A curriculum developed to help youth understand:

- why chemicals from medicines are found in the environment
- the harm these chemicals can cause
- what can be done about it

Sensible Disposal of Unwanted Medicines

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The *Sensible Disposal of Unwanted Medicines* curriculum was developed to help high school youth understand why chemicals from medicines are being found in the environment, the harm these chemicals can cause, and what can be done about it.

Five inquiry-based lessons are included:

- So, what's the big deal?
- What are the issues?
- What should I be concerned about?
- What are my options?
- How can I let other people know about these issues?

These lessons are intended to be introduced and led by an adult instructor (4-H volunteer, Extension educator, teacher, or other educator) but with the youth increasingly taking leadership as they progress.

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Table of Contents

Each activity contains the following items:

- Objectives—general and specific for each activity
- Time—an estimate of the time needed for the activity
- Resources—items needed to complete the activity. These should be assembled prior to meeting. Youth can be given the responsibility of obtaining needed resources.
- Activity—an overview of what will be done
- Instructions
  - suggested dialogue for the instructor
  - possible answers and suggestions for the inquiry activities (in a shaded box)
- Evaluation—ideas for evaluating youth learning
- Share Your Knowledge— ideas for youth to share new knowledge. This will help them process and retain the information.
- References
- National Science Standards
- Life Skills—a listing of the possible life skills learned by youth doing the activity
- Success Indicators—ideas on how to evaluate youth understanding of the objectives

► *Note to the Instructor*

Thank you for taking the time to work with youth and to help them understand and address a very important environmental issue. Your involvement and interest in this issue has several benefits: youth will learn about an emerging environmental concern and will be working with a concerned, caring adult. This interaction has benefits for you, the youth, and the environment.

Thank You!

Photos courtesy of Mel Lenig, Penn High School.

So, what's the big deal?

General Objective

- Learn why the proper disposal of unused and expired medicines is important.

Specific Objectives

Youth will learn how to:
- Hypothesize about what happens to pollutants that are flushed down the toilet
- Understand the difference between municipal sewage treatment and private sewage treatment
- Use the scientific method to:
  – Set up an experiment
  – Measure experimental data
  – Plot/graph results
  – Draw conclusions

Time

1.5 - 2 hours

Resources needed

___ Copies of Figures 1-4 *(pages 6 and 8)* (color photos are available at www.iisgcp.org/education/SafeDisposal_4H.html).

___ Journals – These can be small spiral notebooks or bound, data-collection books. Each student should have one, and they should be collected after each meeting by the instructor until the last lesson (so they will not be forgotten). The youth should be given their journals at the final meeting and encouraged to continue to use them.

___ Copies of the *Scientific Method Worksheet* for each student *(page 13).*

___ Materials for filtration experiment:
- 2 plastic water bottles or clear plastic drink cups for each group
- 2 bowls for each group
- Porous media (solids that have an interconnected network of pored filled with a liquid. Soil is a porous medium)
- at least two of the following: soil, sand, gravel, aquarium gravel, marbles
- Food coloring
- Measuring cup
- Timer (watch or clock with a second hand)

Activity

After a brief discussion about wastewater treatment systems and water contamination, youth will hypothesize about what happens to pollutants that are flushed down the toilet and explore the difference between municipal sewage treatment and private sewage treatment. They will then conduct a guided experiment to explore how unwanted medicines can end up in local waters. Youth will:
- Learn about wastewater disposal.
- Use the scientific method to study water movement through a porous medium.
- Learn that contaminants from discarded medicines have been found in water and soils.
- Use the scientific method to study how a porous medium can remove some contaminants from water, but not others.

Instructions

► ***Instructor***

Water contamination can come from many sources. These pictures (Figures 1 and 2) show some possible agricultural and urban sources of contamination.

- What do you notice about these pictures?
- What do they show about how contaminants can enter water sources?

Possible discussion points

- Figure 1 shows that water contaminants can come from agricultural fields (pesticides, herbicides, and fertilizers), animal manure, and malfunctioning septic systems. These contaminants can enter surface water (not shown) and groundwater. If contaminants enter groundwater, they can be taken up by well pumps.
- Figure 2 shows that water contaminants can come from impervious surfaces (roads, parking lots, and roofs), lawns, and improperly disposed trash.

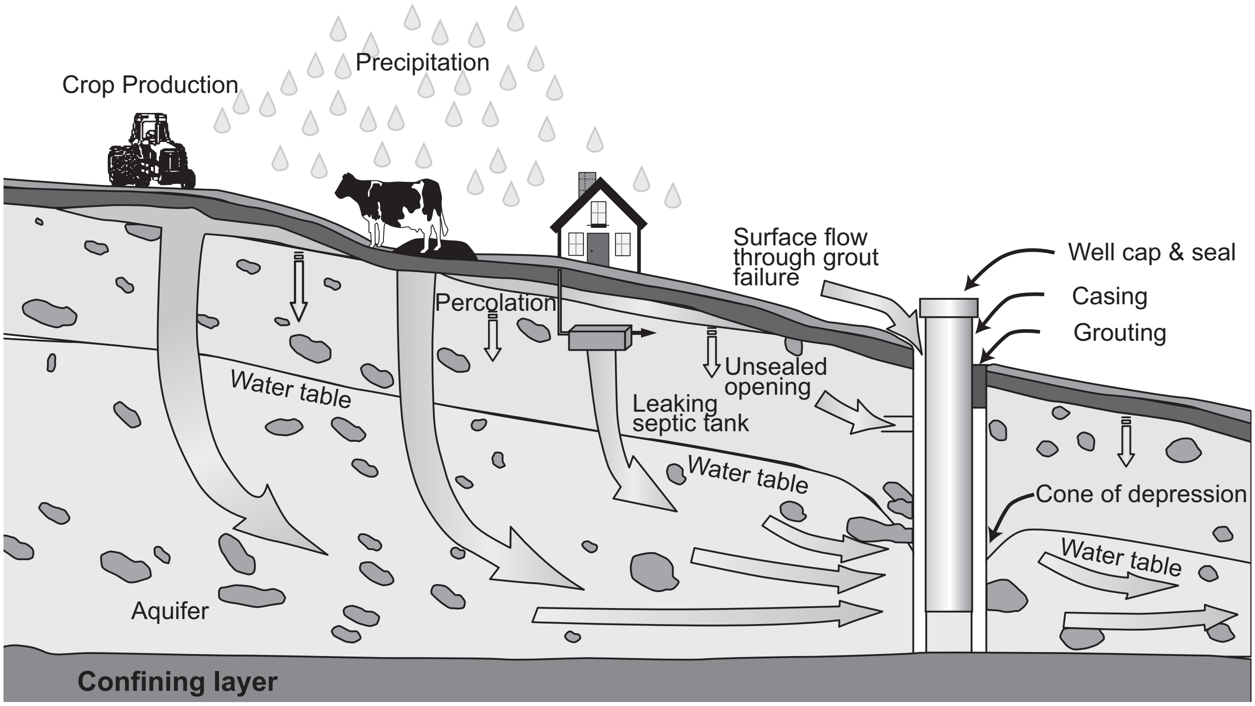

Figure 1. Agricultural contamination sources. (Courtesy – © MWPS (Midwest Plan Service), Iowa State University, Ames, IA, http://www.mwps.org. Used with permission: Private Water System Handbook. MWPS 14.)

Figure 2. Urban contamination sources. (Istock photo.com)

Instructor

There are two major ways that wastewater is processed. In most cities and towns, municipal water treatment plants treat wastewater (from homes, businesses, and sewer systems). Most people that live in the country have private wastewater treatment systems, often called septic systems. These diagrams (Figures 3 and 4) show how these two systems work.

- What components do you see in the diagrams?
- How are the two treatment systems similar? How are they different?

Possible discussion points

- Figure 3 shows a private wastewater system (often called an onsite system). This system has two main components—the *septic tank*, where sludge settles to the bottom, and the *absorption field,* where liquids (effluent) are filtered through soil.
- Figure 4 shows a municipal system. This system utilizes three treatments and disinfection:
  - Primary treatment – separates large solids from the waste stream using metal grates and a grit tank (where sand and gravel settle out). The waste stream goes to the primary sedimentation tank, where about half of the suspended, organic solids settle out as sludge.
  - Secondary treatment – effluent from the primary treatment flows into a trickling filter bed, aeration tank, or sewage lagoon for biological degradation of the dissolved organic compounds.
  - Tertiary treatment removes plant nutrients, especially nitrates and phosphates.
  - Disinfection with chlorine or ultraviolet radiation is used to kill disease-causing organisms. Other treatment processes are used as needed.

In general: waste from drains or toilets is treated in a municipal or private onsite (septic) waste treatment system (often called sewage treatment). Solids settle out and are disposed of, often used for fertilizer on farm fields. The water (effluent) is treated and released to surface water. Filtration of water through soil is used in both systems. Filtration removes many contaminants and is relatively cheap. The solids in both types of treatments (private and municipal) are periodically removed by tanker trucks and often incorporated (mixed with soil) to add nutrients to farm fields.

Instructor

Filtration is an important component of wastewater management. We will study how the amount of filtration depends on the type of soil that the water is moving through. But first, we need to refresh our memories about the steps involved in the *Scientific Method*. Who remembers the steps that scientists follow?

The Scientific Method

An organized way to think about problems and solve them.

1. **Stating the problem:** Think about what you want to learn.
2. **Forming the hypothesis:** After you choose a problem to study, describe what you think might happen.
3. **Observing and experimenting:** Observe or set up an experiment to test your hypothesis. Tally your data. You can make your own charts by hand or on the computer.
4. **Interpreting data:** Once you have collected your data, you need to understand what it tells you. The data can be interpreted by comparing numbers visually or in graphic form.
5. **Drawing conclusions:** Consider how your observations and/or experiments affect your hypothesis.

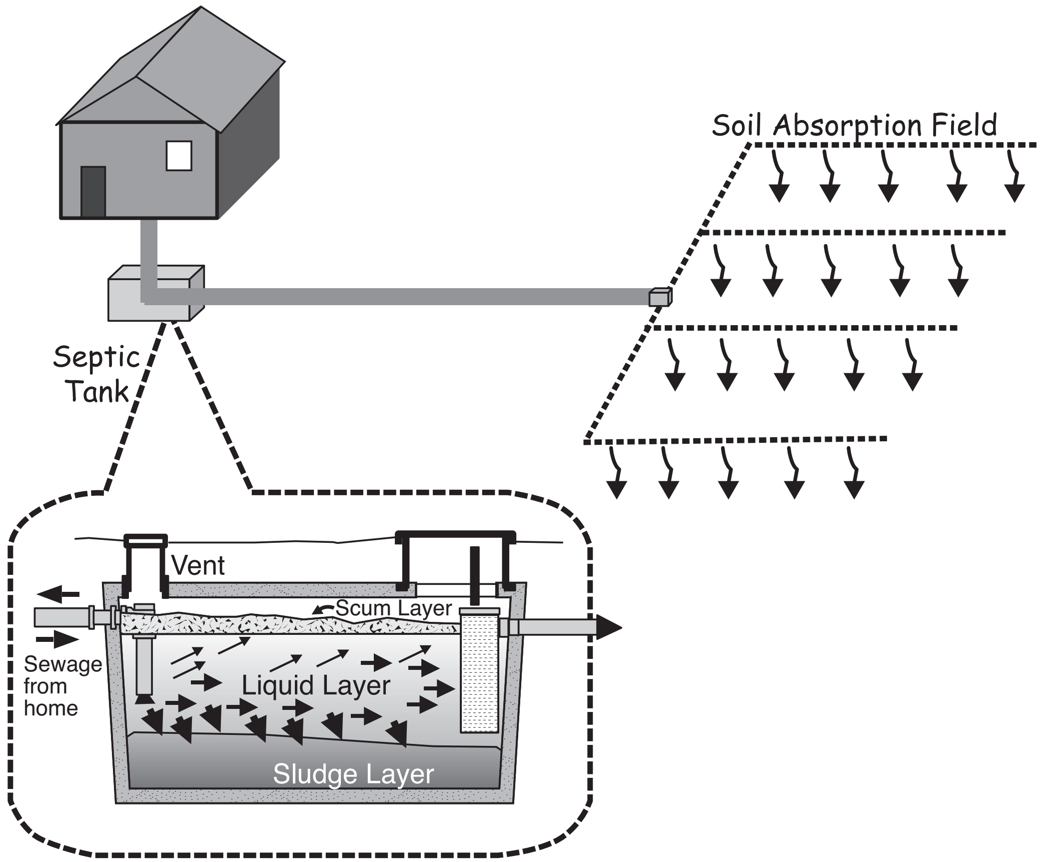

Figure 3. Private wastewater system. (Courtesy: Don Jones, Purdue University)

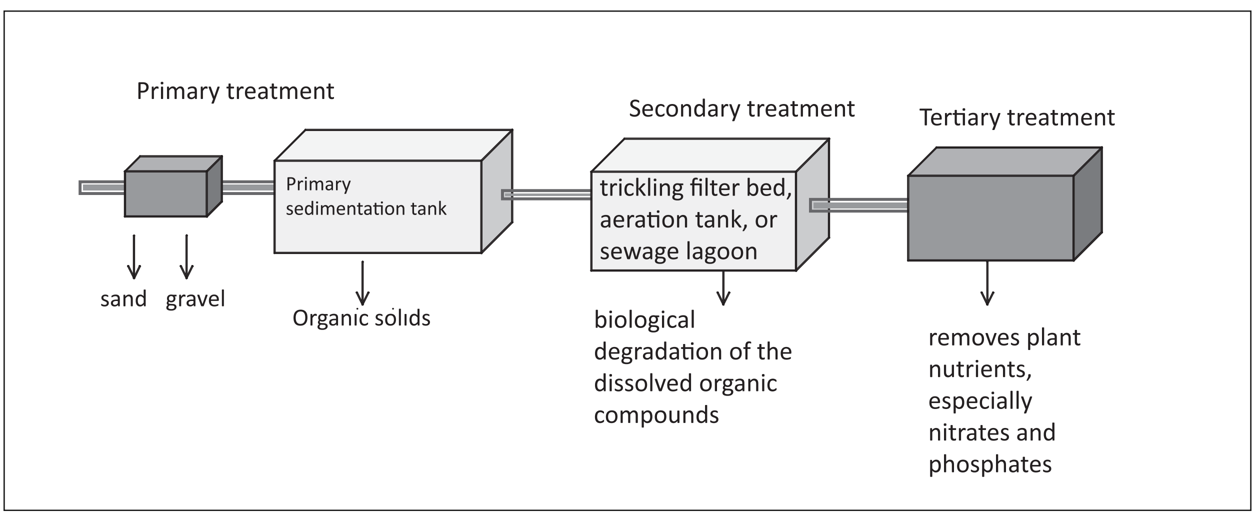

Figure 4. Municipal wastewater system. (Natalie Carroll, Purdue University)

► ***Instructor***

Work together in teams of 2-4 (if you have a large enough group). Use the *Scientific Method Worksheet* on page 13 and the materials we have available to complete an experiment comparing how water flows through different porous media. Our Statement of the Problem is to study water movement through a porous medium. Your hypothesis should be based on your estimate of which porous medium the water will flow through faster.

Follow these steps

Note to instructor: *The instructions are given on the Worksheet (page 13).*

- As you do this experiment, record your results and complete the scientific method worksheet on p. 13 (interpret your data and draw conclusions). Write a hypothesis of what will happen when you pour water through two different types of porous media (e.g., aquarium gravel, sand, marbles, soil, etc.).
- Cut the tops and bottoms off two (matching) clear water bottles. These will be your "test tubes."
- Put two inches of different porous media in each water bottle and set it in a plastic bowl (to hold the medium, catch the water as it drains out, and allow you to see the entire tube).
- Be ready to time how quickly the water moves through the porous media as soon as it is introduced, as some porous media will transmit the water very quickly (others will not).
- Add ¼ cup of water to the first bottle, and see how long it takes before you see any in the bowl.
- Repeat with the second medium. If the water in the first bottle is moving slowly you can run these simultaneously.

The results of this experiment will depend on the porous medium that the youth choose. Generally, water flows through porous media with larger particle size faster than porous media with smaller particles because of the increased pore space for water to travel through. So, water will flow through gravel faster than sand, through sand faster than loam soil, and through loam soil faster than through clay, because clay is made up of very small particles. Let the youth choose the porous media from those you have brought in, and then lead a general discussion of what medium transported water the fastest. The speed that water moves through soil is a critical factor in the amount of filtration (removal of contaminants) that occurs.

You may also wish to discuss how this affects the following:

- crops – water is available longer in soils with smaller particles, sometimes too long, as can happen with some clay soils
- absorption fields – water needs to move through the soil at the proper speed: too fast and contaminants are not held in the soil, too slow and water is not removed from the system fast enough and ponding above the field can occur

Marbles

Aquarium gravel

Sand

Soil

► ***Instructor***

The conclusions that the youth make will depend upon their experiment. Ask the students:

- Is your hypothesis supported or rejected by your observations and experiments?
- How do the results give you ideas for future studies and new hypotheses?
- If you were to run the experiment again what would you do differently?

Notes: Water flows through the marbles almost immediately, whereas the aquarium gravel took about 1-2 seconds, and the (damp) sand about 6 seconds. Potting soil was used for the soil test. When the soil was simply poured in the container, water flowed through almost immediately. When the soil was tamped down (packed using the end of the ruler or a pencil), the water took almost two minutes to emerge from the bottom of the test tube. Using soils with different levels of packing is a good way to show how compaction affects water movement.

Notes: If you have access to an aquifer model, you can show how water moves. Use red food coloring as a point source to show how a contaminant can move to a lake or stream.

► ***Instructor***

Unfortunately, traditional methods of sewage treatment do not remove all the harmful contaminants that pass through waste systems. Contaminants poured down sinks or flushed down toilets can enter and harm the environment. Some contaminants dissolve in water and move through the waste disposal system with water. Other contaminants do not dissolve and become part of solid waste, which is applied to fields. We can show how contaminants will flow with water by adding some food coloring to water or by putting drops of food coloring on top of wet sand or soil.

Materials that dissolve in water will flow though the soil, while those that do not dissolve will stay on the top of the soil. Many variables affect how contaminants are filtered through soil, including: soil composition (Soils are only very rarely made of one type of porous medium.); depth of soil (The more soil that water flows through the more filtering that can take place. This is why private wells should be at least 100 feet deep.), the amount of organic matter and soil moisture; the presence of cracks and fissures (providing preferential flow paths); and the chemical composition of the contaminant.

The easiest way to show contaminant movement is to add a few drops of food coloring and ¼ cup of water to the wet sand. (Soil is too dark to see movement, although youth can see food coloring as it exits the bottle with water.)

► ***Instructor***

Increasing evidence illustrates that improper disposal of prescription medicines and personal care products is an emerging environmental concern.

Food coloring demonstrates contaminant movement.

Traditional disposal methods for these items were to flush them down toilets or pour them down a sink. Contaminants from discarded medicines that have been flushed or poured down a sink have been found in water and soils.

▶ ***Instructor***

How could a scientist test whether some medicines that are flushed down the toilet are removed or treated by our traditional wastewater treatment methods, while others are not? Lead a general discussion about the knowledge needed to discover how medicines and personal care products are causing environmental damage and what can be done to stop it. You might ask:

- What type of knowledge would be needed to carry out a study of the environmental impact of medicine disposal?
- What disciplines teach this?
- Do you think this study would be costly? Would it be time consuming?

Possible answers

Researchers trained in many different disciplines work in teams to study the origins of contaminants on plant and animals in our environment. The U.S. EPA has primary responsibilities for this work, as do researchers in colleges, universities, and the Sea Grant College Program.

- What type of knowledge would be needed to carry out a study of the environmental impact of medicine disposal?
  - An ability to test soil and water to determine what chemicals are present and the levels of contamination.
  - A knowledge of plants and animals, especially aquatic plants and animals.
- What disciplines teach this?
  - Chemistry
  - Biology
  - Mathematics
  - Wildlife Ecology
  - Geography
- Do you think this study would be costly?
  - The cost will be dependent on the number of tests run, how long they take, and the cost of experts who will analyze the data. This work is fairly expensive.
- Would it be time consuming?
  - Yes, running the tests and analyzing results takes time.

▶ ***Instructor***

Now that you have an idea of how water moves through soil and how wastewater is treated, we will start to talk about how medicines can get into our environment. To prepare for our next session, write the following questions and record answers from five people. Do not record people's names (keep it anonymous) but indicate if you asked a child, teen, or adult. If you asked an adult these questions, indicate if they have any special training (for example: adult – doctor; adult – researcher). We will discuss their answers next time.

- What do you do with medicines you no longer need?
- What should people do with medicines they no longer need?

What did you learn today? Please take 5-10 minutes to reflect on today's lesson, what you learned, and what questions you have. Write about this experience in your journal. Be sure to put today's date on the page with your entry.

Journaling is a great way for youth to process what they have learned. By asking whether they have questions after they have had some time to write, you may find topics for further discussion or future activities or that more information is needed. It is especially nice if you can have a small notebook or another special place or way for the students to keep their personal notes. Collect the journals between meetings to review what the youth learned or to make note of questions that they did not share. Collecting the journals will also ensure that youth will have them for the next meeting.

Plan to post the flip chart sheets for the next meeting to remind the youth about this activity.

Evaluation

- Do the youth understand how wastewater treatment works in both private and public sectors?

- Did the youth follow the scientific method properly?
- Did they write an appropriate hypothesis and determine whether their experiment lead them to accept or reject their hypothesis?
- Do the participants understand why some medicines are entering our surface and groundwater?

Share Your Knowledge

Youth can share what they learned during this session in many ways. The following are some examples:
- Speech and demonstrations (including *action demonstrations*)
- Project exhibits (ex: soil & water conservation)
- Jr. Leader activities
- Mentoring a younger 4-H member

References

- Illinois-Indiana Sea Grant Program, **www.iisgcp.org/unwantedmeds** - Appendix D gives background information.
- U.S. EPA Classroom Activities, **www.epa.gov/safewater/kids/wsb/pdfs/682.pdf**, *Purification of Water* – more detailed information about the steps in a wastewater treatment plant.
- Appendix A has some additional activities that can be used.

Science Standards

Appendix C

Life Skills

Acquiring knowledge, keeping records, making decisions, planning and organizing, solving problems, using scientific methods, and communicating.

Success Indicators

Youth can explain that pharmaceuticals are detected in aquatic and terrestrial ecosystems as well as the negative impacts this has on our natural resources and, potentially, on all life forms, including humans.

Filtration Experiment Instructions

1. Write a hypothesis of what will happen when you pour water through two different types of porous media (e.g., aquarium gravel, sand, marbles, soil, etc.).

2. Cut the tops and bottoms off two (matching) water bottles. These will be your "test tubes."

3. Put two inches of different porous media in each bottle and set each bottle in a plastic bowl (to hold the medium, catch the water as it drains out, and allow you to see the entire tube).

4. Be ready to time how quickly water moves through porous media as soon as it is introduced, as some porous media will transmit the water very quickly (others will not).

5. Add ¼ cup of water to the first bottle and see how long it takes before you see any on the plate.

6. Repeat with the second medium. If the water in the first bottle is moving slowly, you can run these simultaneously.

7 Record your results, and complete the scientific method worksheet (interpret your data and draw conclusions).

Scientific Method Worksheet

1. State the problem. (to study water movement through soil)

2. Write your hypothesis.

3. Observe and experiment (create a data sheet).

4. Tally, study, and interpret your data.

5. Draw conclusions.
   a. Was your hypothesis supported or not? *(check one)* __ Yes __ No
   b. If no, why wasn't it supported?

   c. Was your hypothesis supported or rejected due to your observations and experiments?

   d. How do the results give you ideas for future studies and new hypotheses?

   e. If you were to run the experiment again what would you do differently?

What are the issues?

General Objective

- Learn the implications of improper disposal of unused or expired medicines and disposal alternatives that are better for the environment.

Specific Objectives

Youth will learn:
- Improper methods for disposing of expired and unused medicines.
- To work together to explore alternatives and draw conclusions.

Time

1 – 1 ½ hours

Resources needed

- Markers
- Flip Charts
- Computer access
- Journal (small booklet or spiral notebook)

Activity

Youth collect information to learn the history of disposal of unused and expired medicines.
Youth learn what people in their community currently do with unused and expired medicines.

Instructions

Gather materials and resources for students to use for research and discovery. Assemble students into groups of 2-4. Give each group markers and a flip chart. The following instructions can be read aloud or can be written on a board or overhead.

► ***Instructor***

During our last session we explored water movement and how our wastes are treated. We also discussed that not all contaminants are removed by municipal sewage treatment or septic systems. Today we will be studying why prescription and over-the counter (OTC) medicines are found in surface water (streams, lakes and rivers) and fields.

At the end of our last session I asked you to ask five people:
- What do you do with medicines you no longer need?
- What should people do with medicines they no longer need?

Each team has been provided with a flip chart and markers. Compile the answers you received into a table. Study the table to see if answers differ by respondent age (child, teen, adult) or expertise (none, medical personnel, scientist).

> Give the students time to determine how to compile results into a table and to discuss trends. Facilitate a general discussion of the results. Note common answers from multiple groups as compared with answers from any one group. If you have multiple teams, compile the results into one table.

1. What do people generally do with medicines they no longer need?

> - Answers will vary. Responses may include: flushing down a toilet, disposing of in the trash, returning medicines to a pharmacy, incinerating, or no action (leaving them in the medicine cabinet).
> - Follow-up question: Why do many homes have unused and/or expired medicines in medicine cabinets?
>   - Improvement of health condition
>   - No longer in use because of side effects
>   - More medicine given than was needed
>   - Death of person needing medicine
> - Follow-up question: What did people in your community do with unused or expired medicines 20 years ago?
>   - Most doctors and pharmacists recommended flushing unused and expired medicines down a toilet.

2. What should people do with medicines they no longer need?

- Youth may not find any answers to this question. Our understanding is still evolving and there are no easy answers. Because prescription medicines are legally controlled substances and because the chemical composition of medicines varies, there is no single proper method of disposal. The following section explores this further.

3. What environmental impacts might occur when unwanted medicine is poured down the drain, flushed, or thrown in the trash?

- The chemicals in most medicines are harmful to plant and animals. Years ago it was thought that they would be diluted when disposed of through the wastewater system, but this has been found to be false. Researchers have found that several chemicals from medicines are potentially harmful to organisms, even in small quantities.

4. How could you find information about the proper disposal of unwanted medicine?

- Internet search for research by college and university scientists (*.edu websites) and government (*.gov websites)
- Library research
- Talk to a scientist who works in this field.
- Ask knowledgeable community members: pharmacists, doctors, and nurses.

► ***Instructor***

Now let's see what information you can find on the Internet to answer the questions:

1. Why do so many people dump medicines down a drain or flush them down a toilet?
2. What should people in our community do with medicines they no longer need?

Use only college and universities (*.edu) or government (*.gov) websites for your research. Why do you think I want you to stick with *.edu and *.gov websites?

Take one-half hour to complete the assignment.

University and governmental websites (*.edu and *.gov websites) are more likely to have unbiased information. Other websites may have very good information too, but there is no assurance that they are subject to peer review and revision. It is better for youth to learn that general Internet searches provide information that may not be verifiable.

If the youth are having difficulty finding information, suggest the following websites:

- **http://www.iisgcp.org/unwantedmeds**
- **http://www.epa.gov/ppcp**
- **http://toxics.usgs.gov/regional/emc**

► ***Instructor***

What did you learn about traditional medicine disposal and our current understanding about proper disposal?

Facilitate a general discussion.

Youth may find that, historically, it was recommended that unused and expired medicines be flushed down toilets. This is no longer the case because traces of medicines have been found in both surface water (streams, rivers, and lakes) and farm fields. Researchers are beginning to find that chemicals from medicines cause problems to aquatic life.

Some communities, hospitals, and clinics now use high temperature incinerators, with specialized air filtering equipment, to dispose of unused medicines. This equipment is expensive and is not available to most people.

We need to continue to explore alternatives that allow us to make good decisions with respect to helpful actions that people can take.

Optional:

Take-home assignment

Ask youth to continue their research about proper disposal of medicines, particularly with respect to local regulations. They might find answers through:
- Interviewing knowledgeable community members such as pharmacists, doctors, nurses, etc.
- Interviewing a scientist who works in this area (in person or via e-mail)
- Library research – ask a librarian for assistance

Interviews can occur in person, by e-mail, or telephone. If physicians, nurses, vets, or pharmacists are to be interviewed, youth may need to make an appointment to visit an office or pharmacy. They might be able to get information from staff or employees at a hospital or clinic. Note: Youth should not interview people at nursing homes or retirement homes because there are special regulations in place that do not apply to residential medicine disposal.

Note for next week: Plan to take some time at the start of the following session to discuss any information that youth learn from this assignment. You can do this briefly or have them work in teams and combine their responses.

► ***Instructor***

While I collect your flip charts, take 5-10 minutes to reflect on what you did today, what you learned, and what questions you have. Write about this experience in your journal. Date your page entry.

Journaling is a great way for youth to process what they have learned. By asking whether they have questions after they have had some time to write, you may stimulate a brief discussion of future project activities and/or alert you to where more information is needed. It is useful if you can have a small notebook or another special place or way for the students to keep their personal notes. Collect the journals between meetings to review what the youth learned or to make note of questions that they did not share. Collect the journals to ensure that youth will have them for the next meeting.

Note for next week: Post the flip chart sheets for the next meeting as a reminder of this activity.

Evaluation

- How many types of information were gathered?
- How many sources of information were used?
- If there are multiple teams, where were reports similar? Where did they differ? Why?
- What types of final questions did the youth have?
- What knowledge was gained?

Share Your Knowledge

Youth can share what they learned during this session in many ways. Some examples follow:
- Speech and demonstrations (including *Action demonstrations*)
- Information display boards
- Jr. Leader activities
- Mentoring a younger 4-H member

References

- Illinois-Indiana Sea Grant Program—*Disposal of Unwanted Medicines: A Resource for Action in Your Community* at **www.iisgcp.org/unwanted meds.** Appendix D in this 4-H guide provides background information from this site's Introduction section.
- Illinois-Indiana Sea Grant Program—Education webpage with links to this 4-H Guide and *The Medicine Chest,* a high school service-learning curriculum linked at **www.iisgcp.org/education/gros_educ.html**

Science Standards

Appendix C

Life Skills

Acquiring knowledge, communicating with others, and teamwork.

Success Indicators

Youth understand that our lack of knowledge about the impacts of unused and expired medicines has led to water quality concerns. So, while we do not "blame" people for the water quality problems we are having now, we do need to educate people to properly dispose of unused and expired medicines in the future.

What should I be concerned about?

General Objective

- Learn what medicines have been found in the environment.

Specific Objectives

Youth will:
- Learn what water contaminants are of primary concern.
- Understand the harm that medicines can cause in our waterways.

Time

One hour

Resources needed

- Computer access
- Markers
- Flip charts
- Journal

Activity

Youth will use online resources to learn about the medicines of primary concern (based on our current knowledge) to our water resources. They will compile the knowledge they gain into a report to acknowledge contaminants that have been found in water in their community.

Instructions

Gather materials and resources for students to use for research and discovery. Students will work on their own or in groups of two, using numerous sources for their reports. These instructions can be read before they begin to work, written on the board, or projected on an overhead.

► ***Instructor***

As we discussed at the last session, a lack of knowledge has led to improper disposal of medicines. These medicines can harm the environment. Today we will study what contaminants have been found in our water. Let's take a few minutes to consider the following questions:
1. Are over-the-counter medicines harmful to the environment?
2. Are prescription medicines harmful to the environment?
3. Do personal care products such as hairspray, soap, or contact solution harm the environment?
4. Are human sources the only ones we need to worry about? Where else are medicines used?

> Give the students time to discuss possible answers to these questions before they begin doing any research. Encourage them to remember how contaminants get into the environment (through water and soil). Use any method that works well with your learners. For example, you might write the questions on the board and ask learners to reply to each or have a general discussion of each question.

► ***Instructor***

Now that you have thought about these questions and have some ideas, we will do some research to see what the experts say. Today, we'll be looking for government data and national news stories on these topics. I'd like you to use the following websites to find information:
- **www.epa.gov/ppcp -** U.S. EPA: see the Basic Information tab and the poster, *Origins and Fate of PPCPs in the Environment* (PDF), at the bottom of that page.
- **www.iisgcp.org/unwantedmeds** - Illinois-Indiana Sea Grant Program: *Disposal of Unwanted Medicines: A Resource for Action in Your Community*; Chapter 1, Introduction and Background – see the PDF Introduction file for a wealth of information.
- **http://toxics.usgs.gov/highlights/pharm_watershed/** - United States Geology Survey (USGS): Toxic Substances Hydrology Program —"Are Pharmaceuticals in Your Watershed?..." and other related headlines from USGS
- **www.productstewardship.us** - Product Stewardship Institute: Click on the Products tab—then click on "Pharmaceuticals."

While you are looking, you can open a Word document to copy and paste any useful information that you find. Title this document *Disposal of Unwanted Meds*. When you find answers to our questions, be sure to write down the information source and to copy the web address so you can go back to that site easily. You should also note the date that you retrieved this information.

Examples of information collection follow. The first sample shows data presented in a table format.

Web site	**http://www.iisgcp.org/unwantedmeds/toolkit/1.0Introduction.pdf**
Retrieval date	April 1, 2009
Source	Illinois-Indiana Sea Grant Program
Notes	• Recent studies have identified a wide range of pharmaceutical chemicals in rivers and streams nationwide. It has also been shown that some of these compounds are potentially harmful to aquatic organisms, affecting reproduction and development—even at low concentrations. • The long-term impacts of medicine disposal on human and environmental health are not fully known. Unless action is taken, the quantity of these chemicals reaching our waterways will continue to increase as pharmaceutical usage increases.
Web site	**http://toxics.usgs.gov/topics/reconnaissance_studies.html**
Retrieval date	April 1, 2009
Source	USGS
Notes	• The Toxics Program has conducted reconnaissance studies of the occurrence and distribution of contaminants in rivers and streams, surface-water reservoirs, ground water, and precipitation.
Web site	**http://toxics.usgs.gov/pubs/FS-027-02/index.html**
Retrieval date	April 1, 2009
Source	USGS
Notes	• A recent study by the Toxic Substances Hydrology Program of the U.S. Geological Survey (USGS) shows that a broad range of chemicals found in residential, industrial, and agricultural wastewater commonly occurs in mixtures at low concentrations downstream from areas of intense urbanization and animal production. The chemicals include human and veterinary drugs (including antibiotics), natural and synthetic hormones, detergent metabolites, plasticizers, insecticides, and fire retardants. One or more of these chemicals were found in 80 percent of the streams sampled. Half of the streams contained seven or more of these chemicals, and about one-third of the streams contained 10 or more of these chemicals. This study is the first national-scale examination of these organic wastewater contaminants in streams and supports the USGS mission to assess the quantity and quality of the nation's water resources. A more complete analysis of these and other emerging water-quality issues is ongoing. • Website contains a map showing 139 streams that were measured in 1999 and 2000 for pharmaceuticals, hormones, and other organic wastewater contaminants.

The sample below presents findings in a paragraph format.

http://www.iisgcp.org/unwantedmeds/toolkit/1.0Introduction.pdf, retrieved April 1, 2009. Source: IL-IN Sea Grant Program

Recent studies have identified a wide range of pharmaceutical chemicals in rivers and streams nationwide. It has also been shown that some of these compounds are potentially harmful to aquatic organisms, affecting reproduction and development—even at low concentrations.

The long-term impacts of medicine disposal on human and environmental health are not fully known. However, unless action is taken, the quantity of these chemicals reaching our waterways will continue to increase as pharmaceutical usage increases.

Before we start, can anyone tell me what I should be aware of when doing a Google™ search (or any other web search)?

There is nothing wrong with a Google™ (or other search engine) search. The problem is that the possibility for biased or otherwise incorrect information is much higher from random websites, so you have to be careful about the sites you select to visit from your search results. Educational (*.edu) and government (*.gov) websites are highly regarded because the information posted has been peer reviewed and does not promote an individual viewpoint.

While other sites may have very good information, it is better for youth to stick to those that are generally considered unbiased, as young people may not have the background to determine accurate sources of information.

Allow about 30-45 minutes to complete the web-based research.

► ***Instructor***

Now we will discuss the information that you have found. Who would like to take notes on the flip chart for question 1?

(Note: Ask different people to record notes for each question and to include the website or person who found the information, so you can find the source later, if needed.)

- How can over-the-counter medicines and prescription medicines harm the environment?
- What personal care products can harm the environment?
- What other uses of medicine do we need to worry about?

Facilitate the discussion but encourage the youth to take leadership. Be sure that each person shares information. Ask different youth to record information to involve as many people as possible. Ask "Evaluation Strategies" questions for wrap-up.

You can get *Consumer Confidence Reports* from your local water supplier listing what contaminants have been found in your water. The reports are required by the Federal Safe Drinking Water Act Amendments of 1996. Systems serving over 10,000 people must mail these reports to bill-paying customers. Those who do not receive water bills directly, such as renters, can find the reports in the newspaper, on the Internet, in public places, and through some organizations, or they can request the report from their water supplier. Smaller water suppliers have the option to print reports in the newspaper.

Additional information is available at: **https://engineering.purdue.edu/SafeWater/drinkinfo/WQ-33.htm.**

► ***Instructor***

Please take 5-10 minutes to reflect on what you did today, what you learned, and what questions you have. Write about this experience in your journal. Be sure to put today's date on your entry page.

Journaling is a great way for youth to process what they have learned. By asking whether they have questions after they have had some time to write, you may stimulate a brief discussion of future project activities and/or alert you to where more information is needed. It is especially helpful if you can have a small notebook or other special way for the students to keep their personal notes. Collect the journals between meetings to review what the youth learned or to make note of questions that they did not share aloud. Collecting the journals will also ensure that youth will have them for the next meeting.

Note for following week: Plan to post the flip chart sheets for the next meeting to remind the youth about this activity.

Evaluation Strategies

- What medicines are of particular concern with respect to our environment?
- What does PPCP stand for? (Pharmaceuticals and Personal Care Products)
- What PPCPs have been identified as causing possible environmental harm?

Share Your Knowledge

Youth can share what they learned during this session in many ways. The following are some examples:

- Speech and demonstrations (including *Action demonstrations*)
- Information display boards
- Jr. Leader activities
- Mentoring a younger 4-H member

References

- **www.epa.gov/ppcp** - U.S. EPA: see the Basic Information tab and the poster, *Origins and Fate of PPCPs in the Environment* (PDF), at the bottom of that page.
- **www.iisgcp.org/unwantedmeds** - Illinois-Indiana Sea Grant Program: *Disposal of Unwanted Medicines: A Resources for Action in Your Community*; Chapter 1, Introduction and Background – see the PDF Introduction file for a wealth of information.
- **http://toxics.usgs.gov/regional/emc** - United States Geology Survey (USGS), *Emerging Contaminants in the Environment*.
- Appendix D gives background information from the Illinois-Indiana Sea Grant website, **www.iisgcp.org/unwantedmeds.**

Science Standards

Appendix C

Life Skills

Information gathering, informal analysis, and decision making.

Success Indicators

Youth understand and can both correctly locate and present data on the PPCPs of primary concern to water quality and our environment.

What are my options?

General Objectives

- Learn recommended ways to reduce use of medicines and personal care products.
- Explore where unused or expired medicines can be properly disposed of in their community and who they can talk to about the issue.

Specific Objectives

Youth will:
- Investigate local alternatives for proper disposal of expired and unused medicines.
- Explore important aspects involved with proper disposal, such as safety, cost, and what reporting requirements exist.

Time

One hour, plus research time

Resources needed

___ Markers
___ Flip charts
___ Poster boards for displays
___ Computer access
___ Journals

Activity

Youth will work in teams to brainstorm how they can help address improper disposal of expired and unused medicines. They will consider community education opportunities and investigate community collection options for unused or expired medicines and PPCPs (pharmaceutical and personal care products). If no current options are found in the community, youth will explore how to get a collection started and what action steps should be taken.

Instructions

Gather materials and resources for students to use for research and discovery. Youth should work in teams of 2-4. Instructions can be read before they begin working, written on the board, or projected on an overhead.

► ***Instructor***

We have explored the fact that our environment is being contaminated by medicines that are flushed down toilets. Each of you should have a good understanding of this issue and its possible consequences. Our next tasks are to figure out how we can help others understand the issues and explore what options we have in our community for the proper disposal of medicines (and other PPCPs). You will work in groups of 2-4 to determine how you can answer some questions. Each group has been provided a flip chart and markers. Write the following questions at the top of a new sheet, and then brainstorm possible answers.

- How should expired and unused medicines be disposed of?
- What local alternatives for disposal of expired and unused medicines are available in our community?
- What must be considered for the proper disposal of unwanted medicine?
- What are the costs and benefits of different disposal options? Consider safety, cost, and any reporting requirements that you learn about.
- What sensible disposal options are available in our community for expired and unused medicines?
  - If there are currently no options for proper disposal of medicines:
    - Who might hold a collection event?
    - What steps should be involved in planning an event?
    - What organizations can help with this event?

> Allow 10-15 minutes for youth to think about these questions and review any answers that they may already know from previous research. This activity builds upon Activity 2—*What are the issues?*—so the youth should not need as much guidance as in previous lessons. They may already have collected some information on this topic during that activity.

► ***Instructor***

Now we will report back. Do you want to have each team report their discussion or just have a general discussion on each of the topics?

Now that you have guided the youth through the research stage, encourage them to take charge of study, discussion, and decision stages. It is best if this is *their* project—offer suggestions and support only as needed. You may want to suggest that they summarize responses on flip chart sheets.

Youth may find that they need additional information from key community personnel. They will need to include local decision makers: legislators, planners, county commission members, and/or mayors. Discuss the best ways to get information from these sources. Youth may find that people are unaware of the issue. They may be asked for more information or to do a presentation based on their newly-acquired knowledge. (For suggestions, see Activity 5, *How can I let other people know about these issues?*)

► ***Instructor***

What should we do now?

Give the youth time to brainstorm about possible partners and next steps. You might suggest that they compile their deliberations on a flip chart. Encourage them to seek additional sources and materials to back up their ideas using the internet, a survey, or a library, etc. If the students decide to do a survey, they should include local decision makers: legislators, planners, county commission members, and the mayor.

- The web page **www.iisgcp.org/unwantedmeds** links to *Disposal of Unwanted Medicines: A Resources for Action in Your Community*, which has great resources. Chapters 2, 3, and 5 may be most useful for this activity.

The proper disposal of medicine is a growing concern. Consequently, government agencies are trying to address the issue and give their recommendations.

- Recommendations from the White House, Office of National Drug Control Policy (ONDCP), Health and Human Services (HHS), and U.S. EPA, February 2007:
  - Dispose of unused prescription drugs through pharmaceutical take-back programs.
  - If take-back programs are not available:
    - Take unwanted prescription drugs out of their original containers, mix with an undesirable substance, place in a sturdy, opaque, non-descript container, and throw in the trash.
    - Flush prescription drugs down the toilet ***only*** if the label specifically instructs doing so.

- Recommendations from the American Pharmacists Association and the U.S. Fish and Wildlife Service (2/14/07)
  - Ask your pharmacist for advice.
  - Do ***not*** flush unwanted medications.
  - Check for approved state and local collection programs or with area hazardous waste facilities.
  - When you must dispose of unused medications:
    - Crush or dissolve solid medications.
    - Mix with kitty litter or a solid kitchen substance.
    - Place in a sealed plastic bag to reduce poisoning risk.
    - Remove and destroy ***all*** identifying personal information

► ***Instructor***

Our next session is our last scheduled meeting. We will be creating educational materials to help inform others about the problem of improper disposal of medicines. We will also discuss the audiences we want to share this information with and where and when we might do that. We need to decide if there is more we can do to help with this problem.

Please take 5-10 minutes to reflect on what you did today, what you learned, and what questions you have. Write about this experience in your journal. Be sure to put today's date on your entry page.

> Journaling is a great way for youth to process what they have learned. By asking whether they have questions after they have had some time to write, you may stimulate a brief discussion of future project activities and/or alert you to where more information is needed. It is especially helpful if you can have a small notebook or other special way for the students to keep their personal notes. Collect the journals between meetings to review what the youth learned or to make note of questions that they did not share aloud. Collecting the journals will also ensure that youth will have them for the next meeting.
>
> Note for following week: Plan to post the flip chart sheets for the next meeting to remind the youth about this activity.

Evaluation

- Does your community offer a collection dropoff location or a collection event for unused and expired medicines and personal care products?
- If your community does offer a collection dropoff location or a collection event, when, where, and what are the requirements?
- If your community does not offer a collection dropoff location or a collection event, what can people do with their PPCPs?
- Is there a possibility (interest) in starting one?
- What would need to happen and who would need to be involved?

Share Your Knowledge

Youth can share what they learned during this session in many ways. Following are some examples:

- Speech and demonstrations (including *Action demonstrations*)
- Information display boards
- Jr. Leader activities
- Mentoring a younger 4-H member

References

- Illinois-Indiana Sea Grant, **http://www.iisgcp.org/unwantedmeds** - Appendix D gives background information.
- U.S. EPA, **http://www.epa.gov/ppcp**
- USGS, **http://toxics.usgs.gov/regional/emc**
- P^2D^2, **http://www.p2d2program.org**, Prescription Pill and Drug Disposal Program
- Indiana Department of Environmental Management: Fact Sheet, **http://www.in.gov/idem/files/factsheet_pharmaceuticals.pdf**
- Household hazardous waste collection information, **http://www.recycle.IN.gov**

Science Standards

Appendix C

Life Skills

Acquiring knowledge, communicating with others, and teamwork.

Success Indicators

Youth understand that we need to reduce use of medicines and personal care products. They also know how and where the medicines and PPCPs can properly be disposed of in their community and who they can talk to about the issue.

How can I let other people know about these issues?

General Objective

- Educate others about the growing concern of the environmental quality of our waterways due to improper disposal of unused or expired medicines.

Specific Objectives

Youth will:
- Combine information learned in previous lessons on the effect of unwanted and expired medicines on our environment and water quality.
- Combine information they learned in previous lessons about how and where to properly dispose of unwanted and expired medicines in their community.
- Use this information to educate others in their community about the issue.

Time

Two hours, plus planning and preparation time

Resources needed

- Display boards
- Previous research and reports
- Design materials for projects, such as:
  - Markers
  - Graphics or pictures
  - Scissors
  - Poster board / tri-fold boards
- Journals

Activity

Youth work in teams to develop ways to educate community members about proper disposal of medicines and possible community options.

Instructions

Have materials and resources ready for students to use in creating their posters or display boards. Post flip charts from previous lessons.

▶ ***Instructor***

This is the final lesson in the *Sensible Disposal of Unwanted Medicines* guide. Now that you understand how improper disposal of medicines can impact our environment, what can we do to help others understand?

> Students should suggest that they need to inform and educate others through at least one of the following: talks, educational posters, public service announcements (PSAs), news articles, or other means.

▶ ***Instructor***

Who needs to be informed? How? Where would it be best to do this?

> Suggestions may include:
> - Who: everyone—grade school students, high school students, fairgoers, shoppers, county/city councils, TV and radio news reporters, newspaper reporters, older adults, pharmacies, police, or veterinarians.
> - How: poster displays, public service announcements (PSAs), or presentations.
> - Where: school, public meetings, the fair, the shopping mall, city halls, post offices, schools, senior centers, hospitals and pharmacies.

▶ ***Instructor***

Today we are going to spend time taking all the information you have gathered from previous activities and put it together to educate the public about proper disposal of medicines.

What questions do you have?

Give the youth time to decide how they would like to share their information. They may want to make a display, write a PSA, or prepare a presentation. If you have enough youth to split into different groups, you may want to have them work on different forms of communication based on their interests.

You might suggest that they review the PowerPoint presentation at **http://www.iisgcp.org /unwantedmeds** for an overview to see if they have forgotten anything.

After the students decide what display they want to create, encourage them to map or plan out what it will look like before they begin. One poster could be made for each of the four preceding activities: *So, What's the Big Deal?*; *What are the Issues?*; *What Should I be Most Concerned About?*; and, *What are My Options?* Or, one poster could briefly address all four themes.

An action demonstration format (one that engages the audience) should be strongly encouraged for presentations to the community stakeholders.

Each team should discuss the best place or places to display this information.

► ***Instructor***

Let the youth decide how they want to proceed, including specific approaches for information sharing and the best venues.

► ***Instructor***

Before you leave, please take 5-10 minutes to reflect on what we did today and what you hope happens because of the activities we have shared. Write about this experience in your journal. Be sure to put today's date on your entry page. You may take your journals home. They are yours to keep.

Evaluation

- Quality of the display(s)
- Number of venues used to inform
- Number of people impacted in communities
- Anecdotal stories (personal or, news stories,)

Share Your Knowledge

Youth can share what they learned by:
- Speech and demonstrations (including Action demonstrations)
- Information display boards
- Jr. Leader activities
- Mentoring a younger 4-H member
- Outreach to older adults

References and Resources

- Appendix E: 4-H poster / display guidelines, action demonstration guidelines and score sheets, and news article template
- Recommendations from teachers, Extension educators, scientists, and other professionals
- Review by parents and friends to gain feedback on the efficacy of the display.
- Illinois-Indiana Sea Grant Program, **http://iiseagrant.org/unwanted meds** - Appendix D gives background information.
- Illinois-Indiana Sea Grant Program, **http://iiseagrant.org/education/safe_disposal_curriculum.html** - See the inside back cover for a content overview of *The Medicine Chest: A collection of safe disposal curriculum activities and service-learning resources*.

Science Standards

Appendix C

Life Skills

Helping others to learn, being a responsible citizen, and developing confidence.

Success Indicators

Youth created an educational display(s) and they were exhibited in a number of public settings to help inform and educate others. Action demonstrations were also given to share their knowledge.

Appendix A. Additional Activities

Visit a local water treatment plant and talk with people who work there. Preparing 5-10 questions ahead of time will enhance learning.

Visit the following websites for more activities:

Down the Drain and into the Yard

https://engineering.purdue.edu/SafeWater/kids/activity4.htm

- Build a mock septic tank system to see how substances added to water will travel through the system.
- Background on how septic systems work
- Hands-on activity
- Allows for creativity, while observing how the actual process works (you will be creating your own septic system model)
- Time constraints (could take a while to build the model) – maybe an hour
- Lots of materials needed (though they are not that expensive)
- Use of sharp objects in the beginning (if working with older students it should be fine, otherwise organizers could do preparations in advance)
- Measuring the slope of the leaching bed could be tricky (experiment suggests 0%, 1%, and 2%—could perhaps use a level?)

U.S. EPA Classroom Activities

http://www.epa.gov/safewater/kids/wsb/pdfs/682.pdf

- Contaminant Scavenger Hunt
- Safe Alternatives to Toxic Home Cleaners
- Desalination / Freshwater
- How Soft or Hard is Your Water?
- How to Treat Polluted Water
- Leaky Faucet
- Let's Give Water a Treatment (potable water and why it is treated for drinking)
- Purifying Water (general information about cleaning water and how bleach can be used to kill organisms in water)
- Water Treatment Plants (plants used in wetlands to help clean water)
- Purification of Water (municipal wastewater treatment)
- Bacteria in Water
- Indicating Insects
- Water Pollution Solutions

More Websites

- **http://www.iisgcp.org/unwantedmeds**
- **http://www.epa.gov/safewater/kids/wsb/pdfs/9122.pdf**
- **http://www.epa.gov/safewater/kids/wsb/index.html# 3-5**
- **http://www.sandiego.gov/mwwd/kids/** (has nice virtual tour for younger students)
- **https://engineering.purdue.edu/safewater/kids/activity4.htm**
- **http://chicagoriver.org/upload/choices_make_a_dif.pdf**
- **http://biblioteca.universia.net/ficha.do?id=37690470**

Appendix B. Unwanted Medications: A Prescription for Troubled Waters

By Irene Miles, Illinois-Indiana Sea Grant Communication Coordinator

We are a society that takes a lot of drugs – each year, the use of prescription medicine increases and new drugs come on the market. But, what happens to all the prescription and over-the-counter drugs that are brought home, but for one reason or another, end up unused?

The use of prescription medicine increases and new drugs come on the market every year in the U.S. When people's prescriptions change, their drugs expire or are no longer necessary, these medicines are typically flushed or thrown away. "Chemicals from medicines flushed down the toilet can pass untreated through sewage plants, damage septic systems, and contaminate nearby waterways," said Beth Hinchey Malloy, Illinois-Indiana Sea Grant (IISG) Great Lakes ecosystem specialist. "Medicines thrown in the trash can be scavenged or they have the potential to contaminate landfill leachate."

The U.S. Geological Survey (USGS) sampled water down-stream from wastewater treatment plants in 30 states in 2000. They found at least one pharmaceutical in 80 percent of 139 streams. Researchers have also found that several of these compounds are potentially harmful to aquatic organisms, even in small quantities.

"Some pharmacies will take back some unwanted medications, and some communities have one-day collection events, but there is no long-term solution to this growing and potentially dangerous waste stream," said Susan Boehme, IISG coastal sediment specialist. "We field calls every week from community leaders, state officials, pharmacists, doctors, solid waste managers or environmental activists looking for information, support, and solutions."

IISG and the U.S. EPA Great Lakes National Program Office have developed a resource kit for those thinking about starting a take-back program or creating other disposal programs. The kit includes background information on unwanted medicines, what's known about their impact on the environment, as well as numerous resources for addressing the problem, including extensive collection program case studies.

Over seven 50-gallon barrels of medication were collected in Springfield, Illinois at a 2007 hazardous waste collection event. (Photo credit: Sangamon County Department of Health.)

In Illinois and Indiana, IISG has distributed the resource kit and co-hosted workshops for over 100 local solid waste management officials, health department workers, and others. As a result, in Springfield, Illinois seven 50-gallon drums of household medicines were brought in for safe incineration as part of a larger collection event. In Kendall County, Illinois, an ongoing collection program is now underway – residents can drop off medicines at the police station anytime.

Boehme and Hinchey Malloy have had requests for the kit from community leaders and others from 15 states, plus Washington D.C. and Canada. Close to home, they are providing advice to the City of Chicago Department of Environment on its unwanted medicines collection program.

They are now working closely with state and local agencies and programs, including Michigan Sea Grant, to facilitate take back projects and to reach new audiences in Michigan, New York, and Wisconsin. They are also taking their message directly to pharmacists. "The model of pharmacies accepting unwanted medicines has been very successful in other countries," said Hinchey Malloy.

"As more sustainable take back programs are put in place, we hope to shift our focus to raising awareness with the broader public to enhance the success of these programs," said Boehme.

The resource kit is available online at **http://www.iisgcp.org/unwantedmeds** or in CD format by e-mailing **hinchey.elizabeth@epa.gov** or **boehme.susan@epa.gov**.

The Illinois-Indiana Sea Grant College Program is one of more than 30 National Sea Grant College Programs. Created by Congress in 1966, Sea Grant combines university, government, business and industry expertise to address coastal and Great Lakes needs. Funding is provided by the National Oceanic Atmospheric Administration (NOAA), U. S. Department of Commerce, the University of Illinois at Urbana-Champaign and Purdue University at West Lafayette, Indiana. For more information: **www.iiseagrant.org**.

Appendix C. Science Standards

National

Science as Inquiry

Content Standard A—
As a result of their activities in grades 9-12, all students should develop understanding of:

- ***Abilities necessary to do scientific inquiry***
  - Identify questions and concepts that guide scientific investigations.
  - Design and conduct scientific investigations.
  - Formulate and revise scientific explanations and models using logic and evidence.
  - Communicate and defend a scientific argument.

- ***Understandings about scientific inquiry***
  - Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.
  - Scientists conduct investigations for a wide variety of reasons. For example, they may wish to discover new aspects of the natural world, explain recently observed phenomena, or test the conclusions of prior investigations or the predictions of current theories.
  - Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.
  - Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.
  - Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge.
  - Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists. In communicating and defending the results of scientific inquiry, arguments must be logical and demonstrate connections between natural phenomena, investigations, and the historical body of scientific knowledge. In addition, the methods and procedures that scientists used to obtain evidence must be clearly reported to enhance opportunities for further investigation.

Life Science

Content Standard C—
As a result of their activities in grades 9-12, all students should develop understanding of:

- ***Interdependence of organisms***
  - Human beings live within the world's ecosystems. Increasingly, humans modify ecosystems as a result of population growth, technology, and consumption. Human destruction of habitats through direct harvesting, pollution, atmospheric

National *(cont.)*

changes, and other factors is threatening current global stability, and if not addressed, ecosystems will be irreversibly affected.

-1- Science in Personal and Social Perspectives

Content Standard F—
As a result of their activities in grades 9-12, all students should develop understanding of:

- ***Natural resources***
  - The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that cannot be renewed.
  - Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

- ***Environmental quality***
  - Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.
  - Materials from human societies affect both physical and chemical cycles of the earth.
  - Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth.

- ***Natural and human-induced hazards***
  - Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change.
  - Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.

- ***Science and technology in local, national, and global challenges***
  - Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.
  - Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. Decisions involve assessment of alternatives, risks, costs, and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them. Students should understand the appropriateness and value of basic questions—

National
(cont.)

"What can happen?"—"What are the odds?"—and ''How do scientists and engineers know what will happen?"
- Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use—which decreases space available to other species—and pollution—which changes the chemical composition of air, soil, and water.

-2- History and Nature of Science

Content Standard G—
As a result of their activities in grades 9-12, all students should develop understanding of:

- ***Science as a Human Endeavor***
  - Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.
  - Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.
  - Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. The core ideas of science such as the conservation of energy or the laws of motion have been subjected to a wide variety of confirmations and are therefore unlikely to change in the areas in which they have been tested. In areas where data or understanding are incomplete, such as the details of human evolution or questions surrounding global warming, new data may well lead to changes in current ideas or resolve current conflicts. In situations where information is still fragmentary, it is normal for scientific ideas to be incomplete, but this is also where the opportunity for making advances may be greatest.

Illinois

State Goal 11

Understand the processes of scientific inquiry and technological design to investigate questions, conduct experiments and solve problems.

Illinois Learning Standards

LEARNING STANDARD A. Know and apply the concepts, principles and processes of scientific inquiry.
LEARNING STANDARD B. Know and apply the concepts, principles and processes of technological design.

Illinois
(cont.)

Illinois Assessment Framework Objectives

Benchmark: 11.A.4a	Formulate hypotheses referencing prior research and knowledge.
Benchmark: 11.A.4b	Conduct controlled experiments or simulations to test hypotheses.
Benchmark: 11.A.4c	Collect, organize and analyze data accurately and precisely.
Benchmark: 11.A.4d	Apply statistical methods to the data to read and support conclusions.
Benchmark: 11.A.4e	Formulate alternative hypotheses to explain unexpected results.
Benchmark: 11.A.4f	Using available technology, report, display and defend to an audience conclusions drawn from investigations.
Benchmark: 11.B.4a	Identify a technological design problem inherent in a commonly used product.
Benchmark: 11.B.4b	Propose and compare different solution designs to the design problem based upon given constraints including available tools, materials and time.
Benchmark: 11.B.4d	Determine the criteria upon which the designs will be judged, identify, advantages and disadvantages of the designs and select the most promising design.
Benchmark: 11.B.4e	Develop and test a prototype or simulation of the solution design using available materials, instruments and technology.
Benchmark: 11.B.4f	Evaluate the test results based on established criteria, note sources of error and recommend improvements.
Benchmark: 11.B.4g	Using available technology, report to an audience the relative success of the design based on the test results and criteria.
Benchmark: 11.A.5a	Formulate hypotheses referencing prior research and knowledge.
Benchmark: 11.A.5b	Design procedures to test the selected hypotheses.
Benchmark: 11.A.5c	Conduct systematic controlled experiments to test the selected hypotheses.
Benchmark: 11.A.5d	Apply statistical methods to make predictions and to test the accuracy of results.
Benchmark: 11.A.5e	Report, display and defend the results of investigations to audiences that may include professionals and technical experts.
Benchmark: 11.B.5a	Identify a design problem that has practical applications and propose possible solutions, considering such constraints as available tools, materials, time and costs.
Benchmark: 11.B.5b	Select criteria for a successful design solution to the identified problem.
Benchmark: 11.B.5c	Build and test different models or simulations of the design solution using suitable materials, tools and technology.
Benchmark: 11.B.5d	Choose a model and refine its design based on the test results.
Benchmark: 11.B.5e	Apply established criteria to evaluate the suitability, acceptability, benefits, drawbacks and consequences for the tested design solution and recommend modifications and refinements.
Benchmark: 11.B.5f	Using available technology, prepare and present findings of the tested design solution to an audience that may include professional and technical experts.
Benchmark: 13.A.5a	Design procedures and policies to eliminate or reduce risk in potentially hazardous science activities.
Benchmark: 13.A.5b	Explain criteria that scientists use to evaluate the validity of scientific claims and theories.

Illinois *(cont.)*

Benchmark: 13.A.5c	Explain the strengths, weaknesses and uses of research methodologies including observational studies, controlled laboratory experiments, computer modeling and statistical studies.
Benchmark: 13.A.5d	Explain, using a practical example (e.g., cold fusion), why experimental replication and peer review are essential to scientific claims.
Benchmark: 13.B.5a	Analyze challenges created by international competition for increases in scientific knowledge and technological capabilities (e.g., patent issues, industrial espionage, technology obsolescence).
Benchmark: 13.B.5b	Analyze and describe the processes and effects of scientific and technological breakthroughs.
Benchmark: 13.B.5c	Design and conduct an environmental impact study, analyze findings and justify recommendations.
Benchmark: 13.B.5d	Analyze the costs, benefits and effects of scientific and technological policies at the local, state, national and global levels (e.g., genetic research, Internet access).
Benchmark: 13.B.5e	Assess how scientific and technological progress has affected other fields of study, careers and job markets and aspects of everyday life.

State Goal 12

Understand the fundamental concepts, principles, and interconnections of the life, physical, and earth/space sciences.

Illinois Learning Standards

Learning Standard: A.	Know and apply concepts that explain how living things function, adapt and change.
Learning Standard: B.	Know and apply concepts that describe how living things interact with each other and with their environment.

Illinois Assessment Framework Objectives

Benchmark: 12.B.4a	Compare physical, ecological and behavioral factors that influence interactions and interdependence of organisms.
Benchmark: 12.B.4b	Simulate and analyze factors that influence the size and stability of populations within ecosystems (e.g., birth rate, death rate, predation, migration patterns).
Benchmark: 12.A.5a	Explain changes within cells and organisms in response to stimuli and changing environmental conditions (e.g., homeostasis, dormancy).

State Goal 13

Understand the relationships among science, technology and society in historical and contemporary contexts.

Illinois Learning Standards

Learning Standard: A.	Know and apply the accepted practices of science.
Learning Standard: B.	Know and apply concepts that describe the interaction between science, technology and society.

Illinois *(cont.)*

Illinois Assessment Framework Objectives

BENCHMARK: 13.A.4a	Estimate and suggest ways to reduce the degree of risk involved in science activities.
BENCHMARK: 13.A.4b	Assess the validity of scientific data by analyzing the results, sample set, sample size, similar previous experimentation, possible misrepresentation of data presented and potential sources of error.
BENCHMARK: 13.A.4c	Describe how scientific knowledge, explanations and technological designs may change with new information over time (e.g., the understanding of DNA, the design of computers.
BENCHMARK: 13.A.4d	Explain how peer review helps to assure the accurate use of data and improves the scientific process.
BENCHMARK: 13.B.4a	Compare and contrast scientific inquiry and technological design as pure and applied sciences.
BENCHMARK: 13.B.4b	Analyze a particular occupation to identify decisions that may be influenced by a knowledge of science.
BENCHMARK: 13.B.4c	Analyze ways that resource management and technology can be used to accommodate population trends.
BENCHMARK: 13.B.4d	Analyze local examples of resource use, technology use or conservation programs; document findings; and make recommendations for improvements.
BENCHMARK: 13.B.4e	Evaluate claims derived from purported scientific studies used in advertising and marketing strategies.

Indiana

Principles of Environmental Science— Standard 1

Environmental Systems

Env.1.4	Understand and explain that human beings are part of Earth’s ecosystems and give examples of how human activities can, deliberately or inadvertently, alter ecosystems.
Env.1.8	Recognize/describe the difference between systems in equilibrium and systems in disequilibrium.
Env.1.10	Identify and measure biological, chemical, and physical factors within an ecosystem.

Natural Resources

Env.1.28	Understand and describe the concept and the importance of natural and human recycling in conserving our natural resources.

Environmental Hazards

Env.1.31	Understand and explain that waste management includes considerations of quantity, safety, degradability, and cost.
Env.1.34	Differentiate between natural pollution, and pollution caused by humans; give examples of each.

Indiana *(cont.)*

Principles of Biology— Standard 1

Ecology

B.1.41 Recognize that and describe how human beings are part of Earth's ecosystems. Note that human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

B.1.43 Understand that and describe how organisms are influenced by a particular combination of living and nonliving components of the environment.

B.1.44 Describe the flow of matter, nutrients, and energy within ecosystems.

B.1.45 Recognize that and describe how the physical or chemical environment may influence the rate, extent, and nature of the way organisms develop within ecosystems.

Advanced Life Science: Animals Standards—Standard 4

Animal Genetics and the Environment
Ecology

AS.4.20 Explain the role of resources in every ecosystem. Define trophic level. Explain the concept of energy flow: primary producers, primary consumers, secondary and tertiary consumers, and decomposers.

AS.4.21 Describe the impact humans have on the capacity of any system to support life. List the factors that limit the capacity of an ecosystem. Discuss the interactions that occur between birth rate, population growth, and carrying capacity of the ecosystem.

AS.4.22 Explain difference between exponential and logistic growth curves. Define carrying capacity. Describe the impact of carrying capacity on an ecosystem (community ecology). Predict the impacts of overcrowding, disease, and waste on animal health.

Appendix D. Background Information

From Illinois-Indiana Sea Grant website, **http://www.iisgcp.org/unwantedmeds**, Chapter 1.

Introduction

Unwanted medicine disposal is a rapidly emerging concern that spans a broad range of issues including human and environmental health, water quality, solid waste management, law enforcement, and the health care industry. Substances of concern include both prescription and non-prescription medicines, and this category is sometimes expanded to include cleansing agents, cosmetics, nutritional supplements, and skin care products. The terms "medicine," "medication" and "pharmaceutical" are used interchangeably throughout the documents that follow to refer to substances used in treating disease or illness. Another common term is PPCPs, which is an acronym for Pharmaceuticals and Personal Care Products. There are thousands of products that fall into this classification; all of these substances are specifically designed to interact with biological processes and are widely used around the world. They can enter the environment when people dispose of medicines via trash or toilet, or after use when they are excreted in their original or metabolized form or rinsed off the skin in the case of topical applications.

The Issue

Medicines are produced and prescribed in increasing volumes every year (Figure 1). In the United States, sales of over-the-counter medicines have increased by 60% since the 1990s.[1] In 2006, the U.S. prescription volume rose to 3.7 billion prescriptions.[2] With these increases comes concern about the fate and effects of these compounds in the environment. Recent studies have identified a wide range of pharmaceutical chemicals in rivers and streams nationwide,[3] and it has also been shown that some of these compounds are potentially

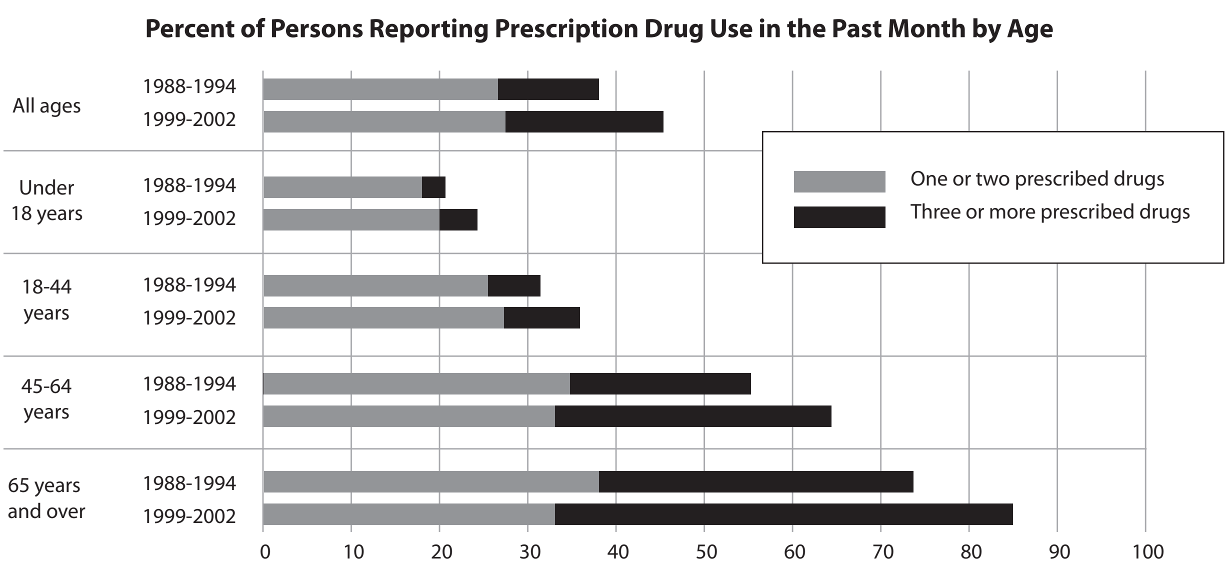

Figure 1. Prescription Drug Use. Source: National Health and Nutrition Examination Survey, 1999-2002. Center for Disease Control and Prevention. National Center for Health Statistics. Available at http://www.cdc.gov/nchs/nhanes.htm.

1 Ann Pistell, Maine Department of Environmental Protection. Presentation at Northeast Water Science Forum, August 9, 2007.

2 "IMS Intelligence.360: Global Pharmaceutical Perspectives 2006", IMS Health Report, February 22, 2007. http://www.imshealth.com/ims/portal/front/articleC/0,2777,6599_40183881_81567488,00.html

3 Kolpin, Dana W., et al. "Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999-2000: A National Reconnaissance." *Environ. Science and Technology*.Vol. 36 no. 6 (2002): pp. 1202-1211.

harmful to aquatic organisms, affecting reproduction and development even at low concentrations.[4] The fate of pharmaceutical chemicals in sewage sludge is also of concern, as sludge from wastewater treatment is often applied to agricultural land as a fertilizer. The long-term impacts of medicine disposal on our health and the health of the environment are not fully known. However, unless action is taken, the quantity of these chemicals reaching our waterways will continue to increase as pharmaceutical usage increases. Thus, Illinois-Indiana Sea Grant recommends a precautionary approach to this issue.

So what can be done? The issues surrounding medicine disposal are complex. Improper disposal of unwanted medicines can pose a risk to children and pets. For example, medicines placed in the trash without taking precautions to secure the container, make the medication unpalatable, or disguise the content are often accessible to children and pets, sometimes resulting in unintentional poisonings. And medicines disposed with their original labels intact can result in identity theft and drug theft. This is an especially important issue for the elderly, who are thebiggest consumers of prescribed medicines.

In early 2007, both the American Pharmacists Association[5] and the Office of National Drug Control Policy[6] issued guidelines for medicine disposal, following on the heels of several states providing advice to their citizens. The two main components of both sets of national guidelines are:

1. Don't flush medications down the toilet and instead,
2. Remove labeling from packaging and dissolve solid medications, mix with unpalatable items (kitty litter, coffee grounds, etc.) and seal in a bag before placing in the trash.

Disposal to trash is considered by some organizations to be an interim solution because medicines placed in landfills may ultimately reach wastewater treatment plants and local streams and rivers. Illinois-Indiana Sea Grant believes that currently, the best disposal solution is incineration of medications in a regulated incinerator. There is, however, a very long list of hurdles to overcome before a national disposal plan can be implemented that is protective of humans, pets and our environment. These hurdles include identifying safe and convenient medicine collection pathways and determining who will pay for this service.

This resource kit was created to help communities design, establish and implement safe and proper collection programs. Included in the kit are several examples of pamphlets, fact sheets and education materials that have been developed by communities and states as they wrestle with this complicated issue. The recommendations and advice vary because jurisdictions are finding different ways to deal with the fact that only interim solutions are available currently.

The good news about this issue is that it touches upon so many different aspects of our lives that there is no end of partners to join with to educate and reach out to the public. This issue impacts the elderly through drug and identity theft issues, accidental poisoning, and health care costs. It matters to the police because prescription drug abuse by teenagers is on the rise. Concerns for the safety of children and pets also can drive behavioral change. And for all of us, our health depends on the health of our environment, including rivers and streams and the creatures that live in them.

Background

Disposal of Unwanted Medicines

For many reasons, medicines are not always entirely used and therefore remain and may eventually expire in the hands of consumers or health care facilities. Some reasons for this include:

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4 For example, see Nash, Jon P., et al. "Long-Term Exposure to Environmental Concentrations of the Pharmaceutical Ethynylestradiol Causes Reproductive Failure in Fish." *Environmental Health Perspectives.* 112.17 (2004): pp. 1725-1733.

5 These guidelines were issued in cooperation with the U. S. Fish and Wildlife Service and can be found online at http://www.aphanet.org/AM/Template.cfm?Section=News_Releases1&CONTENTID=7481& TEMPLATE=/CM/ContentDisplay.cfm

6 Available online at http://www.ondcp.gov/news/press07/022007.html

- Improvement of the patient's medical condition
- Patient or doctor decides to discontinue use of the medication due to side effects or lack of therapeutic effect
- Patient death
- Packaging contains more medication than the patient needs, e.g. with over-the-counter or prescription medicines bought in bulk

Unwanted medicines can be disposed of by individuals and by health care facilities and businesses such as hospitals, hospices, rehab centers, clinics and pharmacies. Health care businesses disposal practices are regulated at the state and federal level. Some states have specific regulations surrounding pharmaceutical disposal. This document focuses on the medicines that are disposed of by individual households. We have provided a short section on the disposal practices of medical facilities because their practices may provide insight for community programs on different ways to approach the collection of unwanted medicines.

Disposal by Individuals

A 1996 survey[7] examined the expired medicine disposal habits in 100 pharmacies and 500 patients (Figure 2). The survey found:

Pharmacies:

- 97% had established policies regarding the disposal of undispensed, expired medicines
- However, only 5% had consistent recommendations for customers on medicine disposal

Patients:

- 54.0% disposed of medicines in the trash
- 35.4% flushed medicines down the toilet or sink
- 7.2% did not dispose of medicines
- 2.0% used all medicines prior to expiration
- 1.4% returned medicines to the pharmacy

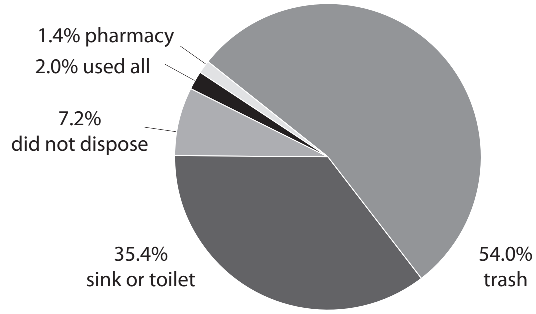

Figure 2: Patient disposal methods of unused medicines (from Kuspis and Krenzolek 1996)

Disposal by Health Care Centers and Pharmacies

Disposal of medicines by health care centers and pharmacies is regulated by some states. For instance, Minnesota instructs its hospitals and other health care facilities to obtain approval from the local wastewater treatment plant before discharging any medicines to the sewer system.[8] Michigan regulates some types of hospital waste as hazardous waste, which requires incineration as the final treatment and does not permit sewering or landfilling.[9]

Large-scale generators of pharmaceutical waste may have market options for disposal of their unused drugs. Pharmacies and health care centers can contract with reverse distribution companies to remove their undispensed expired medicines. Reverse distributors sort the drugs; some are sent for disposal and others are returned to the manufacturers who give purchase credits for certain types of medicines. Reverse distributors do not process pharmaceutical products for reuse. While manufacturers may ultimately process returned medicines for reuse, most medicines returned to manufacturers are sent off-site for disposal by regulated incineration.[10]

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7 Kuspis DA, Krenzelok EP. 1996. "What happens to expired medications? A survey of community medication disposal." *Vet Hum Toxicol.* 38(1):48-9. Online at: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=pubmed&cmd=Retrieve&dopt=AbstractPlus&list_uids=8825752&query_hl=1&itool=pubmed_docsum

8 Minnesota Pollution Control Agency, "Evaluating Pharmaceutical Wastes." August 2004. http://www.pca.state.mn.us/publications/w-hw4-45a.pdf

9 Michigan Department of Environmental Quality, "Waste Management Guidance: Hospital Pharmacies." December 1997. http://www.deq.state.mi.us/documents/deq-wmd-hwp-hospital.pdf

10 Charlotte Smith, quoted in Moran, K. 2004. "Household Pharmaceutical Waste: Regulatory and Management Issues." http://www.tdcenvironmental.com/HouseholdPharmWasteMgtIssuesFinal.pdf

Reverse distributors do not have hazardous or medical waste management or transfer station permits. Instead, they are treated as hazardous waste generators under the law. This is because unwanted medicines that are sent to reverse distributors may have financial value—a value that is only determined by the sorting process at the reverse distributor. Medicines sent to reverse distributors (and from reverse distributors to manufacturers) are treated as "products in commerce" because of this financial value, and thus are not subject to hazardous waste transportation and permitting requirements. The reverse distribution system is only available to consumers in the case of manufacturer or FDA recall of a suspected defective product.

In most of the U.S. there is no structured system for consumers to dispose of partially used or unused medicines. Locally organized, one-time collection events have provided an interim solution to the problem, but many people are calling for a disposal system that would be continuously available, such as a mail-back scheme or ongoing collections through pharmacies. See Section 2 of this resource kit for examples of large- and small-scale collection programs.

Risks of Unsafe Medicine Storage and Disposal

Accidental poisoning

Medicines are the most common poison exposure category in the U.S., and unsecured storage or disposal via the trash is a significant source of accidental poisoning.[11] In the U.S., approximately 78,000 children under 5 years of age are treated for poisoning annually in hospital emergency rooms and approximately 30 children under age 5 die as the result of unintentional poisoning.[12] Medicines account for 45% of these hospitalizations, and of these medicines, aspirin and other painkillers accounted for the most hospitalizations (11.8%).[13] Additionally, as the biggest consumers of prescription medicines, it is possible for senior citizens to misuse and self-prescribe medicines, using out-of-date medicines from past ailments to treat new, undiagnosed symptoms. Having a large number of medicines in the home can contribute to confusion over proper dosages and which pills to take when.

Diversion and Drug Abuse

Medicines are sometimes misappropriated for consumption or sale by family members and friends, workers in homes, and by burglars. Storing numerous medicines in the home or throwing excess medicines in the trash without first securing them can facilitate this type of misuse. The U.S. Department of Health and Human Services found in a nationwide study that 12% of young adults (ages 18-25) used prescription pain relievers non-medically in 2005. Of these users, 67% obtained them from a friend or relative, as compared to 14% who had the medicines prescribed to them by a doctor.[14] The 2006 "Monitoring the Future" Survey conducted by the University of Michigan reported that although illegal drug use by American teens has dropped more than 23% during the last five years, their abuse of medicines, both overthe-counter and prescription, is rising.[15]

Economic waste

Medicines thrown in the trash or flushed down the drain represent wasted health care dollars. Studies identifying the types and quantities of medicines that go unused could lead to better-informed prescription practices and better advice to patients on how to properly take prescriptions.

Improper medicine donations

In response to humanitarian crises, large quanti-

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11 PH:ARM Pilot Team. "Disposal of Medications from Residential Consumers: Issues, barriers, and opportunities." October 12, 2005.

12 U.S. Consumer Product Safety Commission. "Poison Prevention Packaging: A Guide For Healthcare Professionals." 2005. Online at http://www.cpsc.gov/cpscpub/pubs/384.pdf[13] "Perspectives in Disease Prevention and Health Promotion Update: Childhood Poisonings -- United States." 1985. in *Morbidity and Mortality Weekly Report* published by Centers for Disease Control and Prevention. Online at http://www.cdc.gov/mmwr/ preview/mmwrhtml/00000496.htm

14 National Survey of Drug Use and Health, available online at http://www.oas.samhsa.gov/2k6/getPain /getPain.htm

15 see the National Institute on Drug Abuse web site for more information this survey: http://www.drug abuse.gov/DrugPages/MTF.html

ties of medicines are sometimes donated internationally. If the donations do not match the need, or if the donated drugs are expired or otherwise unusable, significant disposal problems can arise overseas, as the receiving areas may have impaired waste treatment systems. See Section 6 of this resource kit for further information on the issues regarding medicine donations.

Environmental impact

Waste discharged through sewage systems can contaminate water resources in the surrounding environment. Pharmaceutical chemicals in waterways pose a potential for deleterious effects on wildlife. Sewage treatment plants are not designed to treat all the substances contained in medicines. Therefore, when they are flushed down the toilet or sink, some of these chemicals pass through the wastewater treatment facility altered or unaltered and can then enter rivers, lakes, living organisms, and groundwater. Additionally, some of these chemicals remain in the sewage treatment plant's sludge, which is frequently applied to agricultural land as a fertilizer.

Some active ingredients in medicines that can cause environmental damage:

- **Estrogens** are a group of steroid compounds that function as the primary female sex hormone. Even at low levels, estrogens can have a feminization effect on male fish, and therefore may decrease the reproductive capacity of affected species.[4]
- **Anti-depressants/Obsessive-Compulsive Regulators** are designed to control or alter behaviors by inhibiting the uptake of key neurotransmitters such as serotonin, norepinephrine, and dopamine. Once released into the environment, they can have similar or unforeseen effects on aquatic species and have been demonstrated to affect the spawning behavior of shellfish[16] and delay fish and frog development.[17] They also have been observed to result in slower heart rates for the water flea *Daphnia*, which could indicate broader physiological effects.[18]

Some pharmaceutical chemicals (e.g. anti-epileptics) persist in the environment; others are "pseudo-persistent"—they break down but are continually replaced because of widespread use. The concentrations of individual pharmaceutical chemicals detected in the influent of sewage treatment plants are typically in the range of a few parts per billion, while concentrations in treated effluent are usually lower, in the range of several hundred parts per trillion up to several parts per billion, depending on the chemical. As the effluent is diluted when it discharges into a river, the concentrations in waterways tend to range from undetectable to a few hundred parts per trillion. In sewage sludge, concentrations are sometimes much higher as the sludge is compacted.

Researchers have found that chronic exposure to low levels of pharmaceutical chemicals–within the same range of concentrations as has been observed in some waterways– can have significant effects on aquatic animals including fish[19] and lobsters.[20] At present, the greatest concern regarding pharmaceutical chemicals in the environment is their potential effects on small aquatic organ-

16 Fong PP. "Antidepressants in Aquatic Organisms: A Wide Range of Effects." in *Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues.* Daughton, C.G. and Jones-Lepp, T. (eds.), Symposium Series 791; American Chemical Society: Washington, D.C., 2001.

17 Holmes, Cat. "Antidepressants delay fish, frog development." *University of Georgia College of Agricultural and Environmental Sciences.* Oct. 29, 2003. http://georgiafaces.caes.uga.edu/pdf/2023.pdf

18 Rebecca Klaper. "Effects of Pharmaceuticals on Non-Target Organisms." Presentation at State of the Lakes Ecosystem Conference, Milwaukee, WI, November 2, 2006.

19 Palace, V.P., et al. "Biochemical and Histopathological effects in pearl dace (Margariscus margarita) chronically exposed to a synthetic estrogen in a whole lake experiment." *Environ. Tox. Chem.* 2006. 25(4): 1114-1125. http://journalclub.tox.ncsu.edu/linked_files/fall06/Palace2006.pdf, Palace, V. P., et al. "Induction of Vitellogenin and Histological Effects in Wild Fathead Minnows from a Lake Experimentally Treated with the Synthetic Estrogen, Ethynylestradiol." *Water Qual. Res. J. Canada*. 2002. v.37, n.3, 637-650. http://www.mindfully.org/Water/Fathead-Estrogen-LakesJul02.htm

20 Spanne, Autumn. "Human hormones hurt lobsters." *The Standard-Times*. Jan. 14, 2007. http://www.southcoasttoday.com/daily/01-07/01-14-07/01perspective.htm

isms. This is mainly because these organisms have short generation times, hence multiple generations are easily exposed. Because of this, there is a greater likelihood that effects will not be restricted to individual organisms but instead will accumulate over time to result in population-level effects.

Pharmaceutical chemicals identified in the environment are generally present in concentrations several orders of magnitude lower than the concentrations those required to exert their known effects on humans. This makes direct human toxicity unlikely but does not rule out the possibility of subtler long-term effects that are harder to detect.[21] The combined effects of medicines in the environment are unknown. Some scientists believe that low-level exposures to numerous drugs with the same or similar methods of action may add up to larger effects on aquatic organisms, that certain combinations of drugs may act synergistically to produce disproportionately large effects, or that other unpredictable interactions between chemicals may occur.[22] Much research remains to be done in this area.

Where are Pharmaceutical Chemicals Present in the Environment?

A United States Geological Survey (USGS) study analyzed 139 streams in 30 states and found 82 different organic wastewater contaminants, including pharmaceuticals and pesticides. 80% of the streams they sampled had at least one organic wastewater contaminant.[3] Furthermore, 75% of the streams tested had more than one contaminant present, 50% had seven or more, and 24% had 10 or more. However, these results are not necessarily representative of all waterways because sample collection was targeted to areas where these compounds were expected, namely downstream from urban areas and areas of livestock production. Since this study, further research has found pharmaceutical chemicals in ponds[23] and rivers[24] in many states and more studies are currently ongoing.

It is possible that there were other substances of potential concern in the water that were unobserved in these studies simply because researchers did not sample for them, or because there are currently no analytical techniques capable of identifying them.[25]

What are these Pharmaceutical Chemicals?

Types of human and animal pharmaceutical chemicals that have been identified in water bodies include

- Hormones
- Antibiotics
- Blood lipid regulators
- Analgesics and anti-inflammatories
- Beta-blockers
- Antidepressants
- Antiepileptics
- Antineoplastics (used in chemotherapy)
- Tranquilizers
- Retinoids
- X-ray contrast media.[22]

The degree to which these and other medicines are destroyed at wastewater treatment plants can vary greatly depending on both the type of medicine and the treatment method used. Various treatment techniques can alter some medicines into different forms that may be more or less toxic; even chemicals that have been converted into non-toxic forms can sometimes revert to more dangerous forms in the environment.

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21 Sherer, Jeffrey T. "Pharmaceuticals in the Environment." *American Journal of Health-Systems Pharmacy*. Vol. 63. Jan 15, 2006.

22 Daughton, Christian G., and Ternes, Thomas A. 1999. "Pharmaceuticals and Personal Care Products in the Environment: Agents of Subtle Change?" *Environmental Health Perspectives*. Vol. 107, Supplement 6. p. 924.

23 Standley, L. Presentation "Contamination of Surface Ponds on Cape Cod, MA, by EDCs and Pharmaceuticals from Septic-Contaminated Groundwater" at Northeast Water Science Forum, August 8, 2007.

24 Furlong, E., P. Phillips, USGS; Lloyd Wilson, NYS DOH. Presentations at Northeast Water Science Forum, August 8, 2007.

25 See Daughton, Christian. "Cradle-to-Cradle Stewardship of Drugs for Minimizing Their Environmental Disposition While Promoting Human Health." *Environmental Health Perspectives.* v. 111 no. 5 (May 2003). Online at http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1241487.

How do Pharmaceutical Chemicals Enter the Environment?

Residential, commercial, and agricultural pharmaceutical chemicals follow two primary pathways to wastewater treatment systems (Figure 3):

Metabolic excretion

Many pharmaceutical chemicals are biotransformed in the body. Biodegradation alters the chemical structure of their active molecules, which, in turn, often results in a change in their physical and chemical properties. Metabolism is frequently incomplete, and excretion rates range from 0 to 100%.[26, 27] This means that sometimes a significant fraction of the medicine is not absorbed into the patient's body and instead is excreted. In some cases, metabolic processes alter the medicine, creating a different chemical that may be more or less toxic than the parent compound and may revert back to the parent form in the sewage treatment plant or in the environment.

Direct disposal

Disposing of unwanted or expired medicines can be a challenge for households. In the U.S., few formal guidelines are available for individual consumers on drug disposal, and, consequently, most of their unused medicines enter septic tanks, sewers, or landfills.

Once they have been discarded or excreted, pharmaceutical chemicals enter surface waters and groundwater through several pathways (Figure 4):

- Effluent from plants that treat household, industrial, and hospital wastewater
- Septic systems
- Runoff and/or groundwater from uncontrolled

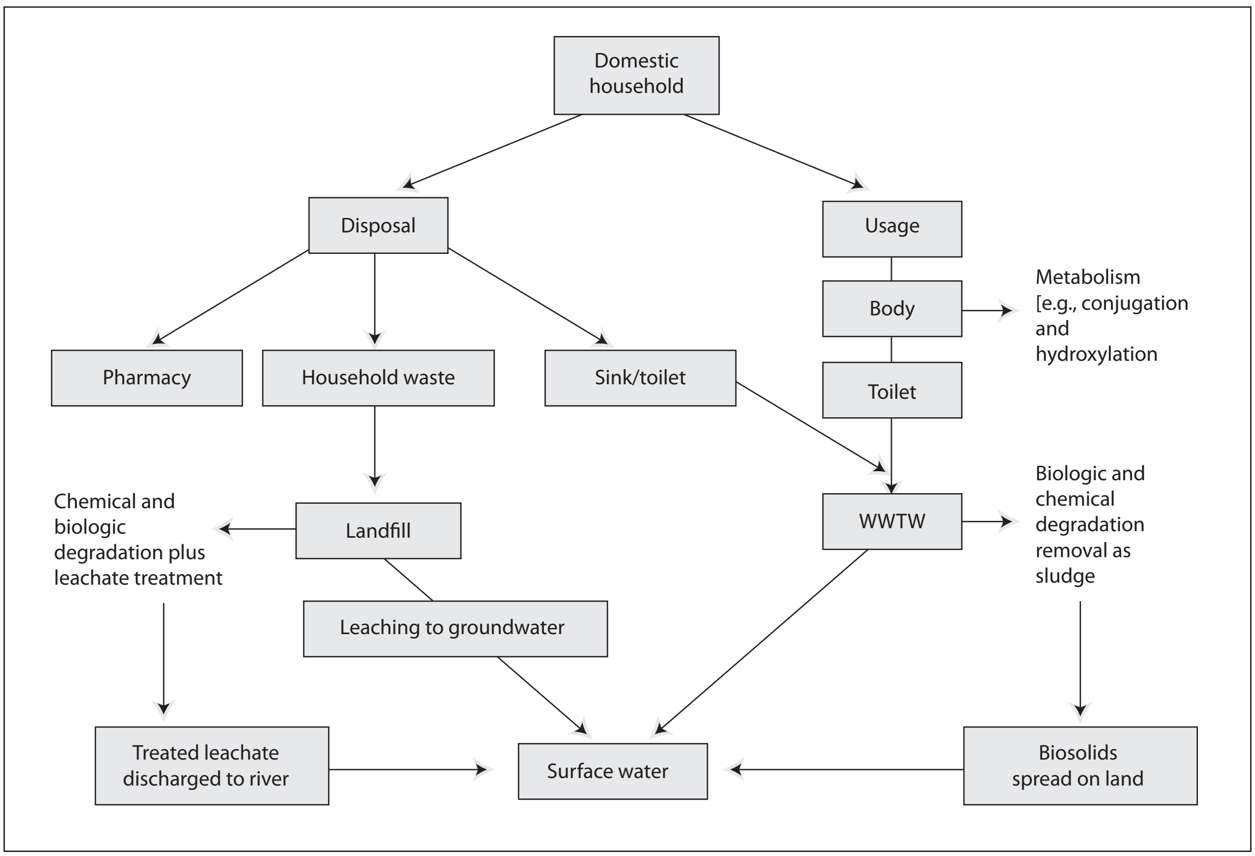

Figure 3. Pathways of drugs from households to the environment from Bound and Voulvoulis 2005

26 Kummerer, K. Pharmaceuticals in the Environment: Sources, Fate, Effects and Risks. Springer. 2nd Edition. 2004.

27 Bound, Jonathon, and Nikolaos Voulvoulis. "Household Disposal of Pharmaceuticals as a Pathway for Aquatic Contamination in the United Kingdom." *Environmental Health Perspectives*. 113.12 (2005):1705-1711.

landfills or landfill leachate sent to waste water treatment plants
- Controlled industrial discharges
- Commercial animal feeding operations and aquaculture
- Surface application of manure and biosolids

In general, wastewater treatment plants were not designed to remove dissolved medicines from water. They were designed to remove solids, organic materials, and some nutrients such as phosphorus and nitrogen. At wastewater treatment plants, water goes through one, two or three stages of treatment, depending on the sophistication of the plant and the needs of the community served.

Primary treatment removes solids, which are either applied to land as fertilizer or sent to a landfill. The treated water still can contain dissolved and colloid organics and bacteria. If the plant does no more than primary treatment, then the water is chlorinated to kill the remaining bacteria and discharged.

During secondary treatment, organic materials and nutrients are removed with the aid of bacteria in aerated tanks. After the bacteria are added, the wastewater flows to settling tanks where the bacteria settle out.

Various types of tertiary treatment are possible, depending on the composition of the wastewater.

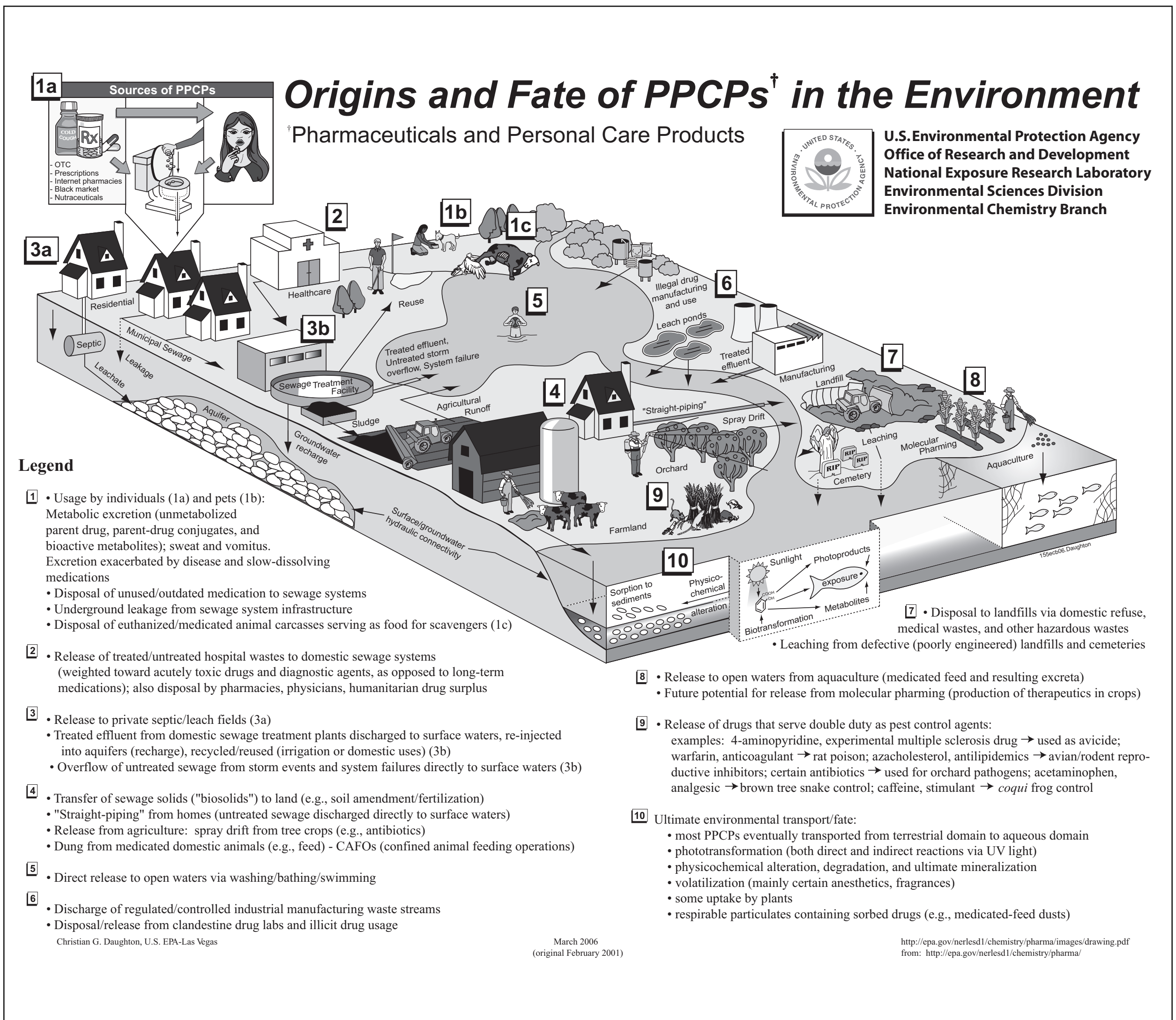

Figure 4. From U.S. EPA's website http://www.epa.gov/ppcp/pdf/drawing.pdf

Typically, tertiary treatment uses chemicals to remove phosphorous and nitrogen from the water, but may also include filter beds and other types of treatment. Chlorine added to the water kills any remaining bacteria, and the water is discharged.[28]

Septic systems represent another source of unwanted medicines to groundwater and ponds, as they are also not equipped to break down pharmaceutical chemicals. Researchers have discovered some estrogenic chemicals in groundwater down-gradient of residential septic systems,[29] and new research indicates higher levels of these chemicals in ponds near areas of higher residential density.[23]

Stockyards and feedlots where animals are treated with steroids, hormones, antibiotics, and other veterinary pharmaceuticals are also significant sources of pharmaceutical chemicals to the environment. The chemicals are excreted by the animals directly onto the land, are dispersed via manure spreading, and are discharged into streams by runoff. Any of these routes may result in impacts to surface and groundwater.[30]

Conclusion

The release of pharmaceutical chemicals into the environment after they are excreted by humans and animals is inevitable without sweeping changes to wastewater treatment systems or to medicine manufacture and design; a wide array of changes in each of the many aspects of pharmaceutical manufacturing, distribution, prescribing, consumption, and disposal has been proposed for reducing the introduction of pharmaceuticals to the environment.[31] In the U.S., both the EPA and FDA regulate waste pharmaceuticals and other byproducts that result from medicine manufacture.

There is currently insufficient information to determine the relative quantities of medicines reaching the environment from each of the various sources. But one area of this complex issue that is amenable to immediate change is in the disposal of unwanted medicines by consumers. This resource booklet discusses several ways to address the issue of unwanted and/or expired medicine disposal from households.

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28 How Sewer and Septic Systems Work, by Marshall Brain, http://people.howstuffworks.com/sewer3.htm

29 Swartz, C. et al. "Steroid Estrogens, Nonylphenol Ethoxylate Metabolites, and Other Wastewater Contaminants in Groundwater Affected by a Residential Septic System on Cape Cod, MA." *Environmental Science and Technology.* Volume 40, number 16, pp. 4894 -4902. Published online July 18 2006.

30 Boxall, L.A. et al. 2004. "Veterinary Medicines in the Environment." *Rev Environ Contam Toxicol.* 180:1-91. See also Society of Environmental Toxicology and Chemistry (SETAC). *Veterinary Medicines in the Environment.* Crane, M.; Barrett, K.; Boxall, A.; Eds., SETAC Press: Pensacola, FL, 2007. (in preparation).

31 Daughton, C.G. "Cradle-to-Cradle Stewardship of Drugs for Minimizing Their Environmental Disposition while Promoting Human Health. I. Rationale for and Avenues toward a Green Pharmacy and II. Drug Disposal, Waste Reduction, and Future Direction." *Environ. Health Perspect.* 111 (2003) 757-785 http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1241487, http://www.pubmedcentral. nih.gov/articlerender.fcgi?artid=1241488

Appendix E. Poster and Exhibit Guidelines and Suggestions

Poster Guidelines

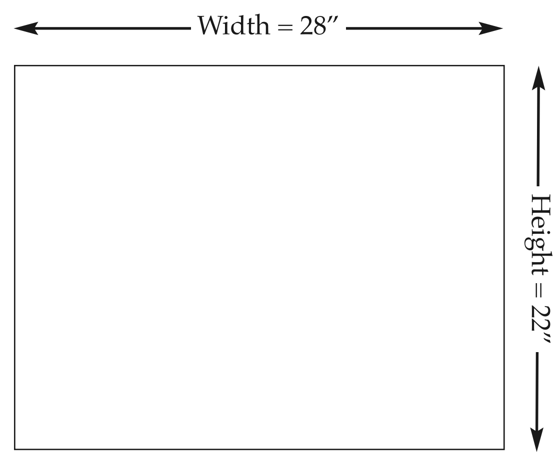
Fair exhibits give youth the opportunity to show the public what they have learned in their project work. Indiana State Fair guidelines require the following:

- Exhibits must be displayed horizontally, sized 22″ x 28″, mounted on a firm backing (foam-core board or other), and covered in clear plastic or other transparent material.
- A display box (18 x 24 inches), orientated horizontally, may be used to make specimens more secure.
- Each exhibit must include a label with name, grade, and county.
- The Indiana State Fair exhibit guidelines are given on the Indiana 4-H website (**http://www.four-h.purdue.edu**, click on "Projects" in the menu bar right under the green "Indiana 4-H").

Poster Suggestions

Adapted from suggestions developed by Roger Sherer, Extension youth educator in Wells County.

- **Poster board –** use white when required. Youth can experiment with other colors when white is not required.
- **Mounting adhesives –** the best is rubber cement since it leaves no marks and won't wrinkle paper. White glue should be used only in cases where wrinkling or damage will not occur.
- **Colored pencils –** the best are soft-leaded – they are easy to color and blend – strokes will not show if handled properly. Soft-leaded pencils can be purchased at art stores. Hard-leaded pencils are less expensive, but are more difficult to use.
- **Labels –** plain 3″ x 5″ file cards work well as they have a smooth finish and are sturdy enough for gluing and removing smudges.
- **Stiff backing –** any material that will keep the poster from bending will work. Foam-core board works well, if you can find it in the correct size, because it can take the place of poster and backing. Examples of backing include: foam-core board, very stiff cardboard, plywood (which makes the poster heavy), and masonite (1/8″ thick works well and can be re-used).
- **Acetate or other clear plastic covering –** this is required for most posters, to keep them clean for judging, especially if fairgoers touch them. Coverings generally come in various thickness (3, 5, 7 ½, and 10 ml) in rolls or sheets.
- **Plastic tape –**not necessary, but it makes attaching poster board to stiff backing easy. Tape is available in many colors and widths and is available in cloth or plastic. The 1½″ wide tape can give the poster a border. Available at discount stores.
- **Lettering –** type labels and title on a computer or typewriter or use stencils, self-adhesive, or press-type letters purchased at discount or art stores.
- **County ID labels –** an identification label should be placed in the lower right hand corner of poster projects. Check your county guidelines for requirements.
- **Format –** Your poster should read like a dollar bill:



Poster Suggestions

Adapted from suggestions from Amy Nierman, Extension educator, Washington County, and Angela Apple at the 1998 Indiana State Leader's Conference.

A Good Poster:

- Attracts attention.
- Is simple and clear.
- Interests someone in some aspect of your project.

Planning

- Know the project requirements.
- Read the manual – look for ideas.
- Brainstorm ideas and make a list.
- Think of titles with alliteration (repeating a sound in words).
- Look at other posters for ideas – but ***don't copy.***

Do

- Be brief. The poster is not intended to show all that you know, but to teach some aspect of your project.
- Use a combination of illustrations and words.
- Be as neat as you can.
- Cut evenly, cement carefully, blend colors when using crayons or colored pencils.
- Leave white space on the poster.
- Make sure the poster is balanced.
- Choose colors carefully. The following are general guidelines:
  - Black tends to be more formal, neat, rich, strong.
  - Blue is cool, melancholy, or depressed.
  - Purple is considered royal, rich, imperial.
  - Red stands for love as well as anger and hatred.
  - Orange is generally used for Halloween and is festive and gay.
  - Yellow tends to be warm, light, or ripe.
  - Green is fresh, young, or growing.
  - White means pure, clean, and neat.

Don't

- Don't make a vertical poster.
- Don't use Saran Wrap to cover.
- Don't use staples, tacks, or tape.
- Don't use fluorescent posters.
- Don't create a poster that is all words or a poster that is all pictures.
- Don't put too much information on the poster. Fairgoers rarely will look at a poster for more than 10-20 seconds, unless it catches their interest right away. Then, they might read it for a minute or two.

Steps to Making Your Poster

- Read your project manual.
- Read your county project requirements.
- Decide on information to include on the poster.
- Sketch out your idea.
- Collect supplies.
- Mark guidelines for lettering and pictures (lightly).
- Layout letters, pictures, etc. on the poster.
- Cement (glue, etc.).
- Clean up the poster so it is neat. Erase any guidelines that are showing. Remove excess rubber cement or glue.
- Glue poster to backing.
- Cover poster with plastic.
- Take your poster to the fair on the right day and at the right time.

Poster Judging Suggestions for Judges

The goal for all project work is to give guidance to youth learning about something they have a particular interest in. The goal of a poster is for the 4-H member to share information that they have learned by doing their project work. The poster is not intended to show all that the 4-H member knows, but to teach some aspect of their project. Posters should be eye-catching and attractive. Fairgoers rarely will look at a poster for more than 10–20 seconds, unless it catches their interest right away. Then, they might read it for a minute or two.

Age-appropriate judging is critical so that each youth is treated fairly. Young 4-H members (grades 3–5) should not be expected to have the fine motor coordination or advanced thinking skills of an older 4-H member. Older youth should begin to take the concepts they have learned and apply them to a particular situation. Originality is expected of high school youth.

Action Demonstration Guidelines

What is an action demonstration (action demo)?

An action demo is a fun way to share with others what you have learned in your 4-H project. It's a kind of "show and tell" but with more action. An action demo is not like a regular demonstration where the audience sits and listens to a prepared talk. An action demo lets the audience get involved.

Action demonstrations can be given anywhere there are a lot of people, such as a county or state fair, shopping mall, street fair, or any 4-H event. Your job as a demonstrator is to interest the audience in your topic so that they stop and learn something new or try their hand at what you are doing.

How do I choose a topic for my action demo?

An action demo can be on almost any subject. The topic should be something that you enjoy and are knowledgeable about. Consider the following questions when choosing a topic:

- Can you complete the action demonstration in 3 to 5 minutes?
- Can it easily be repeated over and over again to fill the assigned time?
- Is your action demo showing something that would interest the general public?
- Is there a good way to involve your audience in your action demo (hands-on or answering questions)?
- Can the supplies for the hands-on section be used over and over again, or will they need to be replaced? (Remember, if the materials must be replaced, it will cost more to do the demonstration.)
- How can I get the audience involved?

The first thing you need to do is be enthusiastic and attract people's attention as they walk by your table. You might have a colorful tablecloth or poster to spark their interest. You might ask them a question, like: "Would you like to play this game?" or "Have you ever made pretzels? Would you like to try?" The best way to attract their attention is having people around your table doing something. People love to do hands-on activities, so once you get a few people at your table, they will attract others. For more information on action demonstrations, watch the video, V-4-H-28.

Involve your audience by having them:

- Do what you are doing.
- Do a "hands-on" activity.
- Judge the quality of various items.
- Play a game.
- Answer questions.

Remember – the key to a good action demo is getting your audience involved.

Checklist for a Good Action Demo

Topic	Yes	No
Was the topic interesting to the general public, causing them to stop, watch, or participate?		
Did the topic stimulate questions from the audience?		
Was the topic of suitable length?		
Did the topic include something hands-on for the audience to do?		
Organizing the Content	**Yes**	**No**
Was the topic organized into short "show and tell" segments that are done repeatedly?		
Were segments presented in logical order?		
Were segments explained so that the audience understands "Why?"		
Was it evident that the 4-H member was knowledgeable about his or her subject and could answer questions?		
Did visuals, pictures, posters, or actual objects clarify the important ideas?		
Presenting the Demonstration	**Yes**	**No**
Did the 4-H member seem enthusiastic?		
Did the 4-H member encourage the audience to become involved in the demonstration?		
Did the 4-H member speak directly to the audience?		
Did the 4-H member show evidence of practice and experience?		
Did the 4-H member show that she/he enjoys talking to the audience?		
Did the 4-H member show enthusiasm, friendliness, and a business-like manner?		
Did the 4-H member describe what he or she learned through this 4-H project?		

Comments

The Medicine Chest

A collection of safe disposal curriculum activities and service-learning resources

Content Overview—What's in Your "Medicine Chest"?

Acquire an understanding of why safe disposal of unwanted medicine is an important issue of concern so your students can become active "agents for change" in your community.

Incorporate a model high school service-learning program, P^2D^2, which establishes a strong partnership between your school, local pharmacies, government officials, law enforcement, and water management agencies. Have your students organize community collection events based on information learned through lesson plans from multiple disciplines, including environmental science, civics, music, art, language arts, and foreign language.

Find out how this service-learning unit aligns with National Education Standards. Relevant Illinois and Indiana state standards are also included, which can provide helpful linkages to standards in other states.

Enhance your students' grasp of the content through supplemental activities that are provided. These offer multiple tools for learning, including word searches, puzzles, an experiment, a risk assessment case study, an estimation activity, an interactive service-learning activity to guide student research and action planning, and a description of a 4-H guide that offers five inquiry-based activities.

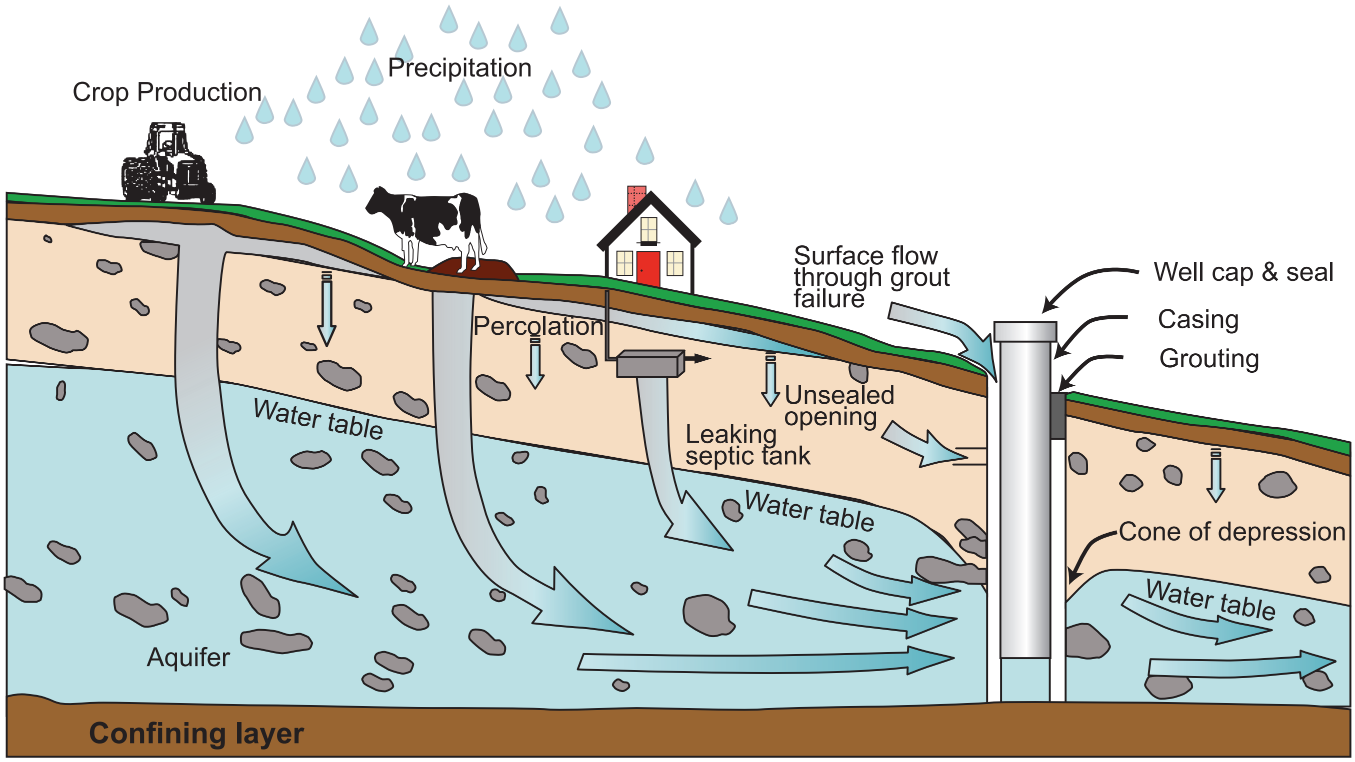
Get the latest links to science-based research and data so your students can do their fact-finding using credible background information from Websites and fact sheets. *Tox Town* and *Tox Mystery* provide great opportunities for interactive learning via the Web.

Discover what makes a service-learning project successful. Included are great prompts for student reflection activities, action plan templates, and tips for building community partnerships and organizing festivals.

Check out creative student projects that have sparked community interest, understanding, and action. You'll see examples of billboards, eco-poems, songs, designed collection boxes, a rain barrel, and student presentations.

Help us improve this educational resource by providing feedback. We will be updating the PDF files on our Website to make them more relevant and current, based on your comments. Please complete and return the Feedback Form at the end of this resource.

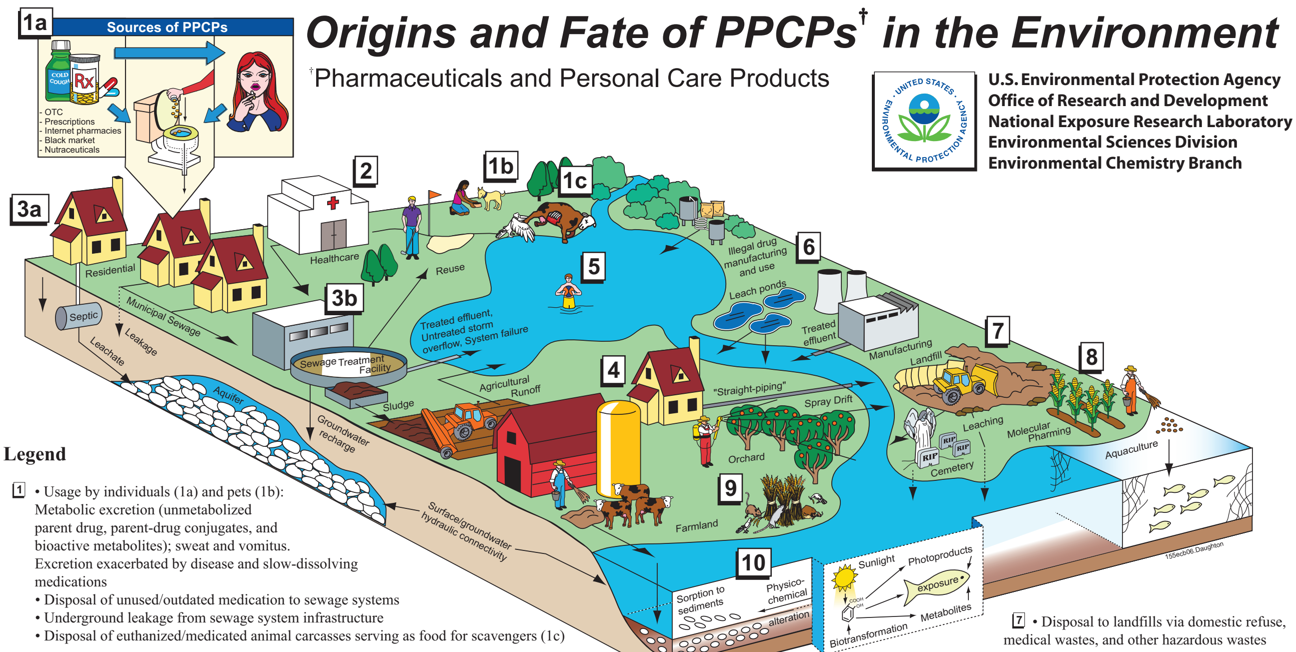
This curriculum can be downloaded at **www.iisgcp.org/education/safe_disposal_curriculum.html**.



Origins and Fate of PPCPs† *in the Environment*

†Pharmaceuticals and Personal Care Products

U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
Environmental Chemistry Branch



Legend

1 • Usage by individuals (1a) and pets (1b): Metabolic excretion (unmetabolized parent drug, parent-drug conjugates, and bioactive metabolites); sweat and vomitus. Excretion exacerbated by disease and slow-dissolving medications
• Disposal of unused/outdated medication to sewage systems
• Underground leakage from sewage system infrastructure
• Disposal of euthanized/medicated animal carcasses serving as food for scavengers (1c)

2 • Release of treated/untreated hospital wastes to domestic sewage systems (weighted toward acutely toxic drugs and diagnostic agents, as opposed to long-term medications); also disposal by pharmacies, physicians, humanitarian drug surplus

3 • Release to private septic/leach fields (3a)
• Treated effluent from domestic sewage treatment plants discharged to surface waters, re-injected into aquifers (recharge), recycled/reused (irrigation or domestic uses) (3b)
• Overflow of untreated sewage from storm events and system failures directly to surface waters (3b)

4 • Transfer of sewage solids ("biosolids") to land (e.g., soil amendment/fertilization)
• "Straight-piping" from homes (untreated sewage discharged directly to surface waters)
• Release from agriculture: spray drift from tree crops (e.g., antibiotics)
• Dung from medicated domestic animals (e.g., feed) - CAFOs (confined animal feeding operations)

5 • Direct release to open waters via washing/bathing/swimming

6 • Discharge of regulated/controlled industrial manufacturing waste streams
• Disposal/release from clandestine drug labs and illicit drug usage

7 • Disposal to landfills via domestic refuse, medical wastes, and other hazardous wastes
• Leaching from defective (poorly engineered) landfills and cemeteries

8 • Release to open waters from aquaculture (medicated feed and resulting excreta)
• Future potential for release from molecular pharming (production of therapeutics in crops)

9 • Release of drugs that serve double duty as pest control agents:
examples: 4-aminopyridine, experimental multiple sclerosis drug → used as avicide; warfarin, anticoagulant → rat poison; azacholesterol, antilipidemics → avian/rodent reproductive inhibitors; certain antibiotics → used for orchard pathogens; acetaminophen, analgesic → brown tree snake control; caffeine, stimulant → *coqui* frog control

10 Ultimate environmental transport/fate:
• most PPCPs eventually transported from terrestrial domain to aqueous domain
• phototransformation (both direct and indirect reactions via UV light)
• physicochemical alteration, degradation, and ultimate mineralization
• volatilization (mainly certain anesthetics, fragrances)
• some uptake by plants
• respirable particulates containing sorbed drugs (e.g., medicated-feed dusts)

Christian G. Daughton, U.S. EPA-Las Vegas

March 2006
(original February 2001)

http://epa.gov/nerlesd1/chemistry/pharma/images/drawing.pdf
from: http://epa.gov/nerlesd1/chemistry/pharma/