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MontGuide

# Pesticide Performance and Water Quality

by Cecil Tharp, Pesticide Education Specialist, MSU Department of Animal & Range Science; and Adam Sigler, Water Quality Extension Associate Specialist, MSU Department of Land Resources & Environmental Sciences

**Poor water quality can significantly reduce the efficacy of many pesticide products. Applicators should always test their water for turbidity, pH and hardness prior to using a pesticide mixture.**

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**IT IS NOT UNCOMMON FOR MONTANA APPLICATORS** to use water sources with pH levels greater than 8.0 and/or hardness ratings greater than 150 ppm. Regions where poor water quality can affect pesticide product performance include stretches along the Madison Valley, many areas along the highline of northern Montana and areas of southeastern Montana. This is because pesticide mixtures are often composed of greater than 95 percent spray solution, thus a slight variation in water quality can have a significant impact on pesticide performance. Even a slight reduction in pesticide performance may result in poor control of tough pests. To compensate, applicators often raise product rates resulting in unnecessary losses in revenue.

Many water sources in Montana antagonize performance of a wide array of pesticides. This may be due to: acidity and alkalinity; minerals dissolved in water; or suspended soil particles (dirty water).

## Acidity & Alkalinity

The pH value describes the acidity and alkalinity of a solution. A small number of water ($H_2O$) molecules break into hydrogen (H+) ions and hydroxide (OH-) ions and the balance between the two is measured as pH. Minerals in the water affect the pH with a scale we think of as ranging from 0 – 14:

- pH = 7…..neutral (H+ equals OH-)
- pH > 7…..alkaline (more OH-)
- pH < 7…..acid (more H+)

This scale is logarithmic. For example, natural rain water has a pH slightly under 6, which is 10 times more acidic than a neutral pH of 7, meaning the concentration of H+ is more than 10 times higher in rain water than neutral water (Table 1, page 2).

*Water pH and Pesticides.* Most insecticides, fungicides and herbicides are weakly acidic or neutral and can be used in pH solutions from 4 - 7. When these pesticides are placed into water in the opposing alkaline pH range (pH > 7) they undergo degradation or hydrolysis. Hydrolysis is the breakdown of a larger pesticide molecule into simpler units. These simpler units often are not absorbed by the pest sufficiently, or are rendered completely inert (Whitford et al., 1986). For example, weak acid pesticides such as 2,4-D amine or glyphosate break down (dissociate) quickly to smaller molecules when mixed in an alkaline solution (pH > 7), while weak alkaline pesticides such as the sulfonyl-urea class (Ally, Escort, Amber, Harmony Extra, Express, and Accent) break down (dissociate) quickly when mixed in an acid solution (pH < 7).

Some common pesticides that are extremely susceptible to pH levels over 7 would be 2,4-D amine, glyphosate, glufosinate ammonium, ammonium salt of imazethapyr, and a wide range of carbamate and organophosphate insecticides (Table 2).

Applicators should test their water prior to a spray application using a pH meter or pH litmus strips. A pH meter is the most accurate method of determining pH of water. Applicators should keep in mind that pH of water sources can change with time and should be reassessed periodically; this is especially true with surface water.

An adjuvant is a general term for any substance added to a pesticide product to enhance performance. Water pH can be adjusted using various adjuvants known as buffering agents or acidifiers. These buffers can lower the pH of the spray solution from alkaline to 6.0-6.5 for weakly acidic pesticides. Some examples of commercially available buffering agents are Buffer Xtra Strength (Helena Chemical Co.), Buffer (Ladda Co.), Spray-Aide (Miller Chemical), Class Ballast (Cenex/Land O'Lakes), LI 700 (Loveland

**TABLE 1. The pH of some common solutions.**

| pH | Type | Solutions |
|---|---|---|
| 14 | Alkaline | Liquid Drain Cleaners |
| 13 | Alkaline | Bleach |
| 12 | Alkaline | Soapy Water |
| 11 | Alkaline | Ammonia Solution |
| 10 | Alkaline | Milk of Magnesia |
| 09 | Alkaline | Baking Soda |
| 08 | Alkaline | Sea Water |
| 07 | Neutral | Distilled Water |
| 06 | Acidic | Rain Water |
| 05 | Acidic | Black Coffee |
| 04 | Acidic | Tomato Juice |
| 03 | Acidic | Orange Juice |
| 02 | Acidic | Lemon Juice |
| 01 | Acidic | Gastric Acid |

Industries), Trifol (Wilbur Ellis), Super Spread 700 (Wilbur Ellis), etc. A detailed listing is available at http://www.herbicide-adjuvants.com/.

To determine how much buffering agent to add to the tank, an applicator must know the pH of the water, the volume needed to treat, and the buffering agent used (Table 3). Applicators should follow all buffering agent directions to determine exactly how much adjuvant to add to the tank. If a buffering agent isn't used to adjust the pH to an ideal range, then applicators should remember to use spray mixtures as soon as possible. This will minimize the amount of time for dissociation to occur.

## Minerals Dissolved in Water

The activity of some herbicides can be adversely affected by certain minerals that are dissolved in water. This is especially true of salt-formulated herbicides such as Roundup (glyphosate), Poast (sethoxydim), Pursuit (ammonium salt of imazethapyr), and Liberty (glufosinate ammonium). Minerals dissolved in the water are expressed as total dissolved solids or TDS.

TDS is typically composed of six major minerals in water. The dissolved minerals carry a positive (cation) or a negative (anion) charge that can be summarized as follows:

| *Positive (cations)* | *Negative (anions)* |
|---|---|
| Calcium (Ca++) | Sulphate($SO_4$- - ) |
| Magnesium (Mg++) | Chloride(Cl-) |
| Sodium (Na+) | Bicarbonate ($HCO_3$-) |

TDS may be determined for a water sample by evaporating it to dryness and weighing the minerals that remain, or by measuring the specific conductance (SC; microsiemens per cm) of the sample. If SC is less than 500 µS/cm (0.5 dS/m) it is unlikely that pesticide performance will be affected.

Treatments vary between high levels of Calcium (Ca++), Magnesium (Mg++), and/or Iron (Fe+++) [hard water] when compared to high levels of bicarbonates (HCO3-).

## Bicarbonate Waters

If bicarbonate ($HCO_3$-) levels are greater than 400 to 500 ppm, performance of some grass herbicides such as Poast (sethoxydim), Select (clethodim), Achieve (tralkoxydim) and 2,4-D amine can be affected. To mitigate this problem applicators can add ammonia type adjuvants, other non-ionic surfactants, acidifiers or buffers.

## Hard Water

The term water 'hardness' refers to presence of metals with a positive charge of more than 1, such as calcium (Ca++), magnesium (Mg++), and iron (Fe++). Total hardness is measured in parts per million or in grains per gallon and labs typically report results in terms of calcium for simplicity, even though other cations are making up part of the hardness. One grain (per gallon) equals 17.1 ppm.

**TABLE 2. The half-life of selected pesticides at different pH values (Deer & Beard 2001; Mckie et al. 2002).[1]**

| Pesticide | | Half-life at different pH solutions | | | | |
|---|---|---|---|---|---|---|
| Common Name | Trade name[2] | 5 | 6 | 7 | 8 | 9 |
| acephate | Orthene | 40 Days | - | 46 Days | - | 16 Days |
| Carbaryl | Sevin | - | 125 Days | 24 Days | 2.5 Days | 1 Day |
| diazinon | Knox-Out | 31 Days | - | 185 Days | - | 136 Days |
| dicamba | Banvel | Stable | Stable | Unstable | Unstable | Unstable |
| dimethoate | Cygon | - | 12 Hours | - | - | 48 Minutes |
| malathion | Digon | - | 8 Days | 3 Days | 19 Hours | - |
| paraquat | Gramoxone | Stable | Stable | Stable | Unstable | Unstable |
| trifluralin | Treflan | Stable | Stable | Stable | Stable | - |
| 2,4-D amine | Weedar 64 | Stable | Stable | Unstable | Unstable | Unstable |

[1] These are estimates that reflect trends. Half-life depends on other factors besides pH of the solution including temperature, contarminants in spray tank, formulations, etc.

[2] This represents only one pesticide product which may be available on the market. Discrimination or endorsement is not intended with the listing of commercil products by Montana State University Extension.

**TABLE 3. Testing and adjusting pH of spray tank for most pesticides (weakly acidic pesticides)**

**Water pH testing procedure**

1. Collect a sample of water in a clean, glass jar from the water source used for pesticide applications.
2. Check the pH of the water using a pH meter or pH litmus strips.
   - pH 3.5-6.0: Satisfactory for spraying and short term (12 to 24 hrs) storage of weakly acidic pesticides
   - pH 6.1- 7.0: Adequate for spraying most pesticides within 2 hours.
   - pH > 7.0: Add buffer or acidifier.

**pH adjustment procedure**

1. Using an eyedropper, add 3 drops of buffering agent to a pint of water.
2. Stir well and re-check the pH of the solution.
3. Repeat steps 1 and 2 until pH is satisfactory.
4. For every 100 gallons of water in spray tank, # add 2 ounces of buffer for each 3 drops of buffer used in adjustment to the pint
5. Mix tank, and check to ensure that the pH is correct in the spray tank.

**TABLE 4. World Health Organization (WHO) hardness classification table.**

| Parts per Million (ppm) | WHO Classification |
|---|---|
| 0 - 114 | Soft |
| 114 - 342 | Moderately Hard |
| 342 - 800 | Hard |
| > 800 | Extremely Hard |

These cations can further reduce the effectiveness of weak acid pesticides, especially if the pH of the water is above the ideal range. The effect happens because of the pesticide dissociating into positively and negatively charged components and the cations in the water binding with the negatively charged portion of the pesticide. This results in molecules that either can't be absorbed by the target pest, enter at a slower rate, or form insoluble salts. Hardness can range anywhere from 0 to over 800 ppm and a simple classification system is provided in Table 4.

Follow these guidelines regarding hardwater:

- Always read and follow precautions regarding hardness on the pesticide product label.
- Weak acid pesticides such as clopyralid, 2,4-D amine, glyphosate and dicamba may lose efficacy if hardness exceeds 150 ppm, especially if pH is greater than 7.0.
- 2,4-D amine formulations can be totally deactivated if hardness is greater than 600 ppm.
- Many other herbicides will lose efficacy if hardness is greater than 400 ppm if iron is present.

Hardness can be reduced with addition of dry ammonium sulfate $(NH_4)_2SO_4$ at 8.5 to 17.5 lb per 100 gallons of water, or liquid fertilizers (such as 28 percent N, 32 percent N, or 10-34-0) at a rate of 1.25 – 2.5 percent per 100 gallons. It works by reducing the pH and also through $SO_4^{--}$ combining with hard water cations. Performance might be enhanced further by addition of a non-ionic surfactant.

## Turbidity

Turbidity is the haziness of a liquid caused by suspended particles. Turbidity is caused by things like soil and organic matter which can reduce the effectiveness of many pesticide active ingredients, especially those with a high soil binding potential (KOC) including: Diquat; Permethrin; Paraquat; Bifenthrin; and Glyphosate.

These pesticides are very susceptible to inactivation by suspended soil particulates so applicators should always use clear, clean water in spray tanks. In addition, soil particulates will plug nozzles and screens leading to uneven spray patterns and lost time repairing equipment.

Applicators can easily test turbidity by dropping a quarter into a five gallon bucket filled with water. If the water is too cloudy to see the quarter, seek an alternative source of water for spray mixtures.

## General Rules to Follow

Always test your water source and assess suitability for spraying pesticides. If water quality is in question, applicators may wish to:

- reduce the water volume to the minimum required for good coverage and performance. This is usually expressed as gallons per acre (GPA) on the pesticide product label. Always check the pesticide product label for the minimum output that is acceptable.
- use pesticides that are least affected by water quality. For example, if an applicator using 2,4-D amine has water with a high pH, he may wish to switch to a 2,4-D ester formulation.
- use non-ionic surfactants, buffers, or acidifiers depending on the water quality problem.
- use the highest labeled rate.
- spray as soon as possible after adding the pesticide to the spray tank.

- use ammonium sulphate fertilizer (21-0-0-24) at a rate of 8.5 to 17 lb per 100 gallons of water for hard water (many weak acid herbicides lose efficacy if hardness is greater than 150 ppm).
- avoid using products containing sethoxydim, clethodim, and tralkoxydim if bicarbonate levels are greater than # 500 ppm. Research has demonstrated liquid ammonium sulphate fertilizer at about 1.5 quarts per acre will overcome the antagonistic effects of bicarbonate in spray water

## Water Quality in Montana

Water quality in Montana varies dramatically from the snowmelt-fed mountain drainages of the west to the arid prairies of the east. In general, shallow aquifers in western river valleys fed by mountain snowmelt have low total dissolved solids with specific conductivity (SC) values commonly under 500 μS/cm. In central and eastern Montana counties, high salinity often produces SC values greater than 5,000 μS/cm; the eastern half of the state also sees most of the highest bicarbonate values. Hardness varies depending on geology and can be high anywhere in the state. The average pH of groundwater across Montana is above 7 and many aquifers are above 8, but there are groundwater sources with natural pH below 7, mostly in the western half of the state. Groundwater quality is typically relatively stable through time but can vary seasonally and can be extremely different in different wells right next to one another. For this reason water testing is very important at multiple intervals during the year.

## Kits and Digital Meters

Water quality can be tested on-site by obtaining litmus test kits or digital meters for testing pH and/or hardness. Testing costs and procedures vary considerably.

Litmus strips can be purchased to test pH and/or hardness. These strips are inexpensive but offer less precision than digital meters. Strips are placed into a water solution for 5 to 30 seconds prior to comparing colors to an easy to read pH chart. They can be purchased at local hardware stores, online, or are available in test kits from various pesticide manufacturers.

Digital pH meters can range from $50 - $150, but offer quick precise measurements if calibrated properly. Digital meters are calibrated by placing the meter in solutions of known pH which can be purchased from a number of online distributors. Applicators using multiple sources of water while performing many applications may wish to purchase digital meters to measure water quality.

Water samples may also be sent to many water quality testing laboratories, or contact your county Extension office for more information on testing water samples. For a list of certified water testing laboratories navigate to http://waterquality.montana.edu/docs/WellEducated.shtml. Applicators may also contact the MSU Pesticide Education Program at:

**MSU Department Animal & Range Science**
103 Animal Bioscience
PO Box 172900
Bozeman, MT 59717-2900
406-994-5067
www.pesticides.montana.edu
Email: ctharp@montana.edu

## References

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