Impact of Urban Agricultural and Horticultural Practices on Drinking Water

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INTRODUCTION

I have taught agricultural science and technology for almost twenty-five years, twenty-one of those years in Houston. It still amazes me to hear students ask the inevitable first day questions, "What exactly is agriculture?" or "Why do we need to learn about farming? This is Houston. There are no farms in Houston." I understand where these questions arise. After all, as the average Houstonian travels the freeways and city streets to and from work, it is hard to imagine agriculture as a part of our urban way of life. Students, as they leave their homes for the short walk or ride to school, certainly see no evidence of "farming" taking place. This would logically then lead to the question, "How could agriculture possibly have any affect on our drinking water?"

However, when one ventures beyond the off ramps and feeder streets and turns into the average neighborhood, agriculture is indeed alive and well in our city (although not in the traditional sense). In actuality it has not been that long ago that lawns and landscaping replaced the rice fields and cattle ranches of early Houston.

Homeowners use a great deal of water to maintain the desired lush appearance of a well-groomed lawn. In fact 25% of potable water used in urban areas is applied to landscapes and gardens. Much of this water is never absorbed and used by the plants and put to use. Runoff from applying water too rapidly and evaporation are two ways water is lost. However, the greatest waste of water is applying too much too often. When you consider the amount of fertilizer and pesticides that are simultaneously added during the watering of our lawns, the potential for pollution is a real concern.

The public concern about water pollution strongly affects nurseries and greenhouses. The typical nurseries in the city of Houston could be classified as container nurseries. Container nurseries have pots sitting on the ground that are frequently irrigated and fertilized through overhead sprinklers. Most of this water – as much as 70% – lands between, rather than in, the pots. Container fields are typically watered and fertilized daily. The potential for water pollution is therefore great.

These "polluted runoff" waters become drinking water for downstream users, therefore students must understand that our agricultural practices may not affect us, but affects downstream users. Like wise upstream activities affect the quality of our drinking water.

In this unit students will explore ways that agricultural and horticultural practices could have impacts on drinking water sources. Students will explore alternative methods for supplying the water and nutrient needs of container grown plants nurseries. Students will also investigate wholesale greenhouse and nursery operations in Harris and surrounding counties, specifically those near Lake Houston. The students will be given the opportunity to complete activities to learn how they, and the average citizen, can prevent practices that lead to “serious” problems.

Students will learn to distinguish the difference between point source pollution and nonpoint source pollution and investigate ways to minimize or possibly eliminate agricultural pollution.

In this unit students will also conduct experiments to observe how lawn chemicals, specifically fertilizers, can impact aquatic life in the storm drains of a typical neighborhood.

Food processing plants are another tremendous user of water, a lot of which becomes part of the final product, to process the foods that eventually make it to our table. No one would argue the importance of using high quality water to process these foods, but what about the waste water from the initial removal of pesticides and pathogenic residues on these foods when they enter the processing plant?

To bring closer connection of this unit to agricultural applications students will research how livestock (feedlot), horse stable, and high school agricultural science feed facilities could possibly impact the quality of surface and groundwater.

BACKGROUND

This unit is primarily designed to assist students who are enrolled in either a horticulture or agricultural science class to examine the practices commonly used in today’s agriculture that could lead to water pollution and to investigate alternative practices to lower or possibly even eliminate these risks. This unit could also easily be used in the environmental science classroom as well. For agricultural science students the driving question for them must be, “What can we do to minimize polluting water that our neighbors downstream will ultimately use for drinking?” Environmental science students would probably want to know, “What impact does agricultural water pollution have on the natural resources of the community in which we live?”

WATER DISTRIBUTION AND USES

The U.S. uses more water than other countries: 525,000 gallons annually per capita. Of that amount, 90 percent of it was used for industry and agricultural needs (including water used for electrical power and for cooling).

Texas has 191, 228 miles of streams and rivers; 10,196 reservoirs; about 6.5 million acres of inland wetlands; 2,394 square miles of bays and estuaries; and 624 miles of coastal shoreline. The state has 23 major watersheds and nearly 200,000 miles of streams and rivers. Of the total miles of streams in Texas, 79 percent of them have intermittent flow during some part of the year, which means these streams have portions that are completely dry some of the time.

According to the Texas Environmental Almanac, about 21 million gallons of wastewater is discharged per day, enough to fill Texas Stadium, home of the Dallas Cowboys, more than twenty-seven times.

CONTAINER NURSERIES AND ROLE IN PREVENTION

Container nurseries are the primary source for plants purchased by most homeowners in the urban area. Nurseries are located throughout the city of Houston in virtually every neighborhood. These centers are filled with a wide assortment of mostly seasonal plants, and many are located in "temporary" locations. Students will explore possible environmental impacts related to the mobility of some operations.

Plants must have scheduled watering in order to survive, especially plants grown in containers. The process of watering thousands of plants can be labor intensive, and most container nurseries are not equipped with automated watering systems, due to the expense. Therefore, the watering method of choice by most nurseries is overhead sprinklers combined with hand watering with a hose and nozzle. This method is not very efficient. Seventy percent of this water never reaches the plants they are intended.

We are not only concerned about the quantity of water used, but also about the potential for pollutants that are leached from pots and washed from foliage during the watering process reaching our drinking water. Customers demand high quality plants. Fertilizers, pesticides, and other chemicals are applied to plants to produce the most attractive plants possible. Some of these chemicals are mixed into the potting medium while others are applied to the foliage.

If container nurseries would use methods of watering that places the water directly into the container, not only would less water be required to accomplish the task, but potential for pollution would also be reduced. Two lesson plans are developed to observe how residue can be washed from plants during watering, and to examine how alternative watering methods can minimize this problem.

POINT SOURCE POLLUTION AND NONPOINT SOURCE POLLUTION

Water pollution can be identified as either point source pollution or nonpoint source pollution. Point source pollution can generally be traced back to the point of origin. Nonpoint source pollution on the other hand is too broad and is very difficult to pinpoint the location of origin, thereby offering investigators a greater challenge. Regardless of the source of the pollution, water quality must be measured to determine the degree of potential risk and determine which pollutants are present. To accomplish this task, monitoring stations are located throughout the state of Texas and are routinely measuring the level of pollutants. Scientists today use "cutting edge" technology such as Global Positioning Systems (GPS) and Global Information Systems (GIS) to locate precise points along different waterways which information can be collected and entered into a database for easy access at anytime. Users of this technology can receive "real time" feed of information if specific coordinates are known. Measurements are expressed in parts per million, parts per billion, and even parts per trillion. The ratio of pollutants to water can be put into perspective if students visualize one part per million would be equal to one drop in 10 gallons or one drop in an average fish tank. One part per billion equals one drop in 10,000 gallons (about the size of a small swimming pool). One part per trillion would be equal to one drop in 10 million gallons (about the size of a small stock pond).

The majority of agricultural and horticultural pollution is classified as nonpoint source. Generally speaking, water quality problems result from five categories of agriculturally related nonpoint source pollution: sediment, nutrients, animal wastes, pesticides and salts.

Some common pollutants that enter streams include pesticides and fertilizers from yards and fields, oils from roadways and parking lots, and improperly disposed wastes, including hazardous materials from illegal dumping.

Preventing Nonpoint Source Pollution

Everyone should share the responsibility of preventing nonpoint source pollution. Students will learn how individual activities affect the water. Individuals can take an active role in preventing nonpoint source pollution in a number of ways. Some of the routine chores performed by the average homeowner can go a long way to protect drinking water as well as conserve water for future use. Some of these practices include keeping pet wastes, leaves, and debris out of gutters and storm drains; applying lawn and garden chemicals sparingly; using nontoxic products in the garden; leaving grass clippings on the lawn; and disposing agricultural pesticides, containers and container residue in an approved manner.

PESTICIDES AND FERTILIZERS FROM YARDS AND AGRICULTURE

Homeowners take great pride and work hard to produce the perfect lawn. Water and mowing alone often do not provide the aesthetic eye appeal desired by most homeowners. Fertilizers, herbicides, and pesticides are used on a routine basis to create the lush lawn that is the trademark of a well-kept neighborhood. Unfortunately too many homeowners either do not read the labels of the products they use or presume “more is better.” This attitude could potentially lead to disaster if continued over the long term. Common sense and the act of following directions can still provide the desired results, although perhaps not as quickly as the homeowner would prefer.

Farmers and ranchers are also sometimes guilty of trying to go for the quick fix to obtain desired end results with the least amount of labor. Most agricultural pesticides are either herbicides, which make up about 50% of the U.S. pesticide usage, or insecticides, which make up about one-third of the pesticide usage.

Over-application or misuse of agricultural chemicals such as pesticides and fertilizers can allow these chemicals to invade surface and groundwater. Pesticide residues can easily be transported into the atmosphere through drift and evaporation, eventually becoming a part of the hydrologic cycle and return to earth in the form of rain or snow. The use of excessive amounts of chemicals on open or porous soils can allow pesticides to leach or percolate into shallow water tables.

Containers that are not properly cleaned or disposed, as well as mixing and loading pesticides in areas prone to runoff can also threaten surface or groundwater. One should read the label or consult local regulations to determine the safe distance form well heads that mixing can occur.

Effect of Pesticides on the Aquatic Environment

The effects of a pesticide on the aquatic environment depend on several different factors such as the physical, chemical, and biological properties of the pesticide. Application practices, including the amount used, method of application and timing are also important considerations that cannot be overlooked. Even the intensity of the first storm that follows application of pesticides can have great impact on the potential for polluting surface waters in the area. Pesticide effects on aquatic life varies with the toxicity of the pesticide, the amount of time it remains active in the environment, and its tendency to accumulate in the food chain. One thing is quite clear. The longer a pesticide persists in the soil, the greater opportunity for it to be transported from the crop area to receiving waters or to groundwater.

Insecticides

Insecticides used today are generally organophosphates (e.g. malathion and diazinon) and carbamates (e.g. carbaryl). Organophosphate insecticides are much less persistent, with half-lives from 1 to 12 weeks. Some carbamates persist only a few days.

Carbamates and organophosphates are not fat-soluble and therefore do not concentrate in organisms nor accumulate up the food chain. Although organophosphates are much safer environmentally, a toxic compound can kill fish in a body of water and quickly degrade with no detectable chemical trace a few weeks later. Both carbamates and organophosphates are soluble in water and can be easily transported in water. These compounds may increase the potential for groundwater contamination.

Herbicides

Herbicides vary greatly in their persistence. Alachlor and 2,4-D are considered nonpersistent, with half-lives less than 20 days. They seldom remain in the soil for longer than four to six weeks when used at recommended levels. Atrazine is much more persistent, remaining in the soil for as long as 17 months. Other herbicides like monuron, picloram, and paraquat are very persistent, remaining in the soil from two to four years. Most herbicides are nonpersistent, breaking down by the end of the growing season. When compared to insecticides, herbicides in use today rank lower in relative fish toxicity and the potential for environmental impact.

FOOD PROCESSING PLANTS

Food products, whether crops or animals, pass through many stages, from production to consumer. Before these products make their way into the supermarket, they must be properly processed. There are strict standards that must be followed to assure that the best quality of product possible reaches the dinner table. This daunting task is the responsibility of the food processing plants that are scattered throughout the world. The food industry cannot survive without water. Its uses include product washing and transport, blanching, steam for cooking and peeling, cooling and cleanup. This water ultimately becomes wastewater. This multitude of potential uses for water creates an equal potential for water-related problems.

Water Use in Canning Operations

Approximately two-thirds of water intake at a cannery is used for actual processing, one-fifth is used for cooling and condensing and the remainder is divided between boiler makeup and sanitary uses.

In general, all makeup water for processing must be of potable quality. Whenever process waters are reused or reclaimed, no chemicals or other materials may be added in concentrations, which could have an adverse affect on the quality or wholesomeness of the products. The water that is used for cooling cans or jars after sterilization must also be of potable quality. Likewise this water should be chlorinated to prevent spoilage of the contents by microorganisms in case cooling water is aspirated by formation of a vacuum in the can.

High-pressure water sprays may be used to free raw foods of soil, dried juices, chemical residue and insects. This wash water may be fresh or reclaimed from other plant operations. Much of the water that is used to transport products by flumes or pumping is also recycled, with chlorination (preferably by chlorine dioxide) to keep it sanitary.

Water Treatment Requirements

The main thing to remember here is to restate the given fact that process water in food processing pants must be treated like potable water. This is handled by the most part by starting with water of potable quality and chlorinating recycled water to keep it free from pathogens.

Boiler and Cooling Waters

Canneries use large amounts of steam for cooking, sterilizing, and cleaning. Even greater amounts of water are used for cooling. Chemicals used for treating boiler water, steam, and condensate and cooling water must have federal governmental approval, even though the treated water may appear to have no opportunity to come into direct contact with food products.

GROUNDWATER QUALITY ADJACENT TO ANIMAL FEEDLOTS

Feedlots as well as other confined animal feeding operations have always been under intense scrutiny because of potential odors, surface and groundwater degradation, wildlife impacts, and an increase in nuisance complaints. Today those feedlots in excess of 1,000-head capacity or 300-head and discharging into a stream are considered a point source and are subject to the federal National Pollution Discharge Elimination System (NPDES) permit or a state-implemented equivalent permit. Permits normally include the implementation of certain pollution control measures. However, while permitting does not usually constitute voluntary actions, there is a certain amount of voluntary discretion left to the feedlot manager. In feedlots with less than 1,000-head capacity, this is especially true. To minimize future regulatory activities, it is critical that all feedlot operations, regardless of size, involve themselves in activities to control pollution.

The major pollutant for feedlots is livestock waste. The goal of the feedlot manager is to prevent these wastes from entering surface or ground waters. As previously stated, those feedlots in excess of 1,000-head capacity or which have 300-head and discharge into a stream are required to be permitted under provisions within the Clean Water Act. In addition to nutrient management techniques, feedlots should use other management practices.

Feedlots, like those common to the Texas Panhandle, contain concentrated livestock wastes, which are loaded with nitrate and bacteria that can contaminate groundwater. This is especially true if precautionary systems are not in place to:

1) divert clean water flow away from the livestock yard;
2) drain water away from the well location; or
3) collect polluted runoff from the yard for diversion to a waste retention structure where its effect on surface or groundwater is minimal.

Livestock waste contaminates groundwater more readily if the facility or area of animal concentration is located on soil which is coarse-textured, especially if the water table is at or near the surface. Other factors that contribute to the ease of contamination include a fractured bedrock within a few feet of the surface, or if polluted runoff is discharged to permeable soils and bedrock.

This part of the unit focuses on managing livestock holding pens in the following areas:

1) Separation distance from well
2) Clean water diversion
3) Runoff control
4) Feedlot cleaning
5) Livestock manure storage and treatment

Separation Distance from Well

It is recommended that wells be located in an elevated area upslope from the feedlot so that runoff will drain away from wells. Texas water well code requires a minimum separation of 150 feet between existing livestock yards and new wells.

Clean Water Diversion

Water pollution from livestock feed yards can be greatly reduced by limiting the amount of clean water entering the open lot. This can be accomplished through the use of the following structures:

1) waterways, small terraces and roof gutters to direct water away from livestock pens;
2) an earthen ridge or diversion terrace constructed across the slope to prevent runoff from entering the feed yard; and
3) a catch basin with a pipe outlet installed above the livestock yard if a diversion terrace is not practical.

Runoff Control

Open lots will typically have an earthen surface which has been compacted by animal traffic. Measures should be taken to shape this surface to a uniform grade for water drainage, so it remains relatively dry except during and immediately after rainfall. Manure accumulates on this surface, which decays and is mixed into the soil by animal traffic, sealing the surface and reducing infiltration.

Water that runs off concrete pads and clean water from roofs and upslope areas can lead to problems if it washes manure from the open lot surface. The risk of contamination is greater with soils having high infiltration and percolation rates.

Producers should collect and store runoff from holding pens for later land application. Systems in place can collect runoff, settle out manure solids, and direct the remaining runoff water to detention ponds.

Feedlot Cleaning

Feedlot surfaces should be cleaned on a routine basis. Various factors contribute to the amount of manure accumulation on the feedlot surface. These factors include animal spacing (square feet per head), hours per day animals spend on the open lot, animal size, and type of feed ration. Dairy operations should preferably be cleaned and scraped once a week, whereas beef cattle only once every month or two. Concrete surfaces are obviously much easier to clean than earthen lots. Earthen lots are generally only cleaned when dry, so solids may be removed less frequently. Allowing a one- to two-inch buildup of compacted manure on the soil provides a good surface sealing. The use of a tractor-drawn box scraper collects manure while leaving a well-graded, uniform manure surface that sheds water and dries out rapidly. Earthen yards can be cleaned only once or twice per year.

Livestock Manure Storage and Treatment Facilities

Manure that is improperly stored can contaminate both surface and groundwater with nutrients and disease causing organisms. The ability to store livestock manure allows producers to spread it when crops can best use these nutrients. Accumulating manure in concentrated areas can be risky to the environment and to human and animal health if not done properly.

According to federal and state drinking water standards, nitrate levels in drinking water should not exceed 10 milligrams per liter. Levels higher than this can lead to health problems for children under the age of six months, including the condition known as methemogloinemia (blue baby syndrome).

High levels of nitrate nitrogen can also affect young livestock. Levels of 20 mg/L to 40 mg/L in the water supply may be harmful, especially in combination with high levels of nitrate nitrogen from feed sources.

Manure is stored in liquid and solid form. Wastes should be stored in an environmentally sound manner until they can be applied to the land. Texas Natural Resource Conservation Commission (TNRCC) regulations apply to the location of and minimum standards for seepage control from lagoons and detention ponds. Livestock wastes are stored in either Long Term Storage Facilities or Short Term Facilities. Long term refers to a storage period generally longer than 90 days. Short-term storage is usually for a period between 30 to 90 days to allow producers to hold wastes during periods of bad weather when daily spreading is not feasible.

Students will review recommended publications and websites to attain additional information about the safe storage and treatment of livestock manure.

URBAN LIVESTOCK FACILITIES (Including FFA Feed Centers)

The value of experiential learning is certainly a recognized practice in the successful learning that takes place in classrooms across the country everyday. Career and technology courses like Agricultural Science and Technology are well suited for delivering these types of learning opportunities to the students that enjoy learning by doing. One of the best living labs that is used by agriculture teacher is the "Land Lab" otherwise known as "the school farm." Very little farming is actually practiced on these facilities, but large numbers of livestock are raised annually by Future Farmers of America (FFA) members as a part of their Supervised Agricultural Experience (SAE) program. This section of the unit will look at ways the "Land Lab" can be used to teach students about the prevention of water pollution as it relates to the agricultural industry.

Since most of the animals raised by students in these programs are raised for the specific purpose of eventually reaching the dinner table, the projects are labeled "feeder" projects. Therefore, similar practices as those related to feedlot operations should also be applied to the high school livestock center. However, the major difference that must be addressed here is that these feedlots are located within city limits, typically in close proximity to neighborhoods.

Generally high school FFA members raise livestock of the following species: cattle, swine, sheep, goats, broilers, rabbits and in some locations, turkeys. Students normally raise poultry and rabbits at their homes. To accommodate the remaining species separate facilities are used for cattle and swine, while sheep and goats are housed in the same barn. There are no mandated standards or housing requirements for livestock facilities, therefore the school or school district you visit will determine the type of structure or structures being used. Some are totally self-contained, closed structures, while others are very open and provide little more than shade for the animals. Some swine barns have concrete floors, which drain into the city sewer system, while others are earthen floors that must be cleaned daily.

TEACHING STRATEGIES

The primary purpose of this curriculum unit is to raise the awareness of students that agricultural practices, although not in the typical sense, do indeed occur in the city of Houston, and these practices do impact the water supply. The premise for success in the agricultural classroom has always been based on "hands on" learning. In fact the FFA motto, “Learning to Do, Doing to Learn, Earning to Live, Living to Serve,” is one of the things that drives me to continue to teach after 25 years in the classroom. Therefore, in this unit students will be given multiple opportunities to demonstrate an understanding of the relationship between agriculture and water pollution through activities that involve “doing.”

Students will conduct various experiments that, in some cases, may involve several weeks to finalize. Results are not always immediately observed as is the case with real life pollution problems. Students will be given the opportunity to explore areas they wish to learn more about, for additional credit. Environmental Science students might be able to use their newfound knowledge for science fair projects if they so choose.

It would be ideal for students to learn about industry practices through actual visitations or field trips. Unfortunately while developing this unit I learned that many times wholesale nurseries are not able to accommodate large groups in a field trip setting. Likewise, it would not be possible to take students to the Texas Panhandle to observe feedlot practices that minimize risk of pollution. To bring these experiences to the classroom, the teacher might want to purchase videotapes that are available from educational resources or create their own videos and PowerPoint presentations by scheduling tours of selected sites.

LESSON PLAN ONE

Distribution of Earth’s Resources

As an introductory lesson to this unit the teacher should begin by performing the following demonstration that vividly illustrates the relationship between land and water on the planet Earth. This wonderful activity, *Teacher’s Pet Project*, was borrowed from Zero Population Growth, Inc. The teacher may wish to practice this activity several times at home before attempting to do it in the classroom. Also, be very careful if you are not particularly skilled using a knife.

EARTH: THE APPLE OF OUR EYE

Concept
A visual demonstration of the limited sources of food available from land and water.

Materials
An apple, a knife, and a paper towel.

Procedure
Slice the apple according to the instructions, following with the italicized text.

PART I: FARMLAND

Apple = Earth
3/4 = water
1/4 = land
1/8 = uninhabitable and non-arable land: poles, deserts, swamps, high/rocky mountains

1/8 = habitable land
3/32 = habitable, but not arable land
1/32 = arable land
1/32 = topsoil

1. Hold the apple out so the class can see it.
   "*This apple represents our planet.*"

2. Cut the apple into quarters. Hold out ¾ in one hand and ¼ in the other.
   "What do these ¾ represent? (water) So, only ¼ of the Earth's surface is land."

3. Set the ¾ (water) aside. Slice the remaining ¼ (land) in half, lengthwise. Take ⅛ in each hand and hold out one of them.
   "One-eighth of the Earth's surface, or half of the land, is inhospitable to people and to crops: these are the polar regions, deserts, swamps, and high or rocky mountains."

4. Set that ⅛ aside and hold out the other.
   "This ⅛ of the Earth's surface, the other half of all land, represents the total area on which people can live, but not necessarily grow food."

5. Slice this ⅛ lengthwise into four pieces. Hold out 3/32 in one hand and 1/32 in the other.
   "Each of these pieces represents 1/32 of the Earth's surface. These three represent land that never was arable because it's too rocky, wet, cold, steep, or has soil too poor to produce food. They also contain land that was once arable but is no longer because it has been turned into cities, suburbs, highways, shopping centers, schools, churches, parks, factories, parking lots, and other forms of development that can no longer be farmed."

6. Set 3/32 aside and hold out 1/32.
   "So only 1/32 of the Earth's surface has the potential to grow food needed to feed all of the people on Earth."

7. Carefully peel the 1/32 slice of Earth, and hold this peel up so they can see it.
   "This tiny bit of peel represents the topsoil, the dark, nutrient-rich soil that holds moisture and feeds us by feeding our crops. Eighty percent of U.S. crop lands currently lose an inch of topsoil every 33 years, twenty times faster than the natural rate."

At this part of the activity students should have a better understanding about the amount of land, which we as agriculturalists have a great responsibility to protect. This activity should lead to another unit related to land usage for a world with a population of six billion people. However, we need now to focus on the issue of water. To illustrate this point, move on to the second part of the activity.

PART II: WATER

3/4 = water
1/8 = food-producing areas
4/32 = coastal areas
4/32 = photic zone: habitat of most marine life
sliver of peel = freshwater (only 0.3% of all Earth's water)

1. Return to the ¾ of the original apple that represents the oceans.
   "Some of our food comes from the sea. Yet, despite the vastness and seeming uniformity, many regions of the world's oceans are unproductive due to the lack of life-supporting nutrients. Nearly one billion people, mostly in Asia, rely on fish as their primary source of protein."

2. Set aside 2/4. Cut the remaining ¼ in half. Set ⅛ aside and hold out the other ⅛.
   "This ⅛ represents the productive zones of the ocean along the equator and the western margins of continents. Currents cause up welling, which brings nutrients to the surface. These nutrients support large numbers of marine plants and animals."

3. Peel the skin from this ⅛.
   "This peel represents the photic zone, the top 100 meters (330 feet) of the ocean of which light can penetrate, supporting photosynthesis. Since the marine food chain depends on algae and photosynthesizing plants, especially phytoplankton, almost all ocean life is concentrated in this narrow photic zone. At 100 meters below the surface, the amount of light is only 1% of what it is at the surface."

4. Cut a very small wedge from the apple skin. Hold it out.
   "Fresh water is another precious and finite resource that is essential to all life on this planet, including human life. It is supplied by rainfall, groundwater, rivers, lakes and streams. Although ¾ of the Earth is covered by water, only 3/10 of 1% is available fresh water in river, lakes and shallow groundwater. It is what we drink, cook with, bathe in, and water crops with when rain doesn't provide enough moisture."

The practices we use to protect this 0.3% are everyone's responsibility. How can agriculturalists and horticulturalists make sure they are doing everything to protect this precious resource? Let's explore the possibilities.

LESSON PLAN TWO

Where Does Pesticide Residue Go When You Water Plants in a Traditional Manner?

Materials Needed

10 small plants
Black plastic
Flat white sheet (Queen size)
Yellow corn meal
Sifter
Water hose with handle and nozzle

Procedure

This activity must be done outside. Spread a 6' x 6' sheet of black plastic on top of level ground to prevent splashing of soil on students. Cover the black plastic with a queen size flat sheet.

Place ten small potted plants in the center of the white sheet.

Use the sifter to sprinkle a generous amount of yellow corn meal onto the foliage of each plant. Try to completely cover the plant. Avoid getting any corn meal onto the black plastic. The corn meal will represent powdered form of pesticide.

Turn on water at half pressure. Use the water hose with handle and nozzle to water the plants. Hold the handle well above the tops of the plants. Continue to water until water flows freely through the drain holes in the pot.

Turn the water off after plants have been sufficiently watered or told to by the teacher.

Answer the following questions about your observations.

1) What happened to the pesticide? (corn meal)
2) Approximately how much pesticide is now on the plant foliage?
3) Approximately how much pesticide is now on the black plastic?
4) Is this a potential source of pollution?
5) Now think about a container nursery that grows 10,000 or more plants and water in this very same way. Should we be concerned about water pollution using the traditional method of watering used by most nurseries?

LESSON PLAN THREE

Where Does Pesticide Residue Go When You Water Plants Using Drip Irrigation?

Materials Needed

10 small plants
Black plastic
Flat white sheet (Queen size)
Yellow corn meal
Sifter
Water hose with handle

Procedure

This activity must be done outside. Spread a 6’ x 6’ sheet of black plastic on top of level ground to prevent splashing of soil on students. Cover the black plastic with a queen size flat sheet.

Place ten small potted plants in the center of the white sheet.

Use the sifter to sprinkle a generous amount of yellow corn meal onto the foliage of each plant. Try to completely cover the plant. Avoid getting any corn meal onto the black plastic. The corn meal will represent powdered form of pesticide.

Turn on the water at the slowest rate possible – a trickle. Use the water hose with handle to water the plants. This time place the handle directly into each pot. Avoid contacting the foliage with any water if possible. Continue to water until water flows freely through the drain holes in the pot.

Turn the water off after plants have been sufficiently watered or told to by the teacher.

Answer the following questions about your observations.

1) What happened to the pesticide? (corn meal)
2) Approximately how much pesticide is now on the plant foliage?
3) Approximately how much pesticide is now on the black plastic?
4) Is this a potential source of pollution?
5) Now think about a container nursery that grows 10,000 or more plants. Should we be concerned about the potential for water pollution using a drip irrigation method?

LESSON PLAN FOUR

Point Source and Nonpoint Source Pollution

In this lesson students will discover a pond that has been "polluted." They will investigate to determine the source of the pollution.

Materials Needed

(4) ring stands
(4) flasks
(4) rubber stoppers with tubing
(4) hose clamps
(4) "factory" labels (student created)
(1) tray with cover, plugged at one end
(1) small aquarium to represent pond
(1) bottle of food color

Procedure

Set up this experiment before students enter the room.

1. Fill four flasks with tap water.
2. Add food color to one flask to create a rich dark color.
3. Plug each flask with a stopper. Make sure the hose is firmly seated and the hose clamp is in place.
4. Cover each flask with a "factory" label to conceal the contents of each flask. Be sure the label is positioned so that once it is inverted the factory will be right side up.
5. Invert each flask and place into a ring stand.
6. Place the loose end of each hose into the tray; then cover the tray.
7. Place a small, half filled aquarium at the end of the tray, just off the end of the lab stand. Slightly elevate the opposite end of the tray.
8. After reviewing point source and nonpoint source pollution begin the activity by asking two students to release the four clamps, allowing the discharge of wastewater from each "factory."
9. After all the flasks are emptied, remove the plug from the end of the tray, allowing the contents of the tray to spill into the small aquarium.
10. Observe what happens to the clean water of the "pond." Ask the students, "Who's responsible for this pollution?"
11. Allow students time to discuss the possible sources of the pollution and to conduct investigations to determine which factory is responsible.

LESSON PLAN FIVE

The Effect of Lawn Fertilizer on Aquatic Life in Storm Drains

This lesson will allow students to observe the effect of different concentration levels of fertilizer placed on the average lawn over time, as well as the importance of following manufacturer's label instructions. Use recycled two-liter soda bottles to construct your Eco-towers by removing the top one-third of the bottle and inverting it to fit snugly into the lower section of the bottle. Carefully punch several holes in the lid before replacing it on the bottle, to act as a strainer, allowing liquids to pass through but hold back solids.

Materials Needed

(4) Eco-Towers, labeled A-D
(1) small flat lawn grass plugs, from local nursery
(24) snails (obtain from Living Resource Center)
(1) small bag of well-drained potting soil
(1) small container of fertilizer
(4) empty, one-gallon water bottles
(1) watering can with spray head
Lab journal for each student

Procedure

1. Set up four Eco-Towers.
2. Place six snails into the lower chamber of each Eco-Tower.
3. Place potting soil in the upper chamber of each Eco-Tower and plant turf grass.
4. Use tap water to mix different concentrations of fertilizer as follows:

   Container A - Mix according to label instructions.
   Container B - Mix 2x recommended strength.
   Container C - Mix 3x recommended strength.
   Container D - Mix 4x recommended strength.

5. Use the prepared solution from each container to water the matching Eco-Tower, using the watering can. Make sure the solution leeches through the soil and into the lower chamber, which represents the storm drain.

6. Observe and the reactions on the snails. Record your observations in your journal.

7. Repeat this process daily for one month, recording observations in your journal as to the effect of the fertilizer on the lawn and on the snails.

8. At the end of one month report your findings.

LESSON SIX

Food Processing and Possible Contaminants

This activity will allow students to observe how possible contaminants are eliminated in the early stages of food processing. To prepare students for this activity obtain a copy of a video on food processing.

Materials Needed

(4) varieties of fresh vegetables
(6) large bowls
(6) strainers
(24) 1-quart mason jars with lids
(24) Peel and stick labels
(4) 1-gallon containers distilled water

Procedure

The teacher should obtain four varieties of fresh vegetables from each of the following sources: farmer's market, supermarket, and home garden if possible. If it is not possible to obtain vegetables from a home garden, the teacher could double the amount of vegetables from the farmer's market and add soils and other "contaminants" to simulate fresh picked vegetables. Place raw vegetables into Ziplock bags**.** Label each bag with a code, known only to the teacher, identifying the source of the vegetables.

Divide the class into six groups. Provide each group with a large bowl, strainer, labels, four mason jars with lids, distilled water, and four bags of vegetables.

Students should write the following information on each label: name of vegetable, predicted source, and date.

Steps to follow:

1. Open one bag of vegetables and place into the strainer.
2. Place the strainer over the large bowl.
3. Slowly pour water over the vegetables to rinse away the solids, capturing them in the large bowl.
4. Transfer the captured contaminated water into a mason jar, close with the lid and place the label onto the mason jar. Set the jar aside.
5. Repeat this process until all the vegetables have been used.
6. Place all mason jars in a secure location to allow contents to settle.
7. When the class reconvenes the next time, do not move the jars. Students should record their observations in their journals.
8. Students should explore the following questions regarding their observations:

    A. What are the particles found in this wastewater?
    B. Are they harmful?
    C. Were all of the particles removed in the initial washing?
    D. Are there other particles that are not visible to the "naked eye" present in this wastewater?

LESSON PLAN SEVEN

Location of Water Wells near the Feedlot

Students will use information learned in this unit to determine the proper location of a new water well for use at a feedlot. Provide each student with a map of a typical feedlot with four proposed locations for a new water well. Students should be able to provide valid reasons for approval or non-approval for each proposed well. If none of the locations are valid, students should determine where the well should be located.

LESSON PLAN EIGHT

High School FFA Feed Centers and Horse Stables

As an alternative to a field trip to a district Agriscience land lab, the teacher could exercise one or more alternative activities. The teacher might arrange for an individual meeting with an Agriscience teacher after school and either video tape an interview with the teacher as the teacher provides a "video" tour of the facility or use a digital camera to download pictures into a PowerPoint presentation. The teacher could also assign teams of students to visit the different Agriscience facilities and horse stables in the district to prepare and present reports to be presented to the class.

LESSON PLAN NINE

Capstone Learning Activity

This activity will take several days to complete and will require a lot of teacher planning and effort if it is to be successful. Students will be given the charge of designing the layout for a livestock feeding center to be located on the school campus. Students would work in groups of four. Students will make "site visits," go through the process of deciding where on campus to locate the facility, and determine which permits must be obtained, where to seek advice, what species and anticipated numbers of livestock are to be raised, what types of structures are to be used, the water source to be utilized and ways to manage waste. Students will use a variety of tools including survey equipment and GPS technology to accomplish this task. If available, students could also use Computer Aided Drafting software to generate drawings for the proposed facility. Students could also prepare a model of their proposed facility. Students would finalize this activity by using a variety of presentation methods to "sell" their plan to the rest of the class.

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The food processing information was taken from this site.

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