The Untapped Military Drinking Water Surveillance Resource

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Overview

- Introduction/Today’s challenge
- Tapped resources
  - COTS equipment
  - On-line equipment/SCADA
- Syndromatic surveillance
- The untapped military resource
- Conclusions
- Recommendations
Today’s Challenge

Water utilities worldwide are searching for an “all-inclusive” drinking water monitor to detect any contamination of the water source and treated water.
The Ideal Water Monitor

- Alarm sounds when there is a problem
- Located at every point in the distribution system
- Provides real-time feedback
- Detects water quality changes
- Detects hydrant access
- Detects pressure changes
- Detect contaminants at $10^{-9}$ ng/L or 0.000000001 grams per liter
- Multi-sensor
  - Odor
  - Taste
  - Color
  - Texture
COTS Equipment

- Handheld water testing equipment
- Advantages
  - Give to operators to check water throughout the system
  - Quick data feedback (with walkie-talkie)
  - Cheaper than online devices
  - Operators can give their opinion
  - Small-portable equipment
  - Results within 5 seconds – 30 minutes
### Available COTS Water Quality Analyses

<table>
<thead>
<tr>
<th>Acidity</th>
<th>Copper</th>
<th>Nitrite Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalinity</td>
<td>Free cyanide</td>
<td>Ozone</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Dissolved oxygen</td>
<td>pH</td>
</tr>
<tr>
<td>Bromine</td>
<td>Fluoride</td>
<td>Reactive phosphorous</td>
</tr>
<tr>
<td>Calcium</td>
<td>Total hardness</td>
<td>Total phosphorous</td>
</tr>
<tr>
<td>Chloride</td>
<td>Hydrazine</td>
<td>Sulfate</td>
</tr>
<tr>
<td>Free chlorine</td>
<td>Iodine</td>
<td>Sulfide</td>
</tr>
<tr>
<td>Total chlorine</td>
<td>Total Iron</td>
<td>Suspended solids</td>
</tr>
<tr>
<td>Combined chlorine</td>
<td>Lead</td>
<td>Turbidity</td>
</tr>
<tr>
<td>Hexavalent chromium</td>
<td>Manganese</td>
<td>Zinc</td>
</tr>
<tr>
<td>Color</td>
<td>Ammonia Nitrogen</td>
<td>And more.......</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Nitrate Nitrogen</td>
<td></td>
</tr>
</tbody>
</table>

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2003 National Defense Industrial Association Conference  
Richmond, VA USA
Parameters Utilities are Choosing to Monitor

- Acidity
- Alkalinity
- Arsenic
- Bromine
- Calcium
- Chloride
- Copper
- Free cyanide
- Dissolved oxygen
- Fluoride
- Total hardness
- Hydrazine
- Iodine
- Total Iron
- Lead
- Manganese
- Ammonia Nitrogen
- Nitrate Nitrogen
- Nitrite Nitrogen
- Ozone
- pH
- Reactive phosphorous
- Total phosphorous
- Sulfate
- Sulfide
- Suspended solids
- Turbidity
- Zinc
- And more……..
COTS Equipment Disadvantages

• Must know limitations
• Instant in time
• Maintenance
• Calibration
• Expensive
• Shelf-life
• Requires on-site use
• False-positive alarms

• Detection limits
• Contaminant interference
• Only provides a value
Online Monitoring (1/2)

- Online sensors and support structure (a.k.a. SCADA)
  - Advantages
    - Information sent and displayed at a central location
    - Real-time data
    - Measure multiple parameters simultaneously: pH, chlorine residual, temperature, turbidity, TDS, pressure
  - Disadvantages
    - Installation and upkeep extremely expensive $$$
    - Maintenance and calibration required $$
    - False positive readings
    - Operator is only provided digital numbers
    - Can be disabled by cyber attack or manually
    - Information limited by sensor placement
USA CH PPM Water Supply Management Program

Online Monitoring (2/2)

Source Water

Water Treatment Plant

Distribution System
Fish Monitors

- Use a continuous acute toxicity monitor to identify developing toxic conditions in surface water
- Continuous monitoring of the breathing and movement patterns of fish
- Developed by USACEHR
- System is being tested at Fort Dietrick and New York City
- Vision to use this in distribution system
Monitoring Population Health

- Public health officials speculated first warning
  - Increased number of people admitted to the emergency room,
  - Increased purchases of flu medicine,
  - Increased absences from school or work
Syndromatic Surveillance (1/3)

• “Pentagon to Track Disease Outbreaks” Washington Times, Aug 02
• “DoD To Develop Biological Agent Early Warning System,” American Forces Press Service, Aug 02
• “Software simulates terror hit, Sandia develops program as tool for public officials,” San Francisco Chronicle, Aug 02
• “Rapid Syndrome Validation Program (RSVP),” developed by Sandia National Laboratories, Aug 02
Syndromatic Surveillance (2/3)

Date

0 10 20 30 40 50 60

Number of Cases Reported

Diarrhea
Fever

13-Mar 14-Mar 15-Mar 16-Mar

AJ Whelton
7-11 March

2003 National Defense Industrial Association Conference
Richmond, VA USA
Syndromatic Surveillance (3/3)

- **Map key**
  - Blue lines: Major roads
  - Dark area: Many illness reports
  - Lighter area: Fewer reports
  - White area: No reports

- **Depiction on a map can show:**
  - Location of people who are affected
  - Density of people affected

Taken from RSVP
What good is syndrome surveillance to military water systems?

• Challenge
  – Military is looking to sure up their drinking water security and surveillance practices

• Leading Evidence
  – Population feedback is being monitored to gauge terrorist attacks
  – Programs such as RSVP can be used to generate bar charts and graphs to give public health officials a visual representation of reported cases
    • ID who is affected
    • ID where people are who are affected
    • ID number of people affected

• Conclusion
  – Use of this methodology could improve drinking water surveillance
Untapped Resource
Drinking Water Consumers

- Indicate problems with water quality
- Detect contaminants at 0.000000001 grams / liter levels
- Sense FAC changes
- Notice pressure problems
- Report hydrant access
- Provide multiple descriptors
  - Taste
  - Odor
  - Color
  - Texture
  - Feelings (i.e., illness)
## Chemical Warfare Agent Aesthetic Attributes in Water

<table>
<thead>
<tr>
<th>Compound Name</th>
<th>Taste Descriptor</th>
<th>Odor Descriptor</th>
<th>Color Descriptor</th>
<th>Turbidity Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen cyanide*</td>
<td>Bitter, metallic</td>
<td>Almonds, peach kernels</td>
<td>Colorless</td>
<td>No</td>
</tr>
<tr>
<td>Cyanogen chloride</td>
<td>Sharp, metallic</td>
<td>Pepperish</td>
<td>Colorless</td>
<td>No</td>
</tr>
<tr>
<td>Soman</td>
<td>Not reported</td>
<td>Fruity, camphor</td>
<td>Colorless</td>
<td>No</td>
</tr>
<tr>
<td>Sulfur mustard</td>
<td>Not reported</td>
<td>Garlic, mustard</td>
<td>Pale yellow</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*Includes KCN and NaCN in water.
Biological Agent Ingestion Symptoms

- *Cryptosporidium parvum* (protozoan)
  - Nausea, diarrhea, and stomach cramps
- *Giardia lamblia* (protozoan)
  - Nausea, diarrhea, bloating, headache, stomach cramps, weight loss
- Smallpox (virus)
  - Nausea, vomiting, fever, headache
- Botulinum toxin (toxin)
  - Paralysis but mentally alert
Effective Example 1

- 1988 Connecticut water utility fluoridation system malfunctions
- Concentrated fluoride pours into the distribution system (40x normal concentration; ~160 mg/L)
- Consumers contacted water utility and reported complaints
  - Illness included nausea, vomiting, diarrhea, cramps, skin irritation
  - Abnormal tastes
  - Turned blue with contact with soap

Petersen et al (1988)
Effective Example 2

- 1993 Milwaukee, WI Cryptosporidium outbreak
- 400,000 people sick; 100+ died
- Illness complaints were reported to the water plant
Effective Example 3

- 1990s at one Army plant
- Contractor super chlorinates an offline storage tank after repairs are completed, 100 ppm FAC
  - Valves are not completely shut
  - Super chlorinated water enters the distribution system
- Consumers filed complaints
  - 4.0 mg/L FAC found at taps
  - 1.0-2.0 mg/L FAC normal
Consumer Complaint System Components

• Standard operating procedures (SOPs)
• Single point-of-contact (POC)
• Electronic database/records
  – Charts and graphs
  – Distribution system map with markings
• Consumer education
Standard Operating Procedures (SOPs)

- Receiving a complaint
- Field investigation
- Pertinent lab analyses
- Internal & external research investigation
- Management & consumer notification
- Follow-up actions
USA CH PPM Water Supply Management Program

Single POC
(Point-of-Contact)

• Coordinates all resolution and investigation actions
• Chooses appropriate lab tests
• Reviews all data
• Ensures all complaints are addressed & rectified
Marked Distribution System Map

- Map of a fictitious distribution system
- Map key
  - 1 circle = 1 complaint
- Conclusions
  - ID the location of each complaint
  - ID number of people affected
Educated Consumers

- Awareness and knowledge of common problems
  - Earthy & musty odors, “red” water
  - Less likely to complain
- When an unusual problem arises…
  - Complaint triggered~!
- Educational tools
  - Consumer confidence reports (CCRs)
  - Articles or advertisements in
    - Installation newspapers
    - In-processing information packages
USACH PPM Water Supply Management Program

In Focus:
Fort Knox, KY

- Serves more than 20,000
- TRACKING/MAPPING
  - Records consumer complaint and ongoing status
  - Use a map to track main breaks, and will for complaints
- FIELD INVESTIGATION
  - Developed water quality field kits
- CONSUMER EDUCATION
  - Use door hangers, email, newspapers, and TV to notify about flushing activities
Conclusions (1/2)

- Find ingenious low cost methods to monitor water quality with our current resources
- COTS and online monitoring equipment are useful
  - Must acknowledge their limitations
  - Must continue to search for ways to better monitor drinking water quality
Conclusions (2/2)

• Terrorist attacks could be first noticed by people
• Complaints not fully and in some cases not at all integrated into military water system surveillance
  – Some are addressed but not filed or mapped
  – Many are seen as nuisance caused (iron in water) vs. water quality problem caused by a terrorist attack (new concept)
• Comprehensive guidance not provided anywhere
  – Department of Defense/Public/Private sectors included
Recommendations

• Talk about how complaints are handled
• Establish a systematic approach
  – POC for all complaints
  – Standard operating procedures
  – Simple database/file to include graphs and maps
  – Consumer education/outreach effort
• Follow the USACHPPM
  – NDIA proceedings paper (on conference CD)
  – Fact Sheet (on USACHPPM web site)
    • Drinking Water Consumer Complaints
• Contact the USACHPPM for additional guidance
Acknowledgements

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