Gas Well Workshop

Chloride

West Virginia has existing water quality standards for chloride (using those from a 1988 US EPA study)[1] and its General Water Pollution Control Permit[2] (hereafter called General Permit) for oil and gas waste disposal by landspraying has chloride concentration requirements.

Chlorides have a number of biological and non-biological effects. Chloride is persistent (chlorides take the form of sodium chloride, calcium chloride, magnesium chloride or potassium chloride) and doesn't degrade.[3] Chloride ions pass readily through soil and will eventually enter surface water. Because chloride moves through soil at the same rate as water it shares the same hydrologic cycle as water. This means chloride deposited on soil's surface can also enter ground water.[4]

Chloride mobilizes heavy metals such as cadmium and can act as a transport helping to deliver these metals to surface or ground water. This is one of the two major non-biological effects of chloride (though these metals can have a profound biological effect).

Another effect of chloride is how it alters the density of water. This means that for lakes and ponds, when enough chloride is present, intermixing of water layers won't occur. Chloride concentrations can become quite high at the bottom layer and wetlands are most vulnerable.

When delivered to soil as sodium chloride serious negative effects to soil structure occur. These effects are persistent since the sodium ion will remain in the soil when the chloride ion leaves with water.

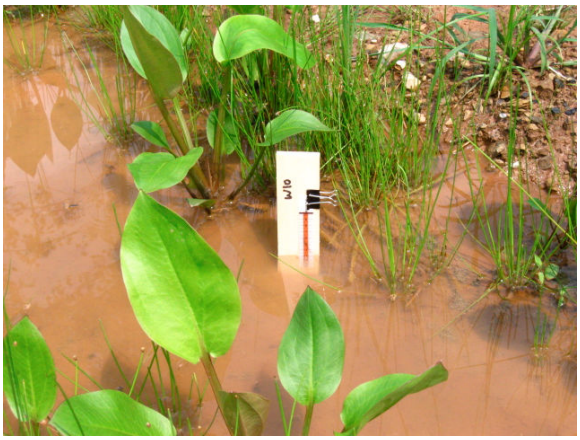
Sodium chloride is inhibiting to soil bacteria at about 50 mg/l. High concentrations of chloride will damage or kill leaves or buds when delivered as a spray. Concentrations first will affect sensitive vegetation and trees (such as beech). High enough concentrations will sterilize soil and prohibit any growth.

Adverse effects have been noted when sodium chloride is applied to roots at 280 mg/l or greater concentration. Vegetation will start to show the effects of sodium chloride spray at 1,000 mg/l. Pine mortality has a threshold of 13,000 ppm chloride. Our discussion below will focus on the state's program of landspraying liquid oil and gas well pit waste which can have very high chloride concentrations. While the intent is, by landspraying

only on vegetation, to deal with chloride through plant uptake, it's hard to see how the program can be effective if the vegetation is killed. Sodium chloride is a registered herbicide.[5]

Chloride in water adversely affects some species of plankton at concentrations as low as 12 mg/l. The 1988 EPA study used chloride's toxic effects on three aquatic species (rainbow trout, cladoceran and flathead minnows) to develop criteria for water quality.[6] The EPA determined that a chronic 4 day average concentration of not over 230 mg/l chloride once every 3 years is acceptable. An acute concentration of 860 mg/l chloride for a period of 1 hour average not more than once in 3 years is also acceptable. These are West Virginia's criteria but without the time variable limitations. Other researchers have found that the EPA's acute concentration is possibly too high and 638 mg/l should be considered instead for water quality standards.[7] The 1988 EPA criteria are perhaps not protective enough for aquatic vegetation and 200 mg/l has been suggested as a better chronic concentration (Siegel, 2007, page 14). Iowa Department of Natural Resources proposes a formula for acute and chronic concentrations of chloride.[8] The formula includes hardness and sulfate concentrations since the harder the water is, the more toxic chloride will be. Sulfate has an inverse function (Iowa DNR, 2009, Table 2, page 5).

Chloride's mobilization and transport of heavy metals is especially troubling within an aquatic environment. Cadmium is toxic to rainbow trout at 1 part per billion. Chloride at 709 mg/l has been shown to release mercury from marine sediments. "Sodium chloride also enhances mercury mobilization from soils" (Environment Canada, 2001, page 80).



We've observed standing water at a well site with an elevated chloride concentration of 113 mg/l harboring tadpoles and frogs coexisting with insects and vegetation. We couldn't directly observe negative effects but some species are halophilic and we might not be noticing a shift of species to those that can withstand higher chloride. We've also seen standing water with much higher concentrations (over 650 mg/l chloride) with no signs of life or vegetation.

What we have noticed at well sites

is where we find elevated concentrations of chloride (42 mg/l and higher) from brine or drilling waste there are numerous deer tracks.[9] When the location is a closed drill waste pit with a large number of tracks and the concentration is over 650 mg/l chloride these animals are exposed to not just the chlorides which they seek out but also other chemicals, some extremely toxic. Sodium chloride can be toxic to animals at concentrations over 1,000 mg/l (Siegel, 2007, page 5).

Studies have shown chlorides, when ingested in significant quantities can be deadly to some birds (notably members of the finch family). For both birds and animals like deer that seek out chloride and the minerals associated with it, chloride can have a stupefying effect, altering behavior around vehicles and people.[10]

Footnotes

[1]Environmental Protection Agency, 1988, *Ambient Water Quality Criteria for Chloride -- 1988*. Fuller bibliographic information and URLs appear under Sources.

[2]West Virginia Office of Oil and Gas, *General Water Pollution Control Permit*. GP-WV-1-88.

[3]We've tried to be precise in our language. Chloride refers specifically to the chloride ion; chlorides are chemicals made up of 2 ions, one of which is chloride. Sodium chloride is the commonest form found in wellfield waste. When sodium chloride concentrations are given, about 60% is the chloride ion. This means 1000 mg sodium chloride/l is roughly equivalent to 600 mg chloride/l.

[4]Much of the description of chloride and its action, which appears below, is from Environment Canada, 2001, *Priority Substances List Assessment Report, Road Salts*.

[5]Lori Siegel, 2007, Hazard Identification for Human and Ecological Effects of Sodium Chloride Road Salt, page 10.

[6]The EPA study used sodium chloride. Potassium, magnesium or calcium chlorides can be more toxic (page 2).

[7]Iowa Department of Natural Resources, 2007, *Draft Ambient Aquatic Life Criteria for Chloride*, pages 6-7.

[8]Iowa Department of Natural Resources, 2009, *Water Quality Standards Review: Chloride, Sulfate and Total Dissolved Solids*, page 62

[9]George Monk and Molly Schaffnit, 2009, *Environmental Assessment for 47-039-02026, Raymond City #6, in Kanawha County, West Virginia*. See also Campbell, Tyler A., et al, 2004, "Unusual white-tailed deer movements to a gas well in the central Appalachians." *Wildlife Society Bulletin* 32(3), pages 983-986.

[10]Environment Canada, 2001, page 116. See also Don Bleitz, 1958, "Attraction of Birds to Salt Licks Placed for Mammals," *The Wilson Bulletin*, March 1958, 7(1), page 92.

Sources:

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