

Groundwater Quality and the Use of Lawn and Garden Chemicals by Homeowners

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Introduction

The people of Virginia use nearly 400 million gallons of groundwater each day to meet industrial, agricultural, public, and private water demands. One-third of Virginia's citizens rely on groundwater as their primary source of fresh drinking water, and 80 percent of Virginians use groundwater to supply some or all of their daily water needs. Groundwater is an important resource, but it is a hidden one and, therefore, is often forgotten. In fact, until recent incidents of groundwater contamination, little attention was paid to the need to protect Virginia's groundwater.

What Is Groundwater?

Water entering the soil either by rainfall or irrigation gradually percolates downward to become groundwater if it is not first taken up by plants, evaporated into the atmosphere, or held within soil pores. This percolating water, called recharge, passes downward through the root zone until it reaches the water table. Below the water table is the saturated zone, where the groundwater is contained.

The geologic formation through which groundwater moves is called an aquifer. Aquifers can vary in size, from smaller ones supplying water to several wells, to larger ones capable of supplying water to thousands of families.

Until recently, groundwater was thought to be immune to the many chemicals, such as fertilizers and pesticides, which we use on our lawns and gardens. It was

only 20 years or so ago that we made the link between what we do on the land surface and what we find in our groundwater supplies. Groundwater becomes contaminated when water percolating through the soil carries pollutants downward to the water table. Once in the saturated zone, these pollutants move with the groundwater, forming a region of contaminated water called a plume. Groundwater moves very slowly, only a few feet a month or even a year. Therefore, it may take years before a plume appears in a well or other water supply some distance away.

Fertilizers, pesticides, and other chemicals that reach an aquifer may make it unusable as a drinking-water source. Because of the slow movement of groundwater, it may take decades for a contaminant to be naturally diluted or removed, and for this reason, preventing contamination of groundwater is of primary importance. Therefore, the Commonwealth of Virginia has adopted an antidegradation policy.

Virginia's Antidegradation Policy

Virginia has a constitutional mandate to protect the quality of its natural resources (Constitution of Virginia, Article XI, Section 1). In keeping with this mandate, the state has adopted an antidegradation policy, which requires the protection of existing high-quality surface waters and groundwater. The policy also provides for the restoration of all other waters of the state to a condition that would permit all reasonable uses (Code of Virginia, Section 62.1-44.4(2)). In administering the antidegradation policy, the Virginia Water

Control Board is responsible for setting groundwater quality standards. The antidegradation policy declares the following:

1. There is no right to degrade the groundwater of Virginia from its natural quality.
2. No groundwater source is preclassified to allow degradation by human activity.
3. Those responsible for groundwater pollution that has occurred or might occur can be required to restore the water to its natural condition.
4. Groundwater protection activities must take social and economic consequences into account.

Sources and Mechanisms of Groundwater Contamination

Groundwater is an important part of the water cycle as Figure 1 illustrates. The water cycle begins with precipitation falling on the earth's surface. A portion of that water runs off into lakes and streams. The remaining water is absorbed into the soil layer where it is taken up by plants or penetrates deeper into the soil. The water that reaches the saturated zone is known as recharge water.

Contaminants, including lawn and garden chemicals such as fertilizers and pesticides, enter the groundwater in two ways. In the first method, they can be carried

by rainwater into a stream as runoff. It is possible for streams to lose water to the ground at some points. In these cases, groundwater is replenished by water from these streams, and the contaminants in the stream are carried into the groundwater. The second mechanism of groundwater contamination is leaching, which is the downward movement of a substance through the soil.

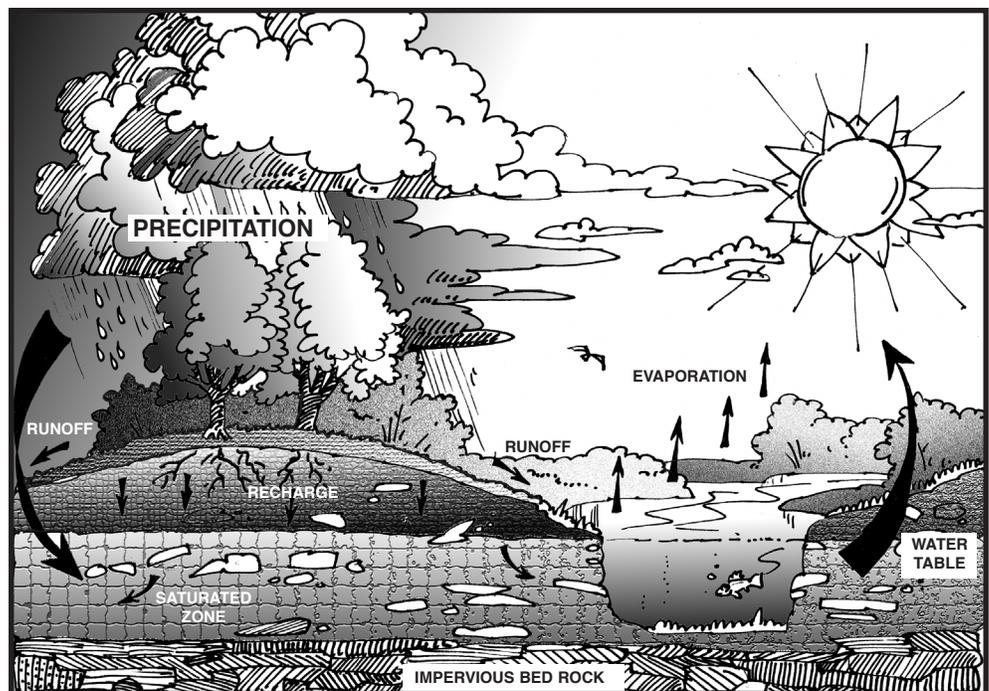
Soil has the ability to filter some contaminants; however, there are several characteristics of soil that determine the effectiveness of this filtration process and the movement of chemicals.

Soil texture is determined by the relative amount of sand, silt, and clay particles a soil contains. The coarser the soil, that is, the larger the amount of sand it contains, the more rapidly water and most chemicals will move through it.

Soil organic matter, which includes completely and partially decayed remains of plants and animals, influences how much water the soil can hold before movement occurs. A higher organic-matter content will increase the water-holding capacity of the soil. Molecules of some chemicals may also adhere to the organic matter particles.

Soil pH, the relative acidity/alkalinity of the soil (sometimes the soil is said to be sour or sweet), can have an effect on the movement of chemicals, especially fertilizers, through the soil by influencing their availability to plants.

Figure 1: The Water Cycle
Source: *Out of Sight, Out of Mind: Groundwater in the Northeast*, Aqua-Terra, At 82-2 Cornell University, Center for Environmental Research



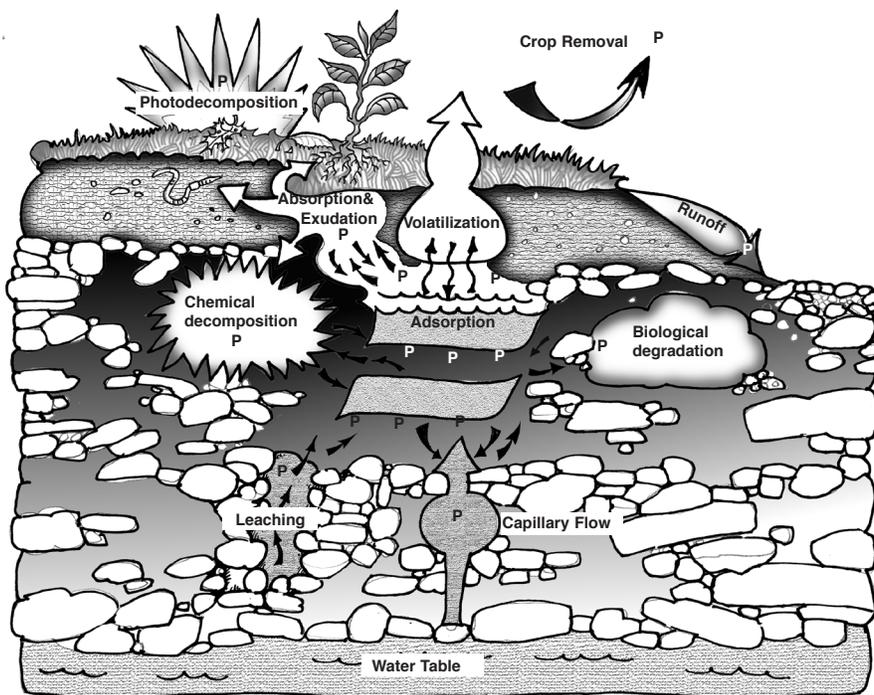


Figure 2: Pathways of Chemical Loss

Adapted from *Herbicide Injury, Symptoms and Diagnosis*, North Carolina Agricultural Extension Service, AG-85, Dec. 1981.

In the case of fertilizers, the residual amount not used by the plant may either leach through the soil or adhere to the soil particles. Those fertilizers which adhere to the soil particles may be gradually released for use by the plant, or they may eventually enter the water cycle by moving with soil particles during surface erosion. The fertilizer may also dissolve into the surface water which recharges the groundwater. Pesticides may vaporize and enter the atmosphere or be broken down by microbial and chemical means into other, less toxic compounds. However, they may also contaminate groundwater by leaching through the soil or moving with soil particles during erosion. Figure 2 shows the various pathways the contaminants can take.

The amount of any given chemical that actually reaches the groundwater depends on two factors: persistence and solubility.

Persistence is defined as the amount of time a chemical remains active in the soil before it is degraded, or broken down, and is measured in "half-life." Each half-life unit measures the amount of time it takes for one-half the original amount of a pesticide in the soil to be degraded. Chemicals that have a long half-life remain active for a longer period of time and have a greater potential for contaminating groundwater supplies.

Solubility is the ease with which a chemical dissolves and mixes with soil water. As a chemical enters the soil, part of it adheres to soil particles and part of it dissolves in the soil water. Therefore, the more soluble a chemical is, the greater its potential for movement into the groundwater.

The combination of persistence and solubility determines the contamination potential of a chemical. A chemical with a long half-life and high-solubility would have the greatest potential for contamination. On the other hand, a chemical with a short half-life and low-solubility would not be chemically active as long and would move through the soil more slowly, thereby reducing the risk of groundwater contamination.

As discussed earlier, the soil texture, organic matter content, and pH all affect the movement of chemicals through the soil.

In addition, the availability of water, either by natural rainfall or irrigation, directly affects solubility. An understanding of all these factors is the basis for developing sound management practices on applying chemicals in an environmentally safe manner.

Fertilizers and Protecting Groundwater

Fertilizers vary in solubility and persistence. Slow-release fertilizers remain in the soil longer and are available to the plants over a longer period of time than are highly soluble ones.

Fertilizers are generally described by three numbers, such as 20-5-5 or 16-4-8. These numbers refer to the percentage by weight of the nitrogen, phosphorous (as P_2O_5), and potassium (as K_2O) respectively, contained in the fertilizer. The portion of the nitrogen in a bag of fertilizer labeled 16-4-8 is 16 percent. In a 50-pound bag that would be 8 pounds of nitrogen ($0.16 * 50 \text{ lb} = 8 \text{ lb}$). The phosphorus would be 2 pounds ($0.04 * 50 \text{ lb} = 2$) and the potassium would be 4 pounds ($0.08 * 50 \text{ lb} = 4 \text{ lb}$).

Since nitrogen in the slowly available form releases over a longer period of time, it would be less likely to leach through the soil to the water table. A fertil-

izer with slowly available nitrogen has its nitrogen in a water-insoluble form. This is identified on the bag of fertilizer with a WIN (Water Insoluble Nitrogen) percentage. For instance, a 20-5-5 fertilizer with a 5% WIN actually has 5/20 (5 of the total of 20%) or 1/4 of the nitrogen in the slowly available form. A 50-pound bag of this fertilizer would contain a total of 10 pounds of nitrogen ($0.20 * 50 \text{ lb} = 10 \text{ lb}$). With a 5% WIN, of the total 10 pounds of nitrogen, 2.5 pounds would be water insoluble nitrogen ($0.05 * 50 \text{ lb} = 2.5 \text{ lb}$), leaving 7.5 pounds of nitrogen in the quickly available, highly soluble form.

Application of Lawn and Garden Chemicals

Sound fertilizer and pesticide management practices are designed to give you the knowledge to be able to supply lawns and gardens with a specific nutrient or pest control. Proper handling and application practices are essential to maintain high groundwater quality. Following are some general handling practices that you should observe when applying any form of lawn or garden chemical:

Follow Label Instructions Carefully - Lawn and garden products have been tested extensively. The application instructions have been developed and approved by the Environmental Protection Agency (EPA) over a period of several years. Failure to follow these instructions may lead to ineffective treatment and may increase

the risk of groundwater contamination. Be sure to read all label warnings carefully. Some products list specific warnings with regard to surface and groundwater contamination.

Mix Accurately - More is not better. Overdosing will not lead to healthier lawns or gardens nor will it do a better job of controlling pests. Application rates that exceed label recommendations will only unnecessarily increase the cost of application and increase the chance of contaminating groundwater supplies.

Prevent Spills and Backsiphoning - Chemical spills near wells or sinkholes can directly enter the groundwater. Avoid spills, but immediately clean up any spills that do happen. When mixing lawn and garden chemicals with a garden hose, a drop in water pressure can cause the entire contents to backsiphon directly into the water supply. To prevent backsiphoning, always keep the end of the fill hose above the water line in the fill tank (see Figure 3). Always use an antisiphoning device when drawing mix water directly from a well. These devices are relatively inexpensive and are readily available from product suppliers.

Dispose of Wastes Properly - To avoid any localized groundwater contamination, dispose of empty containers in a manner consistent with the product label. Thoroughly rinse all containers that have been used to hold or mix chemicals. Avoid having leftover product by mixing only the quantities you need to do the job.

THIS ...
(Backflow prevention)

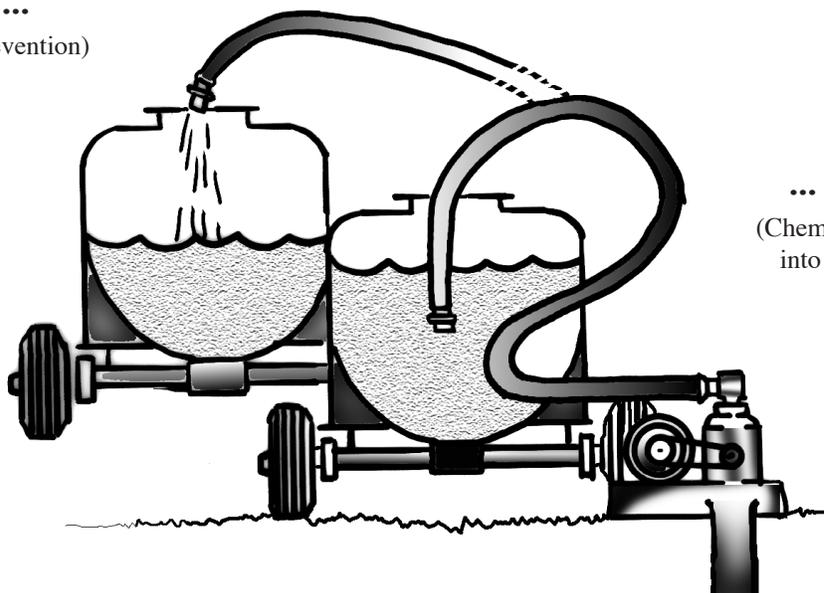


Figure 3: Backflow Prevention
Source: Protecting Our Groundwater, A Grower's Guide, USDA Extension Service

Management Practices for Fertilization of Home Lawns

Home lawns can be improved through the proper use of fertilizers. Excessive amounts or the wrong type of fertilizer will not provide an effective treatment for your lawn and may increase the risk of groundwater contamination. The following are some management practices that you should use to assure a healthy lawn and reduce the infiltration of lawn chemicals into the water supply.

Soil Testing - You should have a soil analysis done every three to four years to assess the pH and availability of nutrients. The soil test will provide an analysis of the amount of phosphorus, potassium, calcium, and magnesium that is available to your lawn. Nitrogen content is not tested because of its high mobility in the soil. The relative amounts of each of the other soil nutrients will determine the appropriate type of fertilizer to apply. For example, for soils containing high levels of phosphorus and potassium, little or no additional phosphorus or potassium is needed. The test report will include recommendations for lime or sulfur application if they are needed, based on the pH level.

Fertilizer Types - The nitrogen content of lawn fertilizers is usually higher than in garden fertilizers. Nitrogen promotes leaf and shoot formation, deep green color, and when used appropriately, promotes root development and food storage. Some phosphorus and potassium typically accompany nitrogen to maintain a proper nutritional balance and to avoid overstimulation in growth that might encourage disease. The amount of nitrogen that will be available to the lawn depends on whether the nitrogen in the fertilizer is quickly available or slowly available. Quickly available nitrogen is water-soluble and becomes available to plants immediately. Slowly available nitrogen is released over a longer period of time. From a groundwater-quality standpoint, quickly available nitrogen is more prone to leaching and should be applied very carefully.

Amount, Frequency, and Timing of Fertilizer Application - The proper amount and scheduling of fertilizer application depends on a variety of factors including the source of nitrogen, soil type, type of turfgrass, and whether or not clippings are collected or left on the lawn. If a significant percentage of the nitrogen in the fertilizer is slowly available, higher rates can be applied with less frequency than otherwise. Sandy soils are more prone to leaching than silt loam or clay loam soils. Higher levels or more frequent nitrogen applica-

tions may be required for sandy soils. However, exercise great care when applying fertilizers to sandy soils to reduce the chance of groundwater contamination. A slowly available nitrogen source may give the best insurance against leaching in sandy soils while providing the proper nutrients.

Cool-season grasses, such as Kentucky bluegrass, tall fescue, perennial ryegrass, and fine-leaf fescues have a lower nitrogen requirement than do warm-season grasses like bermudagrass, zoysiagrass, St. Augustinegrass, and centipedegrass. Timing applications is also important. Excessive application of nitrogen to cool-season grasses in the spring can be detrimental because it leads to excessive leaf growth at the expense of root development. This makes the lawn more susceptible to summer disease and drought. Excessive applications of nitrogen to warm-season grasses in the late summer and early fall encourage excessive fall growth and winter injury.

The best time to fertilize cool-season grasses is from August 15 through November. Warm-season grasses do best when fertilized in the months of March through August in Virginia. Grass clippings left on the lawn can return up to one-third of the annual nitrogen and potassium requirements to a lawn, and do not contribute significantly to thatch buildup, so return clippings whenever possible. If you remove clippings, the lawn will need greater amounts of fertilizer.

Management Practices for Fertilization of Home Gardens

As in the case of lawns, home vegetable and ornamental gardens can benefit from the use of fertilizers. Several management practices should be considered before using any fertilizers on the home garden to maximize the benefits to the plants while minimizing the possibility of groundwater contamination:

Soil Testing - A soil test should be made every three years. Soil pH has a direct effect on availability of nutrients to plants. Most vegetables do well in a pH of 6.2 to 6.8 (slightly acid). A soil test can also tell the relative nutrient levels in the soil. Once the pH and nutrient levels are known, adjustments may be made, but there are other factors to consider.

Tilling the Soil - Tilling can be beneficial if done at the proper time. It aerates the soil and can help control weeds. You also may incorporate organic matter when tilling. If done when the soil is too wet, however, till-

ing can destroy soil structure, which may take years to rebuild. Tilling wet soil also can lead to the formation of a hardpan, which inhibits root growth. Both of these conditions may contribute to soil erosion and the loss of nutrients into groundwater supplies. A no-till approach or a system of raised beds can reduce nutrient and soil loss even more.

Organic Amendments - Compost, manures, and mulches can be very beneficial to the soil by improving its structure, adding nutrients, and increasing its water- and nutrient-holding capacity, lessening the chance of groundwater contamination.

Cover Crops - Cover crops, such as annual rye or wheat planted in the garden in the fall and tilled under in the spring, can add organic matter and lessen the chance of groundwater contamination. A leguminous cover crop, such as alfalfa or clover, also can add nitrogen to the soil. Cover crops, compost, and manures add essential elements, which are required for crop growth.

Fertilizers - Fertilizers for the garden may be either organic or synthetic. Both organic and synthetic fertilizers can be fast or slow acting. In the vegetable garden, fertilizer may be incorporated into the soil either by broadcasting it over the entire garden or by applying it in narrow bands on either side of the plants in the row. Banding it is more efficient because it uses less fertilizer and makes it available to the plant closer to the root zone.

Frequency and Timing of Fertilizer Application - Vegetables vary in their nutrient requirements. Heavy feeders, such as broccoli, sweet corn, and tomatoes, may need more frequent applications of larger amounts of fertilizers than medium feeders, such as beans, carrots, and cucumbers. Generally, you make a first application when you plant the seed or set out the transplants. Depending on the crop, you can make a second application when the plant flowers or starts to set fruit. When you side-dress, the fertilizer becomes available to the plant when it needs it most. It is important to remember that any fertilizer not used by the plant has the potential to leach through the soil and contaminate the groundwater or to be washed into the water supply by erosion.

In flower gardens, incorporate the fertilizer as a slow release or granular fertilizer mixed in the planting hole when you plant annuals. Perennials are best fertilized with a broadcast application applied evenly over the bed when the foliage is dry. Brush granules off the leaves

before irrigation to prevent damage. Do not disturb the mulch. You can water the fertilizer in without removing the mulch. Remember that plants growing in the shade generally require less fertilizer than those growing in the sun. Plants growing in sandy soils generally require more frequent fertilization than those in clay soils due to the limited nutrient holding capacity of sandy soils. In general, flower beds will require more frequent (at four- to six-week intervals) applications of lower rates of fertilizer than those used in the vegetable garden.

Management Practices for Fertilization of Ornamental Shrubs and Trees

The fertilizer requirements of woody shrubs and trees will vary with plant type and age as well as with soil conditions. Mature landscape shrubs and trees do not require frequent fertilization. Some seem to grow on indefinitely without any nutrient supplementation. A moderate rate of growth and good green color are all that is desired of woody plants. Excessive vigor, which is evident by lush green leaves and long shoot growth, is undesirable. Generally, younger plants in active growth will require more fertilizer than more established ornamentals.

First, determine if fertilization is necessary. When new shoots of trees or most woody shrubs grow more than six inches long in one season, no fertilizer is needed. When they grow between two and six inches in length, fertilization is optional, and when new growth is less than two inches in length, unless the plant is a slow-growing or dwarf species, it is time to fertilize. Foliage color is not as good an indicator of fertilizer need as is tree growth. Yellowing foliage can be caused by nutrient deficiencies, but it can also be caused by high pH or excessive moisture. In addition, soil pH has a direct effect on the availability of nutrients. Ornamentals vary in their requirements, and many, such as azaleas, require an acid soil. If nutrient shortages remain suspect after investigating other possible causes, take a soil sample to the local Extension agent for a soil test, which will disclose deficiencies in major (except for nitrogen) and minor soil elements. You can determine nitrogen deficiencies by observing tree growth as described above, and through the cultural history of the tree, such as how frequently the tree has been fertilized in the past. Leaf-tissue testing can definitively determine nutrient deficiencies. Contact your local Extension office for information on the nearest commercial agricultural laboratory performing this service.

If fertilization is necessary, follow amount recommendations given with the soil test results. A 3-1-2 nitrogen-phosphorus-potassium ratio is frequently recommended, though the nitrogen recommendation is usually most important in stimulating new growth. If turf grass or ground covers are growing around the tree to be fertilized, split any application so that no more than one pound of actual nitrogen per 1,000 square feet is applied at any one time. This will prevent fertilizer burn of the ground cover. Space the applications six weeks apart. Surface or broadcast application is the most desirable method of application. Not only is it simple to perform, research indicates that it produces the best results. If the turf is fertilized, it generally is not necessary to apply additional fertilizer to trees and shrubs growing in the turf.

Apply fertilizer at the correct time of year for best results and the minimum potential for groundwater contamination. In Virginia, early summer or late fall is an appropriate time to fertilize ornamental trees and shrubs. Fertilization in late summer can lead to late growth, which is easily winterkilled. Fertilizer can be applied approximately one month after the first frost. At this time, roots are still growing and will benefit from the nutrients, but tender top growth will not be stimulated. A mid-winter application can waste fertilizer because dormant roots will not absorb it, allowing it to leach away. The exception is southeast Virginia where soil temperatures generally stay warm enough to permit continual root growth. The loss of nutrients from winter fertilization is not only expensive, it can result in water pollution.

Understanding Pesticides

Pesticides may be useful when nonchemical methods fail to provide adequate control of pests and when pest populations reach a level of economic injury. The suffix “cide” literally means kill. The term pesticide refers to a chemical substance that will kill pests. Since it is physically impossible to eradicate an entire population of pests, pesticides are used as tools to control or manage pest populations to a level of tolerance. Because of government regulations, chemicals used to attract or repel pests and to regulate plant growth or function are also classed as pesticides.

Types and Functions of Pesticides

- Insecticides control insects.
- Miticides control mites.

- Acaricides control mites, ticks, and spiders.
- Nematicides control nematodes.
- Fungicides control fungi.
- Bactericides control bacteria.
- Herbicides control plants.

When to Apply Pesticides

- Preplant: apply to soil before planting crop.
- Preemergence: use before plants emerge from soil.
- Postemergence: use after the crop or weeds have germinated.

How to Apply Pesticides

- Band is the application to a strip over or along each crop row.
- Broadcast is the uniform application to an area, by scattering.
- Dip is the immersion of a plant in a pesticide.
- Directed is aiming the pesticide at a portion of a plant.
- Drench is saturating the soil with a pesticide.
- Foliar is the application to the leaves of plants.
- In-furrow is the application to or in the furrow.
- Side-dress is the application along the side of a crop row.
- Spot treatment is the application of a pesticide to a small section or area of a crop.

The Pesticide Label

All the printed information, including the label on the product, brochures, and flyers from the company or its agent, about a pesticide product is called labeling. The label printed on or attached to a container of pesticide will tell you how to use the product correctly and what special safety measures you need to take. Specific parts of the label include the following:

Ingredient statement - Each pesticide label must list the names and amounts of the active ingredients and the amount of inert ingredients in the product.

Registration number - A registration number must be on every pesticide label. It shows that the EPA has approved the product for the uses listed on the label.

Precautionary statements - A section with a title simi-

**PRECAUTIONARY STATEMENTS
HAZARDS TO HUMANS**

KEEP OUT OF REACH OF CHILDREN. May irritate eyes, nose, throat, and skin. Avoid breathing dust or spray mist. Avoid contact with skin, eyes, and clothing. Wash thoroughly after using.

ENVIRONMENTAL HAZARDS

This product is toxic to fish. Do not apply directly to water. Drift and runoff from treated areas may be hazardous to fish in adjacent areas. Do not contaminate water by cleaning of equipment or disposal of wastes.

PHYSICAL AND CHEMICAL HAZARDS

Keep product away from fire or sparks.

Distributed by
DRAGON CORPORATION
Roanoke, VA 24019

EPA Reg. 16-131

EPA Est. 16-VA-1

SmartLabel TM Label Design and Process Patent Pending

DIRECTIONS FOR USE

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

STORAGE: Never allow Benomyl to become wet during storage. This may lead to certain chemical changes which will reduce the effectiveness of Benomyl. Store in the tightly closed original container in a cool, dry, preferably locked storage area out of reach of children.

EXCESS PESTICIDE DISPOSAL: Securely wrap original container in several layers of newspaper and discard in trash.

CONTAINER DISPOSAL: Do not reuse empty container. Securely wrap original container in several layers of newspaper and discard in trash.

Benomyl is a systemic fungicide recommended for the control of many important plant diseases. If treatment is not effective following use of Benomyl as recommended, a tolerant strain of fungus may be present; consideration should be given to prompt use of another suitable fungicide. Apply as a spray using sufficient water to obtain thorough coverage of the plant.

ROSES, FLOWERS, ORNAMENTAL, SHADE TREES - Field and Greenhouse: Foliar Spray - Begin applications when disease first appears and repeat at 10 to 14 day intervals throughout the growing season; shorten intervals during humid, rainy weather. Use at the following rates: 1 level tablespoon per 2 gallons of water - for Powdery Mildew. Botrytis Gray Mold, 2 level tablespoonsful per 2 gallons of water - for Anthracnose (begin at bud break): Black Spot of roses: Cercospora, Entomosporium, Ramularia and Septoria Leafspots: Ascochyta and Phomopsis blights; Didymellina Leafspot of iris; Corynespora Leafspot of Ligustrum; Ovulinia Blight of azalea and rhododendron (begin as flowers open): Scab of pyracantha and flowering crab. Addition of a surfactant to spray mixture improves distribution of the spray on hard-to-wet plants, such as roses. (CONTINUED ON BACK PANEL.)

EPA Reg. 16-131 **DRAGON CORPORATION** EPA Est. 16-VA-1

DRENCH TREATMENT - Botrytis, Fusarium, Rhizoctonia and Sclerotinia stem, crown and root rots on herbaceous annuals, perennials, and bedding plants: Cylindrocladium and Thielaviopsis rots on woody ornamentals, such as azaleas, rhododendrons, conifers, and poinsettias - Use 2 level tablespoonsful per 2 gallons of water; apply as a drench or heavy spray (1 to 2 pts. per sq. ft.) after transplanting into propagation beds or containers. Repeat at 2 to 4 week intervals during periods favorable for disease. Benomyl does not control Pythium spp. or Phytophthora spp.

PREPLANT DIP TREATMENT - For diseases listed under Drench Treatment, use 2 level tablespoonsful per 2 gallons of water; immerse plants or cuttings for 10 to 15 minutes; remove and allow to drain.

BULBS (Easter Lily, Tulip, Gladiolus, Daffodil, Iris): Fusarium and Penicillium Rots - Use 2 level tablespoonsful per gallon of water. Soak cleaned Bulbs for 15 to 30 minutes in warm dip (80 to 85F), preferably within 48 hours after digging. Dry bulbs after treatment. If bulbs are for forcing, treat after bulbs have been heat-cured.

LAWNS & TURF GRASSES: For Dollar Spot and Large Brown Patch, apply at the rate of 2 oz. (12 level tablespoonsful) per 1000 sq. ft. in sufficient water to obtain thorough coverage, usually 2 to 5 gals. per 1000 sq. ft. Apply at earliest appearance of disease and continue at 10 to 14 day intervals as long as needed. When conditions are unusually favorable for development of disease, reduce intervals to 5 to 7 days. Do not graze or feed clippings from treated areas to livestock.

Do not mix Benomyl with lime or alkaline pesticides such as Bordeaux mixture or Lime Sulfur.



Figure 4: Sample Specimen Label
(Use of this sample label does not indicate endorsement of this product by Virginia Tech.)

NOTICE

Buyer assumes all risks of use, storage or handling of this material not in strict accordance with label directions and cautions.

lar to “Hazards to Humans and Domestic Animals” will tell the ways in which the product may be poisonous to people and animals. It will also describe any special steps necessary to avoid poisoning, such as the kind of protective equipment needed. If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning.

Environmental hazards - The label tells how to avoid damage to the environment. Some examples are: “Do not contaminate water when cleaning equipment or when disposing of wastes.” “Do not apply where runoff is likely to occur.”

Signal words and symbols - Some pesticides may be hazardous to people. You can tell how toxic a product is by reading the signal word and symbol on the label. Highly toxic pesticides are generally not sold in the home-garden trade.

Directions for use will include:

- The pests the product will control,
- The crops the product can be used on safely,
- How the product should be applied,
- How much to use,
- Where and when the material should be applied, and
- Application to harvest periods.

Misuse statement - This section will remind you that it is a violation of federal law to use a product in a manner inconsistent with its labeling.

Cleaning Equipment

Thoroughly clean all equipment immediately after use. Do not store mixed pesticides. If you have mixed excess pesticide and cannot use it, spray it over an area it will not harm. Check the pesticide label to determine safe areas. Thoroughly clean all spray equipment, but do not dump the rinse water in one place where it will be concentrated and may become a pollutant. Spray the rinse water over a broad area so that the pesticide will be further diluted. NEVER RINSE PESTICIDES DOWN THE DRAIN!

Pesticides and the Environment

Fine mists of herbicides can drift to nearby crops or landscape plants and kill them. Bees and other pollinators can be killed if a crop is treated with a pesticide when they are in the field. Pesticides can also kill

the natural enemies of pest insects. Life in streams or ponds can be wiped out by the accidental spraying of ditches and waterways, runoff from sprayed fields, and careless container disposal. If more than one pesticide will control the pest, choose the one that is the least hazardous to the environment with the least possibility of groundwater contamination. Above all else, avoid excessive use of insecticides, and spray only when the crop and pest populations require their use.

Although most pesticides break down quickly, remaining in the environment only a short time before being changed into harmless products, some pesticides break down slowly and stay in the environment for a long time. These are called persistent pesticides. Some persistent pesticides can build up in the bodies of animals, including humans. These pesticides are called accumulative. Careful use is important even though most persistent pesticides have very limited usage or have been removed from the market. For example, chlordane is a persistent pesticide, and its use is limited to termite and fire-ant control.

Pesticides become problems when they move off target. This may mean moving with soil particles by erosion or leaching through the soil into groundwater supplies.

Following safety precautions and using common sense can prevent harm from pesticides. Before buying a pesticide, identify the pest you need to control and determine which pesticide will control it. If there is a choice of several, choose the least environmentally hazardous product.

Read the pesticide label before you purchase the product and again before you apply it. You need to learn the following: that the host plant and pest are listed on the pesticide label; the pesticide is not phytotoxic to the plant being protected; the safety conditions for its use, such as special equipment and protective clothing; restrictions on its use; and environmental precautions needed.

Disposing of Leftover Lawn and Garden Chemicals

Each different type of lawn and garden chemical poses its own particular disposal problem. Fertilizers are often stored year after year with little fear of problems. However, to be stored safely, they should be kept locked in a cool, dry place, in their original, labeled containers. Many fertilizers can be a fire and explosion hazard, as well as a threat to the groundwater supply.

These rules hold for pesticides also, but there are other points to consider when dealing with these chemicals. Common sense says you should use extreme care not only in their use, but in their storage and disposal as well. **It cannot be overemphasized that most pesticides are poisonous and should be kept locked up and out of reach of children, pets, and others!** Never store them near food supplies, in a tool shed or well house, or near a living area. The results could be disastrous.

The end of the lawn and garden season is the time to clean out your storage space and make sure unused chemicals are still in good condition. Check labels and containers for damage. Only in extreme cases should you transfer a chemical from its original container into another container for storage or use. Never use an old food container. Keep the labels and package inserts with the chemical so that everyone knows what is in the container. It will also mean you have the information for application and safety the next time you use the chemical. Place the original container in a plastic bag, and seal it until needed. Properly dispose of other products. Check on local disposal regulations, such as landfill requirements. **Never pour a pesticide or fertilizer down the drain or anywhere else it may contaminate the water supply!**

Check with neighbors or gardening friends before purchasing chemicals to see about the possibility of sharing chemicals. Your insect or weed problems may be very similar to theirs. Always buy the smallest size needed to minimize the possibility of having to store chemicals. If you have unopened chemicals, try to return them to the place of purchase.

Integrated Pest Management

Although it is questionable whether we could raise all crops without the use of pesticides, it is certainly true that we can reduce the amount of pesticides we use by careful and efficient use. There are some steps to consider before automatically turning to a pesticide. First, identify the suspect pest organism. There are literally thousands of species of insects, but relatively few species are harmful. Many sprays are mistakenly applied to control “pests” which turn out to be lady beetles or other beneficial predatory insects.

Second, determine if control measures are really needed. While considerable scientific basis exists for making pest control decisions in commercial crops,

pest control decision making for home gardens and ornamentals becomes very subjective. Most crops can tolerate a considerable amount of insect damage before any yield loss occurs, so garden crops generally do not need to be kept completely pest free. Frequent inspection of plants can tell whether pest levels are increasing or decreasing.

Usually, each plant species will only be attacked by a few insect pests and plant pathogens. Knowledge of pest identification and life cycles is essential for effective pest management. You can take insects and diseased plants to your local Extension office for identification.

Although pesticides are essential tools in many crop production systems, the many problems associated with pesticide use, including environmental contamination, necessitate the search for viable alternative methods of pest control. Two nonchemical approaches, **biological** and **cultural control**, have been used extensively and successfully for many years. Biological control involves the manipulation of specific organisms that are antagonistic to pest organisms. Cultural control is the deliberate manipulation of the cropping or soil-system environment with the goal of reducing losses to pests. Cultural and biological control approaches can work independently, but are used together for maximum effectiveness. Integrated control, or integrated pest management (IPM), is the integration of various control tactics, including biological, cultural, and chemical, into a comprehensive management strategy.

For example, golf course managers often use a simple, integrated control program for grub proofing against Japanese beetle larvae. A chemical pesticide would be used to protect the more valuable sodded areas of the fairways. Milky spore disease, which is a commercially produced biological control for Japanese beetle larvae, is applied in the roughs. The chemical pesticide gives immediate protection to the sodded areas, while the milky spore disease becomes established in the rough. Then, as the chemical breaks down, milky spore disease can move into the more valuable areas. Once milky spore disease is established, usually no more chemical treatment is needed to protect the turf.

Cultural Pest Control Practices

Although cultural control is often associated with mechanical operations, such as tillage or burning, cultural control involves many aspects of crop and soil management, including crop rotation, time of planting

and harvesting, trap cropping, and crop diversification. Since cultural control is primarily aimed at the prevention and reduction of pest outbreaks, the results of these practices are often unseen and difficult to quantify. When cultural control practices are easily integrated with other cultural practices, they are usually readily adopted by gardeners. However, when cultural control practices require significant modification in gardening practices, the advantages and disadvantages must be weighed carefully. Although cultural practices alone may not give completely satisfactory pest control, they are important in minimizing pest injury and should be considered in any integrated control program designed to protect groundwater quality. Cultural practices that limit the need for chemical use include:

Crop rotation - Crop rotation systems offer numerous advantages in soil structure, fertility, and erosion management, as well as aiding in control of various pest species. Crop rotation for pest management consists of a planting scheme alternating susceptible and nonsusceptible crops. The necessary interval between susceptible crops depends on the length of life cycle, reproductive potential, degree of specificity, and dispersal characteristics of the target pest. Crop rotation is most useful for fairly immobile, soil-dwelling pest species and those pests with a restricted host range or a life cycle of one year or more. The value of crop rotation is limited in controlling highly mobile insects, which readily move from field to field.

Planting and harvest dates - Planting and harvest dates of some crops can be altered to reduce or avoid potential pest damage. Early-planted corn is far less susceptible to corn earworm damage than late-planted crops. Late-planted corn is also more susceptible to European corn borer damage.

Sanitation - Sanitation is a broad term that includes a variety of practices aimed at removing food and shelter from pests during critical life stages or the physical destruction of pests through cultural practices. This approach is particularly effective against pests that spend part of their life cycle in the soil, such as European corn borer and the common stalk borer. Fall tillage which buries crop residues destroys the overwintering habitat of the pests. Removing weeds around crop borders can help reduce common stalk borer infestations because this insect uses a wide spectrum of weed hosts. Burning crop residues is an historically proven method for cultural control of various pests, but air-quality concerns are reducing the use of this practice.

Trap crops - Trap crops are used effectively against many insect pests, including the Mexican bean beetle and the bean leaf beetle. Early maturing bean varieties can be planted ten to 14 days prior to planting the main bean crop. The adult beetles are attracted to these early maturing trap crops, then sprayed with an insecticide. While this technique still relies on insecticidal control, the amount of area treated is greatly reduced. Adjusting row spacing is also an effective cultural control measure for reducing corn earworm infestations. By using narrow row spacing, the canopy closes over the soil quicker, reducing the crop's attractiveness to the host-seeking corn earworm moths.

Biological Control Practices

Many organisms exist in nature that feed on or infect insect pests. Collectively, these organisms provide a significant level of "natural control," in many cases preventing many insect species from ever reaching the status of "pests." The importance of natural control is frequently exhibited when natural enemy populations are destroyed by insecticides, and a previously unimportant insect suddenly escapes natural control and becomes a major pest. There are three general categories of natural enemies: (1) predators, (2) parasitoids (commonly called parasites), and (3) pathogens.

An individual predator, such as the lady beetle, will consume many host individuals in its lifetime. An individual parasitoid, on the other hand (such as the *Trichogramma* wasp), will generally only consume one host during its lifetime. However, this isn't meant to imply that predators are better biocontrol agents than parasitoids. Adult parasitoids are usually active fliers and will parasitize (lay eggs in) many individual hosts. Parasitoids are usually (*Trichogramma* excepted) very host specific. Pathogens are organisms, such as fungi, bacteria, viruses, nematodes, and protozoa that infect insects and cause disease.

Other biological practices include:

- Microbial insecticides, such as *Bacillus thuringiensis* and *Bacillus popillae*
- Botanical and low-toxicity insecticides, such as pyrethrin, rotenone, ryania, and sabadilla
- Other insecticides, such as insecticidal soap, dormant oils, neem, and d-limonene

Each of these has proven effective against certain pests.



Selecting Professional Lawn and Landscape Services

When money is no object, time sometimes is, and a professional lawn or landscape service will take care of many of the time-consuming chores of landscape maintenance. With professional help taking care of fertilizing and weeding the lawn and ornamentals, protecting them from insect and disease damage, and sometimes even mowing the grass, and mulching or pruning, home gardeners are free to turn their attention to other tasks that are more interesting to them. Hiring a professional is no reason to neglect learning about lawn and landscape care, though. Without some knowledge about lawns and ornamentals it will be difficult to select a company that can provide you with good, safe service and meet your desires to protect groundwater resources.

You should first decide the range of services you need or want. Landscape maintenance companies may provide lawn and tree care as well as care of ornamental landscape beds and gardens. The maintenance of landscape ornamentals (shrubs and small trees, ground covers, and flower gardens) may include fertilization; pruning; mulching; insect, disease and weed control; and seasonal clean-up. Services such as pruning and pest control require a higher level of qualifications and more experienced personnel than simple seasonal clean ups. In any case, you should take care to decide on the services you want and then to find a reliable company as described below.

Your first decision when selecting a lawn-care company is whether you want lawn care or lawn maintenance. For general maintenance such as mowing and trimming, a neighborhood teenager may be an affordable solution, and with some initial supervision, will probably do the job as well as you would yourself. For fertilizer and pesticide application, it pays to hire trained professionals who know when and how to apply these chemicals in a manner safe to you, your neighbors, the plants, and the environment.

There are national and local lawn care services; the size of the company is not important, but the training, reliability, and experience of the employees are. When choosing a service, ask for references and then review them. Check with the Better Business Bureau to see if there are any outstanding consumer complaints against any companies with whom you are considering doing business. Also, be sure that the company has a pesticide business license, and that the applicators it employs are properly certified.

When you are satisfied that the company you are considering is reputable, have the representative come to your house to thoroughly discuss the services you require, the services the company can provide, and the prices involved. Walk around your yard together, noting any special problem areas and discussing how the company can treat them. Find out what the basic care package includes and the cost of additional services. Check into the fertilizer and pesticide schedule, and find out what chemicals are applied. The representative should be knowledgeable and answer your questions in a straightforward concerned manner.

Make sure that the company follows good lawn-care procedures. Virginia Tech turf specialists recommend fertilizing cool-season grasses primarily in the fall; check to see that your lawn-care company is up to date on this. Discuss the timing of weed control. The company should apply preemergent crabgrass control before the dogwoods are in full bloom and the broadleaf weed control when those weeds are actively growing. The representative and the workers who perform the lawn or landscape care should show a healthy respect for and knowledge of the chemicals used. Proper application is necessary for proper results and for the safety of surrounding plants, neighboring property, and the environment.

Several lawn and landscape service companies are addressing homeowner concerns over excessive use of pesticides and pesticide drift with alternative lawn-care

programs. They offer a fertilizer-only option, a limited-pesticide option that involves spraying pesticides only when a problem is evident, and a dry-product option that uses granular fertilizers and pesticides to minimize drift onto neighboring property. Many of these services also offer options in natural organic fertilizers and biological pest control alternatives, though the level of effectiveness of these programs is highly variable. Find out if you can obtain similar options from the company you select. A good lawn or landscape management program is likely to change over time as problems are solved and turf quality and health improve. Continue to remain in regular contact with your service representative regarding their programs and the changes you would like to see.

There are numerous ways to accurately deliver fertilizers and pesticides. Well-trained applicators can deliver these products safely and effectively by these methods, and will likely alter their application programs according to the time of year. For instance, most service companies rely on granular applications of chemicals in the fall because of the likelihood of leaves on the turf at that time of year. When applying liquid products, lawn-care services use low-pressure sprayers to reduce the likelihood of drift. Extra care and precautions are never wrong when dealing with pesticides. And, of course, there is no need to apply pesticide to a nonexistent problem; the practice may only lead to contamination of groundwater.

Conclusion

All homeowners share the responsibility of helping maintain a clean water supply. The ways in which groundwater can become contaminated are many, and this publication has attempted to make you more aware of ways to have a productive garden or beautiful landscape without damaging the groundwater supply.

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