

Nitrates and Animals

Minnesota Agricultural Water
Resources Center (MAWRC)

“Minnesota Agriculture and Nitrates”

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College of Veterinary Medicine

Veterinary Toxicology



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Veterinary Diagnostic and Production Animal Medicine (VDPAM)

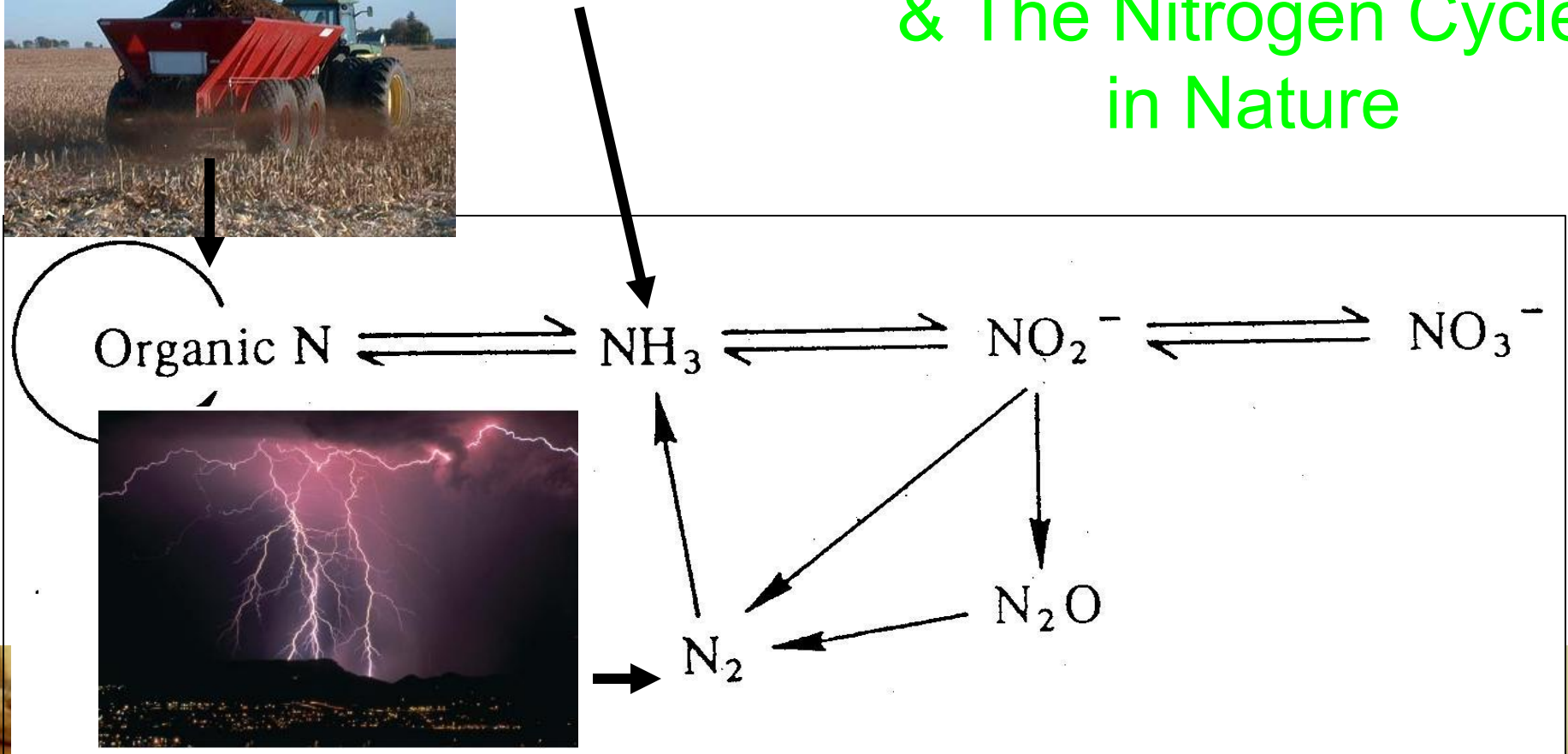
Drought

- Drought only adds to the potential for nitrate toxicosis
- Plants can't go through normal photosynthesis and accumulate NO_3
- When we have to haul water we use tanks previously used to haul fertilizer





Nitrate (NO_3) Nitrite (NO_2) & The Nitrogen Cycle in Nature

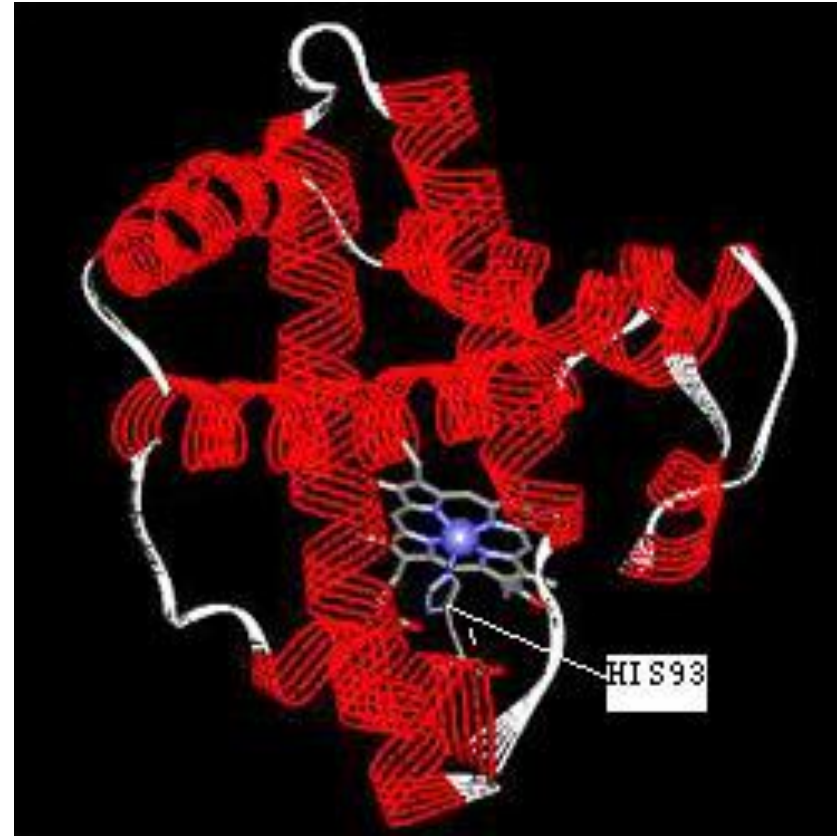
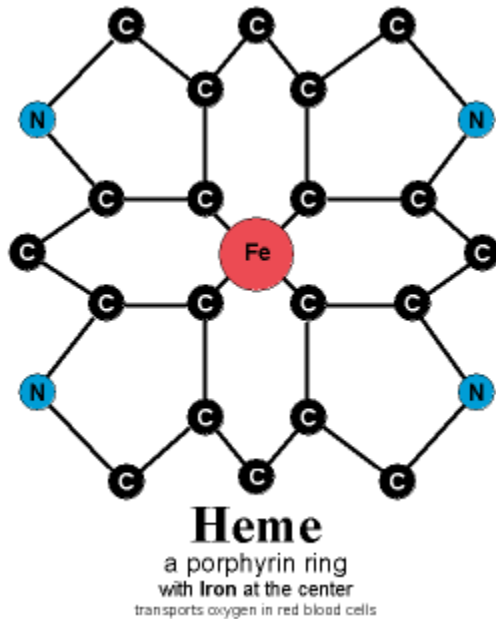


Nitrate - mechanism

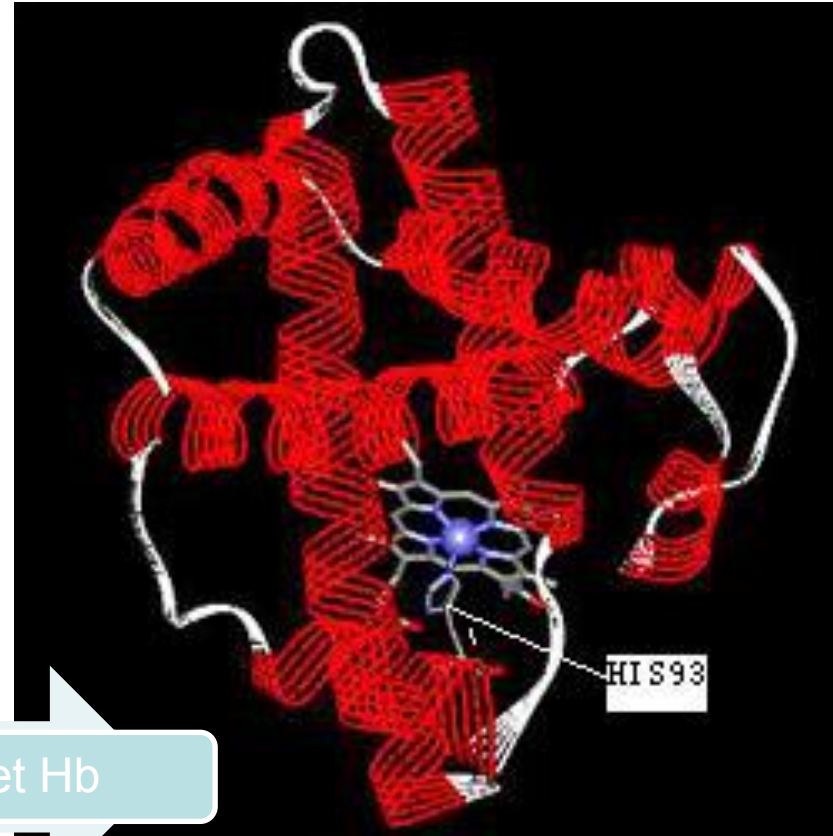
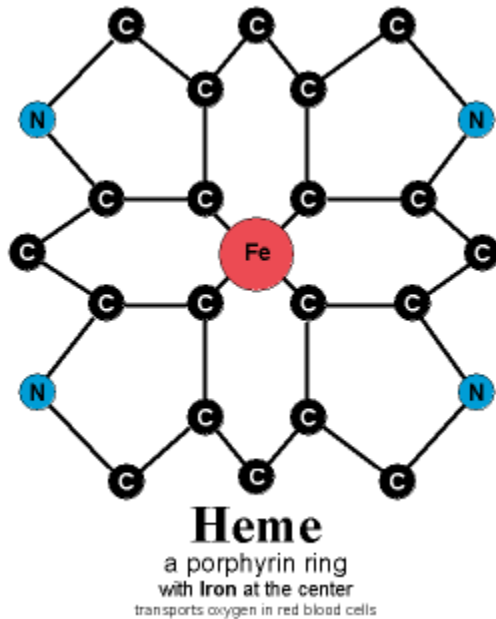
- Bacteria in stomach or rumen convert
Nitrate (NO_3) \rightarrow Nitrite (NO_2)
- $\text{NO}_2 + \text{Hb} \rightarrow \text{metHb}$ (brown)
... cannot carry Oxygen



Hemoglobin



Hemoglobin



Fe is oxidized

Fe³⁺

Met Hb

Nitrate

Human infants...

- Achlorhydria (low acid production in stomach)...
higher bacterial populations in gut ...
"blue baby" syndrome
(methemoglobinemia)
- Basis for human drinking water standards
 - maximum of 45 ppm NO_3
(equivalent to 10 ppm $\text{NO}_3\text{-N}$)



Nitrate

Be aware of units used to report nitrate...

NO_3 vs. $\text{NO}_3\text{-N}$ (the N in NO_2 or NO_3)

- $1\text{ ppm N} = 3.3\text{ ppm NO}_2 = 4.4\text{ ppm NO}_3$



Convert N to NO₃

- N = 14
- O = 16
- N + (O x 3) = molecular wt of NO₃ = 62
- Set up ratio $\frac{62}{14} = \frac{X}{1} = 4.4 \text{ NO}_3$
- Same for other nitrogen salts (Nitrite = NO₂)
- N + (O x 2) = *mw of NO₂* = 46
- *Ratio is* $\frac{46}{14} = \frac{X}{1} = 3.3 \text{ NO}_2$



Nitrate – clinical response

MetHb:

- normal = 1 - 3%
- clinical signs = 30 - 40%
- death = 50 - 90%
- MetHb rapidly decays after collection, so diagnostic value is limited. Rapid freezing may or may not adequately preserve MetHb



Nitrate – clinical signs

- Onset in 30 min to several hours
- Early...salivation, frequent urination
- MetHb → anoxia...
 - dyspnea, rapid weak pulse, cyanotic (or brown) mucous membranes, weakness, ataxia, muscle tremors, low tolerance to exercise, weakness or occasional anoxic convulsions,
 - death in few minutes to 24 hours



Nitrate - sources

Water

...NO₃ is water soluble, so moves with ground water

- especially into shallow wells
- decaying animal or plant protein, animal waste (urea, ammonia)



Nitrate / Nitrite - sources

- **Nitrite** salts...
 - directly toxic without action of gut bacteria



Nitrate - sources

Fertilizer $\text{NO}_3 = \text{N}$ source

...or hauled water contaminated
with fertilizer





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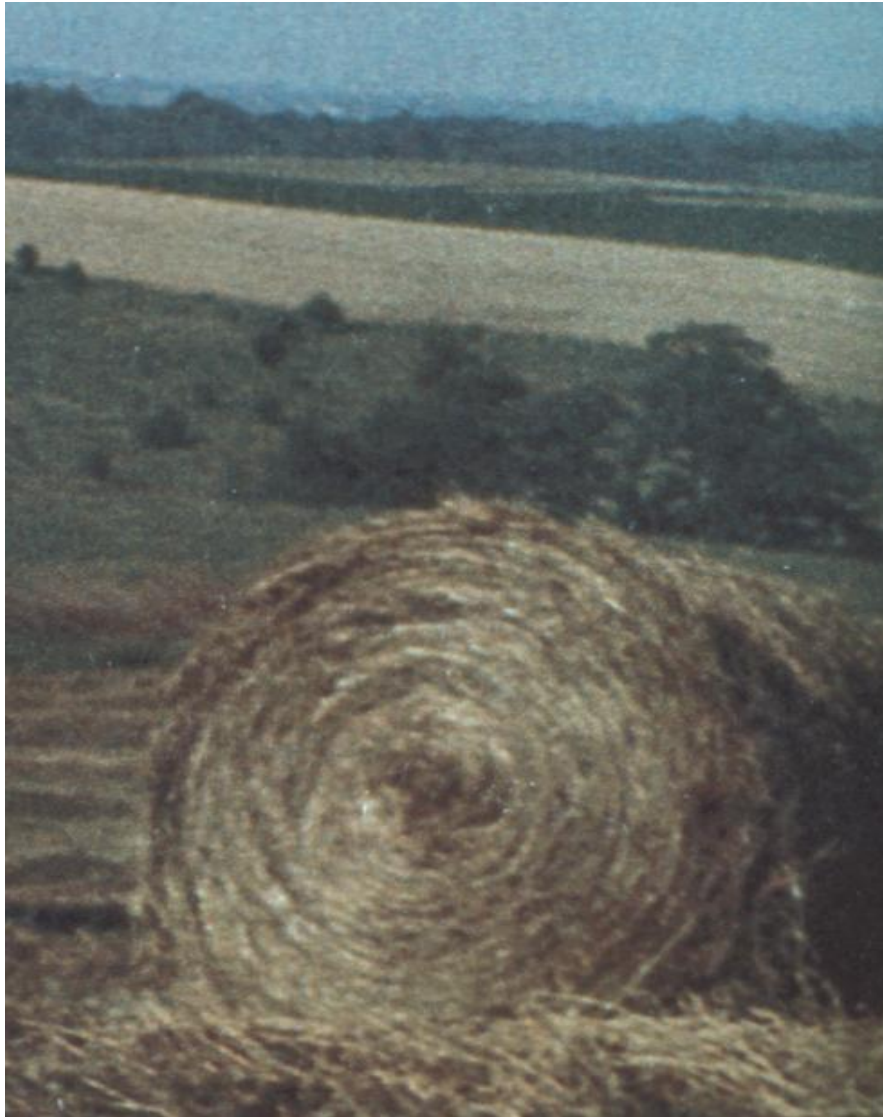
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Nitrate - sources

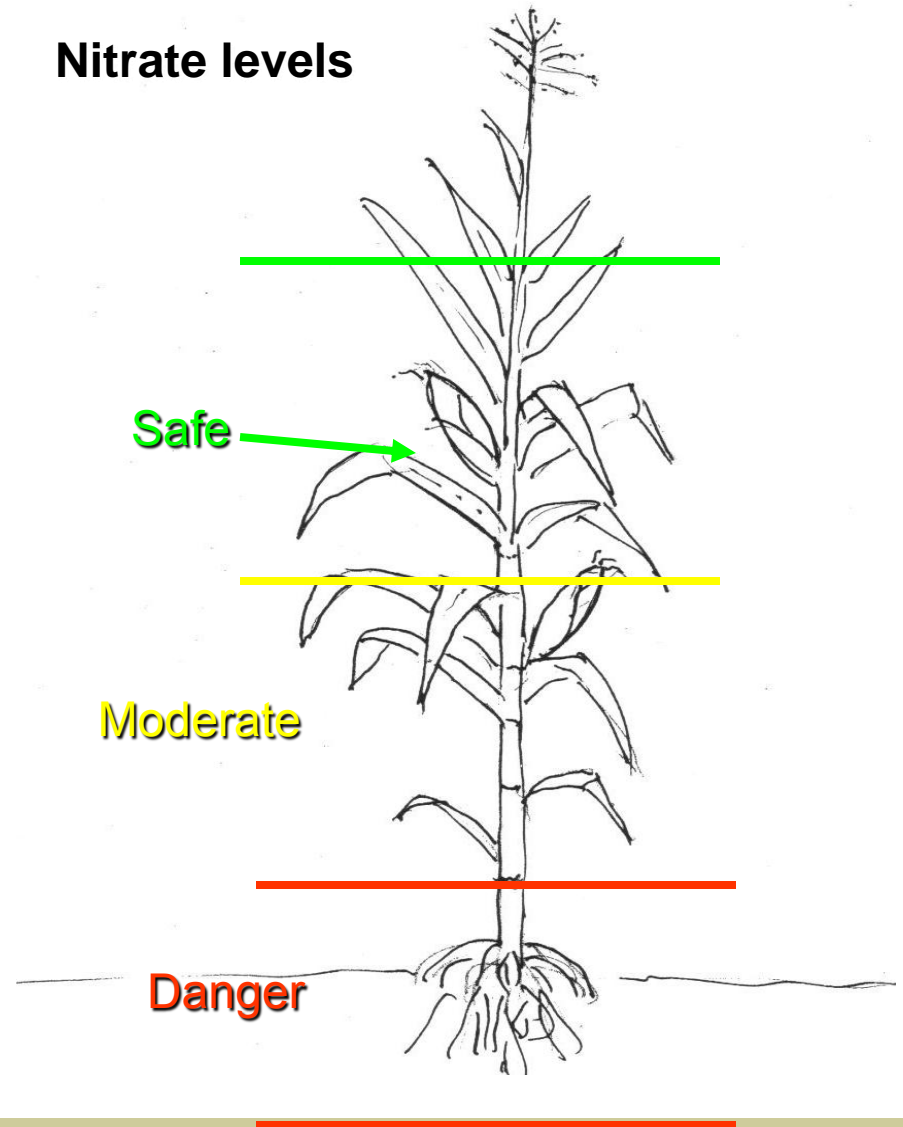
Forage (plant material)

- especially dry weather, frost or shading which deplete Nitrate reductase
- oat hay
- forage sorghums
- corn plant.. highest concentration = lower stalk > leaves >> seeds
- *certain weeds (pigweed, lambs qtrs)*





Nitrate levels



Investigators Target Punch In Wedding Sickness

Doctors Treat 60 People From Wedding

UPDATED: 4:02 p.m. CST March 10, 2003

DES MOINES, Iowa -- State health investigators say Monday they believe they have identified the substance that made more than 50 people sick at an Ankeny wedding over the weekend.

Testing at the State Hygienic lab shows that there was a high concentration of **sodium nitrite** in a liquid punch served at the reception.

Investigators said they are now focusing their efforts on finding how the substance got into the punch.

Doctors said sodium nitrite could cause nausea, vomiting, headaches and low blood pressure. It's commonly found in food items as a color additive or preservative in meat and fish items.

State health officials said they recalled all other batches of the punch prepared at the same time as the drink served in Ankeny.

Investigators said they also discovered a small private party in northwestern Iowa where mild illness was also reported and might be linked to the punch.

Investigators said they are continuing to test the punch and are

Nitrate

Animals at risk...

Ruminants most susceptible;
Horses, pigs, dogs resistant

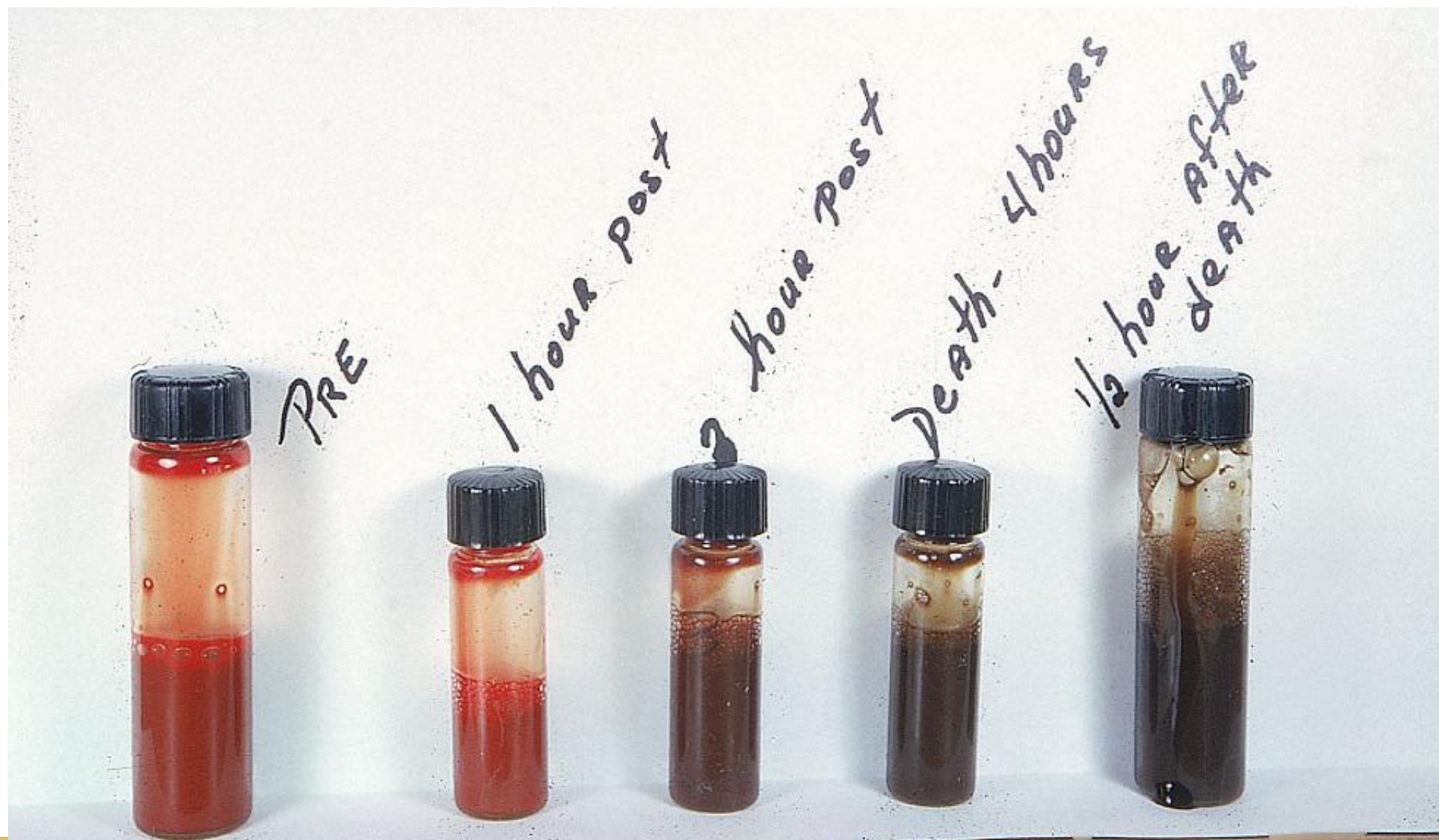


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Nitrate – predisposing factors

- Rate of consumption
- Low dietary energy
- Adaptation to previous exposure
- Endogenous nitrate reductase in plants (damaged by drought , frost & shading)
- Drought → reduced mobilization of NO_3
- Methemoglobin reductase activity in animals





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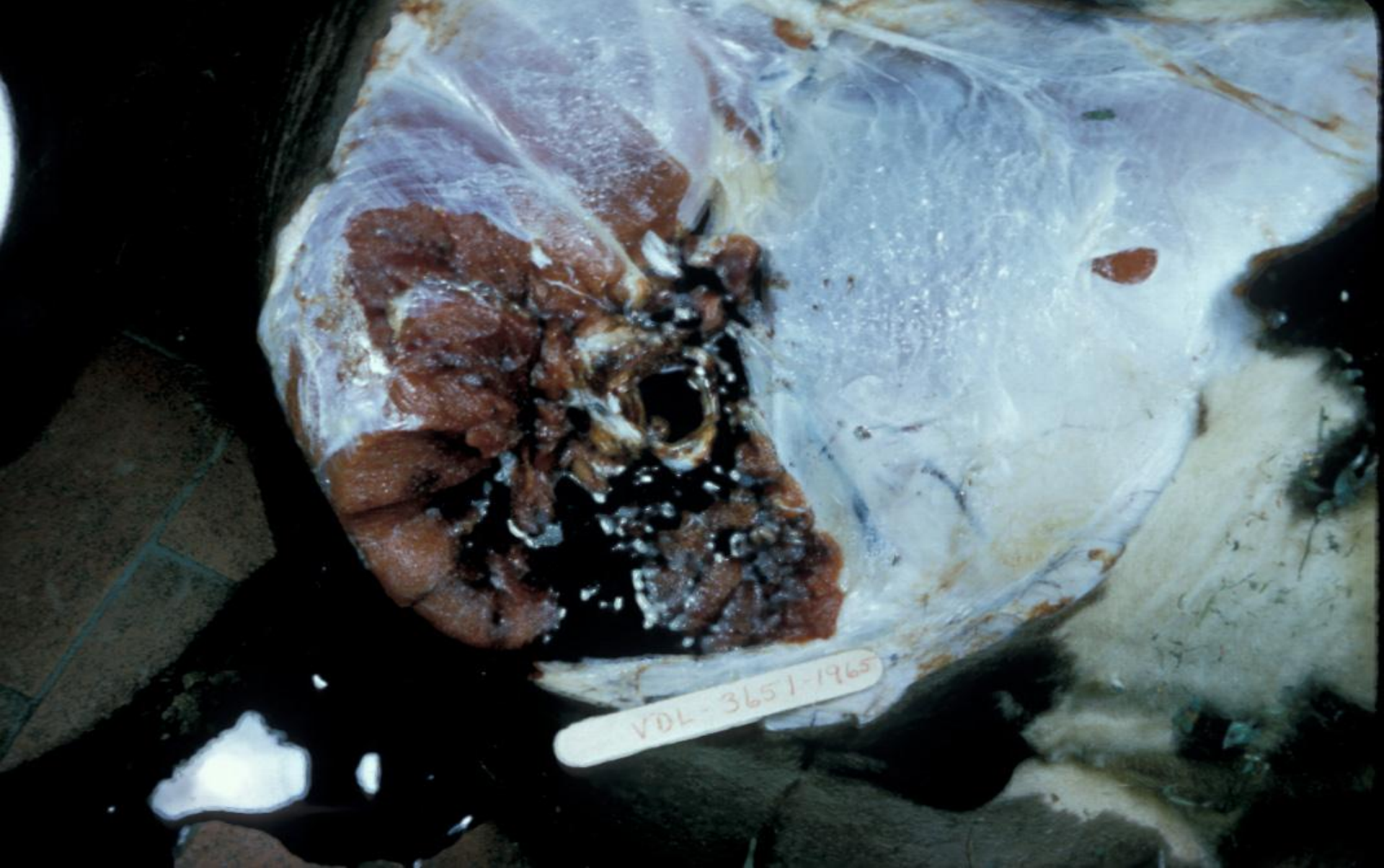
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Nitrate - diagnosis

- Ocular fluid...
- Forage...1% NO_3 on dry matter basis
potentially lethal to ruminants
- Water, suspect material
- Chocolate brown blood, tissues







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Nitrate

- The Iowa Department of Natural Resources (DNR), in conjunction with the University of Iowa Center for Health Effects of Environmental Contaminants (CHEEC), conducted the State Wide Rural Well-Water Survey (SWRL) between April 1988 and June 1989.



Nitrate

- The SWRL survey provided a statistically valid assessment of the proportion of private rural wells and rural Iowa residents affected by various environmental contaminants
- The 1988 SWRL survey sampled 1,048 water samples at 686 sites



Nitrate

- In October 1990, during SWRL 10-3, about 20% of the sites demonstrated nitrates > 10 ppm.
- In June 1991, the SWRL 10-4 was conducted. Approximately 19% of the sites had nitrate levels > 10 ppm.



Nitrate

- A report from Seerely measured the effects of nitrate or nitrite administered continually in drinking water for swine and sheep (Seerely et al., 1965).



Nitrate

- There was no measured effect on average litter size, average pig birth weight, average litter size at weaning, or average weight gain/day/pig preweaning from gilts consuming water containing 1320 ppm nitrate.



Nitrate

- In 1974 the National Academy of Sciences reviewed the value of water as a source of nutrients for livestock and poultry (Subcommittee on Nutrient and Toxic Elements in Water, 1974).
- Recommendations from this publication for safe upper limits of nitrate in water were 440 ppm (nitrite 44 ppm).



Nitrate

- A study by Anderson observed the effects of water high in sulfates, chlorides and nitrates on the performance of young weanling pigs (Anderson and Stothers, 1978).
- This study used drinking water that contained up to 6000 ppm total dissolved solids and up to 1320 ppm nitrate.



Nitrate

- This study found no significant treatment effects on average daily gain, average liver vitamin A values, kidney weights, or kidney histological structure.



Nitrate

- A National Animal Health Monitoring System (NAMHS) report of the initial NAMHS pilot project in Iowa reported on livestock drinking water quality for Iowa farms (Owen, 1989) as well as other health data (Owen, 1990).



Nitrate

- nitrate level had a range of 0-999 with a mean of 48.
- The source of water was 89% well water; 55% of the wells were greater than 25 years old; and 85% of the wells over 30 feet deep.



Nitrate

- A study by McLesse evaluated the quality of ground water supplies used on Saskatchewan swine farms (McLeese et al., 1991).
- One hundred and thirty five wells throughout this Canadian province were sampled for chemical analysis from 122 farms.



Nitrate

- Brunning-Fann studied the associations between drinking-water nitrate and the productivity and health of farrowing swine (Bruning-Fann et al., 1996).



Nitrate

- Data for this study was obtained from the National Swine Survey (NSS) conducted by the United States Department of Agriculture (USDA), Animal Plant Health and Inspection Service, Veterinary Services, National Animal Health Monitoring System (NAHMS) from November 1989 through February 1991.



Nitrate

- This data represents 18 states, which contained 62% of all swine operations and 81% of all hogs in the United States in 1991. Data from 571 swine farms representing 27,207 sows and gilts were used in this study.



Nitrate

- This study focused on nitrate levels in drinking water and swine health and production. Nitrate levels that were measured and correlated with production were greater than 45 ppm and greater than or equal to 100 ppm. et al., 1996).



Nitrate

- At these levels of nitrate when used in a multivariable analysis, no association was measured between nitrate and the health or production of farrowing swine (Bruning-Fann et al., 1996).



Nitrate

- 1) net profit per year per female maintained, 2) pig death loss birth to weaning, 3) pig death loss, weaning to market, 4) breeding stock death loss, 5) average female inventory, 6) number of pigs weaned per litter,



Nitrate

- 7) total pounds of feed per hundred weight of pork produced (feed efficiency) and 8) cost of feed additives and drugs per hundred weight of pork produced.
- These production parameters were correlated with 26 water quality parameters.



Nitrate

- Swine drinking water study conducted in 1992.
- One hundred ninety-two water samples were received from the 173 producers in 1992 and early 1993.



Nitrate

- Nitrate concentrations varied from 9 ppm to 720 ppm in the drinking water of Iowa swine farrow-finish herds.
- No association between drinking water nitrate level and the eight production parameters measured in this study was found.



Nitrate

- Crowley and coworkers conducted a 35 month study in Wisconsin comparing reproductive efficiency and lactational performance for a 54 cow Holstein herd that consumed drinking water containing either 19 or 374 ppm nitrate (Crowley et al, 1974).



Nitrate

- Nitrate was added to the well water by metering a concentrated solution of potassium nitrate by a constant ratio pump.
- There were no effects observed in lactating Holstein cows consuming drinking water with elevated nitrates for the first 20 months of the study.



Nitrate

- During the last 15 months of the study, cattle drinking the elevated nitrate containing water had the highest services per conception and lowest first service conception rates.



Nitrate

- Safe levels of nitrate in water for lactating dairy cattle have been reported to be up to 1320 ppm (Carson, 1978).



Nitrate

- Yeruham (1977) reported a field study of death loss and abortions in two dairy cattle herds exposed to nitrates in feed containing whey.
- This report suggests that nitrate levels of 400 ppm in water can cause abortion in lactating dairy cattle.



Nitrate

- Dairy drinking water study, 2000.
- 128 Iowa dairies had drinking water sampled.
- This study correlated 26 water quality parameters with 29 DHIA production parameters.



Nitrate

- The nitrate concentration in the 133 water samples averaged 31 ppm with a range from 1 to 300 ppm.



Nitrate

- The drinking water nitrate is negatively associated with RHA milk ($P=0.03$), RHA protein ($P=0.03$), summit1 ($P=0.06$), summit2 ($P=0.06$), summit3 ($P=0.07$), ME305 milk ($P=0.06$) and the ECM1 ($P=0.05$).



Minnesota Dept of Agriculture

Land of Sky Blue Waters

- Adrian
- Ellsworth
- Edgerton
- Clear Lake



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Star Tribune

- February 3, 2011 “Poison on Tap”
- 52,000 wells 10% > 10 ppm



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Questions?



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