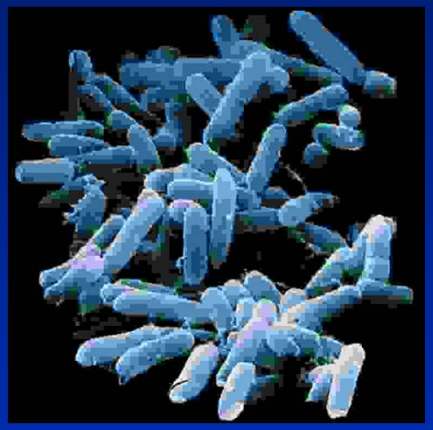
Emerging Contaminants in U.S. and Oklahoma Streams



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science for a changing world

"Emerging Contaminants" are…

- Hormones, food additives, detergents, and pharmaceuticals that may occur in parts-per-trillion concentrations in water;
- Called "emerging" because methods for their analyses are experimental and analytical-method development is on-going,
- Detected in extremely small concentrations, and
- Possible causes of health problems for plants and animals.

Sources of Emerging Contaminants

- Wastewater treatment plants (aka POTWs)
- Domestic septic systems
- Landfills
- Industrial discharges
- Livestock CAFOs
- Wildlife

USGS 1999 National Stream Study

139 streams sampled in 30 states--

- **62 Basins w/CAFOs**
- **52 Urban basins**
- **17 Mixed land-use basins**
- **8 Minimally developed basins**

http://toxics.usgs.gov/pubs/OFR-02-94/index.html

(fact sheet)

"Article of the Year" in ES&T

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Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams

A recent study by the Toxic Substances Hydrology Program of the U.S. Geological Survey (USGS) shows that a broad range of chemicals found in residential, industrial, and agricultural wastewaters commonly occurs in mixtures at low concentrations downstream from areas of intense urbanization and animal production. The chemicals include human and veterinary drugs (including antibiotics), natural and synthetic hormones, detergent metabolites, plasticizers, insecticides, and fire retardants. One or more of these chemicals were found in 80 percent of the streams sampled. Half of the streams contained 7 or more of these chemicals, and about one-third of the streams contained 10 or more of these chemicals. This study is the first national-scale examination of these organic wastewater contaminants in streams and supports the USGS mission to assess the quantity and quality of the Nation's water resources. A more complete analysis of these and other emerging water-quality issues is ongoing.

Background: Chemicals, used everyday in homes, industry and agriculture, can enter the environment in wastewater. These chemicals include human and veterinary drugs (including antibiotics), hormones, detergents, disinfectants, plasticizers, fire retardants, insecticides, and antioxidants. To assess whether these chemicals are entering our Nation's streams, the Toxic Substances Hydrology Program of the U.S. Geological Survey (USGS) collected and analyzed water samples from 139 streams

Pharmaceuticals, hormones, and other organic wastewater contaminants were measured in 139 streams during 1999 and 2000.

Household chemicals can enter streams through wastewater discharges. A wastewater treatment facility near Atlanta, Georgia, is shown above. (Photograph by Daniel J. Hippe, U.S. Geological Survey)

in 30 states during 1999 and 2000. Streams were sampled that were considered susceptible to contamination from various wastewater sources, such as those downstream from intense urbanization or livestock production. Thus, the results of this study are not considered representative of all streams.

Although each of the 95 chemicals is used extensively, there is little information about the extent or occurrence of many of these compounds in the environment. Some may be indicators of certain classes of contamination sources, such as livestock or human waste, and some have human or environmental health implications. The results of this study are a starting point for investigation of the transport of a wide range of organic wastewater contaminants in the Nation's waters.

New laboratory methods were developed in several USGS research laboratories to provide the analytical capability to measure concentrations of 95 wastewater-related organic chemicals in water. Uniform sample-collection protocols and field and laboratory quality-assurance programs were followed to ensure that results are comparable and representative of actual stream conditions.

U.S. Department of the Interior
U.S. Geological Survey

USGS Fact Sheet FS-027-02
June 2002

1999 Ntl. Study—Results Summary

- ECs were detected in almost 80% of samples
- 82 of the 95 analyzed ECs were detected
- EC concentrations were generally small:

  ~5% of the top 30 compounds were > 1 ppb
  ~25% of the sites had > 6 ppb TOTAL ECs

- Few health standards or guidelines were exceeded

  (Only 14 of the 95 analyzed ECs had standards)

- Detection of multiple ECs was common

  34% of samples had > 10 ECs

1999 National study sites in Oklahoma

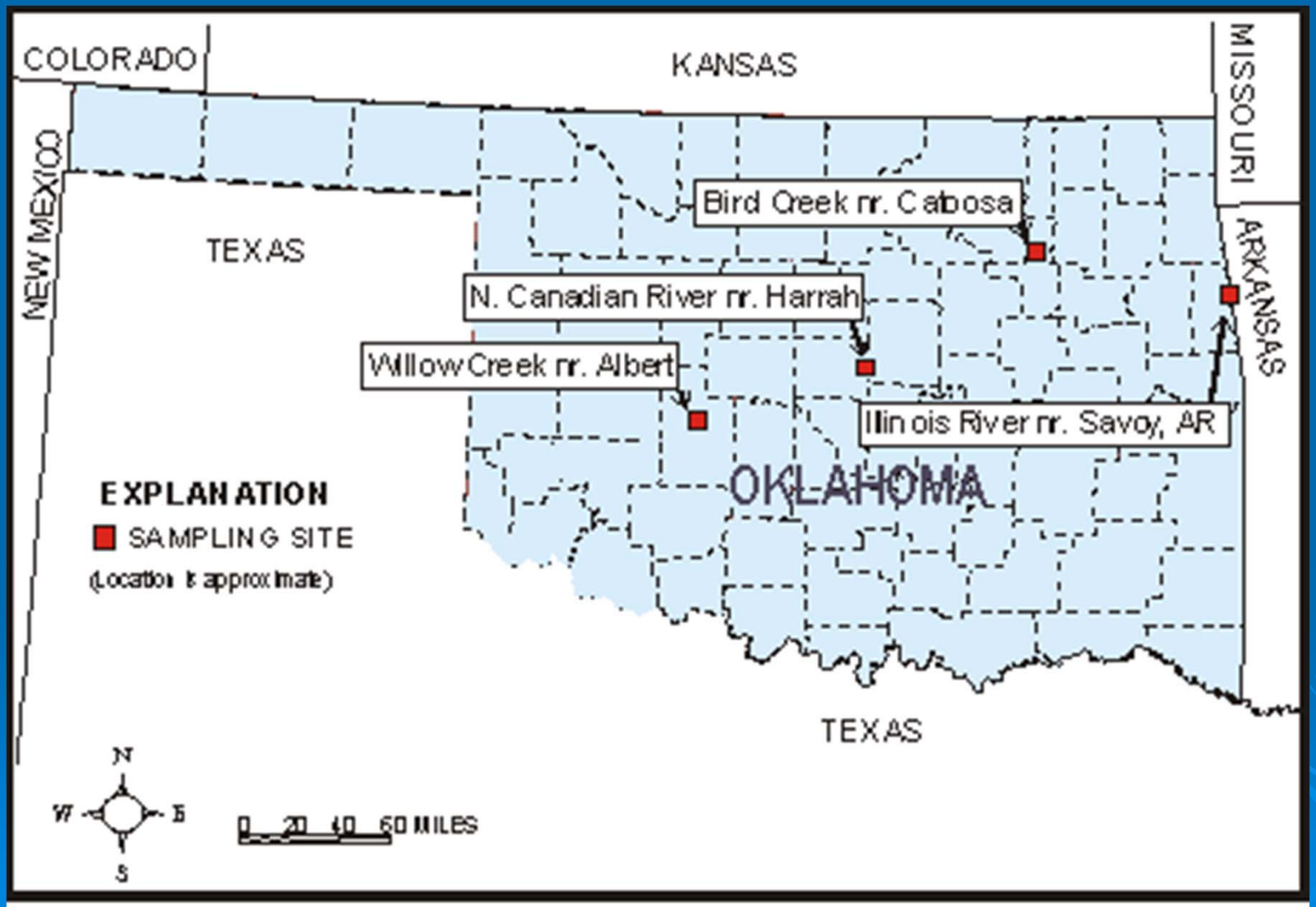
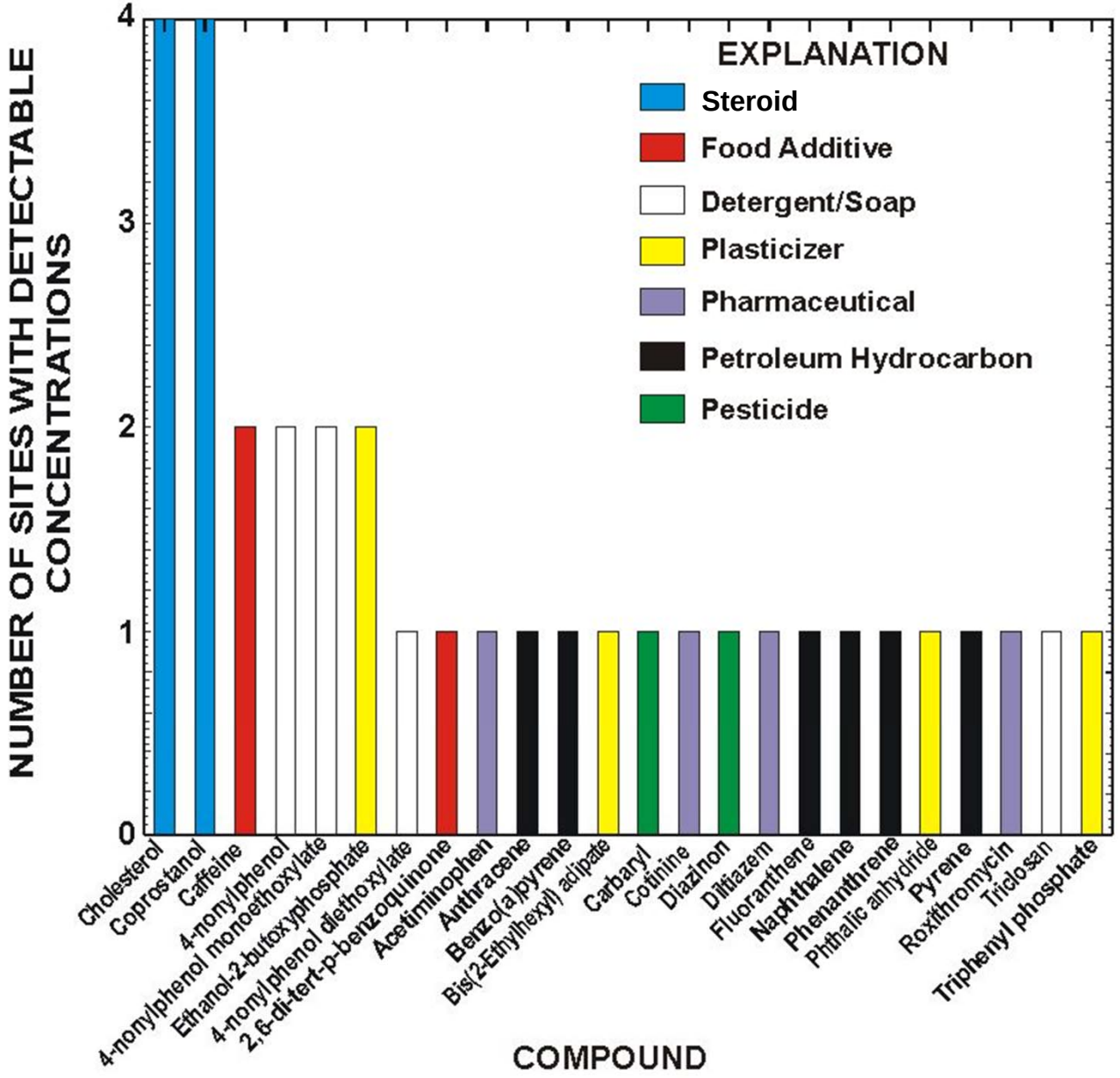


Figure 1. Location of Sampling Sites.

1999 National Study—results for Oklahoma

- Steroids were detected at all 4 sites.
- Caffeine, soap compounds, and a plasticizer were detected at 2 sites.
- Several other types of ECs were detected at 1 of the 4 sites.



Other USGS EC studies in Oklahoma

The USGS has worked with several state agencies, Tribes, cities and the USGS Toxic Substances Hydrology program to measure emerging contaminants and related compounds in streams and groundwater in Oklahoma.

Examples of those studies include:

a) Investigating hydrology, chemistry, and bacterial ribotypes of groundwater and a stream near poultry-processing facilities in Delaware County,

b) Investigating nutrients, ECs, and bacteria in wastewater lagoons and nearby monitoring wells at swine CAFOs.

c) Measuring ECs to investigate nitrate sources in groundwater in Kingfisher County and the Cimarron Terrace aquifer.

d) Measuring occurrence of ECs in leachate from pre- and post-RCRA landfills and natural attenuation of ECs in groundwater.

e) Measurement of time-integrated ECs in several streams in central Oklahoma using semi-permeable membrane devices and polar organic integrative samplers.

- Copies of reports on these topics can be downloaded from:

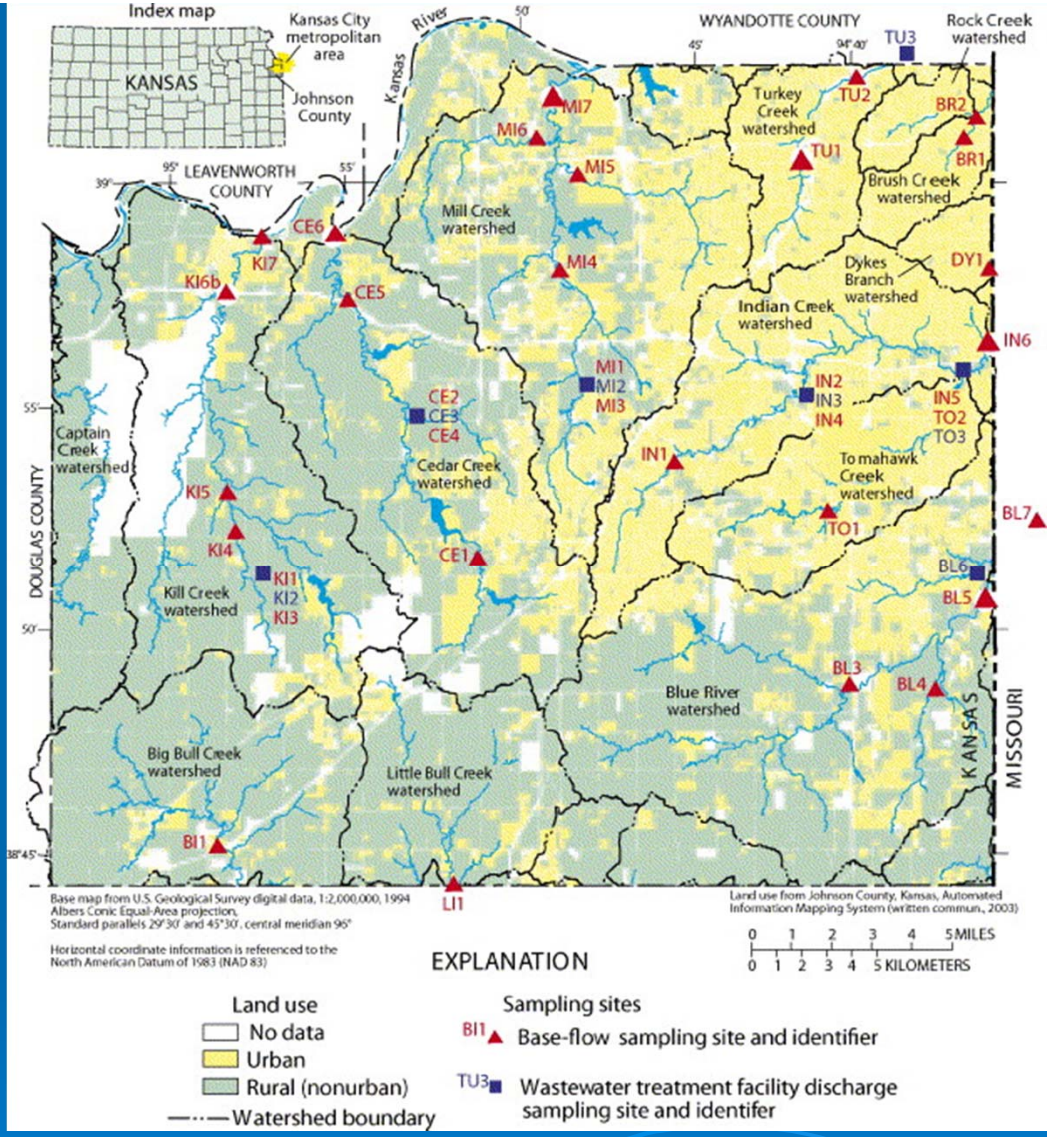
http://ok.water.usgs.gov/publications/pubswrirsir.html

Occurrence of organic wastewater compounds in effluent-dominated streams in Northeastern Kansas

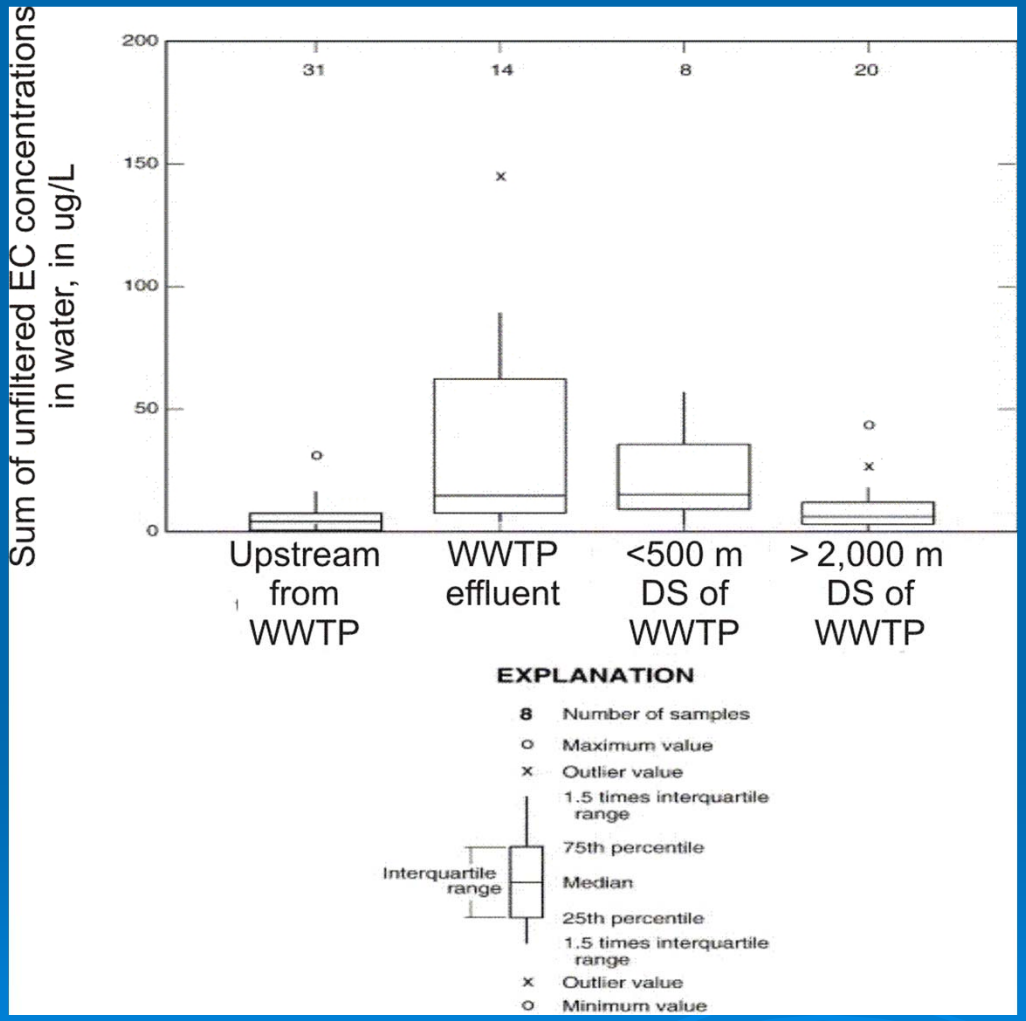
By Casey J. Lee, and T.J. Rasmussen, USGS, Lawrence, KS

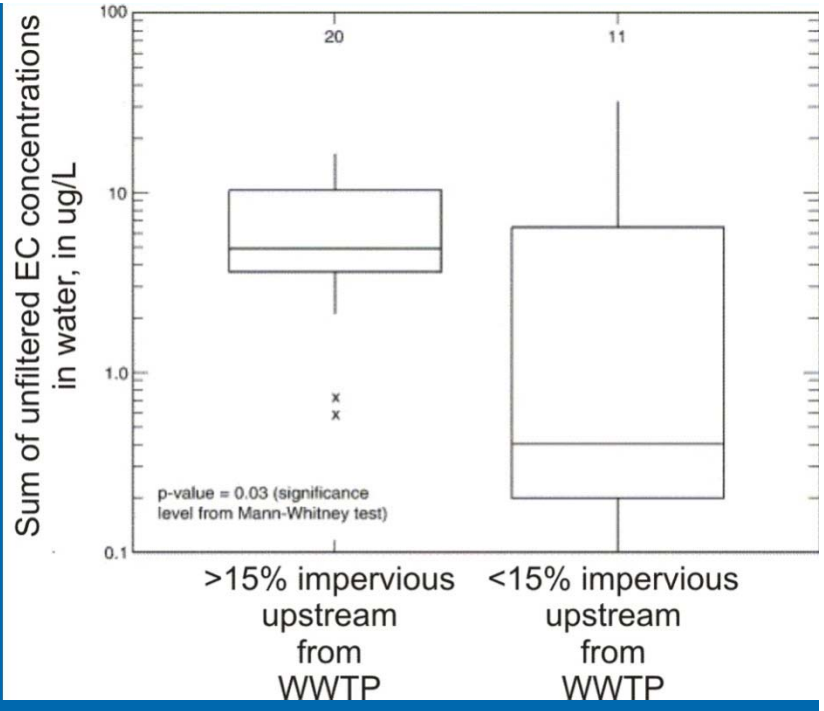
Science of The Total Environment
Volume 371, Issues 1-3, 1 December 2006, Pages 258-269

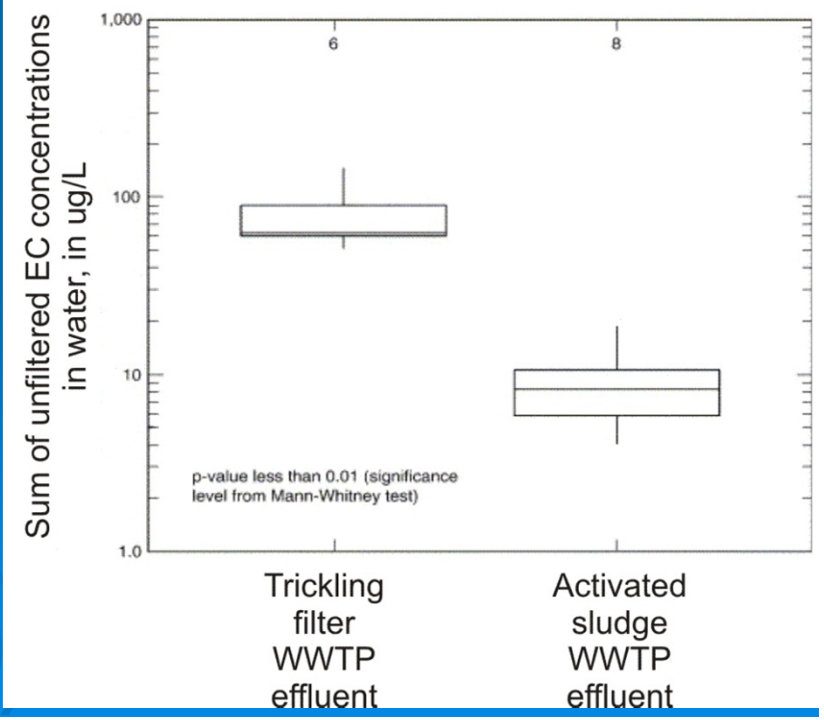
Investigation of natural attenuation of ECs in streams, and the effects of different WWT practices and urban runoff.



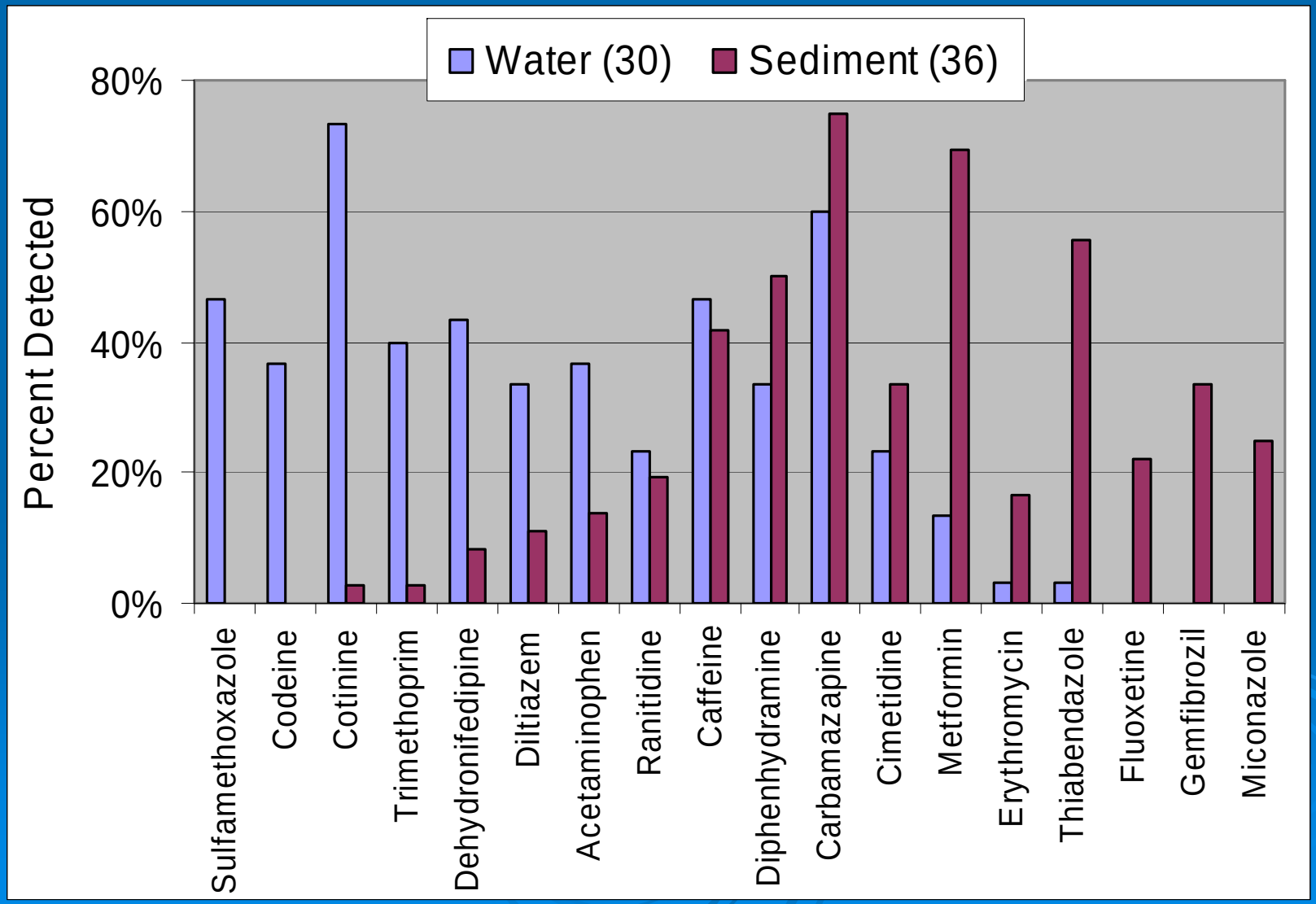
Northeastern KS, continued…



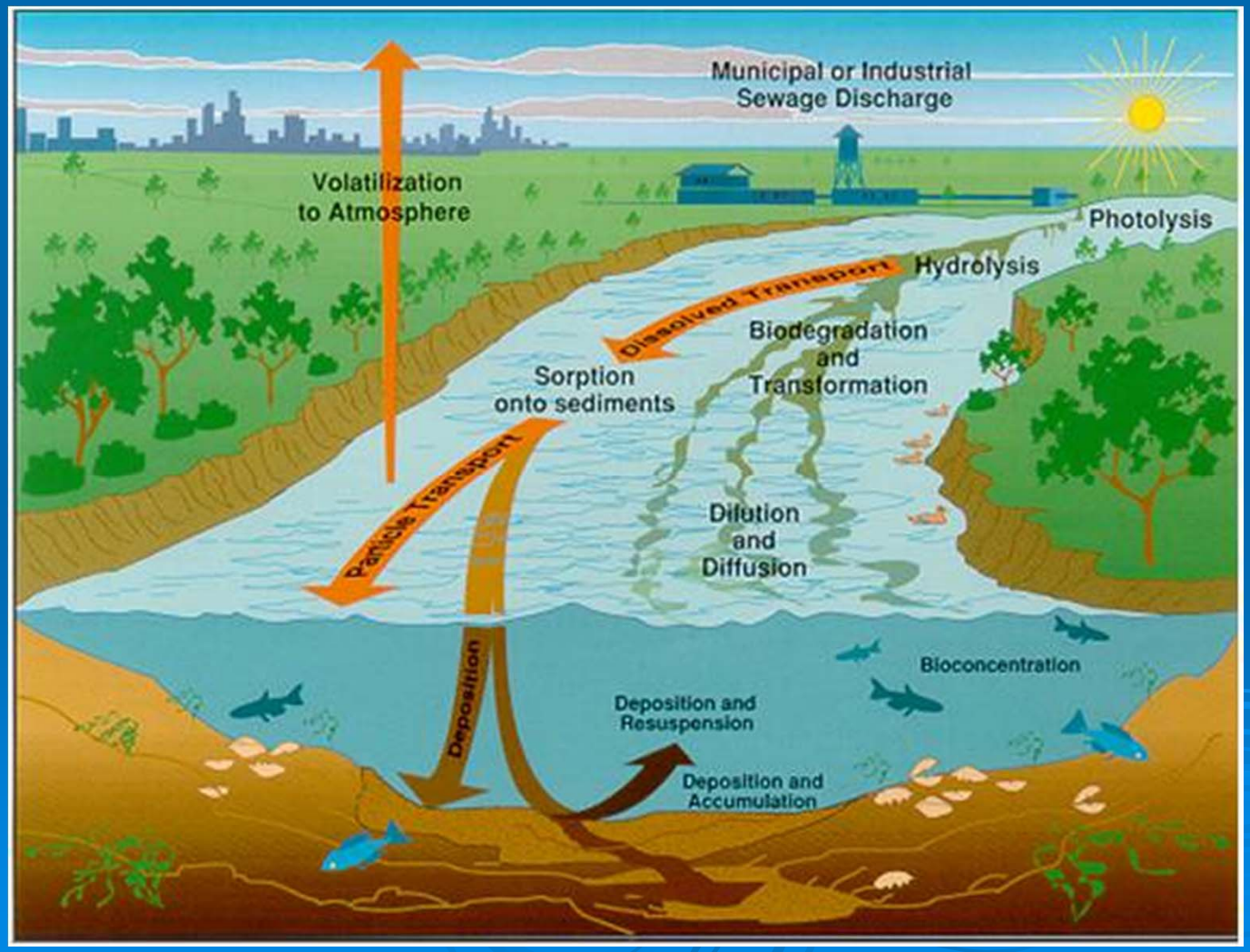




More hydrophobic ECs tend to partition to sediments…



Fate and transport of organic compounds in aquatic ecosystems are complex!



Barber et al. (1995) image

Toxicity of mixtures of dilute ECs

We know that very small amounts of many ECs in foods, beverages, and pharmaceuticals are unlikely to be harmful, but what about mixtures of dozens of these compounds in water?

The USEPA, NIEHS, USGS, Universities, and others have been conducting toxicologic research on dilute mixtures of ECs to determine health risks and establish exposure limits.

Some publications include:

Birnbaum, Linda, 2012, Environmental chemicals: evaluating low-dose effects: Env. Health Perspectives 120:a143-a144.

Pomati, Francesco et al., 2006, Effects of a complex mixture of Therapeutic drugs at environmental levels on human embryonic Cells: ES&T, v. 40, n. 7, p. 2442-2447

Toccalino, Patricia et al., 2010, Quality of source water from public-supply wells in the U.S., 1993-2007: USGS Scientific Investigations Report 2010-5024, 206 p.

Adverse ecological effects from ECs?

Bacteria--

- Reduced soil microbial activity
- Develop of antibiotic-resistant bacteria
- Deleterious effects on planktonic bacteria

Plants--

- Inhibited photosynthesis of microalgae
- Shifts in algal community structure
- Sulfanamide antibiotics disrupt folate biosynthesis (herbicidal effects)

Animals--

- Effects on tadpole development (triclosan)
- Abnormal development in clams and decreased larval survival
- Drug mixtures inhibited growth of human embryonic cells
- Renal failures in vultures (diclofenac)

Regulatory and technical developments

- The European Union banned use of bisphenol-a and phthalates, plasticizers and estrogen mimics, from use in baby bottles and childrens' toys.
- The USEPA is developing a "chemicals of concern" list which will include a substantial number of emerging contaminants, particularly estrogen mimics.
- Through the "Unregulated Contaminant Monitoring Rule 3" (UCMR3), the USEPA is proposing to require drinking-water plants to periodically monitor for concentrations of 6 hormones and 6 perfluorinated compounds (surfactants).
- Increasing numbers of studies are finding greater numbers of emerging contaminants in water, air, and animal tissues.
- More studies are finding demonstrable negative health effects for humans and wildlife exposed to dilute mixtures of emerging contaminants.

Regulatory and technical developments, continued

- Some private companies, for reasons of liability/stewardship/public relations are phasing out uses of emerging contaminants that have potential health effects (e.g. Mattel phasing out phthalates in teething toys, Walmart ceasing to sell products with polybrominated diphenyl ethers (a fire retardant used in fabrics and plastics)).
- Increasing scrutiny is being given to use of massive amounts of antibiotics by livestock CAFOs.
- Drop-off programs for unused pharmaceuticals are becoming more common.
- The public is becoming more aware of environmental and health costs from use of synthetic chemicals and increasingly shops for more sustainable alternative products.

Questions?