USACEHR Advances in Water Toxicity
Sensors and Technology
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USACEHR Mission and Vision

• Mission
  – Develop surveillance capabilities to detect, assess, and prevent health effects from adverse environmental, physiological, and psychological exposures.

• Vision
  – Protect the health of Soldiers from environmental and mission related threats through innovative science.
## Location and Personnel

Building (33,400 sq ft of floor space total)
- Completely renovated in 2003-04
- Automated monitoring and controls system for building
- Office and cubicle space for > 60 personnel (support MRMC HQ offices as tenants)
- Fully equipped conference center with video teleconferencing

In-House Laboratories (~10,000 sq ft)
- Rodent vivarium addition (2014) 1,500 sq ft
- Next-Gen Sequencing laboratories 2500 sq ft
- Complete aquaculture facilities
  - Well water supply and aquaculture distribution system
  - Exposure / Diluter facilities
- Sterile culture / *in vitro* research facilities
- Extensive analytical chemistry
- OMICs Center
  - Mass spectrometry proteomics
  - Gene expression microarray platforms
  - NextGen sequencing platforms

### Number of Personnel

<table>
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<tr>
<th>Military</th>
<th>Civilians</th>
<th>On-site Contr.</th>
<th>TOTAL</th>
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<td>4</td>
<td>20</td>
<td>37</td>
<td>61</td>
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Water in the Army

• Production of Water
  – Quartermaster Corps

• Certification of Potable Water
  – Preventive Medicine Personnel (MEDCOM)

• Certification of Bottled Water
  – Army Medical Department Veterinary Corps (food)
Previous Water Technologies

- Trailer based technologies

- Fish Biomonitor – 4 US and 1 Canadian Patent
  - MWCOG, Aberdeen Proving Ground, New York City DEP, Fort Detrick, etc.
  - Submersible biomonitor

- Killifish Hatching kit for toxicity tests – 2 US Patents

- Environmental Sentinel Biomonitor
  - Cell-based chip
  - Pesticide Assay

- Coliform Bacteria Analyzer
Aquatic Biomonitor Example

Ventilatory Frequency

Whole Body Movement

Ventilatory Depth

Cough Frequency
Test Kit Description:

The ESB system includes two hand-held toxicity sensors to be used in conjunction with the Water Quality Analysis Set – Preventive Medicine (WQAS-PM). The ESB system will rapidly identify toxicity associated with a broad spectrum of industrial chemicals in Army field water supplies.

Electric cell-substrate impedance sensor (ECIS)  ACE sensor
Principles of ACE Inhibition Test

Naked enzymes are freeze-dried with temperature stabilizing reagents and reconstituted with a water sample.

The active form of the enzyme binds to the substrate which is impregnated on the ticket to form a green color (fluoresces under UV light).

If enzyme is interfered with:

Toxic materials that interfere with the enzyme-binding will result in the absence of a green hue. A purple-blue color in the test well will result instead.

Test (unknown) water sample

Contaminated (Positive)

Control (known) water sample

Not Contaminated (Negative)
Principles of Electric Cell Substrate Impedance Sensing (ECIS)

- Membrane Capacitance
- Substrate Adhesion
- Reference Electrode
- Barrier Function

1 μA, 1 mV
1 MΩ
15,000 HZ AC SIGNAL 1 VOLT

Lock-In Amplifier
PC DATA ACQUISITION AND PROCESSING

Graph showing data over time (hours)

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Aquatic Toxicology Capabilities

- Zebrafish models

- Toxicology models, defined strains, in house breeding capabilities


In-house breeding

Diluter (exposure chambers)
Aquatic Toxicology Capabilities

- Xenopus models
- Bluegill models

- Custom high quality water system and diluter, and biomonitoring


- 1300 sq. ft. aquatic
- 2 husbandry rooms
- 1 diluter room
- 1 procedure room
- 150 20L zebrafish tanks
  - up to 6000, 40 per tank
- 3 150G blue gill
  - up to 1050, 350 per tank
- 1 150G frog tanks
  - up to 20 adults per tank

In-house breeding

Well Water System
What we are looking for

• Novel rapid toxicity tests for Toxic Industrial Chemicals
  – Answers within 1 hour

• Novel Coliform Bacteria tests
  – Currently Approved Capability Production Document (Army Acquisition jargon)
  – EPA Alternative Test Procedure passage
  – $

• Business looking to further develop in-house technologies
What we can provide

• Testing of Toxic Chemicals
  – Metals, pesticides, volatile organic chemicals (VOC’s), degreasers, etc.

• Personnel and facilities to test

• Coliform Bacteria $ available provided tech meets or has potential to meet key performance parameters
  – Coli-Lert gives presence/absence in 18 hrs
  – Gold Standard?
Future Operating Environment

Force 2025 and Beyond

- What environmental health threats should we prepare for now?
- What new capabilities, concepts, and doctrine will be required to protect service members?

- World’s population in urban areas will rise to 60% by 2030
- Megacities are locations with high levels of TICs, TIMs and ENMs

Tools are needed for:
- Medical surveillance
- Diagnosis of health effects
- Countermeasures

These tools would enable Armed Forces to operate with confidence and thrive in uncertain and dangerous environments

"Failing to prepare for military operations in dangerous megacities could leave a future president without the means to do something that he or she considers to be in the national interest."

- Steven Metz, Strategic Horizons: How the U.S. Military Might Get Involved in a Megacity

“To ignore megacities is to ignore the future"
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Questions?

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