Emerging Environmental Liabilities: Identification, Management and Multi-jurisdictional Issues

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Overview

- General Introduction
- The Elements of Emerging Issues: Chemistry, Occurrence, Risk and Regulations
- Emerging Liabilities Case Study: MTBE
- Emerging Liabilities Case Study: Perchlorate
- Potential Implications
- Recommendations for Management
Introduction

Emerging Environmental Liabilities:

- An environmental risk (either real or perceived) that was previously unknown to the general public, government bodies, and/or industry.
Risk Components

- **General Public Perception** – if chemical is present (at any concentration) then it will pose an adverse health effect.

- **Perceived Risk = Scientific Risk + Outrage**

- The public pays too little attention to scientific risk, while the experts pay absolutely no attention to outrage.
Five Components of Emerging Issues

Analytical Chemistry
- Method Development
- Detections of new chemicals at some level
- Interpretation of Data near detection limits
- Matrix interferences

Occurrence Data
- Which media
- What locations – point source vs. non point source
- What levels or concentrations
- Localized vs. Population level exposures

Toxicology Data
- Existing data available
- New data required
- Acute/Chronic exposures
- Types of Effects
- Sensitive subpopulations

Risk Assessment
- Hazard, Pathway, Receptor
- Public Health and Safety
- Method development

Regulatory Development
- Science
- Stakeholders
- Media of Concern
- Economic Implications
- Regulations and Enforcement
Emerging Contaminants - Who is Potentially at Risk?

- Industrial Producers
- Industrial Distributers
- Product End User
- Water Utilities (either public or private)
- General public
- Governments
What Makes a Significant Emerging Contaminant?

- New toxicological evidence
- Change in regulatory standard
- Change in analytical method (lower detection limit)
- New chemical or increase in production
- Heightened public awareness
- New legal theories
What Makes a Chemical of Significance?

SOURCE
- High volume
- Widespread use
- Factual

PATHWAY
- Mobile
- Resistant to biodegradation
- Scientific

RECEPTOR
- Toxic
- Other public health concern
- Medical Perception
Emerging Chemicals of Significance

- Fuel oxygenates – MTBE*, TBA
- Rocket propellants – perchlorate*, NDMA
- Metals - hexavalent chromium and arsenic
- Radionuclide – radon
- Naphthenic acids (oilsands)
Emerging Contaminants of Significance

- Solvent Additives – 1,4-dioxane and 1,2,3 TCP
- Pesticides – 1,2,3 TCP
- Pharmaceuticals and other endocrine disruptors
- Biological agents – viruses and bacteria
- Polybrominated diphenyl ethers (PBDE)
- Fluoropolymers (Teflon) byproduct
- Ethoxylate Surfactants
- And ???
MTBE and Other Fuel Oxygenates
Methyl tertiary Butyl Ether (MTBE)

- Used since late 1970s as octane enhancer as part of lead phase-out
- Used since 1992 as an oxygenate in reformulated gasoline (11% to 15% vol./vol.)
- Adds oxygen (2+% by weight) to enhance combustion and reduce emissions
MTBE Production

Second highest volume chemical produced in the USA
WorleyParsons Komex

resources & energy

Steel USTs

Fiberglass USTs

UST Removal
Impact to Drinking Water Supplies in United States

- Approximately 125,000 public wells nationwide
- Estimate 500 to 2,700 public wells to be contaminated with MTBE at 5 ppb or greater
- About 15,000,000 wells nationwide
- 50,000 - 500,000 private wells estimated to be contaminated by MTBE at 5 ppb or greater
- EPA reports 415,000 “confirmed releases (at USTs) … and about 150,000 UST sites remaining to be cleaned up”
The Cost to Address ($USD)

- Public wells – $1 to $33 billion
  - Santa Monica alone ~$350 million
- Private wells – $2 to $16 billion
- LUSTs - $28 to $92 billion
- Total - $30 to 142 billion
- Does not consider LUSTs closed without MTBE testing, bulk plants, terminals, pipelines, refineries, other sources.
- Does not consider non-technical costs (e.g. legal)
<table>
<thead>
<tr>
<th>Location</th>
<th>Amount</th>
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<tr>
<td>Santa Monica, Charnock</td>
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<td>Santa Monica, Arcadia</td>
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<td>Orange County</td>
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<tr>
<td>Morro Bay</td>
<td>$3,000,000</td>
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<tr>
<td>Cambria</td>
<td>$9,000,000</td>
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<tr>
<td>Dinuba</td>
<td>$7,000,000</td>
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<td>&gt;150 other lawsuits related to MTBE in the USA</td>
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Is MTBE a Significant Contaminant?

SOURCE

PATHWAY

RECEPTOR

High volume
Widespread use
Mobile
Resistant to biodegradation
Toxic
Other public health concern

Factual
Scientific
Medical
Perception
A Happy Ending
Or Too Little Too Late?
Perchlorate
Perchlorate is a compound containing one chlorine atom and four oxygen atoms.

Formed by dissociation of perchlorate salts in water:

\[
\text{NaClO}_4 \; (s) \leftrightarrow \text{Na}^+ \; (aq) + \text{ClO}_4^- \; (aq)
\]
Physical-Chemical Properties

- Very high solubility in aqueous solution (2.09 kg/L for NaClO4-) and is unaffected by pH or temperature.
- Low association with cations responsible for the extremely high solubilities of perchlorate salts.
- Very low potential for volatilization and has negligible vapour pressure.
- Perchlorate ion is abiotically stable in even very reducing environments (Eh < 200 mV).
- Thermal decomposition temperature ranging from 400 to 600 ºC.
Natural Sources

- Chilean fertilizer deposits
- New Mexican potash
- Canadian potash
- Californian hanksite
- Bolivian playa crusts
Anthropogenic Sources

- Rocket Fuel
- Fireworks
- High explosives
- Flares
- Herbicides
- Automobile airbags
- Tracer munitions
- Detergents?

The typical perchlorate manufacturing process is as follows:

\[ \text{NaCl (s)} \leftrightarrow \text{NaClO}_3 \leftrightarrow \text{NaClO}_4 \leftrightarrow \text{NH}_4\text{ClO}_4 \]
Solid rocket propellant (50% AP)
Explosive and Munitions
Pyrotechnics, fireworks, munitions
Air bag inflators/other charges
Nuclear reactors/electronic tubes
Additives in oils
Laboratories: perchloric acid
Chilean Nitrate Fertilizers
Evaporite Deposits
Others?
1908 1st manufacture

WWII: significant advances in solid propellants

1948: Aerojet change from KClO₄ to AP

1950s –1990s Cold War/Space Races

1997: DHS DL 400 >> 4 ug/L

1999 - 2002: ~16.5 million lb/yr produced
In 1985, perchlorate contamination discovered in monitoring wells at California Superfund Sites

Contamination of Water sources in US at national scale not recognized until 1997

> 11 million people have perchlorate in public water supplies at concentrations > 4 ug/L

National DW standard does not exist in US or Canada

Various Stakeholders are involved in developing standards

National Academy of Sciences Review

Potential Implications and Liabilities are excessive
A key driver in development of ClO4- regulations

- Electrochemical methods, gravimetric methods used historically – many interferences and high MDLs
- EPA Method 314.0 – Introduced around 1997
  - Ion chromatography/conductivity detector
- MDLs – 1-2 ug/L using EPA 314.0
Drinking Water Standards

- National standard not established but USEPA examining need
- State DW standards in eight states range from 1 to 18 ug/L
- California – Public Health Goal of 6 ug/L for DW
Remediation Standards – National standards don’t exist, set on site by site basis.
- Preliminary clean up goal of 24.5 ug/L established in 2006
- Final clean up determinations take site-specific information into consideration

Water Discharge Standards – National Pollutant Discharge Elimination System (NPDES)
- ClO4- limits set for known producers
• Large source terms for ClO$_4$
  • ClO$_4^-$: Aerojet: ROD: 150,000,000 lbs in groundwater, Kerr McGee >2,500 lb/day removed

• High solubility
• Mobile in groundwater (salt)
• Low biodegradation potential
Perchlorate in Colorado River

Hundreds of pounds into Lake Mead per day
LOCAL ISSUES

ClO₄⁻: 23 wells > 6 ug/L

>400 private wells
Low doses may affect child development

- Causes developmental problems in sensitive ecological receptors

- Taken up by plants and stored in leaves – ingested by foragers

- Ecological health effects relatively unknown
Is Perchlorate a Significant Contaminant?

**SOURCE**
- High volume
- Widespread use

**PATHWAY**
- Mobile
- Resistant to biodegradation

**RECEPTOR**
- Toxic
- Other public health concern

Factual

Scientific

Medical Perception**
Established in 1999 under the Safe DWA

3-tiered system for unregulated contaminants based upon analytical methods and contaminant properties

Candidate Contaminant Lists (CCL) Established in 1998

Perchlorate detections occurred in areas without a known source

Largest contiguous ClO₄⁻ plume in US discovered with UCMR sampling (>50,000 km²) in West Texas
Reviewed USEPA 2002 Perchlorate Risk Characterization

Reviewed current state of science regarding thyroid function and perchlorate exposure

Perchlorate does not appear to be as hazardous as USEPA scientists estimated but is more harmful than industry contends.

USEPA adopted NRD RfD which would correspond to a MCL of 24 ug/L

USEPA has not set a MCL in drinking water
Recent studies have identified perchlorate in foods, milk and forage.

Perchlorate in dairy milk collected from supermarkets in Texas.

Studies identified ppm levels of perchlorate in wheat and alfalfa samples.

Additional inputs of perchlorate from foods will have implications on the levels that be allowed in drinking waters.

62 urine samples contained ClO4-concentrations above trace concentrations in Atlanta water.
Current status with Perchlorate

- Perchlorate – state of science is still advancing
- Sources of perchlorate (both natural and anthropogenic) are still being evaluated
- Occurrence data is expanding
- Massachusetts adopted first DW standard (2 ug/L) in August 06.
- Remediation liability currently unknown
Canadian Perspective

- Difficult to determine
- To date, significant MTBE contamination has not been observed (in most cases)
- Most MTBE produced was distributed and used in US
- To date, significant perchlorate contamination has not been observed.

- However, *these chemicals may not be included in all investigations*
Drinking Water Standards:
- MTBE is not regulated in drinking water supplies
- Perchlorate is not regulated in drinking water supplies

Remediation Standards - BC Contaminated Sites Regulation (CSR)
- MTBE (soil) – Schedule 10
- MTBE (groundwater) – Schedule 6
- Perchlorate soil remedial standards for all land uses and groundwater remedial standard (for DW supply)

Water discharge standards – specific discharge standards for perchlorate and MTBE don’t exist
LESSONS LEARNED

• All contaminant releases may pose risk and liabilities –
  • some can be tolerated, some can be managed, and some have to be mitigated; however, like beauty, risk is in the eye of the beholder.

• Understand the chemical properties of the contaminants and the hydrogeologic setting into which they are released –
  • Chemistry and hydrogeology are the keys to effective protection, investigation and remediation.

• No aquitard is impenetrable –
  • given enough mass, space and time, contamination will find its way to deeper aquifers.
LESIONS LEARNED

- Early action is essential –
  - If an emerging contaminant is detected, take immediate action.
- Treatment technologies can effectively remove emerging contaminants from water –
  - although these options may be more expensive to implement than for other contaminants.
- Don’t rely on Federal or Provincial regulators –
  - Only the respective industries can look after their own best interests.
### HOW CAN INDUSTRY PROTECT ITSELF

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<td>Be informed and proactive, evaluate your own facilities and operations.</td>
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<td>Evaluate emerging contaminants of concern within effluents and products</td>
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<td>Understand potential implications associated with emerging chemicals of concern – to industry, clients, shareholders.</td>
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<td>Establish relationships with regulatory agencies</td>
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<td>Understand the regulatory process in different jurisdictions</td>
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<td>Keep abreast of scientific data</td>
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<td>Take lead on establishing standards, guidelines etc</td>
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Emerging contaminants of concern can pose potentially significant liabilities to stakeholders.

Significant time can pass between analytical detection to regulatory development.

Use lessons learnt from previous emerging contaminants to better manage emerging contaminants in the future.
“Reports that say that something hasn't happened are always interesting to me, because as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know.”

Donald Rumsfeld
Questions?