PESTICIDE BINDING AFFINITY

TOPIC FACT SHEET

npic
NATIONAL PESTICIDE INFORMATION CENTER
1.800.858.7378

What is pesticide soil binding affinity?

Pesticide binding affinity (also called sorption) is the attraction between a pesticide and particles of soil. As you might imagine, the strength of attraction varies and can depend on many complicated factors. **Figure 1** shows some of the factors that can influence a pesticide's soil binding affinity in the environment.

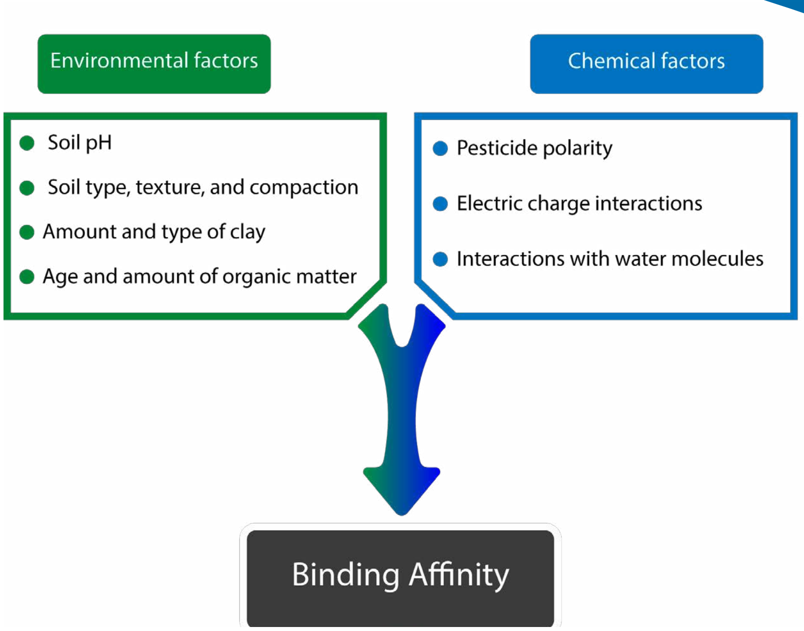

Figure 1. Several factors that work together to drive pesticide sorption in soil.[1,3]

Why is a pesticide's potential to bind to soil important?

When a pesticide binds tightly to soil particles, it is less likely to move down through soil toward shallow groundwater. However, if the pesticide is near the soil's surface, it may still be able to move across the top of the soil and into surface water. For example, when erosion occurs, water flows across the soil surface. The flowing water can take soil particles and bound up pesticides with it.[1]

Strongly bound pesticides may also stay around longer in the environment. Being bound to soil particles can provide protection from things that break down pesticides, like sunlight, water, and microbes. Pesticides may also be less likely to turn into a vapor when bound tightly to soil.[2] In short, a pesticide's potential to bind to soil is one of the key things that determine where it may end up after application. If we know the binding affinity of a pesticide, we can better determine the risk of using it in sensitive areas.

For example, let's say that you are thinking about using a product containing **fenoxaprop-p-ethyl** to control grassy weeds. You know that the area has a shallow water table and you are concerned about contaminating groundwater. Fenoxaprop-p-ethyl has low potential to bind to sandy soil, but a much higher potential to bind to clay soils and organic matter. Knowing that the soil in your area is sandy, you might consider the risk to groundwater to be too high and select a more appropriate pesticide.

How is a pesticide's binding affinity (sorption potential) determined?

To determine a pesticide's potential to bind to soil, studies are done both in the ground and in the laboratory. Typically, a pesticide is added to soil and then mixed with water for 24 hours. Next, scientists measure the amount of pesticide that ends up in water versus soil.[2] The ratio of those amounts is called the K_d (distribution coefficient). The study doesn't always end here, though. The K_d reflects how a pesticide may bind to soil particles in the soil tested. This information may not be as useful if a different type of soil is considered.[2] More details on how these tests are performed can be found in peer-reviewed science literature.

Scientists need a way to compare the binding affinity of multiple pesticides, regardless of the soil type and amount of organic matter. So, to level the playing field and find a value that can be used for this comparison, the K_{oc} is calculated. The K_{oc} is a sorption coefficient that has been normalized for organic carbon content.[3] Pesticide K_{oc} values range greatly, but can be compared to others based on the scale in Figure 2.

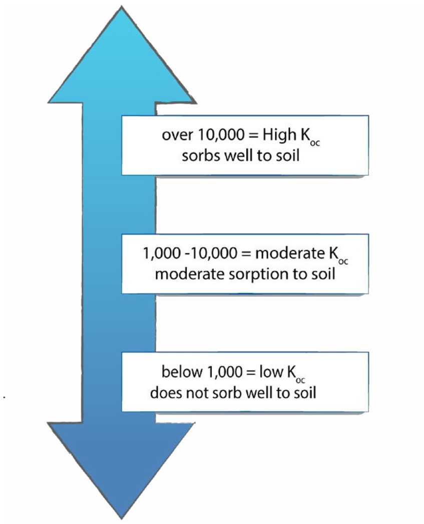

Figure 2. Sorption coefficient ranges for organic chemicals, adapted from Ney (1995).[1]

What can influence a pesticide's binding affinity in the environment?

Soil isn't just "plain ol' dirt". Soils are complex systems with a diverse physical and chemical make up. This make up is incredibly variable and can change how pesticides interact with the environment. Things like the soil texture and type, amount of water present, temperature, and the way that a pesticide is applied can all play a role in a pesticide's potential to bind to soil. These factors can change from one place to the next. This makes it difficult for scientists to report binding affinity values that can be broadly used for all situations.[2]

Just because a pesticide has a high potential to bind to soil particles doesn't mean that it will do so in all types of soil. Soils that have lower clay content and/or organic matter, for example, aren't very attractive to pesticides. Why is that?

To start, the amount of sand, silt, and clay in a soil give it a unique texture. The more sand and silt a soil has, the less attractive it is to an organic (carbon-based) pesticide. This is because the sand and silt particles (large and medium sized particles) don't have places for these pesticides to bind. Clay soils, on the other hand, are made of small particles that are electrically charged. Clay particles also have many layers that attract and trap organic matter. This means that many types of pesticides can be attracted and bind to clay particles.[3] Soil organic matter also plays a role in how well pesticides bind. Organic matter is broken down plant material like fats, carbohydrates, proteins, and waxes. It is structurally complex and provides lots of places where water and pesticides can be held.[3] So, soils that have more organic matter and clay are better able to hold on to pesticides. For a list of some factors that can affect binding affinity, **see Figure 1**.

What happens to a pesticide once it binds to soil?

Pesticides could become bound to soils for a matter of hours to years, depending on the pesticide and soil type. Pesticides that are tightly bound to soil may be protected from breaking down or becoming a vapor.[2] They are less likely to get into shallow groundwater. There is also less of a chance they will move across a surface with flowing water (except in the case of erosion). Strongly bound pesticides tend to stay put in the soil. Because of this, repeated use of these chemicals in the same spot can lead to accumulation or build up.

In addition to erosion, there are other ways that bound pesticides can move away from a treated area. They can be unbound by plant roots or animal ingestion of soil, and can be moved by people, wind, etc.[1] When large amounts of pesticides are poured or spilled all at once, the soil may become saturated. Pesticide-saturated soil may not bind pesticides well. This means they may move in soil or down a slope more than expected.

Where can I find more information?

For more detailed information about pesticide binding affinity please see the list of referenced resources below or call the National Pesticide Information Center, Monday - Friday, between 8:00am - 12:00pm Pacific Time (11:00am - 3:00pm Eastern Time) at 1-800-858-7378 or visit us at npic.orst.edu. NPIC provides objective, science-based information about pesticides.

Date Reviewed: April 2017

Please cite as: Hanson, B.; Hallman, A.; Bond, C.; Jenkins, J. 2017. *Pesticide Binding Affinity Fact Sheet*; National Pesticide Information Center, Oregon State University Extension Services. npic.orst.edu/factsheets/bindingaffinity.html.

References

1. Ney, Jr., R. E. *Fate and Transport of Organic Chemicals in the Environment, A Practical Guide, 2nd ed.*; Government Institutes, Inc.: Rockville, MD, 1995; pp 3, 19, 21, 24, 218.
2. Hornsby, A. G.; Wauchope, R. D.; Herner, A. E. Pesticide Properties: Vapor Pressure. *Pesticide Properties in the Environment*; Springer-Verlag: New York, 1996; pp 2, 14.
3. Tinsley, I. J. Chapter 3: Sorption. *Chemical Concepts in Pollutant Behavior, 2nd ed.*; John Wiley & Sons, Inc.: Hoboken, NJ, 2004; pp 75–78, 81, 85.

NPIC is a cooperative agreement between Oregon State University and the U.S. Environmental Protection Agency (U.S. EPA, cooperative agreement # X8-83560101).