

Fig 2: Total number of agrichemicals detected in BOW water samples

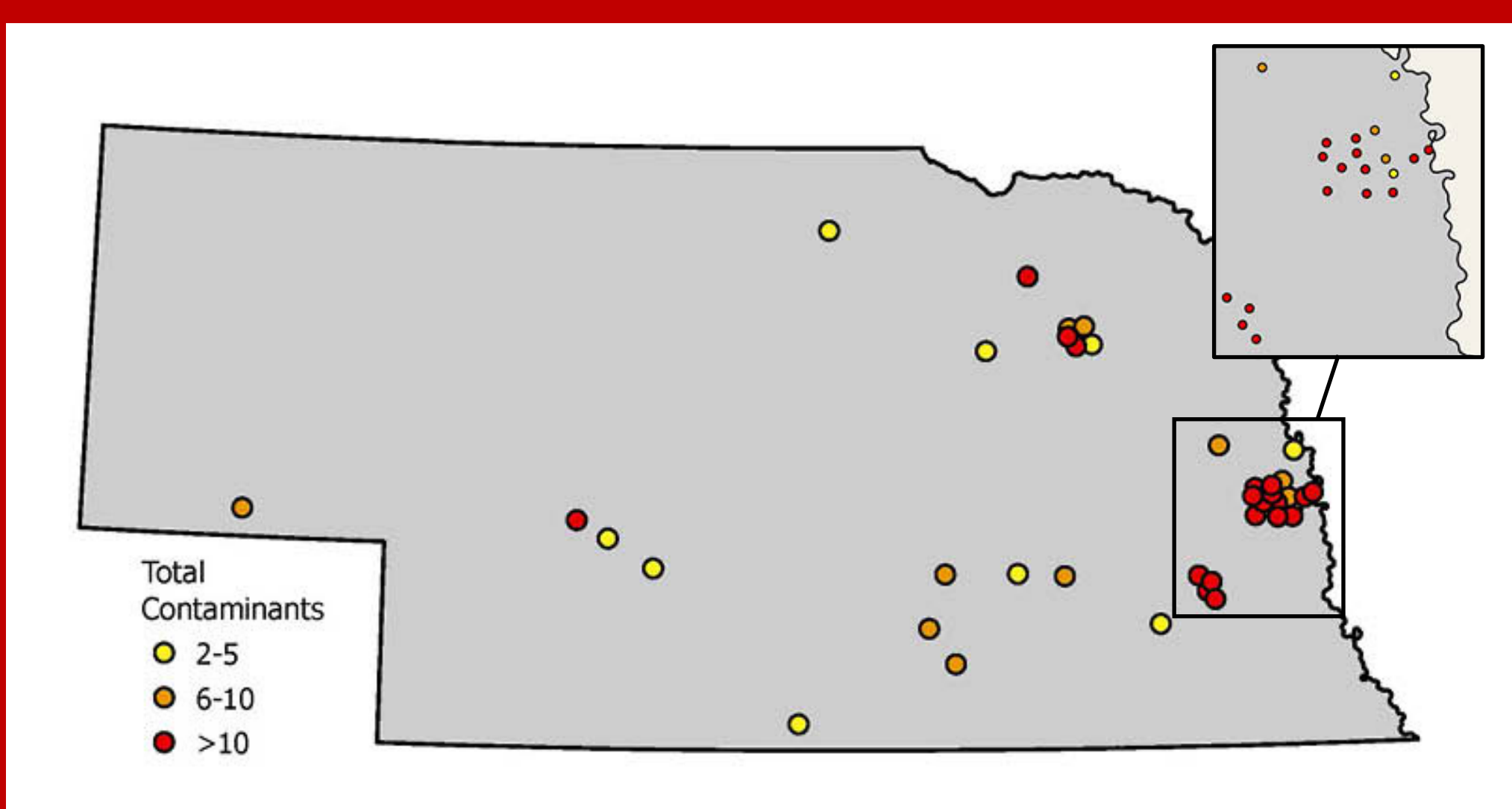


Fig 3: Classification of agrichemicals detected in BOW water samples

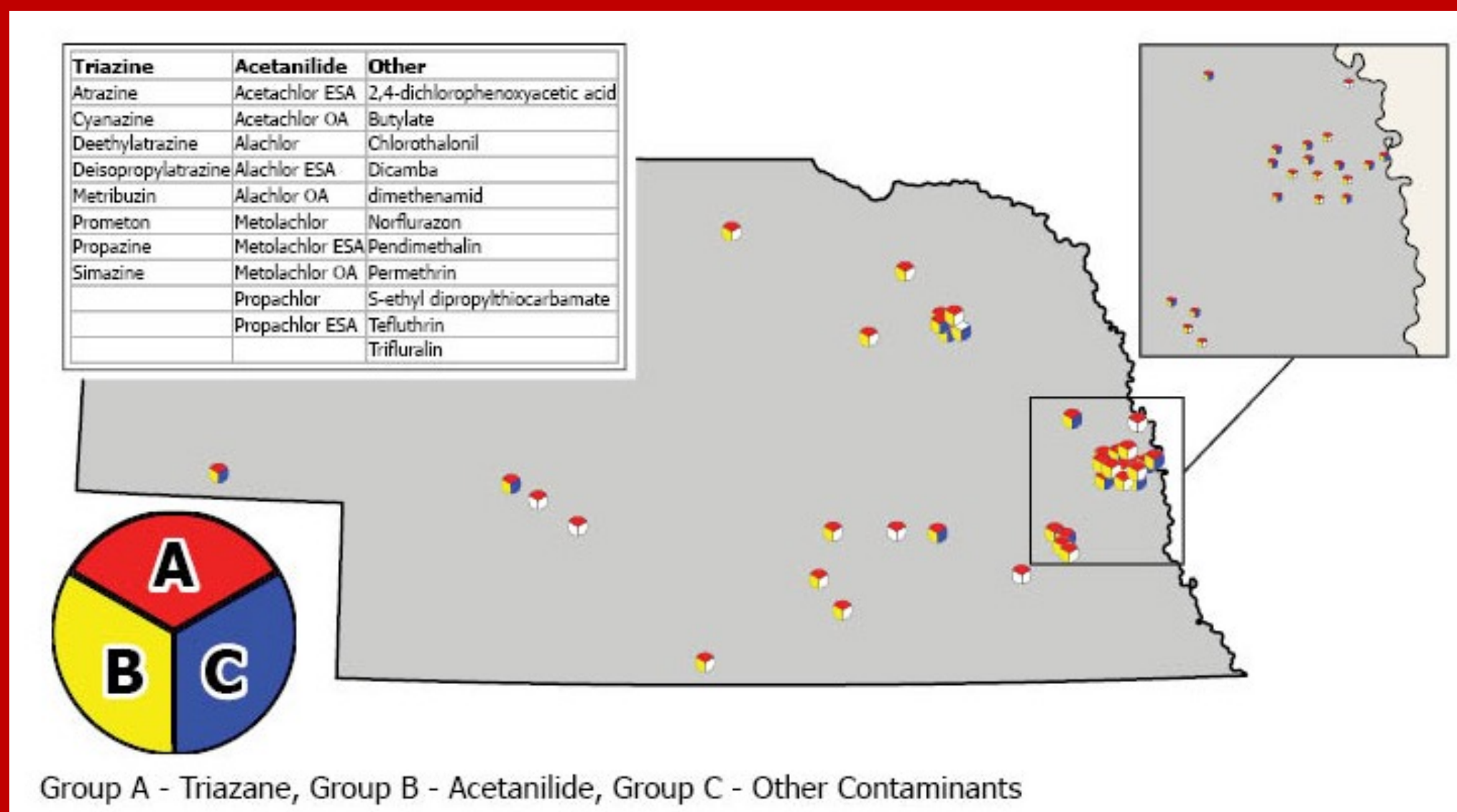


Table 1: Summary of agrichemical detections and range of concentration

Pesticides and Degradation products ($\mu\text{g/L}$)	Detections (N/X samples)	Range of Concentrations	Average concentration
DEA	32	0.001-0.170	0.041
Atrazine	30	0.001-0.560	0.111
Metolachlor	19	0.002-0.074	0.026
Propazine	18	0.001-0.025	0.006
Simazine	19	0.001-0.040	0.009
Dimethenamid	8	0.003-0.021	0.010
DIA	5	0.010-0.086	0.028
Acetochlor	4	0.003-0.010	0.007
Butylate	1	0.001	0.001
Permethrin	1	0.235	0.235
Metolachlor ESA	34	0.004-0.448	0.126
Metolachlor OA	30	0.001-0.272	0.066
Acetochlor ESA	26	0.002-0.204	0.046
Alachlor ESA	27	0.011-0.430	0.074
Alachlor OA	23	0.001-0.480	0.043
Acetochlor OA	22	0.001-0.272	0.090
2-4-D	19	0.001-0.040	0.009
Dicamba	2	0.037-0.367	0.202
Nitrate-N and Nitrite-N (mg/L)			
Nitrate-N	42	0.01-12.20	2.280
Nitrite-N	18	0.001-0.141	0.023

Comparative Analysis of Agrichemical Mixtures in Drinking Water and Birth Defects in Nebraska

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INTRODUCTION

- Many areas of Nebraska struggle with nitrate and the presence of other agrichemicals is a growing concern.
 - Exposure to nitrate and atrazine in drinking water is associated with increased risk of nonHodgkin lymphoma and adverse birth outcomes.
- N-nitrosoatrazine (NNAT) can form *in vivo* after ingesting nitrate and atrazine.
- Hypothesis:** Long-term, low-dose exposure to drinking water containing nitrate and nitrosatable agrichemicals has a greater impact on fetal development than exposure to the single compounds.
- Objective:** Examine association between maternal exposure to nitrate, nitrite and nitrosatable agrichemicals through drinking water and risk of birth defects in Nebraska.

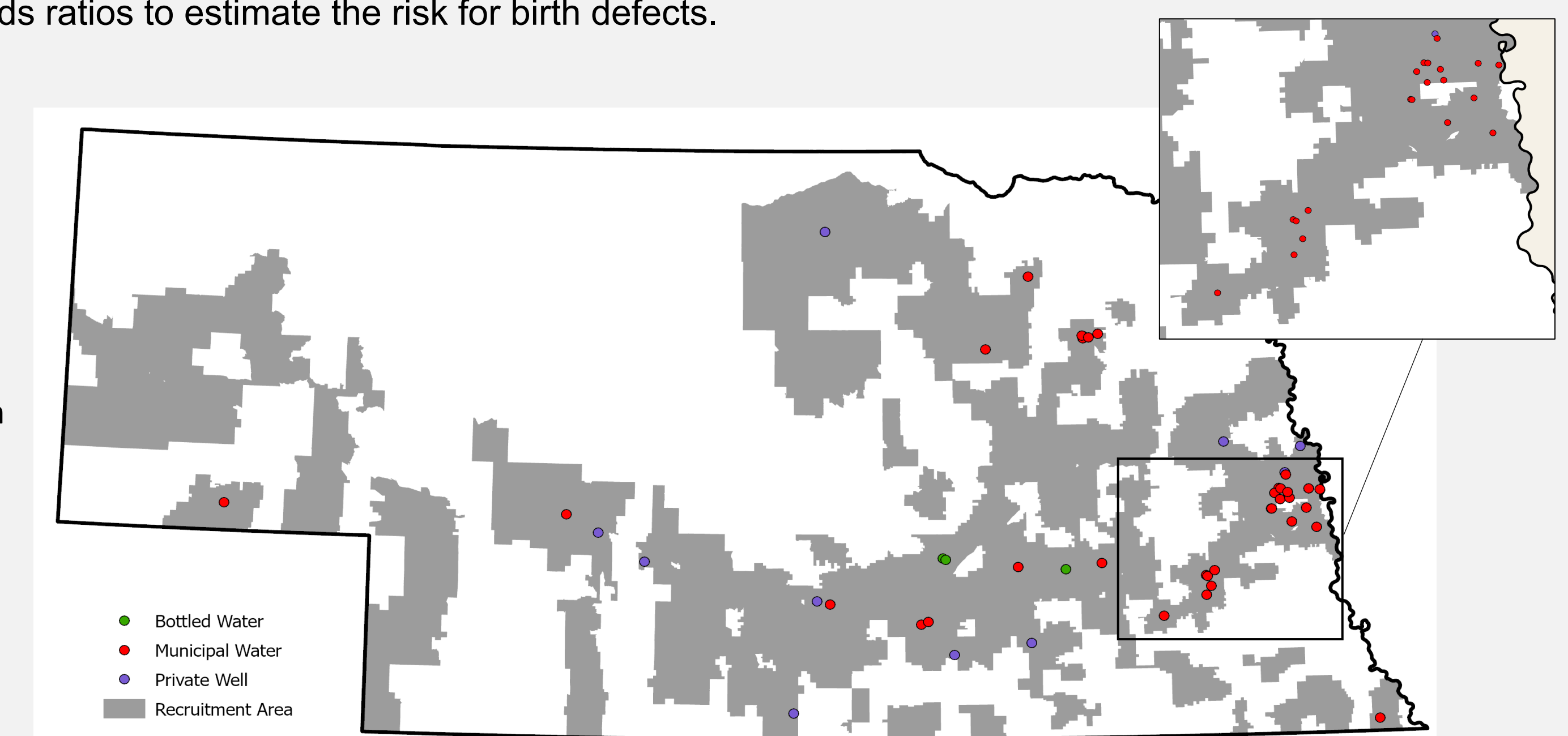
METHODS

- Water samples collected from residence of BOW participants (Fig 1). 34 agrichemicals measured (tables 1 & 5).
- Number (Fig 2) and class (Fig 3) of detected agrichemical contaminants in drinking water.
- Constructed case/control tables to compare agrichemical-exposed vs. unexposed mothers.
- Calculated odds ratios to estimate the risk for birth defects.

Table 5: Agrichemicals not detected in BOW water samples.

Chlorothanil
Cyanazine
EPTC
Metribuzin
Norflurazon
Pendimethalin
Prometon
Propachlor
Trifluralin
4-Hydroxychlorothalonil
Propachlor ESA

Fig 1: Sources of drinking water in Nebraska



AGRICHEMICALS IN NEBRASKA DRINKING WATER MAY BE ASSOCIATED WITH RISK FOR BIRTH DEFECTS

Table 2: Proportion of case/control for exposure vs. nonexposure to single agrichemical compounds

Agrichemicals	Control (n=19)	Case (n=23)	Odds Ratio	P-value
Atrazine	7	5	2.1	0.28
No	12 (63%)	18 (78%)		
Yes				
Metolachlor	12	11	1.9	0.32
No	7 (36.8%)	12 (52.2%)		
Yes				
Acetochlor ESA	9	7	2.1	0.26
No	10 (52.6%)	16 (69.6%)		
Yes				
Simazine	11	12	1.3	0.71
No	8 (42.1%)	11 (47.8%)		
Yes				
Acetochlor OA	11	9	2.1	0.23
No	8 (42.1%)	14 (60.9%)		
Yes				
Alachlor ESA	8	7	1.6	0.43
No	11 (57.9%)	16 (69.6%)		
Yes				
Alachlor OA	10	9	1.7	0.38
No	9 (47.4%)	14 (60.9%)		
Yes				
2,4-D	10	13	1.7	0.38
No	9 (47.4%)	10 (43.5%)		
Yes				
DEA	5	5	1.3	0.73
No	14 (73.7%)	18 (78.3%)		
Yes				
Metolachlor ESA	4	4	1.3	0.76
No	15 (78.9%)	19 (82.6%)		
Yes				
Metolachlor OA	5	7	0.82	0.77
No	14 (73.7%)	16 (69.6%)		
Yes				
Propazine	11	13	1.1	0.93
No	8 (42.1%)	10 (43.5%)		
Yes				

Table 3: Proportion of case/control for exposure vs. nonexposure to some agrichemical mixtures

Agrichemicals	Control (n=19)	Case (n=23)	Odds Ratio(95% CI)	P-value
Nitrite	14	10	3.6 (1.1 – 13.5)	0.04
No	5 (26%)	13 (57%)		
Yes				
Atrazine* Nitrite	15	11	4.1 (1.1 – 16.2)	0.03
No	4 (21%)	12 (52%)		
Yes				
Alachlor ESA* Nitrite	16	12	4.9 (1.2 – 21.4)	0.02
No	3 (16%)	11 (48%)		
Yes				
Alachlor OA* Nitrite	17	13	6.5 (1.3 – 35.1)	0.01
No	2 (11%)	10 (44%)		
Yes				

Table 4: Logistic regression between birth defects and nitrate, atrazine and their interaction

Agrichemicals (water)	Slope	Odds Ratio	P-value
Nitrate-N	-0.04	0.96	0.74
Atrazine	2.32	10.14	0.40
Nitrate* Atrazine	0.53	1.70	0.71

Pesticides and their degradation products, nitrate and nitrite detections in Nebraska drinking water samples collected from homes of Birth Outcomes and Water (BOW) study participants. Total number of participants = 42 (19 controls, 23 cases).

*DEA-deethylatrazine, DIA-deisopropylatrazine, 2,4-D=2,4-dichlorophenoxyacetic acid, ESA-ethane sulfonic acid, OA=oxanilic acid

RESULTS

- At least 2 contaminants were found in drinking water for all participants (Fig 2).
- One water sample contained 12.2 mg/L nitrate-N concentration above the MCL (10 mg/L), and all participants were exposed to nitrate (Table 1).
- Most common mixture contains nitrate, metolachlor ESA, DEA, metolachlor OA, atrazine, acetochlor ESA, acetochlor OA, alachlor ESA, alachlor OA, and metolachlor OA.
- Mothers exposed to nitrite were 3.6 times more likely to have a child with a birth defect (95% CI, 1.1-13.5) than nonexposed mothers.
- Exposure to co-occurring nitrite and atrazine increased birth defect risk by 4-fold (95% CI, 1.1-16.2).
- Concurrent exposure to nitrite and alachlor ESA increased risk for birth defects nearly 5-fold (95% CI, 1.2-21.4).
- Exposure to the combination of nitrite and alachlor OA was associated with a 6.5-fold increased risk for birth defects (95% CI, 1.3-35.1).
- No significant association between birth defect risk and exposure to nitrate ($p=0.7$) or atrazine as single compounds ($p=0.4$), or nitrate in combination with any nitrosatable agrichemical measured (Table 4).

DISCUSSION

- Analytes monitored by US EPA (MCL): 2,4-D (70 $\mu\text{g/L}$), alachlor (2 $\mu\text{g/L}$), atrazine (3 $\mu\text{g/L}$), nitrate-N (10 mg/L), nitrite-N (1 mg/L), and simazine (4 $\mu\text{g/L}$).
- Most pesticide transformation products not monitored by the US EPA. This may be a health concern and regular monitoring may be required.
- Absence of monitoring makes it difficult to establish adequate safety measures and regulations.
- Agrichemical mixtures (especially containing nitrite) should be considered when evaluating associations between exposure to agrichemicals in drinking water and adverse birth outcomes.
- Exposure to agrichemical mixtures may have a greater impact on adverse health outcomes than single compounds.

NEXT STEPS

- Examine other risk factors
 - Lifestyle and family/health history
 - Pesticide application
 - Gene x environmental interactions
- Expand the study
 - 286 cases and 286 controls
 - Extend to other agricultural states

ACKNOWLEDGMENTS

- Participants:** This important research would not be possible without the participants.
- Funding:** University of Nebraska Collaboration Initiative Seed Grant and Daugherty Water for Food Global Institute
- Graphics:** Dee Ebbeka
- Cartography (maps):** Greg Brinkman