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Minimizing Pesticide Contaminated Soil Around the Home and Garden

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This publication was developed as a tool to reduce the prevalence of contaminated manure, grass clippings or compost while teaching homeowners to recognize toxicity symptoms and purchase only non-contaminated soil amendments.

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SOIL AMENDMENTS MAY INJURE SENSITIVE plants if contaminated with pesticides. Certain pesticides degrade quickly under aerobic conditions, but surprisingly slow under anaerobic conditions which often persist in manure and compost piles. The MSU Plant Diagnostic Laboratory has reported a sharp increase in symptoms of pesticide toxicity which may be due to pesticide contaminated grass clippings, manure or compost. The reasons for this are still unknown, but one possible reason is new chemistries which are available over the counter. Montana State University's Schutter Diagnostic Laboratory reported pesticide toxicity towards beneficial plants resembling growth regulator herbicide damage in 16 counties in 2009, and 21 counties in 2010. A total of 112 reports of symptoms resembling growth regulator herbicide contamination were investigated by MSU from May 2009 to July 2010. Most non-target symptoms were reported on homeowner gardens, trees and shrubs, with a few reports on field crops.

The Breakdown and Movement of Pesticides in the Soil

Many homeowners and applicators assume pesticides within contaminated soil, manure or compost will break down to safe levels within 12 months. This is not always the case as pesticide movement and degradation rates vary depending on leaching, ability of a pesticide to bind with soil, volatilization, microbial degradation, chemical degradation, photo-degradation and pesticide persistence.

Movement of Pesticides

A pesticide may move out of soil or compost but may be a new threat in a separate location. Pesticide infiltration into the soil profile is known as ***leaching.*** Leaching can eventually lead to contaminated ground water which may cause non-target toxicity or other health concerns. The use of compost may actually decrease the threat of leaching. This is due to pesticides binding readily with organic matter prevalent in composted soils.

Pesticide residual within contaminated soil or compost often will decrease as the amount of water infiltrated through the soil profile is increased. The rate at which pesticide will decrease is dependent on the sorption potential, water solubility, and persistence of a pesticide.

Many pesticides are ***water soluble,*** while others are not. Highly water soluble pesticides tend to move easier through the soil profile into groundwater. Water soluble pesticides may be leached out of shallow soils or composts where pesticide contamination is a problem if they also have a low sorption potential.

The ability of a pesticide to bind to soil particles is its ***sorption potential.*** A pesticide with a high sorption potential binds to soil particles thereby resisting further infiltration within the soil column. These pesticides resist movement into groundwater but may persist bound to soil particles for quite some time due to being less bio-available to microbes. A pesticide which has a low sorption potential leaches readily into the soil profile. A pesticide with a moderate sorption potential may remain in the root zone while being available for plant uptake and microbial and chemical degradation. Sorption potential is one of the most important pesticide factors when determining pesticide movement. Pesticides also bind readily with clay, loamy soils and bind less in sandy soils. Even if a pesticide is water soluble, it will not move through the soil profile if it has a high sorption potential (Table 1, page 2).

Pesticide persistence is the rate of time it takes a pesticide to naturally break down under ideal soil conditions. This is often expressed as a pesticide half-life. Pesticide persistence can be divided into three categories including:

- Nonpersistent: half-life less than 30 days.
- Moderate: half-life of 30 to 100 days.
- Persistent: half-life of more than 100 days.

TABLE 1. Coefficient of sorption, solubility, degradation rate (persistence), and overall leaching potential of some commonly used agricultural and residential pesticides.

Active Ingredient	Product Names[1]	Coefficient of Sorption	Solubility (mg/L)	half-life in soil (days)	half-life in compost (days)	Leaching Potential
2,4-D	Weed-B-Gon	20	796,000	7	7 – 14	Moderate
atrazine	Atrazine	100	33	100 – 300	21 – 50	High
clopyralid	Stinger, Curtail	6	300,000	15 – 287	1 – 2 yr	Very High
glyphosate	Roundup	24,000	900,000	3 – 130	no data	Very Low
picloram	Tordon	16	200,000	20 – 300	no data	Very High

Information gathered from the National Pesticide Information Center (Oregon State University, http://npic.orst.edu/ppdmove.htm) and Ohio State University Extension.

[1] This represents only a few common herbicide products which may be available on the market. Discrimination or endorsement is not intended with the listing of commercial products by Montana State University Extension.

These broad categories only represent a pesticide half-life under ideal conditions, as persistence varies due to degradation factors which vary by soil type. Persistence, solubility, soil type and the sorption potential of a pesticide form the overall leaching potential of a pesticide (Table 1).

When a pesticide diffuses from a solid or aqueous state to a gas it is known as ***volatilization***. Volatilization increases as temperature increases, and as soil is mixed. Mixing soil or compost often leads to a subsequent 30 percent loss of pesticide due to volatilization.

Volatilization and leaching are both examples of pathways which allow pesticides to move out of contaminated soils. Degradation is still needed to breakdown the pesticide into an inactive state.

Degradation of Pesticides

Pesticides in soil primarily break down through ***microbial and chemical degradation***. These reactions increase when temperatures are warm, soil pH is favorable, soil is moist but not saturated, and when aerobic soil conditions persist. Anaerobic conditions persist in manure piles, un-worked compost, when treated forage is dried and baled, or in compacted soils. If compost or manure is thoroughly mixed, microbial and chemical degradation will increase due to the increase in oxygen.

A pesticide breaks down from sunlight through ***photo-degradation***. The rate of breakdown is influenced by the intensity of sunlight, length of exposure, and pesticide properties. Pesticide residues on the surface of compost or manure will be reduced quickly through photo-degradation, but a majority of the pesticide will be within compost or manure where photo-degradation has little effect. Mixing compost will increase the rate of photo-degradation significantly.

Pesticide persistence combines with microbial and chemical factors to produce the final degradation rate (Table 1). Most insecticides, diquat, paraquat and 2,4-D breakdown readily in compost piles, while pyridine pesticides (Table 2) and some chlorinated hydrocarbon insecticides take years to breakdown in compost and soils. Fungicides may temporarily slow down the degradation process by suppressing decomposing fungi in a compost pile. Some pesticides may break down more quickly under soil conditions than in compost piles due to anaerobic conditions which may be present under some composting conditions.

The percentages of some active ingredients may actually increase under poor composting conditions (Granatstein 2001). This is due to a total compost mass decrease by half during decomposition.

TABLE 2. Active ingredients and a subset of agricultural and residential pesticide products[1] which may persist for years under anaerobic conditions present in manure and/or compost.

Picloram	Clopyralid	Aminopyralid	Aminocyclopyrachlor
Tordon K	Curtail M	Cleanwave	Imprelis
Tordon 22K	Cutback M	Chapparral	Method 240 SL
Outpost 22K	Redeem R & P	Opensight	Viewpoint
Terva 22K	Accent Gold	Milestone	Streamline
Terva K	Hornet WDG	Milestone VM	
Trooper 22K	Transline	Milestone VM Plus	
Grazon	Confront	Forefront R&P	
Picloram 22K	Stinger	Pasturall	

[1] This represents only a few high risk growth regulator herbicide products which may be available on the market. Discrimination or endorsement is not intended with the listing of commercial products by Montana State University Extension.

Applicators should be Aware

Applicators should be wary if using many growth regulator herbicides, especially if the applicator is spraying grasses which may be used for compost or converted to manure which will be distributed as a soil amendment. Active ingredients of highest concern are picloram, clopyralid, aminopyralid, and aminocyclopyrachlor due to the high persistence these active ingredients display under anaerobic conditions present in manure and/or compost (Table 2). Some other common growth regulator herbicides which may contaminate gardens but break down much faster are the active ingredients dicamba (Banvel, Clarity, Fallow Star, Vision, etc.) and 2,4-D (Hardball, Latigo, Unison, etc.). These pesticide products target invasive and troublesome broadleaf weeds while allowing desirable grasses to survive.

Always read and follow all 'Environmental Hazard' and 'Use Precaution' statements on the pesticide product label. Many pesticides also have re-cropping or planting restrictions which inhibit the planting of many broadleaf crops in subsequent seasons. A re-cropping or planting restriction may last as long as one to three years. These restrictions are under the 'Use Precautions' statement on the pesticide product label. Applicators should be aware of other factors which increase risk toward non-target sites:

1. Precipitation immediately after application will increase leaching into groundwater and runoff onto other non-target sites.
2. Wind (more than 10 mph) will increase drift onto non-target sites.
3. Applying pesticide products at rates above rates written on the pesticide product label may increase risk of injury to non-target plants into future seasons.
4. Applying pesticide products illegally onto sites not on the pesticide product label (ex. Spraying Milestone or Tordon products on lawns).

There may be other pesticide products which can offer broadleaf weed control while being safe for use on grasses. Contact your local MSU Extension office or the MSU Pesticide Education program for alternative chemistries which may be available.

Homeowners and Suppliers should be aware

Homeowners and suppliers purchasing or distributing grass hay, straw, manure or compost for use as soil amendments should be aware of potential pesticide contamination. When purchasing grass clippings, manure or compost, ask the supplier if their plant stands or pastures were treated with high risk growth regulator herbicides (see Table 2). Do not purchase grass clippings, manure or compost if the distributor verifies the application of high risk growth regulator herbicides while not following one of the use restrictions that are often on a herbicide's pesticide product label.

Bioassay for testing manure or compost.

1. Compare plants grown in pots with suspect mixture, to plants grown in non-contaminated potting mix or soil. Peas, beans and tomatoes are good candidates for testing as they are extremely sensitive to growth regulator herbicide contamination.
2. Observe plants for symptoms of herbicide injury, such as poor seed germination, yellowing, dead leaves or shoots, or cupped or curled leaves.
3. If there is apparent herbicidal activity, do not use the tested manure or compost. If already in use, don't plant the intended crop (another option is to plant non-susceptible crops in the garden).

- Do not use manure from animals that have grazed forage or eaten hay harvested from treated areas within the previous three days, if manure will be applied to areas where susceptible broadleaf plants may be grown.
- Grass clippings from treated areas should not be used where broadleaf plants grow, or used as compost or mulch which will later be applied to areas where susceptible broadleaf plants grow.
- Do not plant broadleaf plants in soils treated in the previous year with manure from animals that have grazed forage or eaten hay harvested from treated areas until a bioassay is conducted to determine that concentrations in the soil are at safe levels.

Homeowners should be aware of symptoms of growth regulator herbicide toxicity when using compost, grass clippings or manure on their vegetable gardens or ornamentals. This would include leaf cupping, curling, stunted growth, and curling of the growing points on any broadleaf plants. Broadleaf plant species especially sensitive to this type of herbicide damage include beans, peas, tomatoes, potatoes, lettuce, spinach, sugar beets, carrots, dahlias, and some roses. A simple bioassay may be used to verify the presence of herbicides (see box above).

Don't use grass clippings, manure or compost if plant toxicity symptoms are visible using the bioassay. For further confirmation of pesticide toxicity symptoms, contact the local MSU Extension office or the MSU Pesticide Education Program.

Homeowners have a few options if contaminated soil is evident in their gardens or ornamentals. Homeowners may:

- plant other non-susceptible garden plants including wheat, corn, berries, and many woody and perennial ornamentals (if soil is contaminated from a growth regulator herbicide).

- create another vegetable garden in a different location until the contaminated garden passes toxicity tests in subsequent seasons.
- incorporate one to two lb/100 square feet of charcoal in the top six inches of contaminated soil. This should adsorb some of the pesticide and decrease toxicity towards non-target plants.
- trench between trees and contaminated areas by cutting roots. (*Warning:* This may damage the tree by decreasing water and nutrient uptake but will prevent further pesticide uptake.)
- remove soil and replace with clean soil. This may be less costly if homeowners have smaller gardens.

If you see toxicity symptoms in your garden you should retest for toxicity the following season prior to planting. Growth regulator herbicides such as picloram, clopyralid and aminopyralid may take as long as two to five years to breakdown to safe levels for many susceptible broadleaf vegetable plants.

Can I Eat the Vegetables or Fruit?

It is unlikely although uncertain whether pesticide contamination would warrant a health concern if vegetables or fruit grown from a contaminated area were later ingested. Follow the directions on the pesticide product label regarding the pesticide which is contaminating your garden. If your vegetables or berries are not listed as a site on the pesticide product label then do not ingest the produce. If the produce is listed as a site on the product label, it may be safe to ingest. Read any further harvest restrictions if present. NEVER ingest produce if the exact pesticide contaminating your produce is unknown. Homeowners may need to wait at least one season to ingest vegetables or berries from contaminated locations.

For seeking legal advice or an investigation regarding pesticide contamination contact the Montana Department of Agriculture, (406)444-5400.

Conclusions

Applicators can eliminate the potential for soil, manure or compost contamination by reading and following the pesticide product label. Homeowners should be aware of the possibility of contaminated compost, grass clippings or manure prior to purchase by asking a few simple questions to their supplier. If you suspect contamination, conduct a simple toxicity test prior to planting precious vegetables or ornamentals. Finally, it may take quite some time for chemicals to break down to safe levels once within flowerbeds or vegetable gardens. It may be necessary to plant non-susceptible crops, or create a secondary garden in a separate location.

References

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Ohio State University Extension Fact Sheet. 2003. Michel, Frederick C., and Douglas Doohan. *Clopyralid and other Pesticides in Composts*. http://ohioline.ag.ohio-state.edu.

Pesticide Properties Database. 1994. P.A.Vogue, E.A. Kerle, and J.J. Jenkins. National Pesticide Information Center. http://npic.orst.edu/ppdmove.htm

For More Information

Visit the 'Nontarget Plant Toxicity around your Home and Garden' website at www.pesticides.montana.edu by selecting the 'Nontarget Plant Toxicity' link. You may also contact your local MSU Extension Office or the MSU Pesticide Safety Education Program Office at:

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