(I) Wastewater Treatment Lab Report

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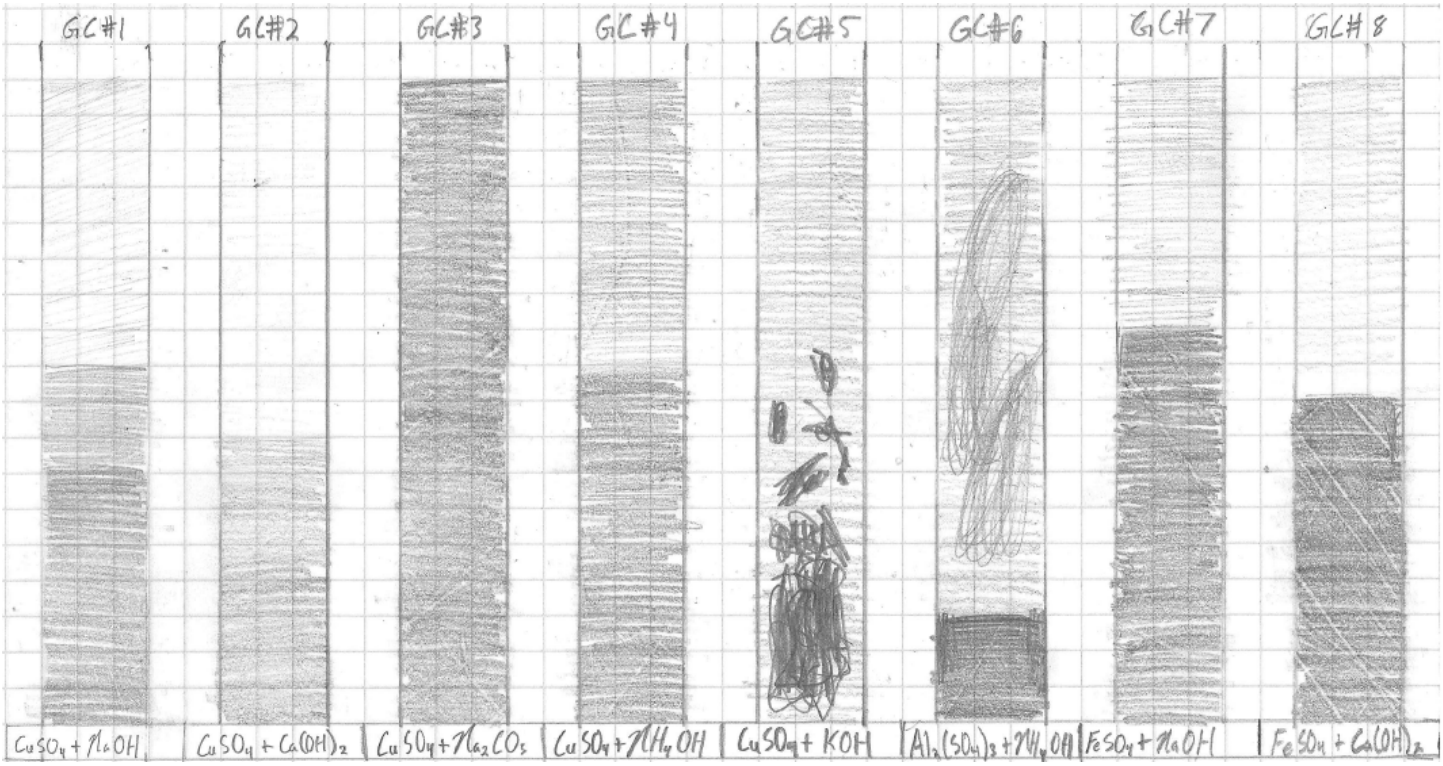
Biology

(II) Problem Statement: To purify water containing copper sulfate, soil, and iron sulfate; and to determine the best method based on cost, ease of use, and effectiveness.
(III) Materials: 8 100 mL graduated cylinders (abbreviated GC), 8 pipettes, 7 150 mL beakers, 13 glass stirring rods, dirt, copper sulfate, iron sulfate, alum, ammonium hydroxide, sodium hydroxide, calcium hydroxide, sodium carbonate, potassium hydroxide.
Method: Set out all 8 graduated cylinders, put dirt into graduated cylinder #6, and fill each with water to the 90 mL mark. In a beaker, put in 2 tablespoons of copper sulfate, and fill it with water to the 100 mL mark. Stir until the copper sulfate has dissolved into the water. Pour an equal amount of the copper sulfate solution into graduated cylinders #1-5, and use the glass rods to stir each. Put 1 tablespoon of iron sulfate into a beaker and fill it with water to the 50 mL mark. Stir until the iron sulfate dissolves into the water. Pour an equal amount of the iron sulfate solution into graduated cylinders #7 and #8, and use the glass rods to stir each. In a beaker, put in 1 tablespoon of sodium hydroxide, fill the beaker to the 50 mL mark with water, and use a glass rod to stir. Using a pipette, transfer an equal amount of the resulting solution into graduated cylinders #1 and #7. In a beaker, put in 1 tablespoon of calcium hydroxide, and fill the beaker to the 50 mL mark with water, using a glass rod to stir the solution until it becomes uniform. Add the resulting slurry to graduated cylinders #2 and #8, and stir with glass rods. Put 2 teaspoons of sodium carbonate into a beaker and fill it to the 50 mL mark with water. Stir the solution until the sodium carbonate dissolves, and use a pipette to transfer some of it into graduated cylinder #3. Using a pipette, transfer some sodium hydroxide to graduated cylinders #4 and #6. In a beaker, combine 2 teaspoons of potassium hydroxide 50 mL of water, stirring until the potassium hydroxide dissolves. Using a pipette, transfer some of the solution to graduated cylinder #5. In a beaker, dissolve 2 teaspoons of alum into approximately 100 mL of water. Using a pipette, transfer some of the alum solution to graduated cylinder #6. Allow the chemicals time to precipitate the debris out of the solutions, and witness the results.



Chemicals Reactions:

GC #1: $CuSO_4 + NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$

GC #2: $CuSO_4 + Ca(OH)_2 \rightarrow Cu(OH)_2\downarrow + CaSO_4$

GC #3: $CuSO_4 + Na_2CO_3 \rightarrow CuCO_3\downarrow + Na_2SO_4$

GC #4: $CuSO_4 + NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$

GC #5: $CuSO_4 + KOH \rightarrow Cu(OH)_2\downarrow + K_2SO_4$

GC #6: $Al_2(SO_4)_3 + NH_4OH \rightarrow Al_2(OH)_3\downarrow + (NH_4)_2SO_4$

GC #7: $FeSO_4 + NaOH \rightarrow Fe(OH)_2\downarrow + Na_2SO_4$

GC #8: $FeSO_4 + Ca(OH)_2 \rightarrow Fe(OH)_2\downarrow + Ca_2SO_4$

(IV) Results:

- GC #1: The sodium hydroxide precipitated the copper sulfate well, was very easy to work with, and readily available, but sodium hydroxide is very expensive.
- GC #2: The calcium hydroxide worked just as well as the sodium hydroxide for precipitating the copper sulfate, and is extremely inexpensive. However, calcium hydroxide is very hard to work with, as it forms a slurry, and hardens over time; this problem can be remedied in an industrial setting by using a lime-slaker machine.
- GC #3: Sodium carbonate did not precipitate the copper sulfate very well, as it didn't settle. This problem could be remedied by straining the resulting solution of debris. However, sodium carbonate is readily available, inexpensive, and easy to use.

- GC #4: The ammonium hydroxide worked well, but died the water sapphire blue. Ammonium hydroxide is also very expensive, but easy to use.
- GC #5: The potassium hydroxide forms a blue solid which sinks to the bottom of the graduated cylinder.
- GC #6: The aluminum sulfate clung to the dirt particles, which, when in contact with the ammonium hydroxide, formed a snot-like substance which did not settle. The solution could be strained to remove large particles and the resulting snot-like substance.
- GC #7: The sodium hydroxide precipitated the iron sulfate well, but the precipitate did not settle very well. Sodium hydroxide is easy to use, readily available, and expensive.
- GC #8: The calcium hydroxide precipitated the iron sulfate very well, and is cheap. However, calcium hydroxide forms a slurry, and hardens when left still. In an industrial setting, a lime-slaker machine will remedy this issue.

(V) Conclusion: For removing copper sulfate and iron sulfate from water, calcium hydroxide is the most economical and inexpensive option. However, it requires the use of a lime slaker system to keep it from hardening and clogging pipes. For removing dirt from water, a combination of aluminum sulfate and ammonium hydroxide forms a snot-like substance which must be strained.

Wastewater Treatment Methods

Experiment performed by Mr. Johanson's biology class of 2024
Lab report written by Ayumi Torii

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Biology

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This lab will be exploring different methods of cleaning up pollution as well as which one works best. For this simulation, the types of pollution involved will be iron, copper, and agricultural pollution.

The materials used in this experiment are:

- graduated cylinders x8
- 250 mil beakers x3
- water
- plastic pipettes
- Sharpie
- aluminum sulfate, or $Al_2(SO_4)_2$
- copper sulfate, or $CuSO_4$
- potassium hydroxide, or KHO
- caustic soda, or NaOH
- lime water, or $Ca(OH)_2$
- washing soda, or Na_2CO_3
- ammonium hydroxide, or $NH_4(OH)$
- iron sulfate, or $FeSO_4$

First, the graduated cylinders were filled with 90 milliliters of water. Some dirt from the ground outside was added to on of them and allowed to settle. About 2 tablespoons of aluminum sulfate was added to one of the beakers. That beaker was then filled with some water. About 2 tablespoons of copper sulfate was added to the second beaker and some water was added to it. In the third beaker, 2 tablespoons of iron sulfate was placed and about 25 mil water added. The liquids in the beakers were stirred for a couple minutes until they were completely dissolved or mixed with the water. Some of the iron sulfate mixture was poured into two of the graduated cylinders, while some of the copper sulfate mixture was added to the remaining five. Caustic soda, lime water, ammonia,

washing soda, and potassium hydroxide were each added to those five graduated cylinders, respectively. Aluminum sulfate was added to the graduated cylinder with dirt and water. Lime water and caustic soda were added to the two graduated cylinders with the iron and water mixture in them. After waiting for contents to settle, results were recorded. Everything was put away.

I. Copper

The caustic soda drew out the copper, which settled as dark blue material on the bottom the graduated cylinder, leaving mostly clear but somewhat bluish colored water on top. The lime water also brought out the copper and dark blue material settled at the bottom, but the water was clearer than the water in the caustic soda's graduated cylinder. The ammonia caused a layer darker than the ones in the graduated cylinders with caustic soda and lime water except on the top of the water. There was a light blue color settled in the middle and the lightest (the cleared water) was on the bottom. The washing soda completely mixed in with the water and did no clearing whatsoever. The potassium hydroxide had a similar effect to the copper that the caustic soda had.

Caustic soda: $CuSO_4 + NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$
Lime water: $CuSO_4 + Ca(OH)_2 \rightarrow Cu(OH)_2\downarrow + CaSO_4$
Ammonium hydroxide: $CuSO_4 + NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$
Washing soda: $Na_2CO_3 + CuSO_4 \rightarrow CuCO_3\downarrow + Na_2SO_4$
Potassium hydroxide: $KOH + CuSO_4 \rightarrow Cu(OH)\downarrow + KSO_4$

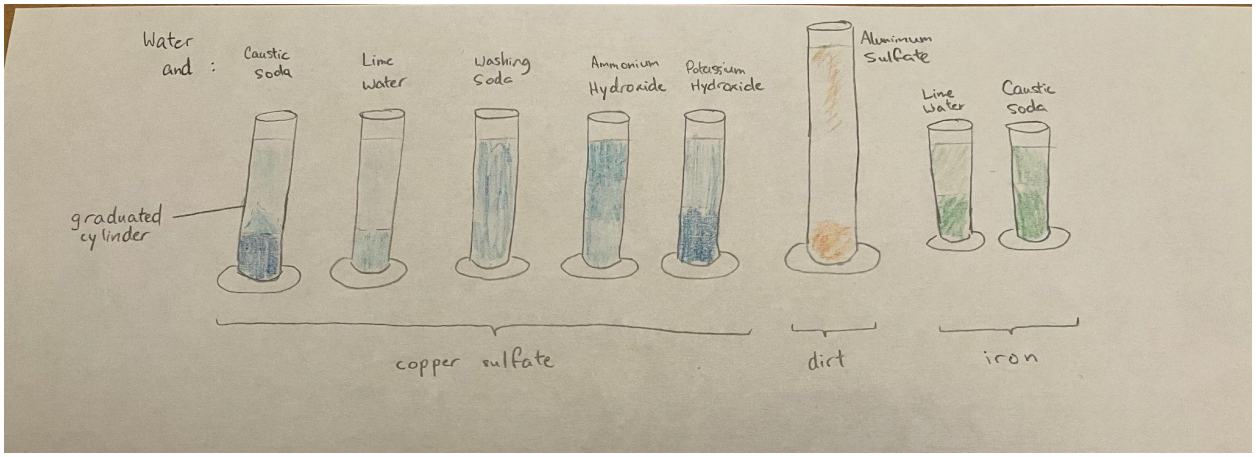
II. Dirt

After the dirt was added to the beaker, most of it settled on the bottom while some floated and stayed as a layer on the top, otherwise known as the silt. The aluminum sulfate pulled down the silt. After some time, the silt was still near the top, but was slowly starting to settle.

III. Iron

The lime water drew out a greenish gray iron pollution from the water, with a clearish water above that layer. The caustic soda brought out dark green iron with little clear parts.

Lime water: $FeSO_4 + NaOH \rightarrow Fe(OH)_2\downarrow + Na_2SO_4$
Caustic soda: $FeSO_4 + Ca(OH) \rightarrow Fe(OH)\downarrow + CaSO_4$



To sum it all up, the lime water worked the best in clearing up the copper pollution, the aluminum sulfate worked slowly to clear out the silt, and the lime water also worked best with the iron pollution.

Bonus: After cleanup when all of the liquids were mixed together in a jar, the pH of the gloop was discovered to be roughly 6 to 7.

I. **Name:** Keira Wardrip
Class: AP Biology
Date: 4/22/24
Experiment: Cleaning Waste from Water

II. **Problem Statement:** Which solvent works best to separate the water from the waste?

III. **Materials and Procedures:**

Materials:

- Water
- Alum
- Caustic soda
- Dirt
- Copper sulfate
- Calcium hydroxide
- Graduated cylinders
- Sodium carbonate
- Ammonium hydroxide
- Iron sulfate
- Beakers
- Stirring rods
- Potassium hydroxide
- Tablespoon

Procedures:

1. Put about one tablespoon of each solvent (alum, potassium hydroxide, etc.) into a beaker. Add water and stir until dissolved (caustic soda and ammonium hydroxide are liquids, and therefore do not need to dissolve).
2. Fill graduated cylinders up to 90ml of water, and put the pollutant in it (dirt, copper sulfate, and iron sulfate).
3. Add about 1ml of the solvent into the polluted water. The total amount of stuff in the cylinder should be about 100ml.
4. Wait until solvent activates, and watch the pollutant separate from the water.

IV. **Results:**

Dirt:
Alum was added to the water polluted with dirt. After the alum did its thing, the solution looked like a light brown cloud, and most of the “clouds” floated, while the heavier dirt sank to the bottom, and condensed to a deep brown mass.
Chemical Reaction: $Al_2(SO_4)_{3+} + NH_4OH \rightarrow Al(OH_3) + (NH_4)_2SO_4$

Iron (lime water):
The iron/water/lime water solution worked the best out of the two iron samples. The water turned almost clear, and the iron sulfate sunk to the bottom and turned a dark green color.
Chemical Reaction: $FESo_4 + Ca(OH)_2 \rightarrow Fe(OH)_2 + CaSO_4\downarrow$

Iron (caustic soda):
The caustic soda didn't work as well as the lime water solution. It still separated it, but the water was a darker yellow, and the iron at the bottom was a darker green.
Chemical Reaction: $FESo_4 + NaOH \rightarrow Fe(OH)_2 + Na_2So_4$

Copper (caustic soda):
The caustic soda worked well. Most of the water was clear with a tinge of blue. About 3/5 of the way down, a cloudy blue substance floated in the water. Beneath that, dark blue copper sulfate sank to the bottom.
Chemical Reaction: $CuSo_4 + NaOH \rightarrow Cu(OH)_2\ So_4 + Na_2SO_4$

Copper (lime water):
The lime water worked the best. About 4/5 of the water was almost clear with a tinge of blue. There was a medium-light blue at the bottom of the graduating cylinder. There was no dark blue.
Chemical Reaction: $CuSo_4 + Ca(OH)_2 \rightarrow Cu(OH)_2 + CaSo_4$

Copper (ammonium):
The ammonium gets dark once placed in the water. It sits at the top, and needs to be mixed in. The clear water was at the bottom. Ammonium is not the best choice for water filtration.
Chemical Reaction: $CuSo_4 + NH_4OH \rightarrow Cu(OH)_2 + (NH_4)_2\ So_4$

Copper (sodium carbonate):
Too much was added because it made the whole thing a light blue cloudy, goopy mixture. If less was added, there might have been better results. It looked like a blue milkshake.
Chemical Reaction: $Na_2CO_3 + CuSo_4 \rightarrow CuCO_3 + Na_2So_4$

Copper (potassium hydroxide):
The solution separated in a similar way to the caustic soda solution. There was clear water on the top, then a thin layer of cloudy blue water, then the copper sat at the bottom of the graduated cylinder.
Chemical Reactions: $KOH + CaSo_4 \rightarrow Cu(OH)_2 + K_2So_4$

V. Conclusion:

Overall, this experiment helped show how effective different solvents are at cleaning water pollutants. The most effective cleaner was the lime water. Though this product is cheap, it is gets messy really fast. It also doesn't dissolve easily, and could easily clog machinery with little chunks. I think it would also be hard to effectively separate the water from the bottom of the

graduated cylander once the solvent separates it. I learned that copper sulfate is ths easiest pollutant to clean between it, dirt, and iron sulfate.