What is in that Water?

Bacterial Load and Water Quality Experiment

Grade Level:
6-12

Subject Area:
Biology, Ecology, Environmental Science, Aquaculture, Agriculture, Social Studies

Time:
4-50 minute periods with 30 minutes/day for experimental procedure
*Bacteria test strips must be incubated at least 24-36 hours for observable growth to appear

Student Performance Standards (Sunshine State Standards):
01.04 Examine the role of the agricultural industry in the interaction of population, food, energy, and the environment (SC.912.E.5.7; SC.912.L.14.1; SC.912.L.15.13; SC.912.L.17.1, 5, 13, 18, 20; SC.912.N.4.2; MA.912.A.2.1; MA.912.S.3.1, 3).
02.02 Demonstrate proper safety precautions and use of personal protective equipment. (SC.912.L.14.6, SC.912.L.16.10; SC.912.L.17.12, 14, 15, 16; MA.012.A.2.1, 2)
03.02 Demonstrate safe and effective use of common laboratory equipment (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.14.6SC.912.L.16.10; SC.912.L.17.12, 14, 15, 16; MA.912.A.2.1, 2)
03.06 Interpret, analyze, and report data (SC.912.L.16.1; SC.912.N.1.1, 2, 3, 4, 6, 7; SC.912.N.2.2, 5; SC.912.N.3.1; SC.912.N.4.1; MA.912.S.3.1, 2; MA.912.S.4.2; MA.912.S.5.1, 2, 3, 4, 5)
12.01 Recognize and observe safety practices necessary in carrying out aquaculture activities (LA.910.1.6.1, 2, 3, 4, 5).
13.01 Identify and describe the qualities water should possess for use in aquaculture (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.17.In.a).
13.02 Explain how changes in water affect aquatic life (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.17.2, 3, 7, 10)
13.03 Explain, monitor, and maintain freshwater/saltwater quality standards for the production of desirable species (LA.910.1.6.1, 2, 3, 4, 5; LA.910.2.2.2).
13.05 List and explain sources of aquaculture pollution and methods of preventing and/or correcting these pollution problems (SC.912.L.17.9, 11, 12; MA.912.G.2.7; MA.912.A.10.2).
14.01 Identify factors to consider in determining whether to grow an aquaculture species (LA.910.1.6.1, 2, 3, 4, 5; MA.912.G.2.5; MA.912.G8.3, 6; SC.7.L.17.3)
16.04 Identify water quality problems (SC.7.E.6.6).
16.05 Determine quality of water and practice recommended solutions where needed

(SC.912.L.17.9, 11, 12; MA.912.G.2.7; MA.912.A.10.2).

Objectives:

1. Students will be able to explain the importance of bacteria in aquaculture.
2. Students will be able to explain the impact of bacteria in the water on human health.
3. Students will be able to conduct an experiment testing for bacterial levels in water.
4. Students will be able to describe the colony growth of bacteria from various water samples.
5. Students will be able to analyze bacterial growth before and after sanitation using UV light.
6. Students will be able to graph results.

Abstract:

This module will enforce science process skills and train students to use these science skills within the “Water for Life” module, which highlights the topic areas on bacterial life in the water, water borne pathogens, and water sanitation. The module also relates the importance of understanding these topics within the context of aquaculture. Students will be exposed to and learn about the importance of water to life on earth, the concerns with water borne pathogens worldwide, and processes of water sanitation by conducting activities and an experiment on water sanitation and UV sterilization. In this experiment students will learn about bacteria and its helpful and harmful influence in the lives of humans. The bacteria that reside in water can be the driver of the biological filtration in a pond by breaking down waste and dead animals. The major objectives covered through this experiment include not only learning about water sanitation and public health, but also about bacteria populations normally present in the environment. This lesson can also have extensions to learning about the current state of water sanitation in the developing world and the importance of bacteria in aquaculture systems. Students will culture bacteria and find out the total bacterial load in four water samples from different sources. They will then expose the water sample to a source of UV light either from a portable UV light or from the Sun. They will then retest the water to see the change in amount or total number bacteria. A further extension of the experimental method could be to compare different methods for sanitizing and filtering water and determining the variable success of each method.

Interest Approach:

Did you know? Test your water IQ.

1) Less than _____?_____ of the world's fresh water is readily accessible for direct human use.
2) A person can survive weeks without food, but only _____?_____ without water.
3) A person needs _____?_____ gallons of water a day to meet basic needs.
4) The average American family uses _____?_____ gallons of water at home each day. The average African Family uses about _____?_____ gallons of water each day.
5) Each year more than _____?_____ million people die from water-related diseases.
6) This organism called _____?_____ breaks down waste in a pond.

This was part of an extension activity which was a webquest of not- for-profit and governmental websites on water.

Answers:
1) 1%
2) days
3) 13.2 gallons (includes cooking and basic sanitation)
4) 100-176 gallon; 5 gallons
5) 3.5
6) decomposers/detritovores

Student Materials:
1. Bacterial test strip
2. Water sample
3. Bacterial number conversion chart
4. Gloves
5. Lab sheet/lab notebook
6. UV light (or go outside to a place in the sun)

Teacher Materials:

Material	*Store*	*Estimated Cost*
*Four sets of Bacterial test kits (each kit comes with 10 agar/fungal media strips, this equates to ~20 groups with two test strips per group, can accommodate 80 students if	See below	See below

you have 20 groups with 4 students/group)		
20 water samples from four different locations (5 from each location)	NA	Free
UV light water sanitation device	Camping store	$75 and up
Outdoor sunlight	NA	Free
Bacterial number conversion chart (with purchase of bacteria media strips)	NA	NA
Sterile 50 ml water sample vials	See below	See below
Optional incubator	Carolina Biological	$365 and up

*$14-$30/kit x 4 kits = $60-$120 + shipping/handling
This provides a total of 40 media strips. Enough for 1 before test and 1 after test for

Listed are several options for places to get materials:

1. Accepta Advanced Environmental Technologies-media strips
   http://www.accepta.com/default.asp
   $18 (9.77 L) fro 10 tests/kit
2. Bugcheck bacterial and fungal media test kits
   Avalon International Corp. 847-446-9986/fax: 847-446-9946
   http://www.bugcheck.us/
   $30 for 10 tests/kit
3. SteriPen UV light for water sanitation (OPTIONAL…can use sun)
   http://www.steripen.com/testing.html
4. 50 ml sterile vials for water sample collection (OPTIONAL…can use sterile DI water)
   http://www.bmres.com/catalog/catalog/product_info.php?products_id=29


Bacterial test kit

Portable UV light

Optional incubator

Student Instructions:

1. *Experimental Procedure*
   Purpose: To examine the total bacterial load in different types of water and how the numbers of bacteria are affected by exposure to UV rays.
2. *Question*
   How is the amount of bacteria in different types of water affected by solar disinfection process? Types of water include tap water, toilet water, aquaculture tank water, and pond water.
3. *Hypothesis*
   Choices for your hypothesis:
   A. If the water is taken from an area where it is not filtered or treated like a lake or pond, then the water will have high bacterial numbers.
   B. If the water is taken from an area where it is filtered or goes through water treatment then the total number of bacteria will be lower.
   C. If "solar sanitation" works as a method of sanitation, then the number of bacteria present before the testing will be reduced in all samples of the water after exposure to radiation and heat.
   D. If I change the type of water used in the sanitation process then the _____?_____ water with the greatest amount of bacteria will be sanitized the most because _____?_____. (Hypothesis designed with students)
4. *Independent Variable*
   Water samples to be used in the disinfectant process: toilet water, tap water, fish tank water, and pond water.
5. *Dependent Variable*
   Amount or number of bacteria present (colony forming units) in each sample.
6. *Constants*
   A. method of water collection
   B. same type of bottle for each water sample
   C. same amount of time of exposure to solar radiation
   D. same procedure for testing the number of bacteria

   E. same environment placed outside
   F. same amount of water in each bottle
   G. same temperature of water in each bottle
   H. same pre-sample preparation
   I. same amount of time exposed to air during collection of sample

7. *Experimental Procedure DAY 1*
   A. Label the bacterial test strips with the water sample type and the class period. Labe it with a B for water that checked BEFORE it was placed in the sun or exposed to UV light.
   B. Take the bacterial test strips and remove the paddle from the tub. DO NOT TOUCH THE PADDLE SURFACE WITH YOUR HANDS. See figure 1.

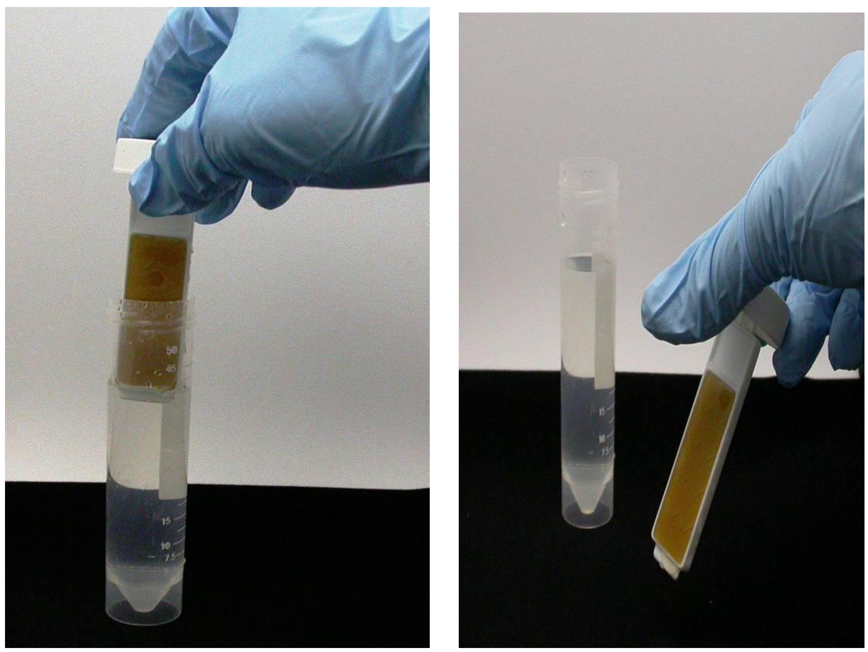


Figure 1: Method for dipping bacterial strip into sample water and returning to container.

   C. When removing cap from water sample be careful not to touch the inside of the cap and when dipping the bacterial test strip, lay the cap on its topside.
   D. Dip the paddle into the water sample for 2-3 seconds. Allow excess water to drain onto a paper towel, but do not place the paddle onto the towel.
   E. Return the paddle to the tube.
   F. Wait 24-36 hours (incubation) for the paddle to grow bacteria.
   G. Replace lid.

8. *Experimental Procedure DAY 2*
   A. Retrieve water sample that has been exposed to sun or UV rays.
   B. Dip the new bacterial test strips into the water that has been exposed to UV rays using a UV light. Take remaining water samples and expose to

UV light. See figure 2.

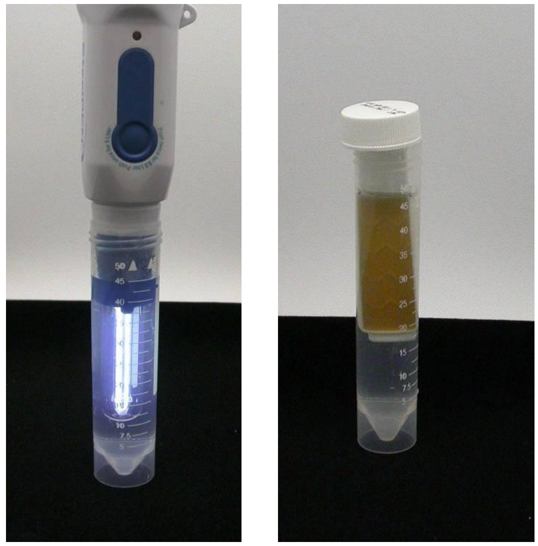


Figure 2: Method for exposing water to UV light using a portable UV light. A new strip is then dipped in the newly disinfected water.

C. Open water sample. Place lid of water sample upside down to avoid contamination. Take top off UV light and press the button on the outside until it flashes green.
D. Insert UV light into the water with the metal prongs on the light fully inserted. Gently rotate the light in the water sample.
E. Leave in water sample with the UV light until UV lamp goes off and green LED light on the button comes on.
F. Return the paddle to the tube. Label the new tube with your correct water sample.
G. Wait 24 hours (incubation) for the paddle to grow bacteria.
H. Review DAY 1 bacterial samples growth. Draw a picture of the bacterial growth on the paddle. Look at the key to determine the bacterial numbers. Match your paddle to the picture below (support materials) to determine colony forming units and total numbers of bacteria per milliliter.
I. Write results in provided format in the lab notebooks.

9. *Experimental Procedure DAY 3*
   A. Review growth from DAY 2 UV water experiment.
   B. Review growth from DAY 1 pre-UV water treatment.
   C. Review fungal growth.
   D. Record observations. See the provided template.
10. *Format for writing lab results*
    Divide notebook paper into four sections

Water Sample Source: ____________________

DAY 2 Observations: Bacterial growth **before** exposure to UV rays. Count Colonies _______ Numbers of bacteria _______	DAY 3 Observations: Bacterial growth **after** exposure to UV rays. Count Colonies _______ Numbers of bacteria _______
Number of colonies _______ Number of fungus _______ Fungal Growth Before	Number of colonies _______ Number of fungus _______ Fungal Growth After

Class bacterial samples (Continue above format)

Water Sample Source: ____________________

DAY 2 Observations: Bacterial growth **before** exposure to UV rays. Count Colonies _______ Numbers of bacteria _______	DAY 3 Observations: Bacterial growth **after** exposure to UV rays. Count Colonies _______ Numbers of bacteria _______
Number of colonies _______ Number of fungus _______ Fungal Growth Before	Number of colonies _______ Number of fungus _______ Fungal Growth After

Teacher Instructions:

Preparations:

Lesson Plan and Experiment Design:

This lesson plan experiment requires water from 4 different locations expected to have different numbers of bacteria. The bacteria is then cultured or grown and one method (the use of UV light) is examined for reducing the total number of bacteria in a water sample.

Advance Preparation: Teacher Pre-experimental preparation

1. Collect 4 different water samples using sterile water bottles.
2. To sterilize just take unopened water bottle and open, cleanse with alcohol, and rinse with sterile water deionized water Then dip bottles into source water, cap under water, and label with a notation from wherever you collected. For making this easier collect one 2-liter water sample from each of

the four locations in a sterile 2 liter bottle. Then divide samples out into smaller sterilized water bottles or water containers so that each group has their own water sample.

3. Collect enough water for each group to have their own sample to examine. Then the class can share their findings.

(Water collected for this experiment was taken from a toilet, the tap, an aquaculture tank or fish tank, and from a pond source.)

The experiment can be modified to use the natural sunlight as the source of UV light instead of a portable UV light. This method is called Solar Water Disinfection, which uses the solar UV from UV-A spectrum of light (wavelengths of 320-400nm) and the increased water temperature to kill pathogenic organisms found in water. This method is commonly used in developing countries to disinfect small quantities of water before consumption. Perform the experiment above in exactly the same manner except place the water samples outside in full sunlight instead of using the portable UV light.

Use plastic bottles made of PET (PolyEthylene Terephatalate) and place water sample inside bottle. Place the plastic bottles containing the sample water on a metal sheet like a cookie sheet and place on a raised stool or chair. Expose the bottles to full midday early summer late spring sunshine (April, May, June or August, September). Ambient temperature outside should be 75° F. The infrared radiation will raise the water temperature to 70°C- 75°C, which is also known as pasteurization.

Activity:

Teachers will need to first demonstrate the procedure for the students and emphasize the importance of the students not contaminating the samples by placing their finger in the water or on the media sample. If the outside UV light from the sun is utilized the teacher will need to supervise the students placing the water samples outside.

Post work/Clean-up:

Minimal clean up is required. Collect all the labeled water samples from the students and all of their labeled bacterial test strips. Keep the bacterial test strips away from the air-conditioning unit in a warm, dry place. Replace materials for the next class period. At end of the entire experiment after bacteria has been cultured you can dispose of it by soaking strips in a strong bleach and water solution. This will kill all of the cultured bacteria and dissolve the media. The bleach/water solution can be disposed off down the drain and the cleaned media strips can then be thrown away. Pour water samples down the drain.

Anticipated Results:

Expected results

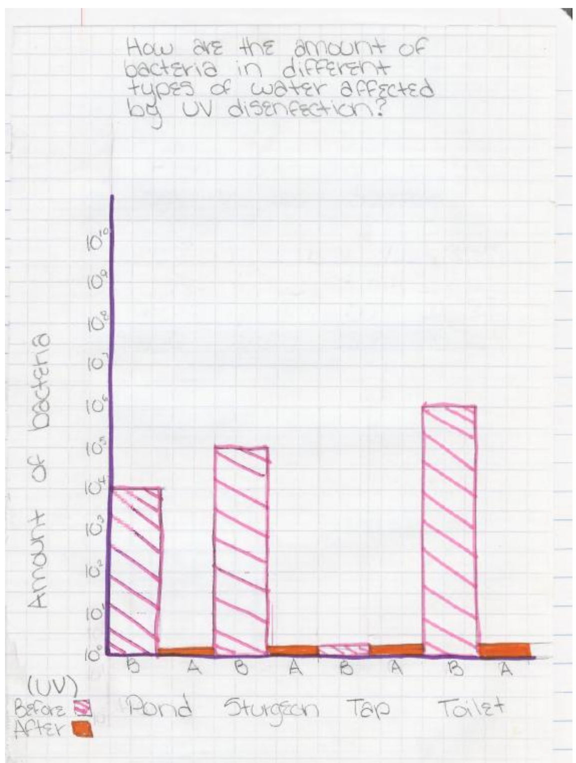
Aquaculture tank Pond Tap Toilet Control

Expected results after exposure to UV light:

Aquaculture tank Pond Tap Toilet Control

A closer look:

Aquaculture tank water sample before and after exposure to UV light. The bacterial load is very high in the water sample, prior to being exposed to UV radiation.



This student's graph details how to compare the results as a class. The amount of bacteria was graphed after the students interpreted the test strips. The first test strip interpreted as a group was the total bacterial load. For the second part of the experiment the amount of bacteria in the water was interpreted, after the water was exposed to UV radiation. In this case, the labeled aquaculture tank was sturgeon (species inside the tank), the other samples from the analysis as pond, tap, and toilet. Toilet water may not always have a high bacterial load, in this particular case the toilet water was loaded with bacteria pointing to a lapse in the cleaning staff for the building.

Support Materials:

1. Teacher's Background
2. List of References and Resources
3. Key for bacterial growth analysis
4. Supplementary Web Quest Activity
5. Student Writing Activity
6. Quick Guide Brochure
7. SODIS/UV Sterilization Manual
8. PowerPoint for Module

Explanation of Concepts:

Importance of water to life
Water sanitation procedures
Global issues of access to clean water
Importance of bacteria to water

Support Materials

Teacher Background

" What is in that water? Bacterial load and Water Quality Experiment."

Title for Lesson Plan: What is in that Water? Bacterial Load and Water Quality Exploration.
Grade Levels K-12: 6-12
Subject Areas: Life Sciences (Biology, Ecology, Environmental science) Aquaculture, Agriculture, Social Studies.
Main Concepts: Sanitation, Waterborne diseases, Microorganisms, Water Use
Topics: Resource Use, Water Cycle, Disease, Sanitation, Public Health
Key Vocabulary: Water Sanitation, Hygiene, Water borne diseases, Microorganisms
Skills: Reading, Research, Scientific Method,
Learning Styles: Visual, Kinesthetic, Auditory
Indoors or Outdoors: indoors
Estimated duration of activity: 4 days, 30 minutes a day for experimental procedure, last day closing and data analysis, 50 minutes
Group size: Groups of 4 students
Florida Science Standards: SC.912.L.16.4 , SC.912.L.16.9 , SC.912.L.17.17, SC.912.L.17.16, SC.912.L.18.12
National Science Standards:
Content standard F: Personal and Community
Health; Content Standard C: The interdependence of organisms.

Key Questions: Why do we need clean water? How can bacteria we ingest cause disease? How can we make water safe to drink? Do all countries have safe drinking water? How does the United States differ from other countries in water sanitation? How does UV light kill bacteria? What is SODIS? Are bacteria needed in the water?

Lesson Summary:

In this experiment students will learn about bacteria and its helpful and harmful influence in the lives of humans. In staying the concept the module "Water for Life", this experiment will show that life in water extends to the world of bacteria. The bacteria that reside in water can be the driver of the biological filtration in a pond by breaking down the waste and dead animals. The major objectives covered through this experiment include not only learning about water sanitation and public health, but also about bacteria populations normally present in the environment. This lesson can also have extensions to learning about the current state of water sanitation in the developing world. Students will culture bacteria and find out the total bacterial load in four water samples from different sources. They will then expose the water sample to a source of UV light either from a portable UV light or from the Sun. They will then retest the water to see the change in amount or total number bacteria. A further extension of the experimental method could be to compare different methods for sanitizing and filtering water and determining the variable success of each method.

Background Information:

Water is essential for all life. But it remains a limited resource with around 70% of the earth covered in water, but less than 1% available for direct human use. So how much water do we need and how does our consumption compare to other countries? How much water in the world is available for human use? Most students are not aware of the global impact that comes with poor access to clean water and sanitation. Many problems face both the nations and individual communities that face water scarcity, contamination, unsustainable uses of water, and ecological degradation that often comes with development. The most basic of all of these problems is the failure to provide billions of people with water that is safe to drink. According to both the World Health Organization and UNICEF approximately 18 percent of the world's population lack access to safe drinking water this equates to about 1.1 billion people (WHO, 2004). A second problem facing many developing nations is that they lack access to basic sanitation. Around 2.6 billion people lack access to sanitation, which includes the ability to have water for washing and disposal of waste. The UN has provided initiatives in its development goals for the world that analyze the problems facing these countries. Africa suffers with the greatest lack of infrastructure for proper water sanitation with only 36% coverage and the lowest levels in Sub-Saharan Africa.

The world concern for clean water:

The world populations as a whole, lack sufficient water supply and sanitation (Mara and Horan, 2003). The UN Millennium Development Goals made it a priority to move toward reducing the number of people without access to safe drinking water by 2015 (UN, 2000). However, this goal has been harder to achieve in countries were scarcity of water and no network of sanitation protocols of water in place. Over 90% of sewage in developing countries is released untreated, which has major consequences not only on people's health, but also on the environment through pollution of lakes, streams, and coastal areas (Langergraber and Mulleger, 2005). Sanitation in the context of water is defined as the safe handling and disposal of human excreta (Avvannavar and Mani, 2008). As a result of poor sanitation diarrheal diseases are the leading cause of morbidity and mortality in children under 5 in the developing world (UN, 2000). Part of the lack of sanitation is compounded by the lack of facilities for water to be allocated to the household or livestock. In Sub-Saharan Africa millions of people have to share their water resources with livestock that can lead to a breeding ground for pathogens (Human Development Report, 2006). There are thousands of bacteria that can inhabit water and many other waterborne pathogens such as viruses and protozoan infections. Disease can be caused by ingesting the drinking or recreational water that contains Giardia, Crytosporidium, Salmonella, E.coli, Vibrio, and other major pathogens (Tepliski and Butler, 2008).

How do we monitor and test water for bacteria?

There are many ways in which water is tested in the developed world to insure its safety for consumption. One such way is through the presence and absence of fecal coliform bacteria. Fecal coliforms include species in the genera *Enterobacter*, *Escherichia, Hafnia, Klebsiella, Citrobacter, Yersinia, and Serratia* (Mara and Horan, 2003). Do not let the names confuse you since essentially bacteria in this group are generally of fecal origin and most are principally Escherichia coli or E. coli.

One method for measuring and estimating the number of live heterotrophic bacteria in water is a heterotrophic plate count in which water from a sample is taken and diluted with pure sterile water and mixed with agar media before being poured into a petri plate. Agar plates are then incubated and colonies of bacteria are enumerated (method summary from Standard Methods Examination of Water and Wastewater). A simplified method for total bacterial load includes use of a dip paddle that contains a bacterial growth media on one side and a key for numerating the numbers of total colony forming units or CFUs. Since bacteria can't be seen with the naked eye they are difficult to count unless many of them grow together and form a colony of bacteria. Then the colonies are counted and this number is extrapolated to give the total amount of bacteria in one milliliter of sample water.

The importance of bacterial testing in aquaculture water:

Aquaculture is the practice of farming or cultivating aquatic animals. This industry has seen much growth in recent years and is currently providing approximately 53% of all fisheries products (SOFIA, 2006). Aquaculture can also provide a great opportunity to relate the science behind water to the students and help them understand the importance of maintaining good water quality. Aquaculture management also uses many of the same concepts in water sanitation and water quality to maintain the organisms that they are raising whether they are for food or for aquariums.

Microbial food webs are crucial to many aspects of aquaculture specifically pond aquaculture. The main reasons for the necessity of bacteria in pond and intensive aquaculture is that bacteria along with algae have direct influence on the oxygen content of the water (Moriarty, 1986). While algae produce oxygen with photosynthesis during the daylight, bacteria are the predominant oxygen consumers and respirators. Bacteria also help to fix the nitrogen in the form of toxic unionized ammonia from fish waste that has been excreted, and process it to a less toxic compound. This means that bacteria are beneficial biological filters for the water. Bacteria can also directly influence the productivity of a pond food web. They serve a role as both decomposers and help to recycle nitrogen and phosphorus crucial to primary production (Moriarty, 1997).

Other pathogenic bacteria can cause problems in an aquaculture facility like those in the genus of *Vibrio, Pseudomonas,* and *Alteromonas.* As a result of the great density of fish in many aquaculture facilities many aquaculturalists have established methods to control bacterial populations such as the use of salt, ozone, ultraviolet light, and food containing antibiotics (Maeda et. al., 1997).

How do we clean water?

In more industrialized nations the problem of cleaning our water has been the responsibility of the local municipal public works. For example a common way that water is treated follows the procedure below. First raw water is pumped from the aquifer or reservoir. Chlorine, which is an oxidative chemical, is then added to the raw water to remove noxious gasses such as hydrogen sulfide are removed. The reason that chlorine is added as is seen to be effective at eliminating many pathogens is because chlorine can negatively affect cell processes and DNA activity (Haas and Englebrecht, 1980). In Florida the water is softened often by the addition of lime. Carbon Dioxide is added to lower the pH and in some cases fluoride is added to reduce and prevent tooth decay. Water is then filtered to removed bacteria and more chlorine is added to the filtered water.

Another method of water disinfection and often part of the sanitation process is the use of UV radiation. Many aquariums and aquaculture facilities employ the use of large UV lights that water flows by in order to disinfect the water before circulation through the tanks. UV radiation as a disinfection method works by damaging the nucleic acids in the DNA in many pathogenic bacteria.

Resources and References

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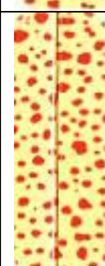
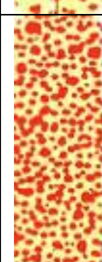
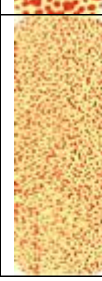
World Health Organization and United Nations Children’s Fund Joint Monitoring Programme for Water Supply and Sanitation. 2008. Progress in Drinking Water and Sanitation with focus on sanitation. UNICEF New York and WHO Geneva.

Websites:

http://www.unicef.org/wes/

KEY FOR BACTERIAL GROWTH ANALYSIS.

Industry standard for measuring the total bacteria per volume. This pictorial guide shows the general amount of colonies present and how the total number of bacteria per milliliter represents this. This is based on growth CFUs/mL or colony forming units.

Bacteria/ mL 10^3 or 1000	
10^4 or 10,000	
10^5 or 100,000	
10^6 or 1,000,000	
10^7 or 10,000,000	

Supplementary Webquest Activity

We Need Clean Water Webquest

Title for Lesson Plan: We Need Clean Water Web Quest
Grade Levels K-12: 6-12
Subject Areas: Life Sciences (Biology, Ecology, Environmental science) Aquaculture, Agriculture, Social Studies.
Main Concepts: Sanitation, Waterborne diseases, Microorganisms, Water Use
Topics: Resource Use, Water Cycle, Disease, Sanitation, Public Health, The scientific process ,Characteristics of living things, Cells and Cell theory,Human Impact on the Environment
Key Vocabulary: Water Sanitation, Hygiene, Water borne diseases, Microorganisms
Skills: Reading, Research, Synthesis
Learning Styles: Visual, Kinesthetic, Auditory
Indoors or Outdoors: Indoors (Computer Lab)
Estimated duration of activity: 75 minutes (10 minutes introduction of web quest directions, 50 minutes of computer time, 15 minutes review of answers and discussion of major concepts).
Group size: Individually or in pairs.
Florida Science Standards: SC.912.L.16.4 , SC.912.L.16.9 , SC.912.L.17.17, SC.912.L.17.16, SC.912.L.18.12
National Science Standards: Content standard F: Personal and Community Health; Content Standard C: The interdependence of organisms.

Key Discussion Questions: Why do we need water for life? How much water do we use? Why does drinking water have to be clean? What kind of diseases can we get from unclean water? Does everyone in the world have access to clean water?

Lesson Summary: This lesson in the 'Water Life Test' module is a way to introduce the importance of having access to clean water. The context of this lesson is that students will do guided research on the concepts of water sanitation, waterborne disease, microorganisms, and the importance of water to human health. This will also take on a global context when comparing water use of the average American to that of an African family. Students will be asked to go on a research quest through the web and fill in the blanks by navigating to each URL and reading the appropriate information. For several of the questions students will have to not only fill in the blanks but synthesize their own answer from context clues on the appropriate website. This lesson works to introduce the students to importance terms in water sanitation, the problems associated with unclean water, and lack of worldwide access to water. However, to have the greatest impact of students finish with a discussion of the answers they found on the web.

Student Learning Objectives:

- Students will navigate through several governmental and non-profit websites on water availability, water sanitation, and water facts.
- Students will paraphrase material from the various websites in this worksheet that relate to the fill in the blank questions of water sanitation.

- Students will analyze the water facts found from the web quest in a group discussion session and become familiar with using a range of scientific vocabulary and terminology consistently.

Material: Access to internet connection for each student or student pair.

Background Information:

Water is essential for all life. But it remains a limited resource with around 70% of the earth covered in water, but less than 1% available for direct human use. So how much water do we need and how does our consumption compare to other countries? How much water in the world is available for human use?

Most students are not aware of the global impact that comes with poor access to clean water and sanitation. Many problems face both the nations and individual communities that face water scarcity, contamination, unsustainable uses of water, ecological degradation that often comes with development. The most basic of all of these problems is the failure to provide billions of people with water that is safe to drink. According to both the World Health Organization and UNICEF approximately 18 percent of the world's population lack access to safe drinking water this equates to about 1.1 billion people (WHO, 2004). A second problem facing many developing nations is that they lack access to basic sanitation. Around 2.6 billion people lack access to sanitation which includes the ability to have water for washing and disposal of waste. The UN has provided initiatives in its development goals for the world that analyze the problems facing these countries. Africa suffers with the greatest lack of infrastructure for proper water sanitation with only 36% coverage and the lowest levels in Sub-Saharan Africa. This web quest activity involves students in introductory research to the topics of water resources, water availability, and water sanitation.

Advance Preparation: Make sure to visit each site listed below to ensure that school internet use policies do not accidently block access to any of the internet sites.

Sites to visit:

1. http://esa.un.org/iys/water_quality.shtml
2. http://www.wateryear2003.org/en/ev.php-URL_ID=1600&URL_DO=DO_TOPIC&URL_SECTION=201.html
3. http://www.water.org/waterpartners.aspx?pgID=916

Procedure: Students will research water sanitation, water borne disease, and water availability through a web quest that will strengthen their ability to access information in an online format, perform comprehensive research, and serve as an introduction to the 'What's in that water' lesson plan two background information.

Assessment Suggestions: The worksheet for the web quest can be graded as a small quiz grade or participation grade.

Extensions: Have students go more in depth with their research and discuss the findings from within the websites listed. They contain much more information relevant to the topics than was outlined in the web quest.

References:

World Health Organization. 2004. Water, Sanitation, and Hygiene Links to Health Fact Sheet.
http://www.who.int/water_sanitation_health/publications/facts2004/en/index.html

Name: _________________________

Go to the websites listed and answer the various questions or fill in the blanks or answer from the websites you are directed to go to.

First website: http://www.water.org/waterpartners.aspx?pgID=916

Drinking Water Facts

1) Less than ____________ of the world's fresh water (or about 0.007% of all water on earth) is readily accessible for direct human use.
2) A person can live weeks without food, but only ____________ without water.
3) A person needs ____________ gallons of water a day to survive.
4) The average American individual uses ____________ gallons of water at home each day. The average African Family uses about ____________ gallons of water each day.
5) Each year more than ____________ million people die from water-related disease

Sanitation Facts

6) The Year 2008 is the International Year of Sanitation. Its five key messages are:
    a. Sanitation is vital for human health
    b. Sanitation generates economic benefits
    c. Sanitation contributes to dignity and social development
    d. Sanitation helps the environment and
    e. ___________________________________.
7) ____________ percent of cases of diarrhea worldwide are attributable to unsafe water, inadequate sanitation or insufficient hygiene. These cases result in ____________ deaths each year, most being the deaths of children.
8) What does sanitation mean? **Hint: Look up on the WEB and write answer!**

Go to this website: http://esa.un.org/iys/water_quality.shtml

9) ____________, ____________, and ____________ from human excreta (poop) enter the environment, where they might remain for some time in water or soil. By drinking contaminated water, or eating food that has been irrigated with untreated water, these microorganisms infect people, who in turn will contaminate the environment via their ____________ and/or urine.

Go to this website: http://www.wateryear2003.org/en/ev.php-URL_ID=1600&URL_DO=DO_TOPIC&URL_SECTION=201.html

10) Water-borne diseases include ____________, typhoid, bacillary dysentery, polio, meningitis, hepatitis A and E and diarrhea, among others. These are diseases caused by ____________ water, and most can be prevented by treating water before use.

Student Writing Activity

Water Sanitation Article for the Student Based Essay

Vocabulary

Waterborne diseases: caused by the ingestion of water contaminated by human or animal feces or urine containing pathogenic bacteria or viruses; include cholera, typhoid, amoebic and bacillary dysentery and other diarrheal diseases.

Water-based diseases: caused by parasites found in contaminated water; include giardia, dracunculiasis, schistosomiasis, and other helminths.

Water-related diseases: caused by insect vectors, especially mosquitoes, that breed in water; include dengue, filariasis, **malaria**, onchocerciasis, trypanosomiasis and yellow fever.

Parasites: require a host to live and often cause damage or sickness to the host.

Sanitation: Application of measures designed to protect public health and reduce the number of disease causing agents. This often includes the disposal of sewage and other materials that are unsafe to human health.

Pathogen: any disease causing agent such as microorganisms like bacteria, viruses, and parasites.

Fecal coliform bacteria: bacteria commonly found in the digestive tracts and feces of humans and animals.

Water is essential for survival of all humans. We need it to drink and maintain our bodies, we need it to give to our crops and animals, we need it to maintain clean homes and bodies, and we need it for many, many industries. Think about it…without Water there is no LIFE. One problem that arises is that many countries do not have access to water or they do not have access to clean water.

In the United States we have large wastewater treatment plants and standards for clean water set by the EPA or Environmental Protection Agency. We also made a law that protects and requires that our water be clean for drinking this law was called the Clean Water Act. We have people that work to monitor and keep clean our drinking water supply. This is why you can turn on the tap water or water fountain and drink the water without getting sick. Other developing nations such as those countries in Africa, Latin America, and Asia do not have access to the same facilities and often people have to use water that is unsafe and contaminated. Every eight seconds a child dies of a water-related disease. While every year more than five million human beings die from illnesses linked to unsafe drinking water, unclean domestic environments, and improper waste disposal.

There are six main **Waterborne and Water-based diseases** associated worldwide with poor water supply and poor water sanitation including diarrhea, ascaris, dracunculiasis, hookworm, schistosomiasis, and tranchoma. These diseases are caused by bacteria, parasites, or viruses that grow and develop well in water that is either contaminated with human feces or in areas that naturally have these bacteria and parasites present such as rivers, lakes, and streams. The lack of water sanitation contributes to these diseases in the developing world.

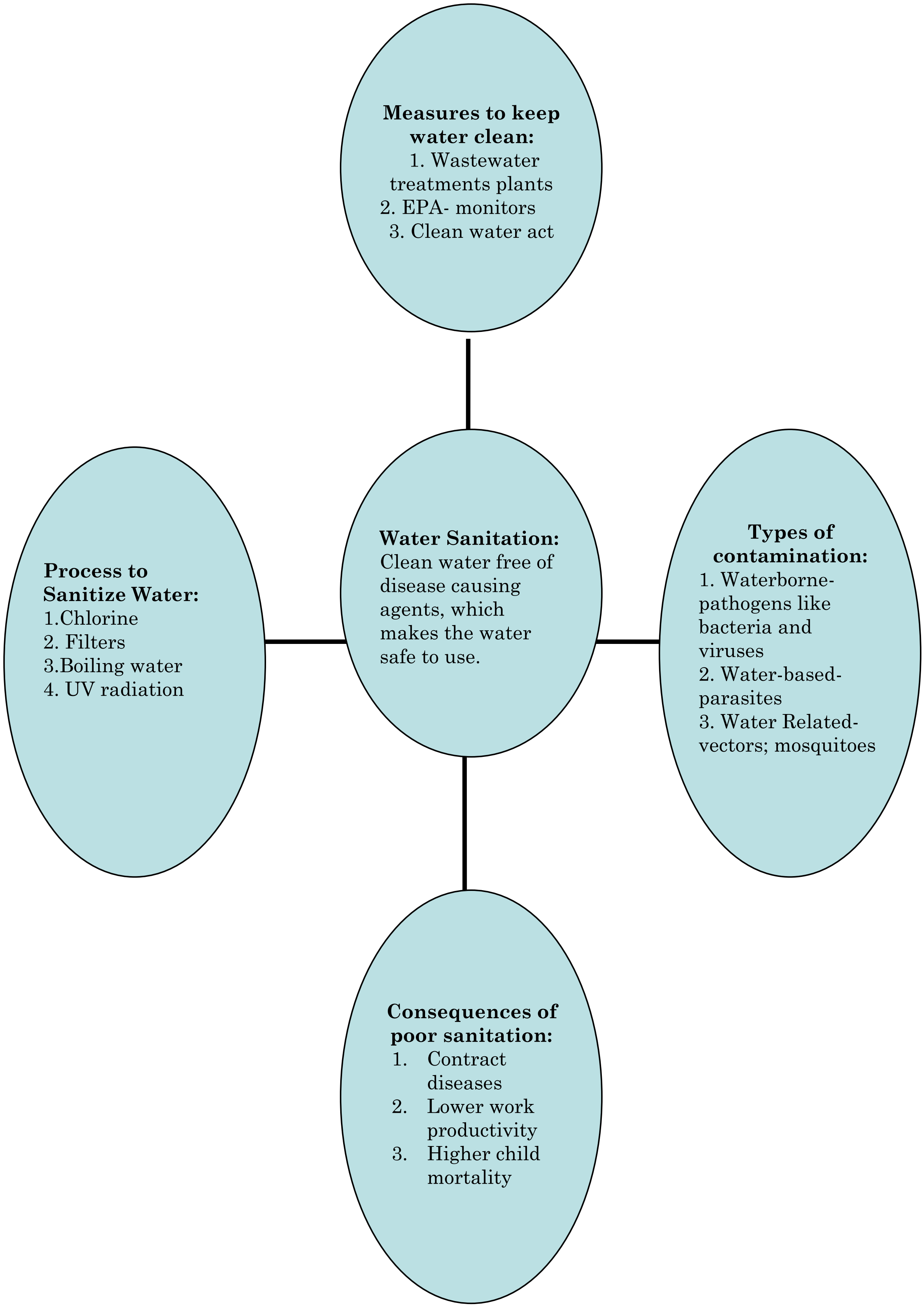
The year 2008 is the International Year of Sanitation for the United Nations. This means that this large organization wants the world to improve its water sanitation. **Water Sanitation** means many different things, but mainly it means to have safe management of human excreta (poop) usually by means of a toilet that either confines waste until it can be removed or enables the waste to be flushed away. Other methods of sanitation include hand washing, environmental cleanliness, garbage removal, and wastewater disposal. Sanitary excreta (poop and urine) disposal is the isolation and control of feces from both adults and children so that they do not come into contact with water sources, food or people.

Waterborne pathogens belong to groups of bacteria, viruses, and parasites. Many common **bacterial pathogens** included Vibrio cholera, Shigella, Salmonella, and E.coli. Bacteria are single-celled organisms that are found in the air, water, soil, and inside our bodies. These organisms can only be seen with a microscope. The bacteria can be both helpful and harmful to humans and other animals. Some are helpful and break down materials and recycle wastes. Other bacteria are both harmful and helpful because they aid in digestion and are found in the excrement of humans, livestock, and wildlife. This bacterial group is called **Fecal coliform bacteria**. The most common member is the bacteria Eschericia coli or E.coli. However, when these bacteria and others that are fecal coliforms find their way into water systems and are consumed by humans can cause illnesses that usually result in severe diarrhea and death.

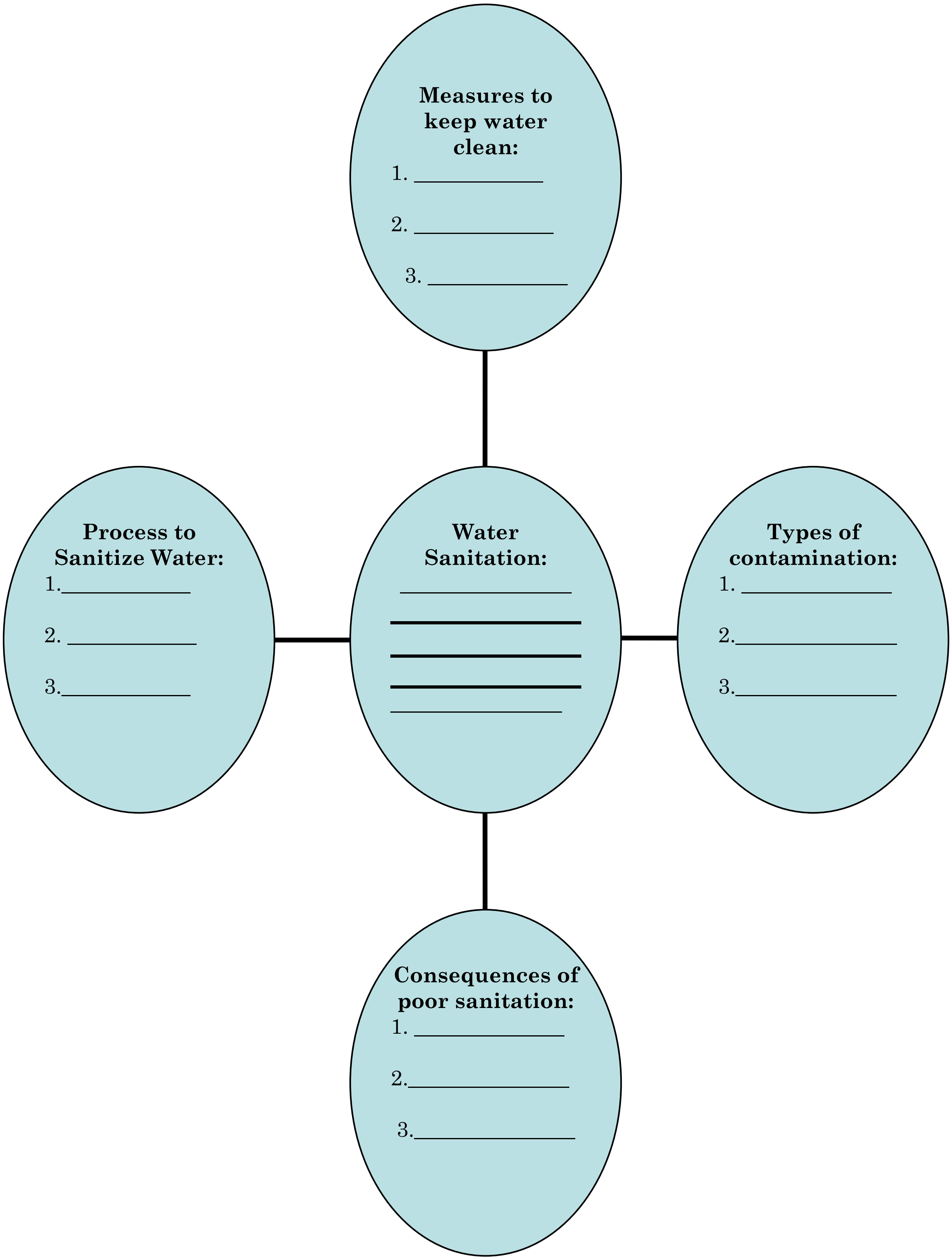
The two main ways these bacteria can cause disease include **their ability to survive in the environmen**t such as in the water and **the total number of pathogens that infect a human**.

To avoid illness from bacteria, viruses, and pathogens from contaminated water it must first be sanitized for human use. There are several methods for sanitizing water to kill microorganisms that can cause disease and death. These include the use of chlorine to disinfect water, the use of solar radiation (from the sun) to kill pathogens, the use of filters to screen out microorganisms, and the use of heat or boiling the water to kill all pathogens.

Since clean water is essential, many countries are working to better develop their water sanitation systems. Other countries are also working to build sewage treatment plants or septic systems that keep harmful bacteria found in waste away from water. What other methods would you use to help with water sanitation in those countries?


Measures to keep water clean:
1. Wastewater treatments plants
2. EPA- monitors
3. Clean water act
Process to Sanitize Water:
1.Chlorine
2. Filters
3.Boiling water
4. UV radiation
Water Sanitation:
Clean water free of disease causing agents, which makes the water safe to use.
Types of contamination:
1. Waterborne- pathogens like bacteria and viruses
2. Water-based- parasites
3. Water Related- vectors; mosquitoes
Consequences of poor sanitation:
1. Contract diseases
2. Lower work productivity
3. Higher child mortality

WATER SANITATION ARTICLE GRAPHIC ORGANIZER



Quick Guide Brochure

PURPOSE

This module will enforce science process skills according to the Sunshine State Standards Nature of Science and train students to use these science skills within the "Water for Life" module. Topics explored were bacterial life in the water, water borne pathogens and related diseases, solar radiation, and water sanitation. Students will be exposed to and learn about the importance of water for life on earth, the concerns with regard to water borne pathogens worldwide through lessons and an experiment focusing on a UV water disinfection method. For this presentation the brochure highlights Lesson 3.

Lessons for the module "Water for Life"

Lesson 1 "We Need Clean Water".

Lesson 2 "Water Sanitation Article and Research Essay."

Lesson 3 " What is in that water? Bacterial load and Water Quality Experiment."

Lesson 4 Lesson 4 "Indentifying Aquatic Life with a Dichotomous key".

Did you know? Test your water IQ

1) Less than__________of the world's fresh water is readily accessible for direct human use.

2) A person can survive weeks without food, but only _______without water.

3) A person needs _________ gallons of water a day to meet basic needs.

4) The average American family uses _______ gallons of water at home each day. The average African Family uses about ______gallons of water each day.

5) Each year more than ______ million people die from water-related diseases.

* This was part of Lesson 1 which was a webquest of not- for-profit and governmental websites on water.

Answers: 1) 1%, 2) days, 3) 13.2 gallons (includes cooking and basic sanitation), 4) 100-176 gallon; 5 gallons 5) 3.5.

Science Topics Covered:

1) The scientific process
2) The water cycle
3) Characteristics of living things, Cells and Cell theory
4) Human Impact on the Environment

Focus on Lesson 3 " What is in that water? Bacterial load and Water Quality Experiment"

This lesson plan experiment requires water from 4 different locations expected to have different numbers of bacteria. The bacteria is then cultured or grown and one method (the use of UV light) is examined for reducing the total number of bacteria in a water sample.

- ✓ Students will describe how bacteria in the water can affect human health.
- ✓ Students will design an experiment for testing bacterial levels in the water.
- ✓ Students will observe the colony growth of bacteria from four different water samples.
- ✓ Students will analyze and graph the total bacterial growth before and after sanitation using UV light.

Question: How is the amount of bacteria in different types of water affected by a solar UV disinfection process? Types of water tested include Tap water, Toilet water, aquaculture tank water, and pond water.

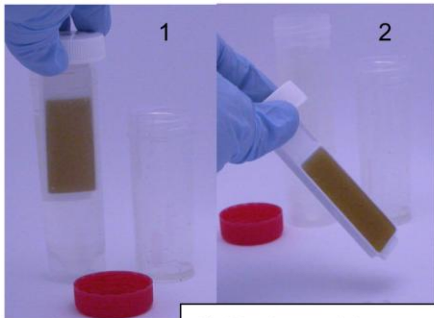
Hypothesis: If I change the type of water used in the sanitation process then the ______water with the greatest amount of bacteria will be disinfected the most because_________.

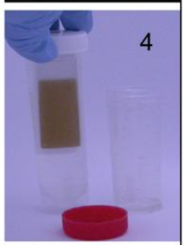
Materials

Bacterial Test Kit

Portable UV Light or Sun

Experimental Procedure





1) Dip bacterial test strip into initial water sample.

2) Let drip excess water. Return to its container and leave for 24-36 hours.

3) Expose water sample to UV light or sun.

4) Retest with new bacterial media strip. Review growth and compare results.

5) -Aquaculture tank water sample before and after exposure to UV light. The bacterial load is very high in the water sample, prior to being exposed to UV radiation.

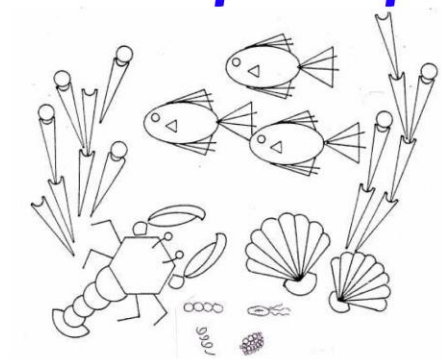
METHOD FOR PLACING SAMPLE IN FULL SUN INSTEAD OF UV LIGHT.
The experiment can be modified to use the natural sunlight as the source of UV light instead of a portable UV light. This method is called Solar Water Disinfection, which uses the solar UV from UV-A spectrum of light (wavelengths of 320-400nm) and the increased water temperature to kill pathogenic organisms found in water. Perform the experiment above in exactly the same manner except place the water samples outside in full sunlight instead of using the portable UV light.

Use plastic bottles made of PET (PolyEthylene Terephatalate) and place water sample inside bottle. Place the plastic bottles containing the sample water on a metal sheet like a cookie sheet and place on a raised stool or chair. Expose the bottles to full midday early sunshine (April, May, June or August, September). The infrared radiation will raise the water temperature to 70°C- 75°C which is also known as pasteurization.

For the full module visit us at our website.

http://www.spice.centers.ufl.edu/

Water for Life



An education teaching module

by Elisa Livengood
University of Florida, and
Carmella O'Steen
Mebane Middle School, FL

SPICE

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