Health Concerns with Nitrates in Drinking Water

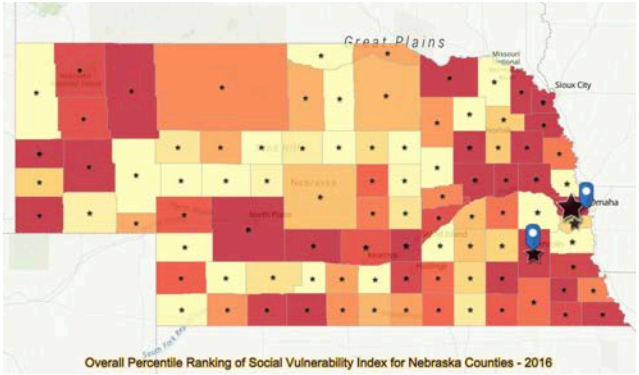
Jesse E. Bell, PhD
Claire M. Hubbard Professor of Health and Environment
Director of Water, Climate and Health Program at UNMC
Director of Water, Climate and Health at Daugherty Water for Food Global Institute
Department of Environmental, Agricultural, and Occupational Health
College of Public Health
University of Nebraska Medical Center

Water for Food
DAUGHERTY GLOBAL INSTITUTE
at the University of Nebraska

UNMC

Nebraska Populations

- Where Nebraskans get their water
  - 20% from private domestic wells
  - 80% from a community public water system
- Agriculture
  - 92% of Nebraska's land
  - 1 in 4 jobs is related back to agriculture
  - 77,097 producers
- 2019 estimated population of 1,934,408 people – 660,417 living in rural areas (USDA-ERS)
- Indigenous Populations
  - 4 state and federally recognized tribes with headquarters in NE (Omaha, Santee Sioux, Ponca, and Winnebago); neighboring states such as the Iowa, Sac and Fox, Pawnee, and Oglala Sioux

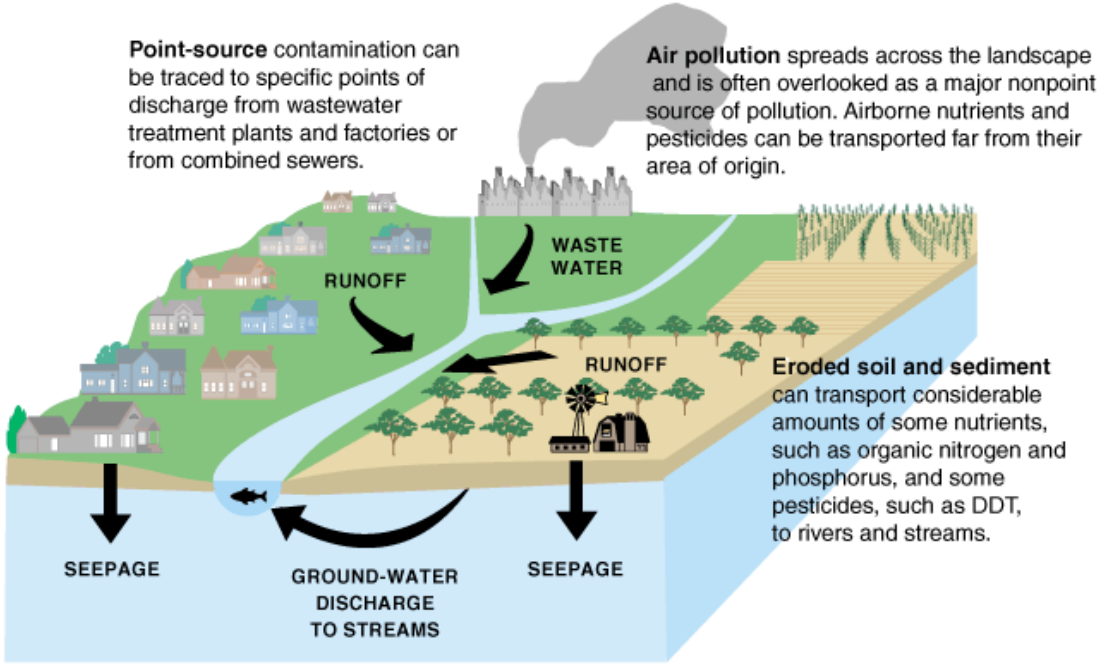


Overall Percentile Ranking of Social Vulnerability Index for Nebraska Counties - 2016

Water Quality Issues

Issues

- Nutrients
  - Organic Nitrogen, Phosphorus
- Pathogens
  - Bacteria
- Geogenic contaminants
  - Arsenic, uranium, etc.
- Emerging contaminants
  - Hormones, antibiotics
- Pesticides
- Lead



usgs.gov

Nebraska towns pay millions to fight nitrates as water bills go up

By Jessica Fargen Walsh Special to The World-Herald May 1, 2020 Updated May 1, 2020 4

"If you are a community of 500, this is just devastatingly expensive,"

- Millions spent to mitigate water contamination; taxes increasing
- Small communities disproportionately impacted; fewer resources to address the problem

Watch: Small Towns Look For Unique Solutions To Agricultural Water Pollution

By JEREMY BERNFELD • SEP 28, 2016

Stange and his team have designed a unique line of defense. They're using wells strategically placed on the outskirts of town to act as a filter for the aquifer, skimming off nitrates as they move toward the city.

The city of Hastings will spend $46 million to build the system, Stange says, which is a big hit to a city of just 25,000 people.

Links to Health

Nitrate in Drinking Water

- **Sources:** Nitrogen fertilizers, animal and human waste
- **Regulatory limit:** 10 mg/L as NO_2-N (USA)
- **Greatest exposure**
  - Agricultural areas
  - Private wells
    - Not regulated
    - Sparse measurements

N-nitroso compounds

- Several hundred NOC compounds have been tested
    - 80% are carcinogenic
- 40 animal species
    - Several type of cancers
- *In utero* exposure causes congenital malformations
    - Central nervous system
    - First trimester

Nitrate and Human Health

- Regulatory limits of nitrate in drinking water are set for infant development of methemoglobinemia, not for other health outcomes
- Numerous scientific studies have looked at the relationship of nitrate in drinking water on human health
- High concentration of nitrate in drinking water have been linked to adverse health outcomes
- Strongest links
    - Methemoglobinemia (Infants less than 6 months)
    - Colorectal cancer (5 studies; 4 positive)
    - Thyroid disease (3 positive studies)
    - Neural tube defects (birth defects of spine, brain and spinal cord)

Other links to health

- Increased heart rate, nausea, headaches, and abdominal cramps
- Other cancers
  - Pediatric brain cancers (2 studies; 2 positive)
  - Kidney cancer (2 studies; 2 positive)
  - Bladder cancer (4 studies; 2 positive)
  - Non-Hodgkin lymphoma (3 studies; 1 positive)
- Non-Hodgkin Lymphoma had a three-fold increase in risk with nitrate and atrazine in Nebraska study (Rhoades et al 2013)
- Alzheimer's, Diabetes And Parkinson's Disease

Adverse reproductive outcome

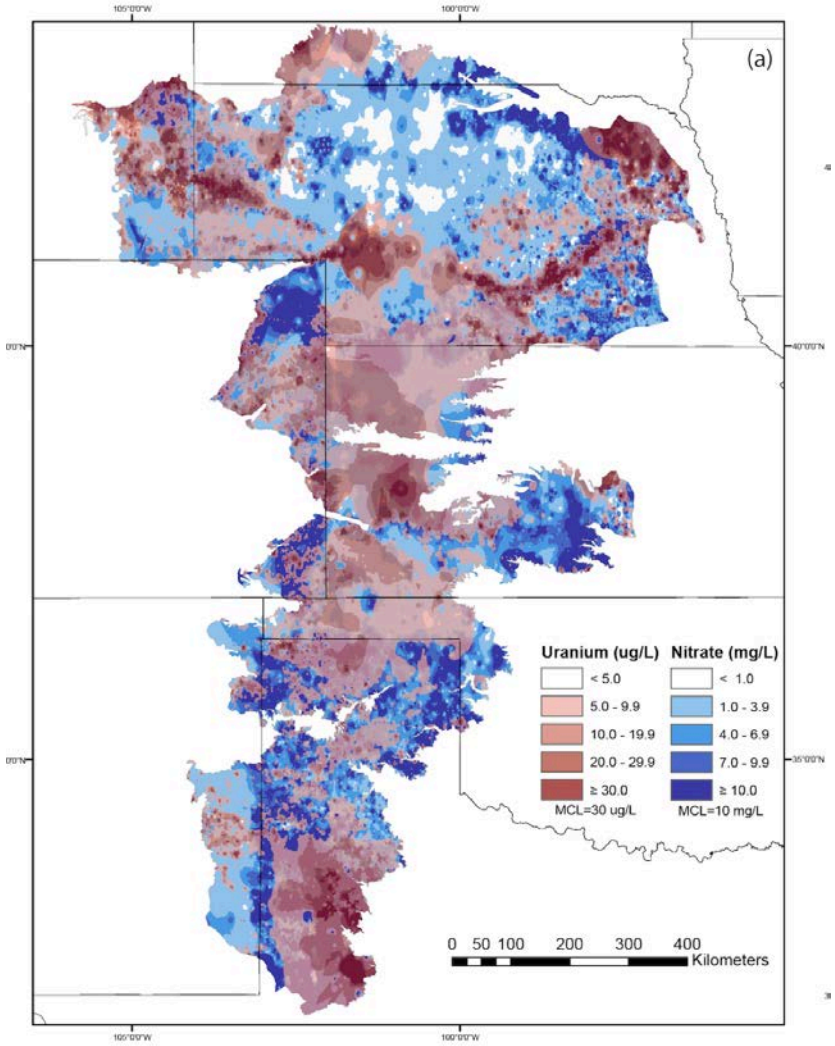
- CDC report 1996 showed a cluster of spontaneous abortions (miscarriages) in rural Indiana
    - Private wells >20 mg/L NO_2-N
    - Switched to low nitrate water and healthy births

- Central Nervous System (CNS) Malformations
    - 5 of 6 studies found a positive association with nitrate
    - 4 of the studies had concentrations less than 10mg/L

Most Vulnerable Populations

- Young infants (< 6 months of age) appeared to be particularly sensitive to the effects of nitrite on hemoglobin
- Pregnant women and her fetus
    - Especially at 30 weeks of pregnancy
- People with oxygen transport or delivery conditions like anemia, cardiovascular disease, lung disease, sepsis and presence of other structural hemoglobin variants
- People with nitrate in their well water
    - Diet also plays a role

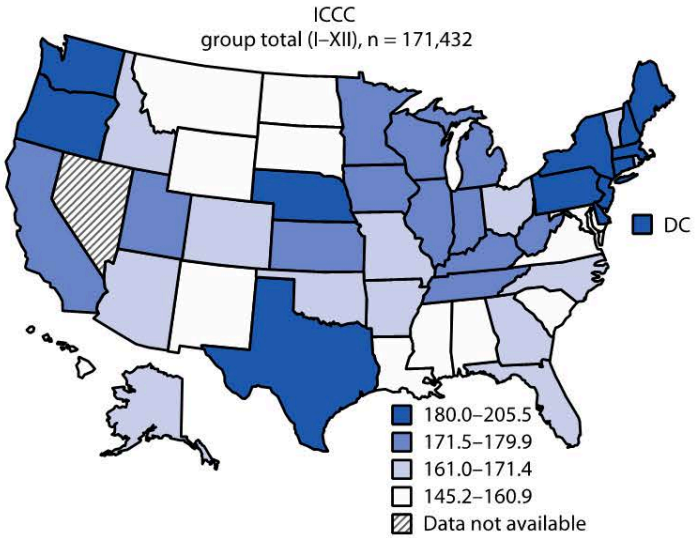
Uranium and nitrate concentrations in groundwater in Great Plains region



Source : Natural uranium contamination in major US aquifers linked to nitrate
J Nolan, KA Weber - Environmental Science & Technology Letters, 2015
https://pubs.acs.org/doi/abs/10.1021/acs.estlett.5b00174

Centers for Disease Control and Prevention

Data from 2003 – 2014 and reported as age-adjusted incidence rates of childhood cancer per 1 million:



ICCC: International Classification of Childhood Cancer

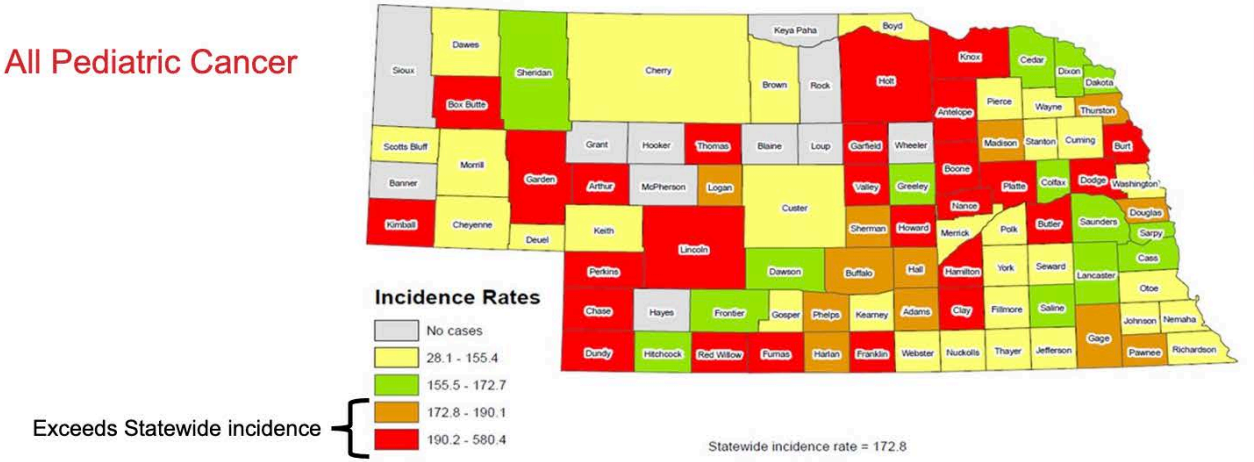
United States	173.7
New Hampshire	205.5
New Jersey	192.3
Maine	190.5
New York	190
Pennsylvania	186.6
Connecticut	185.8
Nebraska	183.2
Texas	183.2
Oregon	182.6
Massachusetts	181.5

Siegel et al. Geographic Variation in Pediatric Cancer Incidence - US, 2003–2014. *MMWR*, 2018

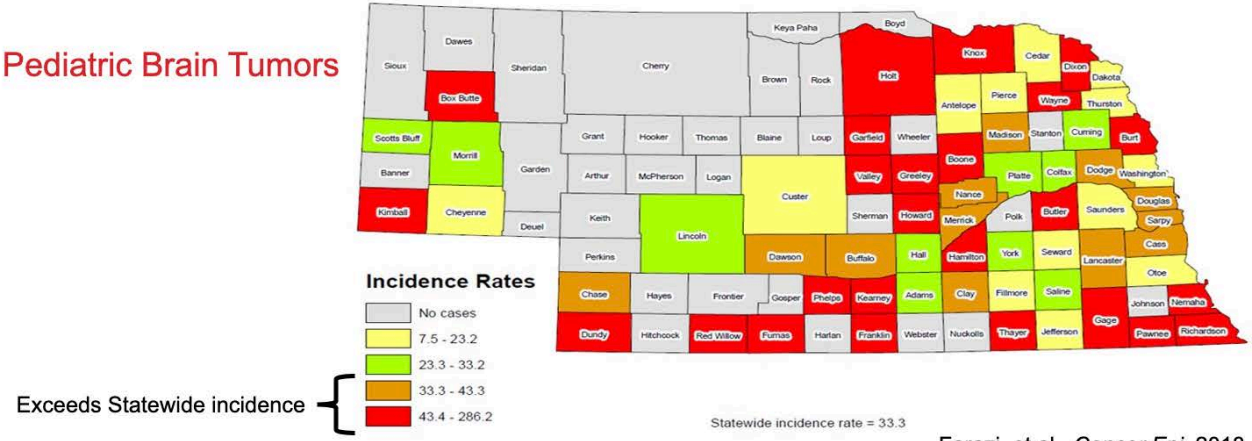
Courtesy of Don Coulter, MD

Incidence of pediatric cancers in Nebraska is among the **five highest** in the United States (Farazi et al., 2018).

All Pediatric Cancer



Pediatric Brain Tumors



Farazi, et al. *Cancer Epi*, 2018

Courtesy of Don Coulter, MD

Watershed

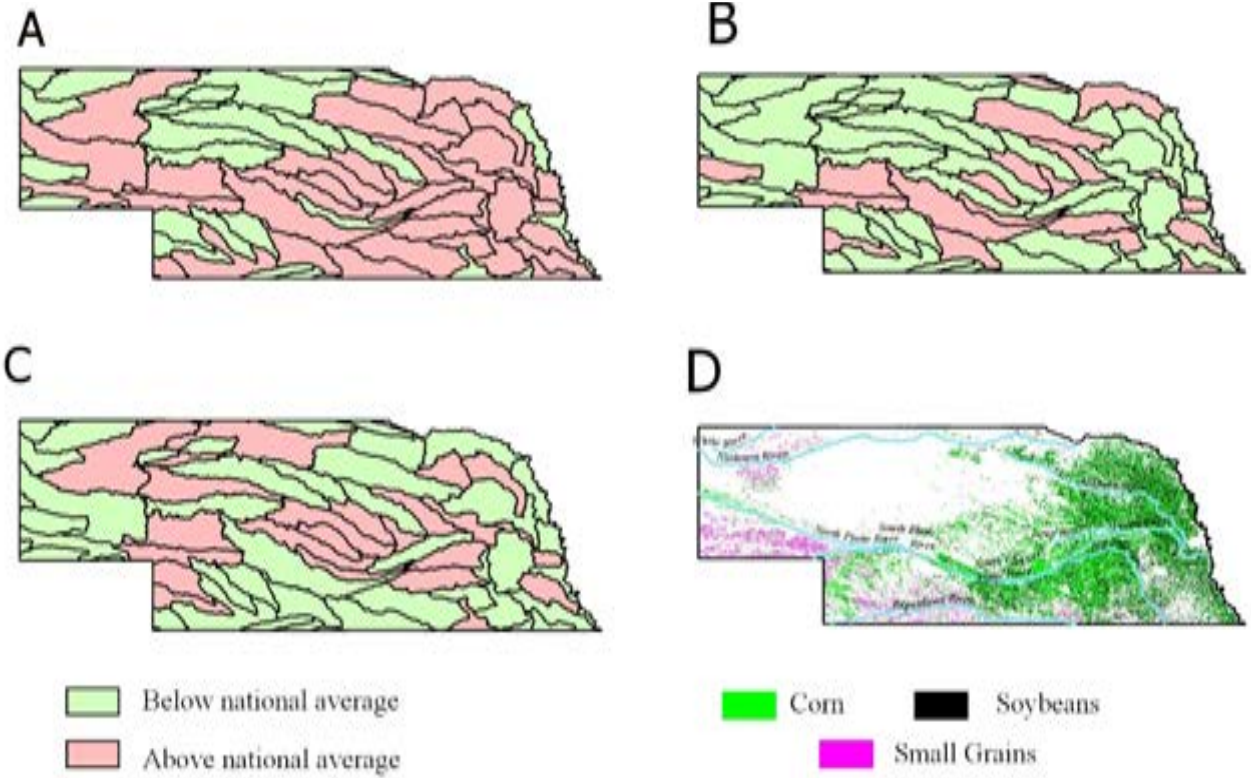


Fig. 1. Age-adjusted cancer incidence in Nebraska Watersheds VS national average for (A) CNS Tumors, (B) Leukemia, (c) Lymphoma; (D) Land use

63% (54/86) Pediatric CNS Cancers

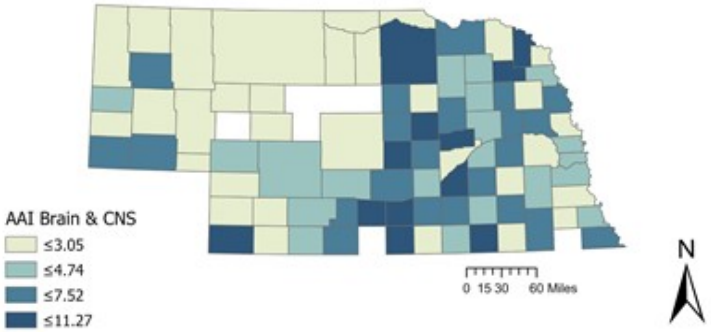


Fig 1A. Age-adjusted incidence (AAI) of pediatric brain and other CNS cancer per county in Nebraska from 1987-2016

41% (35/86) Pediatric Leukemia

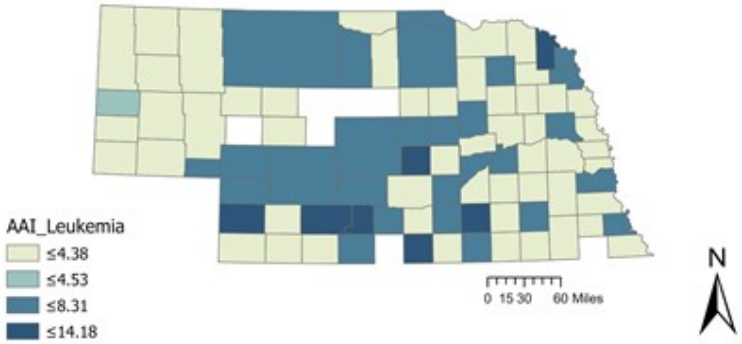


Fig 1B. Age-adjusted incidence (AAI) of pediatric leukemia per county in Nebraska from 1987-2016

Counties with groundwater nitrate concentration between 2.1 and 5 mg/L have higher incidence

43% (38/86) Pediatric Lymphoma

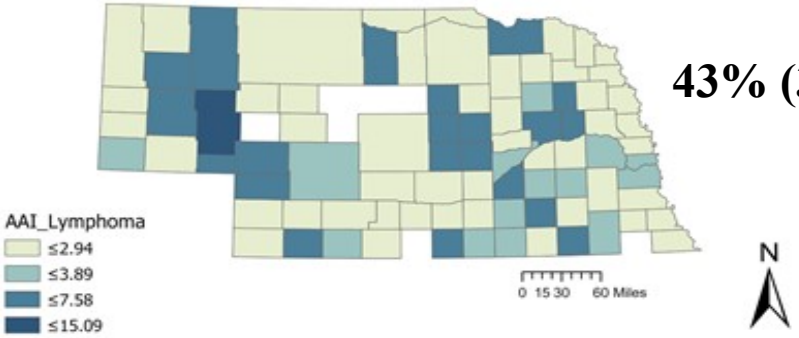


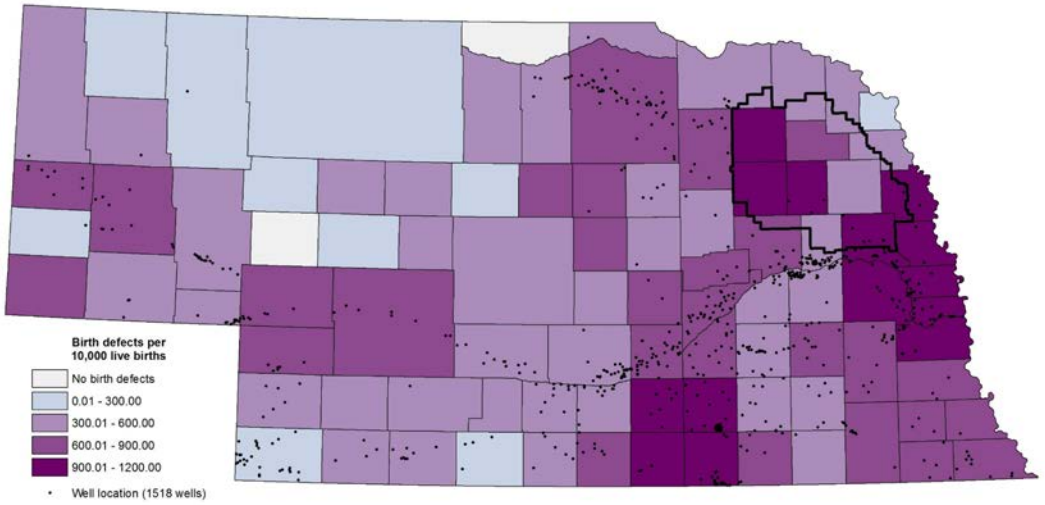
Fig 1C. Age-adjusted incidence (AAI) of pediatric lymphoma per county in Nebraska from 1987-2016

Birth Defects in the Lower Elkhorn NRD

- Total congenital anomalies in LENRD= 1,140 (1995-2014)
- 468 – females (avg. birth weight 3,126 gm)
- 672 – males (avg. birth weight 3,164 gm)
- 229 pregnant women with history of smoking
- 55 women diagnosed with gestational diabetes

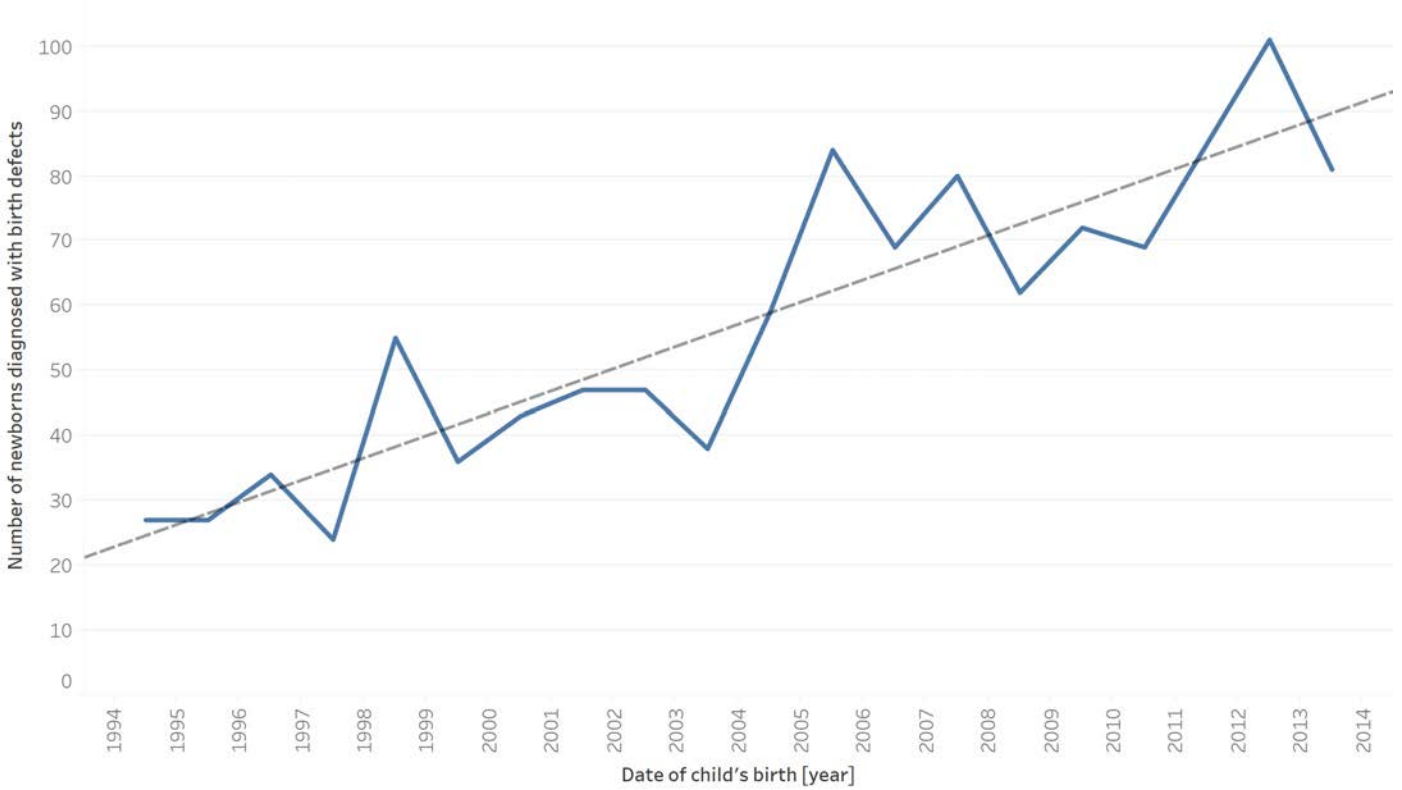
Birth Defects

- National average: 3.3% of all live births
- Nebraska (2005-2014): 5.8%
- Counties in parts of NE reaching 9-12%
- Counties with higher birth defects had greater prevalence of agrichemicals in water



New-Aaron, Moses; Meza, Jane L.; Shea, Patrick J.; and Rhoades, Martha, "Birth outcomes and water: A multidisciplinary study" (2018). *Posters and Presentations: College of Public Health*. 11. https://digitalcommons.unmc.edu/coph_pres/11

Trend in Birth Defects: LENRD



The median compound growth rate of birth defects in LENRD: 7.08% (95% CI 5.73-8.42)

Median compound growth rate in Nebraska: 4.71 (95% CI 3.73-5.70)

Summary

- Studies have found that various negative health outcomes are associated with high concentrations of nitrate in drinking water
- Nebraska has one of the highest rates of some pediatric cancers
    - Some of these pediatric cancers seem to have an association with areas that have high nitrate
- Number of birth defects are increasing in Nebraska

Public Health Solutions

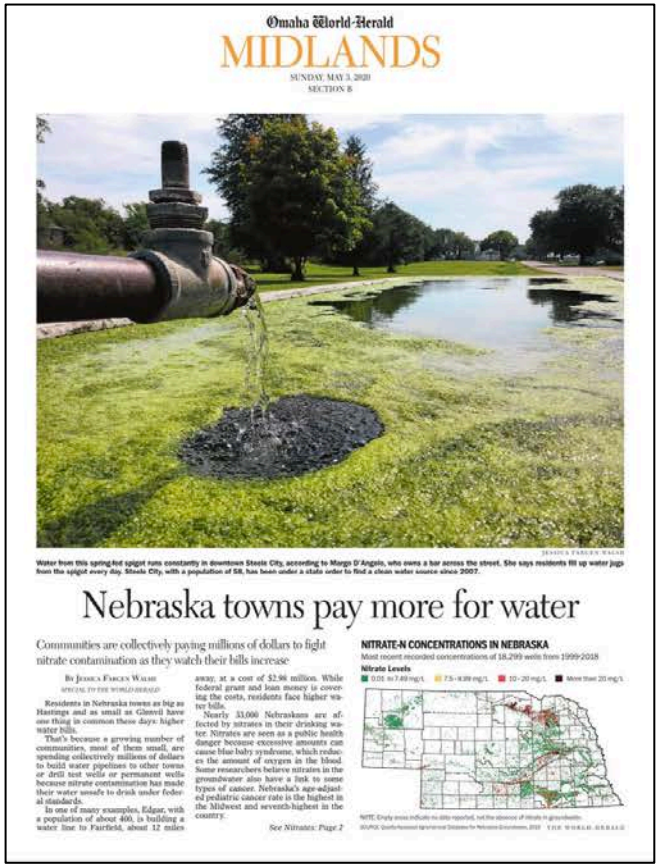
- Public health can assist with addressing, educating, and understanding the health impacts.
- Public health spending is estimated to be between 1.5% and 3% of all U.S. health spending

Water, Climate and Health Program

The Claire M. Hubbard Foundation

- Interdisciplinary collaborations across University of Nebraska system
- Address Nebraska's public health challenges related to water and climate
  - Research
  - Education
  - Policy Development
  - Training

Water Quality



Omaha World-Herald

MIDLANDS

SUNDAY, MAY 3, 2020

SECTION B

Water from this spring-fed spigot runs constantly in downtown Steele City, according to Margo D'Angelo, who owns a bar across the street. She says residents fill up water jugs from the spigot every day. Steele City, with a population of 58, has been under a state order to find a clean water source since 2007.

Nebraska towns pay more for water

Communities are collectively paying millions of dollars to fight nitrate contamination as they watch their bills increase

By Jessica Fargen Walsh

Special to the World-Herald

Residents in Nebraska towns as big as Hastings and as small as Glenvil have one thing in common these days: higher water bills.

That's because a growing number of communities, most of them small, are spending collectively millions of dollars to build water pipelines to other towns or drill test wells or permanent wells because nitrate contamination has made their water unsafe to drink under federal standards.

In one of many examples, Edgar, with a population of about 400, is building a water line to Fairfield, about 12 miles away, at a cost of $2.96 million. While federal grant and loan money is covering the costs, residents face higher water bills.

Nearly 33,000 Nebraskans are affected by nitrates in their drinking water. Nitrates are seen as a public health danger because excessive amounts can cause blue-baby syndrome, which reduces the amount of oxygen in the blood. Some researchers believe nitrates in the groundwater also have a link to some types of cancer. Nebraska's age-adjusted pediatric cancer rate is the highest in the Midwest and seventh-highest in the country.

See Nitrates: Page 2

NITRATE-N CONCENTRATIONS IN NEBRASKA

Most recent recorded concentrations of 18,299 wells from 1999-2018

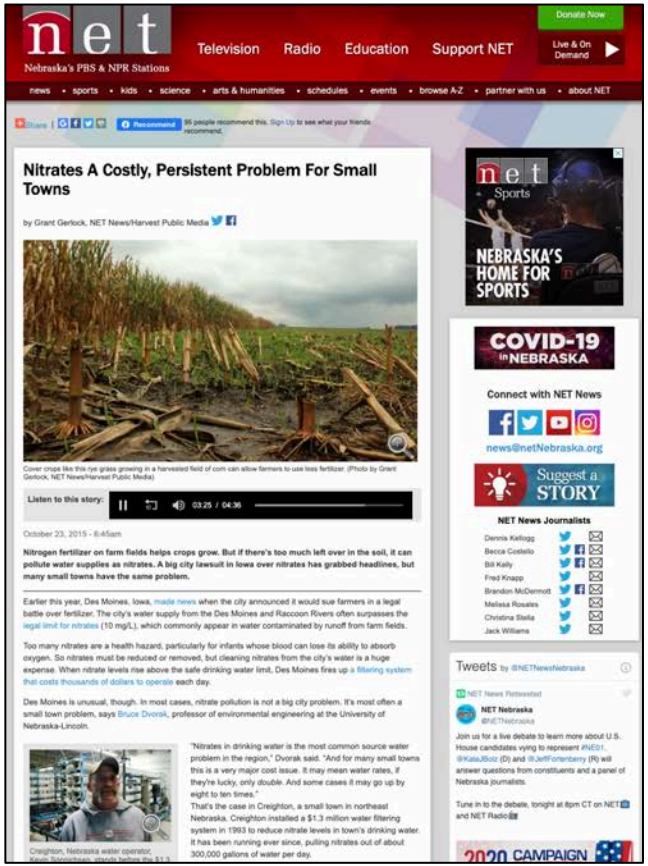
Nitrate Levels

0.01 to 7.49 mg/L | 7.5 - 9.99 mg/L | 10 - 20 mg/L | More than 20 mg/L

NOTE: Empty areas indicate no data reported, not the absence of nitrate in groundwater.

SOURCE: Quality-Assured Agricultural Database for Nebraska Groundwater, 2018

THE WORLD-HERALD



net

Nebraska's PBS & NPR Stations

Television | Radio | Education | Support NET | Donate Now | Live & On Demand

news • sports • kids • science • arts & humanities • schedules • events • browse A-Z • partner with us • about NET

Share | Recommend 95 people recommend this. Sign Up to see what your friends recommend.

Nitrates A Costly, Persistent Problem For Small Towns

by Grant Gerlock, NET News/Harvest Public Media

Cover crops like this rye grass growing in a harvested field of corn can allow farmers to use less fertilizer. (Photo by Grant Gerlock, NET News/Harvest Public Media)

Listen to this story: 03:25 / 04:36

October 23, 2015 - 6:45am

Nitrogen fertilizer on farm fields helps crops grow. But if there's too much left over in the soil, it can pollute water supplies as nitrates. A big city lawsuit in Iowa over nitrates has grabbed headlines, but many small towns have the same problem.

Earlier this year, Des Moines, Iowa, made news when the city announced it would sue farmers in a legal battle over fertilizer. The city's water supply from the Des Moines and Raccoon Rivers often surpasses the legal limit for nitrates (10 mg/L), which commonly appear in water contaminated by runoff from farm fields.

Too many nitrates are a health hazard, particularly for infants whose blood can lose its ability to absorb oxygen. So nitrates must be reduced or removed, but cleaning nitrates from the city's water is a huge expense. When nitrate levels rise above the safe drinking water limit, Des Moines fires up a filtering system that costs thousands of dollars to operate each day.

Des Moines is unusual, though. In most cases, nitrate pollution is not a big city problem. It's most often a small town problem, says Bruce Dvorak, professor of environmental engineering at the University of Nebraska-Lincoln.

Creighton, Nebraska water operator, Kevin Bonnichsen, stands before the $1.3

"Nitrates in drinking water is the most common source water problem in the region," Dvorak said. "And for many small towns this is a very major cost issue. It may mean water rates, if they're lucky, only double. And some cases it may go up by eight to ten times."

That's the case in Creighton, a small town in northeast Nebraska. Creighton installed a $1.3 million water filtering system in 1993 to reduce nitrate levels in town's drinking water. It has been running ever since, pulling nitrates out of about 300,000 gallons of water per day.

net Sports

NEBRASKA'S HOME FOR SPORTS

COVID-19 in NEBRASKA

Connect with NET News

news@netNebraska.org

Suggest a STORY

NET News Journalists

Dennis Kellogg
Becca Costello
Bill Kelly
Fred Knapp
Brandon McDermott
Melissa Rosales
Christina Stella
Jack Williams

Tweets by @NETNewsNebraska

NET News Retweeted

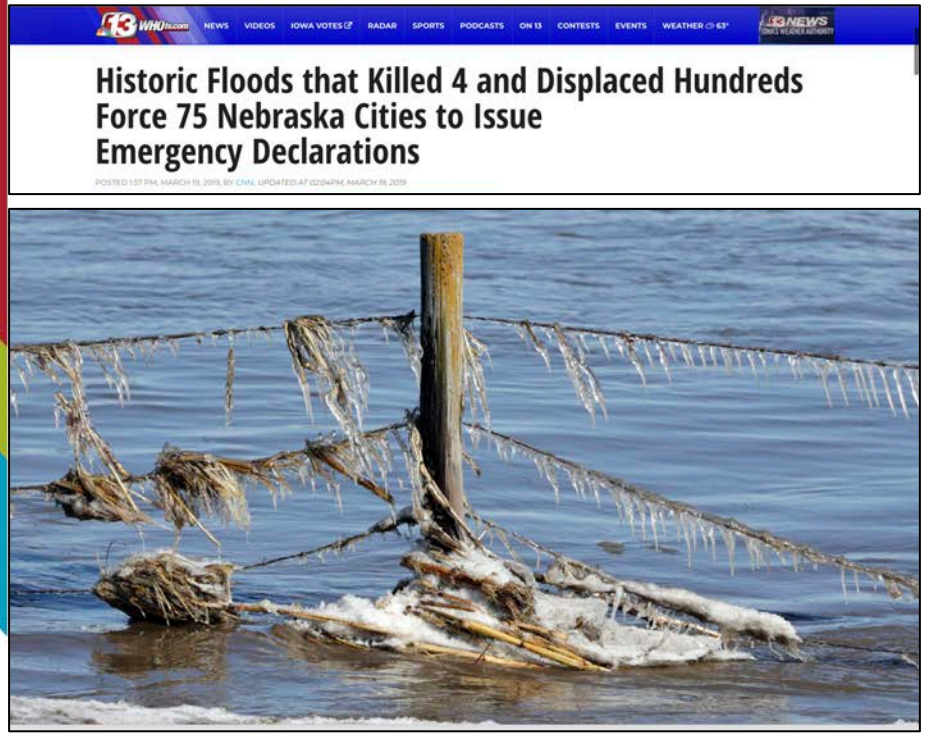
NET Nebraska
@NETNebraska

Join us for a live debate to learn more about U.S. House candidates vying to represent #NE01. @KaleiBoitz (D) and @JeffFortenberry (R) will answer questions from constituents and a panel of Nebraska journalists.

Tune in to the debate, tonight at 8pm CT on NET and NET Radio

2020 CAMPAIGN

Water Quantity



Safer and Healthier State

- Identifying multidisciplinary solutions to Nebraska's water and health issues
- Building collaborations with leaders tackling water and health issues
- Educating and informing Nebraskans about these environmental issues
- Providing mentorship and support to the next generation of problem solvers
- Recruiting experts to help address these issues

What comes next?

- Fellowships for students
- Pilot grants
- Water and Health Summit, June 2021
- Climate Summit, Fall 2021
- Expanding Public Health Education into UNMC curriculum
  - Emerging Medical Education Track beginning Fall 2021

Acknowledgements

Our Team
Meghan Langel, MPH
Siddhi Munde, MS
Yeongjin Gwon, PhD
Conor O'Neill

People that made this possible
Anne Hubbard, MD
Ali Khan, MD MPH
Mike Boehm, PhD
Peter McCornick, PhD
Elli Rogan, PhD
Molly Nance
UNMC, UNL, DWFI
Nebraska Foundation

Water for Food
DAUGHERTY GLOBAL INSTITUTE
at the University of Nebraska

The Claire M. Hubbard Foundation

Interest in the Program

If interested in the **Water, Climate and Health Program** please contact:

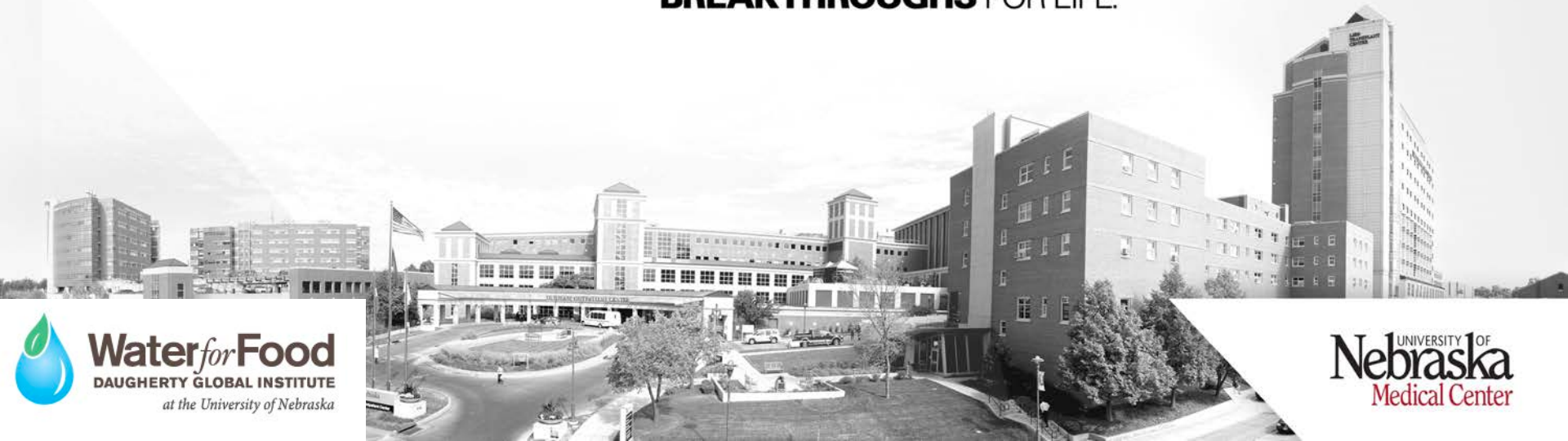
Meghan Langel, MPH
Program Manager
meghan.langel@unmc.edu
402-559-5271

Our Team

The Claire M. Hubbard Foundation

UNMC[SM]

BREAKTHROUGHS FOR LIFE.®



Water for Food
DAUGHERTY GLOBAL INSTITUTE
at the University of Nebraska

University of Nebraska Medical Center