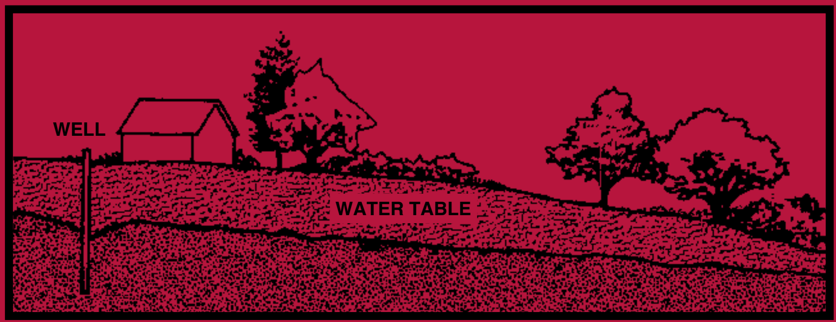
Microbial Pest Management - A Training Manual for Commercial Pesticide Applicators and Registered Technicians (Category 5B)
Michigan State University Extension Service
Julie Stachecki, Editor
Issued May 2010
98 pages
Replaces E2052

MICHIGAN STATE
UNIVERSITY
EXTENSION

Microbial Pest Management

A Training Manual for Commercial Pesticide Applicators and Registered Technicians (Category 5B)



Extension Bulletin E -2435
Minor Revisions, May 2010
Michigan State University Extension

Microbial Pest Management

A Training Manual for Commercial Pesticide Applicators and Registered Technicians (Category 5B)

Compiled and edited by Julie A. Stachecki, MSU Pesticide Education Program associate.

Technical assistance by Doug Foyteck, Aquatrol, Ladell Jones, Dow Chemical Co., Bob Karbowski, Dow Chemical Co., John Kools, Mitco Inc., Robert Othmer, Enerco Corporation, Larry Schultz, Aquatrol

Minor revisions by Larry G. Olsen, MSU Interim Pesticide Education Coordinator and Brian Rowe, Pesticide Section Manager, Pesticide and Plant Pest Management Division, Michigan Department of Agriculture

Preface and Important Information on How to Use This Study Manual

This manual presents basic pest management and pesticide handling information for persons managing bacteria, fungi, algae or viruses in cooling towers, air washers, evaporative condensers, pulp and paper mills, sewer treatment, etc. (See the introduction for an explanation of the difference between commercial and private applicators and registered technicians.)

This manual is a training guide for persons pursuing either registered technician or certified commercial pesticide applicator credentials in category 5B, Microbial Pest Management (see important information in the "Notice of Upcoming Changes" below). The examinations for these two groups will have questions that emphasize different information from this manual. If you are preparing for the **registered technician** exam, focus your learning on the general pesticide safety and handling information. If you are pursuing **certification** in category 5B, microbial pest management only, be prepared to answer questions on all the material found in this manual including general pesticide safety and handling, microbial pest specific information, application techniques common to microbial pest management and equipment. If you are using this manual to prepare for a 5B category exam **in addition to other category exams** be familiar with the entire contents of this manual but focus on the microbial pest specific information. The 5B category exam questions will be primarily on microbial specific information with some general pesticide safety and handling questions.

This is not intended to provide all the information necessary for effective pest control with the use of biocides. Obtain up-to-date information about recommended materials and methods from biocide labels, manufacturers, reference manuals, and professional associations. The label carries important information about proper dilution rates, timing and placement of biocides in a system. The label is the law. Follow all directions on pesticide labels.

Acknowledgments

We express our appreciation to the following people for contributing to or reviewing the original manuscript prior to publication: William Creal and Sylvia Heaton, Michigan Department of Natural Resources and Environment, Great Lakes and Environmental Assessment Section, Surface Water Quality Division, Dr. Ned Walker, Michigan State University, Department of Entomolgy. Photographs of cooling tower equipment were provided by Paul Love, photographer, Michigan State University, Pesticide Education Program.

The Cornell University, "Pesticide Applicator Training Manual; Category 7, Industrial, Institutional, Structural, and Health, Subcategory Cooling Towers," was a valuable source of information for this manual. The foundation for this manual was based on the Michigan State University publication, "Commercial and Private Pesticide Applicator Core Manual: Certification and Registered Technician Training," E-2195, edited by Joy Neumann Landis, Robin R. Rosenbaum, and Julie A. Stachecki, 1992. Special thanks to Ken Dettmer of Graphicom for the efficient, timely and professional design and typesetting of this manual.

Notice of Upcoming Changes

The next printing of this manual will create changes in the study materials required for microbial pest management certification and registered technician training.

At that time, registered technicians will study Part A of the *Michigan Commercial Pesticide Applicator Core Training Manual (E-3008),* pass an exam on the information and then pursue their category specific training.

Persons wanting commercial applicator certification in Category 5B, Microbial Pest Management will need to study the *Michigan Commercial Pesticide Applicator Core Training Manual (E-3008),* and the *Microbial Pest Management Training Manual (E-2435)*. To become certified or recertified, you must pass an exam on information in the Core manual and an exam on the category manual information (microbial).

TABLE OF CONTENTS

CHAPTER 6: PESTICIDE HANDLING, STORAGE AND DISPOSAL

CHAPTER 7: THE PESTICIDE LABEL

CHAPTER 8: PESTICIDE APPLICATION EQUIPMENT

CHAPTER 9: PESTICIDE LAWS AND REGULATIONS

APPENDIX

INTRODUCTION

Why Should Pesticide Applicators be Certified or Registered?

Pesticides are used to protect food and non-food crops, ourselves, homes, pets, livestock, and for various industrial processes. New measuring techniques have shown that some pesticides may reach groundwater, remain in crops, or persist in the environment. To better protect the environment and human health by assuring the safe use and application of pesticides, the Michigan Department of Agriculture (MDA) administers the certification and registration program for pesticide applicators. Certification or registration requires obtaining the necessary knowledge to purchase and safely use pesticides. The following sections explain who must be certified or registered. For additional information, see the laws and regulations chapter of this manual.

Certification/Registration Requirements

Act 451, Part 83, Pesticide Control, requires any person who applies a pesticide product for a commercial purpose, or applies any pesticide in the course of his or her employment, or other business activity for any purpose other than a private agricultural purpose to be either a commercially certified applicator or a registered technician. Pesticide applicators, who are *not* required to be licensed by the Act and who only use general-use, ready-to-use pesticide products are exempt from the certification and registered technician requirements. For example, a person who works at a hospital, school, factory, golf course or an apartment complex that uses only a general use, ready-to-use product for managing a pest is not required to be a certified applicator or a registered technician.

Certification of Commercial Applicators

To become certified as a commercial applicator in Microbial Pest Management (Category 5B) in Michigan, you are required to successfully complete a written examination. Exam questions are based on information provided in this training manual developed by Michigan State University Extension, MDA and representatives of the microbial pest management industry. This manual presents basic pest management and pesticide handling information for persons managing bacteria, fungi, algae or viruses in cooling towers, air washers, evaporative condensers, pulp and paper mills, sewer treatment, etc. This manual is self-teaching and contains a study guide with self-help questions at the end of each chapter. This manual addresses the standards required of all registered technicians and commercial applicators for Category 5B, microbial pest management. Information necessary for certification in other categories is contained in separate category study manuals.

Recertification for Certified Commercial Applicators

Similar to a Michigan driver's license, you are required to be recertified every three years. You can be recertified by one of two methods. First, you can request from the MDA to take another exam (recertification exam) which shows a sustained level of knowledge in proper pesticide use. Study manuals are available from MSU. Second, you can attend approved seminars or workshops relating to microbial pest management and accumulate twelve credits over the three-year period to satisfy the recertification requirements for category 5B. For specific information on recertification, contact your local MDA regional office.

Registered Technicians

To become a registered technician in Category 5B, the applicator must successfully pass an examination based on this training manual and participate in an approved training program specific to microbial pest management. To receive a registered technician application form, contact your local MDA regional office. (See preface for important changes in this procedure for Category 5B, in the future.)

Registered technician status is for three years. At the conclusion of a registered technicians three-year registration period, they may renew their registered technician credentials by examination or by accumulating a specific number of reregistration credits. Credits toward reregistration are earned by attending approved workshops and seminars during the three-year registration period. A registered technician may also choose to fulfill the requirements for becoming a certified commercial pesticide applicator instead of the registered technician credential.

Suggestions for Studying This Manual

This manual is designed to assist commercial applicators to meet registered technician or certification requirements. You may already know some of the material from your experience with pesticides. The manual has nine chapters. A list of self-help questions are included at the end of each chapter. These questions are to help you study and are not necessarily the questions on the certification examination. If you have problems using the manual, please consult your county extension agent, your supervisor or a representative of the MDA for help. Please read the preface of this manual which explains the type of information from this manual that registered technicians or certified applicator candidates should focus on learning.

Some suggestions for studying the manual are:

1. Find a place and time for study where you will not be disturbed.

2. Read the entire manual through once to understand the scope and the manner in which the material is presented. A glossary at the back of the manual defines some of the terms used in the chapters.

3. Study one chapter of the manual at a time. Consider underlining important points in the manual or take written notes as you study the chapter.

4. Answer, in writing, the self-help questions at the end of each chapter. These questions are intended to help you study and evaluate your knowledge of the subject. They are an important part of your study.

5. Reread the entire manual once again when you have finished studying all of its sections. Review with care any sections that you feel you do not fully understand.

This manual is intended to help you use pesticides effectively and safely when they are needed. We hope that you will review it occasionally to keep the material fresh in your mind.

CHAPTER 1

Pests and Pest Management

Pests are plants, animals or microorganisms that create undesirable conditions or interfere with humans and their activities. The major pests that require pest management are weeds, insects, microorganisms, nematodes, and vertebrates which are discussed in detail in chapter 2.

Historical records contain many examples of how pests have had major impacts on humans and how they have altered history. One classic example is the Irish potato famine of the 19th century which directly influenced the population of the United States. A fungal disease called late blight essentially eliminated potatoes, the staple food crop of Ireland. Potatoes that were not destroyed in the field rotted in storage due to this disease. As a result, thousands of Irish starved and more than one million immigrated to the United States. Late blight continues to be a major problem of potatoes, but today pest management techniques of resistant varieties, proper sanitation practices, and pesticide use have limited this problem.

Other examples of how pests have and still affect people are the 1976 Philadelphia, Pennsylvania, and the 1986 Romulus, Michigan outbreaks of Legionnaires' disease. In both cases several persons died because of a disease caused by bacteria, *Legionella pneumophila,* growing in the air cooling system of the buildings they occupied.

This chapter explains integrated pest management and the techniques that should be considered when managing pests. The primary goal of a pest management program is to reduce pest damage to an acceptable level. In most cases, the objective is not total eradication of the pest. Eradication is usually an unrealistic goal and our efforts may, in the end, create more problems than they solve (e.g., pest resistance, secondary pest outbreaks, resurgence, environmental contamination, or equipment damage). However, in aquatic and microbial pest management the eradication of pests in specific equipment is possible and necessary because of the limited area treated and the potential hazard to persons and property the pest may cause if it is not controlled completely.

Integrated Pest Management

To better understand the complex biological system in which we use pesticides, and to effectively manage pests with a range of pest management tools, a system known as **Integrated Pest Management (IPM)** was developed. IPM is the use of all available tactics or strategies to manage pests so that an acceptable yield and quality can be achieved economically with the least disruption to the environment. The need for IPM came about for several reasons: sole reliance on pesticides has proven to be detrimental to the environment; pests have developed resistance to chemicals; and applicators have spent more money than is necessary for pest management. IPM provides the applicator with a diverse pest management program that avoids sole reliance on one technique and its potential shortcomings. Many successful IPM programs have reduced energy and pesticide use, thereby saving money and causing less harm to our environment.

Pest identification, life cycles, pest density, and the pest's relationship to the host or mechanical system in which it exists are essential information for an IPM program. Proper identification is necessary to determine the proper pest management strategy. Knowledge of pest, plant, and animal life cycles can help to time management practices at the pest's susceptible stage without damage to the host plant, animal or system. IPM includes biological monitoring (scouting), sampling and trapping, and environmental monitoring (weather). Lastly, pest densities help determine the economics of the proposed management practice.

IPM systems vary with each situation. Changes in mechanical systems, pests, available management techniques (natural and applied), weather, and economic circumstances all contribute to variability. Consider the following five steps when developing an IPM program.

1. Detection

It is extremely important to detect pest infestations before they become a problem. Failure to do so will often result in increased cost of control, less effective or ineffective management measures, potential damage to the equipment or product (i.e. paper in a pulp mill), and increased cost for cooling when treating a cooling tower.

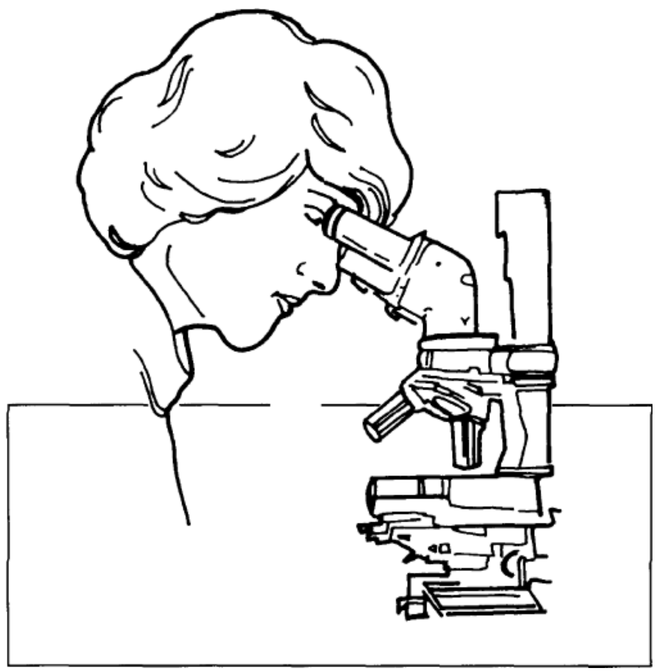
Inside the basin of cooling towers there are many surfaces and areas that provide favorable places for microbial organisms to grow.

Proper pest detection requires frequent and careful visual checks of cooling or process equipment, a knowledge of the common microbial pests, an ability to recognize potential problems, periodic bacteria cultures, and a thorough knowledge of the system you are maintaining. Realizing that cooling towers, evaporative condensers, and similar open recirculating systems, by design, can scrub a wide and varied group of organisms from the air during normal operation should alert the manager to their potential growth in the system. In contrast, closed recirculating cooling water systems are much less subject to operating problems caused by microorganisms. However, when they do occur, a more limited group of organisms may be involved. Fungal slimes, for example, are sometimes encountered in such closed systems. Also, once-through cooling systems involve a limited group of organisms, rarely including algae, for example.

2. Identification

The more that is known about microorganisms (pest) and factors that influence microbial growth, the easier and more successful pest management becomes. When you identify a pest, you gain important biological information that influences management decisions. You can determine what type of controls are necessary, and what the elements or management program should be. Knowing a pest's life cycle may assist in selecting the pesticide treatment program and time of application.

Weather conditions and activities in the surrounding area can effect the population of organisms. For example, the growth of algae in cooling systems can be enhanced if the cooling tower is located near a bakery, candy plant or similar area where atmospheric conditions tend to foster rapid algae growth. Other factors to consider include the amount of sunlight and oxygen that is available. Each water treatment system and its problems must be considered individually.



3. Economic Significance

Control of a particular pest should be considered only when it is believed that health or economic damage will occur if it is not controlled. Remember that when dealing with microbial organisms a relatively small number of pests have a great potential for disease, product damage, or equipment shutdown (unlike in agriculture where a small number of pests may cause a limited, tolerable amount of damage). Normally, economics are the primary consideration used to determine when to control a pest, but with microbial populations the potential for diseases and mechanical problems must be recognized. Both disease potential and system maintenance become part of the two factors that affect the economic decision-making process. These are:

A. **Economic injury level:** the level of pest density at which the cost to manage the pest is equal to the losses that the pest causes.

B. **Economic threshold** or **action threshold:** the level or density of a pest population where management measures (action) are needed to prevent the pest from reaching the economic injury level.

Certainly if diseases were generated in your facility, or mechanical failures occurred, these would result in economic injury.

Pest management should be considered if economic damage will occur and the population is at or above the economic threshold. Keep in mind that when dealing with aquatic-microbial control the difference between the two levels may be very slight. This is why detection is so important. Realize that, in many cases, the economic threshold for microbial pests is zero.

Remember, when making a microbial pest management decision, consider the potential for disease, the cost of the product and its application, cost of running the cooling system, the possible adverse effect of the chemical on the mechanical system, such as corrosion, and the effect this treatment may have on the environment.

4. Method Selection

Once a microbial pest problem is identified, the biology of the pest understood, and the economic significance established, then the appropriate method or combination of methods can be selected to manage the pest in an effective, practical, economical and environmentally sound manner.

Proper selection requires that you be thoroughly familiar with all available management methods and that you fully evaluate the benefits and risks of each. When making a selection consider the type of water system equipment, the prior operating history of the equipment, the nature of the treatment programs being used to protect the system against corrosion and scale formation, and the cost. Consider the toxicity of your choice and whether something less toxic or nontoxic is an effective option.

5. Evaluation

It is extremely important to evaluate the results of your pest management program. This can be done in several ways such as monitoring pest populations or infection before and after treatment, comparative damage ratings, etc. Visual observation, chemical testing, and bacteria cultures may be used to monitor and evaluate the effectiveness of treatments.

Keeping records and knowing prior operating history of a water processing system serves as a guide to selection of pest management tactics including biocides. Records can show the extent to which biological growths have occurred and the type of biocides used, if any, and their effectiveness.

Records may also provide additional guidance. For example, if a cooling system serving an industrial plant leaks fluids from heat exchangers into the cooling system that provides nutrients for microorganisms, a selective biocide for a particular type of microorganism living on this source of nutrients may be required. It may also limit the biocide selection to types that do not chemically react with the products that leak into the cooling water. Lastly, evaluations and records are useful for overall equipment maintenance, i.e. correct the leak and prevent the potential for microbial growth.

Treatments for land-based pests can be evaluated by leaving untreated checks to use as a basis for comparison. In most microbial situations it is impossible to leave untreated checks. Therefore, it is important to continually evaluate the effectiveness of your treatments and overall program, and record the results from your observations and cultures for future reference.

Techniques Used in Pest Management

Natural and applied techniques are used to manage pests. Proper identification, knowledge of the pest's density, and understanding the environment that favors pest development allows applicators to choose the right method or any combination to manage the pest in the most economic manner.

1. Natural Controls

Natural controls are measures that check or destroy pests often without dependence upon humans for their continuance or success. In fact, humans cannot greatly influence these measures. Natural controls include:

- climatic factors such as wind, temperature, sunshine, and rain;

- topographic features such as rivers, lakes and hills;

- naturally-occurring predators, parasites, and pathogens. Humans can protect and encourage this particular type of natural control in some pest infested areas but not aquatic, microbial environments.

Wasp parasitizing an aphid.

Cooling towers, sewers, and pulp/paper processes are artificially designed and constructed. Therefore, most of the above natural controls do not influence the microbial populations found in these systems.

2. Applied Controls

Applied controls are controlled by humans. Their use is necessary when natural controls have not held harmful pests in check. Under applied control, we employ methods of mechanical and physical control, sanitation control, and chemical control in the treatment of aquatic-microbial pests.

Physical and mechanical controls prevent the spread or reduce the infestation of pests using physical or mechanical means.

Removable sunlight covers on distribution decks are used to minimize algae growth. (Winter photo shows snow on covers.)

An example of a physical control is the installation of sunlight covers on a cooling towers' distribution pans to prevent the growth of algae. Other examples include:

- Using screens and air filtering devices to keep insects, birds, and debris out of cooling towers;

- Locating towers away from air intake or discharge vents (in both of the earlier mentioned Legionella outbreaks the bacteria were introduced through the air intake vent);

- Locate towers with consideration to the prevailing wind and away from sources of debris; and

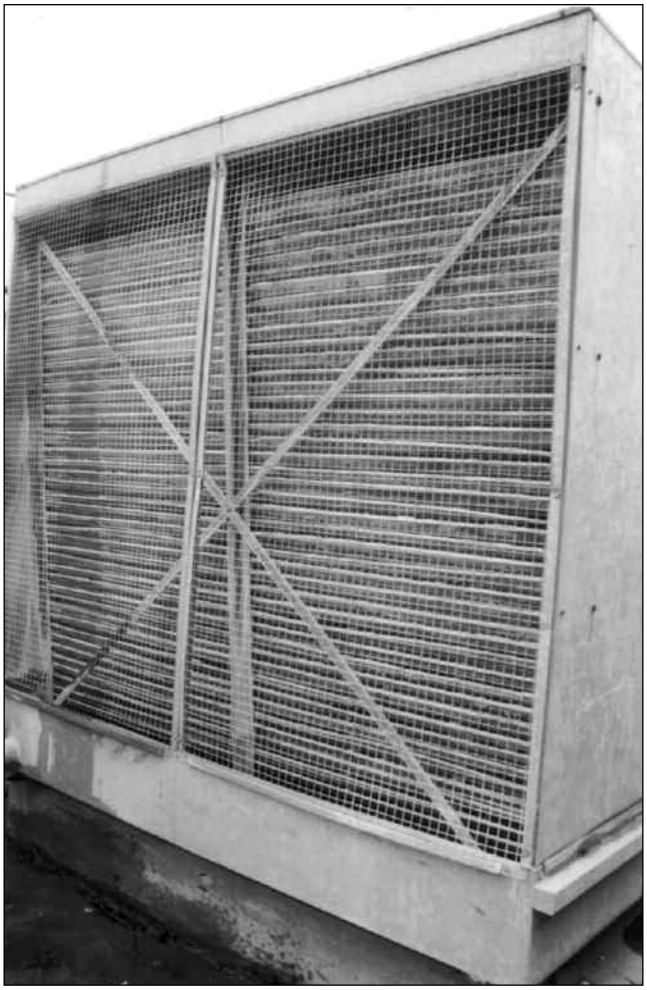
- Use side stream filters to remove dirt.

Fine feeder roots of trees often obstruct sewer systems. A mechanical means of control can be obtained by inserting a mechanical cutter into, and preferably through the clogged line. Limitations to this procedure are:

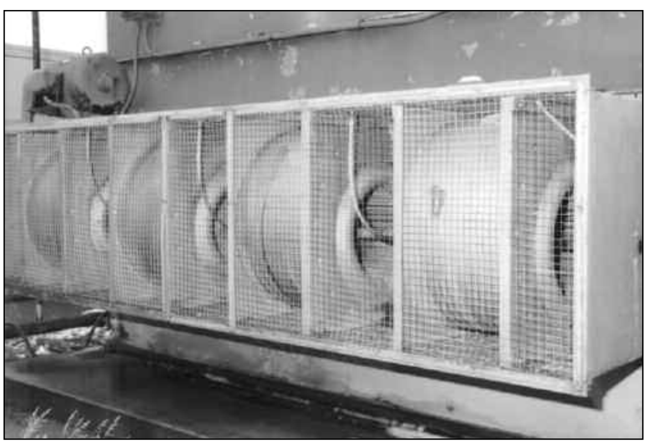
• Control is achieved principally near the service entrance to the sewer.

• Long cable runs require heavy equipment.

• Large roots are difficult to sever.



Screening on this induced draft tower system is a mechanical control measure used to prevent birds from nesting in the exhaust portion of the tower equipment.

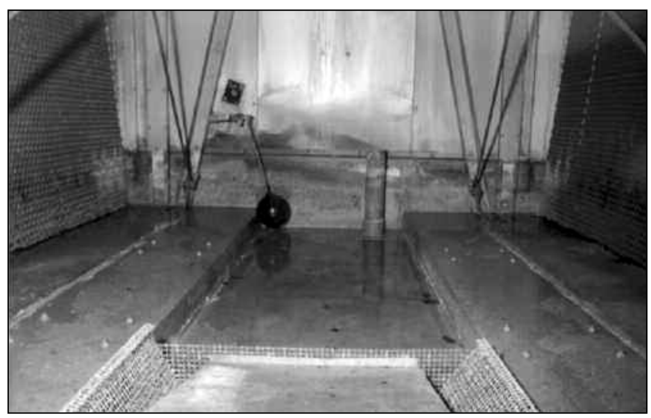


The fans on this forced draft tower are screened and strategically located with respect to prevailing winds and away from sources of debris.

The use of ultraviolet (UV) radiation to kill microbial organisms in some cooling or process systems is an example of mechanical control. UV radiation can kill vegetative cell bacteria, but not fungal and bacteria spores. UV radiation does not penetrate well and, therefore, may not kill microorganisms which are either in clumps or covered by dust and other debris.

Sanitation is an important aspect of pest control. Clean-up measures to remove and maintain sanitary conditions to prevent breeding sites and eliminate food supplies for pests is an effective and necessary means of control.

Cooling towers are air scrubbers. Because of the function and design of cooling towers, any and all of the debris in the air will be washed into the tower system. The use of filtering systems of many different types helps remove this debris while the tower is "on-line". Periodically the tower should be taken "off-line" and the basin or sump cleaned of debris. Removing debris eliminates a major source of food for microbial organisms that infest towers. It also removes the deposit layer that other organisms require for their development and spread. The sludge or deposits that accumulate may require the use of a shovel and wheel barrow for removal. The sump and/or basin area of cooling towers should be inspected monthly and thoroughly cleaned twice per year.



The interior basin area of cooling towers must be kept clean, requiring system shut down for thorough sanitation servicing.

When planning and designing a system, provide convenient access, hose connections, and drains for physical removal of algae and slime accumulations from cooling towers, and backflush connections for their removal from heat exchangers. This structural planning is important for systems in which there is a good chance for biological problems to develop, such as those in which sewage treatment plant effluent is used for makeup water.

Chemical controls include naturally derived or synthetic chemicals called pesticides which kill, repel, attract, sterilize, or otherwise interfere with normal behavior of pests. When dealing with pesticides, many of the chemicals will have the suffix "cide" or"cidal" that means to kill. Examples of biocides include:

Algaecides kill algae.

Bactericides kill bacteria (but not ordinarily bacteria spores).

Fungicides kill fungi (including yeast).

Slimecides kill slimes.

A related example would be sanitization (reducing the number of organisms to safe levels as determined by public health requirements) of potable water systems by using chlorine.

Biocides are typically used in an on-going microorganism management program. When biocides are used to clean-up severe infestations of algae or slime, manual cleaning may be necessary to remove the destroyed organisms from the system.

The following are other applied controls that are not effective for microbial management in towers, air washers, paper/pulp mills, or sewers. These tools and techniques are useful in other areas of pest management and should be understood by pesticide applicators.

Biological controls introduce, encourage, and artificially increase plants and animals that are parasites or predators of a pest. Biological controls are most commonly used to manage insects, mites and some weeds.

Cultural controls are routine management practices that prevent pests from developing. These may include maintaining a specific water flow rate through a processing system, rotating crops, tilling the soil, varying the planting time, destroying crop residues, and pruning, thinning, and fertilizing plants. These practices tend to disrupt the normal association between a pest and its host, making the environment less favorable for pest survival, growth, or reproduction.

Legal controls limit the development of pest populations by restricting human activities. This is done by a series of federal, state and local laws and regulations. Quarantines, inspections, embargoes, drinking water standards, compulsory plant or animal destruction, and similar actions are legal control measures.

Resistant varieties are plants and animals bred for their resistance to pests.

Review Questions - Introduction and Chapter 1 – Pests and Pest Management

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. Why do you have to be a certified applicator or registered technician?

   a. to protect you and the environment

   b. it's the law

   c. to buy restricted use pesticides

   d. to obtain a baseline knowledge of safe pesticide use

   e. all of the above

2. Any person who applies a general or restricted use pesticide in the course of his or her employment except for agricultural purposes, must be either a registered technician or certified applicator. (True or False)

3. Sunlight covers are an example of physical control of pests. (True or False)

4. What is Integrated Pest Management?

5. _________________________control would be demonstrated when a UV light is installed in a cooling system.

6. List five steps to consider in planning and implementing an effective Integrated Pest Management plan.

   1)
   2)
   3)
   4)
   5)

7. What is required to perform proper pest detection?

8. When the pest reaches the ________________, pest management procedures need to be applied to prevent the pest from reaching economically damaging populations, or the ________________.

9. How are "natural controls" different from "applied controls" as pest management methods?

10. List four methods of applied pest control and give an example of each.

CHAPTER 2

PEST IDENTIFICATION

Accurately identifying pests is extremely important because different pests respond to different types of management tactics. Failure to properly identify the pest may result in wasted time, money, chemicals and effort. Each species of plant and animal can be identified by its scientific name. Although most plants and animals also have common names, the scientific naming system is universal, assigning an organism one name to be used regardless of where it is found. This naming system categorizes organisms based on their similarities: organisms with common characteristics are placed into large groups, then subdivided into smaller groups, and finally given a name.

In this chapter you will learn to recognize some pests directly from their presence and the presence of other pests by the signs of their activity. In cooling systems, air washers and paper plant processes, the pests are frequently too small to be seen by the naked eye. However, the effects of the pests' activity can be readily observed.

Pest Detection

Many of the pests discussed here belong to the microbial world. These organisms are invisible to the naked eye, no matter what their population size. Other pests when found in large numbers, such as some algae, are easily seen without magnification.

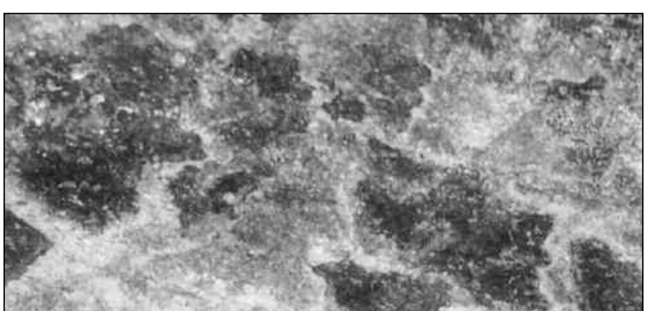
Of the microbial pests requiring magnification for identification, bacteria leave the most easily observed signs of their presence. The thick, sticky slime masses found in heat exchangers and various process equipment are usually signs of bacterial activity. The slime mass results from gelatinous excretion during the metabolic processes of certain bacteria.

Foul odor is another telltale sign of bacterial activity. In some process systems this can be so severe that entire buildings or parts of buildings must be shutdown because the stench causes workers to become ill. Here again, the presence of bacteria is indicated by indirect means.

Corrosion of process equipment is linked to or caused by microorganisms in certain cases. The link may be direct when the microorganisms produce acidic chemicals in their metabolic processes. In other cases the presence of slime or other deposits create conditions favorable for corrosion to occur but the microorganism is not directly involved.

The presence and in some cases the relative quantities of these pests can be confirmed in laboratory cultures with the use of growth studies.

These studies are useful, but don't place too much reliance on them. It is critical to understand exactly what is being grown. Figure 2-1 shows typical examples of a culture study.



Algae build-up and debris accumulation at bottom of sump.

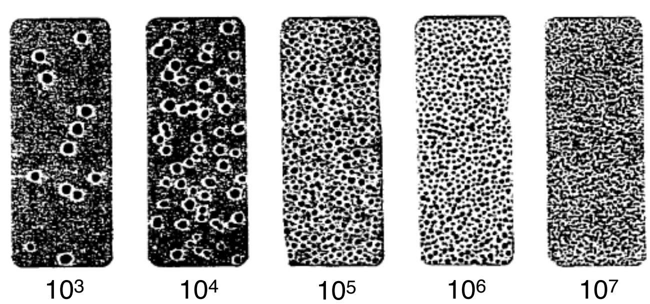


Figure 2-1. Typical density chart (Bacteria/ml). General guidelines consider bacterial counts of 10^4 as a light infection, 10^5 to 10^6 a moderate infection, and 10^6 or more as a heavy infection. (*Illustrations from brochure by Orion Diagnostica, Helsinki, Finland.*)

Microbial Pests

The pests normally encountered in cooling systems, air wash systems and paper mills fall into a number of separate groups. Each group is represented by a variety of species. To aid your understanding of these organisms they are covered in general terms only. Microbiological pests include viruses, bacteria, algae, mold, fungi, and slime associated with these organisms.

Viruses are obligate, intercellular parasites. This means they can only multiply in the cells of another organism (host). A virus' occurrence in a building's water system is limited to the times when other pests are in that same system.

Bacteria are single celled, microscopic organisms that lack chlorophyll. Bacteria are a diverse group. Cells may be rod-shaped, spiral, or spherical and may occur singly, in pairs, or in large groups. They reproduce by division. Different strains of bacteria are adapted to a wide range of environments, including temperature, pH, oxygen availability, etc. Some bacteria require air (aerobic bacteria) while others grow only in the absence of air (anaerobic bacteria). See Figure 2-2.

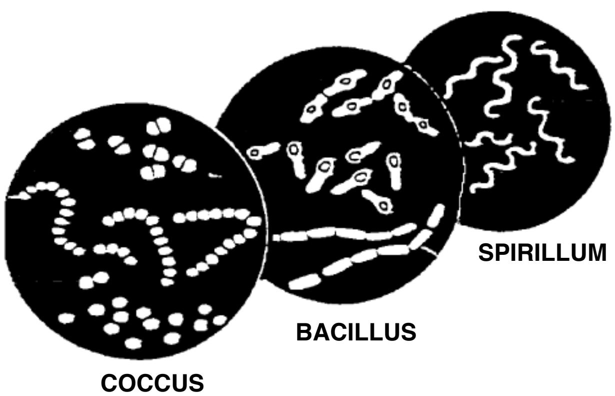


Figure 2-2. These are typical examples of the three groups of bacteria. ***Illustration from "Modern Biology," by T. J. Moon, J. H. Otto, and A. Towle, Henry Holt and Company, Inc. 1960.***

Legionella pneumophila and related organisms are small gram-negative bacilli which will not grow on ordinary unenriched media. Gram-negative bacteria are those which do not retain the primary dye of the gram stain procedure used for identifying bacteria types. There have been, thus far, approximately twenty species of Legionella described. Some of these are responsible for what is commonly known as Legionnaire's Disease.

Many of the problems found in water systems can be traced to the direct or indirect result of bacterial activity. Bacteria grow in any water that contains organic matter or certain inorganic compounds that serve as nutrients. Many of the bacteria surround their cells with slime deposits.

All cooling water bacteria will grow in a temperature range of 68 – 104^{o}F, and some species will grow in a broader temperature range of about 50 – 158^{o}F. The aerobic slime-forming bacteria normally require a pH range of 4 to 8 and favor about 7.4. Aerobic spore-forming bacteria have a slightly narrower pH range of 5 to 8.

Because microorganisms are so widely distributed in nature, some undoubtedly enter cooling systems with the makeup water. However, the bulk of bacteria found in open cooling water systems are scrubbed from the air that passes through the evaporative cooling device. The slimes developed from microorganisms also serve to bind other suspended matter, such as air-borne dirt, corrosion products, and scale. This sometimes has the effect of causing a rapid accumulation of deposits under circumstances where none would have formed had there not been some microbiological growths.

In a number of industrial processes, such as the extrusion of aluminum, cooling water becomes contaminated with lubricants or other organic materials used in the process. In other cases where the cooling water is used in the scrubbing of air discharged from a process, organic materials may be dissolved in it. Bacterial growth is frequently accelerated because of the presence of such organic materials and can then cause odors in a cooling tower as described above.

Algae are very simple plants without roots, leaves or stems that grow in aqueous environments. Algae contain chlorophyll, a green pigment, and produce their own food from water, air, and sunlight by a process known as photosynthesis. One celled algae are invisible to the naked eye but may form long strands of cells. The masses of algae which occur in improperly treated cooling systems are clearly visible.

Algae masses cause problems by directly inhibiting water flow and heat transfer. In all types of water cooling equipment algae have a habit of breaking away from surfaces of original growth, moving about in the water and then attaching to other surfaces where they grow and expand further. Algae may deposit in pipe lines to cause congestion and clogging. They may clog strainers and nozzles. On heat transfer surfaces algae can create an insulating effect impeding heat transfer, thereby reducing the efficiency of the equipment. Typically, algal growth appears on a cooling tower distribution tray, fill, screens, and drift eliminators.

Indirect effects of algae are corrosion of processing equipment and enhancement of the aquatic environment in a way that allows other microorganisms to flourish. Figure 2-3 on page 17 shows some common algae forms.

Most forms of algae can be grouped into four classifications based on their pigmentation or color. These groups are:

1. Green algae – green to yellow-green, colored by chlorophyll.
2. Blue-green algae – blue.
3. Diatoms – brown to light green, contain silica in their cell walls.
4. Pigmented flagellates – green to brown.

Most algae grow best in the pH range of 5.5 to 9.0. Green algae grow best in the temperature range of 86-95^{O}F; blue-green algae 95-105^{O}F; and diatoms at a range of 64-96^{O}F.

Fungi are saprophytes or parasites. They are a diverse group of plant-like microorganisms that, like algae, have no roots, stems or leaves, and require moisture and oxygen for growth. Because of their oxygen requirement they are generally found at or above the water line in a cooling system. Fungi differ from algae in that they contain no chlorophyll or other pigments. They are a pest of greatest concern in systems where wood is used as a material of construction or where the process involves wood and wood by-products. Cooling systems may develop either or both of the two groups of fungi: filamentous fungi or molds, and yeasts.

The filamentous fungi are made up of colorless groups of cells arranged end to end that reproduce by spores. The color of the molds is due to the black, gray, brown, tan, blue, green, or pink color of these spores. Molds are often found on the wood components of systems where they can cause surface rot or internal decay. The filamentous fungi generally grow in the pH range of 2 to 8, with 5.6 the optimum, and in a temperature range of 32-100^{O}F.

Yeasts require about the same conditions for growth as the filamentous fungi or molds. They are similar structurally to bacteria, but they are longer and reproduce by budding. They can produce leathery or rubbery growths which may be colored.

Slime formations consist of a gelatinous mass stemming from growth of a microorganism. Slime frequently contains physically or mechanically entrapped insoluble (will not dissolve in water) matter, organic or inorganics.

Slime and algae in cooling systems are sometimes mistakenly handled as though they were the same problem. This is not the case and can be shown by a simple management practice that is effective for one and not the other. Algae, which require sunlight for their growth, can often be easily prevented by installing an opaque cover on a cooling tower distribution basin which eliminates the algaes' energy source and prevents its development. This preventative action has no effect upon the formation of bacterial slimes in the system.

Problems Caused by Microorganisms in Industrial Water Processing Equipment.
Restrict Flow of Water
Retard Heat Transfer
Binder for Other Deposits
Corrosion
Attack Cooling Tower Wood
Potential Health Hazard
May Clog Nozzles and Strainers

Life Cycles of Microbes

The life cycles of viruses, bacteria, algae and fungi have similar phases of development. Each consists of four stages; lag phase, log phase, stationary phase and death phase. These phases are shown in Figure 2-4.

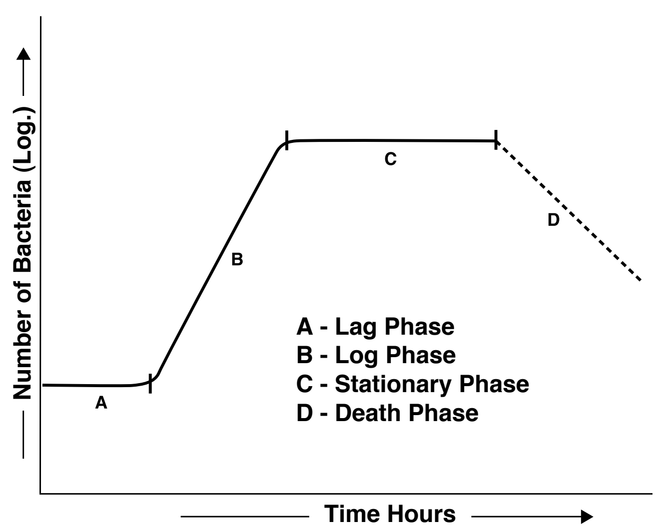


Figure 2-4. Typical growth curve of microorganisms.

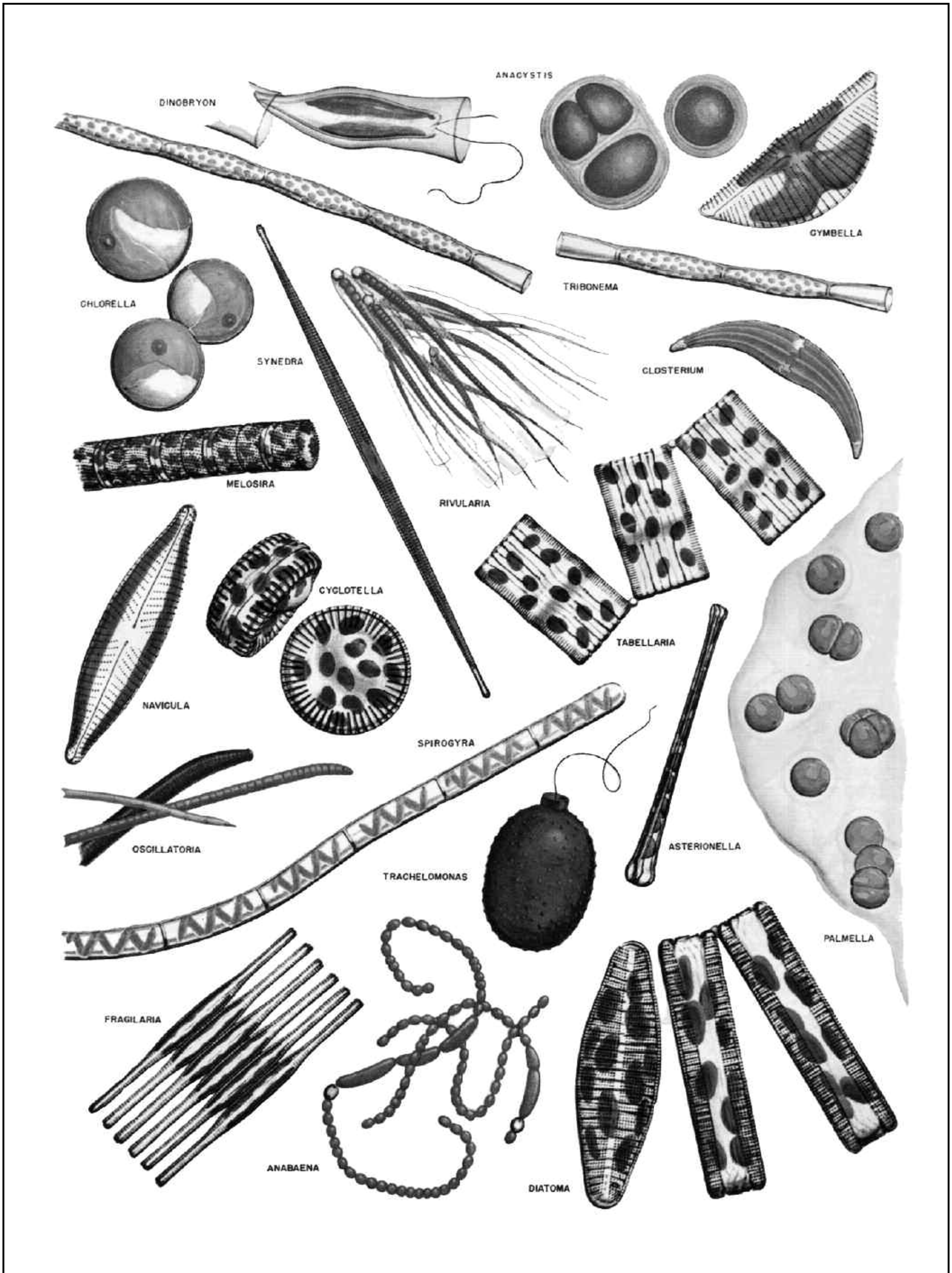


Figure 2-3. Algae, though among the simplest plants, are represented by a rich variety of forms.

During the lag phase, the number of organisms builds slowly until a critical number is reached. Once this critical number is reached, the organism begins the log phase. This stage is a rapid growth of the organism's population. The end of the log phase is a leveling off or stationary phase. If no new food is introduced, the stationary phase will change into the death phase.

If a new nutrient supply is made available, the growth pattern is marked by repeated log and stationary phases resulting in a continuous growth of organisms.

Other Pests

Invertebrate pests in water systems include protozoa, insects and mollusks. Protozoa are small, complex single-celled organisms capable of living in a wide variety of aquatic environments.

Insects are normally present in water processing systems only because they are caught in the water handling system during its operation although midges (true flies or Diptera in the family Chironomidae) may invade and establish themselves in water treatment facilities (both equipment and ponds) and in water storage and distribution systems. Midge larvae, often called bloodworms because some of them are red, may even pass through tap water. Adult midges may emerge in huge numbers from natural or manmade bodies of water and become nuisance pests due to their presence alone or because they clog equipment and soil property, or because the midge skin stimulates allergic reactions in some people. In such conditions, midges may need to be controlled in the water systems where the adults originate.

Larval (immature) midges are aquatic and inhabit the deep zones of the water where there is a sand or mud bottom. At the bottom of a water body, larvae feed on various organic materials, bacteria, and sedimenting algae. Midges are particularly tolerant of poorly oxygenated and polluted conditions and are common in wastewater lagoons.

Larval midges can be controlled through the use of insecticides or by physical modification of the habitats. In wastewater treatment ponds and lagoons, water may be drawn down to expose and strand the larvae. In water delivery systems, larval midge control is difficult. Although many kinds of animals (insects and fish) prey upon midge larvae, their use as biological control agents is limited and of little practical value in a water treatment system. Among the choices for midge control, insecticides directed against the larval stage will yield the most practical results. There are limited insecticides available for this type of application. Consult with a specialist and follow all label directions.

Mollusks are a group of aquatic animals with soft unsegmented bodies and are usually, but not always, enclosed in a shell. Snails and leeches are members of this group. Mollusks contribute to water processing equipment problems by restricting water flow in service lines and plugging flow in smaller lines. The widely publicized, exotic zebra mussel is a mollusk pest in Michigan.

Vertebrate pests include birds and rodents. They don't live in the water systems, but commonly die in the systems if they become trapped. Birds cause problems when droppings and nesting materials enter the water systems. Some rodents cause the same problems, but birds are usually the greater pest.

Occurrence of Pests

Occurrence of various pests in cooling systems, air wash systems and paper mill waters is widespread, though not universal.

Viruses are uncommon in all systems.

Bacteria are the most common and nearly universal in their occurrence.

Algae are common particularly in open recirculation cooling systems.

Fungi are found in systems using wood as a material of construction and in paper mill operations, as well as other operations using wood and wood by-products.Invertebrates can become trapped in many systems, but cause genuine problems mostly where water is drawn from lakes or streams through service lines.

The vertebrates contribute to problems of equipment operation, but only to a small degree.

Impacts of Pests

Pests directly or indirectly effect the efficiency and longevity of the mechanical systems in which they occur. In virtually every instance the impact of their presence is negative.

Bacteria frequently generate slime as a part of their metabolic process. This slime reduces water flow rates through the system and reduces heat transfer across the slime-covered boundary. In

Close-up of cooling tower fill where microbial growths can accumulate and reduce system efficiency.

addition, the slime can create an environment favorable for the development of additional pests.

In addition to the formation of deposits, bacteria frequently contribute to the corrosion process of equipment either directly or indirectly.

The products of metabolism of some bacteria are acidic and hence corrosive. In other cases the bacteria may breakdown the pipe's corrosion inhibiting coating, rendering the system unprotected.

Algae are largely responsible for the visible masses of material which can effect water flow through a system. In addition, algae may produce an environment encouraging the growth of other microbial pests.

The impact fungi has on water treatment systems includes the degradation of system components and, in the case of paper mills, the degradation of product quality.

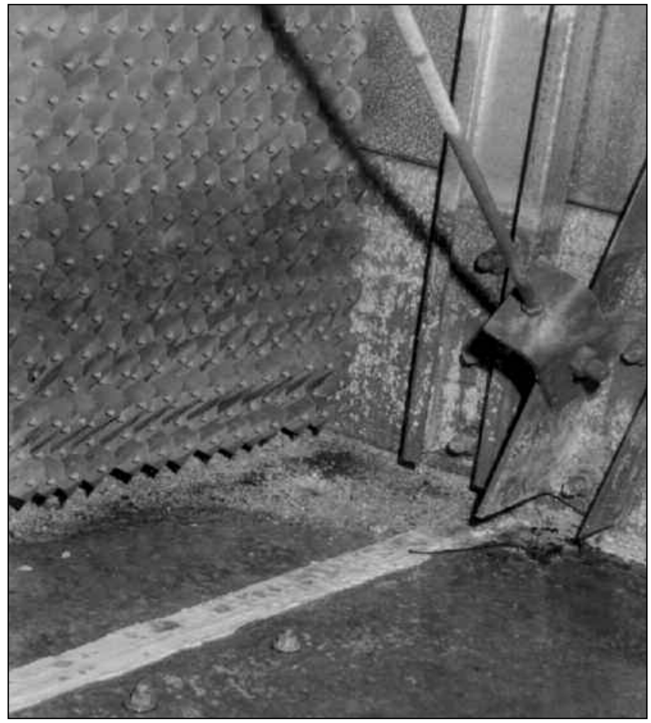
The impact of invertebrates includes the plugging of system water passages. Once plugged, various forms of corrosion can and do occur in these systems. Invertebrate pests can cause heat transfer to drop to zero in plugged areas.

Pest Management

As in other areas of pest control, an integrated approach using several methods is favored over reliance on simply using pesticides.Environmental control includes keeping the system water

- as clean as possible,
- moving at maximum rates consistent with system design,
- and free of particles which can settle to form deposits.

Areas of low flow and stagnant water are associated with the growth of many undesirable organisms, including those responsible for Legionnaire's Disease.



Basins of cooling tower equipment may have low water flow areas with surfaces favorable to microbial growth including the fill, concrete corners, structural supports and screening. Operate systems at the maximum flow rate of the equipment and routinely remove deposits.

Mechanical control of microbial pests includes shading cooling tower decks to reduce growth of green algae. Screening cooling tower decks and air washers to keep out bugs and birds are other methods of mechanical control. The best and most effective control is to maintain maximum allowable flow rates in the system. This reduces the number of places where undesirable microorganisms can grow.

Chemical management of microbial pests is done with chemicals called pesticides. Biocides are the specific group of pesticides used for managing microbial pests. Properly applying these products is discussed in detail elsewhere in this manual.

Review Questions - Chapter 2 – Pest Identification

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. Viruses are commonly found in cooling systems. (True or False)

2. Pest management is easier in clean, rapidly flowing water than in low-flow, stagnant water. (True or False)

3. Algae are the most common and widespread of the microbial pests. (True or False)

4. List three problems caused by microbial pests.

____

____

____

5. In practice, most water system pests are normally detected by:

a. direct observations
b. lab studies
c. observing their effects in the system

6. Water system pests:

a. act alone in the system.
b. frequently interact in the system.
c. frequently kill each other off in the system.

7. Being larger, vertebrate pests cause more damage in water systems than do the bacterial pests. (True or False)

8. The most wide-spread pest group is:

a. virus
b. algae
c. bacteria
d. fungi

9. The strong odor encountered in some water systems is usually caused by:

a. bacteria
b. fungi
c. chemicals

CHAPTER 3

PESTICIDES

Pesticides are substances or mixtures of substances intended to prevent, destroy, repel, or manage pests. In addition, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) has extended the legal definition of a pesticide to include compounds intended for use as plant growth regulators, defoliants, or desiccants, even though they are not normally used as pest management agents, nor are they usually effective as such.

A **pesticide** for our purposes may be defined as any chemical used to directly control pest populations or to prevent or reduce pest damage. In this manual we are concerned with managing microbial pests, and we normally use the term **biocide** to describe the class of pesticides used to manage them. Although the ending "cide" comes from the Latin word *cida*, meaning "to kill," not all biocides actually kill the target organism. For example, some products may simply inhibit the growth of a fungus (one type of microbial pest) without killing it.

Biocides are a mixed blessing. They significantly contribute to the cleanliness of cooling tower water and to improved public health by managing disease-carrying organisms. But biocides can adversely affect people, nontarget organisms such as fish and wildlife, and the environment if not used according to the label directions.

In this chapter you will learn how pesticides are classified, the types of formulations, compatibility complications, and some special concerns with pesticide use. This knowledge will help you use pesticides, or more specifically, biocides, safely and effectively.

Classifications

Pesticides are classified using a number of different methods. Each method serves specific purposes. The four most common methods of classifying pesticides are based on (1) the group of pests managed by the pesticide, (2) how the pesticide works, (3) the chemical nature of the pesticide, and (4) the pesticide formulation.

Method 1: Types of Pests Managed

This pesticide grouping system is as follows:

Pesticide Classification	Pest Managed
Algaecide	Algae
Bactericide	Bacteria
Biocide	Microbial organisms
Fungicide	Fungi
Herbicide	Weeds
Insecticide	Insects & other related animals
Microbiocide	Microbial organisms
Molluscicide	Slugs & snails
Nematicide	Nematodes
Rodenticide	Rodents
Slimeicide	Slimes

In the microbial pest management industry the terms biocide, microbiocide, bactericide, and algaecide are used interchangeably even though bactericide and algaecide represent the specific control of bacteria or algae. This manual uses the general term biocide. The term biocide represents the management of all microorganisms and does not specify or distinguish between bacteria, algae, fungi or slime.

As noted above, biocides are only a small functional part of the larger pesticide group of chemicals. The pesticides, or more specifically the biocides, and their use that are the primary subject of this manual include algaecides, bactericides and fungicides. A biocide that has the ability to kill or inhibit more than one type of organism, e.g. bacteria and algae, is considered a **broad spectrum** biocide.

These terms indicate that the intended target organisms are not necessarily the only organisms affected by the chemical used. For example, in very contaminated cooling tower water, single-celled animals called protozoa are sometimes found. Applying a bactericide may kill protozoa, algae, fungi as well as bacteria.

Other Pesticides	Function
Plant Growth Regulators	Modify normal plant processes
Defoliant	Remove unwanted plant growth
Desiccant	Kill plant foliage before harvest
Repellant	Divert a pest
Attractant	Lure a pest

Method 2: How Biocides Work

The way biocides react, or their "mode of action" is often unknown. However, listed below are several mechanisms which are believed to explain the way some biocides function:

1. Protein denaturation
2. Enzyme inhibition
3. Cell membrane disruption

Other types of pesticides may be grouped or classified based on their mode of action. For example:

Contacts – Pesticides that kill pests simply by contacting the pest.

Broad-spectrums – Pesticides that control two or more pests of a particular system.

Sterilants – Pesticides that manage pests by rendering them incapable of reproduction.

Systemics – Pesticides that are absorbed by one part of the organism and distributed internally to other parts, thereby affecting the entire organism, not just a spot that the pesticide came in contact with.

Fumigant – Pesticides which kill pests by giving off a toxic gaseous vapor.

Method 3: Biocide Chemistry

Biocides are often grouped based on their chemistry. It is common to distinguish two broad categories, oxidizing and non-oxidizing.

Oxidizing Biocides

Oxidizing biocides are characterized by their ability to oxidize, or "burn," biological matter (such as the cell membranes of microorganisms). Since they are indiscriminate in this action, oxidizing biocides are broad-spectrum. Examples of oxidizing biocides include halogens (chlorine and bromine), ozone, and halogen-releasing compounds.

When chlorine or bromine are added to water, they react with the water and form active hypochlorous acid or hypobromous acid, respectively. These hypochlorous (HOCl) and hypobromous (HOBr) acids are the active forms of the biocide compound. They attack many components of the microbial cell with their oxidizing power. The chemistry of bromine is similar in many respects to the chemistry of chlorine.

Since HOCl and HOBr are acids, they can be neutralized with alkaline materials and their effectiveness decreased. These acids are said to be pH sensitive. As the pH of the water increases (becomes more alkaline), the effectiveness of chlorine and bromine decreases.

The pH reading is a measure of the acidity-alkalinity relationship. The pH scale ranges from 1 to 14, with 7 being neutral. Anything with a numerical value less than 7 is said to be acidic and a numerical value greater than 7 is considered alkaline. A graph showing the effect of pH on the amount of hypochlorous acid (HOCl) is shown below.

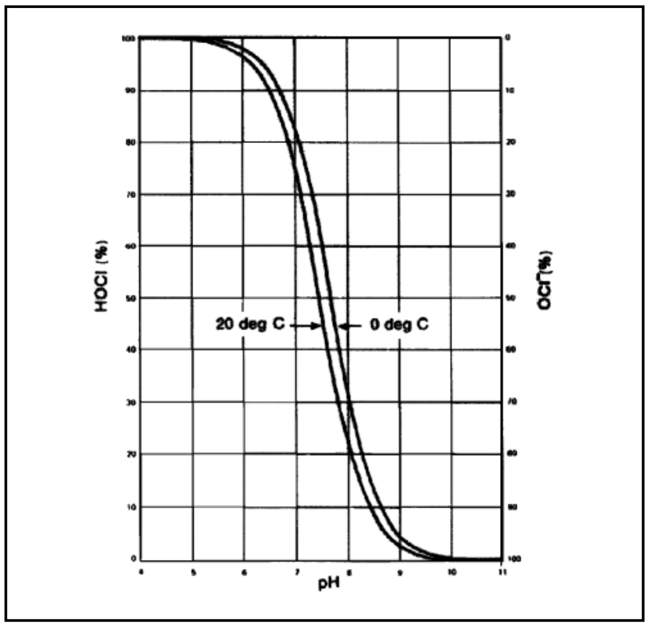


Figure 3-1. Relationship between HOCl, and OCl^-, and pH.

Chlorine and the chlorine-yielding compounds behave chemically in essentially the same way. When added to water they form a mixture of hypochlorous acid and hypochlorite ion. The microbiocidal effectiveness of chlorine and chlorine yielding compounds depends upon the proportion of hypochlorous acid present which, in turn, depends upon the pH of the treated water. Table 3.1 outlines the percent of active and inactive forms of HOCl and OCl- based on the pH of the treated water.

HOCl	H+	OCl-
Hypochlorous Acid (Killing Agent) **Active**, Unstable form	Hydrogen Ion	Hypochlorite Ion **Inactive**, Stable form
%Chlorine as HOCl	**pH**	**%Chlorine as OCl**
90	6.5	10
75	7.0	27
66	7.2	34
45	7.6	55
23	8.0	79
10	8.5	90

Table 3-1: Effect of pH on hypochlorous acid.

Chlorine can react with organic compounds, ammonia, and other materials present in waters so its microbiocidal activity depends upon the residual chlorine available after the chlorine demand of the water has been satisfied, rather than on the dosage of chlorine applied to the water. Chlorine also reacts with the components of wood so that concentrations in excess of one ppm can delignify (degrade) the tower wood, shortening the life of the equipment.

Chlorine in solution is relatively unstable. It can be decomposed by the action of ultraviolet light to which it is exposed in the top decks of cooling towers. Some of it is lost by volatilization each time that the water passes through the sprays or over the fill in a tower.

A thorough review of cooling water chlorination appears in G. C. White, *Handbook of Chlorination*, Chapter 9, "Chlorination of Cooling Water", pages 527-571, (Van Nostrand Reinhold Company, New York, 1972).

Chlorine, chlorine-yielding compounds, and other oxidizing biocides are effective for controlling virtually all cooling water microorganisms.

Non-Oxidizing Biocides

Non-oxidizing biocides can be subdivided into one of several categories including;

- quaternary ammonium compounds,
- organosulfurs,
- halogenated organics, or
- aldehydes.

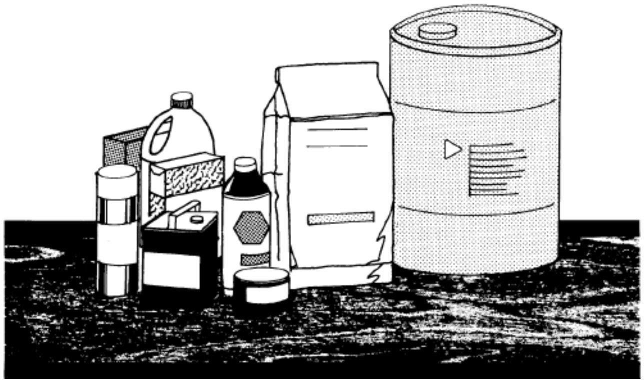
Many non-oxidizing biocides are broad-spectrum, as indicated on the label. The quaternary ammonium compounds represent one of the largest groups of non-oxidizing biocides used for cooling water treatment. They are generally effective in managing most algae and bacteria.

Quaternary ammonium compounds may be included in water treatment formulations as single compounds, as mixtures of several quaternaries, or as mixtures with other types of pesticides. Depending upon the structure of the quaternary ammonium compound, its effectiveness as a biocide can be reduced by the presence of specific materials in the cooling water, such as hardness, high dissolved solid concentration, or organic matter. Excessive dosages of most quaternary ammonium compounds can cause undesirable foaming in the cooling water.

A number of organosulfur compounds are in use, alone or in combination, in cooling tower biocide products. These are used primarily as bactericides.

Method 4: Pesticide Formulations

The component of a pesticide that controls the target pest is called the active ingredient (a.i.). Before a pesticide product is sold, active ingredients are mixed with liquid or dry inert ingredients (non-pesticidal). Although inert ingredients do not kill the pest, they may be capable of adverse environmental and human health effects. Mixtures of active and inert ingredients are called pesticide formulations, or, in our case, biocide formulations. Formulations make an active ingredient more convenient to handle; safer, easier, and more accurate to apply; and in some cases more attractive to the pest.



The active ingredient(s) is always indicated on the label with its percentage. The inert ingredients are usually not listed individually but the percentage total of inactive ingredients is given. Inert ingredients may include surfactants that

- emulsify the active ingredient,
- increase solubility of the active ingredient, and
- dissolve the active ingredient.

Pesticides come in a variety of formulations. The label of a pesticide product may use an abbreviation to describe the type formulation the chemical is in. Table 3-2 lists the types of pesticide formulations that are available on the market and the abbreviations used to describe them.

A = Aerosol
AF = Aqueous Flowable
A S = Aqueous Solution or Aqueous Suspension
B = Bait
C = Concentrate
CM = Concentrate Mixture
CG = Concentrate Granules
D = Dust
DF = Dry Flowables
DS = Soluble Dust
E = Emulsifiable Concentrate
EC = Emulsifiable Concentrate
F = Flowable
G = Granules
H/A = Harvest Aid
L = Flowable
LC = Liquid Concentrate or Low Concentrate
LV = Low Volatile
M = Microencapsulated
MTF = Multiple Temperature Formulation
P = Pellets
PS = Pellets
RTU = Ready to Use
S = Solution
SD = Soluble Dust
SG = Soluble Granule
SP = Soluble Powder
ULV = Ultra Low Volume
ULW = Ultra Low Weight or Ultra Low Wettable
WS = Water Soluble
WSG = Water-Soluble Granules
WSL = Water-Soluble Liquid
W = Wettable Powder
WDG = Water-Dispersible Granules
WP = Wettable Powder
WSP = Soluble Powder

Table 3-2: Abbreviations for formulations.

Formulations

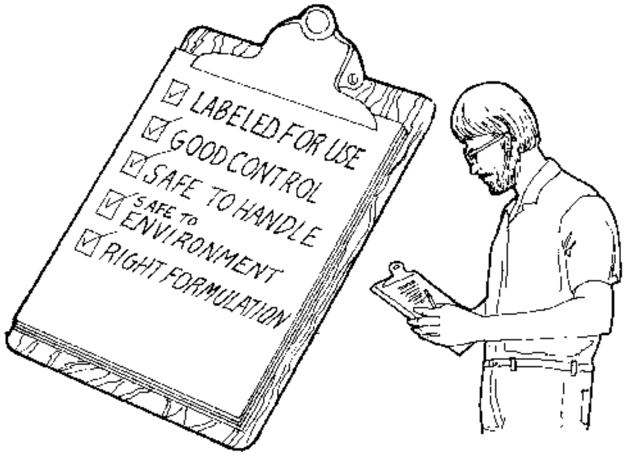
It is important to choose a biocide formulation that is best suited for a particular job based on its effectiveness, cost, practicality, and relative safety to you and the environment.

Dry Formulations

Dry formulations of pesticides are generally available in either granular or tablet form. Many of the tablets dissolve slowly and need special feeders to get them dissolved. This does have an environmental advantage in that only a controlled small dosage can go into the water at any one time. Probably the majority of dry formulations are chlorine or bromine releasing types. Powdered, water soluble biocides are available packaged in premeasured, water dissolvable bags that can be put into the sump of cooling towers without allowing the chemical to contact the applicator. Gloves should be worn when handling these products.

Liquid Formulations

Most biocides are liquids. In this industry liquids are considered more convenient to use than dry formulations. Some biocides are manually added to systems. Liquids can be pumped directly from the shipping container. Direct pumping and metering provides a safe and practical way of applying biocides, especially for larger systems and cooling towers located on building roofs. The applicator pump can be wired through a timer to allow for controlled dosages at specified intervals.



Dosage

The dosage of biocide used is based upon cleanliness of the system and whether an initial treatment or a maintenance treatment is intended. Dosages for each purpose are given on biocide labels. The initial dosage may be higher than a maintenance dosage. This is because the initial treatment is to reduce the existing count of microorganisms in the water to an acceptably low level, after which a lower dosage of biocide can be used to maintain this level. Use the lowest possible dose required to obtain the desired effect. This practice reduces the potential for a pest to build resistance to a specific chemical. Never use a higher rate than is recommended on the label.

Another critical factor in connection with the initial use of a biocide is the physical cleaning of the system to remove, as much as possible, existing deposits of microorganisms. The slime sheaths that many bacteria and fungi surround themselves with protect the organisms against contact with biocides. Therefore, when there is less accumulation of slimes and algae in a cooling water system, any given dose of biocide is more effective in reducing the total population of the organisms.

Frequency

The frequency of treatment, as well as the dosage, depends upon the microbiological population in the water system, the cost of treatment, other related equipment operating considerations, health concerns, and the action threshold as determined by users of the system. In once-through systems, the large volume of water flow may make continuous treatment very expensive. Therefore, chlorination or treatment with chlorine dioxide may be carried out for a half hour to an hour from one to four times daily. Treatments with other types of biocides in cooling towers may vary from as frequently as once a day to as little as once a month, depending upon the need as shown by standard plate counts of organisms in the water or by the appearance of slimes or algae at certain observation points in the system.

Biocide Adjuvants

An adjuvant or additive is a chemical added to a pesticide principally to increase its effectiveness, such as the stabilizer added to the dry chlorine-releasing formulation mentioned above. Other compounds might be included in a biocide formulation to increase the water solubility of the formulation. These compounds may be listed as one of the active ingredients, or considered part of the inert ingredients listed on the label.

These biocide adjuvants are already present in the formulation as purchased from a supplier. **No adjuvants or any chemicals should ever be added to a packaged biocide** unless specifically mentioned on the label. This may be allowed by some agricultural pesticide labels but seldom if ever allowed with biocides.

Biocide adjuvants, however, can be *separately* added to a system. The amount of biocide needed is often dependent on the cleanliness of a system. The cleaner the system the less biocide needed to obtain a desired result. Low molecular polymers and surfactants can be used to clean and disperse particles, allowing the biocide to reach the microorganisms. High molecular polymers have also been used to flocculate contaminants in a flowing system allowing the force of the water to push the flocculated material out of the system.

Compatibility

Never mix two concentrated formulations of biocides together. When an amount of biocide already exists in a very large volume of water, as in the case of a cooling tower system or a swimming pool, other chemicals may be added as long as significant dilution occurs and it is not prohibited by the biocide label. (In this case we may be talking about 1 gallon of biocide added to 10,000 gallons of water). In spite of these recommendations and precautions, compatibility problems may still occur among biocides and other chemicals that may be in the same system.

Physical Incompatibility With Other Biocides

A case of physical incompatibility may occur when two different biocides are pumped into a cooling tower and somewhere before the chemical actually enters the system, a common feed line is used. This is a typical example of how two concentrated chemicals might be mixed, commonly resulting in a plugged feed line.

Chemical Incompatibility

The practice of using one pail to transfer a biocide from a shipping container to the water system can lead to unexpected fireworks. Normally, two biocides are added one at a time to a water system. If the pail used for the transfer is not clean, the next biocide can react with the remains of the previous biocide in the pail. Depending on the biocides involved, explosions and fire can result. This most often occurs when a strong oxidizer, such as a chlorine-containing biocide, reacts with a readily oxidizable organic biocide. Designate different pails for different products and triple rinse the pails between uses and products.

By pumping and metering biocides directly from the shipping container into the system being treated, we reduce the risk of exposure and the incompatibility problem described above.

Timing Incompatibility

Microorganisms are most susceptible when they are actively growing and reproducing. Biocides should be added before the microbiological population overwhelms the system. Microorganisms increase their growth rate as water temperature rises. This means that an applicator must be alert to changing weather conditions, especially in the spring as temperatures go up. Monitor the water system more frequently during high temperatures.

Incompatibility With Corrosion and Scale Inhibitors

Incompatibility between two biocides is discussed previously, and it should not be surprising that incompatibility may also exist between a biocide and other chemicals in a system such as corrosion and scale inhibitors. Biocide formulations used in a particular cooling system must be compatible with these other treatments and with the materials of construction of the cooling water system itself.

For example, if the cooling water system is being treated with a corrosion and scale inhibitor program so that the circulating water has a pH of 8.0 or above, avoid using a biocide that has a very low efficiency or that decomposes in this pH range. Likewise, do not use an oxidizing biocide when one of the other treatment chemicals is readily oxidized. Technical sales representatives should inform you of any potential problems.

This has been a brief summary of the problems of biocide compatibility. Remember, you should never assume that biocides can be mixed together or mixed with another chemical unless the combination is specifically indicated on a product label.

Special Concerns Associated With Biocide Use

Careless biocide use can create microbiological resistance and may harm nontarget species. The following sections explain precautions applicators can take to avoid these problems.

Microbiological Resistance

Microbiological growth and reproduction can be very rapid. Biocides are therefore added to water systems frequently. Depending on the product, biocides may be added once every two weeks in colder weather and three times a week in hot weather in the case of cooling tower applications. Swimming pools require even more frequent applications. Thus, the faster the growth of the microorganisms, the more frequent the application of biocides and the greater the possibility for the microorganism population to develop resistance.

Cross and multiple resistance to some biocides are common. **Cross resistance** is when a microorganism develops resistance to two or more compounds that are usually chemically-related with a similar mode of action. (Mode of action is the chemical's way of exerting a toxic effect.) **Multiple resistance** occurs when a microorganism can tolerate biocides from different classes of compounds with unlike modes of action.

Reducing the problems of resistance involves using new or altered biocides, and changing the use patterns of biocides.

New or Altered Biocides. Single compounds or mixtures of compounds that have more than one mode of action are usually more difficult for the microorganism to develop resistance to than compounds that attack only one chemical site in or on the microorganism. New compounds with different modes of action will also lessen the likelihood of resistance development, at least for a time.

Biocide Use Patterns. Rotating the use of biocides with different modes of action limits the occurrence of pest resistance. When a biocide is added to a system, it is possible that 99.9% of the organisms are killed or inhibited. As time goes on, the few remaining microorganisms (which are the most resistant in the population) begin to multiply. The microbial population has the potential to become almost completely composed of organisms resistant to the product originally used. Avoid developing a resistant population by alternating the type of biocide and use biocides having different modes of action.

Dosage is also important in avoiding pest resistance. Use the lowest rate of biocide that will achieve the desired level of microbial control.

Managing pest resistance is a part of integrated pest management. Resistance must be understood, detected at low levels, and managed by using all of the available techniques to extend the useful life of our current biocides.

Hazard to Nontarget Organisms

Another problem associated with biocide use is potential injury to nontarget organisms. Take great care in selecting and using biocides to minimize injury to applicators and others who may come in contact with biocides. Take care to safeguard birds, fish and other wildlife and nontarget plants.

Consider potential hazards to nontarget organisms.

Information on biocides and their use is available on the label and by contacting the manufacturer's technical service representative or state regulatory agencies. These resources can provide the best information available on biocides, their potential adverse effects, and how to integrate a total pest management program.

Review Questions - Chapter 3 – Pesticides

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. A pesticide is a chemical that:

   a. manages only insects and vertebrates.
   b. directly controls pest populations.
   c. prevents or reduces pest damage.
   d. only a certified applicator may apply.
   e. b and c

2. List the four classification methods of pesticides and give an example of each.

3. Which of the following are pesticides?

   a. biocides
   b. bactericides
   c. insecticides
   d. herbicides
   e. all of the above

4. An algaecide is a biocide used to manage

   ________________________.

   A fungicide is a biocide used to manage

   ________________________.

   A bactericide is a biocide used to manage ________________________.

5. A biocide that controls more than one pest is called a ________________________biocide.

6. A bactericide will only kill bacteria. (True or False)

7. Give an example of an oxidizing biocide.

8. A quaternary ammonium salt (Quats) is a :

   a. oxidizing biocide
   b. non-oxidizing biocide

9. The two letter term that the describes the acidity-alkalinity relationship is______________ .

10. The component of the pesticide that controls the target pest is called the active ingredient (a.i.). (True or False)

11. Biocides may be available as:

   a. liquid formulations
   b. dry formulations
   c. tablet formulations
   d. all of the above
   e. a and b

12. You may add adjuvants to a biocide formulation even if it is prohibited on the label. (True or False)

13. A clean water system will generally require less biocide than a dirty system. (True or False)

14. Biocide incompatibility may occur with:

   a. other biocides
   b. scale and corrosion inhibitors
   c. chlorine containing compounds
   d. potentially any other chemical
   e. all of the above
   f. a and b only

15. List tactics that should be used for avoiding and managing microbiological resistance to a biocide.

CHAPTER 4

BIOCIDES AND THE ENVIRONMENT

As our population continues to grow, so do our demands for clean water and air and an environment that is not threatening to our health and safety. We have become increasingly concerned about the condition of our environment. We worry that the earth's natural resources are not only being depleted, but also becoming polluted and unfit for human use. As a result, many of the activities that we have taken for granted are now being carefully examined for potential damage to the environment. Pesticides are one group of chemicals being blamed for environmental abuse.

Pesticides include the biocides that are used to control pests in cooling towers, pulp and paper mills, evaporative condensers, and other water processing equipment. Cooling towers are used to remove heat from industrial processes, commercial and institutional buildings.

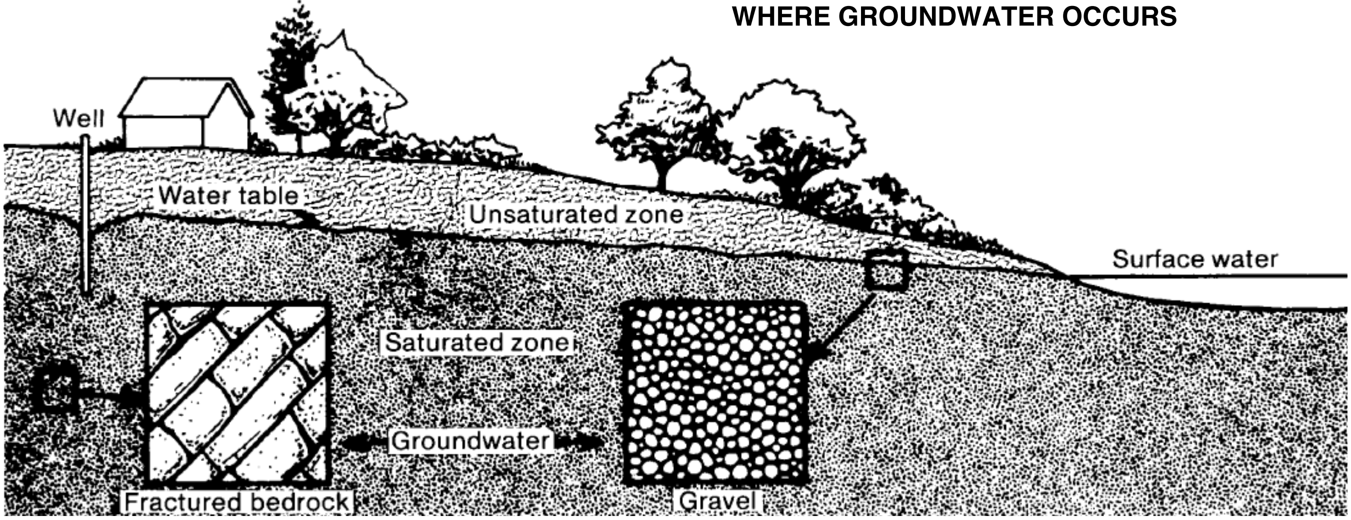
This chapter explores what happens to (fate) biocides after application. You will learn about groundwater and how it can be contaminated. We will discuss the effects of biocides on nontarget organisms and the environment. For our purposes, environment means all of our physical, chemical and biological surroundings such as climate, soil, water, and air and all species of plants, animals, and microorganisms.

Area of Concern for Contamination

Groundwater Contamination

Groundwater is the water found below the earth's surface occupying the saturated zone, that is, the area where all the pore spaces in the rock or soil are filled with water. It is stored in water-bearing geological formations known as **aquifers**. Groundwater moves through aquifers

WHERE GROUNDWATER OCCURS



and can be obtained at points of natural discharge such as springs or streams, or by drilling a well into the aquifer.

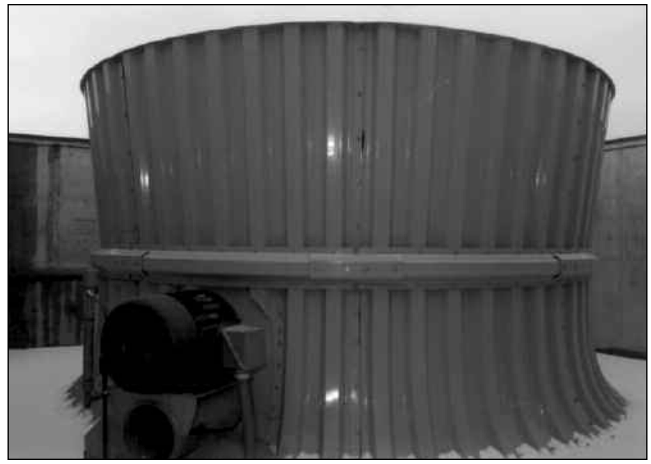
The upper level of the water-saturated zone in the ground is called the **water table.** The water table depth below the soil surface fluctuates throughout the year, depending on the amount of water removed from the ground and the amount of water added by recharge. **Recharge** is water that seeps through the soil from rain, melting snow, or irrigations.

Surface waters are visible bodies of water such as lakes, rivers, and oceans. Both surface water and groundwater can be contaminated by **non-point source pollution.** This type of pollution generally results from land runoff, precipitation, acid rain, or percolation rather than from a discharge at a specific, single location (such as a single pipe). Non-point source pollution occurs when the rate at which pollutant materials entering water bodies or groundwater exceeds natural levels. Contamination from discharge at a single location (such as a single discharge pipe from a factory) is **point source pollution.** A cooling tower is an example of a potential point source pollution.

Cooling tower operations provide the potential for chemicals used as water treatment additives to enter the environment. Biocides can escape the cooling tower equipment by evaporating and as drift. Evaporation is water loss from the circulating water into the atmosphere by the cooling process. Also, water containing biocides can be lost by drift; liquid droplets transported with the exhaust air.

Another way chemicals in cooling towers and boilers can enter the environment is through **blowdown**. Blowdown is the water discharged from the cooling tower or boiler system. Blowdown may also be called bleedoff. Reasons for blowdown procedures include controlling the concentration of salts and/or other impurities in the circulating water. Point source discharges, such as blowdown water discharged to drains, streams, rivers and lakes require a permit from the Water Resources Commission. The Michigan Water Resources Commission has the authority to issue permits for point source discharges under State Act 245 of 1929, and the Federal Clean Water Act. These types of permits are referred to as a National Pollutant Discharge Elimination System (NPDES) permit. The permits contain limits that must meet treatment technology and water quality-based requirements. If water from towers is discharged into sanitary sewer systems, the facility's operations must comply with Michigan Act 293 requirements. (Refer to Chapter 9, Pesticide Laws and Regulations.)

Biocides can be lost as drift from cooling tower equipment, as in this example through the exhaust fan located above the systems basin.



Exhaust tower on an induced draft cooling tower system.

Constraints continue to be imposed on the treatment of microbial organisms in water systems as a result of pollution control regulations and water conservation measures. The latter has led to operating systems at higher cycles of concentration which increases the concentration of nutrients in the circulating water, particularly in some industrial environments such as ammonia plants. At the same time, pollution control regulations limit the toxicity to aquatic life of any blowdown discharged to a river, lake, or surface water. Here we must face the paradoxical requirements for biocides: they must be toxic to the undesirable organisms in the cooling water, but also be non-toxic to organisms, large and small, that live in the water to which the blowdown is discharged. In some cases the receiving water of blowdown may be a biological wastewater treatment plant, in which case the biocide must kill undesirable bacteria in the tower but not be harmful to useful bacteria in the wastewater treatment process. The importance of considering the total cooling water system — water source, water and air conditions in the recirculation loop, and the system receiving the blowdown — when selecting and implementing a water treatment cannot be over emphasized.

The potential for groundwater pollution from improper agricultural and industrial practices is a significant concern. Pesticide residues, in particular, are receiving considerable national attention. The microbial pest management industry must use safe and environmentally sound practices to avoid contributing to contamination problems. Blowdown water needs to be managed appropriately so biocide residues do not enter the environment and harm non-target organisms.

Pesticide and Biocide Fate

As discussed in the last chapter, biocides are pesticides used for managing microbial organisms. It is important to understand the behavior of chemicals used as pesticides once they have been applied according to label directions. We will describe some of the processes that change or influence the availability, effectiveness, structure, or physical identity of chemicals used as pesticides.

When a pesticide is released into the environment it is affected by various processes. Sometimes these processes are beneficial. For example, pesticide degradation can remove nonessential biocide residues from the environment. The leaching of a root-absorbed herbicide into the root zone can enhance weed management. However, some processes can be detrimental. Runoff can move pesticides away from target sites and pests. As a result, chemical is wasted, control is reduced, and there is an increased chance of damage to nontarget plants, hazard to human health, and pollution of nearby soil and water.

Adsorption

Adsorption is the binding of chemicals to soil particles.(This term is sometimes confused with absorption. See the next section.) The amount and **persistence** of pesticide adsorption varies with pesticide properties, soil moisture content, soil acidity, and soil texture. Soils high in organic matter or clay are the most adsorptive; coarse, sandy soils that lack organic matter or clay are much less adsorptive.

Biocides are intended for application to water treatment systems, not as soil applications. Biocides may come in contact with soil when a water system is purged and the released water contains residual biocide concentrations. At this point, the soil environment will have an affect on the persistence of a biocide in the environment. As stated, discharge practices must follow Michigan Act 451, Part 87.

Absorption

Absorption is the process by which chemicals are taken up by plants, animals, humans, or microorganisms. Absorption is another process that can transfer biocides and other pesticides in the environment.

Volatilization

Volatilization occurs when a solid or liquid turns into a gas. Volatilization of chemicals increases with higher air temperature and air movement, higher temperature at the treated surface (soil, plant, etc.), low relative humidity, and when spray droplets are small.

A pesticide in a gaseous state can be carried away from a treated area by air currents; the movement of pesticide vapors in the atmosphere is called vapor drift. Unlike the drift of sprays and dusts that can sometimes be seen during an application, vapor drift is invisible.

Runoff

Runoff is a process that moves pesticides in water. Runoff occurs as water moves over a sloping surface, carrying pesticides either mixed in the water or bound to eroding soil. Runoff may occur after a spill, a poorly timed agricultural field or home lawn application followed by a heavy rain, or when a tower is blowndown to an inappropriate site.

Leaching

Leaching is another process that moves pesticides in water. In contrast to runoff, which occurs as water moves on the surface of the land, leaching occurs as water moves downward through the soil.

Microbial Degradation

Microbial degradation occurs when microorganisms such as fungi and bacteria use pesticides as food sources. One gram of soil may contain thousands of microbes. Microbial degradation can be rapid and thorough under soil conditions favoring microbial growth. Those conditions include warm temperatures, favorable pH levels, adequate soil moisture, aeration (oxygen), and fertility. The amount of adsorption of a pesticide to soil also influences microbial degradation. Adsorbed pesticides, because they are less available to some microorganisms, are more slowly degraded.

The microbial pest management industry views fungi, bacteria and other microorganisms in water treatment systems as pests. The biocides used in these systems are designed to kill microorganisms. Therefore, this category of pesticides, biocides, is not influenced as strongly by microbial degradation as are others, such as herbicides and insecticides. Microorganisms in a water treatment system are undesirable. Yet, microorganisms in the soil and other environments can be very beneficial, acting as chemical clean-up crews.

Chemical Degradation

Chemical degradation is the breakdown of pesticides by processes not involving a living organism. The adsorption of pesticides to soil, soil pH levels, soil temperature and moisture all influence the rate and type of chemical reactions that occur. Many pesticides, especially the organophosphate insecticides, are susceptible to degradation by hydrolysis in high pH (alkaline) soils or spray mixes. We also know that chlorine and bromine-based biocides are less effective or rendered ineffective at high pH levels.

Photodegradation

Photodegradation is the breakdown of pesticides by the action of sunlight. Pesticides applied to foliage, the soil surface, or structures vary considerably in their stability when exposed to natural light. Similar to other degradation processes, photodegradation reduces the amount of chemical present, which can subsequently reduce the level of pest control. Soil incorporation by mechanical methods during or after application, or by irrigation water or rainfall following application, can reduce pesticide exposure to sunlight. Biocides in a water treatment system have limited exposure to sunlight.

Techniques to Limit Pesticide Transfers in the Environment

It is very difficult to purify or clean groundwater that has become contaminated. Treatment is complicated, time consuming, expensive, and often not feasible. The best solution is to prevent the groundwater contamination problem. The following biocide applicator practices can reduce the potential for surface and groundwater contamination.

- Select Biocides Carefully-

Read labels carefully and consult your water service company or product supplier if necessary.

- Follow Label Directions-

The label carries crucial information about the proper dilution rate, timing and placement of biocides in a system. The label is the law. Follow all directions.

- Calibrate Accurately-

Calibrate equipment carefully and often. During the calibration procedure, check the equipment for leaks and malfunctions. Equipment can be calibrated with water instead of the chemical to be metered.

- Measure Accurately-

Concentrates need to be carefully measured before they are placed into the dilution tank. Do not “add a little extra” to ensure the biocide will do a better job. Such practices only increase the likelihood of personal injury, damage to equipment, cost, and the chance of contaminating groundwater.

- Avoid Back-Siphoning-

The end of the fill hose should remain above the water level in the dilution tank at all times to prevent back-siphoning of chemical into the water supply. This practice also reduces the likelihood of the hose becoming contaminated with a biocide.

- Avoid Spills—Clean Up Spills-

When spills occur, contain and clean them up quickly. Chemicals spilled near wells and sinkholes can move directly and rapidly into groundwater.

- Dispose of Wastes Properly-

All biocide wastes must be disposed of in accordance with local, state, and federal laws. Instructions for triple-rinsing and power-rinsing containers are included in the pesticide storage and disposal chapter. Pour rinsates into the water treatment system. Never pour unused pesticides or rinse water into drains, sewers, streams, or other places that will contaminate the environment.

Effects On Nontarget Organisms

Applying, handling or disposing of biocides carelessly can harm nontarget organisms that are beneficial to agriculture, our environment, and our existence. Consider what happens to the biocide once applied into a system and then where it ultimately ends up. What kind of fish, fowl and other organisms live where treated water is released? It is crucial that we know what can be safely applied and discharged and how to properly store and dispose of containers to protect these species.

Bees and Other Pollinators

Bees and other pollinating insects are essential for successful production of many crops such as deciduous tree fruits, small fruits, most seed crops and certain vegetables. Many pesticides, particularly insecticides, are highly toxic to pollinating honeybees and wild bees. Be aware of how bee poisoning can occur and how it can be prevented.

Fish and Other Wildlife

Pesticides can be harmful to all kinds of vertebrates. Direct effects from acute poisoning are the most recognizable impacts. Fish kills often are a direct result of water pollution by a pesticide. Pesticides can enter water via drift, surface runoff, soil erosion, leaching and, in some cases, deliberate or careless release of pesticide directly into the water. Fish kills are most often caused by insecticide contamination of small ponds or streams with low water volume or turnover.

Bird kills from pesticides can occur in a number of ways. Birds can ingest the toxicant in granules, or baits; they may be exposed to pesticide drift; they may consume contaminated water.

Environmental damage can be avoided when pesticides are used carefully, wisely and according to the instructions on the product label.

Review Questions - Chapter 4 – Pesticides and the Environment

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. The upper level of the water-saturated zone in the ground is called the ____________________.

2. Nonpoint source pollution occurs when the rate at which pollutant materials entering water bodies or groundwater exceeds natural levels. (True or False)

3. Name two ways pollutant can enter the environment from a cooling tower.

4. Biocides are not harmful to fish and wildlife. (True or False)

5. Name at least two ways biocides can be destroyed in a cooling tower circuit or the environment.

6. What is the best solution to groundwater contamination?

CHAPTER 5

PESTICIDES AND HUMAN HEALTH

Pesticides are generally toxic to living organisms. They are specifically designed to be toxic to those organisms we consider pests. However, living organisms share some basic features, and a substance that is toxic to one species may be harmful to another, including humans.

This chapter explains how pesticides enter the body, how to protect yourself from contamination, and how to perform first aid if contamination does occur. An explanation of terms will help clarify this information. The words toxicity and hazard often are interchangeably used when describing a pesticide's toxic effects. However, they are not the same. **Toxicity** is a measure of the capacity of the pesticide to cause injury. It is a property of the chemical itself and its concentration. **Hazard**, on the other hand, is the potential for injury. It reflects both the toxicity of the pesticide and the likelihood that significant exposure will occur in a particular situation. Pesticide applicators should be concerned with the hazards associated with exposure to the chemical and not exclusively with the toxicity of the chemical itself.

To avoid or minimize the hazards of pesticide use, know what you are using and how to use it. This means you must read the label carefully and follow the instructions. The attitude of the applicator is of utmost importance. If applicators mistakenly think they know exactly how to use a pesticide, or do not care about what precautions should be taken, accidents are more likely to occur. By taking adequate precautions and practicing good common sense with safety in mind, there should be few accidents from pesticide use.

Exposure: How Pesticides Enter the Body

To cause an adverse effect (including death), a pesticide must first enter the body and reach a susceptible site. Three common routes through which a pesticide can enter the human body are: the skin (dermal), the lungs (inhalation), and the mouth (oral).

Dermal Exposure

The skin is an important route of pesticide entry into the body. Dermal absorption may occur from a splash, spill, or drift when mixing, loading, applying, or disposing of pesticides. It may also result when cleaning or repairing contaminated equipment.

Even if only a small amount of chemical is allowed to remain on the skin and be absorbed into the body, a person can be poisoned. Different parts of the body vary in their abilities to absorb pesticides. The statistics in Table 5-1 were obtained from a study of volunteers and show that you should take special care to protect the scalp, ear canal and forehead. A hat with a wide brim helps to protect these three areas. Note that the scrotal area is 100% absorptive.

Anatomy	Percent Absorption*
Scalp	32.1
Ear Canal	46.5
Forehead	36.3
Forearm	8.6
Palm of Hand	11.8
Abdomen	18.4
Scrotum	100.0
Ball of Feet	13.5

*Parathion, an agricultural pesticide, was used in this study.

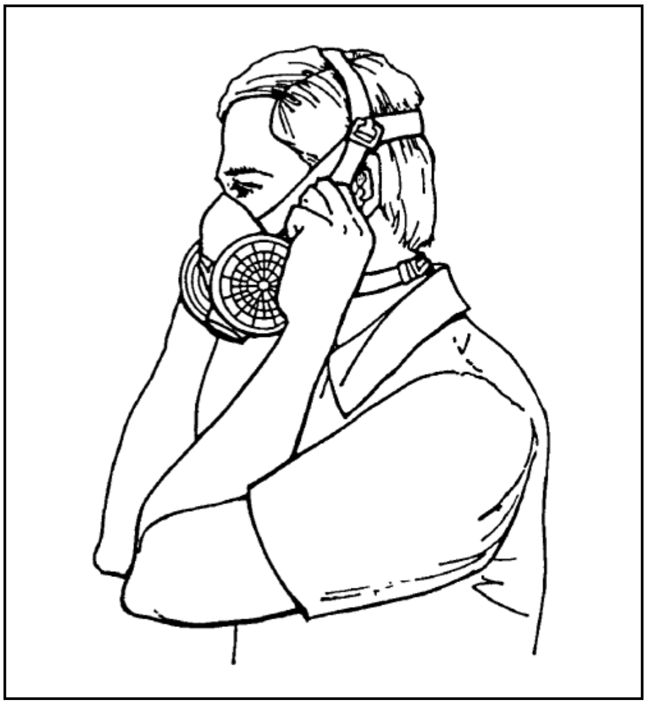
Table 5-1. Absorption rated of pesticides when left in contact with various parts of the body.

The scrotal area and the head tend to be more absorptive, although cuts, abrasions, and skin rashes can enhance absorption in other parts of the body. Pesticide formulations vary in their absorbency through skin. In general, solid pesticides are not as readily absorbed as are liquid formulations.

Under certain conditions and with certain pesticides, absorption through the eyes can be significant and particularly hazardous. Eyes are very sensitive to many pesticides and, considering their size, are able to absorb surprisingly large amounts of chemical. Serious eye exposure can result from a splash or spill, drift, or rubbing the eyes with contaminated hands or clothing. Avoid this type of exposure by wearing protective eye covering, especially when indicated on the label.

Inhalation Exposure

Protecting the lungs is especially important since pesticide powders, dusts, gases, vapors, or very small spray droplets can be inhaled during mixing, loading, or application, or when pesticides are applied in confined areas. Once breathed into the lungs, pesticides may enter the bloodstream rapidly and completely. If inhaled in sufficient amounts, pesticides may cause damage to nose, throat, and lung tissue. The label will indicate whether face masks or respirators are required when using specific pesticides.



Respirators help prevent inhalation exposure.

Oral Exposure

Accidental oral exposure occurs most frequently when pesticides have been taken from the original labeled container and put into an unlabeled bottle or food container. Unfortunately, children are the most common victims. Children under age ten are the victims of at least half of the accidental pesticide deaths in the United States. Keep pesticides in their original container.

Oral exposure also occurs when liquid concentrates splash into the mouth during handling. The mouth should never be used to clear a spray line or to begin siphoning a pesticide. Chemicals can also be swallowed when eating, drinking, or smoking, or even licking one's lips. Since many pesticides are rapidly and completely absorbed by the intestinal tract, it is sound advice to wash hands and face thoroughly before eating, drinking, or smoking. Do not eat and smoke while handling pesticides.

Toxicity and Potential Health Effects of Pesticides

The toxicity of a particular pesticide is determined by subjecting test animals (usually rats, mice, rabbits, and dogs) to different dosages of an active ingredient and to each of its formulated products. From these studies acute and chronic toxicity effects are determined, signal words are assigned and proper handling procedures are determined to reduce risk.

Acute Toxicity and Acute Effects

Acute toxicity is the capacity of a pesticide to cause injury from a single exposure. This is the most common type of pesticide poisoning.

Acute toxicity is determined by at least three methods:

1) dermal toxicity is determined by exposing the skin to the chemical;

2) inhalation toxicity is determined by permitting the test animals to breathe vapors, mists, or an atmosphere containing the dust of the chemical; and

3) oral toxicity is determined by feeding the chemical to test animals.

The harmful effects that occur from a single exposure by any route of entry are termed acute effects. In addition, the effect of the chemical as an irritant to the eyes and skin is examined under laboratory conditions.

Acute toxicity is usually expressed as LD50 (lethal dose 50) and LC50 (lethal concentration 50). This is the amount or concentration of a toxicant required to kill 50 percent of a test population of animals under a standard set of conditions. LD50 values of pesticides are recorded in milligrams of pesticide per kilogram of body weight of the test animal (mg/kg), or in parts per million (ppm). LC50 values of pesticides are recorded in milligrams of pesticide per volume of air or water (ppm). To put these units into perspective, 1 ppm can be compared to 1 inch in 16 miles or 1 minute in 2 years.

The LD50 and LC50 values are used to compare the toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD50 value of a pesticide, the less it takes to kill 50 percent of the population, and therefore the greater the acute toxicity of the chemical. Pesticides with high LD50 values are considered the least acutely toxic to humans when used according to the directions on the product label.

Acute toxicities are the basis for selecting the appropriate signal word (toxicity categories) to be used on a product label.

Signal Words

Signal words indicate the toxicity of a pesticide. Those pesticides that are classified as "highly toxic," on the basis of either acute oral, dermal, or inhalation toxicity, must have two signal words, **DANGER** and **POISON** (in red letters), and a skull and crossbones prominently displayed on the package label. **PELIGRO**, the Spanish word for danger, may also appear on the labels of highly toxic chemicals. Acute oral LD50 values for pesticide products in this group range from a trace to 50mg/kg. As little as a few drops of such a material taken orally could kill a 150-pound person.

Some pesticide products carry the signal word **DANGER** without the skull and crossbones symbol. This occurs when possible skin irritation or eye effects are more severe than suggested by the acute toxicity (LD50) of the product.

Pesticide products considered "moderately toxic" must have the signal word **WARNING** (and may have the Spanish equivalent **AVISO**) displayed on the product label. Acute oral LD50 values range from 50 to 500 mg/kg. From 1 teaspoonful to 1 ounce of this material could kill a 150-pound person.

Pesticide products classified as either "slightly toxic or relatively nontoxic" are required to have the signal word **CAUTION** on the pesticide label. Acute oral LD50 values are greater than 500 mg/kg.

Chronic Toxicity and Chronic Effects

Chronic toxicity is the ability of a pesticide to cause injury from repeated, prolonged exposure. A number of pesticides cause this type of effect. Chronic toxicity is very dangerous because pesticide applicators may not realize anything is wrong until the injury has progressed. Applicators should remember that the absence of any immediate effect is not necessarily an indication of no exposure or safe use. The chronic toxicity of a pesticide is determined by subjecting test animals to long term exposure of an active ingredient. The harmful effects that occur from repeated doses over a period of time are termed **chronic effects**. Some possible chronic effects from exposure to certain pesticides include birth defects (teratogenesis); toxicity to a fetus (fetotoxic effects); production of tumors (oncogenesis), either benign (non-cancerous) or malignant (cancerous or carcinogenesis); genetic changes (mutagenesis); blood disorders (hemotoxic effects); nerve disorders (neurotoxic effects); and reproductive effects. Pesticides are required to include chronic toxicity warning statements on the product label if effects may occur. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than the acute toxicity.

Because of the variety of effects that pesticides can cause and the amount of time it might take for the effects to appear, it is prudent to reduce exposure as much as possible to all pesticides. When effects do occur, treatments are generally available but prevention is much preferable to treatment, especially since some of the effects are irreversible.

First Aid for Pesticide Poisoning

Most pesticide poisonings result from careless use, improper storage or ignorance. By law, everything you need to know to apply pesticides safely is on the pesticide label. Therefore, the most important rules to follow when using pesticides are to **read and follow the instructions and precautions on the label**. Read the label before buying the product, opening the container, mixing or applying the solution and before disposing of unused product or empty containers.

Symptoms and Signs of Pesticide Poisoning

Biocides. Biocides are designed to be toxic to microscopic organisms. Human exposure to toxic levels results in a variety of general symptoms and signs of poisoning. These vary with the biocide, the amount absorbed, and the general health condition of the individual. Some of the most common symptoms and signs are:

• **When a substance is touched:** skin irritation (drying and cracking), skin discoloration (reddening or yellowing), itching, or a burn.

• **When the substance is inhaled:** burning sinuses, throat and lungs, accompanied by coughing, hoarseness and upper respiratory congestion.

• **When the substance is ingested:** mouth and throat irritation, chest pains, nausea (stomach ache), diarrhea, muscle twitching, sweating, headache and weakness.

Symptoms can begin immediately upon exposure or may be delayed for several hours or even days.

Insecticides. Symptoms differ with various insecticides, but all are dependent on both the amount and timing of exposure.

Insecticides of most concern are the organophosphates and carbamates which inhibit **cholinesterase**, a chemical critical for normal functioning of the nervous system. Symptoms may begin almost immediately after exposure to a direct cholinesterase inhibitor. Symptoms may be delayed several hours. Onset of symptoms more than 12 hours after exposure generally excludes organophosphate or carbamate insecticide poisoning, unless it is chronic poisoning from small repeated exposures.

The most commonly reported symptoms, which often appear in progression and depend, in part, on whether the chemical was touched, inhaled or ingested, are:

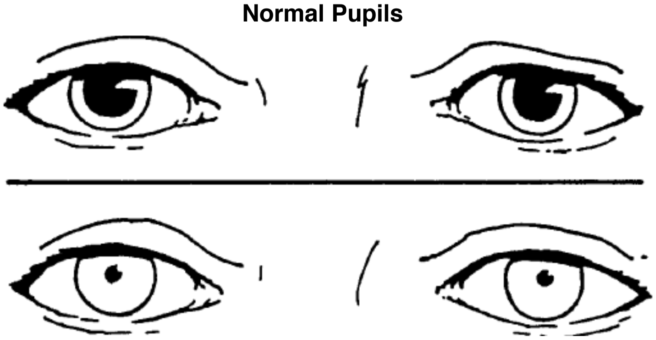
• headache,

• visual disturbances (blurred vision),

• pupillary abnormalities (primarily pin-point pupils, but on rare occasions, dilated pupils), and

• greatly increased secretions such as sweating, salivation, tearing and respiratory secretions.

Normal Pupils



Constricted (pinpoint) pupils

More severe poisonings results in nausea and vomiting, pulmonary edema (the air spaces in the lungs begin to fill with fluid), changes in heart rate, muscle weakness, respiratory paralysis, mental confusion, convulsions or coma and death.

Cholinesterase Tests

Cholinesterase tests are used only for cholinesterase-inhibiting insecticides: organophosphates and carbamates. Urine and blood analysis, together with symptoms, are used to diagnose most pesticide exposures and poisonings.

If you work with organophosphate or carbamate insecticides for an extended time (farmers, pesticide applicators, pesticide manufacturers, formulators) you should establish a regular cholinesterase test program with your doctor. For an applicator, such a program might consist of one (initial) cholinesterase test to determine a "base line level." This test should be made "off season" (January or February). Then, when insecticides are used during the summer, similar tests are conducted and the results are compared with the base line level. Through this testing procedure, you can learn of any changes in cholinesterase levels when you are exposed to pesticides. When cholinesterase levels are low, your doctor may advise you to limit or possibly stop your exposure to these pesticides until the cholinesterase level returns to normal. For more information, contact your doctor or the state health department.

First Aid Instructions

When working with pesticides, it is always best to work with someone. Arranging to have someone with you may sometimes be inconvenient and it may seem like an unnecessary precaution—until something happens.

If you are with someone who is exposed to a pesticide, immediately begin first aid treatment yourself or assist the victim in any way you can. Be careful not to contaminate yourself. If there is any need to seek medical help, call a doctor or take the victim directly to a doctor. **Take the pesticide label or labeled container with you.**

First aid treatment varies according to the type of exposure. Become thoroughly familiar with all of the appropriate procedures. Learn them ahead of time; you probably won't have the time to look them up if you ever need them.

Dermal Exposure

• Observe the manufacturer's recommendations for first aid. In addition, and if the situation demands:

• Remove clothing, if it has been contaminated.

• Drench skin with water.

• Wash thoroughly, including hair if necessary; detergents and commercial cleansers are better than soap.

• Rinse thoroughly using lots of soap and water.

• Wash again and rinse.

• Dry and wrap the person in a blanket.

• Where chemical burns of the skin have occurred, cover loosely with a clean, soft cloth after rinsing with plenty of fresh water. Avoid using ointments, greases, powders, and other medications.

Inhalation Exposure

• Observe the manufacturer's recommendations for first aid. In addition, and if the situation demands:

• Get fresh air immediately.

• If you are with someone who has been poisoned, move the victim to fresh air immediately.

• Do not attempt to rescue someone who has been poisoned in an enclosed area if you do not have the proper respiratory equipment.

• Loosen all tight clothing.

• If breathing has stopped or is irregular, give mouth-to-mouth resuscitation.

• Victim should remain as quiet as possible.

• Prevent chilling (wrap in blankets, but do not overheat).

• If you are with a victim who is having convulsions, watch his breathing and protect him from falling and striking his head. Keep his chin up so the air passages will remain free for breathing. Do not put anything in his mouth.

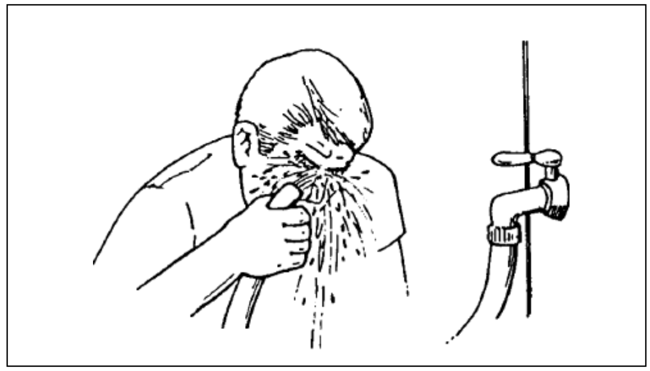
• Do **not** give the victim alcohol in any form.

Eye Exposure

Observe the manufacturer's recommendations for first aid. In addition, and if the situation demands:

• Hold eyelids open and wash eyes with a gentle stream of clean running water. **Use large amounts of water immediately; a delay of even a few seconds greatly increases the possibility of injury.** Continue washing for 15 minutes or more.

• Do **no**t use medications in the wash water—use pure water.



Use clean water to gently flush pesticides from the eyes for at least 15 minutes.

Oral Exposure

Observe the manufacturer's recommendations for first aid. In addition, and if the situation demands:

• If a pesticide has gotten into your mouth, but has not been swallowed, rinse your mouth with large amounts of water.

• If the pesticide has been swallowed, the most important consideration is whether or not to induce vomiting; the decision must be made quickly and correctly. Where specific instructions are given, always follow label directions. Beyond that, never induce vomiting if:

(1) the victim is unconscious or is having convulsions; or

(2) the pesticide is **corrosive.** A corrosive substance is any material, such as a strong acid or alkali (base), which causes chemical destruction of living tissues. Poisoning symptoms include severe pain and a burning sensation in the mouth or throat.

In attempting to induce vomiting, it is important to use safe and effective procedures. If vomiting should be induced, use two tablespoons (one ounce) of Syrup of Ipecac for an **adult** (this can be obtained from your pharmacist without a prescription) and two glasses of water. Induce vomiting in a child with one tablespoon (one-half ounce) of Syrup of Ipecac and one glass of water.

If Syrup of Ipecac is not available, induce vomiting by drinking one or two glasses of water and then touching the back of the throat with your finger. **Do not use salt water to induce vomiting.**

• The victim should be lying face down or kneeling forward while retching or vomiting, to prevent vomit from entering the lungs and causing further damage.

• Collect some of the vomit for the doctor; it may be needed for chemical tests.

• **Do not waste time attempting to induce vomiting; get to a hospital as soon as possible.**

Where the label identifies specific antidotes, this information is intended for use by a doctor. Do not administer antidotes except under the direction of a physician or other medical personnel. Taken improperly, antidotes can do more harm than the pesticide itself.

The name, address, and telephone number of the physician, clinic, or hospital emergency room that will provide care in the event of a pesticide poisoning should be clearly posted at all work sites.

Safety: Protect Yourself From Pesticides

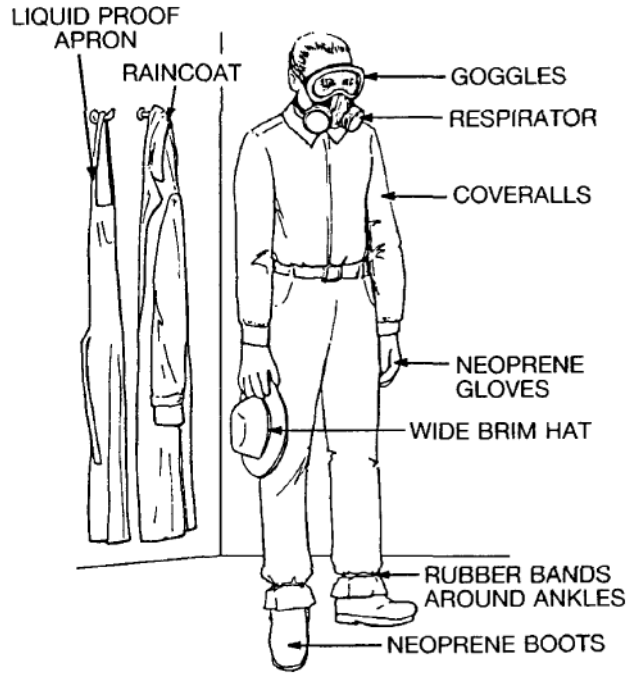
The greatest risk to the pesticide applicator occurs during mixing and loading of pesticide concentrates. Although applying diluted material is usually less hazardous, the hazard is increased when there is significant drift or when appropriate safety and application procedures are not followed. The danger of exposure also exists when cleaning up pesticide spills, making equipment repairs, and entering treated areas prematurely.

Personal protective equipment (PPE) is clothing and devices that are worn to protect the human body from contact with pesticides or pesticide residues. Personal protective equipment includes such items as coveralls or protective suits, footwear, gloves, aprons, respirators, eyewear, and headgear. Remember:

Risk = Toxicity x Exposure

To reduce risk, choose pesticides with lower toxicity and reduce exposure by wearing PPE. Pesticide labeling lists the minimum personal protective equipment you must wear while handling the pesticide. Sometimes the labeling lists different requirements for different activities.

What follows is a brief discussion of the various types of personal protective clothing and equipment, and review some important considerations for their selection and use.



Clothing

At a minimum, protective clothing should include a long-sleeved shirt and long trousers that are clean and made of a tightly woven fabric or a water repellent material. A T-shirt and shorts are not adequate protection when handling pesticides. Common denim provides better protection than more loosely woven fabrics. Specific items of protective clothing are described in the following sections.

Choosing Chemical-Resistant Materials

Always read the pesticide labeling to see what materials are resistant to the pesticide product. CES, pesticide producers, or personal protective equipment manufacturers and distributors may also offer guidance. Refer to the MSDS sheets to obtain information that may help in the selection process.

Remember all PPE has a limited life (length of time it will adequately provide protection). Protection, durability and longevity differ between materials. How they are used, length of time, and the type of chemicals to which they are exposed affect their performance. Replace your PPE frequently.

Neoprene, nitrile, polyvinyl chloride (PVC), and butyl rubber are chemical-resistant materials available in various thicknesses as gloves, coveralls, hoods, boots and other PPE. Each vary in the ability to withstand chemical permeation. Select the material that best suits your particular needs. Latex rubber has natural pores and holes and is not recommended for protection against chemical exposure.

Coveralls, Aprons, Raincoats

Coveralls, whether disposable or reusable, vary in their comfort, durability, and the degree of protection provided. Coveralls should be made of sturdy material such as cotton, polyester, a cotton-synthetic blend, denim, or a non-woven fabric. A liquid-proof apron or raincoat (or rainsuit) should be worn when pouring and mixing concentrates and when using highly toxic pesticides since coveralls usually do not provide adequate protection against spills and splashes of these chemicals. Wear a rainsuit whenever mist or spray drift are likely to substantially wet the work clothes or coveralls. Liquid-proof aprons and rainsuits should be made of rubber or a synthetic material resistant to the solvents in pesticide formulations. The apron should cover the body from the chest to the boots.

Gloves

Wear unlined, chemical-resistant gloves when handling or applying pesticides. Gloves should be long enough to cover the wrist and should not have a fabric wristband. Check gloves carefully to be sure there are no holes—fill them with water and squeeze. Each exposure to a pesticide reduces the gloves ability to protect you the next time they are worn. Gloves are intended to be disposable. Replace them often. Be certain gloves are approved for use with chemicals, i.e., for some fumigant products, do not use rubber gloves. Some rubber products react with certain solvents and become sticky as the rubber dissolves. If this occurs, dispose of the gloves and use gloves approved for use with the specific pesticide. For most jobs, wear shirt sleeves outside of the gloves to keep pesticides from running down the sleeves into the gloves. But if you are working with your hands and arms overhead, put the gloves outside of the sleeves and turn up the cuff of the gloves to catch material that might run down your arms. Wash chemicals off the gloves with soap and water before removing them. This avoids contamination of your hands when removing the gloves.

Hats

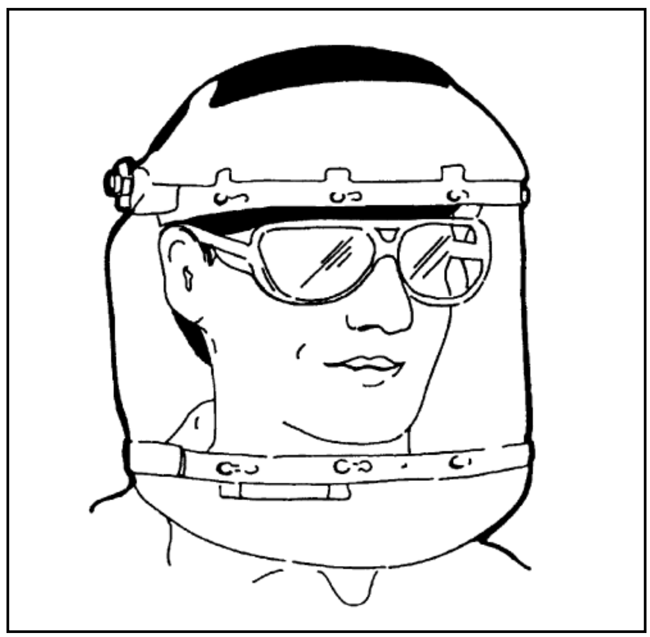
Wear head covering when handling pesticides. It should be liquid-proof and have a wide brim to protect the face, ears and neck. Hats should be either disposable or easy to clean with soap and water; they should not contain any absorbent materials such as leather, straw, or cloth. **Baseball hats do not provide adequate protection.**

Shoes and Boots

Boots should be unlined and made of rubber. Because of their absorbency, never wear boots of leather, canvas, or cloth when handling pesticides. Wear trouser legs outside the boots to prevent pesticides from running down the leg and into the boot. Wash your boots after each use. Replace them after repeated chemical exposure and wear.

Goggles and Face Shields

Wear tight fitting, non-fogging goggles, or a full-face shield when there is any chance of getting pesticide in your eyes. This is especially important when pouring or mixing concentrates or handling dusts or toxic sprays. Those who wear contact lenses may want to consult an eye doctor or physician before using pesticides.



Goggles provide a secure shield around the entire eye area, protecting against hazards coming from many directions. Wear goggles with indirect ventilation when exposed to splash hazards. Face shields that are cupped inward toward your throat give better protection than straight face shields. Goggles and face shields should be kept clean at all times. Wash them with soap and water, and sanitize by soaking equipment for two minutes in a mixture of 2 tablespoons chlorine bleach in a gallon of water. Rinse thoroughly with a clean cloth and allow to air dry. In particular, pay attention to the goggle headbands. They are often made of absorbent materials that require regular replacement.

Respirators

For many toxic chemicals, the respiratory (breathing) system is the quickest and most direct route of entry into the circulatory system. From the blood capillaries of the lungs, the toxic substances are rapidly transported throughout the body. Respiratory protective devices vary in design, use, and protective capability. In selecting a respiratory protective device, first consider the degree of hazard associated with breathing the toxic substance, and then understand the specific uses and limitations of the available equipment. Select a respirator that is designed for the intended use, and always follow the manufacturer's instructions concerning the use and maintenance of your respirators for different chemicals or groups of chemicals. Select only equipment approved by the National Institute of Occupational Safety and Health (NIOSH), and the Mine Safety and Health Administration (MSHA). The NIOSH approval numbers begin with the letters TC.

You can check the fit of a respirator by placing your hands over the cartridges, inhaling and holding your breath. The respirator should collapse and stay collapsed on your face. Also, check the information provided by the cartridge manufacturer to determine when the respirator cartridges will expire. Be aware that beards and other facial hair keep the respirator from sealing around your face and therefore make the respirator useless.

After each use of the respirator, remove all mechanical and chemical filters. Wash and sanitize the face-piece using the same procedure recommended for goggles. Store the respirator face-piece, cartridges, canisters, and mechanical filters in a clean, dry place, preferably in a tightly sealed plastic bag. Do not store your respirator with pesticides or other agricultural chemicals.

Laundering Pesticide-Contaminated Clothing

Wash all protective clothing and equipment at the end of each day of use. Store and wash pesticide contaminated clothing separately from the family laundry. Remember to wear gloves during these handling and laundering steps and be sure to check the label for any specific instructions. Note: Discard clothing that has become saturated with a concentrate.

Some residues may be removed by hosing the contaminated clothing with water or presoaking it in an appropriate container. Washing in hot water removes more pesticide from the clothing than washing in lower water temperatures. The hotter the better; cold water might save energy but it is relatively ineffective in removing pesticides from clothing.

Laundry detergents, whether phosphate, carbonate, or heavy-duty liquids are similarly effective in removing most pesticides from fabric. However, heavy-duty liquid detergents typically have better oil removing ability and therefore are more effective than other detergents in removing emulsifiable concentrates. The ease of pesticide removal through laundering does not depend on toxicity, but on the formulation of the pesticide. **Bleach or ammonia may possibly help remove or break down certain pesticides, but never mix bleach and ammonia because they react to form chlorine gas which can be fatal for those who inhale it.**

Wash clothing at the full water level. After washing, it is important to rinse the washing machine with an "empty load," using hot water and the same detergent. Line drying clothing is recommended for two reasons. First, it eliminates the possibility of residues collecting in the dryer; second, residues of many pesticides will break down when exposed to sunlight. Wash hands and arms after the laundering procedure. Keep protective clothing separate from the pesticide storage area.

Personal Care After Application

After cleaning application equipment and protective clothing, personal cleanup is next. In particular, wash your hands and face thoroughly with soap and hot water before eating, drinking, or smoking. Shower and change clothing as soon as possible. Be sure to scrub your scalp, neck, behind your ears, and under your nails.

Review Questions - Chapter 5 - Pesticides and Human Health

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. What is the difference between toxicity and hazard?

2. The scalp, ear canal and forehead are especially vulnerable to dermal exposure to pesticides. (True or False)

   What could you wear to protect these areas?

3. Pesticide residues are absorbed through the skin at relatively the same rate on different parts of the body. (True or False)

4. ________________ are the most common victims of oral pesticide exposure.

5. Give an example of pesticide inhalation exposure and oral exposure.

6. ___________________toxicity is from repeated exposures to a pesticide over a period of time.

   ___________________toxicity is from one exposure to a pesticide or other chemical.

7. Which LD50 is representative of a highly toxic pesticide?

   a. 640 mg/kg
   b. 5,800 mg/kg
   c. 12,840 mg/kg
   d. 380 mg/kg
   e. 46 mg/kg

8. The signal word on a pesticide label indicates the pesticide's

   a. effectiveness
   b. toxicity
   c. compatibility
   d. formulation
   e. ability to cause tumors

9. Which signal word(s) would indicate the product is least toxic to an applicator?

   a. DANGER
   b. CAUTION
   c. WARNING
   d. DANGER-POISON
   e. Skull and Crossbones

10. Where can the applicator find information he or she needs to know to apply pesticides safely?

11. Insecticides of most concern are the ____and. ____________________________________which inhibit cholinesterase.

12. ______________________________ is a human body's chemical that's critical for normal functioning of the nervous system and may be inhibited by some insecticides.

13. Who should receive regular cholinesterase testing?

14. What pesticide-related document should you take with you when you take a pesticide-poisoned victim to the doctor?

15. List the first aid measures you should perform when someone has been dermally exposed to pesticides.

16. Never induce vomiting in a pesticide-poisoning victim if:

a. the victim is a child
b. the victim is unconscious or is having convulsions
c. the pesticide involved is corrosive
d. all of the above
e. b and c only

17. List the first aid measures you should perform when someone has inhaled a pesticide.

18. To reduce the risk of human pesticide poisoning, the applicator should choose pesticides which have lower ________________ and reduce ________________.

19. A T-shirt, shorts, and baseball hat provide adequate protection when applying pesticides. (True or False)

20. Gloves and boots worn when handling most pesticides should be made of:

a. canvas
b. leather
c.. lined rubber
d. unlined rubber
e. none of the above

21. How frequently should protective clothing be laundered?

22. Pesticide contaminated clothing should be washed separately from the family laundry in hot water with laundry detergent. (True or False)

CHAPTER 6

PESTICIDE HANDLING, STORAGE AND DISPOSAL

There is always danger of exposure whenever handling pesticides. The greatest risk to the applicator is in handling and applying highly toxic materials and in using concentrated pesticides. Therefore, the applicator must use safety measures and also be familiar with what action to take in the event of a spill, leak or fire. Study the safety precautions described in this chapter and use them when handling, applying, transporting, and storing pesticides. You will find that most precautions are common sense.

Handle Pesticides Safely

Opening pesticide containers, connecting application equipment, or transferring pesticides to another container for application all result in the possibility of exposure. Here are some general safety guidelines for these procedures.

• Review the label before opening the container so that you are familiar with current directions.

• Always wear adequate protective clothing and equipment. Put them on before handling or opening a pesticide container. Remember that a respirator or appropriate form of eye protection should be worn if there is any chance of pesticide inhalation or eye exposure. Never eat, drink, or smoke while handling pesticides.

• Carefully choose the pesticide handling area. It should be outside, away from other people, livestock and pets. Pesticides should not be used in areas where a spill or overflow could get into a water supply. If you must work indoors or at night, be sure there is adequate ventilation and light. Have a supply of clean water and soap available. Hydrated lime and bleach can be used to neutralize and cleanup surfaces where spills occur. Clay, cat box filler, activated charcoal, or similar material is also helpful to soak up spills or leaks. If possible, do not work alone.

• Do not tear paper containers to open them; use a sharp knife or scissors.

• When pouring from a container, keep the container at or below eye level and avoid splashing or spilling on your face or protective clothing.

• Never use your mouth to siphon a pesticide from a container.

• Always stand upwind, or so the wind does not blow the pesticide or vapors toward your body.

• If an accident occurs, attend to it immediately. Remove any contaminated clothing and wash yourself thoroughly with soap and water. Take care of any spills on the floor or ground.

• Measure accurately; follow label instructions and use only the amount necessary. Newer measuring devices such as "tip and pours" are a great help in handling small amounts of concentrated pesticide. Keep all measuring devices (spoons, cups, scales) in the pesticide storage area, and label them to avoid their use for other purposes. Rinse measuring cups and put the rinsewater into the system being treated.

• Triple rinse pesticide containers (if applicable) as soon as they are emptied because residues can become dried and difficult to remove later. Pour the rinsewater into the system being treated to avoid disposal problems and wasting product. Replace container caps, and close bags. Return them to the pesticide storage area.

• Equipment should be operational and calibrated before filling and using. Oil, grease and chemical residues can cause incompatibility problems. For your own safety when filling a piece of equipment, always place yourself so that you can see when the pesticide is nearing the top of the tank. However, do not put your head where an accidental splash may reach you. As much as possible, avoid spilling or splashing when filling the system. If two or more pesticides are to be mixed, they must be compatible and mixed in the proper order: wettable powders, flowables, water solubles and emulsifiable concentrates. Small quantities of wettable powders often mix easier if a slurry is made first.

• When adding the additional water to a spray mixture, the water pipe or hose should remain above the level of the mixture, never contacting it. This prevents contamination of the hose and avoids the possibility of back-siphoning the pesticide into the water source.

Keep in mind that water characteristics influence the effectiveness of some pesticides. Alkaline water, for example, leads to chemical breakdown of many biocides, organophosphates and carbamates. The recommended water pH for mixing most pesticides is between 5.0 and 7.0. Buffers and acidifying agents can be used to adjust the pH of the water. Never leave equipment unattended while it is being filled.

Mini-Bulk Containers

Mini-bulk containers range in volumes of 40 to 600 gallons and may provide container and application safety advantages. Most of them are adapted to closed systems which allows the applicator to attach the mini-bulk tank to the sprayer without exposure to the chemical. Typically a pump and drive unit delivers the product, while a meter allows accurate measuring from the mini-bulk to the applicator's sprayer. The mini-bulks are returned for refilling or for a deposit. This process eliminates the applicator's need to triple- or power-rinse multiple, small containers and reduces the volume of plastic going to landfills.

Store Pesticides Safely

Proper pesticide storage helps prolong chemical shelf-life while protecting the health of people, animals, and the environment. A number of conditions are essential for safe pesticide storage. Consult the pesticide product label for specific storage information. Other storage guidelines are presented in the following sections.

Storage Area

Keep all pesticides out of the reach of children, pets, livestock, and irresponsible people. Store pesticides in a locked, secure place, such as a separate building or storage room. Around the home, the same rule applies—lock them up. A storage area should be located where water damage is unlikely to occur. Soil and land surface characteristics should be considered when constructing a storage facility to prevent contamination of surface or groundwater by drainage, runoff, or leaching. In certain situations, dikes may be warranted. For pesticide storage outdoors, erect a fence to prevent unauthorized entry and reduce the chance of theft and vandalism. In addition:

• Post highly visible warning signs on walls, doors, and windows to indicate to anyone attempting to enter the facility that pesticides are stored there. Also post "No Smoking" signs.

• Store pesticides in an area away from food, feed, potable water supplies, veterinary supplies, seeds and protective equipment. This prevents contamination from fumes, dusts, or spills, and reduces the likelihood of accidental human or animal exposure.

• Ventilate the storage area and keep it relatively free from temperature extremes. Very high or low temperatures can cause pesticide deterioration. Exhaust fans directed to the outside reduce the temperature and dust or fume concentrations. Fireproof construction with a sealed cement floor is the best.

• Keep pesticides cool, dry, and out of direct sunlight.

• Keep plenty of soap and water available in or close to the storage area. A fire extinguisher approved for chemical fires, first aid equipment and emergency telephone numbers should all be readily available.

• Store volatile biocides separately to avoid possible cross contamination of other products.

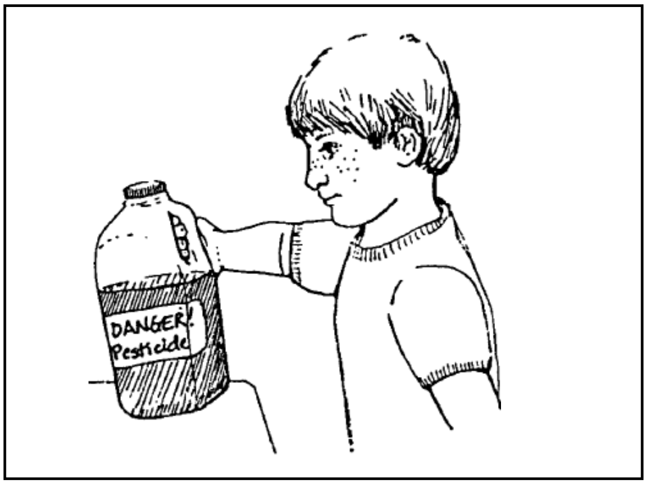
Pesticide Containers

Store pesticides in their original containers rather than using soda-pop bottles, fruit jars, or other types of non-pesticide containers. Serious poisonings could result because small children as well as most adults associate the shape of a container with its contents.

Keep the original label attached to the container. To keep a label legible, protect it with transparent tape or lacquer. Remember, the label is the most important safety factor in the use of pesticides; do not let it become damaged or destroyed.

Never lend a pesticide in an unmarked or unlabeled container. Those who use the pesticide should not rely on verbal directions. Close containers securely when not in use. Dry formulations tend to cake when wet or subjected to high humidity. Opened bags of wettable and soluble powders, dust, and granules can be placed into sealable plastic bags or other suitable containers. This reduces moisture absorption by the material and prevents spills should a tear or break occur.

Store liquid formulations and small containers of dry formulations on metal shelving. Metal shelving does not absorb spilled pesticides and is easier to clean than other surfaces. Store pesticides in the original containers, under cool conditions, on lower shelves. Too much heat can cause the container to break or explode. Containers should not extend beyond shelving where they could be bumped or knocked off. Place larger metal drums and nonmetallic containers on pallets.



Never store pesticides in food or beverage containers. They may be swallowed accidentally.

Check containers regularly for leaks, breaks, rust, and corrosion. If a leak or break occurs, place the container inside another container, or transfer the contents to an empty container which originally held the same material and has the same label attached.

Shelf Life of Pesticides

Keep an inventory of all pesticides in storage and mark each container with the purchase date. If a product has an effective shelf life recorded on the label, you will know how long the product should remain usable. If there are doubts concerning the shelf life of a pesticide, call the dealer or manufacturer. Pesticide deterioration may be apparent during mixing: excessive clumping, poor suspension, layering, or abnormal coloration. Sometimes, however, pesticide deterioration from age or poor storage conditions is apparent only after application. Poor pest control or damage to the treated crop or surface can occur.

To minimize storage problems, buy only as much as you anticipate needing for the season; recommendations may change by next season. Keep records of previous usage to make good estimates of future needs.

Reporting Requirements

Title III of the federal Superfund Amendments and Reauthorization Act of 1986 (SARA) is also called the Emergency Planning and Community Right-to-Know Act. This Act requires, among other things, the reporting of inventories of certain pesticides if the amount stored is greater than a "threshold planning quantity" (see Chapter 9, Pesticide Regulations). It is good policy to inform your local fire department if you store chemicals (including fertilizers). Chemical fires cannot usually be extinguished by ordinary means, and the smoke from the fire can be extremely hazardous to fire fighters. The fire department must be properly prepared in the event of a chemical fire. For more information on these requirements, see Michigan State University Extension Bulletin E-2575 or contact the MDNRE Title III Office at (517) 373-8481.

Dispose of Pesticides Safely

It is the responsibility of the pesticide user to see that pesticide wastes, such as unused chemicals and empty pesticide containers, are disposed of properly. In recent years there has been growing concern that improper disposal of pesticide wastes can create serious hazards for both humans and the environment. Empty pesticide containers are a hazard to curious children and animals. Improperly disposed of pesticides can result in groundwater contamination and plant damage.

It makes good business sense to deal with pesticide wastes properly and safely. Plan carefully and observe the following guidelines:

- Avoid disposal problems associated with excess pesticide by purchasing only the amount needed for one application or one series of applications needed to manage a given pest problem.
- Always read the label for disposal instructions.
- Clothing and protective equipment to be discarded, and contaminated soil or other materials used to clean up spills, should be considered pesticide waste and handled as such.
- Federal and state laws regulate the disposal of containers and other pesticide wastes. Anyone requiring assistance with pesticide disposal should contact the Michigan Department of Natural Resources and Environment Waste Management and Hazardous Materials Division at (517) 335-2690.

Cleaning and Disposing of Containers

Triple rinsing or high pressure rinsing (power rinsing) allows glass, metal, plastic, and even some heavy paper containers to be considered nonhazardous waste. It also saves money because each rinse captures pesticide residues from the sides and bottom of the container that are included in the spray mix and not wasted.

Properly rinse pesticide containers at the time they are emptied because residues can become dried and difficult to remove later.

To **triple rinse,** wear protective clothing and follow these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.

2. Fill approximately 10 percent of the container volume with water, replace the lid, and rotate the container so all the interior surfaces are rinsed.

3. Dump the rinsewater into the spray tank or water treatment system, allowing it to drain for at least 30 seconds.

4. Repeat the procedure two more times.

Power-rinsing is an effective way to make a pesticide container nonhazardous. Power-rinsing requires the use of a special nozzle that directs high-pressure water into the container. Check with your local agricultural chemical dealer for availability. Studies have indicated that power-rinsing may be up to 300 percent more effective than triple-rinsing and can take less time.

To power-rinse, wear protective clothing, especially gloves and goggles or face shield, and follow these steps:

1. Allow the concentrate to drain from the empty pesticide container for 30 seconds.

2. Push the pointed pressure-rinse nozzle through the bottom of the pesticide container while holding it over the spray tank or water system being treated.

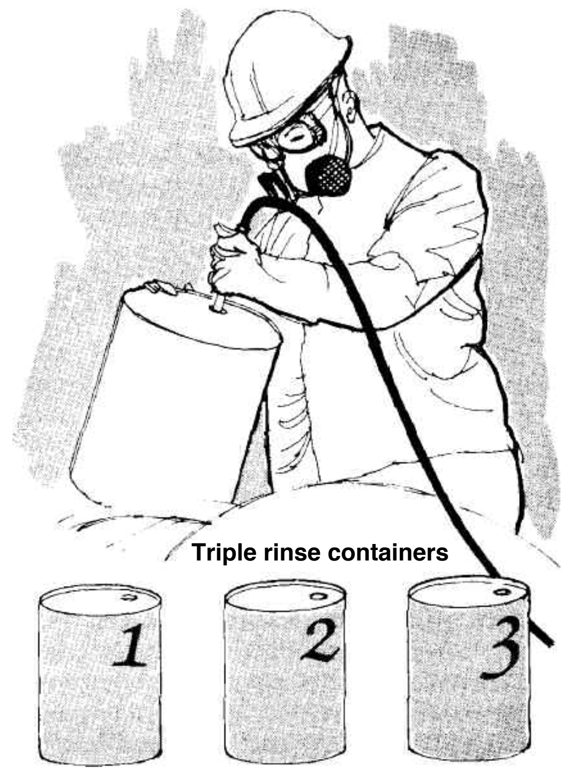
3. Power-rinse the container for 30 seconds allowing the rinsewater to drain into the spray tank or water system being treated.

4. Triple-rinse the container cap with a slower flow of water, capturing the rinsewater in the spray tank or water treatment system.

Triple- or power-rinsed containers that will be held for disposal at a later time should be marked to indicate triple or power rinsing has been done and the date. Pesticide containers that will not be recycled through a recycling facility or the dealer should be rendered unusable by breaking, puncturing, or crushing. Never reuse pesticide containers. Keep all containers in the locked storage area until disposal, and keep away from all possible contact with children and animals.

Disposal of triple-rinsed or power-rinsed containers in a sanitary landfill is permissible, but it is a good policy to check with your local solid waste authority before discarding pesticide containers there.

Whenever feasible, recycle triple- or power-rinsed containers. For information on recycling facilities contact the Michigan Department of Agriculture at (517) 373-1087.



Commercial applicators should be aware of the current hazardous waste guidelines established under the Resource Conservation and Recovery Act (RCRA) as well as state (Act 64) hazardous waste statutes before disposing of pesticide wastes. Pesticide wastes classified as hazardous require special disposal and record keeping practices. MDNRE Waste Management and Hazardous Materials Division (517-335-2690), can provide more information on RCRA and your specific disposal responsibilities under the law.

Follow disposal instructions on the label; seek assistance with disposal problems!

Transport Pesticides Safely

Once a pesticide is in your possession, you are responsible for its safe transport. Accidents can occur even when transporting materials a short distance. Do all you can to prevent a transport problem, but be prepared if an emergency should arise.

Transport Vehicle

The safest way to carry pesticides is in the back of a truck. Flatbed trucks should have side and tail racks. Steel beds are preferable since they can be more easily decontaminated if a spill should occur.

Never carry pesticides in the passenger compartment of a vehicle: hazardous fumes may be released and spills may cause injury and be impossible to remove from seats. If pesticides are transported in a station wagon, windows should be open and no one should be permitted to ride near the pesticides. Never carry pesticides in the same compartment as fertilizers, seed, food or feed; the risk of contamination is too high should a spill occur.

Pesticide Containers

Inspect containers before loading to be sure all caps and plugs are tightly closed and legible labels are attached. Handle containers carefully when loading to avoid rips or punctures. Be sure the outsides of the containers are not contaminated with pesticide.

Secure containers to safeguard against spills or leaks which may result if the containers roll or slide. Packing or shipping containers provide extra protection. All containers should be protected from moisture that would saturate paper and cardboard packages or rust metal. Clean the vehicle thoroughly after unloading.

Protect pesticides from temperature extremes during transport. In hot weather, for instance, the temperature inside the trunk of a car is always considerably higher than outside.

Never leave your vehicle unattended when transporting pesticides in an unlocked trunk compartment or open-bed truck. You are legally responsible if curious children or careless adults are accidentally poisoned from pesticides left unattended and exposed in your vehicle. Whenever possible, transport pesticides in a locked compartment.

Never eat, drink, or smoke when handling pesticides, even if containers are intact and tightly sealed; wash your hands thoroughly when you finish.

Pesticide Fire Safety

Pesticide products vary significantly in their flammability and storage hazard. Those requiring extra precautions bear the label statement, **"Do not use or store near heat or open flame."** Pesticides containing oils or petroleum solvents are the ones most likely to have these warnings, although certain dry formulations also present fire and explosion hazards.

To reduce fire hazards:

- Locate storage areas as far as possible from where people and animals live.
- Keep storage area locked at all times.
- Post signs that indicate combustible materials are stored in the facility.
- Store combustible materials away from steam lines and other heating systems.
- Do not store glass containers in sunlight where they can concentrate heat rays and possibly explode or ignite.
- Install fire detection systems in large storage areas.
- Keep a fire extinguisher approved for chemical fires in all storage areas.
- Notify the servicing fire company as to the location and contents of the storage area. It may save their lives and the lives of others should there be a fire.

In the Event of a Pesticide Fire:

- Clear all personnel from the area to a safe distance upwind from the smoke and fumes.
- Call the fire department and inform the fire fighters of the nature of the pesticides involved. Material Safety Data Sheets (MSDS) which provide technical and emergency information are available from chemical dealers.
- Fire fighting personnel must bring and wear the proper protective clothing and equipment (especially respirators). Assume all protective gear worn at the fire scene is contaminated and hazardous until it is washed.
- Be aware of the potential for explosion of overheated pesticide containers. Nearby containers should be moved or kept cool.
- The principal objective is to contain the fire and prevent contamination of surrounding areas. Use only as much water as is absolutely necessary. Heavy hose streams should be avoided, and any necessary dikes should be built to prevent flow of contaminated runoff into lakes, ponds, streams, wells, or sewers.

Review Questions - Chapter 6 – Pesticide Handling, Storage and Disposal

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. One safe way to open a bag containing pesticides is to tear it open. (True or False)

2. The recommended water pH for mixing most pesticides is between ____________________ and ____________________.

3. List some of the desirable characteristics of a pesticide storage area?

4. Pesticides should be stored:

   a. in any convenient container.
   b. in their original containers.
   c. in containers too heavy for children to handle.
   d. in any container as long as it is tagged with the name of the contents.
   e. none of the above.

5. Liquid formulations and small containers of dry formulations should be stored on metal shelving since metal will not absorb spilled pesticides and is easier to clean than other surfaces. (True or False)

6. Why should you keep an inventory of pesticides and mark purchase dates on the container?

7. List some of the clues that show a pesticide has deteriorated.

8. What is the best way to dispose of a registered pesticide?

9. How do you triple rinse a container?

10. Who do you contact for assistance with disposal problems?

11. Should a poisoning incident occur from a pesticide you are transporting, you will not be liable. (True or False)

12. What is the safest way to transport pesticides?

13. You are legally responsible if a curious child or adult is accidentally poisoned from pesticides left unattended and exposed in your vehicle. (True or False)

14. What types of pesticides are most likely to be flammable and have the following statement on their label: "Do not use or store near heat or open flame?"

15. List three precautions you could take to prevent fire hazards.

16. What should you do first in the event of a pesticide fire?

CHAPTER 7

The Pesticide Label

One of the more important tools for safe and effective use of pesticides is the product label. Pesticide manufacturers are required by law to put certain information on the label, information which when not followed can result in a pesticide accident and legal action against the violator. Labels are legal documents providing directions on how to transport, mix, apply, store, and dispose of a pesticide product or the container. This chapter will teach you how to read and apply the information on pesticide labels.

Parts of the Label

Some labels are very easy to understand; others are complicated. It is the user's responsibility to read and understand the label before buying, using, storing, or disposing of a pesticide. To help you better understand labels, each of the label components will be discussed in this section. The numbers preceding the descriptions correspond to the numbered parts of the sample label at the end of this chapter.

1. Trade, Brand or Product Names

Every manufacturer has trade names for its products. Most companies register each trade name as a trade mark and will not allow any other company to use that name without permission. Different trade names are used by different manufacturers, even though the products contain the same active ingredient. The brand or trade name shows up plainly on the front panel of the label and is the one used in advertisements and by company salespersons.

The brand name often indicates the type of formulation and the percent active ingredient. For example, Sevin 50 WP is a brand name; Sevin is the registered trade name and the formulation is a wettable powder containing 50 percent active ingredient.

2. Ingredient Statement

Every pesticide label must list every active ingredient and the percentage of it in the container. Inert ingredients are not usually named, but the label must show what percentage of the total contents they comprise. The ingredient statement must list the official chemical and common names of the active ingredients. Let's discuss an example:

Sevin 50 WP
Active ingredient:
carbaryl (1-naphthyl N-methyl carbamate)....50%
inert ingredients...50%

The **chemical name** is the complex name that identifies the chemical components and structure of the pesticide. This name must be listed in the ingredient statement on the label. For example, the chemical name of Sevin is 1-naphthyl N-methyl carbamate.

Because chemical names are usually complex, many are given a shorter **common name.** Only those common names officially accepted by the EPA may be used in the ingredient statement on the pesticide label. The official common name is usually followed by the chemical name in the list of active ingredients. The common name for Sevin is carbaryl. By purchasing pesticides according to the common or chemical names, you will be certain of getting the right active ingredient, no matter what the brand name or formulation.

3. Use Classification Statements

Every pesticide product is classified by the EPA as either restricted use or unclassified/general use. Every pesticide product classified restricted use must carry this statement in a prominent place at the top of the front panel of the pesticide label:

> **RESTRICTED USE PESTICIDE**
>
> For retail sale to and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification.

4. Type of Pesticide

The type of pesticide is usually listed on the front panel of the pesticide label. This short statement indicates, in general terms, what the product will control. Examples:

- insecticide for control of certain insects on fruits, nuts and ornamentals
- herbicide for control of woody brush and weeds
- fungicide for control of plant and animal pathogens
- biocide for control of bacteria in cooling tower systems.

5. Net Contents

The front panel of the pesticide label shows how much product is in the container. This is expressed as pounds or ounces for dry formulations or as gallons, quarts, or pint for liquids. Liquid formulations may also list the pounds of active ingredient per gallon of product.

6. Name and Address of Manufacturer

The law requires that the manufacturer or formulator of a product put the name and address of the company on the label. This tells you who made or sold the product.

7. Registration Numbers

An EPA registration number (e.g., EPA Reg. No. 999-000) must appear on all pesticide labels. This indicates that the pesticide product has been registered and its label approved by the EPA. In cases of special local needs, pesticide products may be approved for use in a specific state. These registrations are designated, for example, as EPA SLN No. MI-860009. In this case, SLN indicates "Special Local Need" and MI means that the product is registered for use in Michigan.

8. Establishment Numbers

An EPA establishment number (for example, EPA Est: No. 000) must also appear on the pesticide label. It identifies the facility that produced the product in case a problem arises or the product is found to have been adulterated in any way.

9. Signal Words and Symbols

Every pesticide label must include a signal word. This important designation gives the user an indication of the relative toxicity of the product to humans and animals. Toxicity is one factor you should consider when choosing a pesticide. The signal word must appear in large letters on the front panel of the pesticide label along with the statement, "Keep Out of Reach of Children." The following signal words may be found on pesticide labels.

- **DANGER-POISON, SKULL AND CROSSBONES** – These words and symbol must appear (in red letters) on all products that are highly toxic by any route of entry into the body. Peligro, the Spanish word for danger, must also appear on the label.
- **DANGER** – Products with this signal word can cause severe eye damage or skin irritation.

TOXICITY	HIGH May Cause Death! See a physician immediately.	MODERATE Possible Serious Illness! See a physician if symptoms persist.	LOW or SLIGHT May Cause Illness! See a physician if symptoms persist.
INDICATION ON LABEL	DANGER POISON 	WARNING	CAUTION

The words DANGER and POISON, WARNING, or CAUTION indicate the toxicity level.

• **WARNING** – This word signals that the product is moderately toxic orally, dermally, or through inhalation, or causes moderate eye or skin irritation. Aviso, the Spanish word for warning, must also appear on the label.

• **CAUTION** – This word signals that the product is slightly toxic orally, dermally, or through inhalation or causes slight eye or skin irritation.

Chapter 5, "Pesticides and Human Health," further describes signal words.

10. Precautionary Statements

All pesticide labels contain additional statements to help applicators decide the precautions to take to protect themselves, their employees, and other persons (or animals) that could be exposed. Sometimes these statements are listed under the heading, **"Hazards to Humans and Domestic Animals."** They may be composed of several sections.

Routes of Entry Statements – The statements which immediately follow the signal word, either on the front or side panels of the pesticide label, indicate which route or routes of entry (mouth, skin, lungs) are particularly hazardous and need protection. Many pesticide products are hazardous by more than one route, so study these statements carefully. A **DANGER** signal word followed by **"May be fatal if swallowed or inhaled"** gives you a far different warning than, **DANGER** followed by **"Corrosive—Causes eye damage and severe skin burns."**

Specific Action Statements – These statements usually follow immediately after the route of entry statements. The specific action statements help prevent pesticide poisoning by recommending necessary precautions and protective clothing and equipment. These statements are directly related to the toxicity of the pesticide product (signal word) and the routes of entry.

Protective Clothing and Equipment Statements – Pesticide labels vary in the type of protective clothing and equipment statements they contain. Many labels carry no statement at all. The best way to determine the correct type of protective clothing and equipment is to consider the signal word, the route of entry statements, and the specific action statements on the label.

11. Statement of Practical Treatment

This section lists first aid treatments recommended in case of poisoning.

All **DANGER** labels and some **WARNING** and **CAUTION** labels contain a note to physicians describing the appropriate medical procedure for poisoning emergencies and may identify an antidote. **The label should always be available for emergencies. In the event of a pesticide poisoning, take the label to the hospital with you.**

12. Environmental Hazards

Pesticides can be harmful to the environment. Some products are classified restricted use because of environmental hazards alone. Watch for special warning statements on the label concerning hazards to the environment.

Special Toxicity Statements – If a particular pesticide is especially hazardous to wildlife, it will be stated on the label. For example: "This product is highly toxic to bees," or "This product is toxic to fish."

These statements alert pesticide users to the special hazards posed by use of the product. They should help applicators choose the safest product for a particular job and remind them to take extra precautions.

General Environmental Statements – Some of these statements appear on virtually every pesticide label. They are reminders to follow certain common sense actions to avoid contaminating the environment. The absence of any or all of these statements does not indicate that you do not need to take adequate precautions. Sometimes these statements follow a **"specific toxicity statement"** and provide practical steps to avoid harm to wildlife. Examples of general environmental statements include: "Do not apply when runoff is likely to occur," and "Do not apply when weather conditions favor drift."

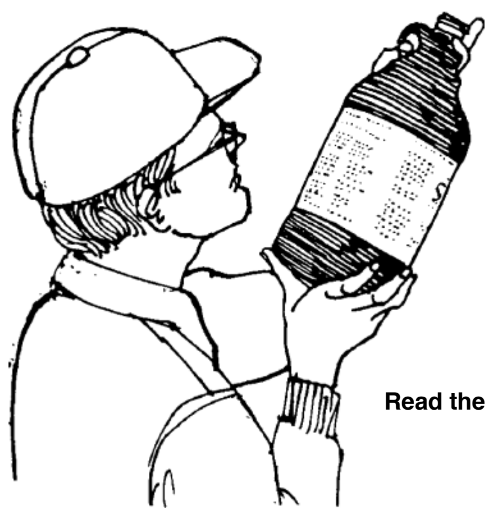
13. Physical or Chemical Hazards

This section of the label describes any special fire, explosion, or chemical hazards the product may pose. For example: "Flammable – Do not use, pour, spill, or store near heat or open flame. Do not cut or weld container."

Hazard statements (hazards to humans and domestic animals, environmental hazards, and physical or chemical hazards) are not located in the same place on all pesticide labels. Some labels group them under the headings listed above. Other labels may list them on the front panel beneath the signal word. Still other labels list the hazards in paragraph form somewhere else on the label under headings such as "Note" or "Important." Prior to use, examine the label for these statements to ensure knowledgeable and safe handling.

14. Restricted Entry Interval Statement

Some pesticide labels contain a restricted entry interval precaution. This statement tells how much time must pass before people can reenter a treated area without appropriate protective clothing and equipment. The restricted entry statement may be printed in a box or it may be in a section with a title such as "Important," or "Note," or "General Information." If no restricted entry statement appears on the label or none has been set by your state, then all unprotected workers must wait at least until sprays have dried or dusts have settled before reentering without protective equipment. That is the minimum legal restricted entry interval.



Read the label!

15. Directions for Use

These instructions are the best way to find out how to apply the product. The use instructions will tell you:

- the site the product is intended to protect
- the proper equipment to be used and mixing instructions
- how much to use (rate) and how often to apply
- compatibility with other often used products
- where and when to apply the material.

Failure to follow the instructions on a pesticide label can result in a serious pesticide accident and constitutes a legal violation subject to civil or criminal prosecution. Remember, the label is a legal document. The user is liable for personal injury, crop damage, or pollution incurred through misuses of a pesticide.

16. Regulations

By law, the pesticide label must contain information on how the applicator must comply with the following regulations if the pesticide falls under the stipulation of the particular regulation:

SARA Title III Law

Endangered Species Act

Worker Protection Standards

For specific information on each of these regulations, see Chapter 9, "Pesticide Laws and Regulations." It is advisable to obtain original copies of these documents to understand their contents thoroughly.

Additional Pesticide Information – MSDS

In addition to pesticide labels, information about a particular pesticide is printed on a Material Safety Data Sheet (MSDS). These forms include information about the pesticide such as medical conditions that it may aggravate, whether it is carcinogenic, and what are its primary routes of entry. The MSDS is available from chemical dealers and are dated to help you identify that the information is current.

3

RESTRICTED USE PESTICIDE

For retail sale to and use only by Certified Applicators, or persons under their direct supervision, and only for those uses covered by the Certified Applicator's certification.

CHEMCO 1 NO PEST BIOCIDE 4

Reg. U.S. Pat. & TM Off.

2 ACTIVE INGREDIENT: BY WEIGHT
deltathion (1,2 phospho-(5)-4 chloromethane .50%
INERT INGREDIENTS 50%
TOTAL 100%

7 EPA Reg. No. 999-000 8 EPA Est. No. 000

10 HAZARDS TO HUMANS AND DOMESTIC ANIMALS

MAY BURN THE EYES *** MAY BE HARMFUL OR FATAL IF SWALLOWED *** MAY BURN THE SKIN ON PROLONGED CONTACT
Do Not Get in Eyes, on Skin, or on Clothing. Chemical Worker's Goggles Must Be Worn When Handling.
Wear Long-Sleeved Clothing and Gloves During Use.

11 STATEMENT OF PRACTICAL TREATMENT

If Swallowed: Do not induce vomiting. Contains aromatic petroleum solvents. Call a physician or Poison Control Center immediately. If in Eyes: Flush with plenty of water for at least 15 minutes. Get medical attention. If on Skin: Wash with plenty of soap and water. Get medical attention if irritation persists. If Inhaled: Remove to fresh air immediately. Get medical attention.

NOTE TO PHYSICIANS: "NO PEST" is a cholinesterase inhibitor. Treat symptomatically. If exposed, plasma and red blood cell cholinesterase tests may indicate significance of exposure (baseline data are useful). Atropine, only by injection, is the preferable antidote. Oximes, such as 2-PAM/protopam, may be therapeutic if used early, however, use only in conjunction with atropine. In case of severe acute poisoning, use antidote immediately after establishing an open airway and respiration.

12 ENVIRONMENTAL HAZARDS

This product is toxic to fish. Apply this product only as specified on this label. Do not contaminate water by cleaning equipment or disposing of wastes. NOTE: Do not discharge into lakes, streams, ponds, or public water supplies unless in accordance with a NPDES Permit. For guidance, contact your regional office of the EPA.

STORAGE AND DISPOSAL

PROHIBITIONS: Do not contaminate water, food or feed by storage or disposal. Open dumping is prohibited. Do not reuse empty container

STORAGE: Store in original container only. Keep container tightly closed when not in use. Store "NO PEST" in a clean dry area out of reach of children and animals. Do not store in areas where temperature averages 115ºF (48ºC) or greater. Do not store in or around the home or garden. Do not store near food or feed. In case of spill or leak on floor or paved surfaces, soak up with sand, earth or synthetic absorbent. Remove to chemical waste area.

PESTICIDE DISPOSAL: Pesticide wastes are toxic. Improper disposal of excess pesticide, spray mixture or rinsate is a violation of federal law. If these wastes cannot be disposed of by use according to label instructions, contact your State Pesticide or Environmental Control Agency or the nearest EPA regional office for guidance.

CONTAINER DISPOSAL: Metal Containers: Triple rinse (or equivalent). Then offer for recycling or reconditioning or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities. Plastic Containers: triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or incineration, or if allowed by state and local authorities, by open burning. If burned, stay out of smoke. Glass Containers: triple rinse (or equivalent). Then dispose of in a sanitary landfill or by other approved state and local procedures.

DIRECTIONS FOR USE 15

It is a violation of federal law to use this product in a manner inconsistent with its labeling.

NOTE: Add "NO PEST" separately to the system. Do not mix with other additives.

To control slime producing bacteria in recirculating cooling systems, add 0.3 to 1.1 pound of NO PEST per 1,000 gallons of water in the system. Additions should be made once/week for clean systems, or more frequently for heavily contaminated systems. For the control of anaerobic bacteria, add 0.8 to 2.0 pounds NO PEST every other day until control is achieved.

13 CHEMICAL HAZARD

"Flammable - Do not use, pour, spill, or store near heat or open flame, Do not cut or weld container."

KEEP OUT OF REACH OF CHILDREN

9 **DANGER POISON**

PELIGRO

6 **CHEMCO CHEMICAL COMPANY, East Lansing, MI 48823** 5 **Net Contents - 1 gallon**

Review Questions - Chapter 7 – The Pesticide Label

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. Labels are legal documents. (True or False)

2. Regardless of the signal words they bear, all pesticide labels must carry the words, **"Keep Out of Reach of Children."** (True or False)

3. The skull and crossbones symbol must appear on every pesticide label. (True or False)

4. Which signal word(s) on a pesticide label would indicate that the product is highly toxic to humans?

   a. "WARNING"
   b. "CAUTION"
   c. "Keep Out of Reach of Children"
   d. "DANGER-POISON"

5. Labels should be removed from pesticide containers and kept in a notebook so they remain clean and legible. (True or False)

6. A certain active ingredient has only one technical chemical name and one accepted common chemical name, but may be in products with several different trade/brand names. (True or False)

7. What are Material Data Safety Sheets and where can you obtain them?

To answer questions 8 through 14, refer to the segment of the No Pest sample label found on the previous page.

8. Should a face shield or goggles be worn when handling "No Pest?" (Yes or No)

9. If a person accidently swallows several mouthfuls of "No Pest" concentrate, should they be immediately administered syrup of ipecac to induce vomiting? (Yes or No)

10. Regardless of the container material (glass, metal, or plastic), all empty "No Pest" containers should be:

   a. burned
   b. punctured
   c. reused
   d. triple or power rinsed
   e. saved

11. Containers of "No Pest" can be kept in the home as long as the storage area is locked. (True or False)

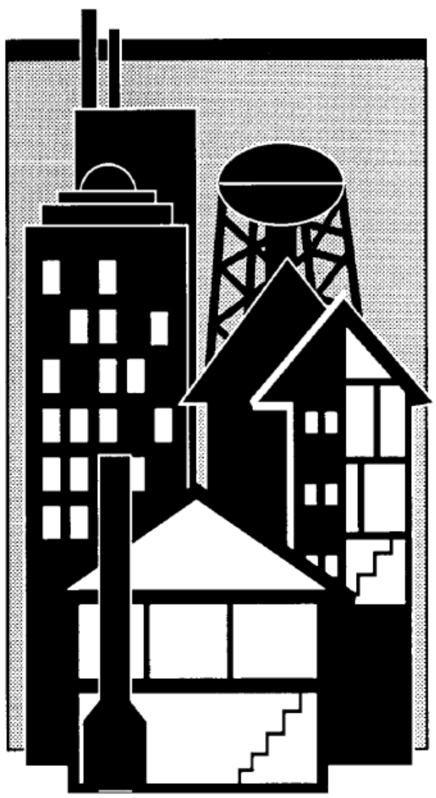
12. Could use of this product present a hazard to any wildlife or other nontarget animals? (Yes or no). List three groups of animals of particular concern: ______________________, ______________________ and ______________________

13. If warning signs are to be posted in a "No Pest" treatment area, the name of the pesticide is all that is required to be written on the sign. (True or False)

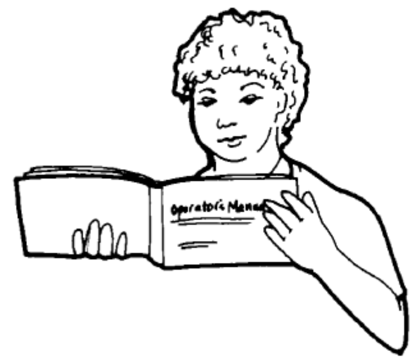
CHAPTER 8

PESTICIDE APPLICATION EQUIPMENT

Now that you have identified the pest, selected the proper pesticide, and safely transported and stored the chemical, you are ready to have the chemical go to work for you. This chapter covers how to select the proper equipment and how to precisely apply the pesticide. Applying chemicals properly saves money and protects the environment and you.



A brief description of some cooling water processing equipment to which biocides are applied may help to establish an understanding of how microbial pest management programs are performed. This review of a limited range of equipment is not intended to provide you with all the information that you need for effective pest control through the use of biocides at your specific facility and situation. Up-to-date information regarding equipment, materials and methods should be obtained from the equipment manufacturer, biocide manufacturer, reference manuals, your supervisor, professional associations and the biocide label.



Cooling water systems in industrial, commercial and institutional establishments may be open or closed. Open cooling water systems may be once-through or recirculating. All closed systems are recirculating.

Open Systems

Once-Through Systems

In once-through systems, water is taken from a river, lake, well or other source. The water is passed through a heat exchanger which extracts heat from another liquid or vapor separated from the water by a metallic barrier. The water is then discharged to the source from which it was obtained or to another surface waterway in accordance with all local and state ordinances. Large electric power generating stations are frequent users of once-through cooling systems. Because of the large quantities of water needed for once-through cooling and the effects of the warmer discharge water on the wildlife of receiving streams, the use of once-through cooling water systems is being sharply restricted, and most cooling water systems are now recirculating systems.

Recirculating Systems

Depending upon the nature of the cooling requirements, open recirculating cooling water systems may include cooling towers, evaporative condensers, or evaporative coolers to reduce the water temperature. Although each of these types of recirculating cooling water equipment differs somewhat from the other in form or operation, the basic principles involved are the same. Cooling water is passed through a heat exchanger as described above for once-through systems. However, instead of discharging the warmed water to waste, it is circulated through an evaporative cooling device in which the evaporation of a small portion of the water absorbs enough heat so that the remainder of the water is cooled to its original temperature. The cooled water is then circulated through the heat exchanger again. Water lost by evaporation is replaced by makeup water from a river, lake, well or city water supply and the cycle is repeated indefinitely.

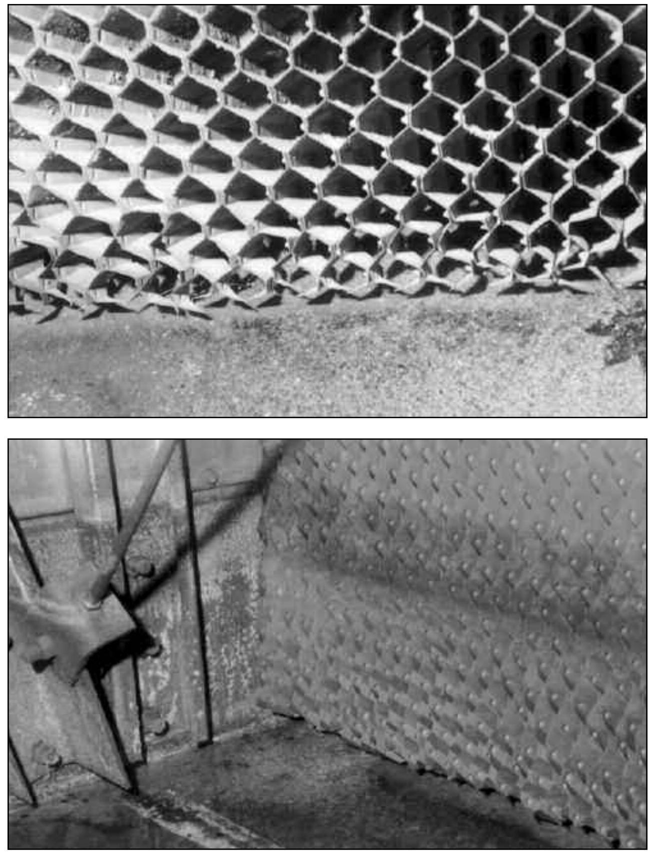
Induced draft-type cooling tower showing air intake vent and safety rails around the top of the tower.

Cooling towers for air conditioning systems are commonly designed to evaporate 1% of the circulating water, thereby absorbing enough heat to cool the remainder of the water by 10°F. Industrial cooling towers frequently operate with higher evaporation rates (2-4%) and somewhat higher temperature differences.

Operational Concerns With Open Cooling Water Systems

Salt Concentration

The process of evaporation can concentrate salts present in the water to a point where they can form scale on the equipment, which reduces cooling capacity. Further buildup of deposits in piping reduces water flow and increases pumping power requirements. To avoid scale and deposit formation, cooling waters are treated with deposit-inhibiting chemicals and a small portion of the circulating water is discharged to waste to limit the concentration of dissolved solids. This discharge is known as blowdown or bleed-off (described in Chapter 4, Pesticides and



Two examples of cooling tower 'fill' through which water circulates.

The Environment). The blowdown rate depends on the cooling tower chemistry and may range from as low as 0.25%, up to 3 or 4% of the circulation rate. For reasons of water and energy conservation and economy of waste water treatment, the trend is toward low blowdown rates.

Deterioration

Oxygen absorbed from the air as the water falls through a cooling tower promotes corrosion of metallic portions of the cooling system. Other impurities can accelerate corrosion or cause more dangerous localized corrosion or pitting. These processes eventually lead to leaks that require replacing portions of the system. Still other impurities can cause the cooling tower wood to deteriorate.

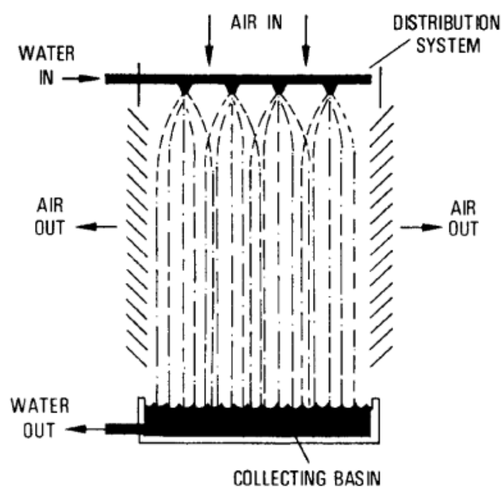
Biological Growths

As discussed in Chapter 2, "Pest Identification," organic impurities, including bacterial slimes and other microbial growths, can accelerate deterioration of equipment. They can also cause odors and, in extreme cases, could create potential health hazards should pathogenic organisms be discharged to the air from evaporative cooling equipment. In addition, the growth of microorganisms in cooling waters seriously interferes with cooling tower system operation and life. Heavy formation of algae can clog spray nozzles and distribution decks and form deposits on heat exchange surfaces. The slimes developed from bacteria and fungi can do the same and also serve to bind other suspended matter, such as airborne dirt, corrosion products, or scale. This rapidly accelerates the buildup of deposits and sometimes causes deposits to accumulate under circumstances where none would have formed had there not been some microbiological growths present.

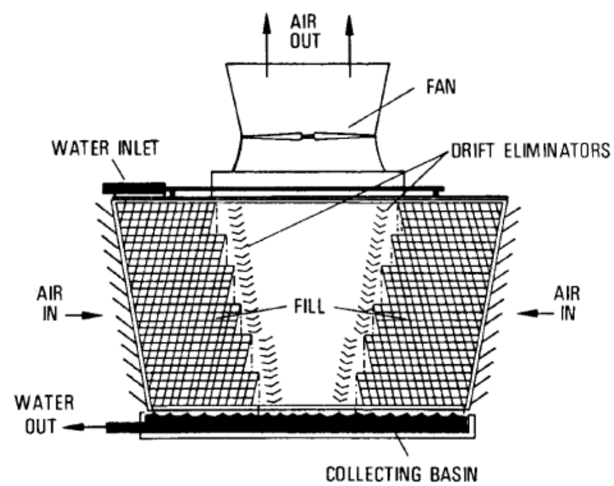
These deposits reduce heat transfer and thus increase energy requirements. Tests show that a 1 mil (0.001 inch) thick deposit of slime reduced overall heat transfer by about 10%, and 20-50 mil deposits reduced heat transfer by as much as 40%. Corrosion is frequently accelerated and localized beneath microbiological growths. For these reasons, it is important to treat cooling tower water with biocides to manage growth of microorganisms.

Closed Recirculating Systems

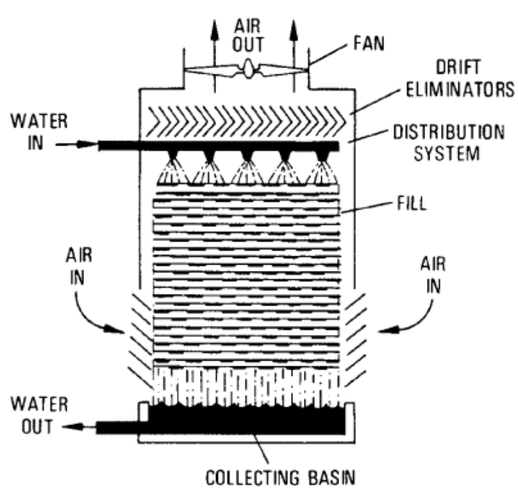
In closed recirculating cooling water systems, the cooling water picks up heat from a heat exchanger as described above for open systems, but this heat is removed by passing the water through a second heat exchanger in which the water is cooled by a flow of cooler water or air on the other side of a metallic barrier. There is no evaporation of water.



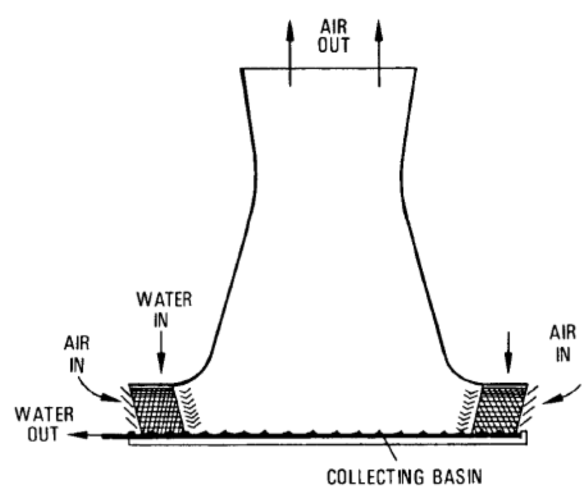
Atmospheric Tower (natural draft)



Crossflow Tower (forced draft)

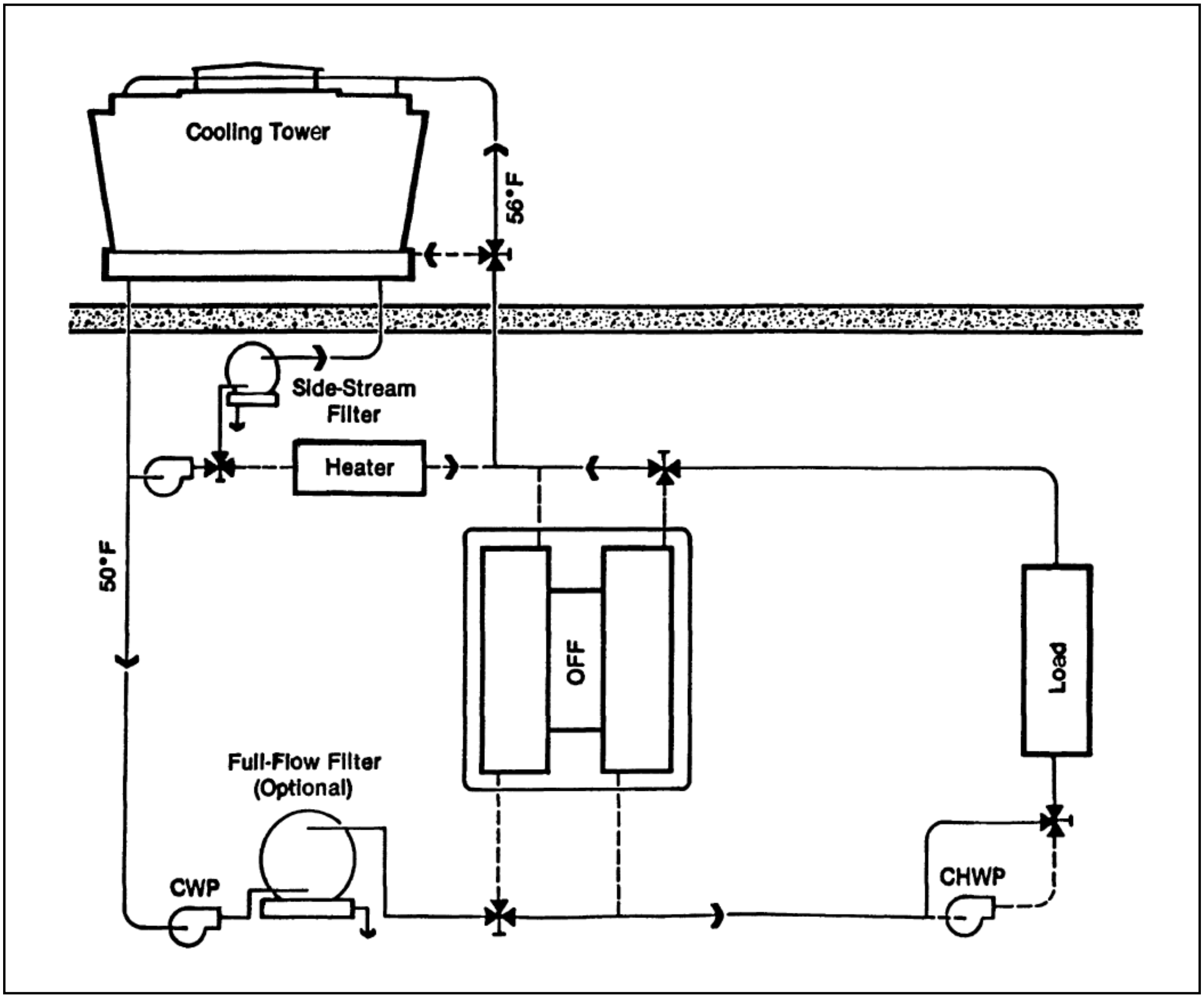


Counterflow Tower (forced draft)



Hyperbolic Tower (natural draft)

Some types of cooling towers.



Comfort cooling system including a free cooling mode.

Central air conditioning systems are an example of a closed circuit. Heat is absorbed from the air into chilled water in an air-to-water heat exchanger. The water then circulates to a refrigeration machine which absorbs this heat and recools the chilled water which is then returned to the air-to-water heat exchanger. Closed recirculating cooling water systems develop problems which require applying a pesticide less frequently than open systems.

Biocide Application

Aquatic-microbial pesticides are usually applied as either a liquid, spray, or a compressed powder (pellets or tablets). The pesticide feed equipment must be matched to the pesticide material as well as the size and type of job. In other areas of pest management, pesticides are applied as dusts, granules, gases (vapors), fogs, baits, rubs or dips. Choosing appropriate application equipment and operating and maintaining it properly is as important to effective pest management as selecting the pesticide. To make an effective, safe and efficient application, the equipment must be properly selected, operated, calibrated, and maintained.

Methods of Application

Before discussing specific types of biocide application equipment, we need to briefly review the ways pesticides are applied in other areas of pest management. The method of application chosen depends on the nature and habits of the target pest, the plant, the pesticide, available application equipment, and the relative cost and efficiency of alternative methods. Always bear in mind that your principal objective is to effectively bring the pesticide into contact with the target organism(s).

Some of the common methods of applying pesticides are outlined below.

1. Broadcast applications uniformly apply pesticide to an entire area. They are made either before or after emergence of the crop.

2. Directed-spray applications are directed at a pest to limit contact with the host.

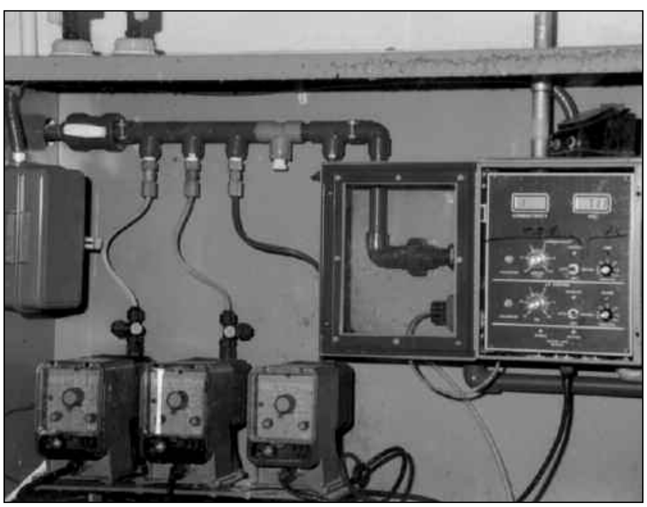
3. Spot treatments apply pesticide to small, discrete areas.

4. Aerosol generators and foggers produce vapors or mists both for indoor and outdoor use.

Normally there are only three methods of applying aquatic- microbial pesticides. Liquid bioicides can be added to the water in the system manually or through a pump. Liquids can also be used in a tank sprayer for special applications. Finally, compressed powders can be added via some form of manual feed or through a tablet feed device.

Application Equipment

Microbial managers use a variety of equipment to place the biocide in the system while at the same time offering safety to the applicator and environment. Common equipment is described here.



Automatic control systems monitor and control system chemistry.

Pesticide (chemical) Pump Activated by Timer

The pump-timer method is perhaps the most widely used and safest means to deliver pesticide into a cooling or process system. As the name implies, the application is done by a pump that is activated by a timer (usually a seven or fourteen day programmable unit).

The chemical metering pump (either diaphragm or piston type) is the heart of the application system. Using the adjustments for speed and/or percent of stroke, the metering pump can be calibrated to deliver a fixed amount of liquid pesticide in a specific amount of time. The programmable timer is set so that the pump is turned on for enough time to deliver the correct dosage at the required frequency.

For example, this system can be set to deliver 15 ounces of biocide per 1000 gallons of system water every three days. It must be pointed out that the pump should be sized so that the correct dosage is delivered in a short period of time since the cooling system is also bleeding water to drain and will dilute the biocide that is available for an effective kill.

Some of these units can activate alternating pumps to supply different biocides. This practice helps to avoid development of resistant populations of organisms.

The calibration of this unit requires only a few minutes and should be checked periodically. To calibrate, flush the pump and hoses (suction and discharge) with water to remove residual biocide. Redirect the injection valve from the treated system into a graduated container (showing ounces of fluid). Manually activate the timer for a designated period of time and measure the amount of water that is pumped during this time frame. Adjust the pump settings as required to produce the correct dosage such as 20 ounces in 5 minutes.

Normally there are limited operational problems with this type of system provided that the applicator does not let the container of biocide run dry. The only maintenance on this system requires resetting the timer (if required by power loss) and checking and replacing check valves and springs as recommended by the manufacturer.

Tablets and Pellets

Tablet feeders are the safest means of introducing compressed powders into the system that requires treatment. This device holds a given weight of tablets, depending on the size of the system and the size of the feeder. The feeder is piped into the system's circulating water supply in such a way that it can be valved off for filling and valved on to allow system water to flow through the feeder. Usually the feeder has a throttling valve that allows the applicator to adjust the amount of water passing through the feeder. As the tablets dissolve, the biocide is continuously fed into the process or cooling system.

This type of unit is commonly used with oxidizers like chlorine or bromine. Caution must be taken never to leave the unit valved off with biocide and water in it because gases can develop that can explode the unit.

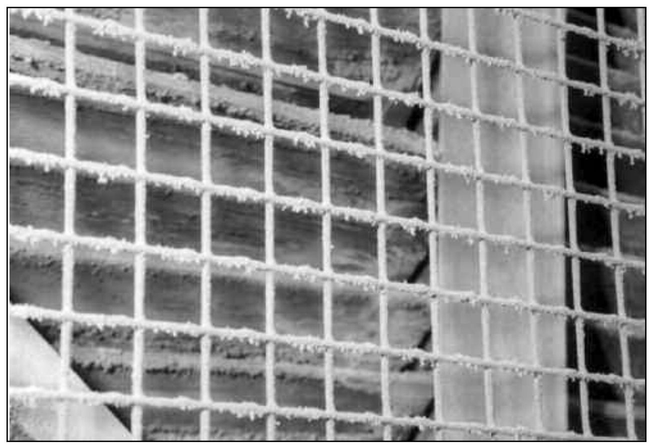
Calibration is done by careful monitoring of the system water for the required dosage of biocide and by adjusting the throttling valve to maintain the correct dosage.

An alternate to the tablet feeder is the use of mesh bags to suspend the compressed powders in the water of the system to be treated. The correct dosage for the volume of water being treated is placed into the mesh bags, the bags are lowered into the system water, and the system water is monitored for the required dosage of biocide. If the level of biocide goes over the proper amount, some of the biocide bags are removed from the water until the correct level is maintained. If the level is too low additional bags of tablets are added. This system is more labor intensive than is the tablet feeder.

Improper application of biocide tablets. Tablets of formulated biocides should be metered and fed, or suspended in the systems water flow rather than dropped in the basin as shown here. Note the dark pock marks in the concrete surface damaged by previous applications.

Sprays

The application of pesticides by spray is of limited use in aquatic-microbial control. The two situations which are appropriate for using a spray application would be in the removal of infestations from cooling tower air diffusers, and for disinfecting towers, tanks, screens, slats, etc. while the system is dry and out of service. For this application a small tank sprayer with a discharge wand can be used to quickly cover the target area with pesticide. Follow the manufacturers directions for the spray tank operation and all personal protection requirements as listed on the pesticide label. Make sure that the spray tank material is not going to be effected by the type of pesticide being used, and thoroughly wash the spray unit after use. Dispose of the wash water per label directions.



A hand-held pesticide sprayer may be used to clean bioaccumulation from the exterior louvers and screens of this equipment.

Avoiding Drift

Drift can be defined simply as the movement of pesticide through the air to nontarget areas, and may occur either as solid or liquid particles or as vapors. When using any spray device to apply pesticide, you must keep drift to a minimum. The following measures help prevent or lessen drift:

a) use the lowest spray pressure possible for the application,

b) keep the spray nozzle as close as possible to the target,

c) use only nonvolatile or low-volatile formulations, and apply only when wind speed is low (if inside control drafts),

d) where practical, use a nozzle type which produces the largest droplets at a given rate and pressure.

Manual or Hand Feeding

Liquid pesticides can be manually applied into cooling and process systems to achieve effective pest control. Manual feeding requires accurate measurement and pouring of the correct amount of biocide into the effected system. Biocides are applied when you have identified an infestation or when the required parts per million of biocide has fallen below the maintenance level or its effective kill range. Like mesh feeding of tablets, this is a labor intensive procedure and, more importantly, exposes the applicator to the biocide more frequently (with a greater possibility of spillage, personal injury, or damage to the environment) than does an automatic system.

Precise Application of Biocides

Biocides must be applied to process or cooling systems according to all label instructions. All applications are measured in either ounces per gallons treated (example: 4 to 20 oz per 1,000 gallons of system water), or in parts per million (ppm) of product in the system water. To safely and legally apply the biocide, the applicator must know the volume of water that is going to be treated.

Determining System Volume

The most simple and accurate method for determining the volume of a cooling system or water bath in a pulp mill is to drain the system and refill it using a water meter on the make-up water supply are before and after readings of volume with the water meter. Many of these systems are drained seasonally or for periodic maintenance. Installing a meter on the fill line will provide not only information about the systems' volume but can be used for chemical feed and to provide a continuing record of actual water use.

Geometry or standard tables of measurement can be used quickly and easily to determine the volume of water in a system being treated. For example, if a closed recirculating system requires sanitizing with chlorine, direct measurements of pipe size and total length of pipe in the closed system can be taken to determine the system volume and the necessary amount of chlorine. Tables of standard measurement (such as Water and Waste Treatment Data Book, compiled by the Permutit Co.) provide the number of gallons of water per foot of pipe. If air separators, expansion tanks, or tower basins are involved, you can size these from the standard tables or use geometry to determine the equipment's volume and multiply by 7.48 to convert the volume of water in cubic feet to gallons. Some of the most commonly used formulas and constants are listed here:

Tank Volume:
Rectangular = Length X Width X Height
Cylindrical = π X r^2 X Height
π = 3.14
r = radius, half the diameter
7.48 gallons per cubic foot of water
8.34 pounds per gallon of water

Pipe Size (inches)	Gallons per Foot
1	0.05
2	0.16
4	0.65
6	1.47
8	2.61
10	4.08
12	5.88
16	10.44
18	13.22
20	16.32
24	23.50
30	36.72
36	52.88

Another method of determining the volume of a system is the use of a **salt test.** This salt test method is also used in systems where the calculations of pipe and equipment size are not easily obtained. To begin a salt test you need an estimate of the system volume, then follow these procedures:

1. Shut off system bleed.
2. Accurately measure the chloride level in the system.
3. Add 1/2 pound of table salt (not rock salt) to the system for each 1,000 gallons of estimated volume. It is best to dissolve the salt in a pail, using system water, then pour the salt solution into the system. In larger systems add the salt in increments to allow it to dissolve.
4. Allow the salt solution to mix completely in the system by circulating for 30 to 60 minutes (for larger systems, circulate longer).
5. Take a chloride test every 10 minutes until the chloride level is stable. The stable level will be the "final" chloride level in the following equation.

NOTE: We are adding salt (NaCl) but only measuring for the chloride level. Chloride is approximately 60% of the salt compound which is why we multiply the pounds of salt added by .60 in the following equation.

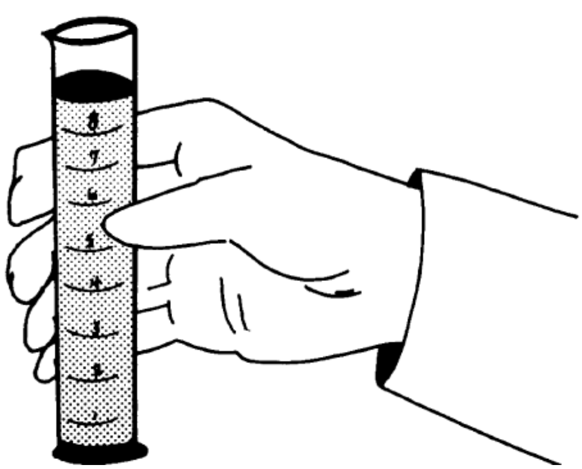
The 1,000,000 and 8.34 lbs/gallon values are part of the equation allowing us to convert ppm and pounds into the unit we need in our answer, which is gallons. See below.

6. **System Volume in gallons** $= \dfrac{(1{,}000{,}000) \times (.60) \times (\text{lbs. salt added})}{(8.34\ \text{lbs/gallon}) \times (\text{Final Chloride ppm} - \text{Initial Chloride ppm})}$

$$= \frac{71{,}942 \times \text{lbs. of salt added}}{\text{Final Chloride ppm} - \text{Initial Chloride ppm}}$$

Note: Many operators use this calculation and round the number 71,942 found in the numerator of the equation up to 72,000. Therefore, an acceptable equation for determining the volume of a system is:

$$\text{System Volume in gallons} = \frac{72{,}000 \times \text{lbs. of salt added}}{\text{Final Chloride ppm} - \text{Initial Chloride ppm}}$$



Application Rate

The amount of biocide that must be applied per system volume is stated on the label. Too much biocide can damage equipment or the environment and lead to fines for discharging higher levels than allowable; too little biocide will not achieve good control.

Biocides are applied in dosages based upon ounces of product per system volume, or ppm of product in the water.

To determine how much product to apply, multiply the amount of product needed per 1,000 gallons by the number of gallons in your system. If 20 ounces treats 1,000 gallons of water and your system holds 50,000 gallons, then:

$$\frac{\text{20 ounces X 50,000 gal.}}{\text{1,000 gallons}} = \text{1,000 oz}$$

If this 50,000 gallon system were to be treated with 125 ppm of product, you need to determine the pounds of product that, when added to 50,000 gallons, would produce 125 ppm. Since ppm is pounds per million pounds in this situation, and one gallon of water weighs 8.34 lbs, use the following formula to calculate:

$$\frac{\text{Desired ppm X System volume (gallons) X 8.34 lbs/gallon}}{\text{1,000,000}} = \text{lbs of product}$$

Therefore:

$$\frac{\text{125 ppm X 50,000 gallons X 8.34 lbs/gallon}}{\text{1,000,000}} = \text{lbs of product}$$

= 52.12 lbs of product

Additional Sample Calculations

I. You need to acheive 150 ppm concentration of biocide in a rectangular process tank in a paper mill to control fungus. The tank is 8 ft. wide, 35 ft. long, and the water depth is 4.5 ft. How many pounds of product do you add?

Determine the volume of the tank:

= L X W X H X 7.48 gallons/cubic foot

= 8 ft. X 35 ft. X 4.5 ft. X 7.48 gallons/cubic foot

= 9,424.8 gallons

Determine the pounds of product needed to produce 150 ppm concentration in this tank:

$$= \frac{\text{Desired ppm X Volume of tank (gallons) X 8.34 lbs/gallon}}{\text{1,000,000}}$$

$$= \frac{\text{150 ppm X 9,424.8 gallons X 8.34 lbs/gallon}}{\text{1,000,000}}$$

= 11.79 lbs of biocide product

II. A cooling tower has a vertical, cylindrical holding tank. The tower water cools the building air by passing it through several cooling coils in air handling units. When the system is shut off there is 6.5 feet of water in the tank. The tank measures 9 feet in diameter. You have checked the prints and know that the system has 1,200 feet of 2″ pipe and 450 feet of 1/2″ pipe in the coils.

If 45 oz. of the selected algaecide treats 1000 gallons of system water, how much algaecide will you need to pump into the system and for how long will you set the timer. Your pump is at maximum capacity of 320 oz. per hour.

Determine the volume of the tank:

$= \pi \text{ X } r^2 \text{ X H X 7.48 gallons/cubic foot}$

$= 3.14 \text{ X } 4.5 \text{ ft.}^2 \text{ X 6.5 ft. X 7.48 gallons/cubic foot}$

= 3,091.5 gallons

Volume of pipe from standard tables:

1/2″ = .01 gallons per foot

2″ = .16 gallons per foot

Determine volume of pipe:

= (0.16 gal./ft X 1,200 ft) + (.01 gal./ft X 450 ft)

= 4.5 gallons + 192 gallons

= 196.5 gallons

Total volume of system:

= volume of tank + volume of pipe

= 3,091.5 + 196.5 gallons gallons

= 3,288 gallons

Treatment Dosage = 45 oz./1,000 gal.

= 45 oz./1,000 gal. X 3,288 gal.

= 148 ounces

Your pump is set for 320 oz. per hour or 5.33 oz. per minute (320 oz./60 minutes).

Therefore:

$$= \frac{\text{Treatment dose in ounces}}{\text{Pump rate in ounces/minute}}$$

$$\text{Time required} = \frac{\text{148 oz.}}{\text{5.33 oz./minute}}$$

= 28 minutes

Note: Most biocides labels have a dosage range so that a timer set for either 25 or 30 minutes would give accurate treatment.

III. A tower system has piping and a lot of small process cooling equipment. The volume is approximately 6,000 gallons. Run the salt test to determine the **actual volume.**

The initial chloride test is 43 ppm. After the concentration stabilizes the level is 85 ppm.

First, add 1/2 lb of table salt to the system for each 1,000 gallons of estimated volume.

$$= \text{Estimated volume in gallons} \quad X \quad \frac{.5 \text{ lb. salt}}{1{,}000 \text{ gallons}}$$

$$= \frac{6{,}000 \text{ X } .5 \text{ lb. salt}}{1{,}000 \text{ gallons}}$$

$$= 3 \text{ lbs. salt}$$

Therefore:

$$\text{Volume of system} = \frac{(72{,}000 \text{ X lbs. of salt})}{\text{Final chloride level ppm} - \text{Initial chloride level ppm}}$$

$$= \frac{(72{,}000 \text{ x } 3 \text{ lbs.})}{85 \text{ ppm} - 43 \text{ ppm}}$$

$$= \frac{216{,}000}{42 \text{ ppm}}$$

$$= 5{,}142 \text{ gallons in system}$$

Review Questions - Chapter 8 - Pesticide Application Equipment

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. List three application methods for biocides.

2. Define drift.

3. Explain how to calibrate a feed system using a timer and a chemical pump.

4. Give two reasons why a manual feed system is less desirable than an automatic feed system?

5. If a 10,000 gallon system requires 145 ppm of pesticide, how many pounds of product are required?

6. When would you apply an aquatic-microbial pesticide with a tank sprayer?

7. List four methods of applying nonaquatic-microbial pesticides.

8. Where would you find information on pesticide dosage?

9. A closed water system has a bacterial infestation. The selected liquid biocide requires a concentration of 125 ppm. From the blue prints and standard tables you know:

   a. The coils contain 100 gallons of water,
   b. There are 900 feet of 2″ pipe (each foot has 0.16 gallons of water).

How many pounds of biocide need to be added to the system to obtain the desired 125 ppm?

10. There is an algae outbreak in a rectangular process tank that is 12 feet long, 7 feet wide, and has a water depth of 5.5 feet. The algaecide to be used requires 50 oz. per 1000 gallons of system water. How much algaecide must be added to the system to obtain an effective treatment?

11. You are responsible for a very old cooling system that no longer has a complete set of prints. The system also has many different sizes of pipes (including old piping that no longer carries water but has not been removed).

You run a chloride test and the initial level is 53 ppm.

With the bleed shut off, you add 15 lbs. of table salt.

When the chloride level stabilizes, you test the chloride level again and the concentration is 110 ppm.

What is the volume of this cooling system?

CHAPTER 9

PESTICIDE LAWS AND REGULATIONS

Pesticide use has increased from approximately 300 million lbs. of active ingredient in 1964 to approximately 1 billion lbs. of active ingredient in 1991. Approximately 275 million pounds of active pesticide ingredients were used for nonagricultural purposes in 1991. New highly sensitive measuring devices are detecting pesticides in groundwater and other parts of our environment. To protect the environment and human health, federal and state laws regulate the proper, safe use of pesticides. In this chapter you will learn about the state and federal laws that regulate pesticide applicators.

Federal Laws

Several federal laws regulate pesticide use. Both state and federal agencies enforce these laws. The following sections describe requirements of pesticide laws and which agency enforces each.

FIFRA

The basic federal law regulating pesticides is the **Federal Insecticide, Fungicide and Rodenticide Act (FIFRA),** first enacted in 1947. This law was amended in 1972, 1978, and 1988.

FIFRA is administered by the U.S. Environmental Protection Agency (EPA). The Michigan Department of Agriculture (MDA) has a cooperative agreement with EPA to enforce the provisions of FIFRA in Michigan. The major provisions of FIFRA are listed here:

• All pesticides must be registered with EPA before they can be used or sold.

•States have the authority to certify applicators, register selected pesticides for use in their state, and initiate programs designed to meet local needs.

•EPA has authority to develop rules establishing national standards for safe use, storage, transportation and disposal of pesticides.

• Pesticides must be classified as either "general use" or "restricted use."

• Applicators who violate the provisions of FIFRA can be served a civil or criminal penalty:

Civil Penalties – A private applicator who violates FIFRA after a written warning or other citation for a prior violation may be fined up to $1,000 for each offense. A commercial applicator may be fined up to $5,000 for each such offense.

Criminal Penalties – An applicator who knowingly violates FIFRA is guilty of a misdemeanor. A commercial applicator may be fined up to $25,000 and may be imprisoned for up to one year. A private applicator may be fined up to $1,000 and imprisoned up to 30 days.

FIFRA defines the term "misuse" as, "to use any pesticide in a manner inconsistent with its labeling." It specifies that the following activities do not constitute misuse:

• Using a pesticide for a pest not noted on the label if the application is made to the plant, animal or site specified on the label.

• Mixing pesticides with fertilizer when such mixture is not prohibited by the labeling.

• Any manner of application unless expressly forbidden by the label.

• Using a pesticide at dosages less (but not more) than the labeled dosage.

These exemptions apply only if the pesticide is otherwise used as directed on the label. For example, you may apply a herbicide for control of a weed not on the label provided that the herbicide is labeled for use on the particular crop and you follow all other label instructions. Do not use these exemptions unless you are certain of their results as the exempted uses may not be covered by the pesticide manufacturer's warranty.

Endangered Species Act

The federal Endangered Species Act became effective in the early 1990s. The Act provides that endangered species of plants and animals be protected from pesticides by prohibiting application of specific pesticides within endangered species habitat ranges. For each pesticide product that has an effect on an endangered species, the Act requires that the labeling include a list of states and counties where the product affects the endangered species and its application is restricted. There will be county maps available where pesticides are sold or from your local county Extension office to further delineate habitat areas. For further information on endangered species, call the U.S. Fish and Wildlife Service, Department of the Interior, at (517) 337-6650. The Michigan Department of Natural Resources administers the Michigan Endangered Species Act (Public Act 203 0f 1974) and maintains the federal and state endangered species lists in the state.

SARA Title III

Title III of the federal Superfund Amendments and Reauthorization Act of 1986 (SARA) is also called Emergency Planning and Community Right-to-Know. This legislation provides a means to protect people from chemical emergencies by requiring state and local agencies to gather information about the quantity and location of hazardous chemicals in their community. Farmers, dealers, custom application businesses, and industrial facilities requiring pesticide applications are some of the groups that must comply with this law. The law is divided into numerous sections.

Section 302 (facility notification) requires that anyone who stores a specified quantity of an EPA designated "extremely hazardous substance" must notify proper authorities and provide the name of the responsible person for the storage facility. One pound of bromine, and ten pounds of chlorine, commonly used for treating water in processing systems, are considered reportable quantities of "extremely hazardous substances." Other chemicals used in water processing systems may also be on the list of "extremely hazardous substances."

Section 304 (emergency notification) requires that applicators or businesses report any release (spills, leaks, etc.) of an "extremely hazardous substance" above specific reportable quantities.

Section 311 requires that businesses that sell and store large quantities of pesticides (dealers) need to supply MSDSs, or a list of chemicals for which MSDSs are available, to the appropriate committees and the local fire department.

Section 312 requires that dealers provide an annual Tier 1 or Tier 2 inventory report form to the same groups.

For more information on SARA Title III and the EPA designated "extremely hazardous substance" list, call the DEQ SARA Title III office (517-373-8481). Two MSU Extension bulletins also explain SARA Title III and how to comply with its requirements: Extension Bulletin E-2173 is for pesticide users and Bulletin E-2174 is for pesticide dealers. Another, more user-friendly bulletin on SARA Title III is E-2575.

Federal Food, Drug, and Cosmetic Act

EPA sets residue tolerances which are enforced by the Federal Food and Drug Administration (FDA) under the Federal Food, Drug, and Cosmetic Act. The pesticide that stays in or on raw farm products or processed foods is called a residue. A tolerance is the concentration of a pesticide that can legally remain on the produce at harvest. The same pesticide may have a different tolerance on different products.

Residues in processed foods are considered to be food additives and are regulated as such. Biocides that are used in production of paper or other material that contacts food must be listed as acceptable for that use by the FDA. Since the antimicrobial (biocide) may move from the packaging materials into the food, leaving residues, a tolerance must be set for these residues.

Most antimicrobial agents should not come in contact with food when properly used. Follow the label directions exactly to be sure you are not breaking the law. If the residue exceeds the tolerance then the product is deemed adulterated or contaminated and may be seized or condemned.

Transportation Regulations

Shipping pesticides and other dangerous substances across state lines is regulated by the Federal Department of Transportation (DOT). DOT issues the rules for hauling these materials. DOT standards tell you which pesticides are dangerous to people and may create a health hazard during transportation.

If you haul pesticides between states, you should know that:

• They must be in their original packages. Each package must meet DOT standards.

• The vehicle must have a DOT-approved sign. Manufacturers must put the correct warning signs on each package.

• Pesticides may not be hauled in the same vehicle with food products.

• You must contact DOT right away after each accident:

-if someone is killed,

-if someone is injured badly enough to go to the hospital,

-if damage is more than $50,000.

• You must tell DOT about all spills during shipment.

Local laws may require you to take additional precautions.

Worker Protection Standards

In October 1992, federal worker protection standards for agricultural employees were enacted. Requirements of these standards include but are not limited to;

• establishment of restricted entry intervals,

• posting and notification of treated areas,

• use of protective clothing, safety devises, hand washing and other methods of protection and decontamination, and

• notification of poison treatment facilities and access to them.

These rules apply to persons involved with the production of agricultural plants. **This rule does not apply to microbial pest management.**

MICHIGAN LAWS

Michigan's environmental laws were recodified in 1995. This impacts two Acts and the related House Bills and Regulations with which pesticide applicators must be familiar. The Pesticide Control Act of 1976, (Act 171, as Amended) and the Groundwater and Freshwater Protection Act (Act 247) have been incorporated as parts of Act 451, Natural Resources and Environmental Protection Act.

Act 451, Natural Resources and Environmental Protection Act

Part 83, Pesticide Control, Sections 8301 to 8336

(Formerly Michigan Pesticide Control Act, Act No. 171)

The Michigan Legislature passed the Pesticide Control Act of 1976 to assure that pesticides are properly registered and applied. The Act was amended and updated it twice. Because Michigan's environmental laws were recodified in 1995, it is now Part 83, Pesticide Control, Sections 8301 to 8336.

This legislation gives the director of the MDA authority to register or certify private and commercial applicators and to prescribe standards for certification and registration. The MDA also:

- registers, suspends and cancels pesticide registrations used in Michigan;
- investigates the use and misuse of pesticides;
- enacts rules;
- licenses restricted use pesticide dealers and firms performing pesticide applications for hire; and
- issues oral and written orders.

The 1993 amendments provided the MDA the ability to develop an EPA-acceptable State Management Plan (SMP) for pesticides that may pose a threat to groundwater quality. (See p. 75, Act 457, Part 87.)

Two classes of applicators are defined under this pesticide law: private and commercial. Within each class, applicators may be certified applicators or registered technicians.

1) Private applicators. Persons using or supervising the use of restricted use pesticides in the production of an agricultural commodity on their own or their employer's land, or on lands rented by them, are private applicators. "Production of an agricultural commodity" means production for sale into commerce and includes crops, livestock, ornamentals, forest products and other products regarded as agricultural commodities.

To become a certified private applicator, an individual must complete an application form, pay the $10 certification fee and pass a written multiple-choice/true-false examination relating to the information found in Part A and Part B of the Core Manual E-2195.

Private applicators are required to keep pesticide application records.

2) Commercial applicators. A commercial applicator is any person other than private applicators applying pesticides.

Subclass A - Any person (including homeowners) who uses or supervises the use of restricted use pesticides (RUPs) for a non-agricultural purpose.

Subclass B - Any person who either:

(i) Applies pesticides other than ready-to-use pesticides in the course of his or her employment.

(ii) Or, applies a pesticide for a commercial purpose (for hire).

Applicators included in subclass A must be certified as commercial applicators. Those in subclass B have the option of becoming certified commercial applicators or registered technicians (applicators). Because pesticides are used in a wide variety of operations, commercial applicators are certified or registered in special commodity or site-specific categories.

Commercial applicators who purchase or apply pesticides must keep records. (See "State Law: Regulation 636" in this chapter.)

Commercial registered technicians. A subclass of applicators called **registered technicians** was established in 1988. This classification includes people who are authorized to apply general use pesticides for a commercial purpose or apply general use pesticides as a scheduled and required work assignment. A registered technician working for a licensed pesticide applicator firm may apply general use pesticides under **supervision** of a certified applicator and restricted use pesticide (RUPs) while under **direct supervision**. The intent of this portion of the Act is to establish minimum competency standards for all commercial applicators.

To become a registered technician you must pass the core examination which tests your knowledge on general pesticide information found in this manual. A manual and test has been developed combining the core manual and 5B microbial pest management information. Please read the preface of this manual to be informed about changes that will occur in the structure of this manual at the time of the next printing (core and category information will be in separate manuals). Next, you must undergo "category specific training." The category-specific training must be designed to deliver specific information to properly prepare you for your job tasks. The training must be approved by the MDA and administered by an MDA approved trainer.

To become a registered technician in any category (besides microbial pest management), you must pass an examination that tests your knowledge on the information found in Part A of the Pesticide Applicator Core Training Manual (E-2195). Next, you must undergo category-specific training by an MDA-approved trainer.

All employees of businesses such as veterinary clinics, golf courses, outdoor and indoor pest control operations, industrial sites, hospitals, schools, municipalities, nurseries, licensed pesticide application businesses, etc., who *apply pesticides other than general use, ready-to-use pesticides* must either be certified applicators or registered technicians.

Act 451, Part 83 defines, among other things, general use pesticide and ready-to-use pesticides as follows:

General use pesticide means a pesticide that is not classified as a restricted use pesticide.

Ready-to-use pesticide means a pesticide that is applied directly from its original container consistent with label directions, such as an aerosol insecticide or rodent bait box, which does not require mixing or loading prior to application.

According to the definitions of private or commercially certified applicators and registered technicians, persons who use only general use, ready-to-use pesticides and who are not required to be licensed as a pesticide business (a non-licensed, commercial purpose) are exempt from certification or registration requirements (e.g., hospital or school employees). Aerosols, pump sprays, strips, ready-to-use baits, etc., are included in the "ready-to-use" group. This exemption applies only to applicators who are not operating on a for-hire basis (license required).

Reciprocity. Each state has its own certification regulations. An agreement between states to allow certified applicators who are residents in one state to obtain certification credentials to use pesticides without taking exams in the other state is called reciprocity. Currently, Michigan has reciprocal agreements with Indiana, Ohio and Wisconsin.

Commercial pesticide application *business* license. Any business established to apply pesticides for hire must obtain an annual **commercial pesticide applicator license** by sending an application and fee to the MDA. Such businesses must employ at least one certified commercial applicator before the license can be issued. Note that the business is licensed, and the applicator is certified. The business must also provide proof of insurance as required by Regulation 636 (R 285.636.14, Financial responsibility).

An applicator may not obtain a **commercial pesticide applicator license** for a business without first meeting the necessary experience requirements. Businesses applying for a license must have one person with at least two years of pesticide application experience or the equivalent, or one year of application experience and a four-year college degree in a related discipline.

Restricted use pesticide dealer's license. Any person or business wishing to sell or distribute RUPs must obtain an **RUP dealer's license** from the MDA. The licensed dealer must keep records on the sale of any RUP and submit those records each month to the MDA. It is illegal to sell or distribute RUPs to anyone who is not a certified applicator.

Penalties. Significant criminal **penalties exist for violators** of the Pesticide Control Act:

- Private and commercial applicators are subject to administrative fines of up to $1,000 per violation of any provision of the act.

- Commercial applicators who knowingly violate this act can be fined up to $5,000. If the violation is with malicious intent, the applicator can be fined up to $25,000.

The MDA is responsible for investigating pesticide misuse and failures of pesticides to perform when used in accordance with label instructions. If you have a complaint involving a pesticide or suspect pesticide misuse or failure, notify the nearest MDA office as soon as possible. Delays greatly reduce the chances of a satisfa ctory investigation.

Preemption and local ordinances. This house bill amends Act 451, Pesticide Control, which makes it illegal for a local unit of government to enact, maintain or enforce an ordinance, regulation or resolution that duplicates or conflicts with the Pesticide Control Act. A local government may enact an ordinance in certain situations. The Agriculture Commission must approve the local ordinance.

Pesticide use at schools. This bill requires that at the beginning of each school year, school administrators must notify parents and guardians of children attending that school (including day care centers) of the right to be informed prior to any application of a pesticide at that school.

Regulation 636 – Pesticide Applicators

As part of Act 451, this regulation establishes the two types of applicators as discussed above —private and commercial. The regulation also sets the criteria for registered applicator standards. It states that persons who do not work for a licensed pesticide applicator and who use general use, ready-to use pesticides are exempt from the certification or registration requirements. All other persons and businesses that apply pesticides for hire, such as using flea shampoos on animals or treating pests in agricultural fields, homes, lawns, schools or industrial systems for pay, must satisfy the regulation's requirements. The following are some of the primary components of Regulation 636 and are not intended to represent the regulation in its entirety. Check the actual regulation for details.

Regulation 636 expanded the pesticide **recordkeeping** requirements. All commercial applicators shall maintain records of pesticide use for a time period not less than the following:

- **General use pesticides.** One year following application.

- **Restricted use pesticides.** Three years following the application.

All records shall contain the following:

A) The name and concentration of the pesti cide applied.

B) The amount of pesticide applied.

C) The target pest or purpose.

D) The date the pesticide was applied.

E) The address or location of pesticide application.

F) Where applicable, the method and rate of application.

The records must be made available to the MDA upon request.

Regulation 636 also enacted the **registered technician** classification for pesticide applicators as a minimum competency standard. Part of Regulation 636 and the registered technician program involves **approved trainers**.

Approved trainers are certified applicators who have two years' experience in the category they intend to train in and who have participated in a designated seminar to earn credentials making them eligible to train registered technicians.

Regulation 636 also provides an exemption from some provisions of the Act for **incidental uses**. An individual or firm may make a written request to the MDA for an exemption to the registered technician or certified applicator requirement if they meet the following conditions:

- A general use pesticide is used.
- The person is not regularly engaged in the application of pesticides for hire.
- The pesticide application is an integral part of another operation.

Regulation 637 – Pesticide Use

Regulation 637 of Act 451, Pesticide Control, sets standards for pesticide use. It requires that pesticides be used in a manner consistent with their labels, that applications be made in a manner that prevents off-target discharges of pesticides, and that pesticide application equipment be properly calibrated and in sound mechanical condition. The following rules are found in Regulation 637.

RULE -

1-3) Establish definitions and terms.

4) Requires specific conduct of all pesticide applicators to protect people and the environment.

5) Establishes a registry of persons who must be notified before ornamental or turf pesticide applications occur on adjacent properties.

6-7) Require the use of containment structures for certain mixing/loading and washing/rinsing operations of commercial applicators.

8) Defines acceptable means for disposing of pesticides and pesticide-containing materials by all applicators.

9) Requires all applicators to use the personal protective equipment (PPE) required by the label and establishes minimum PPE requirements for commercial applications.

10) Addresses avoidance of off-target drift and use of Drift Management Plans by all applicators.

11) Calls for the posting of certain areas treated commercially with pesticides and notification of the public prior to right-of-way and community pesticide applications.

12) Requires commercial service agreements that include application and risk/benefit information to be supplied to the customer.

13) Prohibits false claims regarding pesticide safety.

14) Requires commercial applicator training in integrated pest management and use of IPM programs in certain areas.

15) Describes manners of commercial pesticide use in and around schools.

16) Establishes a registry of certified organic farms.

Obtain a copy of Regulation 637 to understand the components of each rule and how your pest management practices must comply. Regulation 637 became effective in 1992.

Regulation 640 – Commercial Pesticide Bulk Storage

Commercial applicators, dealers, wholesalers, and/or service-type operations that store pesticides in bulk quantities fall under the regulatory requirements of Regulation 640 of Act 451. If **BOTH** of the following conditions apply to your facility or operation, it must be registered annually with the MDA.

1.) Stores pesticides in individual quantities greater than 55 gallons (liquid) or 100 pounds (dry).

2.) Distributes these bulk pesticides as a direct sale or as part of a service you perform.

Regulation 640 sets rules for commercial pesticide storage (refer to the actual regulation for details) regarding:

- Registration.
- Siting of the storage facility.
- Primary (tanks and plumbing) and secondary containment (diking).
- Liquid level gauging.
- Venting.
- Security.
- Operational area containment (pad).
- Containment area management.
- Abandoned containers and site closure.
- Bulk dry pesticide storage.
- Discharge response plan.
- Inspection, maintenance, recordkeeping.
- Remediation.

- Advisory information (other agency regulations).

For more information, contact your local MDA office or call (517) 373-6544.

Act 451, Natural Resources and Environmental Protection Act

Part 87, Groundwater and Freshwater Protection, Sections 8701 to 8717 (formerly Michigan Groundwater and Freshwater Protection Act, Act 247)

The Groundwater and Freshwater Protection Act was enacted in 1993 and was recodified and incorporated into the Act 451, Natural Resources and Environmental Protection Act as Part 87, Sections 8701 to 8717. This law allows the MDA to satisfy the EPA requirements for State Management Plans (SMP). The SMPs outline the actions that will be taken to prevent pesticides, particularly those that may pose a threat to groundwater, from causing environmental harm. Without the SMP, the MDA would not be able to register certain pesticides (those that may pose a threat to groundwater) for use in Michigan. Those pesticides that currently require an SMP to be in place include alachlor, atrazine, bromacil, carbofuran, cyanazine, metolachlor, metribuzin and simazine.

The Groundwater and Freshwater Protection Act allows the MDA to promote pesticide education, technical assistance and cost-share programs for persons interested in joining a groundwater stewardship program. A key component of this program is the development of groundwater stewardship practices designed to protect groundwater.

Information, demonstration and technical assistance programs are provided for persons interested in implementing the groundwater stewardship practices. For more information, contact the MDA Pesticide and Plant Pest Management Division, Groundwater Program, at (517) 335-6545.

The Safe Drinking Water Act maximum contaminant levels (MCL) -1994.

Primary contaminants	Maximum contaminant level (MCL)
Organic chemicals - pesticides and PCBs	
Endrin	0.002mg/l
Lindane	0.0002 mg/l
Methoxychlor	0.04 mg/l
PCBs	0.0005 mg/l
Toxaphene	0.003 mg/l
Silvex 2,4,5-TP	0.05 mg/l
2,4-D	0.07 mg/l
Alachlor	0.002 mg/l
Atrazine	0.003 mg/l
Chlordane	0.002 mg/
Dalapon	0.2 mg/l
Dinoseb	0.007 mg/l
Heptachlor	0.0004 mg/l
Heptachlor Epoxide	0.0002 mg/l
Hexachlorobenzene	0.001 mg/l
Hexachloro-cyclopentadiene	0.05 mg/l
Picloram	0.5 mg/l
Simazine	0.004 mg/l

Hazardous Waste Regulations

The Michigan Department of Environmental Quality (MDEQ) formerly Michigan Department of Natural Resources (MDNR), Waste Management Division, administers both the federal Resource Conservation Recovery Act (RCRA) and state (Act 64) hazardous waste regulations. Pesticide applicators must be aware of these regulations because many of the waste materials that are generated by an applicator may be hazardous. When waste is classified as a hazardous waste, strict disposal and handling requirements must be followed. Questions about hazardous waste requirements should be directed to the MDEQ Waste Management Division at (517) 373-2730.

Containers that have held certain products or wastes can be hazardous if they are not empty and triple-rinsed or power-rinsed. To ensure that a container is nonhazardous, triple-rinse or power-rinse (with a high pressure nozzle) the container when it is empty before disposal. Such containers may be placed in a licensed Type II sanitary landfill. Remember that no free liquid chemicals can be placed in any landfill in the state.

The Waste Management Division of the Michigan Department of Environmental Quality (MDEQ) administers two acts that may require information to be filed for certain industrial activities relating to microbial pest management. Understand and comply with the following acts and their reporting requirements.

A. "Critical Materials and Waste Water," Act 293 P.A. 1972. Specific forms are required to be filled out each year to comply with this act. The reporting deadline is April 1 of each year.

B. "Industrial and Commercial Waste Water Discharge Application", Act 245 P.A. 1929, as amended, requires a three-or five-year permit to be filed and requires monthly reporting. This form represents the National Pollution Discharge Elimination System (NPDES) and is typically required for direct discharges to surface or ground water.

A site or facility may be required to file both of the above reports. A third possible reporting requirement is with the local or municipal sewer authority. Check with them for guidelines.

Any spills or discharges of any polluting material (pesticides) that can potentially reach surface or groundwater must be contained. Spills or discharges of pesticides must be reported to the Pollution Emergency Alerting System (PEAS) at 1-800-292-4706. For response assistance you may also call 1-800-405-0101, the Michigan Department of Agriculture Spill Response hot-line.

Michigan Occupational Safety and Health Act

The Michigan Department of Public Health (MDPH) and the Michigan Department of Labor (MDOL) jointly enforce the **Michigan Occupational Safety and Health Act (MIOSHA)**, Act 154, which was amended in 1986 to include what is commonly known as the Michigan Right-to-Know Act. This act incorporated the Federal Hazard Communication Standard into the MIOSHA Right-to-Know Act.

The MIOSHA Right-to-Know requires employers to:

- Obtain and retain Material Safety Data Sheets (MSDS) on all hazardous chemicals for employee review which includes pesti cides. These can be obtained from pesticide distributors at the time of purchase or upon request.
- Develop and implement a written employee training program.
- Ensure that all containers of hazardous materials are properly labeled.

If you have concerns or complaints about MIOSHA Right-to-Know, notify either MDPH, Division of Occupational Health, at (517) 335-8250 or MDOL, Division of Safety Standards, at (517) -322-1809. Pesticides are not exempt from the provisions of the MIOSHA Right-to-Know Act.

Occupational Safety and Health Act (OSHA)

The federal Occupational Safety and Health Administration (OSHA) is in the Department of Labor (DOL). OSHA record keeping and reporting requirements apply to employers with 10 or more workers. The records must include all work related deaths, injuries, and illnesses. Minor injuries needing only first aid treatment need not be recorded. A record must be made if the injury involves any of the following:

- Medical treatment;
- Loss of consciousness;
- Restriction of work or motion;
- Transfer to another job.

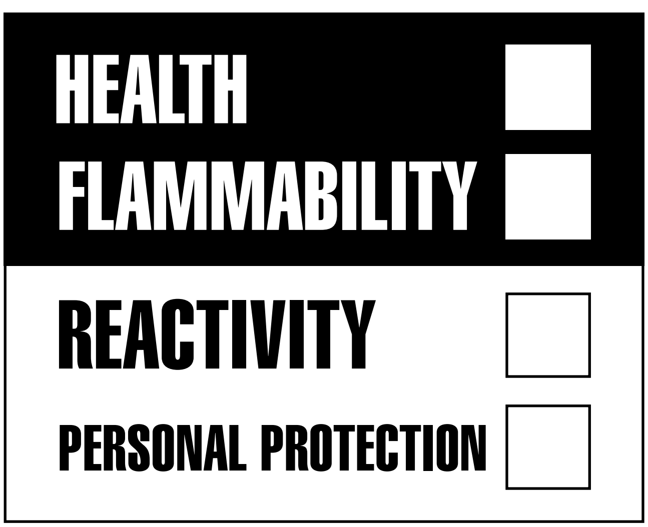
Regardless of the number of employees you have, if there is a work-related death or if five or more employees are hospitalized, OSHA must be notified within 48 hours.

Three Methods of Rating Hazardous Materials

Material Safety Data Sheets (MSDS) - In compliance with OSHA and its final rule on Hazard Communication (29 CFR1910.1200) issued November 25, 1983, manufacturers of antimicrobial agents and certain other chemical products have developed Material Safety Data Sheets (MSDS) as an effective means of informing those workers handling such products of any hazards that may exist. These data sheets identify the hazardous chemical components of each product, physical data, the fire and explosion dangers, and potential threats to the safety of persons using the product. First aid procedures, product reactivity data, spill or leak procedures, and other special precautions are also listed. The MSDS for each product must be on file and readily available if the need should arise. Before handling biocides, have workers read both the label and MSDS to avoid product misuse and possible injury.

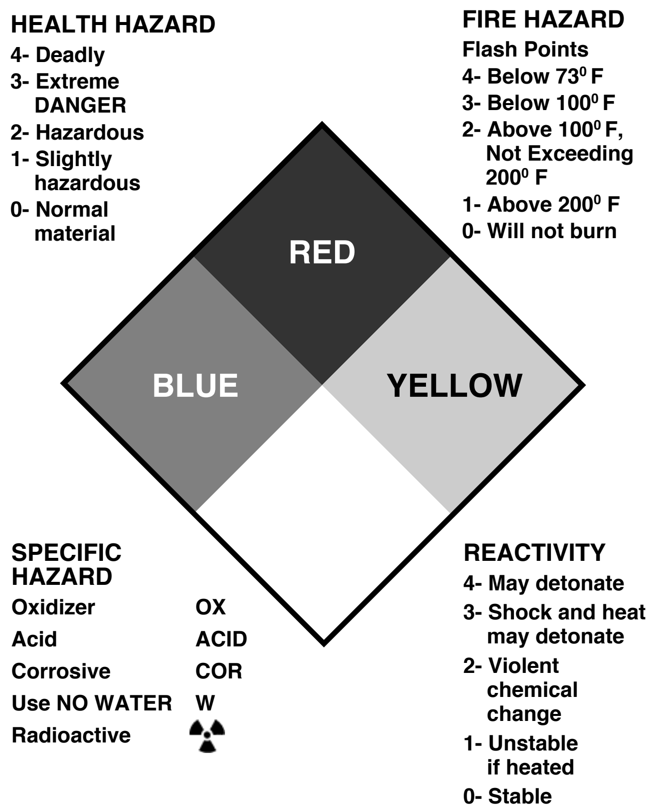
Hazardous Materials Identification System (HMIS) - In addition to the Material Safety Data Sheets, there is the Hazardous Materials Identification System, or HMIS program, developed by the National Paint and Coatings Association. Because raw material suppliers are the most knowledgeable about the inherent properties of their products, they also are the best qualified to provide HMIS information.

Once familiar with the HMIS numerical ratings, they serve as a quick assessment of a product's hazard. The ratings are expressed on a scale from zero to four, with zero denoting a minimal hazard and four denoting a severe hazard. Rated by this code are the health, flammability, and reactivity hazard. There is a separate code system for personal protection equipment needed to handle the product and designation of chronic health hazards. While much of the HMIS material is aimed at protection of workers formulating the product it can also be used for the benefit of the user. For example, there are labels with rating hazards attached to the product.



Example of a Hazardous Materials Identification System label.

National Fire Protection Association (NFPA) - Another hazardous rating system that may appear on some products is the NFPA Hazard Classification System. This system uses a diamond-shaped warning symbol. The top, left, and right boxes refer to flammability, health, and reactivity hazards, respectively, and contain a number from 0 to 4. The bottom box is used for special hazards; the most common of these is a warning against the use of water. See the diagram below.



Review Questions - Chapter 9- Pesticide Laws and Regulations

Write the answers to the following questions, and then check your answers with those in the back of this manual.

1. The basic federal law regulating pesticides is referred to as ___________.

2. Restricted use pesticides can be sold only to ____.

3. Restricted use pesticides can be used by any person, at any time, as long as they are purchased by a certified applicator. (True or False)

4. For each pesticide product that may have an effect on an endangered species, the Endangered Species Act requires that the pesticide labeling include a list of states and counties where the product affects the endangered species and pesticide application is restricted. (True or False)

5. SARA Title III requires that _________________ who store(s) a specified quantity of an EPA designated "extremely hazardous substance" must notify proper authorities.

a. commercial applicators
b. dealers
c. farmers
d. anyone

6. The pesticide that stays in or on raw farm products or processed foods is called a __________________. A ________________ is the concentration of a pesticide that can legally remain on produce at harvest.

a. residue, tolerance
b. tolerance, residue
c. reciprocity, toxicity
d. toxicity, reciprocity

7. Shipment of pesticides and other dangerous substances across state lines is regulated by the ____.

8. Who administers the pesticide applicator certification program in Michigan?

9. Farmers who apply restricted use pesticides are private applicators. (True or False)

10. What must a *certified* private applicator do to provide "direct supervision" for a noncertified applicator? What must a certified *commercial* applicator do to provide "direct supervision" when required by pesticide labeling?

11. Any person (including homeowners) who uses or supervises the use of RUPs for a nonagricultural purpose must be a:

a. private applicator
b. commercial applicator

12. Employees of golf courses, hospitals, and schools who apply pesticides (other than general-use, ready-to-use products) as part of their work assignment must be either certified or registered. (True or False)

13. Commercial applicators are not required to keep records of RUP applications. (True or False)

14. What is reciprocity?

15. Any business established to apply pesticides for hire must obtain a commercial pesticide applicator license and employ:

a. three or more people.
b. at least one certified commercial applicator.
c. at least one registered technician.
d. none of the above. There are no hiring requirements.

16. Commercial and private applicators may be fined for unlawful conduct under Act 451 Pesticide Control. (True or False)

17. Who investigates complaints about pesticide misuse and pesticide failures in Michigan?

18. The ________________________________ administers both the federal (RCRA) and state (Act 64) hazardous waste regulations in Michigan.

19. Pesticide containers may be placed in a licensed Type II sanitary landfill only if they have been triple rinsed or power rinsed. (True or False)

20. SARA Title III requires that you must notify authorities if you are responsible for storing a specified quantity of an EPA-designated "extremely hazardous substance." (True or False)

21. Farmers do not have to comply with the requirements of SARA Title III. (True or False)

22. What are the MIOSHA Right-to-Know requirements for employers?

23. OSHA requires that anyone with ten or more employees keep records and make periodic reports of all work-related deaths, injuries and illnesses. What are the guidelines for whether or not an injury must be recorded to comply with OSHA regulations?

Answer Key to Microbial Pest Management Review Questions

Introduction & Chapter 1
Pests and Pest Management

1. e
2. True
3. True
4. Use of all available tactics or strategies to manage pests so that an acceptable yield and quality can be achieved economically with the least disruption to the environment.
5. Mechanical
6. Detection, identification, economic significance, method selection, evaluation
7. Frequent and careful visual checking, a knowledge of the common microbial pests, an ability to recognize potential problems, periodic bacteria cultures, and a thorough knowledge of the mechanical or processing system.
8. Economic action threshold, economic injury level.
9. Humans cannot greatly influence natural controls.
10. Any of the following: biological control, cultural control, legal control, mechanical and physical controls, resistant varieties, sanitation control, and chemical control.

Chapter 2
Pest Identification

1. False
2. True
3. False
4. Flow restriction

   Corrosion

   Reduce heat transfer
5. c
6. b
7. False
8. c
9. a

Chapter 3
Pesticides

1. e
2. 1. Type of pest managed – algaecides control algae.
   2. How pesticides work – contact – kills pest by contact.
   3. Chemistry – oxidizing – chlorine and bromine.
   4. Formulation – liquid formulation.
3. e
4. Algae, fungi, bacteria
5. Broad-spectrum
6. False
7. Chlorine
8. b
9. pH
10. True
11. d
12. False
13. True
14. e
15. Refer to pages 26 and 27.

Chapter 4
Pesticides and the Environment

1. Water table
2. True
3. Drift and blowdown
4. False
5. Chemical and microbial degradation
6. Prevention

Chapter 5
Pesticides and Human Health

1. Toxicity measures the capacity of a pesticide to cause injury. Hazard is the potential for injury.

2. True. Wear a hat.

3. False

4. Children

5. Inhaling pesticides during mixing, loading, application. Any activity where pesticides enter the mouth: siphoning a pesticide with your mouth, eating or drinking while working with pesticides.

6. Chronic, acute

7. e

8. b

9. b

10. Pesticide label

11. Organophosphates, carbamates

12. Cholinesterase

13. People who work with organophosphates or carbamates for an extended time.

14. Pesticide label

15. Remove contaminated clothing; drench skin with water; wash with soap and rinse twice; dry and wrap person in a blanket; cover chemical burns with a loose, clean, soft cloth.

16. e

17. Get to fresh air; loosen tight clothing; give mouth-to-mouth resuscitation if needed; keep victim quiet; prevent chilling.

18. Toxicity, exposure

19. False

20. d

21. Wash clothing at the end of each day of use.

22. True

Chapter 6
Pesticide Handling, Storage and Disposal

1. False

2. 5.0 and 7.0

3. See the section entitled "Storage Area," p. 46.

4. b

5. True

6. The date will help you determine if the pesticide is too old to be effective and allows you to use older products first.

7. During mixing, you may see excessive clumping, poor suspension, layering, or abnormal coloration.

8. Apply the pesticide in the recommended manner to another crop or site listed on the label.

9. See the section entitled "Cleaning and Disposing of Containers," p. 48.

10. Michigan Department of Environmental Quality Waste Management Division

11. False

12. In the back of a truck.

13. True

14. Pesticides containing oils or petroleum solvents.

15. Any of the points listed under the section "Pesticide Fire Safety," p. 49.

16. Clear everyone from the area.

Chapter 7
The Pesticide Label

1. True

2. True

3. False

4. d

5. False

6. True

7. Health and safety information about a particular pesticide. They are available from chemical dealers.

8. Yes

9. No

10. d

11. False

12. Yes, birds, fish and bees.

13. False

Chapter 8
Pesticide Application Equipment

1.
   1. Liquid pesticide added to water system manually or through a pump.
   2. Liquids applied with tank sprayer for special applications.

3. Compressed powders added manually or through a tablet feed device.

2. The movement of pesticides through the air to nontarget areas as solid or liquid particles or as vapors.

3. First, flush the pump and hoses (suction and discharge) with water to remove residual biocide. Redirect the injection valve from the treated system into a graduated container (showing ounces of fluid). Manually activate the timer for a designated period of time and measure the amount of water that is pumped during this time frame. Adjust the pump settings as required to produce the correct dosage.

4. Manual feeding of biocides subjects the applicator to potentially more exposure; and manual feeding is more labor intensive.

5. $$\frac{145 \text{ ppm} \times 10{,}000 \text{ gal.} \times 8.34 \text{ lbs./gal}}{1{,}000{,}000} = 12.09 \text{ lbs of product}$$

6. Removing infestations from cooling tower air diffusers, and for disinfecting towers, tanks, screens, slats, etc. when system is drained and out of service.

7. Broadcast, directed-spray, spot treatment, aerosol and fog generators.

8. The pesticide label.

9. 900 ft. X 0.16 gal. = 144 gals.;

144 gal. + 100 gal. = 244 gals.;

$$\frac{125 \text{ ppm} \times 244 \text{ gal} \times 8.34 \text{ lbs/gal}}{1{,}000{,}000} = 0.25 \text{ lbs of biocide}$$

10. 12 ft. X 7 ft. X 5.5 ft. = 462 cubic ft.:

462 cu. ft. X 7.48 gal/cu.ft. = 3455.7 gallons;

3455.7 gal. X 50 oz./1,000 gal. = 172.8 oz of algaecide

11. $$\frac{72{,}000 \times 15 \text{ lbs salt}}{110 \text{ ppm} - 53 \text{ ppm}} = 18{,}947.4 \text{ gallons}$$

Chapter 9
Pesticide Laws & Regulations

1. FIFRA
2. Certified pesticide applicators.
3. False
4. True
5. d
6. a
7. Department of Transportation.
8. Michigan Department of Agriculture.
9. True
10. A private certified applicator must be physically present the first time a noncertified applicator uses a particular RUP. This includes supervising: equipment calibration, mixing, application, operator safety, and pesticide disposal. A certified commercial applicator must be physically present during a commercial application of an RUP.
11. b
12. True
13. False
14. Agreements between states to allow certified applicators in one state to use pesticides in another state.
15. b
16. True
17. Michigan Department of Agriculture.
18. Michigan Department of Environmental Quality.
19. True
20. True
21. False
22. Make available to employees MSDS on all hazardous chemicals; develop and implement a written employee training program; ensure that all containers of hazardous materials are properly labeled.
23. If the injury involves any of the following: medical treatment; loss of consciousness; restriction of work or motion; transfer to another job.

GLOSSARY

Abiotic: Not relating to living organisms.

Absorption: The uptake of a chemical into plants, animals, or minerals. Compare with adsorption.

Active ingredient: A component of a pesticide product which has pesticidal activity. Active ingredients are normally mixed with inert or inactive ingredients in the formulation process.

Acute exposure: Exposure to a single dose of pesticide.

Acute toxicity: A measure of the capacity of a pesticide to cause injury as a result of a single exposure.

Additive: Same as adjuvant.

Adherence: Sticking to a surface.

Adjuvant: A chemical added to a pesticide formulation to increase its effectiveness or safety.

Adsorption: The binding of a chemical to surfaces of mineral or soil particles. Compare with absorption.

Adulterated: (1) A pesticide whose strength or purity falls below that specified on the label. (2) A food, feed, or product that contains illegal pesticide residues.

Aerobe: An organism that requires oxygen for growth.

Agitation: The process of stirring or mixing in a sprayer.

Algae: A group of photosynthetic aquatic organisms containing chlorophyll, which may occur as simple cells or as long strands of cells.

Allelopathy: The production of growth inhibitors by one plant which retard the development of another plant.

Anaerobe: An organism which does not require oxygen for its growth.

Annuals: Plants that complete their life cycle within one year.

Antagonism: The loss of activity of a chemical when exposed to another chemical.

Antibiotic: Chemical compounds produced by microorganisms which are toxic to other microorganisms.

Antidote: (1) A chemical applied to prevent the phytotoxic effect of a specific herbicide on desirable plants. (2) A practical treatment for poisoning, including first aid.

Anti-siphoning device: An attachment to the filling hose designed to prevent backward flow into the water source.

Aquatic plants: Plants which grow on, in, or underwater.

Aqueous: Indicating the presence of water in a solution or environment.

Attractants: Substances that lure insects to traps or to poison-bait stations.

Avicide: A chemical used to control birds.

Bacteria: One-celled microorganisms able to grow independently without the presence of light. The cells may be spherical, spiral, or rod shaped.

Band application: Placement of a pesticide in a narrow area either over or along the crop row.

Beneficial insects: Those insects which are useful to people, e.g. predators and parasites of pest species, bees and other pollinators.

Bioaccumulation: The buildup of pesticides in the bodies of animals (including humans), particularly in fat tissue.

Biocide: A chemical able to kill microbial organisms.

Biological control: Control by predators and parasites, either naturally occurring or introduced.

Biological degradation: The breakdown of a pesticide due to the activities of living organisms, especially bacteria and fungi.

Biology: The science that deals with the structure, function, development, evolution, and ecology of living organisms.

Biotic: Relating to living organisms.

Biotype: Usually refers to a subdivision of a race.

Blowdown: The amount of circulating water which is discharged to waste water to limit the concentration of dissolved solids. Sometimes also known as "bleed-off."

Brand name: The specific, registered name given by a manufacturer to a pesticide product; same as trade name or proprietary name.

Broadcast application: The uniform application of a pesticide to an entire field or area.

Broad-spectrum pesticide: A pesticide that is effective against a wide range of pests or species.

Calibration: Measurement of the delivery rate and distribution of application equipment.

Carbamate: A synthetic organic pesticide containing carbon, hydrogen, nitrogen, and sulfur.

Carcinogen: A substance which has the ability to cause cancer.

Carrier: A liquid or solid material added to a pesticide active ingredient or formulated product to facilitate its field application.

Caution: Signal word associated with pesticide products classified as either slightly toxic or relatively nontoxic.

Cell: The basic structural unit of all living organisms: An organism may be composed of a single cell (e.g. bacteria) or many cells working together (all "higher" organisms, including man).

Chemical degradation: The breakdown of a pesticide by oxidation, reduction, hydrolysis or other chemical means.

Chemical name: The scientific name of an active ingredient which complies with accepted guidelines established by chemists.

Chemigation: The application of an agricultural chemical by injecting it into irrigation water.

Chlorophyll: The green photosynthetic substance in plants which allows them to capture solar energy.

Cholinesterase: An enzyme found in animals that helps control the activity of nerve impulses.

Chronic exposure: Exposure to repeated doses of a pesticide over a period of time.

Chronic toxicity: A measure of the capacity of a pesticide to cause injury as a result of repeated exposures over a period of time.

Closed mixing system: Systems in which liquid pesticide concentrates are transferred from their original containers to mix or spray tanks through a closed series of hoses, pipes, etc.; they are designed to prevent or reduce exposure to the concentrates.

Coliform: A specific group of Bacillus bacteria associated with human or animal excreta.

Common name: (1) The standard, commonly-used name of a pesticide active ingredient established by appropriate professional societies. (2) A commonly used name of a particular species. Unlike scientific names, there may be a number of common names for the same species.

Compatibility agents: Chemicals that enhance the effective mixing of two or more pesticide products.

Concentration: The amount of active ingredient or herbicide equivalent in a quantity of diluent expressed as percent, lb/gal, kg/l, etc.

Cross contamination: When one pesticide gets into or mixes with another pesticide accidently; usually occurs in a pesticide container or in a poorly cleaned sprayer.

Cultural control: Control by changing management practices to reduce pest numbers without the use of pesticides.

Danger: Signal word associated with pesticide products that are highly toxic by acute toxicity tests (LD50) or may cause skin irritation or eye effects more severe than suggested by the LD50 of the product.

Days to harvest: The minimum number of days allowed by law between the final application of a particular pesticide and the harvest date.

Deflocculating agent: A material added to a suspension to prevent settling.

Degradation: The breakdown of a pesticide into a simpler compound which is usually, but not always, nontoxic; degradation may be either chemical, physical, or biological or any combination of the three.

Deposit: The amount of a pesticide on a treated surface immediately following an application.

Dermal: Of the skin; through or by the skin.

Dermal Toxicity: Ability of a chemical to cause injury when absorbed through the skin.

Diatoms: Algae that have structured cell walls containing silica.

Diluent: Any liquid or solid material used to dilute or carry an active ingredient.

Dilute: To make thinner by adding water, another liquid or a solid.

Directed-spray application: A herbicide is directed specifically at target weeds in an effort to minimize contact with crop.

Dispersing agent: A material that reduces the attraction between particles.

Dormant: State in which growth stops temporarily. May refer to plants, plant parts, microorganisms, and certain animals.

Dose, dosage: Quantity of a pesticide applied.

Drift: (1) The movement of pesticides through the air to nontarget areas either as solid or liquid particles or as vapors. (2) (Legal definition) The drifting or movement of pesticide by air currents or diffusion onto property beyond the boundaries of the target area to be treated with pesticide, other than by pesticide over-spray.

Dust: A finely-ground, dry pesticide formulation in which the active ingredient is combined with an inert carrier such as talc, clay, powdered nut hulls, or volcanic ash; dusts are applied in the dry form.

Ecology: The science which studies the interrelationships of living organisms and their environment.

Economic damage: The amount of injury which will justify the cost of applied control measures.

Economic injury level: The population density at which a pest causes a reduction in the value of the crop that is greater than the cost of control.

Economic threshold or action threshold: The population density at which management measures should be instituted to prevent an increasing pest population from reaching the economic injury level.

Emulsifiable concentrate (EC or E): A pesticide formulation produced by mixing the active ingredient and an emulsifying agent in an organic solvent.

Emulsifier: A substance which facilitates the formation and maintenance of an emulsion.

Encapsulated pesticide: A pesticide formulation in which the active ingredient is encased in extremely small capsules made of inert synthetic polymers. The pesticide is released gradually over a period of time.

Endangered species: A group of organisms on the brink of extinction.

Entomology: The science that deals with the study of insects.

Environment: All of our physical, chemical, and biological surroundings such as climate, soil, water and air and all species of plants, animals and microorganisms.

Enzymes: Proteins that increase the rate of specific chemical reactions.

EPA: The Environmental Protection Agency.

Epidemic: A temporary widespread outbreak of a disease.

Epinasty: That state in which more rapid growth on one side of a plant organ or part (especially leaf) causes it to bend or curl downward.

Eradication: The complete elimination of a pest from a site, area or a geographic region.

Erosion: Movement of soil and associated materials, principally by water and wind.

Exposure: To come in contact with a pesticide.

FDA: Food and Drug Administration.

FIFRA: The Federal Insecticide, Fungicide and Rodenticide Act: federal law dealing with pesticide regulations and use.

Filamentous algae: Algae that occur as long strands of cells.

Filamentous fungi: Fungi with an end-to-end arrangement of cells to form colorless branch filaments.

Flowable (F or L): A pesticide formulation in which the active ingredient is impregnated on a diluent such as clay which is then finely ground and suspended in a small amount of liquid; the resulting "paste" or "cream-like" formulation is added to water in the spray tank and forms a suspension.

Foaming agent: A material designed to reduce drift, which causes a pesticide mixture to form a thick foam.

Foliar application: Application of a pesticide to the aerial portions of either a crop or weed.

Food chain: A group of plants, animals, or microorganisms linked together as sources and consumers of food.

Formulation: The pesticide product as purchased, usually consisting of a mixture of active and inert ingredients.

Fumigants: Pesticides or mixtures of pesticides which produce vapors that are toxic when absorbed or inhaled.

Fumigation: The application of a fumigant.

Fungi: A group of lower parasitic plants lacking chlorophyll. Fungi are generally colorless, but may appear with a variety of colors (black, brown, green, pink, etc.) due to the color of the reproductive spores.

Fungicide: A chemical used to control fungi.

GPA: Gallons per acre.

GPM: Gallons per minute.

Gram-negative bacteria: Bacteria which do not retain the primary dye of the Gram stain procedure used for identifying bacteria.

Gram-positive bacteria: Bacteria which retain the primary dye of the Gram stain procedure used for identifying bacteria.

Granules (G): A dry pesticide formulation made by applying a liquid formulation of the active ingredient to particles of clay or another porous material. Granules are applied in the dry form and have a particle size substantially larger than dusts.

Herbicide: A chemical used to kill or inhibit plant growth.

Host: An organism such as a plant or animal that is invaded by a parasite and serves as its food source.

Hydrolysis: Decomposition of a chemical compound by reaction with water.

Immune: Not susceptible to a disease or poison.

Impermeable: Cannot be penetrated. Semipermeable means that some substances can pass through and others cannot.

Incompatibility: When two or more pesticides cannot be effectively mixed without a loss in activity, an increase in toxicity or hazard to the applicator, or harm to the crop or the environment.

Inert ingredients: The materials in a pesticide formulation which have no pesticide activity.

Inhalation toxicity: A measure of the capacity of a pesticide to cause injury when absorbed through the lungs.

Inhibition: The process of slowing or stopping plant growth with an herbicide.

Inorganic pesticides: Pesticides of a mineral origin that do not contain carbon.

Insecticide: A chemical used to control insects.

Integrated pest management (IPM): An ecological approach to pest management in which all available techniques are consolidated into a unified program so that pest populations can be managed to avoid economic damage and minimize adverse effects.

Invert emulsion: An emulsion in which water is dispersed in oil -rather than oil in water; invert emulsions are normally quite thick and thus less susceptible to drift.

Invertebrates: A class of animals that lacks a spinal column.

Label: The information printed on or attached to the pesticide container or wrapper.

Labeling: The pesticide label and all additional product information such as brochures and flyers provided by the manufacturer and handouts provided by the dealer.

Larvicide: A pesticide used to kill insect larvae.

LC50: The concentration of an active ingredient in the environment which is expected to cause death in 50 percent of the test species so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas or vapor.

LD50: The dose of an active ingredient taken by mouth or absorbed by the skin which is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD50 of 10 milligrams per kilogram (mg/kg), it is more toxic than one having an LD50 of 100 mg/kg.

Leaching: Movement of a substance downward or out of soil as the result of water movement.

Lethal: Causing or capable of causing death.

Life cycles: The progression of stages in the development of an organism.

Material Safety Data Sheets (MSDS): Sheets of information on toxicity, first aid, personal protection and other safety data. MSDS are available from dealers or manufacturers.

Mechanical control: Pest control by physically altering the environment.

Microbicide: A chemical able to kill microorganisms. Includes bactericides, algaecides, and fungicides.

Microorganism: An organism that can only be seen with a microscope.

Miscible liquids: Two or more liquids that can be mixed and will remain mixed under normal conditions.

Miticide: A chemical used to control mites.

Mode of action: The way in which a pesticide exerts a toxic effect.

Mold: The vegetative phase in the growth of certain fungi displaying long filamentous extensions.

Molluscicide: A chemical used to control snails, slugs and other mollusks.

Mutagenic: Capable of producing genetic change.

Mutation: A change, usually harmful, in inherited genetic material.

Narrow-spectrum pesticide: A pesticide that is effective against only one or a few species; the term is usually applied to insecticides and fungicides.

Natural enemies: The predators and parasites which attack pest species.

Necrosis: Localized death of living tissue such as the death of a certain area of a leaf.

Necrotic: Showing varying degrees of dead areas or spots.

Nematicide: A chemical used to control nematodes.

Nematodes: Small, slender, colorless roundworms that live saprophytically in soil or water or as parasites of plants, animals, or fungi; plant-parasitic nematodes are so small that they cannot be seen except through a microscope.

Neoprene: A synthetic rubber characterized by superior resistance to penetration by pesticides.

Neurotoxic: A pesticide which is harmful to nerve tissue.

Nontarget organisms: All plants, animals and microorganisms other than the intended target(s) of a pesticide application.

Noxious weed: A plant defined as being especially undesirable or troublesome.

Nutrient medium: A specially prepared chemical mixture able to support microorganism growth in the laboratory.

Oil solution: A liquid pesticide formulation in which the active ingredient is dissolved either in oil or some other organic solvent.

Oncogeny: A substance having the ability to cause tumors; the tumor may or may not be cancerous.

Oral: Of the mouth; through or by the mouth.

Oral toxicity: Ability of a pesticide to cause injury when taken by mouth.

Organic compounds: Chemicals that contain carbon.

Organic pesticides: Pesticides that contain carbon; most are synthetic, some are derived or extracted from plants.

Organophosphate: A synthetic organic pesticide containing carbon, hydrogen and phosphorus; parathion and malathion are two examples.

Ovicide: A chemical that destroys eggs.

Parasite: A living organism that obtains all or part of its food from other living organisms.

Pathogen: Any disease-producing organism.

Penetrant: An adjuvant that enhances the absorption of a systemic pesticide.

Percolation: Downward seepage of water through the soil.

Perennials: Plants that live for more than two years.

Persistence: A measure of how long a pesticide remains in an active form at the site of application or in the environment.

Pesticide concentrate: A pesticide formulation as it is sold before dilution.

Pesticide interaction: The action or influence of one pesticide upon another and the combined effect of the pesticide on the pest(s) or crop system.

Pesticide registration: The status given to a product to allow for its sale and use as a pesticide by the Environmental Protection Agency or by the state to meet a special local need.

pH: A measure of the acidity or alkalinity of a solution.

Phloem: The tissue in higher plants which transports organic nutrients manufactured in the leaves to other portions of the plant.

Photodecomposition: Degradation of a pesticide by light.

Photosynthesis: The process in green plants of synthesizing carbohydrates from carbon dioxide and water using light energy captured by chlorophyll.

Physiology: The branch of biology that deals with the functions and activities of living organisms.

Phytotoxicity: Injury to plants due to chemical exposure.

Piscicide: A pesticide used to kill or control fish.

Plant growth regulator (PGR): A substance that increases, decreases or changes in some manner the normal growth or reproduction of a plant.

Plant pathology: The science that deals with nature and causes of plant disease.

Postemergence: After the emergence of a specified weed or crop.

PPB: Parts per billion.

PPM: Parts per million.

PPT: Parts per trillion.

Predator: An animal that attacks, feeds on, and kills other animals.

Preemergence: Before the emergence of a specified weed or crop.

Propagation: Reproduction by either sexual or asexual means.

Propriety name: Same as brand name.

Protectant: A chemical applied to a plant or animal in anticipation of a pest problem to prevent infection or injury.

Protective equipment: Clothing or any other materials or devices that reduce exposure when using pesticides.

PSI: Pounds per square inch.

RCRA: The Resource Conservation and Recovery Act; a federal law that regulates the transport, storage, treatment and disposal of hazardous waste.

Restricted entry interval (REI): The length of time that must elapse after a pesticide application before people who are not using personal protective equipment can enter the treated site.

Registered pesticide: A pesticide approved by the Environmental Protection Agency for use as stated on the label or by the state to meet a special local need.

Registration: The regulatory process designated by FIFRA and conducted by the EPA through which a pesticide is legally approved for use.

Residual pesticide: A pesticide that continues to be effective for an extended period of time after application.

Residue: (1) The amount of a pesticide remaining in or on raw farm products or processed foods. (2) Undesirable persistence of a pesticide at the site of application.

Residue tolerance: The maximum amount of a pesticide that may legally remain in or on a raw farm product intended for consumption by people or livestock.

Resistance (pesticide): The genetically acquired ability of an organism to tolerate the toxic effects of a pesticide.

Respiration: (1) The process by which living cells utilize oxygen to transform the energy in food molecules into biologically useful forms. (2) The act of breathing.

Restricted-use pesticide: Pesticides designated by the Environmental Protection Agency for restricted use because without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator, could occur. A "restricted-use" pesticide may be used only by or under the direct supervision of a certified applicator.

Resurgence: A dramatic increase in the population level of a target pest after a pesticide application due to the destruction of its natural enemies by the pesticide; pest numbers may soon surpass pretreatment levels.

Saprophyte: An organism that obtains its food from dead or decaying organic matter.

Scientific name: The Latin name of the genus and species of an organism, designated by taxonomists and universally accepted. Scientific names are often used to avoid confusion which can result from the use of common names which may vary from one area to another.

Scouting (monitoring): Checking a site on a regular basis and in a prescribed manner to determine pest population levels and the extent of pest damage.

Signal words and symbols: Standardized designations of relative levels of toxicity which, by law, must appear on pesticide labels.

Site: The crop, animal or area infested by a pest and to which a pesticide is applied.

Slime: A mucus layer produced by and surrounding an organism, such as bacteria.

Slurry: A thick suspension of a finely-divided pesticide in a liquid.

Solubility: The capacity of a pesticide to dissolve in a specific solvent.

Soluble: Will dissolve in a liquid.

Soluble powder (SP): A finely ground dry pesticide formulation which forms a true solution.

Solution: Mixture of one or more substances in another in which all ingredients are completely dissolved.

Solvent: A liquid which will dissolve a substance to form a solution.

Special local need (SLN): An existing or imminent pest problem within the state which cannot be adequately controlled by the use of any available federally registered pesticide product. The EPA can approve temporary use of a pesticide to alleviate the need.

Species: The basic unit of taxonomic classification designating a group of closely related individuals who are capable of interbreeding.

Spot treatment: Application of a pesticide to small, discrete areas.

Spreader: A chemical that increases the area that a given volume of liquid will cover on a solid or on another liquid.

Standard plate count: See total bacterial count.

Sterility: The inability of a living organism to reproduce.

Sticker: An adjuvant which increases the ability of a pesticide to stick to treated plant surfaces.

Stomach poison: A pesticide that must be swallowed by an animal to be effective. It will not kill on contact.

Stomata: Minute openings on the surfaces of leaves and stems through which gases (e.g. oxygen, carbon dioxide, water vapor) and some dissolved materials pass into and out of plants.

Strain: A subgroup of a species with a common ancestry and distinguishing physiological characteristics.

Surfactant: A chemical that increases the emulsifying, dispersing, spreading and wetting properties of a pesticide.

Susceptible: Capable of being diseased or poisoned; not immune.

Suspension: Finely divided solid particles mixed in a liquid.

Synergism: The combined activity of two or more pesticides that is greater than the sum of their activity when used alone.

Synthetic chemical: A man-made chemical.

Systemic pesticide: A chemical absorbed and translocated within a plant or animal.

Tank mix: A mixture in the spray tank of two or more pesticide products for simultaneous application.

Target organism/pest: The pest at which a particular pesticide or other control method is directed.

Taxonomy: The classification of living organisms into groups based on similarities and relationships.

Thickeners: Drift control agents such as cellulose, gels, and swellable polymers which cause the formation of a greater proportion of large spray droplets.

Tolerance: (1) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes, or pesticides. (2) The amount of a pesticide that may legally remain in or on raw farm products at time of sale.

Total bacteria count: A measure, expressed in organisms/ml, which provides a relative indication of the total bacterial population in a system.

Total plate count: See total bacteria count.

Toxicant: A poisonous chemical.

Toxicity: A measure of the capacity of a pesticide to cause injury.

Toxin: A poisonous substance produced by a living organism.

Trade name: Same as brand name.

Translocation: The internal movement of food, water, minerals or other materials (e.g. pesticides) from one part of a plant to another.

USDA: United States Department of Agriculture.

Vapor pressure: The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Vascular system: The conducting tissue of plants, composed principally of xylem and phloem.

Vegetative reproduction: Production of new plants from vegetative plant parts such as rootstocks, rhizomes, stolons, tubers, cuttings, etc., rather than from seed.

Vertebrate: An animal with a spinal column.

Virus: An obligate parasite often consisting only of a piece of genetic material surrounded by a protein coat. Viruses are so small that they cannot be seen with an ordinary microscope.

Volatility: The degree to which a liquid or solid changes into a gas (vapor) at ordinary temperatures when exposed to air.

Volatile: Evaporates at ordinary temperatures when exposed to air.

Warning: Signal word associated with pesticide products considered moderately toxic.

Water-dispersible granules: A pesticide formulation in which finely-divided powders are formulated into concentrated, dustless granules which form a suspension in water.

Water-soluble concentrate (WS): A liquid pesticide formulation in which the active ingredient is soluble in water and is formulated either with water or another solvent such as alcohol which mixes readily with water.

Weed: An unwanted plant.

Wettable powder (WP or W): A finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting or dispersing agent; a wettable powder forms a suspension rather than a true solution in water.

Wetting agent: A chemical which causes a liquid to contact surfaces more thoroughly.

Xylem: The tissue in higher plants which transports water, dissolved salts, and other materials (e.g. pesticides) from the roots to aerial portions of the plant.

Yeast: The unicellular growth phase of fungi.

Zone of inhibition: A standardized test of microbicide effectiveness in keeping an area free from microorganism growth. Used to test the ability of treated cooling tower wood to resist fungal attack.

APPENDIX

Convenient Conversion Factors

Multiply	By	To Get
Acres	0.405	Hectares
Acres	4,047.0	Square Meters
Acres	4,840.0	Square Yards
Acres-feet	43,560.0	Square feet
Acre-feet	1,233.49	Cubic Meters
Acre-feet	43,560.0	Cubic Feet
Acre-feet	325,850.58	Gallons
Bushels	0.0461	Cubic yards
Bushels	1.2437	Cubic feet
Bushels	4.0	Pecks
Bushels	32.0	Quarts (dry)
Bushels	35.24	Liters
Bushels	64.0	Pints (dry)
Bushels	2,150.42	Cubic inches
Centimeters	0.3627	Inches
Centimeters	0.01	Meters
Centimeters	10.0	Millimeters
Cubic centimeters	0.0610	Cubic inches
Cubic centimeters	0.03381	Ounces (liquid)
Cubic centimeters	1.0	Milliliters of water
Cubic centimeters	1.0	Grams of water
Cubic feet	0.0283	Cubic meters
Cubic feet	0.0370	Cubic yards
Cubic feet	0.8040	Bushels
Cubic feet	7.4805	Gallons
Cubic feet	25.71	Quarts (dry)
Cubic feet	28.32	Liters
Cubic feet	29.92	Quarts (liquid)
Cubic feet	51.42	Pints (dry)
Cubic feet	59.84	Pints (liquid)
Cubic feet	62.4	Pounds of water
Cubic feet	1,728.0	Cubic inches
Cubic feet	28,317.0	Cubic centimeters
Cubic meters	1.308	Cubic yards
Cubic meters	35.31	Cubic feet
Cubic meters	264.2	Gallons
Cubic meters	1,000.0	Liters
Cubic meters	1,057.0	Quarts (liquid)
Cubic meters	2,113.0	Pints (liquid)
Cubic meters	61,023.0	Cubic inches
Cubic meters	1,000,000.0	Cubic centimeters
Cubic inches	0.000016	Cubic meters
Cubic inches	0.0005	Bushels
Cubic inches	0.0006	Cubic feet
Cubic inches	0.0019	Pecks (dry)

Multiply	By	To Get
Cubic inches	0.0037	Gallons (dry)
Cubic inches	0.0043	Gallons (liquid)
Cubic inches	0.0149	Quarts (dry)
Cubic inches	0.0164	Liters
Cubic inches	0.0173	Quarts (liquid)
Cubic inches	0.0298	Pints (dry)
Cubic inches	0.0346	Pints (liquid)
Cubic inches	0.0361	Pounds of water
Cubic inches	0.5540	Ounces (liquid)
Cubic inches	16.3872	Cubic centimeters
Cubic yards	0.7646	Cubic meters
Cubic yards	21.71	Bushels
Cubic yards	27.0	Cubic feet
Cubic yards	202.0	Gallons (liquid)
Cubic yards	807.9	Quarts (liquid)
Cubic yards	1,616.0	Pints (liquid)
Cubic yards	7,646.0	Liters
Cubic yards	46,656.0	Cubic inches
Cups	0.25	Quarts (liquid)
Cups	0.5	Pints (liquid)
Cups	8.0	Ounces (liquid)
Cups	16.0	Tablespoons
Cups	48.0	Teaspoons
Cups	236.5	Milliliters
Feet	0.3048	Meters
Feet	0.3333	Yards
Feet	12.0	Inches
Feet	30.48	Centimeters
Feet per minute	0.01136	Miles per hour
Feet per minute	0.01667	Feet per second
Feet per minute	0.01829	Kilometers per hour
Feet per minute	0.3048	Meters per minute
Feet per minute	0.3333	Yards per minute
Feet per minute	60.0	Feet per hour
Gallons	0.00378	Cubic meters
Gallons	0.1337	Cubic feet
Gallons	3.785	Liters
Gallons	4.0	Quarts (liquid)
Gallons	8.0	Pints (liquid)
Gallons	8.337	Pounds
Gallons	128.0	Ounces (liquid)
Gallons	231.0	Cubic inches (liquid)
Gallons	269.0	Cubic inches (dry)
Gallons	3,785.0	Cubic centimeters

Multiply	By	To Get
Gallons of water	0.0038	Cubic meters
Gallons of water	0.0049	Cubic yards
Gallons of water	0.1337	Cubic feet
Gallons of water	3.7853	Kilograms
Gallons of water	8.3453	Pounds of water
Gallons of water	3,785.3446	Grams
Grains	0.0648	Grams
Grams	0.001	Kilograms
Grams	0.0022	Pounds
Grams	0.0353	Ounces
Grams	15.53	Grains
Grams	1,000.0	Milligrams
Grams per liter	10.0	Percent
Grams per liter	1,000.0	Parts per million
Hectares	2.47	Acres
Hectares	10,000.0	Square meters
Hectares	11,954.8	Square yards
Hectares	107,593.2	Square feet
Inches	0.0254	Meters
Inches	0.02778	Yards
Inches	0.08333	Feet
Inches	2.54	Centimeters
Kilograms	0.0011	Tons
Kilograms	2.205	Pounds
Kilograms	35.28	Ounces
Kilograms	1,000.0	Grams
Kilometers	0.6214	Miles
Kilometers	1,000.0	Meters
Kilometers	1,093.611	Yards
Kilometers	3,280.833	Feet
Kilometers per hour	0.6214	Miles per hour
Kilometers per hour	16.6667	Meters per minute
Kilometers per hour	18.2268	Yards per minute
Kilometers per hour	54.6806	Feet per minute
Liters	0.001	Cubic meters
Liters	0.0353	Cubic feet
Liters	0.2642	Gallons (liquid)
Liters	1.0	Kilograms of water
Liters	1.057	Quarts (liquid)
Liters	2.113	Pints (liquid)
Liters	33.8143	Ounces
Liters	61.02	Cubic inches
Liters	1,000.0	Cubic centimeters
Liters	1,000.0	Grams of water

Multiply	By	To Get
Meters	0.001	Kilometers
Meters	1.094	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Meters	100.0	Centimeters
Meters	1,000.0	Millimeters
Metric tons	1.1	Tons (U.S.)
Metric tons	1,000.0	Kilograms
Metric tons	2,204.6	Pounds
Metric tons	1,000,000.0	Grams
Miles	1.6093	Kilometers
Miles	1,609.3	Meters
Miles	1,760.0	Yards
Miles	5,280.0	Feet
Miles per hour	1.467	Feet per second
Miles per hour	1.6093	Kilometers/ hour
Miles per hour	26.8217	Meters per minute
Miles per hour	29.3333	Yards per minute
Miles per hour	88.0	Feet per minute
Miles per minute	26.82	Meters per second
Miles per minute	29.333	Yards per second
Miles per minute	88.0	Feet per second
Milliliters	0.00105	Quarts (liquid)
Milliliters	0.0021	Pints (liquid)
Milliliters	0.0042	Cups (liquid)
Milliliters	0.0338	Ounces (liquid)
Milliliters	0.0676	Tablespoons
Milliliters	0.2029	Teaspoons
Milliliters	1.0	Cubic centimeters of water
Milliliters	1.0	Grams of water
Ounces (liquid)	0.00781	Gallons
Ounces (liquid)	0.03125	Quarts (liquid)
Ounces (liquid)	0.0625	Pints (liquid)
Ounces (dry)	0.0625	Pounds
Ounces (liquid)	0.125	Cups (liquid)
Ounces (liquid)	1.805	Cubic inches
Ounces (liquid)	2.0	Tablespoons
Ounces (liquid)	6.0	Teaspoons
Ounces (dry)	28.3495	Grams
Ounces (liquid)	29.573	Milliliters
Ounces (dry)	437.5	Grains
Parts / million (PPM)	0.0001	Percent
Parts per million	0.001	Liters/cubic meter
Parts per million	0.001	Grams per liter

Multiply	By	To Get
Parts per million	0.001	Milliliters per liter
Parts per million	0.013	Ounces per 100 gallons of water
Parts per million	0.0584	Grains per US gallon
Parts per million	0.3295	Gallons per acre-foot of water
Parts per million	1.0	Milligrams/ liter
Parts per million	1.0	Milligrams per kilogram
Parts per million	1.0	Milliliters per cubic meter
Parts per million	2.7181	Pounds per acre-foot of water
Parts per million	8.345	Pounds per million gallons of water
Pecks	0.25	Bushels
Pecks	8.0	Quarts (dry)
Pecks	16.0	Pints (dry)
Pecks	537.605	Cubic inches
Percent (%)	1.33	Ounces (dry) per gallon of water
Percent	8.34	Pounds per 100 gallons of water
Percent	10.00	Grams per kilogram
Percent	10.00	Grams per liter
Percent	10,000.00	Parts per million
Pints (dry)	0.0156	Bushels
Pints (dry)	0.0625	Pecks
Pints (liquid)	0.125	Gallons
Pints (liquid)	0.4735	Liters
Pints (liquid)	0.5	Quarts (liquid)
Pints (dry)	0.5	Quarts (dry)
Pints (liquid)	2.0	Cups
Pints (liquid)	16.0	Ounces (liquid)
Pints (liquid)	28.875	Cubic inches (liquid)
Pints (dry)	33.6003	Cubic inches (dry)
Pounds	0.0005	Tons
Pounds	0.4535	Kilograms
Pounds	16.0	Ounces
Pounds	453.5924	Grams
Pounds	7,000.0	Grains
Pounds of water	0.0160	Cubic feet
Pounds of water	0.1198	Gallons
Pounds of water	0.4536	Liters
Pounds of water	27.693	Cubic inches
Quarts (liquid)	0.00094	Cubic meters
Quarts (liquid)	0.0012	Cubic yards

Multiply	By	To Get
Quarts (dry)	0.03125	Bushels
Quarts (liquid)	0.0334	Cubic feet (liquid)
Quarts (dry)	0.0389	Cubic feet (dry)
Quarts (dry)	0.125	Pecks
Quarts (liquid)	0.25	Gallons (liquid)
Quarts (liquid)	0.9463	Liters
Quarts (liquid)	2.0	Pints (liquid)
Quarts (dry)	2.0	Pints (dry)
Quarts (liquid)	2.0868	Pounds of water
Quarts (liquid)	4.0	Cups
Quarts (liquid)	32.0	Ounces (liquid)
Quarts (liquid)	57.75	Cubic inches (liquid)
Quarts (dry)	67.20	Cubic inches (dry)
Square feet	0.000009	Hectares
Square feet	0.000023	Acres
Square feet	0.0929	Square meters
Square feet	0.1111	Square yards
Square feet	144.0	Square inches
Square inches	0.00064	Square meters
Square inches	0.00077	Square yards
Square inches	0.00694	Square feet
Sq. kilometers	0.3861	Square miles
Sq. kilometers	100.0	Hectares
Sq. kilometers	247.104	Acres
Sq. kilometers	1,000,000.0	Square meters
Sq. kilometers	1,195,982.7	Square yards
Sq. kilometers	10,763,865.0	Square feet
Square meters	0.0001	Hectares
Square meters	1.308	Square yards
Square meters	10.765	Square yards
Square meters	1,549.9669	Square feet
Square miles	2.5899	Square kilometers
Square miles	258.99	Hectares
Square miles	640.0	Acres
Square miles	2,589,735.5	Square meters
Square miles	3,097,600.0	Square yards
Square miles	27,878,400.0	Square feet
Square yards	0.00008	Hectares
Square yards	0.00021	Acres
Square yards	0.8361	Square meters
Square yards	9.0	Square feet
Square yards	1,296.0	Square inches
Tablespoons	0.0625	Cups
Tablespoons	0.5	Ounces
Tablespoons	3.0	Teaspoons
Tablespoons	15.0	Milliliters

Multiply	By	To Get
Teaspoons	0.0208	Cups
Teaspoons	0.1667	Ounces
Teaspoons	0.3333	Tablespoons
Teaspoons	5.0	Milliliters
Tons	0.907	Metric ton
Tons	907.1849	Kilograms

Multiply	By	To Get
Tons	2,000.0	Pounds
Tons	32,000.0	Ounces
Yards	0.000568	Miles
Yards	0.9144	Meters
Yards	3.0	Feet
Yards	36.0	Inches

PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, immediately contact the following emergency information centers for assistance.

Current as of January 2010

Human Pesticide Poisoning

POISON CONTROL

From anywhere in the United States, call

1-800-222-1222

Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

____
Phone No.

or

Animal Poison Control Center ($55 consultation fee per case)

***1-888-426-4435**
www.aspca.org

Pesticide Fire

Local fire department:

____
Phone No.

and

***911**

Traffic Accident

Local police department or sheriff's department:

____
Phone No.

and

***911**

Pesticide Spill

District Michigan Department of Natural Resources and Environment (MDNRE) Office Phone No.

1-800-662-9278

and

MDNRE Pollution Emergency Alerting System (PEAS):

***1-800-292-4706**

also

Michigan Department of Agriculture Spill Response

(for fertilizer, pesticide, and manure spills)

***1-800-405-0101**

Pesticide Disposal Information

Michigan Clean Sweep, Michigan Department of Agriculture Environmental Stewardship Division.

Monday– Friday: 8 a.m.–5 p.m.

1-517-241-3933

National Pesticide Information Center

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance. Funded by EPA, based at Oregon State University

7 days a week; excluding holidays
6:30 a.m. – 4:30 p.m. Pacific Time Zone

1-800-858-7378
FAX: 1-541-737-0761
Web: npic.orst.edu

*** Telephone Number Operated 24 Hours**

Revised by Sue Risley, *Pesticide Safety Education Program, Michigan State University Extension*

NOTES

Minor Updates 5:10- 150- LKP- This manual E-2435 replaces E-2052.