Unit Title: Water Quality
7th grade Science

Unit Summary:

This unit emphasizes the importance and limited availability of groundwater to humans and the issues related to groundwater contamination, detection, and remediation. Since a majority of the population rely on groundwater for many basic water needs, understanding how to keep our existing sources clean and remediate polluted sources is imperative. Building on prior knowledge of the water cycle, these lessons expand on topics related to groundwater, such as understanding the components of a watershed, groundwater uses, movement, and relationship to surface water, water quality and the issues linked to land usage, and contaminant identification, prevention, and remediation in groundwater. Using local water quality databases and real-world situations, students will evaluate local sites with known groundwater contamination and determine monitoring, minimization, and cleanup strategies.

Next Generation Science Standards:

MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

WHST.6-8.8: Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Learning Objectives:

- Predict their daily water budget.
- Calculate their daily water budget, and estimate their household daily water budget.
- State the sources of water found on Earth, both fresh and saltwater.
- State the phases that water is found in on Earth.
- Create two pie charts, displaying 1) the distribution of total water and 2) the distribution of freshwater on Earth.
- Explain why freshwater is a limited resource on Earth.
- Graph their daily water usage before and after water conservation efforts have been employed.

- Name at least 5 water conservation methods that can be performed in the home.
- Define the following groundwater vocabulary terms: groundwater, aquifer, confining layer, infiltration, saturated zone, unsaturated zone, water table, recharge, area of influence, cone of depression, porosity, permeability.
- Explain how groundwater and surface water are connected, and how water moves between and through the two sources.
- Explain how pumping wells affect groundwater aquifers.
- Calculate porosity and permeability for certain aquifer materials (sand, clay, soil, gravel).
- Determine the most and least porous and permeable aquifer materials.
- Describe how particle size and shape affects porosity and permeability.
- Determine a reason for a home pumping well to stop yielding water in a hypothetical scenario.
- Define water quality and what factors can affect water quality.
- Describe why good water quality is important.
- Name at least 5 factors that can affect water quality.
- Perform water analysis tests and describe what each test signifies in terms of water quality.
- Define at least 3 groundwater remediation strategies.
- Write a groundwater remediation scenario for a hypothesized contamination spill.
- List 3 pros and cons for their remediation scenario.
- Present their remediation scenario to the class with a visual aid.

Keywords

- freshwater
- saltwater
- water audit
- water availability
- conserve
- water usage
- groundwater
- aquifer
- confining layer
- infiltration
- saturated zone
- unsaturated zone
- water table
- recharge
- area of influence
- cone of depression
- porosity
- permeability
- water quality
- temperature
- pH
- dissolved oxygen
- conductivity
- turbidity
- nutrients
- heavy metals
- groundwater remediation
- pump and treat
- air sparging
- permeable reactive barrier
- chemical treatment
- bioremediation
- phytoremediation

Lesson Title - Brief Description	Learning Objectives	NGSS Addressed	Materials Required
Lesson 1 - Why is freshwater so important Importance and limited availability of freshwater	• Predict their daily water budget. • Calculate their daily water budget, and estimate their household daily water budget. • State the sources of water found on Earth, both fresh and saltwater. • State the phases that water is found in on Earth. • Create two pie charts, displaying 1) the distribution of total water and 2) the distribution of freshwater on Earth. • Explain why freshwater is a limited resource on Earth. • Graph their daily water usage before and after water conservation efforts have been employed. • Name at least 5 water conservation methods that can be performed in the home.	**MS-ESS3-3** **MS-LS2-4** **WHST.6-8.7**	• Whiteboard - 1/group • Marker - 1/group • Calculators (optional/student supplied) • Computers (for graphing activity) - 1/student • **Why is Freshwater So Important** PowerPoint • **Water Water Everywhere** handout • **Water Audit** handout • **Water Sources Labels** • **Graph the World's Water** handout • **How Much Water Do We REALLY Have To Use** handout
Lesson 2 - A window into groundwater Groundwater terms, lab looking at porosity and permeability	• Define the following groundwater vocabulary terms: groundwater, aquifer, confining layer, infiltration, saturated zone, unsaturated zone, water table, recharge, area of influence, cone of depression, porosity, permeability. • Explain how	**MS-ESS3-3** **MS-LS2-4** **WHST.6-8.7**	• Water • 1 - 250 or 400 mL beaker • 1 - 100 mL graduated cylinder • 1-3 plastic or paper cups • Thumbtacks or push pins • Filter material - coffee filter, old panty hose,

	groundwater and surface water are connected, and how water moves between and through the two sources. • Explain how pumping wells affect groundwater aquifers. • Calculate porosity and permeability for certain aquifer materials (sand, clay, soil, gravel). • Determine the most and least porous and permeable aquifer materials. • Describe how particle size and shape affects porosity and permeability. • Determine a reason for a home pumping well to stop yielding water in a hypothetical scenario.		etc. • Aquifer materials - gravel, sand, clay, soil • Duct tape • Scissors • Stopwatches • **Groundwater vocabulary** handout • **Porosity and permeability lab** handout • **WTDK take-home** handout • **A window into groundwater** PowerPoint
Lesson 3 - What are we drinking? Water quality parameters and hand-on lab	• Define water quality and what factors can affect water quality. • Describe why good water quality is important. • Name at least 5 factors that can affect water quality. • Perform water analysis tests and describe what each test signifies in terms of water quality.	**MS-ESS3-3** **WHST.6-8.7** **WHST.6-8.8**	• Computers/Internet access • Water quality testing equipment • HACH DR 900 Multiparameter Handheld Colorimeter • Water samples, from local water sources, students' fish tanks, backyard ponds, etc. • Thermometer • **Water quality pre-assessment** handout • **How do different characteristics of water affect water quality** handout • **Water quality lab** handout

			• **RAFT take-home** handout • **Water quality** PowerPoint
Lesson 4 - Remediation Scenario In-depth look at groundwater remediation scenarios	• Define at least 3 groundwater remediation strategies. • Write a groundwater remediation scenario for a hypothesized contamination spill. • List 3 pros and cons for their remediation scenario. • Present their remediation scenario to the class with a visual aid.	**MS-ESS3-3** **MS-LS2-4** **WHST.6-8.7** **WHST.6-8.8**	• Computers/Internet access • Poster boards • Markers • Magazines (that can be cut up) - for pictures, words, etc. • **Groundwater remediation strategies** handout • **Remediation techniques** PowerPoint

Safety Considerations:

Broken glass - sharps

Spilled water - slipping hazard

Chemical hazards associated with chemicals used with water quality testing equipment (see SDS included with kit)

Evaluation Plan:

Lesson 1:

Written assignment reflecting on the importance and availability of freshwater to humans, especially living in a Great Lakes state.

To evaluate whether the students understand the concept of how scarce and important freshwater is to the Earth.

Lesson 2:

Written assignment (WTDK) acting as an Environmental Engineer to evaluate the reason for a family's dry well.

To evaluate the student's grasp of the groundwater vocabulary terms and if they can apply them to a real world scenario.

Lesson 3:

Written assignment (RAFT) reflecting on water quality and the water characteristics evaluated in the lab.

To evaluate the student's understanding of good water quality and different water characteristics dictate the quality of a waterbody.

Lesson 4:

Cleanup plan for a contaminated site in Michigan.

To evaluate the students' understanding of remediation techniques used for groundwater cleanup projects.

Resources (websites):

- USGS Current Water Data for Michigan - http://waterdata.usgs.gov/mi/nwis/rt
- Department of Environmental Quality, Michigan - http://www.michigan.gov/deq
  - Drinking Water - http://www.michigan.gov/deq/0,4561,7-135-3313_3675---,00.html
  - Groundwater Discharge - http://www.michigan.gov/deq/0,4561,7-135-3313_4117---,00.html
  - Surface Water - http://www.michigan.gov/deq/0,4561,7-135-3313_3682---,00.html
  - Water Quality Monitoring - http://www.michigan.gov/deq/0,4561,7-135-3313_3686---,00.html
- EPA A Citizen's Guide to Cleanup Technologies - http://cluin.org/products/citguide/

Brief description of how this unit relates to your graduate research:

In my research, I am studying the issues related to a very common groundwater contaminant called tetrachloroethene, its transport and fate in groundwater, and the physiological requirements of certain bacteria found in aquifers that have the ability to detoxify tetrachloroethene. This unit is directly related to my research because the lessons go into detail about groundwater systems, more so than the basic seventh grade water cycle curriculum covers, and also highlights concepts related to water quality and contaminant identification, transport, and remediation practices in a watershed.

The link between groundwater and surface water in a watershed, groundwater movement, and the limited availability, and thus importance, of clean groundwater to humans are all topics covered in this unit. Students are introduced to the concept of groundwater pollutants, anthropogenic sources of contamination, how to locate and monitor their movement, and possible adverse effects to humans and the environment. Water quality is an overarching theme in this unit, as well as in my research, and contaminant issues tie in nicely with this discussion.

Students are taught various techniques currently used in groundwater remediation, including those I study in my research, parameters required to enhance bioremediation in groundwater aquifers. They

are also presented with actual site data from a USGS website and asked to devise a cleanup plan for a contaminated Michigan groundwater site, including recommendations for water quality sampling, well monitoring, contaminant tracking, Best Management Practice suggestions, and remediation techniques. These skills are imperative for future scientists to learn early and utilizing local scenarios gives the students a close connection and a vested interest in the problem.

The lessons I have devised here are wholly intertwined in many of the topics I deal with in my research. Watersheds are directly linked and impacted by groundwater contamination and water quality and site remediation are always recurring themes in environmental engineering problems. Giving the students an opportunity to perform the tasks that scientists carry out daily will help educate them in critical environmental issues and hopefully cultivate budding environmental stewards in the process.