Salinity in Natural Waters and Hydraulic Fracturing Waters

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This hands-on (lab) activity may be used to give Environmental Science or Chemistry students the experience with 1) mixing salt solutions that simulate ocean water and waste waters from hydraulic fracturing; and, 2) comparing the specific conductance (used as an indicator of salinity) of drinking water sources to specific conductance of simulated ocean and hydraulic fracturing wastewater. This is similar to an activity that Tom Abe of Fort Berthhold Community College did with us during the 2014 PETE Indigenous Fellows Institute, but adds in the component of evaluation of the amount of salt in ocean water and simulated hydraulic fracturing water that are frequently five times more saline than ocean water (McGoverna et al.)

Learning Outcomes

1) Students will learn about the minerals in seawater, salinity and specific conductance as an indicator of salinity.

2) Students will learn how to use analytical balances and lab glassware to prepare solutions of sodium chloride (table salt) as a surrogate for seawater.

3) Students will calculate the amount of salt needed to simulate a solution of hydraulic fracturing wastewater.

4) Students will learn to use a specific conductance meter to measure drinking water sources and simulated seawater and hydraulic fracturing wastewater.

5) Students will record and evaluate specific conductance of samples to compare differences in salinity and mineral content between drinking water sources and simulated seawater and hydraulic fracturing wastewater.

Materials:

- Table salt (sodium chloride)
- Analytical Balance to measure mass of salt.
- Distilled water for mixing simulated solutions and rinsing probe between measuring specific conductance of water samples.
- Beakers or containers to contain salt plus water to a volume of 1 Liter. (You can use lab beakers or Erlenmeyer flasks or 1 L drinking water bottles.)
- Conductivity Meter with probe
- Various containers of drinking water sources and natural waters. I recommend getting a couple of commercial sources of bottled water, one labeled “spring water” and another “drinking water”. Also, have students bring water from home tap water, lakes, streams, groundwater, etc. to compare with simulated water solutions.

This lesson follows a lecture that introduces the technology of hydraulic fracturing for oil and gas development. The lesson will describe all aspects of drilling, injection of water and hyrdraulic fracturing chemicals, extraction of oil and gas along with wastewaters.

Introduce the topic of minerals (calcite, gypsum, halite and other evaporated salts) that are in underground geologic formations that were formed in prehistoric marine and freshwater systems environments. Minerals are important to human and environmental health. Ask students what they know about minerals in drinking water, both healthy and unhealthy amounts of different chemicals.

Discuss how surface waters injected into a hydrofracturing well will dissolve some of the ancient minerals in the rocks so that the water coming out of fracking wells contains many more dissolved minerals. This increases the salinity of the waters. Ask: Can we drink ocean water? Why not? Students will talk about it being too salty. {OPTIONAL for Chemistry class: You can show a table (Stumm and Morgan, p567) that describes the ions that are in ocean water. Discuss salinity as the mass of dissolved minerals (grams per kilogram of water) when bromide and iodide ions are replaced by chloride and carbonate species are replaced as oxides. }

Give information about ocean water having Salinity that is equivalent to dissolving 35 grams of table salt (sodium chloride) in 1 liter of water. THEN, give information that Hydraulic Fracturing fluids have five to seven times more Salinity than seawater.

Inform the students that they are going to prepare solutions to simulate seawater and fracking water, and measure the solutions' conductivity. Demonstrate use of the analytical balances.

A. Ask groups of students to measure out 35 grams of table salt and dilute it to 1 Liter with distilled water.

B. Ask groups of students to calculate and then measure out the amount of table salt that would make a solution 5 times more saline that ocean water. Then dilute it to 1 Liter with distilled water. This will simulate the hydraulic fracturing wastewater solution.

Inform the students that they can compare the amount of minerals dissolved (ie. Salinity) by measuring the conductivity of the two solutions. They will also compare the conductivity of drinking and surface water samples they brought from home and community.

Discuss Conductivity as qualitative evaluation of the amount of minerals dissolved by passing electricity through water. <u>The more positive and negative ions are in the water from dissolved minerals, the higher the conductivity reading of the water.</u>

Show the chemical equations that describe aqueous dissolution of minerals of halite (sodium chloride) and gypsum (calcium sulfate) that are found in prehistoric marine sediments.

Halite added to water: $NaCl\ (solid) \rightarrow Na^{+}(aqueous) + Cl^{-}\ (aqueous)$

Gypsum added to water: $CaSO_4$ (solid) → Ca^{2+} (aqueous) + SO_4^{2-} (aqueous)

Demonstrate how to use the conductivity meter and rinse and pat dry probes carefully between samples. Discuss conductivity units of microSiemanns (µS) for dilute solutions and milliSiemanns (mS) for more concentrated solutions (review conversion with 1000micro – 1 milli).

The students can measure the conductivity of the samples and record them in a table like this:

Sample Name	Sampling Location	Conductivity (µS)

The students and faculty can have a group discussion of the data generated. Several observations may be made about the different drinking solutions. Often students find that the purchased water may actually be distilled or Reverse Osmosis water that lacks healthful minerals. They should discover that drinking water from groundwater sources (springs or wells) have a higher conductivity than surface waters.

Questions for discussion: Why do freshwater surface waters have a lower conductivity than groundwater, ocean or wastewater? (Leads to diagram and discussion of water cycle and dissolution of minerals.) Why are some groundwater sources (aquifers) of drinking water appropriate for drinking water and others are not? How might spills of hydraulic fracturing wastewater affect ponds, reservoirs and streams? What about spills impacts on soils? Is there potential for contamination of groundwater? Do students believe the problems are related to the technology or the misuse of technology? What would they do to improve current use of hydraulic fracturing?

Students may be asked to write up a lab report, depending upon the educational setting. We ended with only the discussion for our Natural Resources Issues Seminar. An Environmental Science or Chemistry class would write up a formal lab report following the activity.

References:

"Electrodialysis identified as potential way to remove salt from fracking waste water." By David Szondy October 26, 2014 at http://www.gizmag.com/salt-fracking-waste-water-mit/34419/

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