**THE SCIENCE, ETHICS, AND POLITICS OF WATER**

**A Grade 12 and College Level Curriculum**

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A STEM Curricula project integrating the Chemistry and Social Justice of Water on Community, National, and International Scales

**LESSON 1 – AN INTRODUCTION TO THE BASICS OF WATER AND THE ROLE OF THE FEDERAL GOVERNMENT**

**Objectives:**

* Students will understand and develop their ideas on the basic chemical structure and properties of water as well as the crucial role that water plays in their daily life experience.
* Students will collectively examine the United States’ water contamination problem and assess the roles of the federal government, scientists, and the public in relation to the issue. They will also engage in critical thinking and deep analysis using discussion questions.
* Students will integrate all subjects and topics explored through the connective concept mapping activity.
* Students will engage in writing, discussion, and individual activity utilizing the World Wide Web and software tools in order to deepen and expand their understandings and to diversify their interactions with the course content.

**Time:** One Session (3 hours)

**Resources:**

Stanley E. Manahan *Water Chemistry: Green Science and Technology of Nature's Most Renewable Resource* (25-47)

National Science Foundation Module – The Chemistry of Water: *http://www.nsf.gov/news/special\_reports/water/index\_low.jsp?id=properties*

Water: The World of Chemistry (DVD) University of Maryland and the Educational Film Center. 1990.

Inspiration 9: Inspiration Software Concept Mapping Technology <http://www.inspiration.com/>

World Wide Web Online Exploration Activity: epa.gov

**Suggested Student Preparation:**

Read p.25 – 47 *Water Chemistry: Green Science and Technology of Nature's Most Renewable Resource* Chapter: Properties of Water and the Hydrosphere

Explore NSF Chemistry of Water Module: http://www.nsf.gov/news/special\_reports/water/index\_low.jsp?id=properties

**Suggested Procedure:**

1. **Integrative Writing Assignment**:

 Have students answer the following questions individually based upon their own personal life experiences, previous knowledge of the science of water, and the science of water discussed in the assigned reading and module activities. The focus of this activity should be based on **integration** of the science of water (basic chemical concepts discussed in module and assigned reading) to daily life experience with respect to water. After some time has been given for individual writing and reflection, allow students to share their responses and note them on the board in order to visually illustrate and encourage further critical analysis.

1. What is water? In a daily life/experiential level? In a chemical level?
2. What role does water play in your life in its many forms? Emphasize the concepts of drinking water, water cycles, waste water management, water as a necessary resource.
3. **Short Film Screening and Discussion- *“*Water: The World of Chemistry*”***

Screen the following sections of the film followed by breaking up the class into small groups of 4-5 members per group to discuss the given questions. Emphasis during the discussions should be based upon ethics of water consumption and quality management with respect to the roles of the government and the roles of the public.

 Part 1: 0 -7:42

 Part 2: 17:20 – 25:23

Discussion Questions/Topics – Small group activity:

Topics to keep in mind: Contaminants in drinking water. “How clean must our water be before it is considered safe?”, Roles of the federal government, the public, and scientists.

Questions:

1. What are the effects of water’s dissolving ability?
2. Explain the benefits of water to industry?
3. Explain the contamination problem, what are the causes and dangers of returning contaminated waters to the environment
4. Do you think there will be more “lead scenarios” on the basis of new knowledge?
5. Who created the water contamination problem, is it a problem, and who is responsible for solving it?
6. Do you agree or disagree with the following statement from the film “The quality of our water will improve because of a science that is creative and a public that is well-informed.”
7. **Web Activity and Discussion:**

Have the students explore the following EPA websites individually:

<http://water.epa.gov/drink/contaminants/index.cfm>

<http://water.epa.gov/polwaste/nps/whatis.cfm>

Have the class involve in a brief discussion connecting ideas from the EPA web exploration and the film using the above questions as basis for delving deeper into the subject of water contamination and sources of pollution as a group. Use the list of basic information on federal guidelines of maximum contaminant levels allowed in order to study the role of the government in water management and to get a general idea of some compounds and their accepted levels. This activity will help in getting students acquainted with chemical compounds that will be a part of an upcoming drinking water analysis experiment.

1. **Final Activity: Concept Map**

Students are invited to get as creative as possible in integrating all that they have learned and discussed for the day through a concept map. An example map has been attached in the following page. This activity will allow students to identify key concepts discussed in class and to create connections between them. Students can choose to make concept maps either by hand or using the Inspiration 9 software tool. Collect concept maps for evaluation and analysis.

See the attached page for an example concept map:
<http://serc.carleton.edu/files/sencer/power_water/pow_concept_map.pdf>

**Suggested Homework Assignment:**

Read p.46 – 61, 75-77 *Water Chemistry: Green Science and Technology of Nature's Most Renewable Resource* Chapter: Fundamentals of Aquatic Chemistry

Explore EPA modules on MTBE, a toxic contaminant used in fuels:

<http://www.epa.gov/mtbe/gas.htm>

<http://www.epa.gov/mtbe/water.htm>

<http://www.epa.gov/mtbe/clean.htm>

**LESSON 2 – REAL LIFE CASE STUDY ANALYSIS ON WATER CONTAMINATION: EXXON VS. NH**

**Objectives:**

* Students will “use complex, real-world problems as the context in which to learn scientific concepts, their interconnections, and their applications. This extensive and complex problem solving will require students to ask and refine questions, find and weigh evidence, evaluate likely interpretations, and build consensus conclusions.”[[1]](#footnote-1)
* Students will independently investigate federal and scientific facts of the carcinogenic water contaminant MTBE and connect their findings with a real-world scenario.
* Students will engage in discussion and writing in order to deepen and expand their understandings and to diversify their interactions with the course content.
* Students will participate in a final reflection that will allow students to connect their understandings of the course content to their own personal lives, making course content directly and personally relevant. They will also reflect on their own growth through the process.

**Time:** One Session (3 hours)

**Resources:

N**PR Article**:** Exxon Mobil Guilty In N.H. Contamination Suitby Sam Evans Brown

EPA Modules on MTBE
<http://www.epa.gov/mtbe/gas.htm>
<http://www.epa.gov/mtbe/water.htm>
<http://www.epa.gov/mtbe/clean.htm>

**Suggested Procedures:**

1. **Individual Writing Activity:**

Have students write 1-2 questions on the MTBE assigned readings and identify points of confusion individually. Then, have students share their questions and address their questions on the subject in preparation for the real life case study below. Keep some of the most common conceptual pertaining to ethics of water contamination for later integration into the large-group discussion.

1. **Real Life Case Study: Exxon vs. New Hampshire MTBE contamination**

In Class Preparation for Real-Life Case Study

Review the main ideas and concepts from the assigned reading, engage in a brief discussion with the students and proceed to introducing the Exxon Mobile article when you are certain that students are clear on the basics of MTBE. Students should have a clear understanding of answers to the following questions:

1. What is MTBE? What is it used for?
2. What are its properties? In what ways is it toxic in large doses? Is it still toxic in small doses?
3. What are the federal regulations on MTBE?
4. What are some of the procedures for cleaning up water contaminated with MTBE?

After these questions have been clearly understood, introduce the following article to the students and have them read the article. Instruct them to pay close attention to the multiple perspectives offered in the article (the side of Exxon Mobil and New Hampshire State as well as the Federal Government).

“Court: Exxon Mobil Guilty In N.H. Contamination Suit” by Sam Evans Brown

After sufficient time has been given for students to analyze the article, have students gather in large circle for a classroom discussion. Begin the discussion with the following guiding questions and integrate student’s previous conceptual questions from the beginning of class individual writing activity.

1. What is the issue at hand?
2. Who is affected by the issue?
3. Who is involved? (Introduce multiple perspectives involving Exxon and NH)
4. What are your thoughts on Exxon’s attorneys’ statement: “The government essentially put us into a position where MTBE had to be put into the gasoline. We didn't have another choice.”
5. When does “not having another choice” in the case of an Oil Company triumph over public safety and preservation of the environment, if ever?
6. Whose fault is it? (involving the roles of the federal government, the public, the state, and Exxon)
7. Does Exxon have a good case?
8. **Final Individual Reflection Activity**

Have students reflect individually on the discussion through writing. Some questions to emphasize include - what were their ideas and concepts of water contamination and federal, public, corporate, and individual roles before and after participating in the real-life case study analysis. How did their previous viewpoints change? What are their new understandings? What are their thoughts on the case-study itself? Was it helpful in understanding the topics of discussion at hand? How is this case-study directly relevant to their own lives as residents of the US? Where were they stretched by the experience? What were their favorite and least favorite aspects of the activity? After students complete this assignment, collect their reflections for analysis and assessment.

**Suggested Homework Assignment:**

Explore Modules on water in the Earth, access to water, and watersheds

<http://ga.water.usgs.gov/edu/earthwherewater.html>

<http://www.unep.org/dewa/vitalwater/article194.html>

http://water.epa.gov/polwaste/nps/watershed/index.cfm

**LESSON 3 – ANALYSIS OF LOCAL WATERSHEDS AND LOCAL DRINKING WATER QUALITY**

**Objectives:**

* Students will understand and examine their local watershed through a Google Earth Web Based Activity
* Students will assess properties of their local watershed and compare it with a watershed form a different area in order to further understand distinctions between watersheds.
* Students will engage in a collaborative laboratory experiment analyzing chemical characteristics in local drinking water samples using water test kits.
* Students will analyze findings of experiment using scientific investigation and analysis. They will also analyze findings in context of federal regulations on chemical levels in water as determined by the EPA as well as compare the findings of the experiment with the local annual water quality report for further investigation of findings.
* Students will then speculate on next possible action steps involving community members and elected officials based on the findings of their experiment.

**Time:** One Session (3 hours)

**Resources:**

Earthlabs Project: What’s a Watershed? Google Earth Activity
Online Module: <http://serc.carleton.edu/eslabs/drought/2b.html>

Donald E. Keith, Ph.D, Professor of Biology Tarleton State University Laboratory Procedure: Procedure for Water Analysis Using Lamotte Water Test Kits

Federal Government Annual Drinking Water Quality Report: <http://water.epa.gov/drink/local/index.cfm>

Lamotte Water Test Kits

Online Modules:
<http://ga.water.usgs.gov/edu/earthwherewater.html>
<http://www.unep.org/dewa/vitalwater/article194.html>
http://water.epa.gov/polwaste/nps/watershed/index.cfm

**Suggested Procedure:**

1. **What’s a Watershed? Exploring Watersheds Activity[[2]](#footnote-2)**

Have students visit the following webpage and follow the instructions of the module.

<http://serc.carleton.edu/eslabs/drought/2b.html>

This module uses Google Earth, therefore the computers used should have Google Earth capability, otherwise, students may download the program and proceed with the instructions.

Have students explore their local watershed. Close attention should be paid to noticing the different aspects of the watershed involving streams, tributaries, landcover, drainage divides. To further extend the activity, have students compare their local watershed with a watershed in another region in the country or another region in another country.

As an extension of the Watershed exploration, students may also answer the questions from the Stop and Think Activity in the module in small groups.

Questions include (taken directly from Stop and Think activity on Module):

1. “What differences do you see in the landscape, landcover, and population densities near the areas' largest streams compared to its smallest tributaries?
2. Write a description of your watershed. Include information about the shape of the land and how the land is used.
3. What purposes do the dams in your watershed serve?
4. Indicate how the population density of the area changed from 1990 to 2000.
5. Briefly discuss some advantages and disadvantages of using drainage divides rather than rivers as political boundaries.”[[3]](#footnote-3)
6. **Drinking Water Analysis Experiment**

Have students break up into groups of 4 and use Lamotte Water Test Kits in order to conduct independent water quality analysis of local drinking water samples. This experiment may be later extended to analyze chemical characteristics of water samples from multiple sources including but not limited to – local rivers, streams, creeks, ponds, lakes, groundwater, etc. See the attached procedure compiled and created by Dr. Donale E. Keith.[[4]](#footnote-4)

Group 1 – test pH, alkalinity, and Chloride

Group 2 – test Iron and Hardness

Group 3 – test Nitrate, Ammonia, and Sulfides

Group 4 – test Phosphate and Dissolved Oxygen

Collect and compile results of experiment

Collect and compile results of experiment. Note specific values for pH, alkalinity, Chloride, Iron, Hardness, Carbon Dioxide, Nitrate, Ammonia, Sulfide, Phosphate, and Dissolved Oxygen levels. Compare the obtained levels with the National Primary and Secondary Drinking Water Regulations found on this link that students have previously explored in Lesson 1: <http://water.epa.gov/drink/contaminants/index.cfm>

Another Extension of the activity is to compare the obtained results with the local annual drinking water quality report, either obtained from local water filtration labs or from the following website: <http://water.epa.gov/drink/local/index.cfm>

Comparison should involve basic analysis of disparities or similarities in numbers with respect to safety levels as noted by the EPA. Is there a compound which is determined to be present in unsafe amounts? If such a compound is discovered, have the class speculate on some of the reasons that this may be so using knowledge and information from previous lessons.

See attached for an example of an annual drinking water report.

 Albany - <http://www.albanyny.gov/_files/2011AlbanyAWQR.pdf>

1. **Next Steps and Results**

Using the data collected, have students collectively brainstorm some action steps should action be necessary. Which experimental data collected call for deeper analysis? Are there unacceptable levels of certain metals or compounds present in either or even both the annual water report and the experimental results? What are some ways in which sustainable action may be taken involving both students and community – maybe involving contacting elected officials, contacting local water filtration companies, communicating with local pollution control or wastewater management organizations to further analyze results and address some questions and concerns.

**Suggested Homework Assignment:**

Watch the following interview with environmental activist Dr. Vandana Shiva

“The Roots of India’s Water Crisis”

<http://www.globalonenessproject.org/library/interviews/roots-indias-water-crisis>

Read the following NY Times Article on India’s Water Crisis: <http://www.nytimes.com/2006/09/29/world/asia/29water.html?pagewanted=1&_r=0>

Read pages p. 1-10 and 126 – 130 of Water and Women Report for the National Commission of Women by Dr. Vandana Shiva and Kunwar Jalees

Available at: <http://www.navdanya.org/attachments/Water_Democracy1.pdf>

**LESSON 4 – A SOCIAL JUSTICE APPROACH TO INDIA’S WATER CRISIS**

**Objectives:**

* Students will examine India’s water crisis through a scope of understanding of political climate, infrastructure, industrial activity, and social justice issues through film, writing, readings, discussion, and reflection in order to deepen and expand their understandings and diversify their interactions with the course content.
* Students will integrate topics of water contamination with women’s rights, human rights, national development through discussion and obtain holistic perspectives on the ethics of water.
* Students will participate in a final reflection that will allow students to connect their understandings of the course content to their own personal lives, making course content directly and personally relevant. They will also reflect on their own growth through the process.

**Time:** One session (3 hours)

**Resources:**

 Global Oneness Project Interview with Dr. Vandana Shiva - “The Roots of India’s Water Crisis”

Article by Somni Sengupta: “In Teeming India, Water Crisis Means Dry Pipes and Foul Sludge

Water and Women Report for the National Commission of Women by Dr. Vandana Shiva and Kunwar Jalees

**Suggested Procedures:**

1. **Individual Writing activity:**

Have students write 1-2 questions on the assigned readings and interview and identify points of confusion individually. Then, have students share their questions and address these questions collectively on the subject in preparation for the discussion below.

1. **Film Screening: “Drowned Out”**

Screen Franny Armstrong’s documentary: “Drowned Out: The Truth Will Out”

1. **Formal Discussion on “Drowned Out” Dr. Shiva Interview, and Assigned Readings**

After addressing some of the common points of confusion and uncertainty in the students experience of completing the assigned readings and viewings, arrange for a broader large circle discussion using the following questions as guides:

1. What are some of the unsustainable water technologies that Dr. Shiva talks about which contribute to India’s water crisis?
2. What is the role of industry in contamination of groundwater in India? How does this connect to what we learned about industry in the U.S. in Lesson 1.
3. Which industries specifically are involved in the contamination and pollution of water resources?
4. What are the assaults on and issues directly associated with major rivers such as the Yamuna in India as discussed in Dr. Vandana’s interview as well as in the NY Times article?
5. What is the role of women in distribution and collection of water in India? What are some of the challenges that are faced specifically by women as discussed in the *Water and Women* report as well as the NY Times article?
6. What is the connection between climate change and the water crisis?
7. What are the similarities between Dr. Vandana’s statements in her interview and the NY Times article?
8. What is your answer to Sunny Verma’s question, “This river is worshipped, is this the right way of worshipping it?”
9. What are the similarities and differences between America’s water problems we have discussed in the previous days and India’s water crisis?
10. What are some resolutions to India’s water problems pertaining to industrial abuse, lack of infrastructure, lack of political focus on the issue, and improper distribution?
11. Can/should water be owned? See Human Rights chapter from the Women and Water report.
12. What are some action steps we can take immediately in order to abide by principle 8 from the Human Rights section of the Women and Water report: “No one has the right to overuse, abuse, waste, or pollute water systems.”
13. What are ways water is currently treated as a commodity and why is this dangerous?
14. **Final Individual Reflection Activity**

Have students reflect individually on the discussion and film through writing. Some questions to emphasize include - what were their ideas and concepts of India’s water crisis on the federal, corporate, and public level before and after participating in discussion and viewing the film. How did their previous viewpoints change? What are their new understandings? What are their thoughts on the film or discussion? Was it helpful in understanding the topics of discussion at hand? Where were they stretched by the experience? What were their favorite and least favorite aspects of the discussion? After students complete this assignment, collect their reflections for analysis and assessment.

WORKS CITED

**LESSON 1**

Stanley E. Manahan. *Water chemistry: green science and technology of nature's most renewable resource*. CRC PressI Llc, 2011.

*Water: The World of Chemistry*. Perf. Roald Hoffman. University of Maryland and the Educational Film Center, 1990. DVD.

**LESSON 2**

Brown, Sam E. "Court: Exxon Mobil Guilty In NH Contamination Suit." *NPR*. National Public Radio, 10 Apr. 2013.http://www.npr.org/2013/04/10/176758081/court-exxon-mobile-guilty-in-n-h-contamination-suit. 12 Apr. 2013.

Dowling Fink, Alix D. *The Power of Water Course Syllabus*. *SENCER*. Longwoods University, n.d. Web. 12 Apr. 2013. <http://serc.carleton.edu/sencer/power\_water/the\_course.html>.

**LESSON 3**

Keith, Donald E. *Procedures for Water Analysis Using Lamotte Water Test Kits*. *Http://www.tarleton.edu/Faculty/dekeith/dekeith.html*. Tarleton State University, n.d. Web. 12 Apr. 2013.

What's a Watershed? Explore You Watershed in Google Earth." Earth Labs in Carleton College. Carleton College and National Oceanic and Atmospheric Administration, n.d. Web. 12 Apr. 2013. <http://serc.carleton.edu/eslabs/drought/2b.html>.

**LESSON 4**

Sengupta, Somini. "In Teeming India, Water Crisis Means Dry Pipes and Foul Sludge." (2006).

"The Roots of India's Water Crisis." Interview. *Global Oneness Project*. Global Oneness Project, n.d. Web. 12 Apr. 2013. <http://www.globalonenessproject.org/library/interviews/roots-indias-water-crisis>.

Shiva, Vandana, and Kunwar Jalees. *Water & Women: A Report by Research Foundation for Science, Technology, and Ecology for National Commission for Women*. Navdanya/RFSTE, 2005.

Armstrong, Franny. "Drowned Out: The Truth Will Out." *The Guardian* 26 (2002).

1. Dowling Fink, Alix D. The Power of Water Course Syllabus. SENCER. Longwoods University, n.d. Web. 12 Apr. 2013. <http://serc.carleton.edu/sencer/power\_water/the\_course.html>. [↑](#footnote-ref-1)
2. "What's a Watershed? Explore You Watershed in Google Earth." *Earth Labs in Carleton College*. Carleton College and National Oceanic and Atmospheric Administration, n.d. Web. 12 Apr. 2013. <http://serc.carleton.edu/eslabs/drought/2b.html>. [↑](#footnote-ref-2)
3. "What's a Watershed? Explore You Watershed in Google Earth." *Earth Labs in Carleton College*. Carleton College and National Oceanic and Atmospheric Administration, n.d. Web. 12 Apr. 2013. <http://serc.carleton.edu/eslabs/drought/2b.html>. [↑](#footnote-ref-3)
4. Keith, Donald E. *Procedures for Water Analysis Using Lamotte Water Test Kits*. *Http://www.tarleton.edu/Faculty/dekeith/dekeith.html*. Tarleton State University, n.d. Web. 12 Apr. 2013. [↑](#footnote-ref-4)