Contaminants of Emerging Concern in Human and Animal Wastewaters

Federal Remediation Technologies Roundtable
December 6, 2006

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Emerging Contaminants?

- Human Drugs
- Vet. Drugs
- Antibiotics
- Hormones
- Steroids
- Detergents
- Plastics
- Antioxidants
- Fire retardants
- Disinfectants
- Fumigants
- Fragrances
- Insecticides/ Repellants

New and understudied contaminants!
How do we decide which chemicals to look for?

- Quantities produced/used.
- Pathways for chemical release.
- Anticipated environmental behavior.
- Health significance.
- Potential as indicators/tracers.
- Ability to measure.
- Stakeholder priorities.
Human Waste Pathways

- WWTF
- CSOs
- ISDS
- Industrial Disch.
- Landfills
- Water Reuse.
Animal Waste Pathways

Animal Agriculture
- Waste lagoons
- Land application
- Processing
- Aquaculture
The Important Questions

- What compounds enter the environment?
- What are the sources?
- At what levels are they found?
- In what mixtures?
- In what media (water, sediment, tissue)?
- Do they persist and accumulate?
- Do they transform and to what?
- Do they pose an ecological health risk?
- Do they pose a human health risk?
- Are our stewardship activities sufficient?
USGS Priorities

I. Methods Development.
II. Occurrence and Source Pathways.
III. Transport & Fate.
IV. Ecological Effects.
I. Methods Development

<table>
<thead>
<tr>
<th>158 Compounds in Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 45 Antibiotics</td>
</tr>
<tr>
<td>• 20 Human Drugs</td>
</tr>
<tr>
<td>• 14 Hormones and Steroids</td>
</tr>
<tr>
<td>• 79 Household and Industrial Compounds</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>83 Compounds in Sediment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 3 Antibiotics</td>
</tr>
<tr>
<td>• 19 Human Drugs</td>
</tr>
<tr>
<td>• 61 Household and Industrial Compounds</td>
</tr>
</tbody>
</table>
New Methods Priorities

- SSRI’s
- Flourochemicals
- Hormones
- Antibiotics
- Statins
- Benzodiazepenes
- Cox II inhibitors
- Algal Toxins

- Additional Environmental Media
- Lower Reporting Levels
II. Occurrence & Source Pathways

What have we learned?
1) Present at *low concentrations* in water.
2) Present as *mixtures* (up to 38 in 1 sample).
3) A wide range of compounds and classes reflect a range of human activities & inputs.
4) The compounds and concentrations detected depend on the media sampled.
Source Characterization Studies

**Human**: septic tanks, municipal biosolids, municipal effluents, municipal holding ponds, hospital waste.

**Animal Agric**: poultry, swine, dairy, beef cow operations, food processing plants, aquaculture.
III. Transport & Fate

- Transport processes
- Environmental media
- Degradation byproducts
- Persistence

Dye Injection
Tracer Tests

Fourmile Creek, IA

Trailing Edge
Are they in the water or sediments?

Furlong et al., 2003
WWTP Study: 10 Plants, US/DS

Graph showing frequency of detection and median concentration of DEET, galaxolide (HHCB), tonalide (AHTN), tributylphosphate, and triclosan at different locations: Upstream, Effluent, Downstream 1, and Downstream 2.

PBDE’s in Soil near Weathered Outdoor Computer Scrap

- PBDEs in soil is varied as high as 1500 ppb (PBDE 183)
- limited movement to the stream.

**Conc (ng/g dry wt) PBDEs in Soils & Sediment, Computer Scrap Site**

- Soil on monitor case
- Soil, end of pile
- Soil meter from pile
- Stream sediment

Orazio et al., 2006
Biosolids

~ 6.9 million dry tons of biosolids produced in 1998 (USEPA)

50% of all biosolids are recycled and land applied

Results of sampling 9 WWTP biosolids enroute to land application

• Each sample had between 34 and 45 of 87 ECs tested
• diethylhexyl phthalate (plasticizer) – up to 20,000 mg/kg
• 1,7-dimethylxanthine (caffeine metabolite) – up to 6,200 mg/kg

Kinney et al., 2006
<table>
<thead>
<tr>
<th>Site #</th>
<th>Water (µg/L)</th>
<th>Sediment (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.021</td>
<td>&lt;25</td>
</tr>
<tr>
<td>(-0.1 km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3.1</td>
<td>2000</td>
</tr>
<tr>
<td>(0 km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.7</td>
<td>580</td>
</tr>
<tr>
<td>(2.9 km)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>200</td>
</tr>
<tr>
<td>(8.4 km)</td>
<td></td>
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Tonalide (musk) in Fourmile Creek, IA

Schnoebelen, et al., in press
IV. Health Effects

- Endocrine Disruption
- Antibiotic Resistance
- Chemical Mixtures
- Pathogens
- Other Ecological Effects

Intersex

Cellular Abnormalities
male
female

External Deformities
WWTP Effluent and Endocrine Disruption

Study focuses on sewage plants
CU researchers are trying to determine if chemicals in area wastewater are causing deformities.

By Theo Stein
and Miles Moffett
Denver Post Staff Writers

When Colorado biologist John Wooddling and a team of researchers pulled fish from the South Platte River and Boulder Creek two years ago, they found deformations they had never

Mutant fish prompt concern

Sex, in Percent

Female
Male
Intersex

Norris and others, 2004

Hypothalamus
Gonads
Pituitary
Liver

White sucker
(Catostomus commersoni)

(Norris and others, 2004)
Antibiotic Resistance

- Resistance develops in organisms.
- Environmental Transfer of Genetic Determinants.
- Development of Multiple Resistance.
- Resistance from non antibiotics.
- Is resistance facilitated by chronic low-level exposure?

Direct use in orchards.

Animal waste lagoons

Aquaculture
Studies finding potential effects of selected compounds

- **Carbamazepine**: Effect thru sediment exposure of benthic insect (Oetkin, et al., 2005).

- **Antibiotics**: Affecting soil microbial activity and bacterial denitrification (Costanzo et al., 2005; Thiele-Bruhn and Beck, 2005).

- **Diclofenac**: consumption of diclofenac-treated meat caused renal failure in vultures (Nature, 2004)
Studies finding potential effects of selected compounds

• **Ciprofloxacin, triclosan, Tergitol NP 10**: shifts in community structure of suspended and attached algae (Wilson et al., 2003).

• **SSRIs**: Found in fish tissue (Brooks et al., 2005); delayed development in fish and delayed metamorphosis in frogs (Black et al., 2006).

• **Drug Mixtures**: Effects at Env. Levels on Human Embryonic Cells 13 drugs in environmental mixtures and concentrations (Pomati et al., 2006).
Interagency Coordination

CENR, Toxics & Risk Subcommittee,
- Pharm.’s in the Environment Work Group
- Endocrine Disruptors Work Group

Activities
- Coordination and collaboration of Fed.’s.
- Research Strategies.
- USGS Gathering input on Methods Development (Contaminant) Priorities.
Acknowledgements

Team Leader: Dana Kolpin, Iowa City IA  
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The USGS Toxics Program:  
toxics.usgs.gov

Emerging Water Quality Issues:  
toxics.usgs.gov/regional/emc.html

Bibliography with over 125 publications