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Chemistry: The Dead Zone and Solubility

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Engineering a *Solution* to the "Dead Zone"

NGSS HS PS1-2 Unit Phenomenon and Plan

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Discussion:

At first glance, what important Chemistry topics seem to be *missing* from NGSS?

Background:

Previous School (Riverside, Oakland)

- Physical Science required for all Freshmen
  - Attempted to include all Physical Science standards
  - Emphasized Chemistry & The Periodic Table
    - Included the basics of Nuclear Chemistry
- Approximately 70% of Juniors took Chemistry
  - Content went beyond NGSS
- Mostly traditional grading with some tenets of Standards-Based Grading

Background:

Sequence of Chemistry Units:

- Electrons & Periodic Patterns
- Covalent Bonding, VSEPR, Intermolecular Forces (2019)
- **Ionic Bonding & Solubility**
  - Aligns with HS-PS1-2 for predicting the outcomes of reactions
- The Mole & Formulas
- Stoichiometry
- Reaction Rates, Equilibrium, and Acids/Bases

Anchoring Phenomenon

Student Brainstorm:

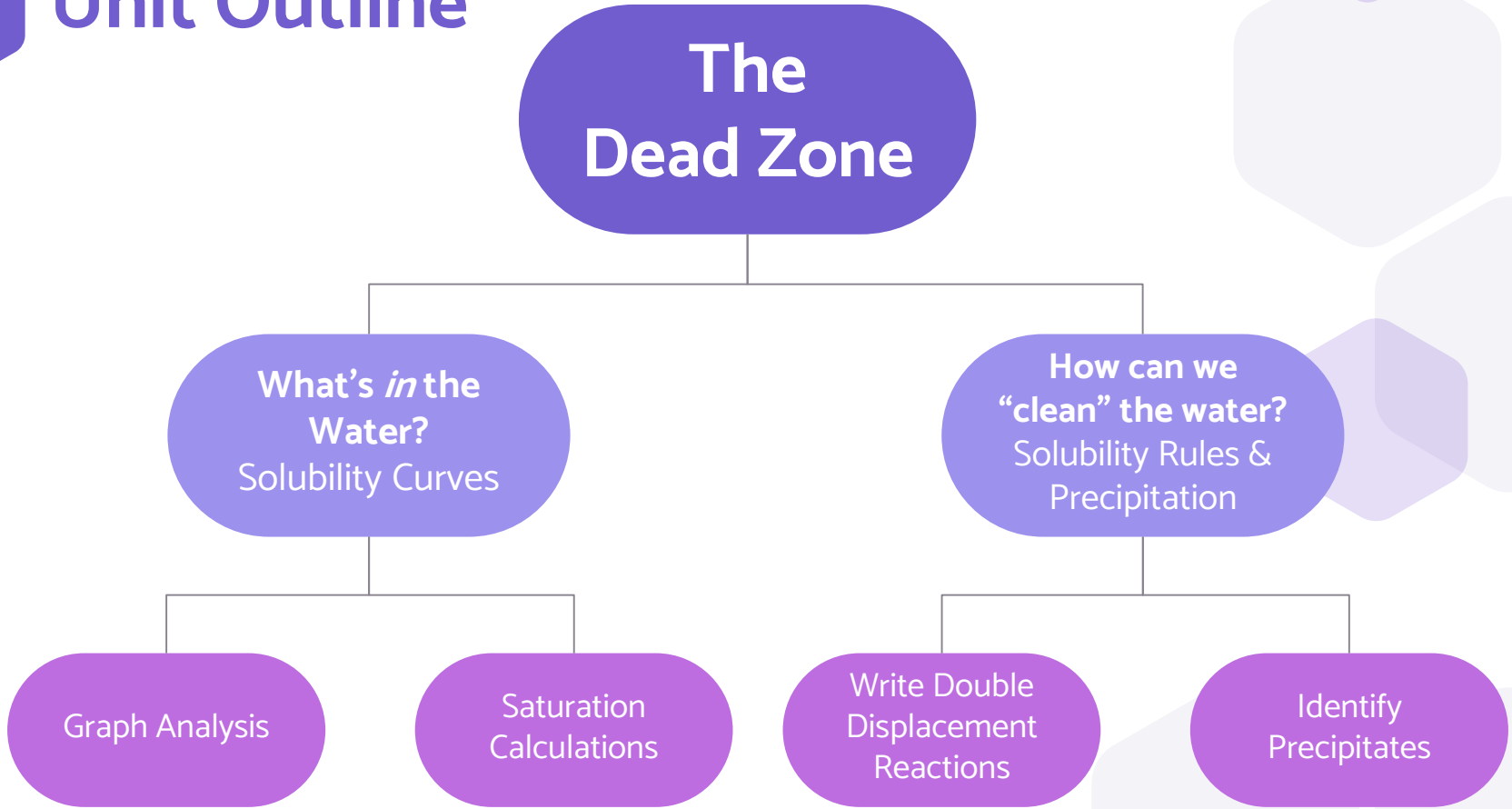
What do you think could be happening to the water in the Gulf of Mexico that causes marine life to die?

How do you think this Dead Zone relates to life in Iowa?

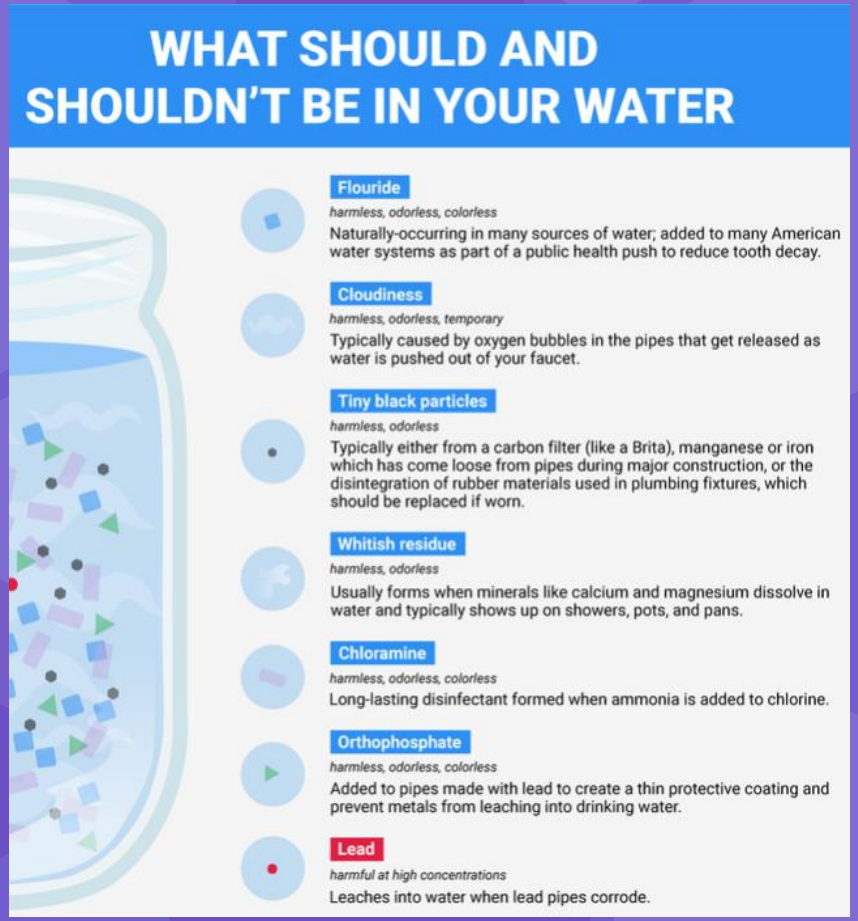
Teacher Note: Facilitating Discussion

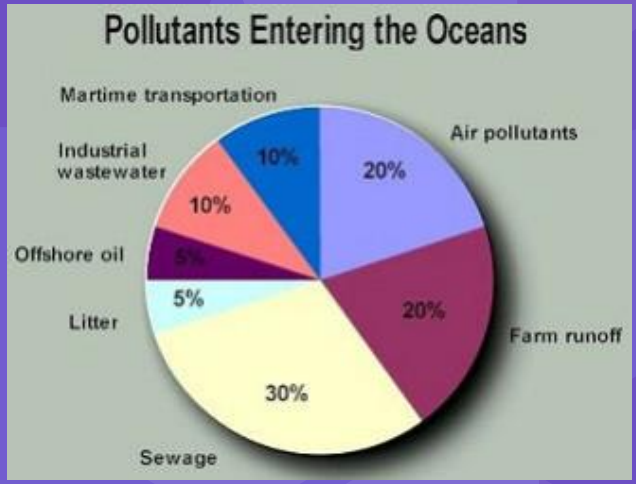
- Encourage students to share brainstorms
  - Have students share with partners first, then the whole class
- Stay positive & open to possibilities
- Try ***not*** to show judgment of student ideas (positive or negative)
- Steer conversation towards the next relevant topic

Unit Outline



Lesson-Level Phenomenon





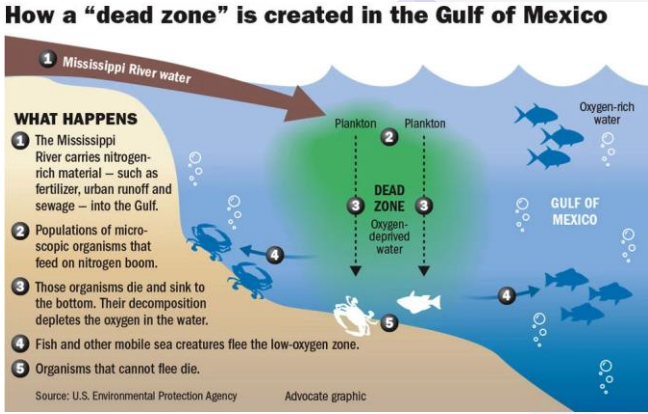
Student Brainstorm:

What type of water pollutant do you think is responsible for the loss of marine life off the coast of Louisiana?

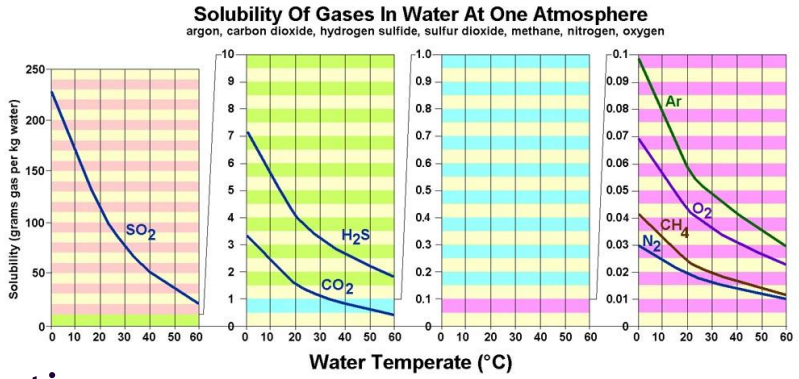
Why do you think that pollutant causes animals to die?

Make a “Dead Zone” Model

- After discussing initial ideas, students read an article about all of the factors leading to the Dead Zone.
- Students make a model displaying the the roles and relationships of each factor:
  - Chemical runoff
  - Watershed maintenance
  - Algae bloom
  - Bacteria digestion
  - Small fish & crustaceans cannot escape
  - Calm, seasonal waters
- Students devise and debate possible treatment and/or prevention plans related to each factor

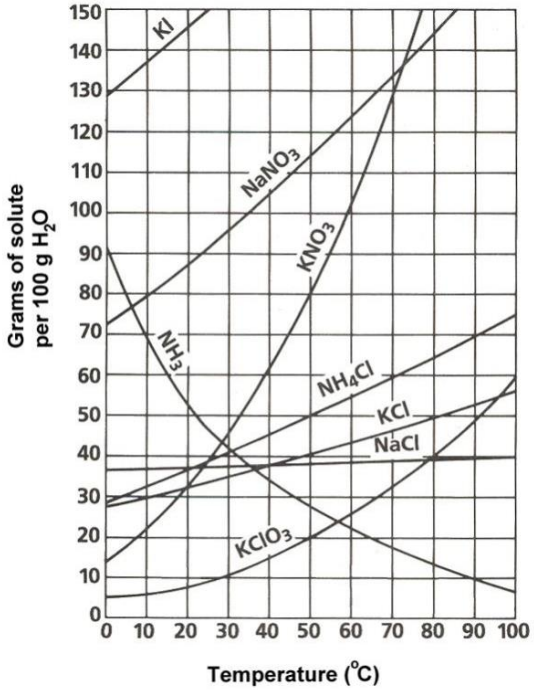


Solubility Curves

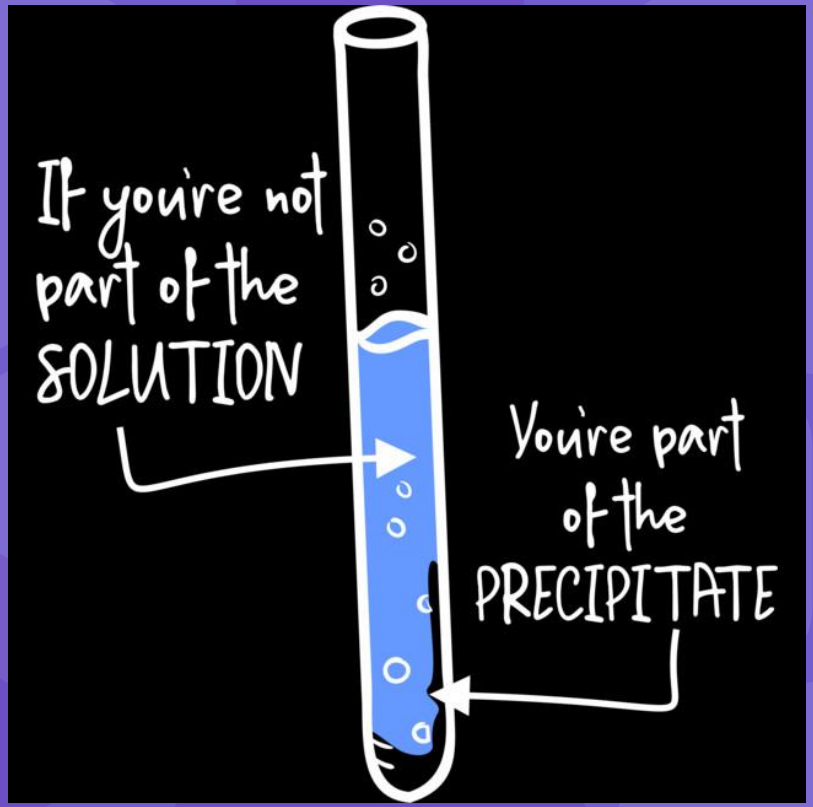


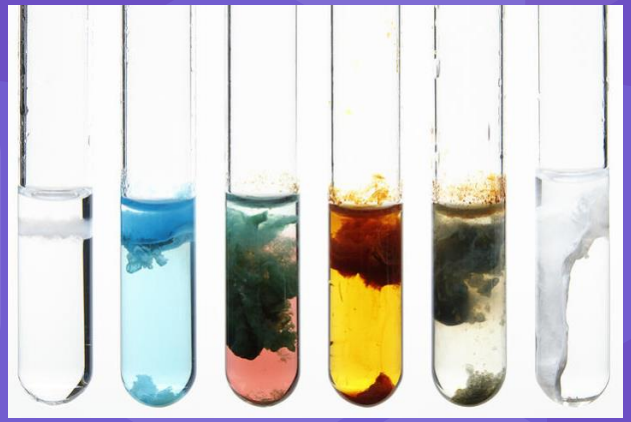
At this point, we examine...

- Solubility curves for determining saturation
  - Ratios to calculate saturation
- Patterns in solubility of gases and ionic solids
  - Discussion of how ionic, covalent, and polar bonding relates to solubility
- *Follow-up question* - Does the Dead Zone have a problem with saturation, unsaturation, or both? Why?



Lesson-Level Phenomenon





Student Brainstorm:

What are the main differences between a solution and a precipitate?

How could the formation of a precipitate help to prevent the Dead Zone?

Lab: Identifying Precipitates

- Students use the results of twelve different reactions to determine the identity of each observed precipitate
- Patterns in precipitation lead to the discussion of Solubility “Rules”
- At this point, we practice writing Double Displacement reactions with proper formulas and states of matter

1. $CuSO_4\ (aq) + NaOH\ (aq) \rightarrow Cu(OH)_2 + Na_2SO_4$
2. $CuSO_4\ (aq) + NaCl\ (aq) \rightarrow Na_2SO_4 + CuCl_2$
3. $CuSO_4\ (aq) + Pb(NO_3)_2\ (aq) \rightarrow Cu(NO_3)_2 + PbSO_4$
4. $Na_2CO_3\ (aq) + CuSO_4\ (aq) \rightarrow CuCO_3 + Na_2SO_4$
5. $Na_2CO_3\ (aq) + Pb(NO_3)_2\ (aq) \rightarrow NaNO_3 + PbCO_3$
6. $Na_2CO_3\ (aq) + NaCl\ (aq) \rightarrow NaCl + Na_2CO_3$
7. $NaOH\ (aq) + KNO_3\ (aq) \rightarrow NaNO_3 + KOH$
8. $NaOH\ (aq) + CaCl_2\ (aq) \rightarrow Ca(OH)_2 + NaCl$
9. $NaOH\ (aq) + Pb(NO_3)_2\ (aq) \rightarrow NaNO_3 + Pb(OH)_2$
10. $AgNO_3\ (aq) + NaOH\ (aq) \rightarrow AgOH + NaNO_3$
11. $AgNO_3\ (aq) + NaCl\ (aq) \rightarrow NaNO_3 + AgCl$
12. $AgNO_3\ (aq) + NaC_2H_3O_2\ (aq) \rightarrow NaNO_3 + AgC_2H_3O_2$

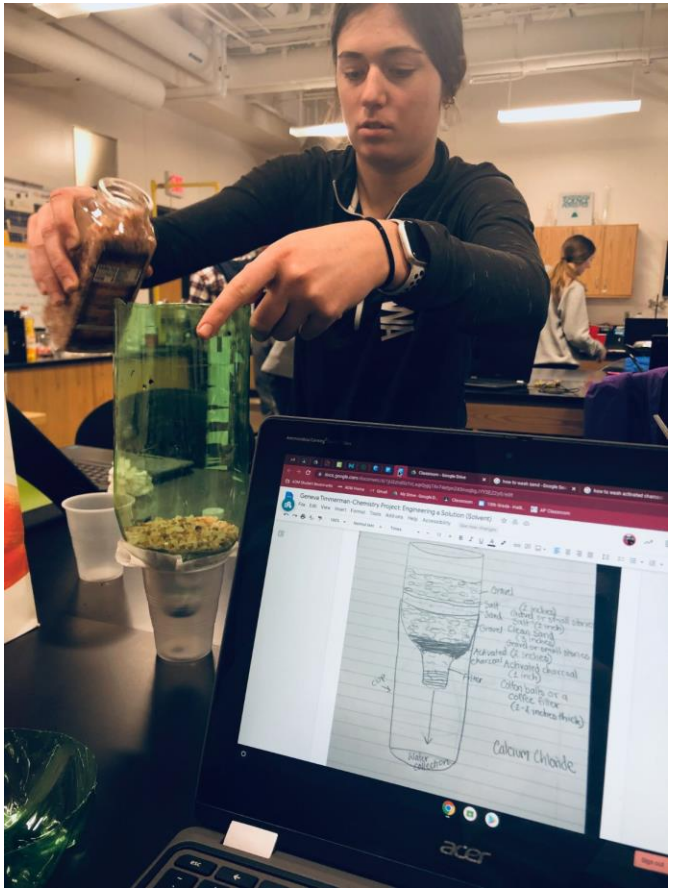
Engineering a “Solution”

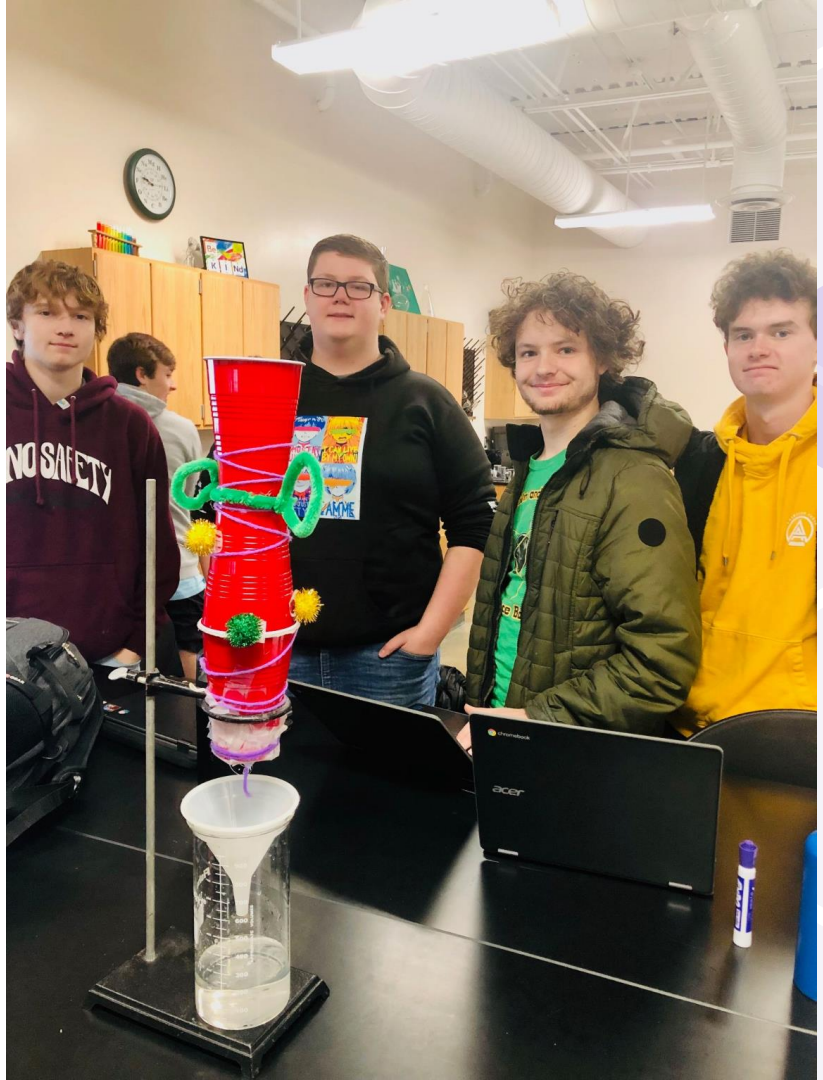
A sample of water has been contaminated with vegetable oil, coffee grounds, garlic powder, and **sodium phosphate** (fertilizer). Your task is to design and construct a water filtration process that will reclaim as much purified water as possible.

Engineering a “Solution”

Materials: Plastic cups, funnels, beakers, flasks, filter paper, fabric, activated charcoal, sponges, sand, gravel, cardboard, plastic tubing, straws, box cutters, pipets, materials from home, and various ionic compounds NaCl, $NiCl_2$, CuO, $ZnSO_4$, $MgSO_4$, $Ca(NO_3)_2$, $CaCl_2$

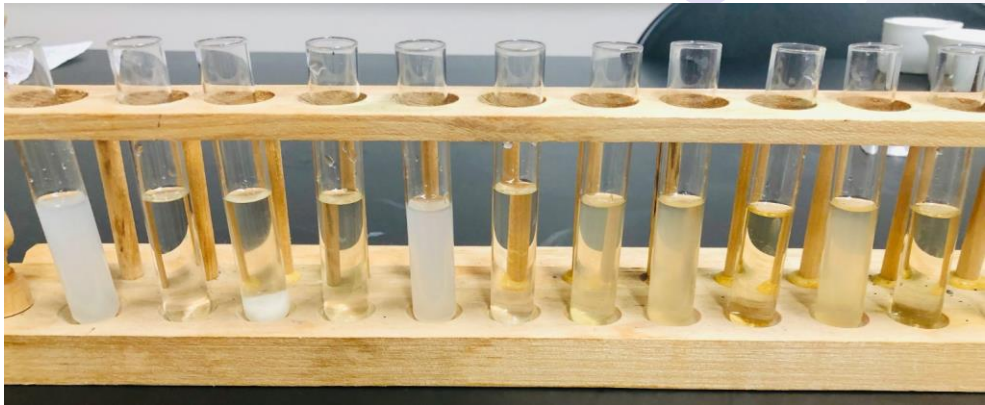
ADM Scientists at Work





Engineering Lab Evaluation

- Students are evaluated based on their design, rationale for design choices, reflection, and filtered water outcome
- Water samples are reacted with both “fertilizer” and a solution of their chosen ionic compound to see which one is in excess
  - This provides a segue to Stoichiometry!



In Summary: Benefits of the Unit

SOLUBILITY

NGSS does not explicitly include Solubility curves or rules but both can be included with PS1-2

NOMENCLATURE

Provides a context for learning how to name and write Ionic Compounds as new precipitates form

POLYATOMIC IONS

Have students learn the common ions relevant to solubility and precipitation reactions

STOICHIOMETRY

Students don't know how much ionic compound to use, this leads to questions about amounts in reactions

New School Scope & Sequence

Current School (ADM)

- Earth & Space Science required for Freshmen
- Chemistry required for all Juniors (two levels available)
- “Fully” aligned with NGSS
- Completely SBG for student mastery of each standard
  - One single grade for each standard and it causes some units to be very long!

Sequence of Chemistry Units

- Atomic Structure & Nuclear Reactions*
- Periodic Patterns
- **Chemical Reactions***
- Stoichiometry
- Reaction Rates & Equilibrium
- Energy Conversions*
- Intermolecular Forces & Materials Science

Reflection...

- Students need more experience with the engineering design loop prior to a complex project
  - Have students complete simple engineering challenges throughout the year
  - Remind students to refine prototypes
- Limit the amounts of materials able to be used by each group (especially filters, sand, and activated charcoal)
  - Provide clean sand and rinsed charcoal
- Develop an Engineering Rubric to assess students with Standards Based Grading

Materials

- Entire Chemical Reactions (PS1-2) Notes
  - Next year, this may be divided into two units
- Precipitation Reactions Lab
- Peer Reviewed Research Article about Wetland Restoration - summarized into a slideshow
- Engineering a Solution Project

Final Note: If you would like to collaborate on Chemistry content in central Iowa this summer, please let me know!