CAN MITIGATION PRACTICES PROVIDE PROTECTION FOR GROUND AND SURFACE WATERS?

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Introduction

The best solution to ground and surface water contamination is to prevent it from occurring. By assessing the risks of a pesticide application to water sources followed by the use of mitigation practices, water sources can be protected or the effects or the application minimized.

Nonpoint source ground water contamination, unlike point source contamination, occurs over wide areas and usually involves low concentrations. A nonpoint source problem could arise from repeated use of the same pesticide over many years, frequent use of the same material in a season, or high application rates in a single year. If pesticides travel downward through the soil, ground water can be contaminated. Ground water contamination depends on the rate at which the chemical moves through the soil, the rate at which it degrades into inactive materials, and the depth to ground water. Ground water also can be polluted by direct introduction of pesticides through sinkholes, poorly constructed wells, and back-siphoning into wells. Surface waters are directly affected when pesticides move off site either through runoff or with eroded soil.

Movement of pesticide residues from agricultural applications to ground water has been well documented (Hallberg, 1989). Ground water surveys conducted within the U.S. have shown that patterns of detection are related to cropping patterns (Kolpin et al, 1997). In the Mid-West, for example, detection of residues for parent and breakdown products of atrazine, alachlor, metolachlor and acetochlor have been related to use as pre-emergence herbicides in the production of corn and soybeans, the predominant Mid-Western crops. In contrast, residues for parent and breakdown products of simazine, diuron, and bromacil predominates detections in California. These pesticides are also pre-emergence herbicides, but they are widely used in grape and citrus production and for non-crop weed control (Guo et al, 2000).

Understanding Pesticide Movement

The pathway for movement of residues to ground/surface water are needed to determine if mitigation measures can be developed that allow continued use, but that are also protective of underground aquifers. This approach has been applied to regulation of pesticides detected in California's ground water because decisions made at the State level balance economic considerations with environmental protection. For example, on coarse-textured sandy soils, guidelines for irrigation management have been suggested to minimize movement of residues lost to deep percolation, whereas in hardpan soils with low infiltration rates, improved incorporation of pre-emergence herbicides is recommended to reduce concentrations in runoff water that eventually recharges ground water (Troiano et al, 2000).

These two scenarios are not representative of all geographical settings where residues have been detected in California's ground water, so further investigations were needed to determine movement of pesticides to ground water. A recently completed study investigated potential pathways for movement of hexazinone and diuron residues to ground water in an area dominated by cracking clay soils. Residues of these pre-emergence herbicides were detected in wells sampled near the town of Tracy, California where the predominant cropping pattern was a rotation of alfalfa with corn and beans. The residues were related to agricultural applications, especially since hexazinone could only have been used on alfalfa. Although the soil is clayey, rapid water movement through cracks, termed macropore flow, has been identified as a potential pathway for rapid movement of solutes to lower layers of soil (Bouma et al., 1982: Lin et al., 1998). Investigation on soil distribution of atrazine had occurred for cracking clays soil condition in another area of California, but a definitive description of a pathway to ground water had yet to be determined (Graham et al., 1992).

Movement of Diuron and Hexazinone

Movement of diuron and hexazinone in this cracking clay soil was confined to the upper reaches of the soil profile even though water percolated past the deepest depths sampled (1 meter). Very little diuron was detected beneath the first 0 - 69 mm depth, whereas, concentrations of hexazinone in the deeper segment were equal to those measured in the first segment. Little to no residues was measured for either herbicide in the third segment, which represented the 271-339 mm depth. Based on a comparison of their physical-chemical properties, greater movement through soil would be expected for hexazinone, caused primarily by its lower soil adsorption value (Koc). After the second irrigation (June), the magnitude of the residues for both pesticides was reduced to levels that were similar to those measured in the background samples. The mass of diuron removed from the field in the runoff water as mean of treatments was 1.97 grams per hectare for the two irrigation events. Hexazinone was lower at 0.0615g/ha. The mass was carried in 84 cubic meters of runoff water per hectare.

Significant amounts of herbicide were delivered to the pond via the runoff waters then infiltrated over a 5 day period of time. The pond did not have a return system. The mass of residues infiltrated through the pond as a result of the 32-acre field for diuron was 10.13 grams while hexazinone was 0.79 grams as a result of the two irrigations. These values could have been larger or smaller depending on the runoff management. Ground water depth at the site was at 11 feet. Concentration of diuron measured in the groundwater at season's end declined with distance from the pond starting at 2.5 ppb with a linear decline with distance to non-detectable at 12 meters. Hexazinone, by virtue of its lower soil adsorption value (Koc), was constant from the pond water to the farthest distance measured (49m). Significant amounts of herbicide were moved by runoff to the pond then infiltrated over a 5 day period of time. Mitigation practices would obviously consist of a tail water return system to minimize the infiltrated water.

Mitigation Practices

A study conducted in 2003 in the same area suggests when runoff is consistently returned to the top of the field, a 96% reduction in the volume of infiltrated water is possible. The only water infiltrated occurred during the pond-filling phase and from water which remained in the pond which was below the pump intake. An evaluation of costs for installation and operational costs are currently under way. Since the runoff water contained the herbicide residue, a threat to surface water also exists if released to a surface water source. The use of a pond with a return system would completely eliminate the off-site moment to surface waters.

The production of food and fiber often requires complex strategies that must balance profitable and efficient farming with water quality and quantity concerns. At their most effective implementation, mitigation practices must be technically feasible; economically viable; socially acceptable; and scientifically sound. This mitigation study will provide the level of reduction of herbicide movement to the ground water and the associated costs to do so.

References

Bouma, J., L.W. Dekker, and C.J. Muilwijk. 1981. A field method for measuring short-circuiting in clay soils. J.Hydrol. 52:347-354.

Graham, R.C., A.L. Ulery, R.H. Neal, and R.R. Teso. 1992. Herbicide residue distributions in relation to soil morphology in two California vertisols. Soil Science 153:115-121.

Guo, F., D.Bartkowiak, D. Weaver, J. Troiano, M. Pepple, F. Spurlock, and C. Nordmark. 2000. Update of the well inventory database. EH 00-15, Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, California EPA, Sacramento, CA. http://www.cdpr.ca.gov/docs/empm/pubs/ehapreps/eh0015.pdf.

Hallberg, G.R. 1989. Pesticide pollution of groundwater in the humid United States. Agriculture, Ecosystems and Environment, 26:299-367.

Kolpin, D.W., S.J. Kalkhoff, D.A. Goolsby, D.A. Sneck-Fahrer, and E.M. Thurman. 1997. Occurrence of selected herbicides and herbicide degradation products in Iowa's ground water, 1995.

Lin, H.S., K.J. McInnes, L.P. Wilding, and C.T. Hallmark. 1998. Macroporosity and initial moisture effects on infiltration rates in vertisols and vertic intergrades. Soil Science 161(1):2-8.

Troiano, J., F. Spurlock, and J. Marade. 2000. Update of the California vulnerability soil analysis for movement of pesticides to ground water: October 14, 1999. EH 00-05 Environmental Monitoring and Pest Management Branch, Department of Pesticide Regulation, California EPA, Sacramento, CA. http://www.cdpr.ca.gov/docs/empm/pubs/ehapreps/eh0005.pdf.