

Detection of septic system waste in the groundwater of Beaumont California using chemical and isotopic tracers

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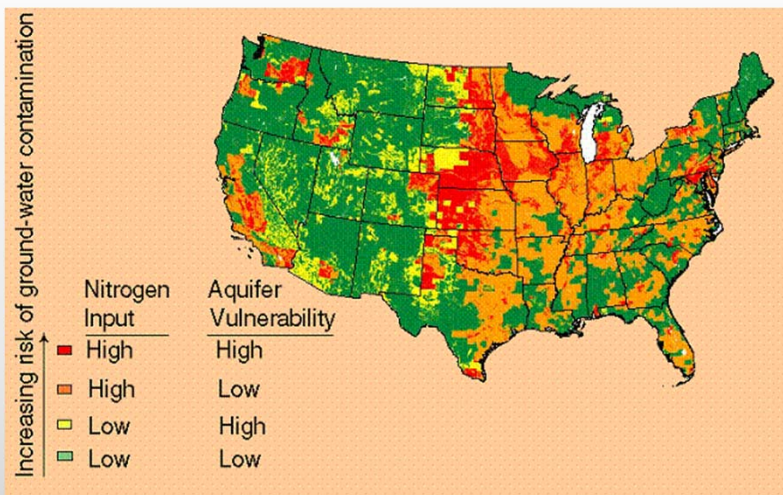
Why is excess nitrate in groundwaters a problem?

1. Ingestion of nitrate in drinking water by infants can cause low oxygen levels in the blood (blue baby syndrome, a potentially fatal condition)
 - a. US EPA maximum contaminant level = 10 mg N-NO₃ /L
2. Nitrate concentrations > 4 mg/L in rural drinking-water supplies have been associated with increased risk of non-Hodgkin's lymphoma*
3. Elevated nitrate in groundwater could indicate potential for pathogen contamination

*Ward, M. H.; Mark, S. D.; Cantor, K. P.; Weisenburger, D. D.; Correa-Villasenor, A.; Zahm, S. H. Epidemiology 1996, 7, 465-471



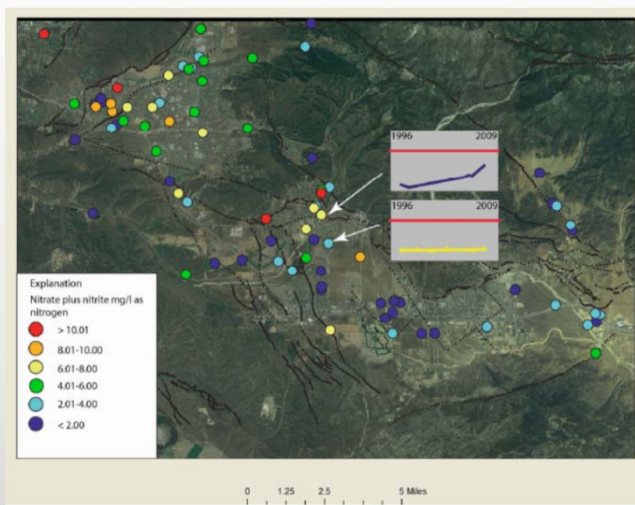
What is the extent of the problem in the United States?



USGS

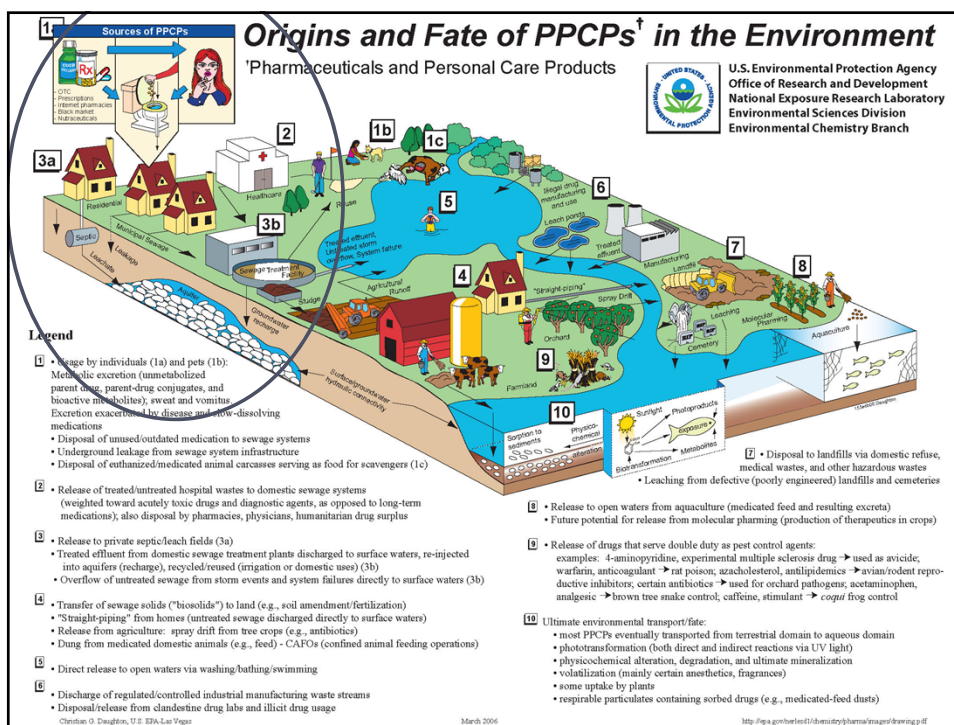
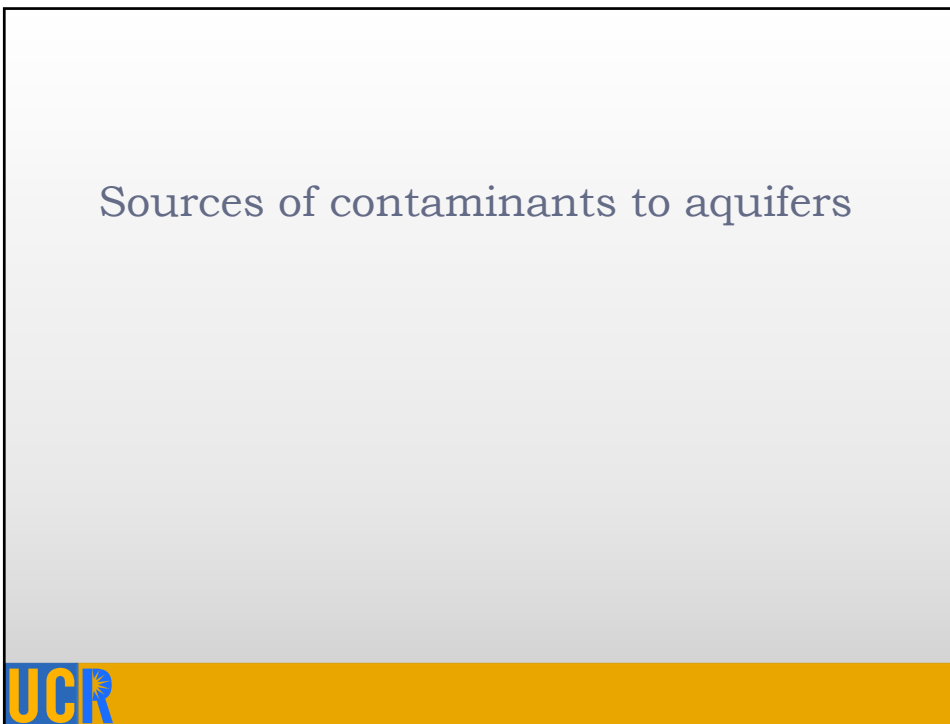
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Nitrate levels in local groundwater?



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Isotope fingerprinting of nitrate sources

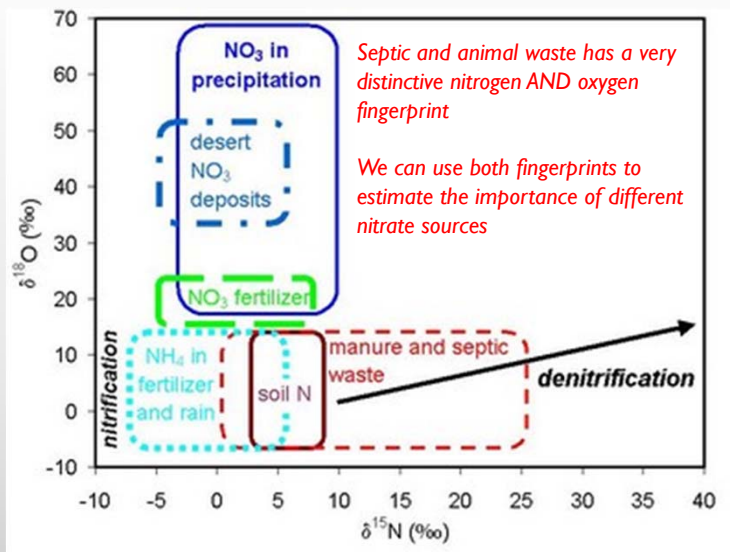


Isotopes in nature

- ▶ Elements like nitrogen can have different numbers of neutrons in their atomic nucleus
 - ▶ ^{14}N - Nitrogen with 7 neutrons
 - ▶ ^{15}N - Nitrogen with 8 neutrons
- ▶ One way to understand isotopes is to think of them as different “colors” of an element
- ▶ We use a special instrument called a mass spectrometer to measure the relative proportions of different element colors in samples

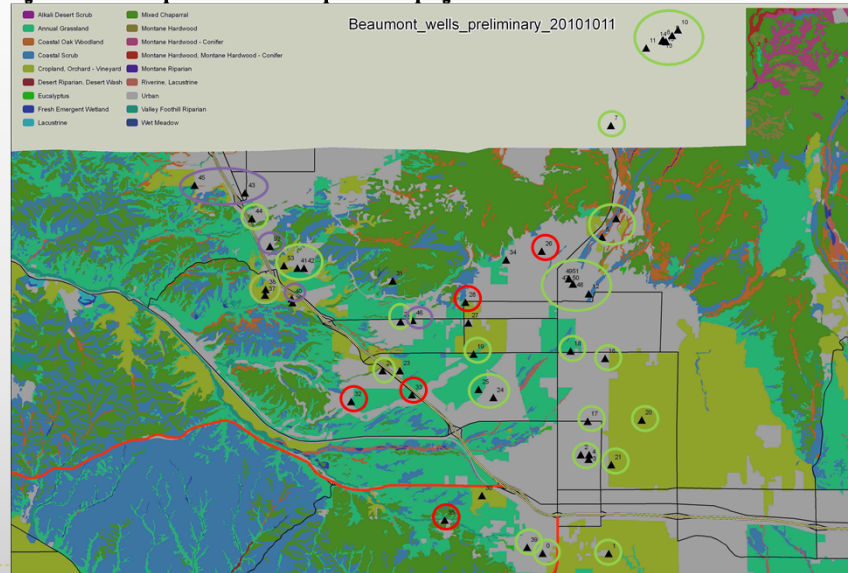


Isotopes of nitrate in Nature



Project design: sample wells and surface water

Figure 1. Land use map of Beaumont with all potential sampling sites identified.



Project design: Chemical analyses and modeling

1. Measure major cations, anions, nutrients in 35-40 wells and streams
2. Determine sources of nitrate in wells using isotope fingerprinting
3. Determine concentrations septic waste indicators (Jeremy Conkle and Jay Gan – next slides)
4. Use groundwater modeling to determine source areas where contamination is detected (HYDRUS and MODFLOW)



Indicators of Septic Waste in Groundwater



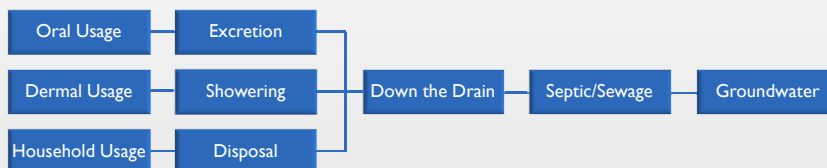
What are SWIs?

- ▶ Medicines
 - ▶ Prescription
 - ▶ Over the counter
- ▶ Herbicide
 - ▶ Diuron
- ▶ Hormones
 - ▶ Estrone
- ▶ Insect repellent
 - ▶ DEET

Target Compound	Use
Acetaminophen	Headaches
Primidone	Anti-epileptic
Meprobamate	Anti-anxiety
Carbamazepine	Anti-epileptic
Dilantin	Anti-epileptic
Sulfamethoxazole	Antibiotic
Atenolol	Blood Pressure
Diazepam	Anti-anxiety
Trimethoprim	Antibiotic
Fluoxetine	Anti-depressant
Atorvastatin	Cholesterol
Ibuprofen	Headaches
Naproxen	Headaches
Gemfibrozil	Cholesterol
Estrone	Hormone
Triclosan	Antibacterial
Diclofenac	Arthritis
Simvastatin	Cholesterol
Diuron	Herbicide
Caffeine	Stimulant
DEET	Insect Repellent

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How do SWIs get into the groundwater?



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SWI concern to humans?

- ▶ Rarely have compounds been detected in groundwater
- ▶ Concentrations when found in groundwater are very low
 - ▶ Parts-per trillion or ng L^{-1}
 - ▶ 0.000,000,000,001

	ng L^{-1}	Source	Use	Human Dose	Years (1 dose, 5L day)
Sulfamethazine	76.0-220.0	CAFO	Veterinary	500 mg (estimate)	1200
Sulfadimethoxine	46.0-68.0	CAFO	Veterinary	500 mg (estimate)	4029

Batt, A. L.; Snow, D. D.; Aga, D. S., Occurrence of sulfonamide antimicrobials in private water wells in Washington County, Idaho, USA. *Chemosphere* 2006, 64, (11), 1963-1971.

Over 1000 years drinking 5 L of contaminated water a day to get 1 dose of these compounds

- ▶ No studies have shown any impact humans
 - ▶ Only verified impacts are to small organisms
 - ▶ Fish, bacteria, plants, algae

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Why do we care about SWIs?

- ▶ Can be used as a tracer
 - ▶ Signal human impacts
- ▶ Indicate incomplete septic treatment
 - ▶ Wastewater not required to treat SWIs
- ▶ Potential leaching from agricultural operations
 - ▶ Veterinary medicines

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Questions?

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