

Conceptual Story: SEPUP *INVESTIGATING WASTEWATER: SOLUTIONS AND POLLUTION*

Solutions and Pollution puts students in the role of scientists. They first develop a working knowledge of mixtures and solutions. They use this understanding and their new lab skills to solve a local issue of cleaning up wastewater from a chemical plant. Through the unit, students gather evidence to determine if they can make solutions more like water. Filtering, dilution, neutralization, and precipitation are processes they explore. Each process has trade offs. In the end, they propose a solution for cleaning up wastewater that incorporates one or more of the above processes. Their proposal must be supported with evidence.

Scenario: ACME Chemical Company wants to expand operations and they have asked the community of Barksdale for permission to dump “pickling waste” into Barksdale Lake. The “pickling waste” comes from the cleaning of rust from iron. The student scientists need to determine if the wastewater is acceptable as is or recommend what ACME needs to do to clean the wastewater prior to dumping it into the lake.

Different solutes and different solvents have different properties that produce solutions of varying concentrations. Concentrations for solutions are measured in parts per million (ppm). Adding water to a solution will make the solution more like water. How do we know ACME wastewater is a solution?

Lesson 1: Investigating Mixtures

Focus Questions: What does it mean when a substance dissolves? How can dissolved and undissolved substances be separated? Why is it important to have only one variable in an investigation?

Students are introduced to the importance of water and to the SEPUP 4-2-1 approach to group interactions and individual responsibilities. Students then investigate the making of mixtures with a solid and a liquid. Students are then introduced to dissolved substances and the issue of wastewater disposal and treatment.

- 1.1 **Properties of Systems:** Properties of Substances
- 1.3 **Changes in Systems:** Physical and Chemical Changes

Lesson 2: Investigating Solutions

Focus Question: What are the possible solutions that result from mixing solids in varying amounts in a liquid?

Students further investigate solutions, with an emphasis on solubility as a property of substances. Students operationally define solution, soluble, insoluble, and saturated. Basic concepts of the particle theory of matter are introduced.

Lesson 3: Reproducibility and Proper Use of Laboratory Equipment

Focus Question: What is necessary for results from investigations to be reproducible?

Students are introduced to the importance of consistent lab techniques and investigate reproducible ways to use SEPUP dropper bottles and droppers. The emphasis in this activity is on the processes of investigation using SEPUP materials.

- AAAS ATLAS:**
- Structure of Matter:** Chemical Reactions (p. 61)
- Scientific Inquiry:** Scientific Investigations (p. 19)

POM - 2

Solutions are a special type of mixture that can be made by mixing a solid with a liquid. Filtering cannot separate solutions. When too much solid is added to a liquid, the solution becomes saturated. Laboratory techniques can lead to reproducible results that allow us to compare properties of solutions. Is dilution an answer to the ACME wastewater problem?

Lesson 4: Comparing Solubility

Focus Questions: Do solids dissolve the same way in different liquids? What is the difference between clear and colorless?

Students predict the solubility of several substances in water and alcohol. They then test their predictions using a controlled experiment. Based on their results, they are introduced to the concept of water as a “universal solvent.”

- 1.1 **Properties of Systems:** Properties of Substances
- 1.3 **Changes in Systems:** Physical and Chemical Changes
- 3.1 **Designing Solutions:** Designing and Testing Solutions

Lesson 5: Parts Per Million

Focus Questions: What is the difference between “observations” and “inferences”? What is the difference between qualitative and quantitative observations? What is meant by “ppm”?

Students explore the concept of one part per (million, billion or trillion) and use it as a measurement for concentration of chemicals that are found in solutions. Students are introduced to this concept through the process of serial dilution. Students learn how to quantify the concentration of a solution in parts per million. The difference between an observation and an inference is defined operationally.

- AAAS Atlas:**
- Structure of Matter:** Atoms and Molecules (p. 55)
- Scientific Inquiry:** Scientific Investigations (p. 19)

POM - 2
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Indicators can distinguish between a solution of acid and a solution of base. Different concentrations of acids and bases cause indicators to turn different colors. When acids and bases are mixed in certain ratios, the resulting solution can be neutral or more like water. Is neutralization an answer for the ACME wastewater problem?

POM - 2
HBS - 1 (apply)

Lesson 6: Identifying Acid and Base Solutions

Focus Questions: What are acids, bases and indicators? How can an acid or base be made to change to the other? Is the ACME wastewater an acid or a base? What is one piece of evidence that a chemical change has occurred when an indicator is mixed with an acid or a base?

Students explore the interactions among four different liquids (HCl, KOH, water and universal indicator.) Operational definitions of acid, base, and indicator are introduced. Students have further experiences with variables and how to control them in an investigation. The knowledge about indicators is used to determine whether the simulated industrial waste is acidic, basic, or neutral.

Lesson 7: Diluting Acids and Bases

Focus Question: What happens to acids and bases as more water is added to each?

Students observe the change in color of universal indicator in an acid or a base as the solution becomes more dilute. They continue the development of operational definitions of acids, bases and indicators. Students know what the simulated wastewater contains acid. They are asked to consider the trade-offs involved in using dilution to prevent the pollution of a lake by industrial waste.

Lesson 8: Acid-Base Neutralization

Focus Question: How can an acid or a base be made to be more like water? (What is meant by "neutralization"?) What can be inferred when different amounts of a base are required to neutralize an acid with an equal % concentration?

Students use pH indicators to investigate the effect on pH of various ratios of 0.1% HCl and 0.1% KOH. Students are introduced to the concept of neutralization and then go on to explore it quantitatively. They determine the ratio of 0.1% HCl and 0.1% KOH solutions that must be mixed to produce a neutral solution. Their results are used to reinforce the particle model to further explore concentrations and explain neutralization.

- 1.1 **Properties of Systems:** Properties of Substances
- 1.3 **Changes in Systems:** Physical/Chemical Changes, Interdependence of Life
- 2.1 **Investigating Systems:** Questioning, Planning and Conducting Investigations

AAAS ATLAS:
Structure of Matter: Chemical Reactions (p. 61); Atoms and Molecules (p. 55)
Scientific Inquiry: Scientific Investigations (p. 19); Evidence and Reasoning in Inquiry (p. 17)

Some solutions, when mixed together, produce a chemical reaction as evidenced by a precipitate as well as changes in color and temperature. Is precipitation an answer for the ACME wastewater problem?

POM - 2, 3

Lesson 9: Removing Dissolved Substances from a Solution

Focus Questions: What can happen when two solutions are mixed? What is the evidence a chemical change has occurred?

Students explore the use of chemical reactions that produce precipitates as a means of removing dissolved substances from a solution. Students investigate the formation of an insoluble precipitate when two solutions are mixed and the separation of the precipitate from the liquid by filtration. This process is then evaluated as a possible method for cleaning the simulated industrial wastewater.

- 1.2 **Systems of Systems:** Structure of Matter

AAAS Atlas:
Structure of Matter: Chemical Reactions (p. 61)

Filtration, dilution, neutralization, and precipitation are processes that can be employed to make a solution more like water. How do you make ACME wastewater more like fresh water? What is the best solution for cleaning the ACME wastewater?

POM - 2, 3

Lesson 10: Treating ACME Wastewater

Focus Question: Considering dilution, filtration, neutralization and precipitation, what is the best procedure (or set of procedures) for making the ACME wastewater more like fresh water in order to safely dispose of it into Barksdale Lake?

Students use the knowledge and understandings developed in this module to plan and carry out an investigation that will help them decide which method is acceptable for treating the simulated industrial wastewater.

- 1.2 **Structure of Systems:** Structure of Matter
- 1.3 **Changes in Systems:** Physical and Chemical Changes
- 2.1 **Investigating Systems:** Planning and Conducting Investigations, Explaining, Modeling, Communicating
- 3.1 **Designing Solutions:** Identifying Problems, Designing and Testing Solutions, Evaluating Potential Solutions

AAAS ATLAS:
Structure of Matter: Chemical Reactions (p. 61); Atoms and Molecules (p.55)
Scientific Inquiry: Scientific Investigations (p. 19); Evidence and Reasoning in Inquiry (p. 17)