Human Impact on Water Quality

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Introduction

It was last year after I was half-way through the quarter where I was teaching hydrology that one of my 8th grade students, (Lilly), made this statement; "You talked about being careful not to pollute our water, how people can prevent water pollution, and how much it costs to clean our drinking water. So how can I make a real difference in the quality of our water?" I redirected her question to the class, and asked if other students may have some ideas or suggestions that they have done or wanted to try. This statement lead to a frank and open discussion on how much one person affects local water quality. After this discussion, the class concluded that we did not know how much of a significant difference that one person can make on improving our water quality.

This simple statement and an article on disrupted food webs that explored the relationship between overfishing and dead zones in the Chesapeake Bay area brought me back to the significance of what I was teaching about water quality and the importance of becoming good stewards. This article, which was published in Science Scope, talked about students analyzing historic and present-day food webs and graphing their historic and present-day Chesapeake Bay data[1]. Students were able to discover the importance of having a complex food web to insure a healthy ecosystem.

This curriculum unit is designed for sixth grade students but can be adapted to any middle or high school grade. It is intended to give students real world experience in finding solutions for an existing problem. Since as long as I can remember, I always have had an interest in water. Where did it originate, what is contained in the water, why will some substances mix with water while other substances do not, what makes water safe for human consumption, and how do we protect the quality of our drinking water?

I plan on developing ideas that will engage my students about how individuals impact water quality. I am envisioning ways my students can become active advocates for the improvement of our local water quality. It is my plan to have them present their water quality improvement recommendations to our school administration. In order for my vision to succeed, I need a group of students who are interested water quality, willing to

make a learning commitment, and would like to make lifestyle choices that will benefit the community.

Overview

Charlotte, NC is located in the southwestern part of the state in a region known as the Piedmont[2]. According to the US Census Bureau, Charlotte, NC is the 18th largest city[3] in the United States with a population of 630,478[4]. The Charlotte metropolitan area which includes Mecklenburg County has a population of 913,639[5]. The Charlotte metropolitan area encompasses two major river basins, the Catawba and the Yadkin-Pee Dee. The majority of this population receives their drinking water from Charlotte-Mecklenburg Utilities with the water source being the Catawba River. The Charlotte metropolitan area has a hilly topography with over 30 creeks and tributaries that flow into the Catawba and Yadkin-Pee Dee river basins[6].

Between 2000 and 2009, the Charlotte metropolitan area had a 31.4% increase in population. Large portions of Mecklenburg County went from being rural to being suburban and urban.There was widespread development during this time period much of which affected the water quality of these creeks and tributaries. With the increase in population, there has been an increase in water demand from both residential and business owners. According to Charlotte-Mecklenburg Utilities, the number of customers that it serves grew from 100,000 in 1990 to over 775,000 in 2010[7]. The Environmental Protection Agency estimates that an average family of four can use 400 gallons of water per day[8]. Charlotte-Mecklenburg Utility now pumps and treats an average of 100 million gallons of water daily from Lake Norman and Mountain Island Lake in order to supply residents and businesses with fresh drinking water[9]. The construction of new homes and businesses on land that was farm or other open field increased the hard surface areas resulting in an increase in storm-water runoff, and an increase in recreational use in and around the source of our drinking water.

Objectives

The primary objectives in teaching this unit are to have the students increase their understanding of the relationships between water quality and land use. Secondary objectives include increasing students' ecological awareness of their neighborhoods and facilitating discovery of how their lifestyle choices can increase or decrease the availability of fresh clean water.

Rationale

What can I do to decrease my ecological impact on the world? And will my choices make a real difference in improving the water quality in my community? These are two questions that I put to my middle school students. Ever since I began teaching middle school science, I have found that many of my students have a difficult time relating the impact that their lifestyle choices have on water quality and their environment. My students hear what is being taught but don't seem to grasp how their personal choices have a positive or negative effect on the water quality, wildlife, and other environmental issues locally, nationally, or globally, Over the years I have used many different teaching strategies and resources in order to help my students understand how their everyday actions and personal choices affect the water quality and the environment but, based on their responses on a variety of classroom assessments, have only achieved limited success.

In order to help students make a personal connection to the environment, my students will investigate how decisions at our school have affected the local terrestrial and aquatic food webs, specifically in the water quality of Doby Creek located near our school. In addition to learning about water quality issues, my students will learn to use different technologies when monitoring water quality. They will be using the internet to connect to other water monitoring stations located throughout the Charlotte area accessing that data and analyzing data collect at our monitoring site.

It is my desire that my students will realize that they can make a difference, that one person with conviction can be the catalyst for improved water quality and sustainability in their community. In addition, their experience working with monitoring equipment and collecting samples will help them understand the complexity of the local environment, the interdependence between terrestrial and aquatic organisms, and, by using this information, predict probable outcomes based on specific events. Finally using their predictions, my students will develop plans that will mitigate negative impacts form such events.

Background Information

Protecting our water and the environment from pollution caused by man or nature is not a new idea. The 1888 Rivers and Harbors Act stated that it was illegal to pollute any waterway in the United States and, if you were caught, you had to pay a high penalty[10].

Individuals such as President Theodore Roosevelt, Henry David Thoreau, John Muir, co-founder to the Sierra Club, and Gifford Pinchot recognized some of the pollution people were doing to our waterways. Saving our water ways by preservation and conservation was the desire of early environmentalists. But even with this effort, the pollution of our waterways continued. In 1969, the Ohio River along the industrial sections of Cleveland caught fire because of the amount of pollution that was present and in 1970, Lake Erie, one of the five Great lakes, was considered "dead"[11]. In 1972, the US Federal Government enacted the Federal Water Pollution Control Act better known as the Clean Water Act. This cornerstone of surface water quality protection in the United States does not deal directly with ground-water nor with water quality issues. Instead it employs a variety of methods, both regulatory and non-regulatory, to reduce point source pollutant discharges, finance municipal wastewater treatment facilities, and manage polluted runoff[12]. It wasn't until the late 1980's that efforts to address non-point source pollution increased significantly. This act has been amended a number of times in order to address various water pollution issues. Some of the issues addressed are aquatic sediments, effluent limitations, and water quality standards. The fact that the Clean Water Act now requires storm water permits for construction projects to insure that construction site sediments are kept on site and not transported due to surface runoff is a result of these amendments.

There are many types of pollution ranging from fertilizer runoff to raw sewage that affects the ecology of our rivers, lakes, and streams. Based on their origin, most of these pollutants that affect our water quality can be classified as municipal, industrial, and agricultural water pollutants[13]. Municipal water pollution consists of waste water from our homes and commercial establishments. These wastes are treated at a municipal waste water treatment facility with the clean water released into a local waterway. Depending on the industry, location of that industry, federal, state, and local laws and regulations, treatment of water pollutants from industries may differ from pollutants classified as municipal. In many cases, industrial wastes are first treated on site by the industry before being released either to a waste treatment facility or, if meeting clean water standards, released directly to a local waterway. Again, depending on the state, treatment of agricultural water pollutants may be different. In agriculture, the primary causes of water pollution are surface runoff and infiltration of pollutants into the soil that reach the groundwater. Over application of fertilizers, pesticides, improper storage, or unsafe loading practices are major sources of agricultural pollutants. Unlike industrial and municipal water pollution where regulation, capture and removal of pollutants are the primary methods to insure improved water quality, agriculture relies on the proper

application and storage to reduce the impact that these pollutants have on the water supply. Depending on the type of agricultural business, its location, and existing regulations, settling ponds along with the testing and treatment of the water in these ponds may be required before any water can be released to a waterway.

Strategies, Activities, and Lessons

This unit is written for sixth grade students. It addresses various goals and objectives found in the K – 12 North Carolina Standard Course of Studyfor Science that is issued by the North Carolina Department of Instruction[15]. Also it is designed to give students real world experience in solving an existing problem. There is an erosion problem involving surface runoff in our school parking lot. Clay and other debris enter Doby Creek in the storm-water system. These pollutants increase the turbidity of the creek. Evidence of these pollutants can be seen in our parking lot surrounding our storm drains and where the storm water is discharged into Doby Creek. Students will investigate how this increase in turbidity relates to the pH of the water, water temperature, dissolved oxygen, and the aquatic organisms that are found in this waterway. They will monitor the water quality of similar local creeks that, along with other tributaries, flows into the Catawba River, the source of drinking water for the Charlotte metropolitan area. My students will investigate the dynamics of a food web, the interdependence of different organisms that make up a food web, and how a food web relates to its environment. At the end of this unit, my students will be able to understand that a food web is a system in which organisms receive energy in order to live, each organism plays an important and unique role that directly or indirectly effects each organism in the food web, the quality of water has a direct bearing on the success or failure of an ecosystem, and the stability of the ecosystem is dependent on all components including the actions of individual people.

This unit is divided into six phases. Phase one addresses competency goal 3 and objectives 3.07 and 3.08. It will begin with an overview of the water quality of our rivers and how point source and non-point source pollution is affecting our water quality. Students will see the relationship between water quality and what is happening to the Carolina heelsplitter (*Lasmigonadecorata*), an endangered species that is only found in Charlotte, NC. In phase two which address competency goal 3 and objectives 3.06 and 3.08, students will trace the flow of water as it travels from our parking lot, to Doby Creek, down to the Catawba River, and, eventually to our homes. Students will read a topographic map and construct a model of this region. Their models will then be used to examine the movement of pollutants and predict areas of potential pollution problems.

During the third phase which addresses competency goal 3 and objective 3.08, students will learn how land use in the Charlotte area has changed overtime and the impacts people have made on our waterways. Using satellite images, small groups of students will be able to compare and contrast this same area over time. They will draw conclusions about human impacts on the environment. Then these groups will share their observations and conclusions with the entire class. Finally, as a class, students will use this information and make predictions that identify potential future problems that will affect the water quality.

The fourth phase addresses competency goal 3 and objective 3.05. Students will collect specific data on the health of Doby Creek. Some of this data will be water pH, temperature, dissolved oxygen, and turbidity. In addition, students will be conducting a survey of the different types of macro-organisms and plants found along this creek. Analyzing this information, students will determine the current health of this waterway.

Phase five will be for students to create a comic strip describing the different experience of a water molecule as it travels from the school's parking lot down to the creek, from Doby Creek to the Catawba River, to the water treatment facility, to their home, from their home to the waste water treatment facility, evaporating into the atmosphere, and arriving back to the school's parking lot.This phase addresses competency goal 3 and objective 3.02.

The final phase of this unit, phase six, is for students to address the erosion problem in our parking lot showing how it is affecting the water quality. Students will present a plan to our school principle outlining the problem, how it is affecting the water quality of the creek, and potential solutions that address this issue. This phase addresses competency goal 3 and objectives 3.06, 3.07, and 3.08.

Activities

Phase 1

The activities during this phase may take more than one class period. First, I engage my student's interest in water quality by demonstrating how much fresh water is available in the world for human consumption. Starting with a 1000 mL of water poured into a graduated cylinder, I tell my students that the water in this graduated cylinder represents all the water found on Earth. Next I have my students make a series of predictions on

how many milliliters of this water would be fresh water, where would this fresh water be found, and how much is readily available for human consumption. Using data from the USGS stating approximately 97% of all the water found on Earth is salt water and 3% is fresh water, I place 30 mL into a 100 mL graduated cylinder. Emphasizing that the 30 mL is all the fresh water in the world, my students predicts how much is frozen, how much is stored as groundwater, and how much is found in lakes, rivers, swamps, and surface runoff.Pouring 21 mL (approximately 68.7%) of this water into another graduated cylinder, I am able to demonstrate to students how much freshwater is found frozen in the glaciers and the icecaps. The remaining 9 mL represents liquid fresh water located as groundwater, surface water, and in the atmosphere. Using a transfer pipet, I remove 0.9 mL and place it into another graduated cylinder. This amount represents the all the fresh surface water that is found in lakes, swamps, and rivers. This demonstration visually depicts how little fresh water is available for people to use. Finally, in order to help my students connect how their individual actions have an effect on how much fresh water is available for use, I conduct an informal classroom survey to find out how many students leave the water running when they brush their teeth. I have them conclude that they can conserve fresh water if they don't leave the water running while brushing their teeth.

I continue this phase by introducing students to the following problem: How does human activity affect our water quality? I have my students divided into small groups with each group brainstorming different ways people affect water quality. Students will then report to the entire class the different ways people affect water quality that they identified. This information will be recorded on a large sheet of paper posted in the classroom and can be used as a reference.

Next, I introduce students to the Carolina heelsplitter, an endangered mollusk that is only found in Charlotte, NC. Using a globe of the world, I locate Charlotte, NC emphasizing that this is the only place in the world that this heelsplitter lives. Giving students a newspaper article, I have them read about what is happening to their environment and why. I then display a map of North Carolina that highlights the major river basins located in this state and close-up images of major rivers that flow in North Carolina and provides a source of drinking water for people in this region. Students discuss how human activities have an effect on the water quality of these rivers.

Finally I give students a seven question pre-assessment quiz on water quality and sources of water pollution. I follow this pre-assessment by using two short videos. The first one is a 5 minute video titled "A Natural Focus with Laurie Sanders: Water Quality".

It is available online from Discovery Education[14]. This video discusses the Clean Water Act, its impact on river water quality, non-point source water pollution, and the current state of American rivers. The second is a 7 minute video titled "Watershed Overview and Pollution Prevention" produced by the Charlotte-Mecklenburg Storm Water Services and addresses both point source and non-point source water pollution and how it affects our watershed. After viewing these videos, I facilitate a classroom discussion about water pollution and different methods that people can use to prevent or mitigate some of the effects of these pollutants. I conclude this phase by having students complete a post-assessment quiz on water quality and sources of water pollution. This post-assessment is the same quiz that was given as the pre-assessment.

Phase 2

I begin this phase by asking the question: How do people use maps to identify and predict potential problems that can decrease water quality? I have students discuss this question in small groups then report their findings to the entire class. This information is recorded and posted along side of the information gathered during phase 1.

How to read a topographic map and interpret satellite images is a review for my students. In order to recall what they know about topographic maps and satellite images, I give them a sample map that I created. This map contains contour lines, a river, lake, a road, trail, campground, marsh, and some buildings. I have them summarize their knowledge of topographic maps by analyzing this map and answering a series of questions that solve hypothetical problems. Next, I give my students a Landsat satellite image of the Tampa Bay area having them answer a series of questions that identify potential problems. In small groups, I have students discuss these potential problems along with possible solutions. After this small group discussion, I have the class summarize what appear to be obvious solutions to these potential problems.

Next, students are given topographic and satellite images of our school and Doby Creek. By interpreting these maps and satellite images, students will trace the flow of water from Doby Creek to the Catawba River. With this information, they will construct a model that will be used to examine the movement of pollutants by surface runoff and trace the flow of water from our parking lot to Doby Creek. Students then test their models by placing material that represents different types of pollutants on their models and, by use of a bottle that spritzes water, demonstrate how the pollution moves in this

area. Finally, by using what they observed with their models, they will predict specific areas that they would expect to find water pollutants flowing into Doby Creek.

Phase 3

During this phase students will answer the question: What changes in land use took place in this area since 2000? This activity involves the use of maps and satellite images to compare and contrast the changes that have taken place over the last ten years. Working in small groups, students will research changes in land development that took placed in this region over the last ten years. Using maps, satellite images and knowledge of this area, students will locate these developments identifying potential water pollution issues that may have taken place and how these developments have impacted the water quality of this area.

Next, by following a rubric that I created, these student groups will create a power point presentation that summarizes their findings and conclusions. Students will give this presentation to the entire class. Finally, as a class, students will make predictions that identify potential future water quality problems based on the information presented by all the student groups. I use this activity as an assessment to show the student's ability to synthesize their learning of topics covered in phases one through three.

Phase 4

This phase is divided into three sections, water chemistry,macroinvertebrates, and Doby Creek. Under water chemistry, students will conduct a number of tests to determine the water quality of several samples. During the macroinvertebrates section, students will investigate how scientist use macroinvertebrates to determine the water quality of both a simulated and actual creek that boarders our school.

Water Chemistry

These activities will have students investigate how scientists determine water quality by looking at the condition of different water samples and conducting several different tests. The first activity is an investigation on concentration of food coloring in water. I begin this activity by modeling different concentrations of lemon juice and water. Using five 50 mL beakers I mix different amounts of lemon juice and water in each beaker. I challenge my students to find a way to describe the concentration of lemon juice in each beaker. This challenge leads into the activity on concentration. In this activity, I begin by

introducing the concept of parts per million by reading How Much is a Million? This short story illustrates what a million would look like. This is followed up by having students use parts per million to describe the concentration of food coloring in water.

The materials needed for this part of the activity are two pipets or eye droppers, food coloring, a dilution tray or series of ten test tubes for each group. Students will begin by creating a table that contains four columns and ten rows. The columns are labeled container number, color description, concentration one part in X number of parts, and concentration in percent. Students will place ten drops of food coloring in the first cavity, (if they are using a dilution tray), or test tube. In cavity number two, students will place one drop of food coloring and nine drops of water carefully mixing this solution. Next students will transfer one drop of the food color-water mixture and place it in cavity number three. Then they will add nine drops of water to this cavity and carefully mix this solution. Students will then transfer one drop of this mixture from cavity number three and place in in cavity four along with nine drops of water. Students will continue with this procedure transferring one drop of the food color-water mixture from the previous cavity and adding nine drops of water.Once the transfers are completed, students will record their observations about the color of the different dilutionsand calculate the concentration of each cavity. This activity is based on the one found on page 14 in Issues Evidence and You. Students will then answer a series of questions about their experience with this activity and on concentration. Finally, they will write down how they would explain what a million is to a first grade student.

The next activity involves students collecting water samples from different sources at our school. These sources may include water from different drinking fountains, sinks, fish tanks, and pond area. Students will be determining the pH, dissolved oxygen, hardness, level of nitrates, and turbidity of each of these samples. Next they will create a presentation of their results and conclusions that will be presented to the class. Finally, students will create a poster addressing the water quality tested from that location. These posters will be displayed next to these locations.

I begin this activity by assigning students to different groups and having one member from each group randomly select a water sample location. Using a water source in my classroom, I then model the proper way to collect and handle a water sample. Next students collect their water samples and begin a series of tests to determine the water quality of these samples. Recording their results in their science journal, students will research the safe drinking water standards and compare their results with these standards.

Finally, students will create a presentation on the water quality of their water sample and a poster the highlights these findings. This poster will identify their results and inform others of the quality of that water. These posters will be on displayed next to each of these water sources.

Macroinvertebrates

In this activity, students will investigate how scientists determine water quality using macroinvertebrates. To engage my students in this activity, I begin by using a slide show that projects images of a number of macroinvertebrates that are used to help determine water quality. We discuss different methods used to determine water quality, what an indicator is and talk about reasons why macroinvertebrates can be used as indicators of water quality such as their sensitivity to changes in the ecosystem and that they cannot escape changes in the water quality. I model ways that these macroinvertebrates are collected and how they are identified.

Prior to the start of this part of this activity, I mark out an area that will represent a creek where macroinvertebrates live. Though I normally take my students outside for this part of the activity, it can be done indoors in the hall or gym. Then I spread laminated cards that have pictures of class I, class II, and class III macroinvertebrates throughout this designated area. After assigning students to small groups, (up to four students in a group), I have them collect these macroinvertebrate cards. In order for students to collect a variety of different macroinvertebrates, I deliberately do not tell them which macroinvertebrates are classes I, II, or III until after they record their data.

Once back in the classroom, students classify their macroinvertebrates by different species recording this data on a bio-index table. I model how to calculate the biotic index value and explain how it is used in determining water quality. Students then calculate the biotic index value for their collection of macroinvertebrates and, based on their data, determine the water quality for this imaginary creek. One student from each group records their quantitative biotic index value and qualitative water quality on a table located on the wall. Also, they graph this data from each group in the class. Using this information, students answer several questions about the water quality on this simulated waterway.

Doby Creek

This entire phase ends with this activity. Students will apply the skills and knowledge learned during the prior activities to conduct a survey to determine the water quality of Doby Creek where it boarders our school. In assigned groups, students will collect water samples to record the macroinvertebrates living in this section of the creek, water pH, dissolved oxygen, turbidity, and water temperature. Observations about the overall existing conditions of this section of Doby Creek will also be recorded. These observations will include any source of water pollution due to surface runoff, trash or other man-made products that are found in the water, and any other condition that students believe that negatively or positively affect the water quality. Students will analyze this data to determine the water quality then decide on recommendations on how to improve the quality of the water flowing down this creek. Students will present their recommendations to the entire sixth grade class.

Phase 5

In this activity, students will create a comic strip or a travel log that describes an imaginative journey of a drop of water as it travels from the atmosphere landing in our parking lot and flowing to Doby Creek. Following the adventures of this drop of water as it continues along Doby Creek ending up in the Catawba River, then through the water treatment facility to their home, from their home to the waste water treatment facility, leaving the waste water treatment facility traveling to the atmosphere and eventually arriving back on our parking lot. During this journey, students will address the many different items and events that this water drop encounters during its travels. Some examples of these events are how this water drop picks up and carries clay particles, litter, oil, and antifreeze, how it interacts with macroinvertebrates, what sites does it see as it travels along this waterway, and the different processes that clean this water drop. I use this activity to assess my student's understanding of the water cycle, water pollution, and water quality.

Phase 6

In this final phase, students will revisit the issue of soil eroding from the traffic islands in our parking lot entering the storm drain system that empties into Doby Creek. Students will come to a consensus and decide on a possible solution to this issue. By using data and information gathered during the previous phases, they will create a power point presentation that identifies this issue, how this runoff is affecting Doby Creek, and their

solution. Finally, students will make a presentation to our school principal and science facilitator on this issue and their recommended solution.

Notes

[1]Wyner, Yael . "Disrupted food webs: Exploring the relationship between overfishing and dead zones in the Chesapeake Bay." *Science Scope* 33, no. 7 (2010): 78 - 85.

[2]"North Carolina Maps: Browse by Location." University of North Carolina at Chapel Hill Libraries - Home. http://www.lib.unc.edu/dc/ncmaps/browse_location.html (accessed December 5, 2010).
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[14]"Welcome to Discovery Education." Welcome to Discovery Education. http://www.discoveryeducation.com (accessed December 12, 2010).

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Excellent source of background information on environmental sustainability. The author offers a practical solution in solving real-world problems involving environmental sustainability.
Dodds, Walter .*Humanity's Footprint*. New York: Columbia University Press, 2008.
A good source of background information on water use even though readings can be hard to follow.
Rosenzweig, Michael. *Win-Win Ecology: How the Earth's Species Can Survive in the Midst of Human Enterprise*. New York: Oxford University Press, 2003.
Offers interesting interpretations on how both the environment and humans can coexist and benefit from each other by offering suggestions that help humans make ecological sound choices.

Teacher Resources

"H2O CONSERVE."H2O CONSERVE. http://www.h2oconserve.org/home.php (accessed December 12, 2010).
An excellent resource for students to see how their choices impact water use.
"Ecological Footprint Quiz by Center for Sustainable Economy."Ecological Footprint Quiz by Center for Sustainable Economy. http://www.myfootprint.org/ (accessed December 12, 2010).
Great resource to introduce students to ecological awareness and their impact on the environment.
Project Wet Curriculum and Activity Guide. Bozeman: Montana State University, 1998.
Great source for different activities related to water. Activities are broken down by grade level.
"Welcome to Discovery Education." Welcome to Discovery Education. http://www.discoveryeducation.com (accessed December 12, 2010).
Excellent site for videos and interactive labs.

Student Resources

"H2O CONSERVE."H2O CONSERVE. http://www.h2oconserve.org/home.php (accessed December 12, 2010).
Excellent to see how much water is needed to support your life style choices.
"Ecological Footprint Quiz by Center for Sustainable Economy."Ecological Footprint Quiz by Center for Sustainable Economy. http://www.myfootprint.org/ (accessed December 12, 2010).
Great on-line calculator to see how many earths are needed to support your life style choices.

Appendix

Competency Goal 3
The learner will conduct investigations and utilize appropriate technologies and information systems to build an understanding of the hydrosphere.

Objective 3.02
Explain the structure of the hydrosphere including:

- Water distribution on earth.
- Local river basin.
- Local water availability.

Object 3.05
Analyze hydrospheric data over time to predict the health of a water system including:

- Temperature.
- Dissolved oxygen.
- pH.
- Nitrates.
- Turbidity.
- Bio-indicators.

Object 3.07
Describe how humans affect the quality of water:

- Point and non-point sources of water pollution in North Carolina.
- Possible effects of excess nutrients in North Carolina waters.
- Economic trade-offs.
- Local water issues.

Objective 3.08

Recognize that the good health of environments and organisms requires:

- Monitoring of the hydrosphere.
- Water quality standards.
- Methods of water treatment.
- Maintaining safe water quality.
- Stewardship.