

WATER QUALITY RESEARCH IN THE SOUTH GEORGIA COASTAL PLAIN

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INTRODUCTION

Agricultural chemicals are required to assure consistent yields in the South Georgia Coastal Plain. The high annual rainfall, temperate climate, humid conditions and sandy soils support a host of agricultural pests including weeds, pathogens, nematodes, etc. In addition, the predominance of light textured soils with intense rainfall provides the potential for nutrient and pesticide movement to surface water and groundwater.

Ideally, the mobility and fate of all agricultural chemicals should be evaluated under all potential application conditions to determine methods to reduce or eliminate potential contamination. Unfortunately, the breadth of chemicals being used and the variation in chemical characteristics, soils, cropping systems, climatic and topographic conditions, and subsurface flow regimes within this region makes field evaluation of all potential scenarios economically and physically impractical. The introduction of water quality models to predict the movement and fate of chemicals in runoff and groundwater has provided a more economically feasible method of evaluating potential chemical application, soil, cropping, climate, and topographic scenarios. How representative these models are with respect to actual field conditions is still a matter for debate.

Agricultural, non-point source prediction models such as GLEAMS (Leonard et al., 1987) and PRZM (Carsel et al., 1984) have primarily been developed for evaluating the effect of a particular management alternative or parameter change on chemical movement. Unfortunately, the lack of field data on individual flow processes within and below the root zone and the movement of chemicals in these zones has led to more empirical rather than physical representation of the processes. Additionally, more precise field data are required to more accurately determine the

method of chemical movement to improve the representation of these processes in water quality models and to verify the results.

Water table management (WTM) or drainage-subirrigation systems are a relatively new technology to Georgia, but they have been applied extensively in Florida, North Carolina and other places for many years. WTM, as the term implies, is designed to remove excess water during wet periods (drainage) and provide water for plant growth from below (subirrigation) during dry periods. These systems have the potential to increase yields and reduce the effects of excess water, especially in the flatwoods region of the south Georgia Coastal Plain. Current legislation (Swampbuster Act) will no doubt reduce the potential applicability of these systems in some Georgia areas. However, droughts in other areas combined with Georgia's abundant groundwater resources (below the flatwoods) and good climatic conditions will make this type technology more economically feasible in the near future. WTM is a technology which requires soil conditions where water can be maintained near the soil surface. One of the primary constraints of these type systems, which has limited expansion in some areas, is an understanding of the relative impact these systems have on the quality of surface water and shallow groundwater resources. By providing a quicker response to excess water removal during drainage, the potential exists that nutrients and pesticides could be transported more rapidly to surface water. In addition, many rural wells use the shallow water table aquifer which is the primary control zone for WTM. Understanding and evaluating these processes as they relate to the movement of chemicals is a priority research item which must be addressed before this type technology can be promoted.

Many current measurement techniques to analyze shallow subsurface water quality have been adapted from sampling

techniques for deep aquifer systems. These techniques may or may not be appropriate considering the extreme soil characteristic variabilities encountered in a small area. The use of point-source shallow well chemical concentrations or drain tubing outflow as a representation of chemical concentrations in a large area needs further investigation.

The following projects are only a small portion of the research effort underway at the University of Georgia Coastal Plain Experiment Station and other locations in south Georgia related to water quality and chemical movement. However, these projects are cooperative efforts of the UGA-CPES and the USDA-ARS Southeast Watershed Research Laboratory.

EXPERIMENTAL SITES AND RESULTS

Gopher Ridge

A 0.7-ha experimental site has been established near Tifton to observe the transport of agrichemicals through both the vadose (unsaturated) and saturated zones (Fig. 1). The site is located on the UGA-CPES Gopher Ridge research farm which has soils which are classified as Lakeland sand (Typic Quartzipsamments, thermic, coated). The soil is underlain by a restricting layer at 1.9 to 4.4 meters which impedes downward percolation of rainfall and irrigation water and forms a transient water table. At this impeding layer, the primary saturated flow component is lateral and the water eventually enters a forested riparian zone and reappears as surface flow in to the Little River.

The herbicides atrazine and alachlor, along with a bromide tracer were surface applied to a 36 X 12 m strip near the upper edge of the site (Smith et al.,

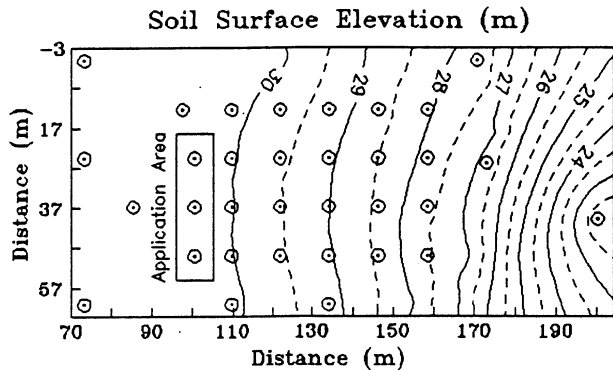


Figure 1. Contour Map of Soil Surface Showing Locations of Wells and Application Area.

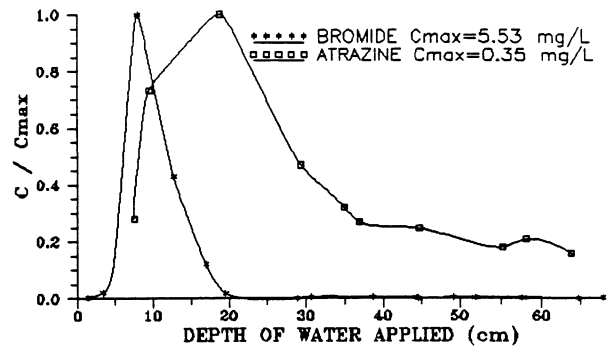


Figure 2. Bromide and Atrazine Concentrations in Soil Water at a Depth of 61 cm.

1988). Vertical movement of the chemicals through the sandy soil is monitored using soil samples and water samples from suction lysimeters. A network of 36 monitoring wells is used to monitor lateral movement of chemicals within the shallow water-table aquifer.

Results from the first year of data collection showed atrazine leaching to a depth of approximately 2.5 m within two months of application. Alachlor was not observed to leach below a depth of 45 cm. Figure 2 shows the concentrations of atrazine and bromide leaching past a depth of 61 cm as a function of the total volume of water applied. The atrazine moved laterally within the saturated zone in excess of 100 m within two months of its first appearance within the groundwater. Figure 3 shows the total mass of atrazine within the saturated zone as a function of time since application. The maximum mass of 4 g (3% of total mass applied) occurred six months after application. Using ground penetrating radar in conjunction with the data from the wells, it is anticipated that improved mass balances of water and chemicals can be developed.

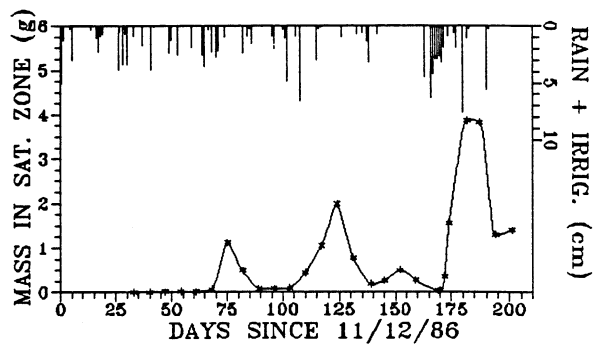


Figure 3. Total Mass of Atrazine Within the Saturated Zone. Atrazine Was Applied on 11/12/86.

Bell Farm

Water quality data has been collected continuously since the fall of 1986 from shallow wells and outlets from a farmer-owned 40-ha water table management (WTM) system located in the Georgia flatwoods (Thomas et al., 1987; Shirmohammadi et al., 1985). The system is unique with both open and closed-type control structures (head stands) with a variety of crops over the years, including rabbiteye blueberries (36 ha), corn-soybean (in rotation), and peanut. Wells were also installed in adjacent forested and cleared areas for comparison. Nitrate-N, ammonium-N, phosphate-P, and chloride concentrations as well as pH and electrical conductivity were measured on the water samples (Thomas et al., 1987).

Results show significantly higher nitrate-N concentrations in the WTM area as compared to adjacent cleared and un-irrigated areas (Fig. 4).

Outflow from the WTM system had significantly lower nitrate-N concentrations as compared to infield samples, and no individual samples exceeded the drinking water limit of 10 mg/L. In mid November of 1987, the nitrate-N concentration exceeded 13 mg/L in the scrub forest section down-slope from the WTM system. Samples were taken immediately after a storm event which followed nearly two months of minimal rainfall. The WTM system was supplying water to the field during this period, and the down-slope flow was apparently sufficient to produce an increase in nitrate-N concentration.

Phosphate-P concentrations were similar across all sampling locations and no significant effects due to WTM were indicated from the samples obtained.

Ammonium-N concentrations at one of the well sites in the WTM area were

significantly higher than the concentrations in the outflow samples, although the difference was not dramatic. Several locations exhibited ammonium-N concentrations above 2 mg/L (detrimental to some aquatic organisms). One site in particular is the open ditch head stand at a two meter depth which exhibited an ammonium-N concentration near 15 mg/L. It is suspected that disturbance of the ditch sediment may have produced the high value, but this level of ammonium-N concentration could be detrimental to aquatic life.

Chloride concentrations were highly variable between sampling locations with a detrimental effect due to the WTM system. Chloride concentrations were significantly higher in the WTM sites as compared to most of the cleared, un-irrigated and forested sites. However, the chloride concentration in the scrub forest site (down-slope from the WTM area) was significantly higher than all sites except the sampling location directly upslope in the WTM area. Parker et al. (1983) showed that chloride concentrations above 26 mg/L could affect growth and yield of selected soybean varieties. In-field samples exhibited chloride concentrations as high as 129 mg/L. Samples at the pump even approached 27 mg/L. Chloride toxicity could be a major problem if sufficient rainfall does not occur to promote leaching of the salts.

Bowen farm

A research oriented WTM system located on the UGA-CPES Bowen farm has been used to evaluate drainage system and soil variability effects on chemical concentrations within the saturated zone. In the first year of this study the movement of the nematicide fenamiphos and nitrate applied to peanut were monitored. Results from this experiment are incomplete at this time.

This system is currently being used to evaluate chemical concentrations in spatially averaged water quality samples (drain tubing outflow) as compared to infield point source well samples. Fifty randomly placed wells are being used to determine the in-field variability of concentrations of surface-applied bromide and nitrate within the saturated zone. The mean concentration in the wells will be compared to the concentrations of bromide and nitrate observed in the tubing outflow. In addition, the arrival time of the chemicals will be analyzed.

Future research on this site will focus on crop response to WTM and development of automated control

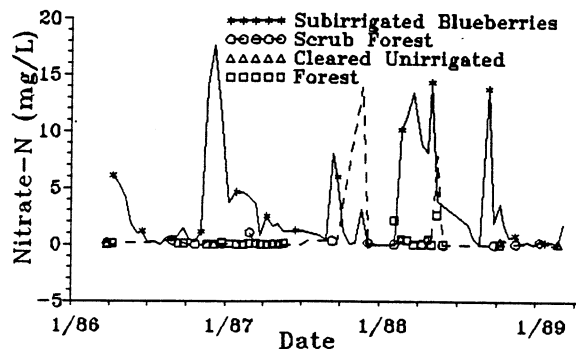


Figure 4. Nitrate-N Concentrations from the Scrub Forest, Water Table Management Blueberries, Cleared Un-irrigated, and Forested Areas.

procedures for WTM systems. A secondary emphasis, however, will be to monitor chemical leaching and tubing outflow quality as affected by water table management, drain spacing, chemical application management and crop type.

SUMMARY

Water quality data are being collected from three different study sites in south Georgia. Data from these studies are being used to discern the mechanisms controlling chemical fate and transport in both the vadose and saturated zones, evaluate monitoring methods and test transport models. Data collection from these sites will continue and plans are being made to initiate similar studies at two more sites.

Work is underway to link vadose zone and groundwater transport models. Data from the Gopher Ridge study cited above will be used to test the linked models.

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