# 25.10.22: Water quality lab

- Make sure to read the previous notes on watersheds before beginning.
- We will be measuring several virtual water samples (less toxic, and a greater variety available here)
- Metrics are physical (turbidity, temperature, chemical (DO, pH, nitrate, BOD, conductivity) and biological (coliform, fecal coliform)
- Here is data on one sample:

**Sample X**

- DO: **4.0 mg/L**
- Turb: **60 NTU**
- Cond: **1100 µS/cm**
- pH: **7.0**
- T: **20 °C**
- $NO_3$: **5.5 mg/L**
- $PO_4$: **0.9 mg/L**
- BOD: **20 mg/L**
- Total coliform: **2000 CFU/100 mL**
- E. coli: **1200 CFU/100 mL**

**Source:** stagnant trough used by cattle — runoff and direct fecal input.

What do each of these mean?

- **1. Dissolved Oxygen (DO) — 4.0 mg/L**
- **Meaning:** The amount of oxygen available in the water for aquatic life. aeration and cooler water typically have higher dissolved oxygen, hot water has lower DO
- **Typical range:** Healthy streams and lakes usually have **>6 mg/L**.
- **Interpretation:**
  4.0 mg/L is **low** — may stress fish and other organisms, often due to high organic matter or low flow.

# 2. Turbidity (Turb) — 60 NTU

- **Meaning:** Cloudiness of the water caused by suspended particles (silt, algae, organic matter). High turbidity blocks photosynthesis in aquatic plants, so is often tied to lower DO
- **Typical range:** Drinking water should be **<1 NTU**; natural streams usually **<10 NTU**.
- **Interpretation:**
  60 NTU is **very high**, indicating **muddy or polluted** water, possibly from runoff, erosion, or algae blooms.

# 3. Conductivity (Cond) — 1100 µS/cm

- **Meaning:** Measures how well water conducts electricity, which depends on the concentration of dissolved ions (salts, minerals, pollutants). Often found near industrial waste or mines, where metallic minerals are leaching into the water
- **Typical range:** Freshwater is **50–1500 µS/cm**.
- **Interpretation:**
  1100 µS/cm is **moderate-high** — could reflect **urban runoff, fertilizers, or wastewater influence**.

# 4. pH — 7.0

- **Meaning:** Acidity or alkalinity of the water (7 is neutral). Acid pH is often associated with acid rain or industrial pollution.
- **Typical range:** Most aquatic life prefers **6.5–8.5**.
- **Interpretation:**
  7.0 is **ideal** — neutral and safe for most organisms.

# 5. Temperature (T) — 20 °C

- **Meaning:** Affects metabolic rates, oxygen solubility, and species composition. Higher temp is called "thermal pollution" and lowers the DO level
- **Typical range:** Cold-water species thrive **<15 °C**; warm-water species tolerate **20–30 °C** .
- **Interpretation:**
  20 °C is **moderate**, but can **reduce oxygen solubility**, contributing to low DO levels.

# 6. Nitrate ($NO_3$) — 5.5 mg/L

- **Meaning:** Nutrient essential for plants but harmful in excess (from fertilizer, sewage). Often associated with with eutrophication.
- **Typical range:** Unpolluted waters usually **<1 mg/L**.
- **Interpretation:**
  5.5 mg/L is **elevated** — may promote **algae growth (eutrophication)** and affect drinking water safety.

# 7. Phosphate ($PO_4$) — 0.9 mg/L

- **Meaning:** Another plant nutrient, often from detergents or fertilizers. Another source for eutrophication.
- **Typical range:** Clean water is **<0.05 mg/L**.
- **Interpretation:**
  0.9 mg/L is **very high** — likely to trigger **algal blooms**.

# 8. Biochemical Oxygen Demand (BOD) — 20 mg/L

- **Meaning:** Amount of oxygen needed by microorganisms to decompose organic matter. High BOD usually associated with sewage leaks, can be linked to fecal coliform (see below)
- **Typical range:** Unpolluted water: **<3 mg/L**; polluted water: **>10 mg/L**.
- **Interpretation:**
  20 mg/L is **very high**, showing **strong organic pollution** (sewage, waste discharge).

# 9. Total Coliform — 2000 CFU/100 mL

- **Meaning:** Bacteria indicating potential contamination by pathogens. Fecal coliform is e. coli from the gut of animals, including humans (see below). Animal waste may also include leptospirosis or other pathogens not measured by the total coliform (see below).
- **Typical range:** Safe for recreation: **<200 CFU/100 mL**; drinking water: **0 CFU**.
- **Interpretation:**
  2000 CFU/100 mL is **unsafe** — suggests **fecal contamination** or poor sanitation.

# 10. E. coli — 1200 CFU/100 mL

- **Meaning:** Specific indicator of fecal contamination (from warm-blooded animals). Humans, livestock, wild animals are all sources.
- **Typical range:** Safe for recreation: **<126 CFU/100 mL**; drinking water: **0 CFU**.
- **Interpretation:**
  1200 CFU/100 mL is **very high**, indicating **sewage or animal waste contamination**.

# Summary

| Parameter | Your Value | Condition | Possible Concern |
|---|---|---|---|
| DO | 4.0 mg/L | Low | Oxygen stress for aquatic life |
| Turbidity | 60 NTU | High | Sediment/algae pollution |
| Conductivity | 1100 µS/cm | Moderate-high | Dissolved salts, runoff |
| pH | 7.0 | Normal | None |
| Temperature | 20 °C | Warm | Lowers oxygen solubility |
| Nitrate | 5.5 mg/L | High | Nutrient pollution |
| Phosphate | 0.9 mg/L | Very high | Eutrophication risk |
| BOD | 20 mg/L | Very high | Organic waste |
| Total coliform | 2000 CFU/100 mL | Unsafe | Fecal contamination |
| *E. coli* | 1200 CFU/100 mL | Unsafe | Sewage or animal waste |

**Site Summary**

This analysis evaluates the chemical, physical, and biological quality of the sampled water based on ten standard parameters: dissolved oxygen (DO), turbidity, conductivity, pH, temperature, nitrate ($NO_3$), phosphate ($PO_4$), biochemical oxygen demand (BOD), total coliform, and *E. coli*.

# 1. Physical Characteristics

- **Turbidity (60 NTU)** — The water is **highly turbid**, indicating heavy sediment load or algal growth. Such levels often result from soil erosion, stormwater runoff, or organic pollution.
- **Temperature (20 °C)** — Moderately warm. While not harmful itself, it **reduces oxygen solubility** and can exacerbate low DO levels.

# 2. Chemical Characteristics

- **pH (7.0)** — Neutral and within the healthy range for aquatic organisms (6.5–8.5).
- **Conductivity (1100 µS/cm)** — Indicates **moderately high dissolved ion content**, suggesting influence from urban runoff, road salts, or agricultural fertilizers.
- **Dissolved Oxygen (4.0 mg/L)** — **Low** oxygen availability, likely from organic pollution and high BOD. Fish and invertebrates may be stressed under these conditions.
- **Biochemical Oxygen Demand (BOD, 20 mg/L)** — Very high, showing **strong organic pollution**, such as sewage or decaying vegetation, which consumes oxygen.
- **Nitrate (5.5 mg/L)** and **Phosphate (0.9 mg/L)** — Both are **elevated nutrients**, commonly linked to fertilizer runoff or wastewater. These can trigger **eutrophication**, leading to algal blooms and oxygen depletion.

# 3. Biological Characteristics

- **Total Coliform (2000 CFU/100 mL)** and **E. coli (1200 CFU/100 mL)** — Levels far exceed recreational and drinking standards, confirming **fecal contamination** from sewage or animal waste sources.
  Such contamination increases risk of pathogens like *Giardia* or *Salmonella*.

# 4. Overall Assessment

| Category | Status | Primary Concern |
|---|---|---|
| Oxygen levels | Poor | Low DO, high BOD |
| Nutrients | High | Runoff, eutrophication |
| Clarity | Poor | Sediment/algae |
| Bacteria | Unsafe | Fecal contamination |
| pH | Good | Within acceptable range |

The combination of **low DO, high turbidity, high nutrients, and bacterial contamination** indicates **significant organic and nutrient pollution**, likely from **agricultural runoff, storm drains, or untreated wastewater**.

Below are 11 water samples taken from various locations

Your goal is to match each one with a list of possible locations below:

- Power plant discharge
- Tidal estuary
- Livestock trough
- Groundwater well (deep aquifer)
- Industrial discharge
- Algal bloom
- Leaking septic system

- Treated municipal water system
- Street runoff
- Agriculture runoff
- Pristine mountain stream

**Common parameter units / quick legend**

• DO = dissolved oxygen ($mg \cdot L^{-1}$)
• Turb = turbidity (NTU)
• Cond = conductivity ($\mu S \cdot cm^{-1}$)
• pH = pH (unitless)
• T = temperature (°C)
• $NO_3$ = nitrate ($mg \cdot L^{-1}$ as $NO_3^-$)
• $PO_4$ = orthophosphate ($mg \cdot L^{-1}$ as $PO_4^{3-}$)
• BOD = biochemical oxygen demand ($mg \cdot L^{-1}$, 5-day if using $BOD_5$)
• Total coliform / E. coli = colony forming units per 100 mL (CFU/100 mL)

**Sample 1**

> • DO: **9.5 mg/L**
> • Turb: **1 NTU**
> • Cond: **40 µS/cm**
> • pH: **7.4**
> • T: **10 °C**
> • $NO_3$: **0.2 mg/L**
> • $PO_4$: **0.01 mg/L**
> • BOD: **1 mg/L**
> • Total coliform: **<1 CFU/100 mL**
> • E. coli: **<1 CFU/100 mL**

**Sample 2**

> • DO: **6.0 mg/L**
> • Turb: **35 NTU**
> • Cond: **420 µS/cm**
> • pH: **7.2**
> • T: **18 °C**
> • $NO_3$: **8.5 mg/L**
> • $PO_4$: **0.8 mg/L**
> • BOD: **6 mg/L**
> • Total coliform: **150 CFU/100 mL**
> • E. coli: **90 CFU/100 mL**

**Sample 3**

> • DO: **5.8 mg/L**
> • Turb: **120 NTU**
> • Cond: **950 µS/cm**
> • pH: **7.0**
> • T: **20 °C**
> • $NO_3$: **2.0 mg/L**
> • $PO_4$: **0.6 mg/L**
> • BOD: **8 mg/L**
> • Total coliform: **400 CFU/100 mL**
> • E. coli: **180 CFU/100 mL**

**Sample 4**

> • DO: **7.0 mg/L**
> • Turb: **5 NTU**
> • Cond: **1200 µS/cm**
> • pH: **7.6**
> • T: **16 °C**
> • $NO_3$: **6.0 mg/L**
> • $PO_4$: **1.2 mg/L**
> • BOD: **10 mg/L**
> • Total coliform: **50 CFU/100 mL**
> • E. coli: **10 CFU/100 mL**

**Sample 5**

> • DO: **0.8 mg/L**
> • Turb: **400 NTU**
> • Cond: **1800 µS/cm**
> • pH: **6.8**
> • T: **22 °C**
> • $NO_3$: **10 mg/L**
> • $PO_4$: **3.5 mg/L**
> • BOD: **120 mg/L**
> • Total coliform: **>10,000 CFU/100 mL**
> • E. coli: **>10,000 CFU/100 mL**

**Sample 6**

> • DO (surface): **3.2 mg/L** (can vary; may be supersaturated midday)
> • Turb: **80 NTU**
> • Cond: **600 µS/cm**
> • pH: **8.5** (alkalinity increases during bloom)
> • T: **24 °C**
> • $NO_3$: **1.0 mg/L**
> • $PO_4$: **1.8 mg/L**
> • BOD: **15 mg/L**
> • Total coliform: **200 CFU/100 mL**
> • E. coli: **60 CFU/100 mL**

**Sample 7**

> • DO: **4.5 mg/L**
> • Turb: **10 NTU**
> • Cond: **4500 µS/cm**
> • pH: **6.5**
> • T: **30 °C** (elevated)
> • $NO_3$: **0.5 mg/L**
> • $PO_4$: **0.05 mg/L**
> • BOD: **5 mg/L**
> • Total coliform: **5 CFU/100 mL**
> • E. coli: **<1 CFU/100 mL**

**Sample 8**

> • DO: **2.3 mg/L**
> • Turb: **<1 NTU**
> • Cond: **800 µS/cm**
> • pH: **7.8**
> • T: **15 °C** (stable)
> • $NO_3$: **0.6 mg/L**
> • $PO_4$: **<0.01 mg/L**
> • BOD: **<1 mg/L**
> • Total coliform: **0 CFU/100 mL**

> • E. coli: **0 CFU/100 mL**

**Sample 9**

> “
> • DO: **4.0 mg/L**
> • Turb: **60 NTU**
> • Cond: **1100 µS/cm**
> • pH: **7.0**
> • T: **20 °C**
> • $NO_3$: **5.5 mg/L**
> • $PO_4$: **0.9 mg/L**
> • BOD: **20 mg/L**
> • Total coliform: **2000 CFU/100 mL**
> • E. coli: **1200 CFU/100 mL**

**Sample 10**

> “
> • DO: **6.8 mg/L**
> • Turb: **25 NTU**
> • Cond (salinity proxy): **18,000 µS/cm** (brackish ~10–15 ppt)
> • pH: **7.9**
> • T: **15 °C**
> • $NO_3$: **0.8 mg/L**
> • $PO_4$: **0.2 mg/L**
> • BOD: **4 mg/L**
> • Total coliform: **300 CFU/100 mL**
> • E. coli: **90 CFU/100 mL**

**Sample 11**

> “
> • **DO:** 3.8 mg/L
> • **Turb:** 6 NTU
> • **Cond:** 1050 µS/cm
> • **pH:** 7.6
> • **T: 33 °C** (10–15 °C warmer than intake)
> • **$NO_3$:** 0.7 mg/L
> • **$PO_4$:** 0.05 mg/L

> - **BOD:** 4 mg/L
> - **Total coliform:** 8 CFU/100 mL
> - **E. coli:** < 1 CFU/100 mL

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