US EPA’s Risk Management Research on Endocrine Disrupting Chemicals

Bryan Boulanger and Marc Mills
U.S. EPA Endocrine Disruptors Program

2006 STAR Progress Review Workshop
Underlying RM Science Questions

• What are the major sources and environmental fates of EDCs?
• How can unreasonable risks be managed?

from *Research Plan for EDCs* (1998)
Endocrine Disrupting Chemicals: Goal 4 Risk Management Research

• Policy Relevant Questions

• Approach
  ▪ Understand sources of EDCs
  ▪ Remediation of EDC-contaminated Media

Working collaboratively within ORD, Regions and outside research groups to leverage resources
Why do RM research on EDCs?

Research has shown:

• Waste streams are releasing EDCs to the environment.
• In-stream ecological effects have been observed below waste stream outfalls
• EDC exposure and health effects in humans not well understood
• EDCs detected in DW source waters
NRMRL areas of research

- Wastewater Treatment Plants (WWTPs)
- Concentrated Animal Feed Operations (CAFOs)
- Drinking Water

from *Research Plan for EDCs* (1998)
Why do WWTPs emit endocrine active effluents?
WWTPs Designed for…

- BOD removal
- Suspended solids removal
- pH neutralization
- N, P removal
- Pathogen removal

Trace organics (EDCs)?
WWTP Performance Factors

Effluent levels determined by -

• Influent character

• Plant design
  ▪ Biological treatment
    • Aerobic, anaerobic
  ▪ Solids separations
  ▪ Contact times

• Operations/maintenance
NRMRL’s EDCs in WWT Research

- **Analytical methods development**
  - GC/MS methods for 8 hormones and APs – expanding effort
  - Adapting bioassays for field application

- **Bench scale research**
  - AP biodegradation studies
  - Steroid hormone studies

- **Field scale research**
  - NC Biosolids study
  - Chicago Digester study
  - OW POTW Survey
  - Grailville constructed wetland
  - ORSANCO/USEPA REG3/USEPA ORD Ohio River Study

- **Pilot scale research**
Influent Estrogens

estradiol

estrone

estriol

ethinyl estradiol
Excreted Hormones are Conjugated

- Estriol glucuronide
- Estrone sulfate
## Estrogen Conjugates in Swine Lagoon Waste

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Nonylphenol
Biological Transformation

estrogenic

A₉E₉₊₁

A₉E₁C

A₉E₁

CA₈E₁C
Source Characterization

- **National Effluent Study (NERL/NRMRL) – completed**
  - 50 plants surveyed
  - 22% of the effluents were estrogenic

- **OW Influent/Effluent Survey (OW/NRMRL/NERL) – In progress**
  - OW funded survey of influent/effluent of WWTPs for ~450 chemical, physical, and biological analytes
  - ORD will do EDC chemistry (NRMRL) and effluent bioassays (NERL)
  - Precursor to larger Nationwide Survey (>50 plants)

- **Effluent and Receiving Waters studies (ORSANCO/NERL/NRMRL - Ohio R., Wheeling and ALCOSAN) – in progress**
  - Scoping study in progress this fall
  - Spring is schedule for larger deployment at multiple plants
Bench scale research

Objective
• Evaluate the fate of selected EDCs (alkylphenols and steroid hormones) under conditions common to wastewater treatment and sediments
  Aerobic, Anaerobic, Sulfate reducing, Methanogenic

Results to date
• Alkylphenols
  ▪ Biodegradation of NP occurs under aerobic conditions.
  ▪ Relatively low yield of NP degrading organisms may explain inefficiency of WWTPs.
  ▪ NP isomers degrade aerobically at various rates and the most estrogenic isomers appear to degrade faster.
  ▪ NP is very persistent under the anaerobic conditions (nitrate reducing, sulfate reducing, and methanogenic).
Chicago Digester Study

• Objective: To evaluate the removal efficiency of selected EDCs in sludge digesters.
  ▪ A series of parallel sludge digesters will be sampled over time for the influent and effluent concentrations of selected EDCs.
  ▪ In parallel, an inert, non-toxic tracer study will be performed to evaluate residence time distribution and effective reactor volume.

• Target analytes
  ▪ Alkylphenols (APs) and Bisphenol
  ▪ Hormones

• Experimental Design:
  ▪ Reactors
    • Three replicate digesters
    • Sampling over 3 solids retention times, ~60 days
  ▪ Digester operations
    • Digester design parameters
    • Daily operational parameters
      – Feed schedules, flows, and loadings
      – Operating characteristics (temp, pH, VSS, etc)
  ▪ Sampling
    • Daily sampling: one 1-liter grab samples collected during each 8-hr shift (3/day) and composited

• Collaborations:
  ▪ USEPA NRMRL
  ▪ USEPA REG 5 Water Division
  ▪ USEPA REG CRL
  ▪ MWRDGC

• Status
  ▪ QAPP in progress
  ▪ Expected to start study in late Summer-early Fall
**On-site WWT Research**

- **Grailville Constructed Wetland**
  - Objective: Constructed Wetland designed/operated for nutrient/pathogen removal will be evaluated for efficacy at managing EDCs
  - Collaborators
    - NRMRL WSWRD
    - NERL - MIRB
    - Grailville

- **Status**
  - Preliminary samples collected for screening the EDC concentrations
  - Evaluating matrix interferences
  - QAPP in progress based on EDC levels in influent/effluents

- **Future planned research for On-site WWT**
  - Septic systems
  - Constructed wetlands
Field Application of Biosolids

• North Carolina Study
  - Anaerobically digested and lightly limed biosolids
  - Applied to fescue field in Sept 2004
  - Measure APEO concentration
    - Background: -5 wks, -1day
    - After application: 0 day, 2 wks, 4 wks, 9 wks, 14 wks
    - depths: 0-5 cm, 10-15 cm, 20-25 cm
  - Data not yet finalized

• Biosolids - EDCs research
  - Evaluate other biosolids types
  - Include steroid hormones along with the alkylphenols
  - Continue to leverage against microbial biosolids studies
EDCs and CAFOs
Risk Management Research
CAFOs Risk Management Research Questions

- Are EDCs present in animal wastes?
- Does typical operation result in EDC risk?
- Do typical waste management practices effectively treat EDCs?
- Do RM tools exist that will treat EDCs?
- What new RM tools need to be developed?
Expected Products from CAFOs RM Research

- Better understanding:
  - wastes concentrations
  - fate and transport in soils
  - efficacy of CAFO waste management

- Identification of the RM needs to reduce EDC effluent from CAFOs
CAFO EDC research

• Methods development

• Evaluate CAFO operations as release points:
  ▪ Swine, Poultry, Cattle, Dairy operation

• Evaluate management strategies of CAFOs

• Leverage
  ▪ Projects in Water Quality CAFO program (ie Lizzie, NC Demo Site)
  ▪ With NERL and NHEERL on interlab study
CAFO Contributions of Estrogens

- Cattle: Growth-enhancing hormones added
  - Estrogens (estradiol, estradiol benzoate)
  - Androgens (trenbolone acetate, testosterone propionate)
  - Progestins (progesterone)

- Poultry:
  - No growth hormones added
  - Natural production of estrogens and testosterone

- Swine:
  - No growth hormones added
  - Natural production of estrogens and testosterone
Distribution of Estrogens in Swine Nursery Lagoons

Concentration (ng/L)

Lagoon #1 | Lagoon #2 | Lagoon #3 | Lagoon #4
---|---|---|---

**Estrone**

**Estradiol**

**Estriol**
CAFO Summary

- We have limited field data that show CAFOs can contaminate ground and surface waters with estrogens, but:
  - studied field site represents worst case scenario for ground water evaluation
  - need to monitor long-term fate at each site
Drinking water research – Unit operations

Conventional Treatment

Source Water → Rapid Mix → Flocculation → Sedimentation → Sand Filtration → Clear Well (Finished Drinking Water)

Advanced Treatment

Source Water → Rapid Mix → Coagulant → Flocculation → Sedimentation → Sand Filtration → Granular Activated Carbon (GAC) → Clear Well (Finished Drinking Water)
Drinking water research – Methods development

- Methods development for estrogenic and androgenic hormones
- LC-MS methods for surface waters and treated waters developed
Drinking water research - Bioassay development

• Bioassay development for drinking water treatment operations research

• Adaptation of the MVLN assay for Estrogenic response
Summary

Risk Management research program

- Process to identify research in place that
  - Focuses on most relevant chemicals, sources and RM strategies
  - Allows refocusing as information increases
- Initial projects underway
- Collaborations working
- Initial results having high impact
NRMRL’s future EDC research

• **WW research areas**
  - On-site wastewater treatment
  - Tertiary wastewater treatment
  - Water reuse
  - Leverage against other emerging pollutant programs (ie PFOA)

• **CAFO research areas**
  - Expand characterization of sources
    - More types of CAFOs
    - Conjugated and unconjugated forms of hormones
  - Characterize existing and innovative treatment
  - Collaborative effort on field scale study with NRMRL/NERL/NHEERL
  - Leverage efforts with NRMRL’s WQ CAFOs program (focused on Pathogens and Nutrients management)

• **Drinking Water research areas**
  - Continue unit process work at pilot scale
  - Develop full plant scale data set
  - Surveys of EDCs in source water, treated water, and tap water.
  - Innovative treatment technologies effects on EDCs
Thank you

and now - Q&A