Ground Water Quality

Lesson Plan #4: What does my water have in it?

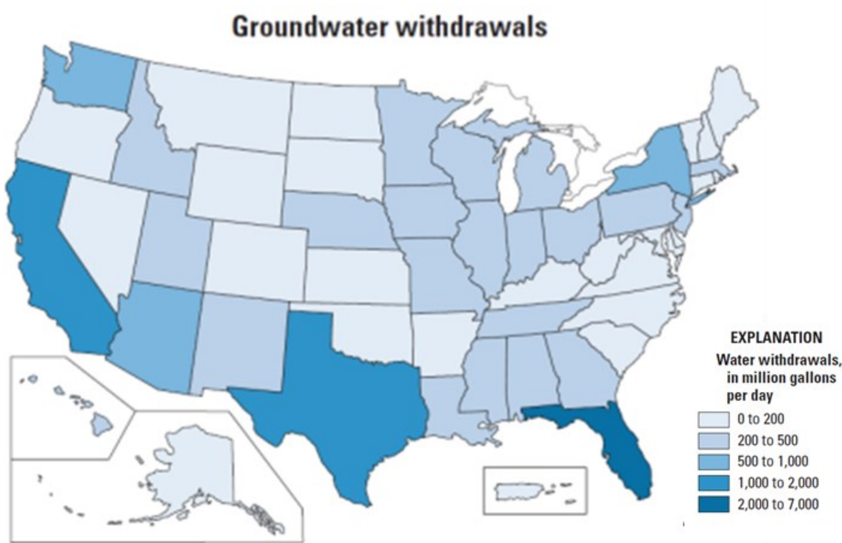
Objective: Learn about ground water quality
- Why is groundwater quality important?
- What are the major constituents in ground water?
- When could ground water be harmful?
- How do you obtain a ground water sample?
- How do you obtain ground water chemistry and interpret the results?

Grades: **10– 12**

Materials:
- Cooler & blue ice
- Test strips
- Sampling containers

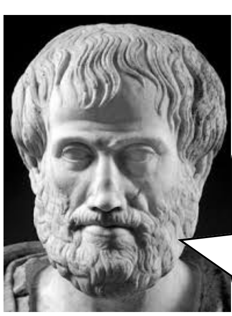
Why is Ground Water Quality Important?

Ground water quality is important because of the large amount of ground water we use for drinking water. Water quality is based on the concentration and type of constituents in ground water. The water quality is a result of natural conditions and at times anthropogenic (manmade) activities.



What's in Ground Water?

As water travels through sand and gravel or through fractures in bedrock it will acquire cations and anions associated with the aquifer material. Cations are positively charged atoms and anions are negatively charged atoms. The most prevalent cations in ground water are calcium (Ca^{2+}), sodium (Na^{+}) and magnesium (Mg^{2+}) and the most prevalent cations are chloride (Cl^{-}), bicarbonate (HCO_3^{-}) and sulfate (SO_4^{2-}). These cations and anions make up about 95% of the constituents in ground water. The concentration of the major cations and anions in drinking water generally do not pose a health risk but if elevated may affect the taste or can effect plumbing.



Aristotle says “when water chokes you, what are you to wash it down?”

The other 5% is made up of trace elements. Trace elements can consist of elements such as of arsenic, aluminum, copper, chromium, iron, nickel, selenium and uranium. Elevated concentrations of these constituents may have health effects and allowable concentrations called maximum contaminant levels (MCL), have been defined by the EPA and State of Idaho. There are MCL’s for health related concerns and these are called “primary standards” and there are also MCL’s for concentrations for constituents that do no cause health related issues but can cause disagreeable tastes or odors in water. These are called “secondary standards”.

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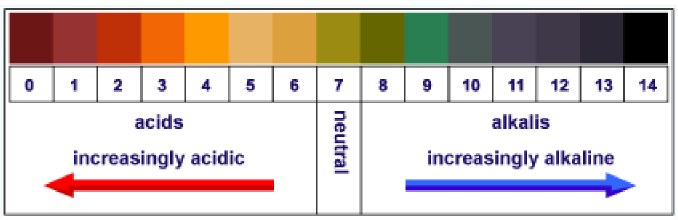
What's are the units of concentration

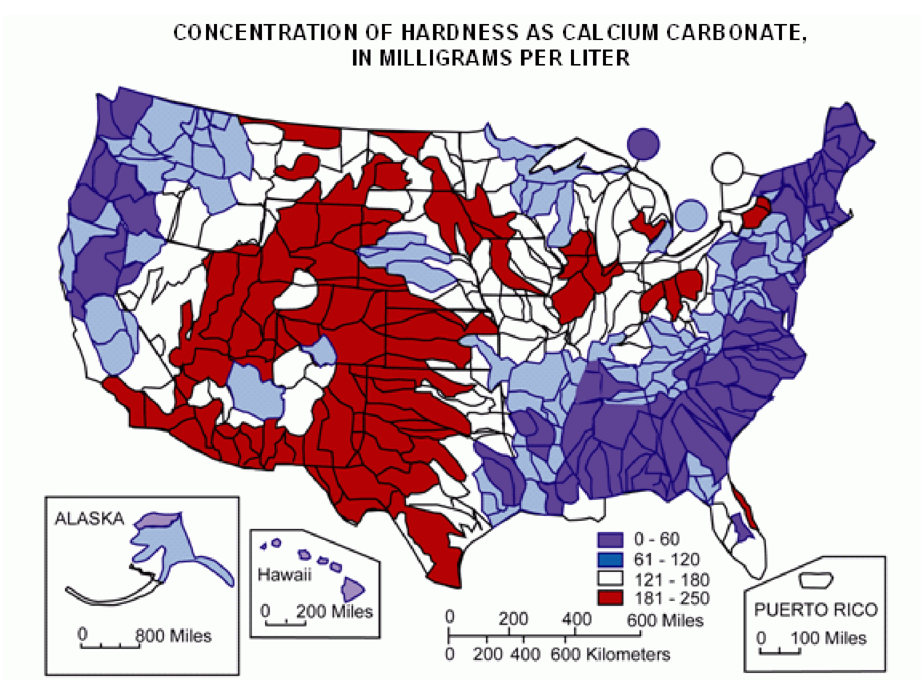
Concentration is measured in mass per volume of water. A typical concentration unit is milligrams per liter (mg/l). Sometimes the concertation is expressed in parts per million (ppm). Parts per million is the ratio between the mass of the constituent vs the mass of a water volume. It turns out the mg/l is the same as ppm. The concentration of these of constituents in ground water is generally dependent on the time in contact with the aquifer material and a number other geochemical factors such as pH and temperature.

pH and Hard Water



The pH is a measure of how acidic or basic the water is. Ground water contains both H^+ and OH^- ions. The pH of ground water is described with a number that ranges between 0 and 14. If there are equal numbers of H^+ and OH^- ions then the pH is 7 and is said to be neutral. If there are more H^+ than OH^- ions then the pH will be less then 7 and is described as acidic. If there are more OH^- than H^+ ions then the pH will be greater then 7 and is described as basic. The pH of most ground water ranges between 6.0 and 8.5. A pH less than 6.5 can contribute to the corrosion of pipes and a pH of greater than 8.5 can contribute to scale build up.

Hard water is water with a significant amount of dissolved minerals, generally calcium and magnesium. Water with high concentrations of these minerals will result in difficulty making lather or suds and the minerals will precipitate out of solution and form a solid that lines the inside of the pipes.



The build up of scale can severely restrict the flow of water in pipes. General guidelines for classification of waters are: 0 to 60 mg/L (milligrams per liter) as calcium carbonate is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard.

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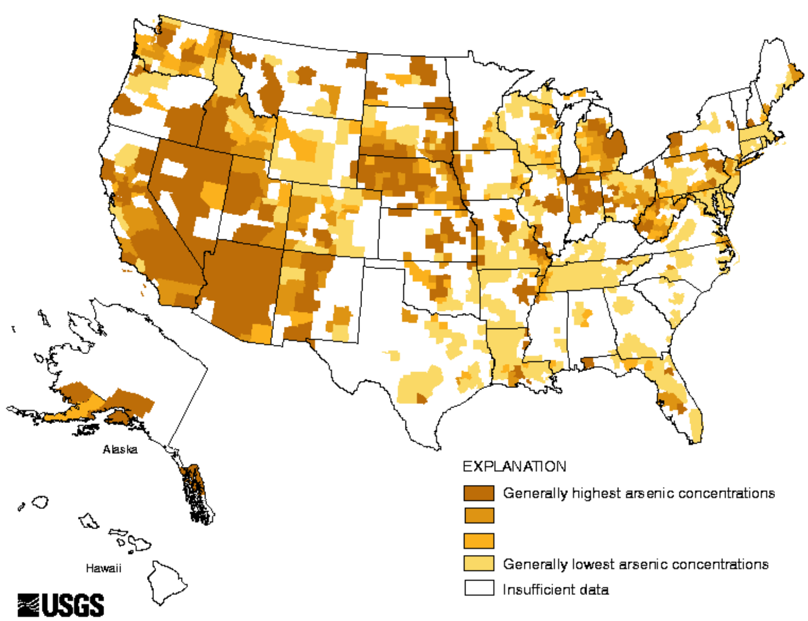
Iron and Arsenic

Iron is an element that is commonly found in basalts or some sedimentary rocks. As water moves through these units a significant amount of iron can be dissolved into the water. Iron does not pose any health impacts but can cause the water to have an odor and poor taste. Iron in water can also cause staining of laundry or plumbing fixtures. The secondary standard for iron is 0.3 mg/l.

Another problem that can occur with water that has high concentrations of iron is iron bacteria. Through a biological process iron bacteria derive energy by combining iron and oxygen in the water. The result is the precipitation of iron rich slime. Over time the slime can clog pump intakes, piping and plumbing fixtures. Most iron bacteria reside in soil at the surface. Their numbers are usually small because of limited iron and oxygen. Often the bacteria are introduced into the well during the drilling process. Drillers will decontaminate their equipment before drilling wells to prevent the contamination of the well. If there is iron bacteria in a well then there are a number of ways to treat and remove the bacteria. One of the most common and cost effective ways for a homeowner to treat their well is through the introduction of chlorine (household bleach) into the well to reduce the number of bacteria.

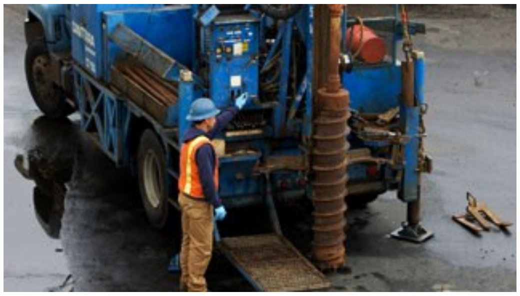
Arsenic is a naturally occurring element found in soil, rocks and ground water. Chemical changes can cause the release and mobilization of arsenic in ground water. Short-term exposure (over days or weeks) to high levels of arsenic in drinking water can result in nausea, diarrhea, and muscle pain. Long-term exposure (over years or decades) to low levels of arsenic in drinking water may cause certain types of cancer. The primary drinking water standard for arsenic is 0.01 mg/l or 10 micrograms per liter (10 µg/l).

If you want to remove arsenic in your water then you will have to chemically treat the water. Heating and boiling will not remove the arsenic. Home treatment systems usually run the water through media that either adsorbs or filters out the arsenic.



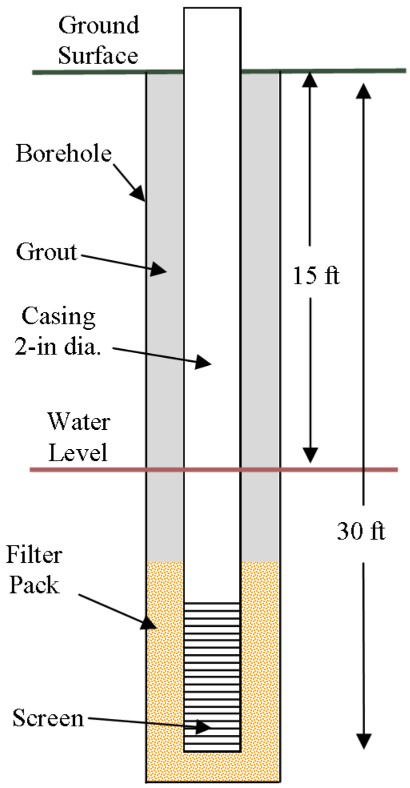
Construction of a monitoring well

Wells are drilled for different purposes. Some are used for supplying water to municipalities, others for irrigation and some are used for things like heat pumps. Monitoring wells are constructed strictly for the purpose of obtaining a water sample that is representative of the aquifer. A monitoring well is constructed by first drilling a borehole to the desired depth and aquifer. The casing and screen are then placed in the borehole. The screen has a number of holes or slots that allows water in and keeps the aquifer material out making sure you can get good clean water samples. Next grout is placed between the filter pack and the ground surface. The grout usually consist of cement and/or clay.



Sampling a monitoring well

To obtain a water sample water the water is either removed with a pump or sometimes a device called a bailer. The pumps may be powered by either electricity or compressed gas. The volume of most water samples are generally less than 1 liter, so not much water is needed. For this reason most monitoring wells have a small diameter. Most are made from 2 inch diameter PVC casing but some of the deeper wells use 6 inch diameter steel casing.



When sampling from a well the well needs to be purged. The stagnant water in the well is exposed to oxygen which can cause chemical changes along with the potential to interact with the well casing and screen. Pumping the well will remove the stagnant water and bring in fresh water from the aquifer.

A general rule of thumb is you need to remove at least three well volumes of water. To calculate three well volumes you need to know the depth to water in the well, the diameter of the well and the depth of the well

For the example;
One well volume (2 –in diameter well) = πr^2 (area of well) x L (saturated length)
= $\pi * (2\ in/2/12\ in/ft)^2 * (30\ ft—15\ ft) = 0.33\ ft^3$
= $0.33\ ft^3 \times 7.48\ gallons/ft^3$
≈ 2.45 gallons
Three well Volumes = 2.45 x 3 = 7.35 gallons

The pump is placed down the well along with some wiring. Water is slowly pumped to the surface. The pump rate is usually very low as you don't want to oxygenate the sample and change any of the chemistry.

The water samples are placed into different types of plastic or glass containers depending on what you are sampling. You don't want the container you are using react with the chemical you are sampling for.

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Sampling a monitoring well cont.

Most water samples that will be submitted for inorganic constituents are placed into plastic containers. Most water samples that will be submitted for organic constituents (gasoline, diesel, herbicides, pesticides) are placed into glass containers.

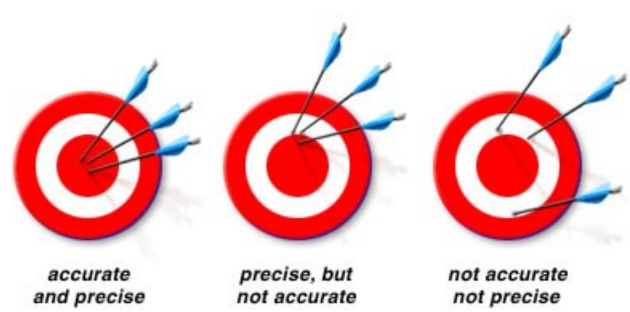
Once the containers are full of water they need to be sent to an analytical laboratory. The containers are usually placed into a cooler with ice to keep them cold. This helps slow down any chemical reactions that could affect the concentration of the constituents. You will need to fill out a form, called a chain of custody form and submit it to the analytical laboratory so they will know what to analyze for. The analytical laboratory has a number of different methods for analyzing water samples and will be specific to what constituents you are interested in. Each method has a unique number with a very specific methodology the lab has to follow. It usually takes about two weeks and the lab will send you a report with your results. A typical lab report is attached.

The lab report gives you a lot of information. There is a header with all the project information including name, the date the samples were submitted. It will tell you the concentration for each constituent along with the concentration unit (mg/l or ug/l) The laboratory method number is also shown so you know how the sample was analyzed.

Each analytical technique can only accurately measure to a minimum concentration of a constituent. The lowest concentration that the laboratory can accurately report is called the minimum reporting level (MRL).   If the concentration of the constituent is below this the laboratory will report this as “less than” the MRL.

There are certain checks that can be made to a water sample to determine the accuracy and precision. Accuracy is how close the results are to the true value and precision is how consistent the results are. Accuracy can be measured by introducing a sample with a known concentration. The “spiked sample” will be run with the other samples and the concentration as determined through the chemical analysis will be compared to the known concentration. This will give a measure of accurate the chemical analysis is.

Another concern is how precise is our sample? If we take a number of samples at the same well at the same time would the resulting concentrations all be the same or would they vary? One way to check this is to take a “field duplicate”. You would obtain two water samples at the same time from the same well and submit them to the analytical laboratory. If the results are precise they should be very similar.



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Exercise:

Obtain a water sample from a monitoring well and (1) obtain measurements with test strips and (2) submit the sample to an analytical laboratory.

Before going to the site:

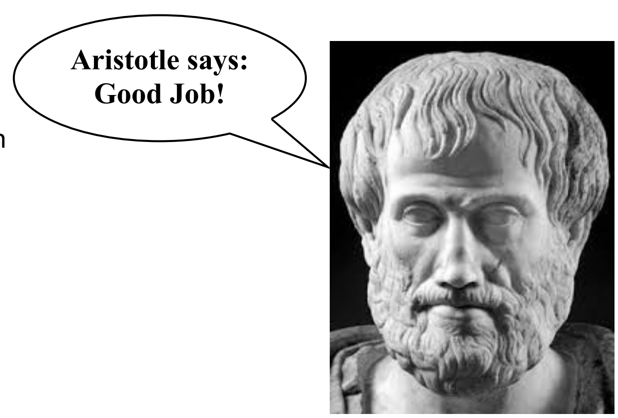
1. Contact an analytical laboratory and obtain a chain of custody form, labels and the necessary containers for the flowing analysis; Ca, Na, Mg, Cl, SO_4, HCO_3, arsenic, iron and hardness
2. Fill out as much of the chain of custody form as possible.
3. Obtain the driller's log for the well and calculate how much water equals three well volumes.
4. Freeze two small blue ice packets and place in cooler immediately before sampling.

Site Activities

1. Have your teacher unlock the well covering to allow access.
2. Place 5-gallon bucket underneath tap.
3. Turn on the water with a low flow rate so the bucket will fill slowly.
4. Empty the 5-gallon bucket when full and place back under tap.
5. Measure the amount of water and note the time when you have pumped three well volumes.
6. Remove the bucket and slowly fill the beaker.
7. Fill the beaker and take the temperature with a thermometer and determine the nitrate-nitrogen concentration and pH with test strips.
8. Fill out labels with necessary information and place on dry laboratory containers.
9. Slowly fill laboratory containers so that they are completely full with no air. Securely cap containers and place in cooler.
10. After filling all the containers, turn off tap and secure and lock the well covering.
11. Complete the chain of custody form.
12. Submit samples and chain of custody form to analytical laboratory.

After receiving analytical report from laboratory

1. Are all the results in mg/l? If not convert all of them to mg/l.
2. Compare the test strip (nitrate) and analytical results to primary and secondary standards. These can be found at http://adminrules.idaho.gov/rules/current/58/0111.pdf.
3. Are there any constituents that exceed the standards?
4. Based on the hardness criteria described on page 2, is the water soft or hard?
5. Would you expect any problems with iron or hardness based on the analytical results?



Acme Analytical Laboratory

100 Main Ave, Coeur d'Alene, ID

IDEQ Coeur d'Alene Regional Office
2110 Ironwood Pkwy
Coeur d'Alene, ID 83814

Project Name: Rathdrum Prairie Aquifer Water Quality Investigation
Work Order: W2178340
Reported: 10/04/15 13:04

Client Sample ID: **Well #1**
Acme Sample ID: W2178340-01

Sampled: 09/25/15 11:25
Received: 09/25/15 15:32
Client Sampler: JNS

Sample Report Page 1 of 1

Major Ions

Method	Analyte	Result	Units	MRL	Batch	Analyst	Analyzed
EPA 200.7	Calcium	33.8	mg/l	0.040	W239146	CD	10/02/15 10:45
EPA 200.7	Magnesium	14.7	mg/l	0.060	W239146	CD	10/02/15 10:45
EPA 200.7	Potassium	1.98	mg/l	0.50	W239146	CD	10/02/15 10:45
EPA 200.7	Sodium	3.44	mg/l	0.50	W239146	CD	10/02/15 10:45
EPA 300.0	Chloride	3.98	mg/l	0.020	W229137	AW	10/03/15 09:23
EPA 200.7	Sulfate	4.13	mg/l	0.030	W229137	AW	10/03/15 09:23
SM2320B	Bicarbonate	138	mg/l	1.0	W125332	DT	10/03/15 10:05

Trace Inorganic Constituents

Method	Analyte	Result	Units	MRL	Batch	Analyst	Analyzed
EPA 200.8	Arsenic	< 3.0	ug/l	3.0	W225212	TK	10/02/15 14:17
EPA 200.7	Iron	0.4	mg/l	0.01	W225212	TK	10/02/15 14:17

Physical Tests

Method	Analyte	Result	Units	MRL	Batch	Analyst	Analyzed
EPA SM2340B	Hardness	72	mg/l	2.0	W235220	JW	10/02/15 10:55

This data has been reviewed for accuracy and has been authorized for release by the laboratory director

John Smith

John Smith
Laboratory Director