000,000 People
- Prolonged ICU Requirement
  - May Exhaust Supply of Ventilators
- Easy to Mass Produce
  - Russia, Iraq, Iran, Syria, North Korea
  - 1991 "Iraqi Stockpile": 19,000 L

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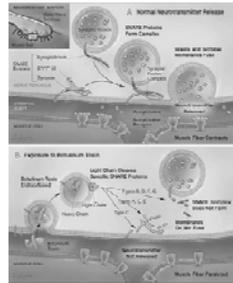
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## Botulism: Toxic Mechanism

Botulinum toxin inhibits acetylcholine release. [Arnon: JAMA 99]



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## Analyzing a bioterror attack on the food supply: The case of botulinum toxin in milk

Lawrence M. Wein\*\* and Yifan Liu\*

\*Graduate School of Business and †Institute for Computational and Mathematical Engineering, Stanford University, Stanford, CA 94305  
Edited by Barry R. Bloom, Harvard University, Boston, MA, and approved April 20, 2005 (received for review November 16, 2004)

We developed a mathematical model of a cows-to-consumers supply chain associated with a single milk-processing facility that is the victim of a deliberate release of botulinum toxins. Because centralized storage and processing lead to substantial dilution of the toxin, a minimum amount of toxin is required for the release to do damage. Irreducible uncertainties regarding the dose-response curve prevent us from quantifying the minimum effective release. However, if terrorists can obtain enough toxin, and this may well be possible, then rapid distribution and consumption result in several hundred thousand poisoned individuals if detection from early symptomatics is not timely. Timely and specific in-process testing has the potential to eliminate the threat of this scenario at a cost of <1 cent per gallon and should be pursued aggressively. Investigation of improving the toxin inactivation rate of heat pasteurization without sacrificing taste or nutrition is warranted.



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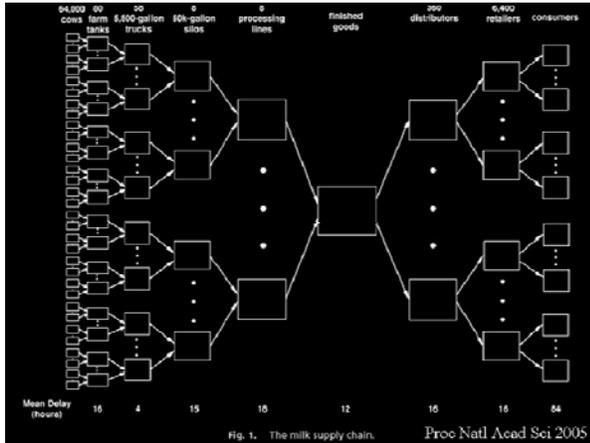
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Chemical Agents of Opportunity for Terrorism:  
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### Botulinum Contaminated Milk

- Toxin placed in holding tank at farm, tanker truck from farm or raw milk silo at plant
- Without detection
  - < 1g toxin → 100,000 poisoned persons
  - 10g → 568,000 poisoned persons
- Early symptomatic detection:
  - 2/3 cases avoided yet
  - 10 g → 100,000 poisonings
- Children would form a larger percentage of the victims with lower doses of toxin

Proc Natl Acad Sci 2005

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### Inactivating Botulinum Toxin

- Botulinum toxin cannot be completely inactivated by radiation or any heat treatment that does not adversely affect the milk's taste.
- Ultrahigh-temp pasteurization (UHT) can inactivate botulinum toxin but has not been embraced by U.S. consumers.

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## Maine Arsenic Poisonings

- 1 died, 15 others were sickened following Sunday services in 2003
- Next day, maintenance man died of gunshot wound to chest
- Victims shared coffee and food
- Arsenic was found in the coffee pot.



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## Toxic Oil Syndrome (Spain 1981)

- Illegally marketed cooking oil
- Rapeseed oil denatured with 2% aniline
- 20,000 poisoned, 12,000 hospitalized
- > 340 died
- Toxic Oil Syndrome
  - Pneumonitis
  - Eosinophilia
  - Pulmonary hypertension
  - Scleroderma-like changes
  - 50% Peripheral neuropathy, myopathy



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## How Safe are US Medications?

- Drug production is a complex process
  - Synthesis → Delivery to the patient
  - Multiple steps for interference
- Depending on the circumstances, the results can be devastating:
  - Primary Impact (fatalities, illness)
  - Fear/Uncertainty
  - Economic Impact

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### Tylenol Murders (Chicago, 1982)

- 7 died from KCN laced Tylenol
- 1-2 bottles per store
- <10 tampered/ deformed looking capsules/bottle
- Capsules filled with KCN (100-150mg)



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### Copycat (1986)

- Woman in WA state killed her husband with cyanide-laced pain killer
- Attempted to cover her tracks by placing packages of poisoned Excedrin and Anacin capsules on the shelves of 3 stores
- Nickell was sentenced to 90 years in prison.

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### The Tylenol Bill

- 1983  
"Tylenol Bill" made malicious tampering with consumer products a federal offense.
- 1989  
FDA established a national requirement for tamper-resistant packaging of over-the-counter products.
- Triple-seal, tamper-resistant packaging now the norm.

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## Diethylene Glycol (DEG)

### Mysterious Cases of Renal Failure (Haiti)

- 86 cases of acute renal failure:
  - Nov 1995 to June 1996 (8 months)
  - Children aged 3 months – 13 years
- Traced to DEG-contaminated pain medication
- DEG was used to dissolve an early antibiotic causing >100 deaths
- Led to passage of the Food, Drug, and Cosmetic Act (1938)
- Epidemics of renal failure and death due to DEG still occur

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## Heparin Contamination

- FDA announced increased allergic reactions and deaths related to the use of heparin in 2008
- Samples contained 5-20% of an inexpensive non-heparin ingredient that mimicked heparin
  - Oversulfated chondroitin sulfate
- The implicated ingredient originated in China

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## Other Aspects of Medication Quality Control

- Dietary Supplement Health and Education Act of 1994
  - Excludes supplements from FDA oversight, unless harm shown
  - Issues of safety, efficacy, contents, and purity are responsibility of manufacturer
    - Asian patent medicine and other ethnic medications
    - Ephedra-containing products
    - Examples of raw ingredient mixing errors
- Fraudulent prescription medicines via Internet
  - Particularly from other countries

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## Conclusions

- Numerous past incidents reveal vulnerabilities
- Potentially very injurious
- Difficult to prevent, detect, mitigate
- Toxicity, availability determine likelihood

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## Questions

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