

Beneath the Plains:

Nitrate in Groundwater and Our Health

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Public Health is the science of protecting and improving the health of people and their communities





Water Quality & Health

Water Quality & Health in Nebraska



WATER QUALITY

Nebraska's nitrate problem is growing worse and it's likely harming our kids

Yanqi Xu Flatwater Free Press Oct 28, 2022 Updated Dec 5, 2022 8

Nebraska's nitrate problem is serious, experts say. Can we solve it?

Matthew Hansen and Yanqi Xu Flatwater Free Press Dec 31, 2022 Updated Jun 5, 2023 1

EDITOR'S PICK TOPICAL TOP STORY

FIGHTING NITRATES

Clean water doesn't come cheap: Nebraska towns are shelling out millions to treat nitrate-laced drinking water

YANQI XU Flatwater Free Press Dec 15, 2022 Updated Jan 20, 2023 3

Omaha World-Herald

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Researchers detect insecticides in water, home near troubled Nebraska ethanol plant

Nancy Gaarder Jun 16, 2022 Updated Aug 24, 2022 3

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 Sornichsen, stands before the \$1.3 million water filter.

"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.

Omaha World-Herald
MIDLANDS
SUNDAY, MAY 3, 2009
SECTION 8



Water from this spring-fed faucet runs constantly in downtown Omaha City, according to Wago's Dvorak, who says a lot of water is lost. She says residents fill up water jugs from the spout every day. Omaha 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 James Francis Weaver

Special to the Omaha World-Herald

Residents in Nebraska towns as big as

Omaha and as small as Creighton have

been fighting to remove these dirty, higher

water bills.

There's a growing number of

communities, most of them small, are

spending collectively millions of dollars

to deal with nitrates in their drinking

water. Nitrates are even on a public health

watch list 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

infant cancer rate is the highest in the

Midwest and seventh-highest in the

country.

In one of many examples, Edgar, with

a population of about 80, is building a

water line to Fairfield, about 17 miles



See Nitrates: Page 2

Nitrate & Drinking Water

85% get their home water from groundwater

Over 360,000 residents get their water from private wells

Sources: Nitrogen fertilizers, animal and human waste

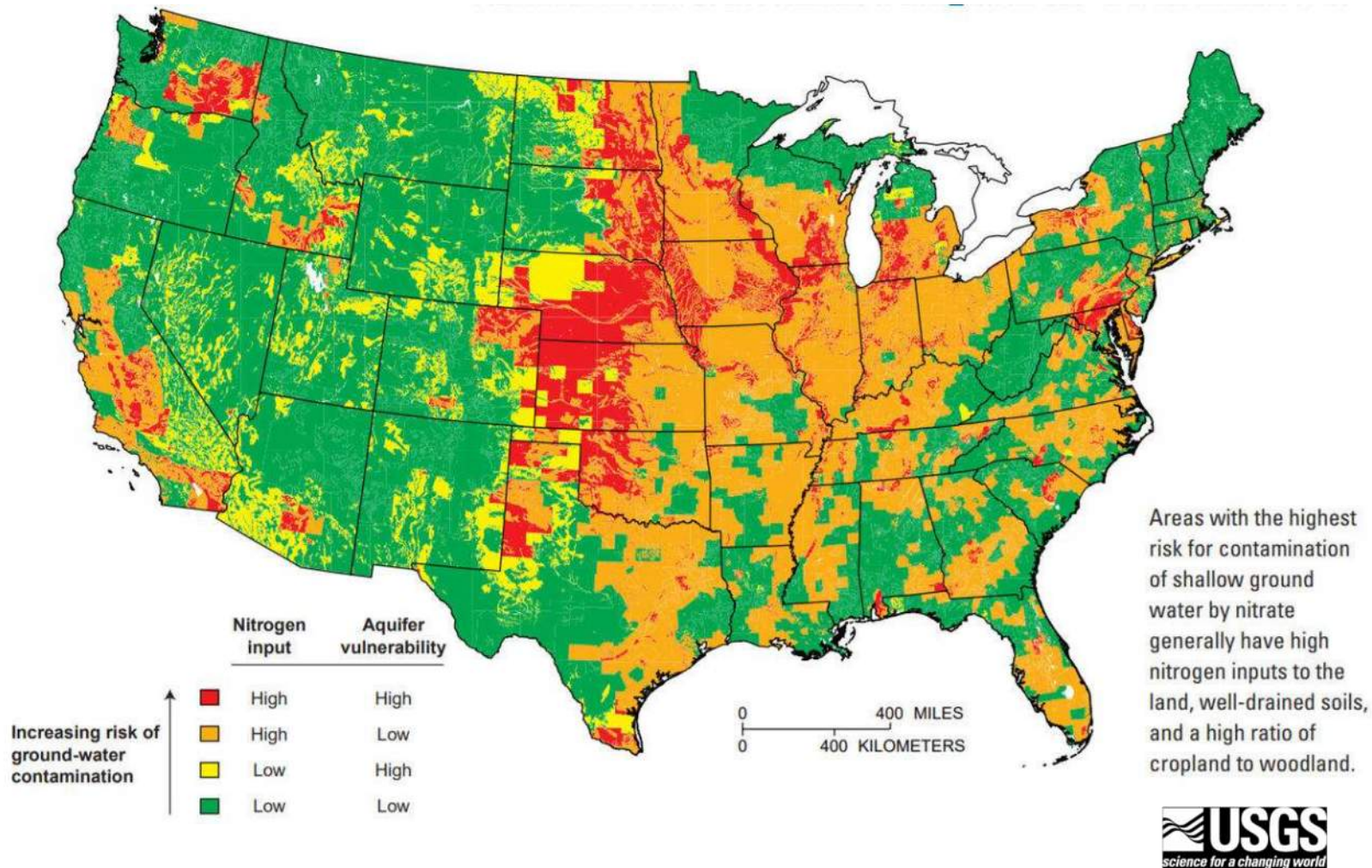
Regulatory limit: 10 mg/L as NO₂-N (USA)

Greatest exposure

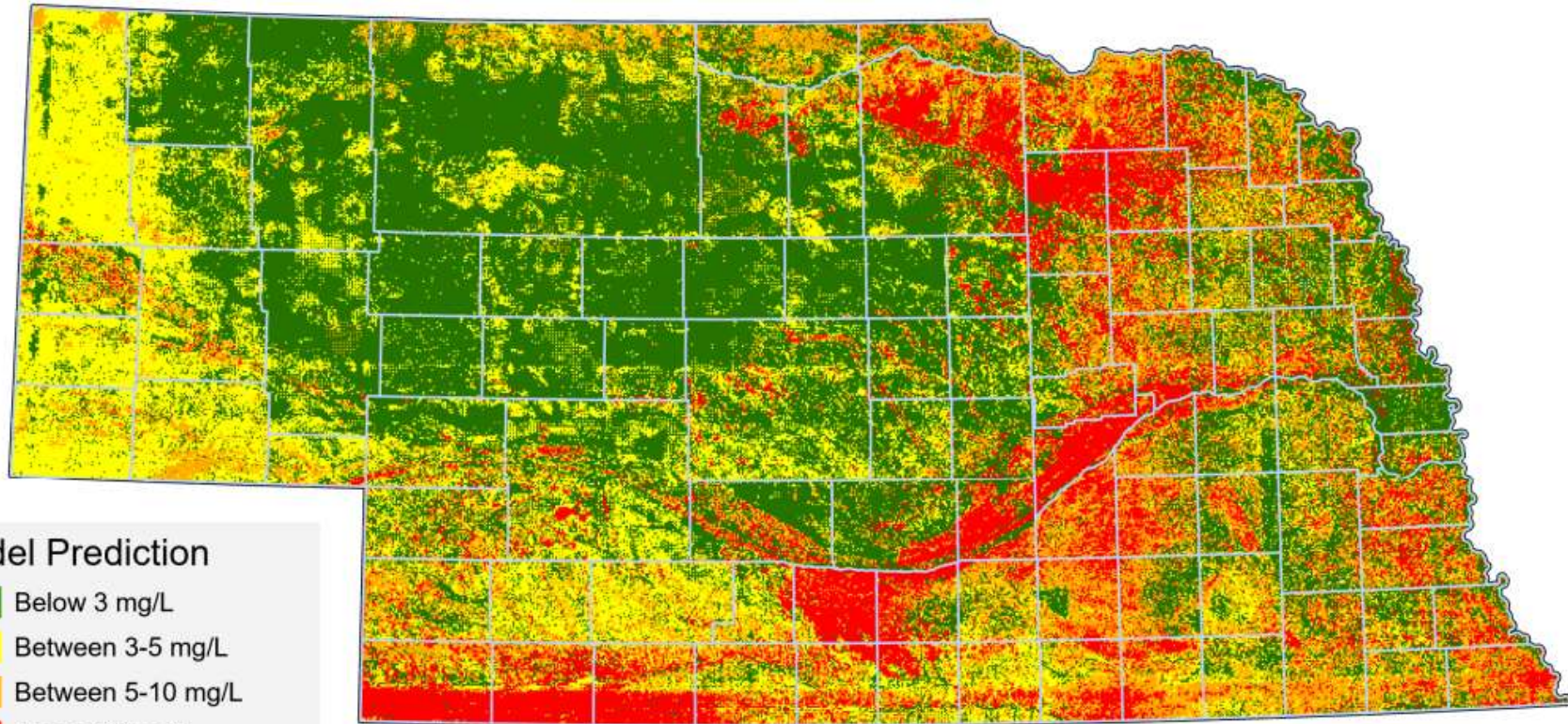
- Agricultural areas
- Private wells
 - Not regulated
 - Sparse measurements



Areas of Highest Risk of Nitrate Contamination



Nitrate impacts most of Nebraska



Model Prediction

- Below 3 mg/L
- Between 3-5 mg/L
- Between 5-10 mg/L
- Above 10 mg/L

Credits: NDEE Drinking Water and
Groundwater Division
Spatial Reference: NAD 1983 State Plane
Nebraska FIPS 2,600 Feet
Projection: Lambert Conformal Conic

NEBRASKA
DEPT. OF ENVIRONMENT AND ENERGY

2025



Nitrate & 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 has been linked to adverse health outcomes

Strongest links:

- Minor health ailments
- Methemoglobinemia
- Preterm birth issues
- Birth defects
- Pediatric cancers
- Adult cancers



N-nitroso compound (NOC) formation from ingested nitrate (drinking water & diet)



Oral bacteria: Nitrate → nitrite

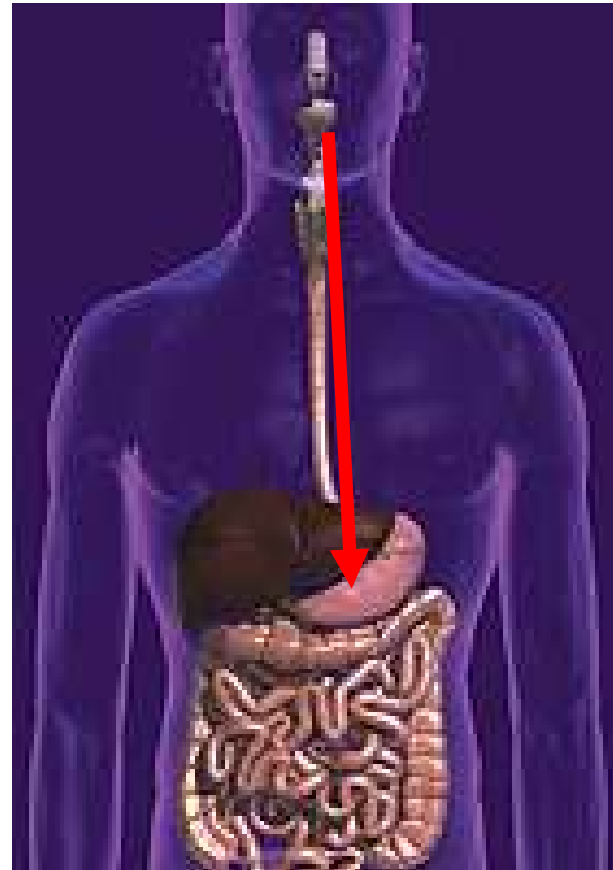
Nitrite + stomach acid

N_2O_3 +
amines/amides

NOC

↑
Heme iron
(red meat)
Thiocyanate
(smoking)

↓
Antioxidants
(vitamin C)



Adult Health Issues



Increased heart rate, nausea, headaches, and abdominal cramps

Cancers

Colorectal cancer (5 studies; 4 positive)

Thyroid disease (3 positive studies)

- Increase risk of thyroid cancer (5 mg/L)

Kidney cancer (2 studies; 2 positive)

Bladder cancer (4 studies; 2 positive)

Non-Hodgkin lymphoma (3 studies; 1 positive)



Alzheimer's, Diabetes And Parkinson's Disease

Research in Iowa



- Long-term ingestion of elevated nitrate in drinking water was associated with an increased risk of bladder cancer among postmenopausal women. *Jones et al. 2016*
- High nitrate levels in public drinking water and private well use may increase ovarian cancer risk among postmenopausal women. *Inoue-Choi et al. 2015*
- Exposure to total trihalomethanes in drinking water is associated with the risk of rectal cancer. Nitrate in drinking water was not associated with risk of colon or rectal cancers. *Jones et al. 2019*
- Positive association between a relatively low dietary intake of nitrite from processed meats and stomach cancer risk in postmenopausal women. No association between long-term exposure to nitrate or TTHM levels in public water supplies and the risk of these digestive system cancers. *Buller et al. 2021*

Health Issues in Children



Multiple health issues have been identified in children

- Methemoglobinemia (Infants less than 6 months)
- Pediatric brain cancers (2 studies; 2 positive)
- Non-Hodgkin Lymphoma (3 studies; 1 positive)
- Non-Hodgkin Lymphoma had a three-fold increase in risk with nitrates and atrazine in Nebraska study (Rhoades et al 2013)



Maternal & Fetal Health Issues



CDC report 1996 showed a cluster of spontaneous abortions (miscarriages) in rural Indiana
Private wells 19-26 mg/L

California study found an increase in spontaneous preterm births with drinking water nitrate of 5 to 10 mg/L (Sherris et al. 2021)

Fetal growth restriction with exposure of high nitrate in drinking water (Coffman et al. 2021)

Fetal hemoglobin is particularly susceptible to oxidation

Study shows elevated methemoglobin cord blood with exposure to nitrate during pregnancy (Tabacova et al. 1998)

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





Which groups are
susceptible to negative
health impacts of nitrate?



Populations of Concern

Pregnant people and their fetus

Young infants (< 6 months of age)

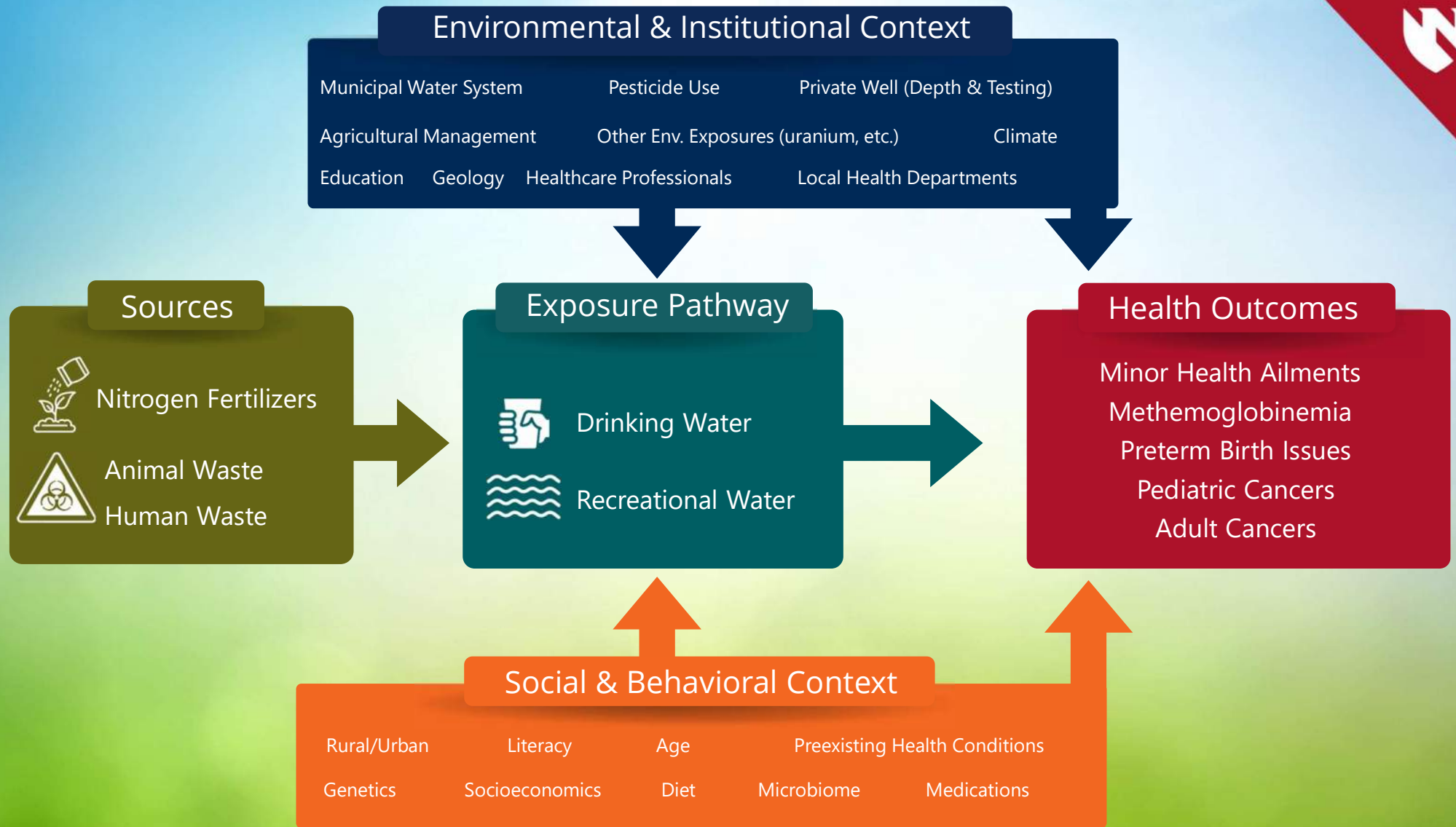
Children

People with oxygen transport or delivery conditions like anemia, cardiovascular disease, lung disease, sepsis and presence of other structural hemoglobin variants

People with high nitrate in their well water

- Diet also plays a role





NEBRASKA

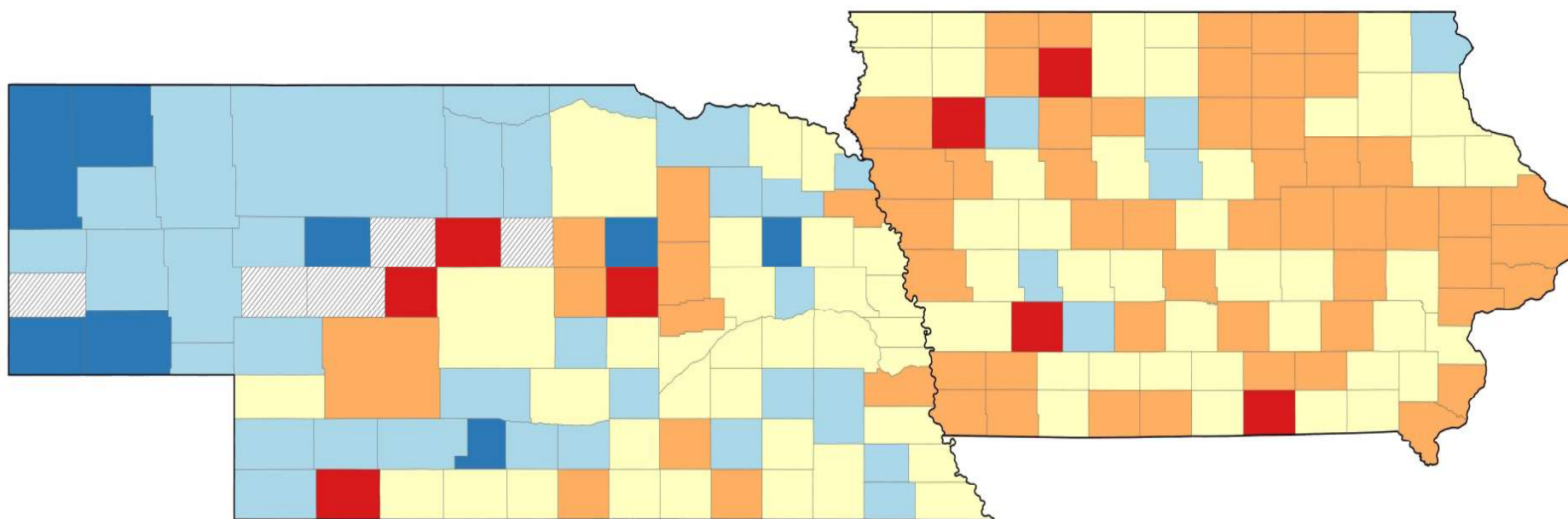
... the
good life



Day

Health Concerns in Nebraska

Iowa & Nebraska have 5 of the Top 25



Incidence Rates

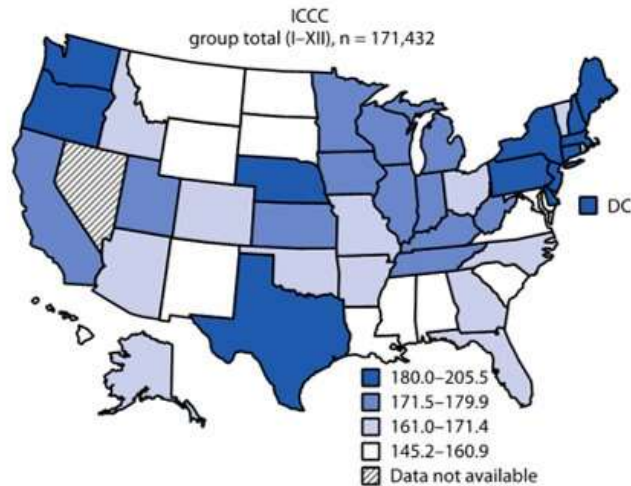


3 in the Top 10

Centers for Disease Control & 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

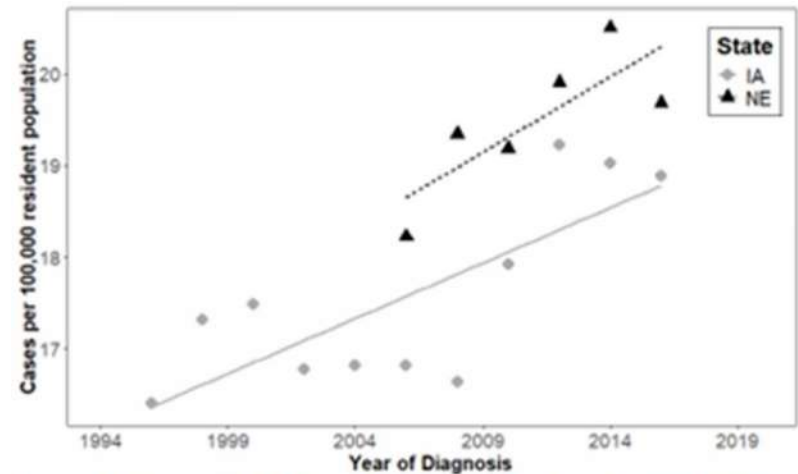


Figure 2. Change in PC Rates in Iowa and Nebraska (1994-2019)

Courtesy of Don Coulter, MD



Exceeds Statewide incidence



Exceeds Statewide incidence

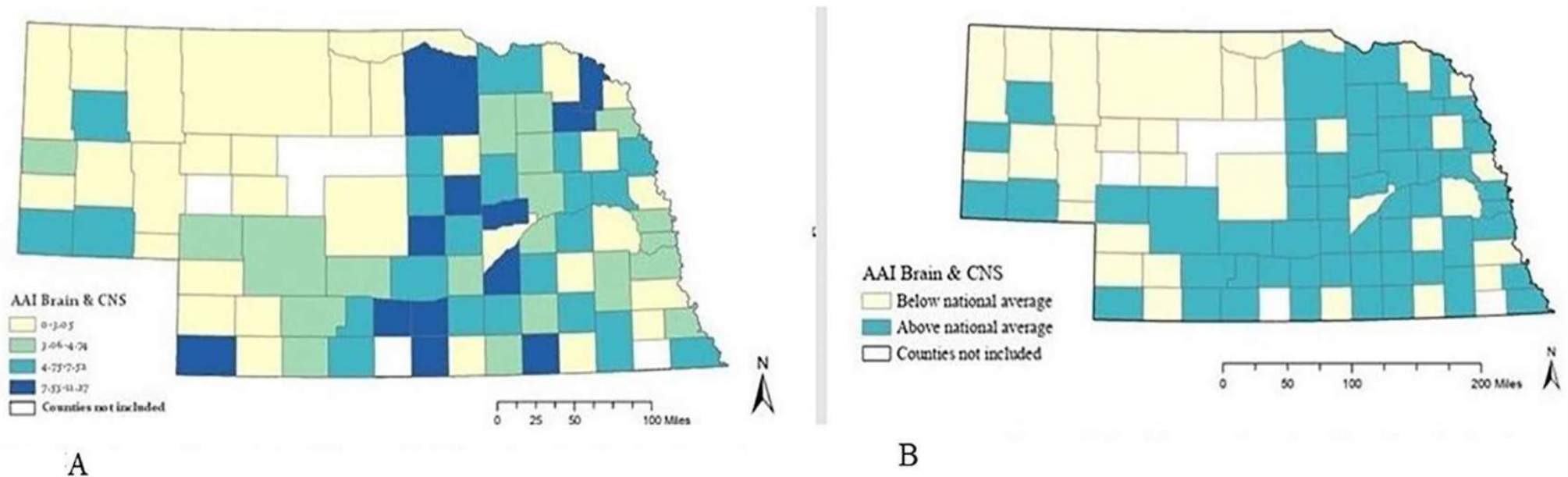


Courtesy of Don Coulter, MD

Pediatric Brain & other CNS Cancers 1987- 2016



Nebraska counties with elevated atrazine or nitrate levels reported more childhood cancers than counties with lower levels of these chemicals.



Relative to the national average, the age-adjusted incidence of pediatric brain and other CNS cancers is higher in 63% (54/86) of the Nebraska counties.

Unexpected Costs

Moving

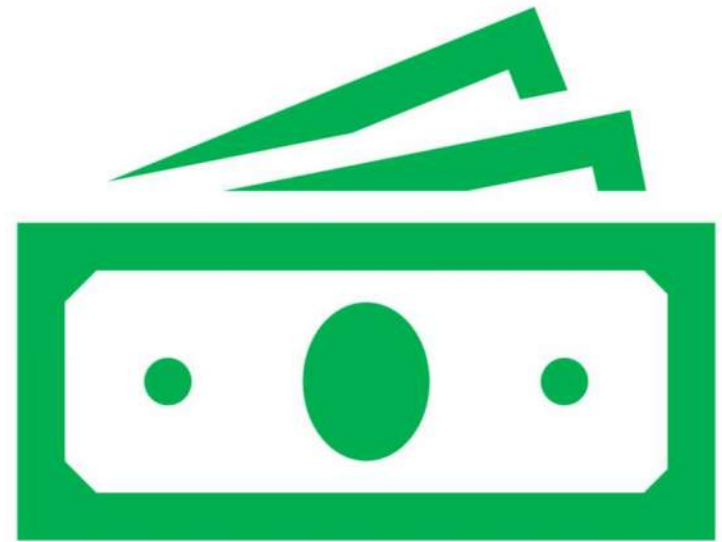
Financial burden

Higher rates of bankruptcy

Wisconsin study:

\$250,000-\$1.5 billion in medical
expenditures

\$1.3-\$6.5 billion lost in productivity



Goals for Addressing Water Quality



Identify at-risk areas and people



Encourage water testing



Find low-cost to no-cost solutions




Maintain these water systems



EXIT

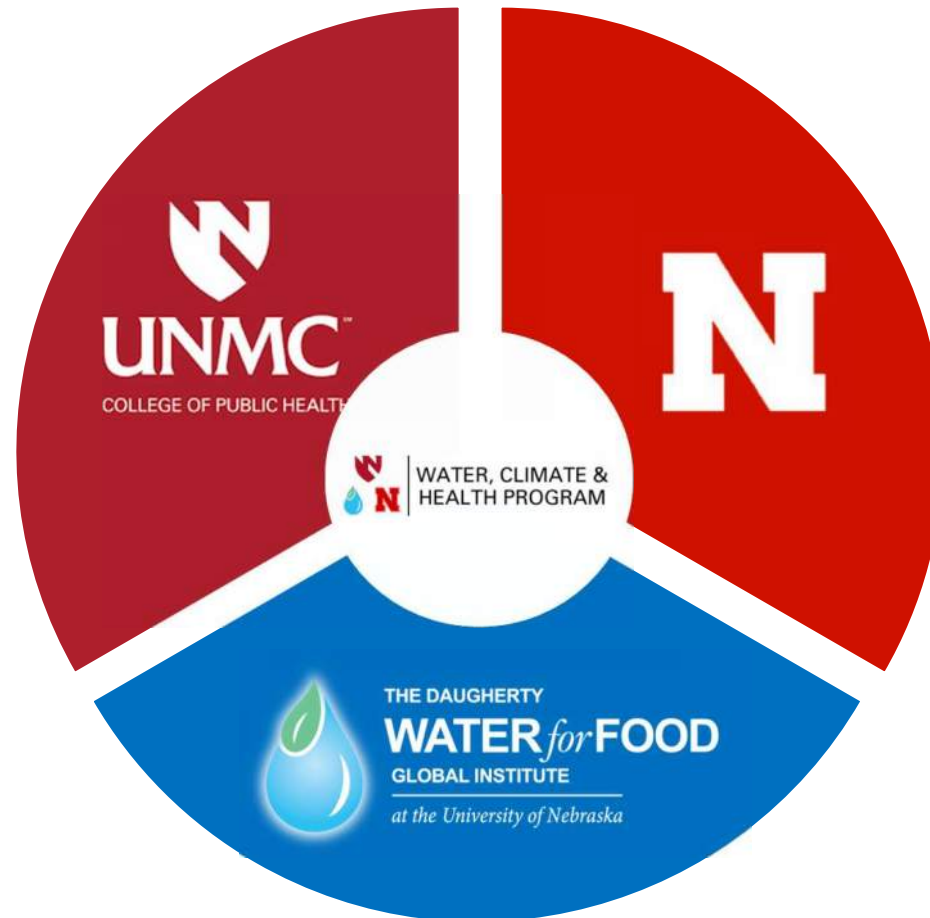
Engagement and Outreach





The Water, Climate and Health Program pioneers interdisciplinary research, education, and collaborative solutions to public health challenges associated with water and climate in Nebraska and around the world.

A Multi-Institution Initiative



Our Foundational Commitments



Research



Education

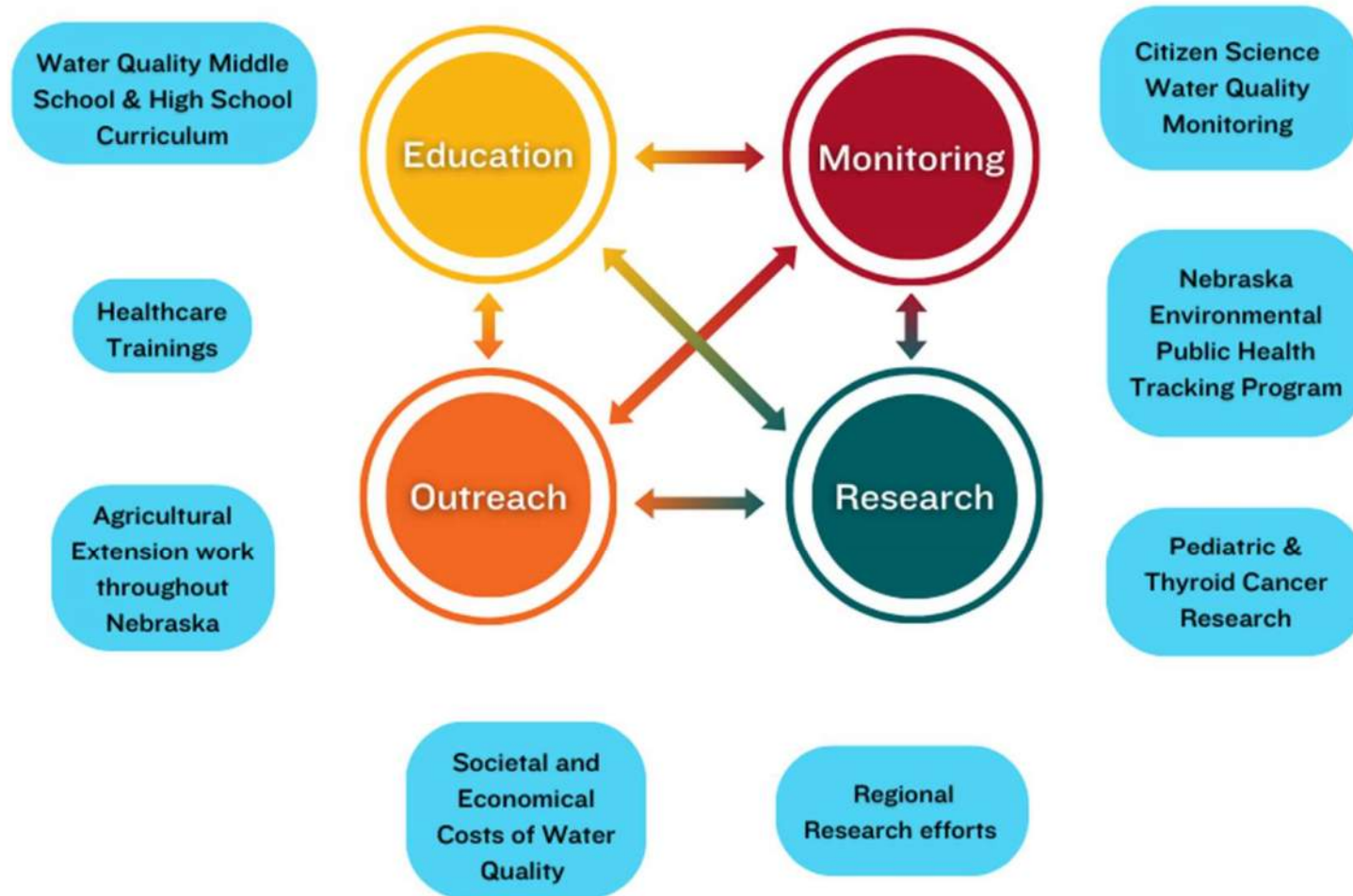


Engagement



Policy Development

Water Quality at the WCHP



Communication: Diverse Opportunities



***689**

Healthcare providers
(HCPs) surveyed

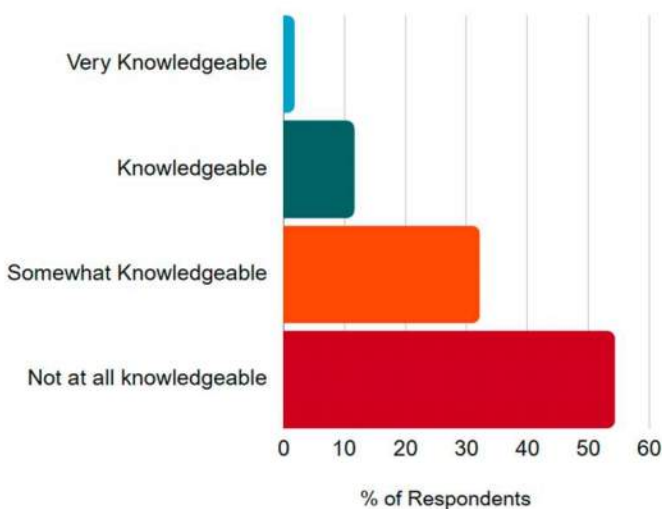


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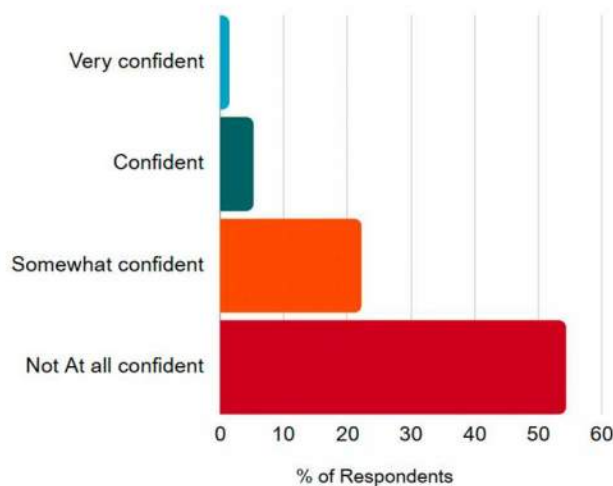
Natural Resource District
employees (NRDs)
surveyed



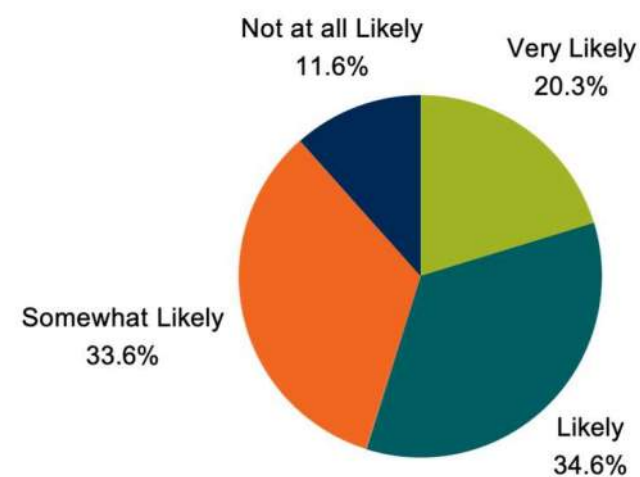
HCPs Self-Rated **Knowledge of the Health Impacts of Nitrate Contaminated Drinking Water (n=655)**



HCPs Self-Rated **Confidence that They Can Advise Patients About the Health Impacts of Nitrate Contaminated Drinking Water (n=655)**



HCPs Self-Rated **Likelihood to Distribute Educational Products to Patients if they were Available (n=596)**



Water Quality Education & Engagement



Nebraskans Can Treat Their Drinking Water for Free!

If your drinking water has high concentrations of nitrate, the Nebraska Department of Environment and Energy (NDEE) is offering an opportunity for you to treat it for free with the Reverse Osmosis System rebate program.

Application opens: January 1st, 2023
Application closes: June 23, 2024

Eligibility Requirements:

- This program is open to anyone with a private well.
- The private well must be registered.
- Applicants will need to submit water quality data from the State laboratory, with testing results dated no earlier than January 1, 2022.
- Only wells with samples above 10 ppm nitrate will be eligible for this program.

Why Apply?

Protecting your drinking water helps protect the health of you and your loved ones.

There are known health impacts for drinking nitrate contaminated water. The strongest linked are:

- Blue baby syndrome
- preterm birth issues
- birth defects
- pediatric cancers
- adult cancers

Application for R.O. rebate program
<https://go.unl.edu/roapp>

Order your lab kit
<https://go.unl.edu/orderkit>

Check if your well is registered
<https://go.unl.edu/checkwell>

How to register your well
<https://go.unl.edu/registerwell>

More program details
<https://go.unl.edu/programdetails>

Get up to \$4,000 reimbursed!



NITRATE AND HEALTH

PROTECT THE HEALTH OF YOU AND YOUR LOVED ONES BY KNOWING WHAT IS IN YOUR DRINKING WATER!

WHERE AND WHAT IS NITRATE?

Nitrate is a form of nitrogen that can sometimes be found in our drinking water. Nitrogen fertilizers used for growing crops are the largest contributor to nitrate in our drinking water. Therefore, if you live in an area where there is a lot of agricultural production, you are at risk of drinking nitrate-contaminated water.

WHAT CAN I DO TO PROTECT MYSELF AND MY FAMILY?

If you drink water from a private well, it is up to you to ensure you are drinking safe water. There are no requirements for private well owners to test or treat their water. Nitrate is colorless, odorless and tasteless. The only way to know if you have nitrate in your drinking water is to test for it.

Private well owners should test their drinking water annually. You can either test for nitrate in a certified laboratory or do-it-yourself test kits are available as well. The do-it-yourself kits should be used as a screening tool only. An analysis by an approved lab is recommended for the most accurate, reliable and precise measurement.

If you find nitrate above the safe drinking water level (10 ppm) in your water, the quickest and easiest solution is to avoid or reverse nitrate under Nitrate Action in your house. For more information, go to <https://water.unl.edu/>

HOW CAN CONSUMING NITRATE IMPACT HUMAN HEALTH?

Children and Infants

- A result in infants consuming nitrate-contaminated water is methemoglobinemia (blue baby syndrome), sometimes fatal within under six months old and at the highest risk. This illness can cause the skin to turn a bluish color and cause serious illness or death.
- There are studies suggesting potential linkages between nitrate concentration and pediatric cancers. Nebraska has the highest rate of pediatric cancer in the Midwest and 7th highest in the entire United States. More research needs to be conducted before we can draw any conclusions.

Pregnant Women

- During pregnancy, it is common for a woman's hemoglobin levels to increase from normal. Therefore, pregnant women are particularly susceptible to methemoglobinemia as well.
- Pregnant women exposed to too much nitrate are at greater risk of giving birth prematurely.
- Potential exposure to nitrate through drinking water has been linked to birth defects. Nebraska has double the national average rate of birth defects.

Other Adults

- The University of Nebraska Medical Center, along with researchers across the globe, continue to study linkages between consuming nitrate and human health impacts.
- A growing body of studies indicate potential associations between nitrate and:
 - Increased heart rate, blood pressure, blood glucose, and blood cholesterol levels.
 - Increased risk of cardiovascular disease, stroke, and death.

These research your doctor if you are experiencing any of these conditions.

Keep Your Baby Safe: Nitrates in Drinking Water from Wells Can Be Harmful

What are Nitrates?

Nitrates are chemicals that can get into private drinking water wells from:

- Farm fertilizers
- Animal manure
- Septic systems

The only way to know if your well water is safe to drink is to test it.

How Can Drinking Nitrates be Harmful?

During Pregnancy

High nitrates can increase the risk of:

- Early birth
- Low birth weight
- Pregnancy problems

Breastfeeding is safer - nitrates do not pass into breast milk.

Babies

High nitrates can increase the risk of "Blue Baby Syndrome" (Methemoglobinemia) which can cause:

- Blue or Purple skin
- Trouble Breathing
- Low oxygen in the blood and even death

Babies under 6 months are especially vulnerable to nitrates. Drinking formula mixed with nitrate-contaminated well water can cause serious health problems and, in severe cases, may be life-threatening. Do not make formula with water that tests above 10 mg/L of nitrate.

Why might we develop middle school and high school curriculum and train teachers to focus on water quality and citizenship skills?



Water Quality & Health Toolkit

Water Quality & Health Communications Resource For Public Health & Health Professionals in Nebraska

Drinking Water and Health

1. Drinking Water in Nebraska

Did you know, water from private wells is not required to be tested or treated? Therefore, the only way to know if your water is safe to drink is to test to find out for yourself.

2. Common Water Contaminants

Throughout much of Nebraska, water monitoring shows several harmful contaminants. The most common contaminant is nitrate - related to nitrogen fertilizer use.

3. Lifetime Health Impacts

There are known health impacts for drinking nitrate contaminated water. The strongest linked are: blue baby syndrome, preterm birth issues, birth defects, pediatric cancers and adult cancers.

4. Who is the Most at Risk?

The most vulnerable populations are pregnant women and their fetuses, young infants, children, and people with oxygen transport/delivery conditions.

5. Test Your Well Water!

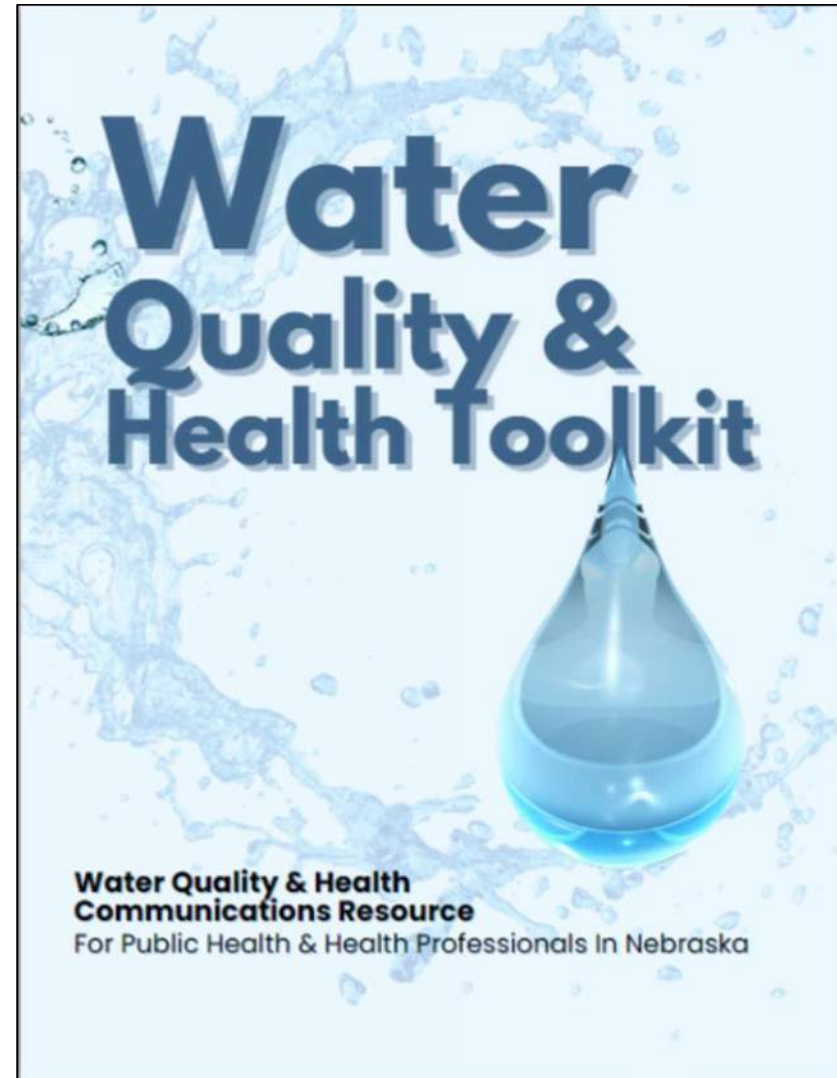
The only way to be sure of what is in your drinking water is to test it! The recommended way to test is to order a testing kit from an official Nebraska lab. After knowing what's in your water, you can begin building a treatment plan if necessary.

For more information:
Laura Neugebauer
lneugebauer@unl.edu OR scan here

NEBRASKA
Ready to get started with water?

Water Quality Communications for Public Health

1. The Basics of Water Quality
2. Water Quality and Health
3. Testing and Treating Your Water
4. Stakeholder Checklist
5. Water Quality Communication
6. Appendix/Resources



Protecting Nebraska's Waters Curriculum

Taylor Hamblin,
PhD at the
WCHP's
Research Seminar
Series in Spring
2023



Citizen Science and Environmental Education Showcase: *Empowering Youth, Inspiring Civic Action*



Middle and High School Curriculum that
engages students with water quality issues.

Developed by WCHP's Taylor Hamblin, PhD

Connections and engagement throughout the
state

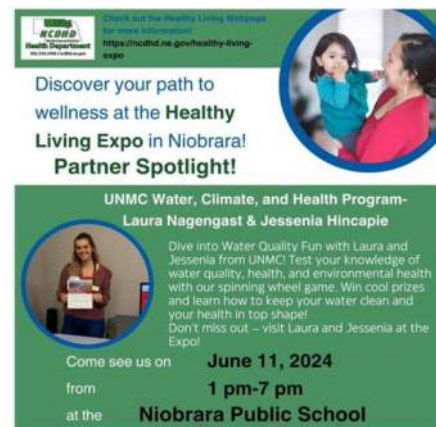


WCHP In the Community & Beyond



Drs. Gold and Bell discussing private well testing on UNMC's *Rural Health Matters*, 2023

“Flatwater Free Press Forum on Nitrates in Nebraska’s Water” in Norfolk, NE in March 2023.



Opportunities for Moving Forward



Partnerships to educate and do outreach



Improve testing of private wells



Continue to research these issues – **it would be great to expand our studies to include Kansas**



Create education materials for stakeholders





The Water, Climate and Health Program is made possible
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