Assessing Environmental Health

**Going Beyond the Sensor**

Arsenic is the highest priority environmental threat on the CERCLA (Superfund) list. On National Priority Sites (in the United States), arsenic is toxic, frequently encountered, and poses a high human exposure risk. Arsenic surpasses lead and mercury in its aggregate threat to superfund sites.
Sensors in Environmental Health

The Mutating, Elusive, & **Ambiguous** Face of Arsenic In Soil

* A neurological threat to children
* A precursor to drinking water poisoning
A Chemical Company dumps toxic waste into appropriate containers in an appropriately contained landfill. Another entity purchases the adjacent land from the Chemical Company and in the process of developing it, breaches the clay landfill barrier, dispersing toxic waste into residential neighborhoods. High rates of miscarriage and birth defects trigger community action. After prolonged testing and legal action, extensive mitigation (buy-out and clean-up) is undertaken.
Arsenic in Post-Katrina New Orleans

Multiple Shipping & Petrochemical Sources

Dispersion by Flooding

Chronic
Long Term Impact

Plants & Soil show no indication

Non-profits Trigger Alarm

Arsenic Sediment Testing

Vague, Variable Exposure Limits

Known Health Effects

Arsenic is the top environmental contaminant in the United States (ATSDR)

The Story (A New Approach)

Hurricanes Katrina & Rita caused extensive flooding in New Orleans; waters from the Industrial Canal, heavily used by commercial shipping, flooded the poorest neighborhoods, leaving behind an “immediate” toxic gumbo in the soil that has distilled into a long term chronic health risk. Ambiguous exposure limits in soil prevent mitigation of arsenic contamination, even when such mitigation is inexpensive and accessible to residents.

Arguable Risk

No Litigation Possible

No Mitigation Action Taken
Health Risk Assessment: Based on the Traditional Approach

Gentilly Neighborhood (New Orleans)

All samples test below the maximum allowable (EPA)
All but one sample test below the Louisiana Background Level
All samples test above the EPA screen level
Health Risk Assessment: Based on our Approach

Arsenic content correlates poorly with pH
Poor Correlation indicates the soil has been disturbed (flooding) ... and that the source of the disturbance is likely inorganic (man-made) arsenic
Health Risk Assessment: Based on our Approach

<table>
<thead>
<tr>
<th>Location</th>
<th>Normalized Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gentilly (NOLA)</td>
<td>0.5</td>
</tr>
<tr>
<td>Ninth Ward (NOLA)</td>
<td>1.0</td>
</tr>
<tr>
<td>DeLisle (MS)</td>
<td>3.0</td>
</tr>
<tr>
<td>Vashon (WA)</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Florida Data: Chirenje et al, 2003

Potential Problem

Arsenic content has low variability in suspect areas. Previous studies have shown low variability to be correlated to soils both disturbed and impacted by man-made arsenic.
Health Risk Assessment: Based on the Traditional Approach

Ninth Ward Arsenic Content

Only one sample tests above the maximum allowable (EPA)
All but one sample test above the Louisiana Background Level
All samples test above the EPA screening level
Health Risk Assessment: Based on our Approach

If we translate the (well defined) exposure limit for arsenic exposure in drinking water to soil (for children based on 32 oz of water consumed per day and 200 mg of soil), the ingestion limit for safe exposure is about **45 ppm in soil**.

Bioaccessible content near a school tests near EPA maximum allowable level for soil AND at exposure limit for drinking water.
Sensing Arsenic in Soil: 
Based on the Traditional Approach

Traditional Methods use sophisticated, EPA-approved laboratory analysis techniques to extract total arsenic content from soil. Research has attempted to translate these laboratory sensing methods to the field with no commercial success. The meaning of total arsenic content is heavily confounded by (natural) background levels in a geographical region and soil properties which influence the type (inorganic vs. organic) and accessibility to the human digestive system.
Sensing Arsenic in Soil: Based on our Health-Relevant Approach

Mediating Properties in Soil can be measured using composite portable sensing instruments (designed for these soil-based problems) and used in conjunction with local arsenic patterns and food related arsenic intake (primarily seafood) to resolve ambiguity of arsenic levels in soil. Resolving ambiguity enables calculation of an actionable health risk (and subsequent mitigation).

**Natural Organic Arsenic**

**Man-Made Organic Arsenic**

**Man-Made Inorganic Arsenic**

**Soil**

**Mediating Properties:**
- pH, soil type, Iron and Aluminum Content
- Local Variability Patterns
- Inorganic Arsenic Content
- Organic Arsenic Content
- BioAccessibility

**X**
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Composite Sensing & Analysis

Vague, Variable Exposure Limits

Carcinogenic & Neurological Impact

Our Approach to Sensing Arsenic in Soil

The Replacement of Arsenic Sediment Testing With Composite Sensing and Analysis Allows Vague, Variable Exposure Limits to Become Indisputable Exposure Limits And Arguable Risk to Become Real Health Risk

Real Health Risk

No Litigation Possible

No Mitigation Action Taken
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Our Approach to Sensing Arsenic in Soil

Placing Composite Sensing & Analysis
In the hands of residents and community organizations
Circumvents No Litigation Possible

So that Mitigation Action Can be taken independent of legal or regulatory action (mulching, iron additions, phyto-remediation)

Real Health Risk

No Litigation Possible

Effective, Accessible Mitigation