POTENTIAL PESTICIDE CONTAMINATION IN GROUND-WATER RECHARGE AREAS: A MODEL SIMULATION

L.E. Asmussen,[1] D.W. Hicks,[2] R.A. Leonard,[3] W.G. Knisel[4] and H.F. Perkins[5]

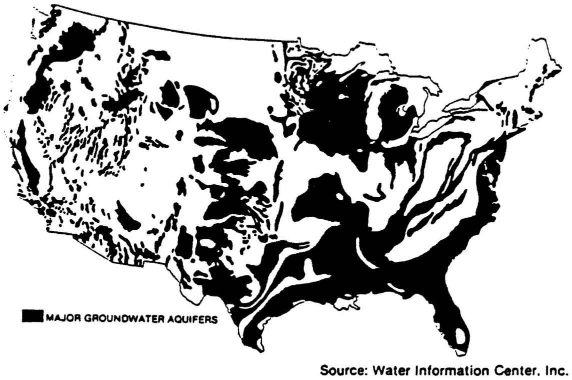
AUTHORS: [1]Geologist, [2]Hydrologist, [3]Soil Scientist, [4]Research Hydraulic Engineer, [1,3,4]USDA-ARS, Southeast Watershed Research Laboratory, Tifton, GA 31793; [2]USGS, 6481 Peachtree Industrial Blvd., Suite B, Doraville, GA 30360; [5]Professor Emeritus, College of Agriculture, The University of Georgia, Athens, GA 30602.

REFERENCE: Proceedings of the 1989 Georgia Water Resources Conference, held May 16 and 17, 1989 at The University of Georgia. Kathryn J. Hatcher, Editor, Institute of Natural Resources, The University of Georgia, Athens, Georgia, 1989.

INTRODUCTION

The preservation of the quality of our nation's ground-water resources is an issue of increasing concern in the United States. Industrial and municipal growth, and increased production demands on the American farmer have put an ever increasing burden on our natural resources, both soil and water. As a result of intensive cropping, agrichemical use has become an integral part of most agricultural production systems. Now roughly 330,000 tons of pesticides and 10.6 million tons of N as commercial fertilizer and 10 million tons through manures, crop residues, rainfall, and biological fixation are applied to agricultural crops yearly.

The vulnerability of our ground-water resources to contamination by surface-applied chemicals varies throughout the United States. In parts of the country, the aquifers are deeply buried and are protected by a thick overburden of relatively impermeable material. However, in other areas, particularly in the southeastern United States, surficial aquifers often are covered by a thin veneer of sandy, highly permeable material (Figure 1). In these ground-water recharge areas, the quality of water leaching into aquifers can be significantly impacted by agricultural management practices. Intense farming activities that include the applying of large volumes of agrichemicals and irrigation, in these recharge areas could contaminate important regional ground-water supplies.



Source: Water Information Center, Inc.

Figure 1. Major groundwater areas in the United States. (SOURCE:WATER INFORMATION CENTER, INC.).

Pesticides such as ethylene dibromide (EDB) and dibromochloropropane (DBCP) have been reported in ground water in the Southeast (Leonard et al., 1986, and Marti et al., 1984). As a result of their detection and potential danger, these compounds are no longer registered for use as surface-applied pesticides. Other agricultural chemicals, such as nitrate-nitrogen have been reported in both deep and shallow ground-water supplies (Hubbard et al., 1984, Timmons et al., 1981, and Watts et al., 1981).

During the 1980's a number of mathematical models were developed that related field-scale agricultural management to water quality (Carsel et al., 1985, Leonard et al., 1987, and Wagenet et al., 1986). In 1987, the U. S. Department of Agriculture's Agricultural Research Service (ARS), developed a mathematical model called GLEAMS (Groundwater Loading Effects of Agricultural Management Systems). The GLEAMS model utilized an existing ARS model called CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems, Knisel et al., 1980) and incorporated a vertical pesticide flux (Leonard et al., 1987). This model includes hydrology, erosion, and pesticide components. Soil data such as porosity, water retention characteristics, and organic matters may be entered by horizons for storage-routing of percolation from layer to layer. The vertical flux of pesticide from the surface layer is separated from the runoff and sediment transport to allow the computation of transport to the underlying soil layers through the root-zone.

LEGISLATION

As a result of public concern for the protection of our Nation's water and the numerous detections of potentially harmful agrichemicals in water supplies, Congress has enacted or proposed specific legislation with an intent to protect these resources. The Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500) set the goal "to restore and maintain the chemical, physical, and biological integrity of the

Nation's waters." Also, the Soil and Water Resources Conservation Act of 1977 (P.L. 95-192) was designed to further the conservation, protection, and enhancement of the nation's soil, water and related resources for sustained use. The Clean Water Act (P.L. 95-217) passed in 1977 had a similar intent. Congress passed the Food Security Act in late 1985. Title XII of the Food Security Act, "Conservation", will do a great deal to effect farm management and the associated environment. In 1987, Congress amended the Clean Water Act of 1977 with the Water Quality Act (H.R.1). The Water Quality Act of 1987, combined with new state legislation, clearly emphasized the need for relating the impacts of farm management on the quality of surface and ground-water resources.

Farm bills proposed for 1990 will stress the emphasis of agricultural science and education programs on food safety, water quality, and pesticide residue (Benbrook, 1988). Senator Wyche Fowler (D. GA) introduced Senate Bill 2989 which ties commodity programs to the detection of fertilizer or pesticide in ground water.

RELATION OF SOIL CHARACTERISTICS AND AGRICULTURAL MANAGEMENT TO GROUND-WATER QUALITY

In many parts of the Georgia Coastal Plain, the quality of ground-water recharge may be largely controlled by characteristics of the surficial soils and agricultural management practices. It is theorized that clayey surficial soils, exhibiting relatively low permeability, would allow agrichemical leachate to infiltrate at a much slower rate than sandy, highly permeable soils. Although soils exhibiting each of these characteristics may occur in an area considered to contribute recharge to a particular aquifer, the potential for leachate contamination of the water resource would be significantly different. It is likely that mobile agrichemicals could be used in an area dominated by clayey soils, but may leach to ground-water if applied in sandy soils. To prevent the contamination of our water resources, we must clearly define ground-water recharge areas and design agricultural management systems that incorporate characteristics of the surficial soils with chemical usage.

A study area, covering 10 counties and an area of about 3,713 mi^2 in the Georgia Coastal Plain was selected to evaluate the potential for ground-water contamination from agrichemicals (Figure 2). The recharge area of the Floridan and Claiborne aquifers was delineated and comprised approximately 42 and 27 percent of the study area, respectively, (Figure 2, Table 1).

Soils data were mapped in the study area and grouped according to their textural characteristics (Figure 3). This grouping showed that clayey soils cover about 50 percent of the total study area.

The GLEAMS model was applied to the study area to generate a 50-year simulation of the transport and degradation of three classes of pesticides. A simulation was made for the pesticides in each of the three soils: sand, loam, and clay. The model results indicate that the predicted mass loss of pesticides ranged from 12.2 percent in the sandy soils, to less than 0.0001 percent for pesticides simulated in clayey soils (Leonard et al., 1989).

CONCLUSIONS

The results of the 50-year GLEAMS simulations indicate that soil characteristics and agricultural management have a profound effect on the quality of ground water in aquifer recharge areas. For this reason, it is important that we develop a system for assessing the long-term impacts of agricultural management on ground-water quality. Moreover, this assessment system must be applicable to regional evaluations of agricultural management schemes, but must also be accurate to the field scale. Future decisions by resource managers relating to the use, or nonuse, of agrichemicals should be guided by a representative evaluation of agricultural management practices.

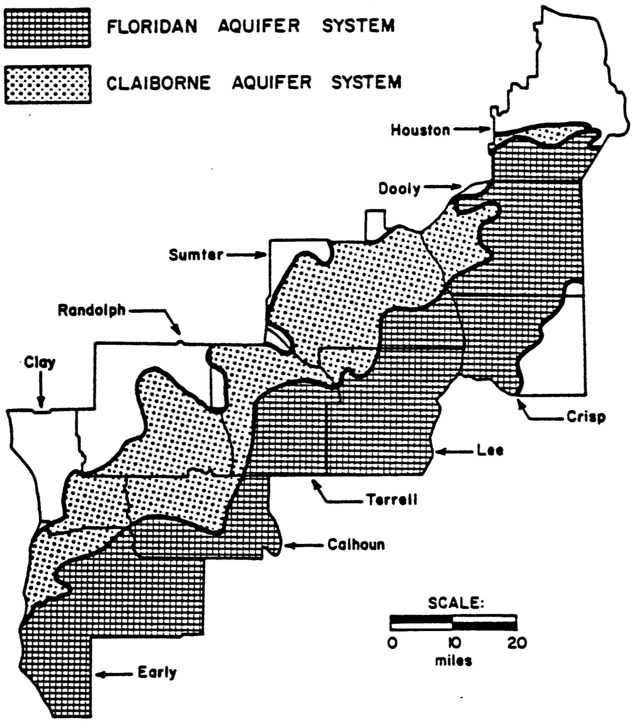


Figure 2. Ground-water recharge area of the Floridan and Claiborne aquifers in the study area. (Data from the Georgia Geologic Survey).

TABLE 1. AQUIFER RECHARGE AREAS BY COUNTIES.

County	Aquifer[1/] Area mi^2	County Area Mi^2	Percent of County
Clay	F - 0 C - 73	224	F - 0 C - 33
Early	F - 407 C - 69	526	F = 77 C = 13
Randolph	F - 0 C - 185	436	F = 0 C = 42
Calhoun	F - 158 C - 103	289	F = 55 C = 36
Terrell	F - 152 C - 118	329	F = 46 C = 36
Lee	F - 288 C - 32	355	F = 81 C = 10
Sumter	F - 71 C - 319	485	F = 15 C = 66
Dooly	F - 270 C - 67	394	F = 69 C = 17
Houston	F - 85 C - 18	379	F = 22 C = 5
Crisp	F - 138 C - -	296	F = 47 C = 0
TOTAL:	F = 1569 C = 984	3713	F = 42 C = 27

[1/] F - Floridan Aquifer
C - Claiborne Aquifer

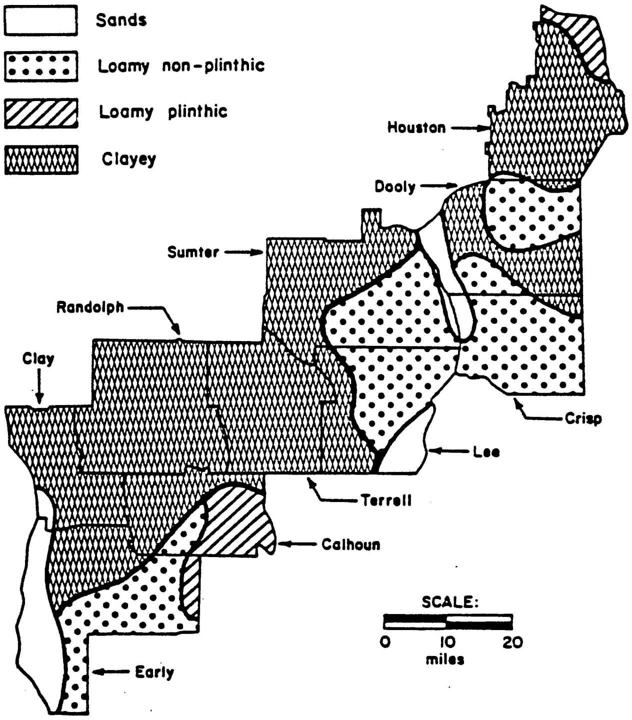


Figure 3. County soil survey maps show more than 50 individual soil mapping units. These soils have been grouped in 3 textured levels (0-50 cm) and 7 levels (50-130 cm).

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