University of California

Nitrogen Management Training

for Certified Crop Advisers

MODULE 1
Part 1

Environmental Impacts of Nitrogen

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Introduction

- How does nitrate impact human health?
- What are the overarching environmental impacts of N in California?

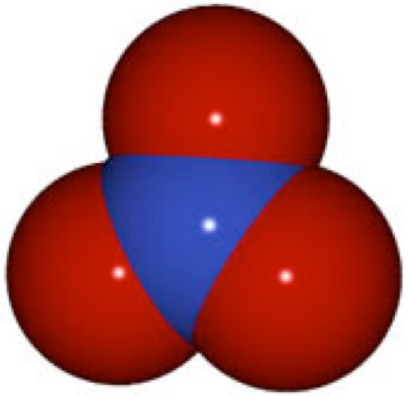
What is the Problem?

- Nitrate in Drinking Water
  - Federal/CA Maximum Contaminant Level is 45 mg NO_3 /L or 10 mg NO_3–N /L.
  - Concentrations in drinking water of some CA aquifers exceeds this level.
  - CA State Water Resources Control Board noted that 8% of drinking water wells exceed the nitrate threshold.

Measuring Nitrate and Nitrate-N Concentrations

Measuring Nitrate:

45 mg NO_3^-/L (measure **N + O**)



Measuring Nitrate-N:

10 mg NO_3^--N/L (measure **N** only)

Impact of Nitrate Polluted Water on Health

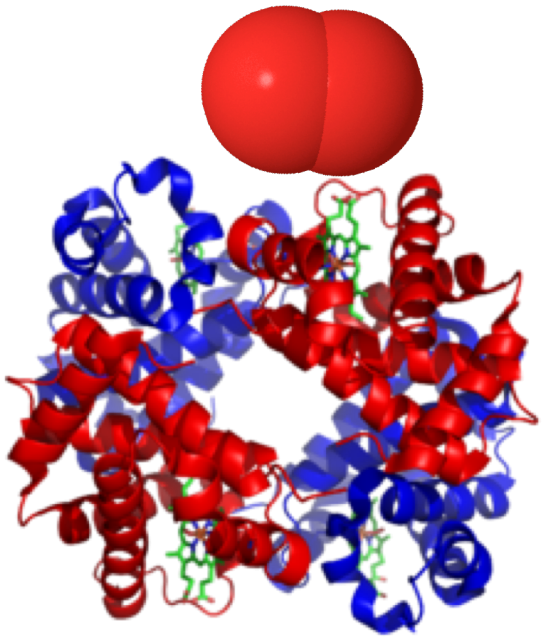
Nitrate (NO_3^-) and nitrite (NO_2^-) effects are related:

- Oral ingestion can lead to methemoglobinemia, “blue baby syndrome” in infants.
  - First described in 1945
  - Reference Dose established 1991
  - Basis of nitrate and nitrite Maximum Concentration Levels

- Not a human carcinogen (2002)

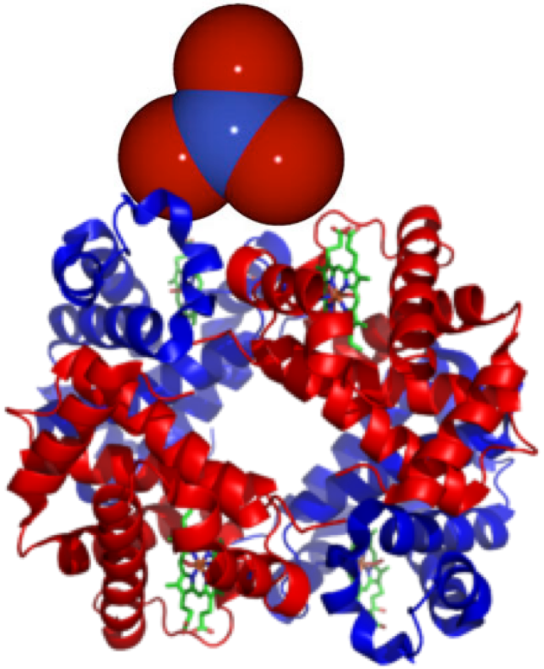
What is Methemoglobinemia?

Healthy:



Hemoglobin binds with oxygen in blood.

Methemoglobinemia:



Hemoglobin reacts with nitrite generating methemoglobin, which interferes with oxygen transport in blood.

What is Methemoglobinemia?

- Known as Blue Baby Syndrome

- Normal hemoglobin is converted to methemoglobin, which does not carry oxygen.
  - 0-20% methemoglobin yields bluish skin (cyanosis)
  - 25-40% yields hypotension, rapid pulse and breathing
  - > 50% can be fatal

- Can be caused by several agents including nitrate

Methemoglobinemia in California

- Agency for Toxic Substances and Disease Registry did an assessment at the request of CA DHS in 2000.

- 42 total methemoglobinemia cases over 13 years studied
  - None specifically associated with nitrate
  - Four located in areas where wells are used

- National figures similar- rare to find a clear, unique association with drinking water nitrate

Is Nitrate a Human Carcinogen?

- USEPA does not currently believe so, based on lack of supporting data and substantial negative data
  - Theory is that NO_3^- --> NO_2^- --> Nitrosamines
- Animal toxicity studies show nitrosamines cause cancer, but not nitrate or nitrite alone
- Human epidemiology studies are not clear

How Did Nitrate Become a Problem?

- In nature, nitrogen cycles through soil, water, and plants at low concentrations.

- California agriculture has a long history of N use, with cropped acreage, N fertilization rates, dairy production, and irrigated land increasing in the last 50 years.

- Agriculture requires high N input to produce profitable crops.

- Inefficiency of irrigation and N application leads to nitrate leaching losses.

Where Does Nitrate Pollution Occur?

- Nitrate is the most common pollutant in drinking water worldwide.

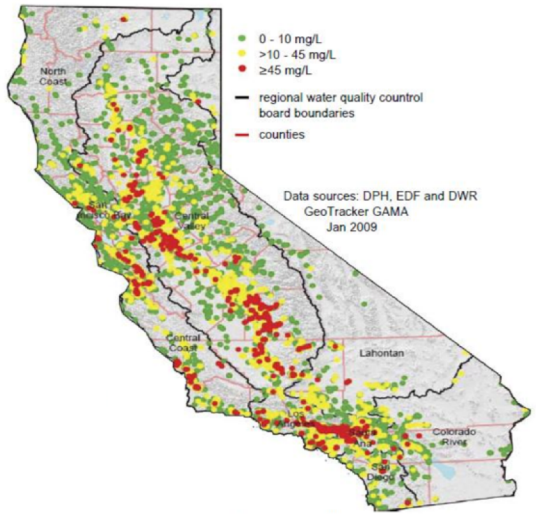
- USEPA estimates 52% of US community water wells and 57% of domestic wells have levels in excess of 2 mg NO_3^- /L (considered background levels).

- USGS estimates up to 15% of wells exceed MCL.

- Problem Areas in California:
  - San Joaquin Valley, Santa Ana Valley and Salinas
  - In CA, nitrate contamination results from intensive agriculture combined with a shallow aquifer.

Sources of Nitrogen Contamination in Water

30 + % of wells exceed EPA drinking water levels (45 mg/L nitrate) and 250,000 people in SJV do not have access to 'safe' water.



(Ekdahl and others, 2009; Addressing Nitrates in California's Drinking Water, 2012)

Lakes, streams and estuaries suffer when nutrient and sediment load is too high.

Where is Nitrate a Problem in California?

- Most nitrate contaminates groundwater, but the California coast has excess nitrate in surface water, causing hypoxia in Monterey Bay.

- Los Angeles, San Bernardino and Tulare counties have the most drinking water violations.

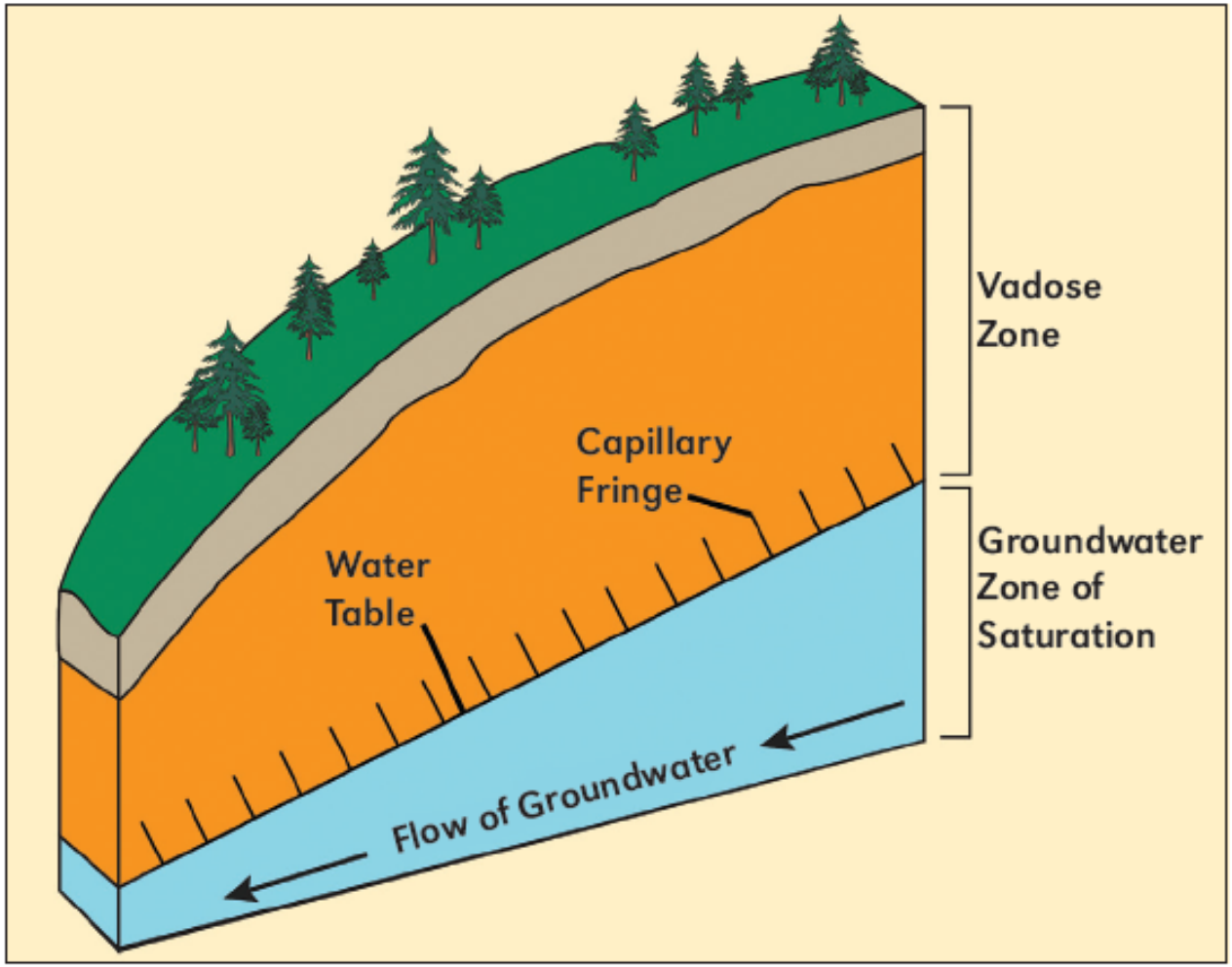
- Nitrate polluted wells occur mainly where there is shallow groundwater.

- Rivers have elevated nitrate concentrations, especially along the coast.

Why is Shallow Groundwater Most Affected?

- Nitrate is an anion and is not retained by soil. It moves with the wetting front.
- Water moving below the root zone carries nitrate with it.
- Nitrates from septic systems can be a local problem.
- After years of downward flow with water, nitrate eventually reaches the aquifer.
- The farther from the source, the longer nitrate takes to reach the groundwater.

What Happens Once Nitrate Moves Below the Rootzone?

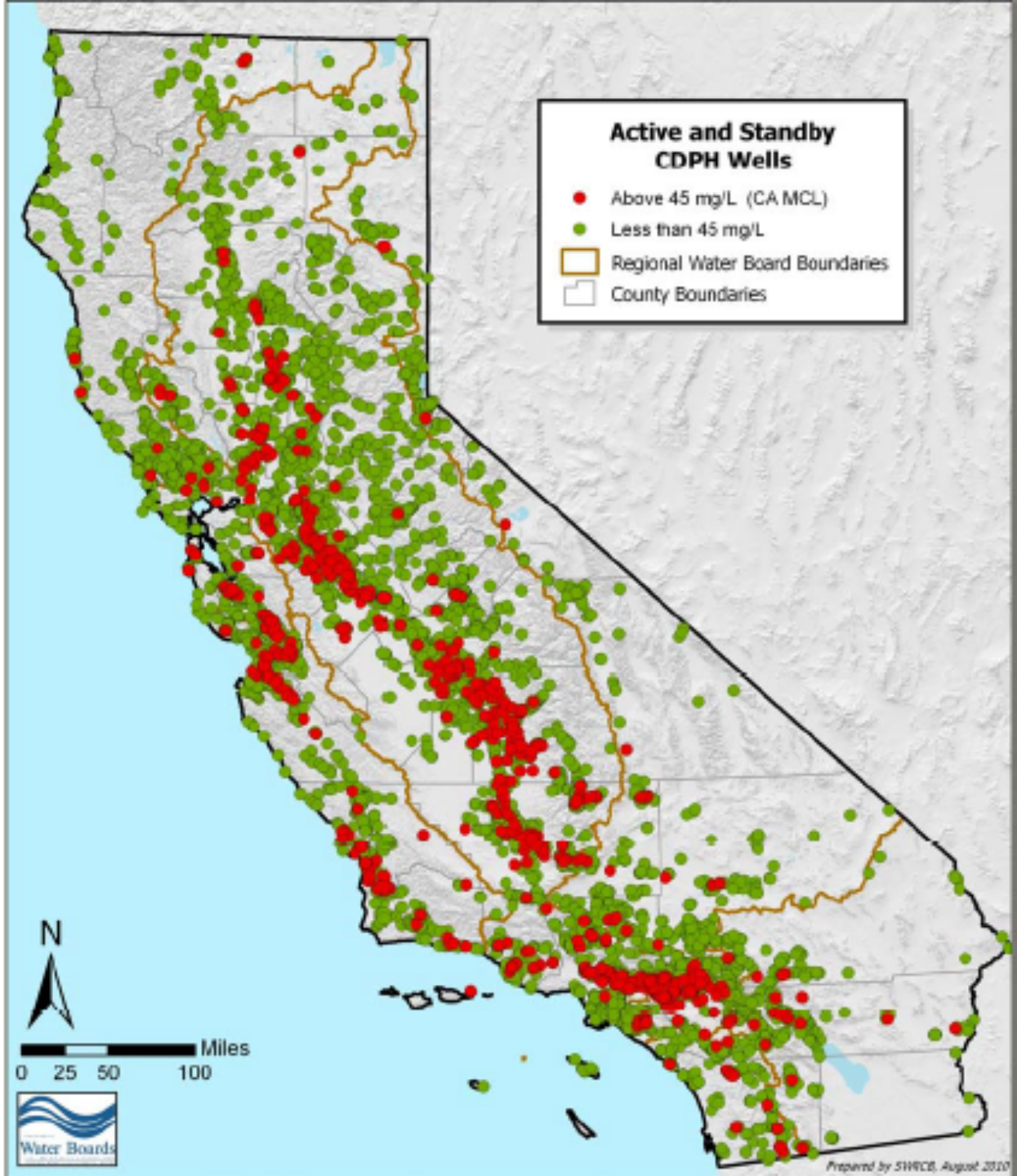


Nitrate moves with water through the "Vadose Zone" until it reaches groundwater.

Nitrate Problem Areas in California

Areas with shallow groundwater and intensive agriculture are vulnerable to nitrate contamination

- **Above** MCL
- **Below** MCL



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Course materials available at:

ciwr.ucanr.edu/NitrogenManagement

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