ARCHIVE: **Archived due to the 2009 rule revision. Refer to VA30007.09.006 for the updated document.**

TITLE: **Issues Related to the Identification and Estimation of Pesticide Residue Levels in Soil Media**

DATE EFFECTIVE: January 2001

KEYWORDS: Pesticides; agriculture; residuals; soil; decay constant

RULES: OAC 3745-300-07; 3745-300-09

QUESTION: For a site which was in prior agricultural land-use, how should the issue of pesticide residues in soils be dealt with?

ANSWER: Pesticides are an important part of agricultural management. However, their widespread use carries with it the potential for misuse in application, storage, or transport. The CP may find that a site possesses some degree of pesticide contamination. Some component of this contamination may be in the form of pesticide residues in environmental media. Pesticides are based on either a single active ingredient or a mixture of several active ingredients, which is typically combined with inert chemicals as carriers, and adjuvants to optimize the properties of a certain pesticide for use in a particular application. This combination of active ingredients, inerts, and adjuvants yield what is known as a pesticide formulation. A particular formulation may produce a broad range of residues, with each residue differing in its persistence in the environment.

Pesticides that were in popular use from the 1940's to the 70's were both more toxic and more persistent in the environment, and less regulated in terms of registration and application. For example, popular insecticides of the 1950's and 60's were chlorinated insecticides such as DDT or Chlordane, which have residues that can persist in the environment for decades. Although these pesticides degrade in the environment, the degradation products are often themselves highly toxic and persistent. Pesticides can themselves be contaminated with hazardous substances. The common herbicides 2,4D and 2,4,5T were found in the 1960's and 70's to be contaminated with dioxin, and therefore this toxic human carcinogen may have been introduced to the environment-at-large as an indirect result of the

widespread use of its herbicidal carrier. In some cases, valuable resources like soil or groundwater can be polluted with pesticides. Pesticides that are water soluble can be leached into groundwater, while yet other pesticidal compounds attach to organic matter or soil particles, which can then be eroded or washed away into surface waters.

Although many pesticides persist in soil, they are eventually broken down. Pesticides are decomposed in the environment by photodegradation, sorption to soil organic matter and clays, microbial attack, and other environmental sinks or degradation pathways. Along with adsorptivity, solubility, and volatility, the degradation rate of a pesticide may be the most important predictor of the presence of pesticide residues at VAP sites. This parameter indicates how long a particular pesticide will persist in the environment. Although few of these compounds persist at any detectable concentration level after a few weeks past the last application, some pesticide residues may be available in significant concentrations, and along many different pathways, to receptors in the environment. One way of calculating residual pesticide concentrations is to model residual soil concentration over time.

To illustrate this, we cite several pesticides as examples. 2,4D is a phenoxy acid herbicide; although it is still widely applied, it is also a predecessor of today's highly-specific herbicides. From the mid 1980's to the present, the predominant burn-down (i.e., non-selective; kills all types of vegetation) herbicide is Roundup (glyphosate). Glyphosate has a lower per-acre application rate, and hence lowers some of the costs associated with weed control. Endosulfon is a broad-spectrum insecticide used in forage, grain and vegetable crops; this insecticide has one of the longer half-lives of all modern pesticides. Toxicity and application data for these pesticidal materials are listed in Table 1. Degradation half-lives for common agricultural pesticides can be found in numerous agricultural bulletins; a particularly informational selection is: Bulletin #XCM-177 Best Management Practices for Agricultural Pesticide Use (Colorado State University Extension, 1995). This document can be found on the Internet at: http://www.colostate.edu/Depts/CoopExt/PUBS/

Table 1. Herbicide Data

Herbicide	Typical Application Rates (lbs a.i per acre)	RfD[1] (mg kg^{-1} day^{-1})	Preliminary Remediation Goals[2] (mg kg^{-1} soil)	Degradation half-life[3] (days)
Endosulfon	0.25-0.75	0.006	370	120
2,4D Amine	1-3	0.015	690	10
glyphosate	0.5-1.5	0.01	6,100	47

[1] From IRIS database
[2] From Region IX Preliminary Remediation Goals Data, integrated hazard quotient for residential soils
[3] Best Management Practices for Agricultural Pesticide Use Bulletin #XCM-177, Colorado State University, 1995

The amount of an active ingredient (a.i.) in a pesticide is calculated on the basis of its concentration, which is specific to a particular pesticide formulation. The concentration of a.i. in a formulation is commonly listed as a number followed by several letters (e.g., 3EC means 3 pounds active ingredient per gallon of the liquid emulsifiable concentrate formulation).

The concentration of residual pesticide in the soil is determined with this formula:

$$R_M = A_M(e^{-0.396(1/t)}) + R_{M-1}(e^{-0.693(1/t)})$$

Where in this equation: R_M = residual pesticide concentration (pounds), A_M = net application rate (pounds a.i. per acre), M = degradation period (months), t = half-life of a single pesticide (months = days $\times$ 0.03). Keep in mind that calculations need to be made for **each month and for each pesticide applied**. The data used in this example bears out that after 2 years of degradation (that is, since the last full-rate application, which occurred only once, and two years ago), the residual soil concentrations are substantially less than US EPA preliminary remediation goals (PRGs).

This formula assumes a first-order degradation rate only. In fact, the rate constant integrates the effects of soil conditions (e.g., soil texture,

organic matter content, soil water dynamics) and its interaction with pesticide-specific parameters such as Henry's law constant, viscosity, depth of incorporation, intrinsic recalcitrance to microbial attack, and soil-water partitioning, among other important parameters. Therefore, it is important to consider any results from a first-order modeling of pesticide degradation to be approximate at best. An alternate, more flexible model that incorporates fugacity into the calculations can be found at:

http://www.trentu.ca/academic/aminss/envmodel/SoilFug.html

In an extreme case, burn-down herbicides have sometimes been used at their maximum application rates for the maintenance of industrial and railroad right-of-way areas. As another example, the degradation half-life of DDT is more than 10 years, and so it is theoretically possible to detect residues of this pesticide and its degradation products from 1970. In any case, an abnormally high application rate will increase the residual amount of a pesticide active ingredient at the site, and therefore increase the amount of time required to degrade to a point below the pesticide's PRG.

Although it is impossible to develop confidence limits for soil residual concentrations of pesticides, any residual concentration that is predicted to be close to the PRG is worthy of further investigation. The CP can expect that both the analysis and the property-specific circumstances under which it is conducted are subject to review by VAP risk assessors.

SUMMARY: Pesticides have a wide range of persistence in the environment. In the case that a pesticide is resistant to degradation, or has been misused or spilled, and therefore may be persistent and cause high levels of concentrated residues in soil media. The CP and/or volunteer should assess the previous practices used on agricultural land to determine which pesticides may have been used on the property. For further information on pesticides and their use in Ohio agriculture, the CP should consult related VAP TDC articles and make a point of contacting county extension personnel, Department of Agriculture divisions concerned with pesticide applicator certification and pesticide registration, or a regional Natural Resources Conservation Service office. Each of these resources can be helpful regarding local and regional pesticide use issues, which may pertain to sites administered under the VAP.

CONTACT: For any questions concerning this issue, please contact the VAP central office at (614) 644-2924.