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A USDA water quality demonstration project in the Eastern Coastal Plain: Initial water quality status

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Even though significant progress has been made in the development and implementation of agricultural best management practices, nonpoint pollution of surface and ground water by agriculture is a major water quality concern (1, 2). A five-year water quality demonstration project involving federal, state, and local agencies, private industry, and local land owners was initiated in 1990 on a watershed, Herrings Marsh Run (HMR), located in the Cape Fear River Basin in Duplin County, North Carolina. Duplin County has the highest agricultural revenue of any county in North Carolina, and in 1990 it had the highest population of turkeys and the fourth highest population of swine of any county in the United States (3).

The total area of the Herrings Marsh Run Watershed is 2044 ha (5050 ac). Agricultural management practices on the watershed are typical for the southeastern Coastal Plain and include 1093 ha (2700 ac) of cropland, 708 ha (1750 ac) of woodlands, and 212 ha (525 ac) of farmsteads, poultry facilities, and swine facilities. The major agricultural crops on the watershed include tobacco (131 ha, 324 acres), corn (415 ha, 1026 acres), soybeans (273 ha, 675 acres), wheat (121 ha, 300 acres), and vegetables (162 ha, 400 acres). The predominant soil series in the watershed is Autryville fine sand; secondary soil series are Norfolk loamy sand, Marvyn-Gritney soil complex, and Blanton sand.

Current annual nutrient usage for crop production on the watershed is estimated at 145 metric tons of nitrogen, 64 metric tons of phosphorus, and 243 metric tons of potassium. Although swine and poultry operations produce sufficient quantities of waste to supply over half of the needed nutrients, 90% of the nutrients applied to cropland are supplied by commercial fertilizers. The application of large quantities of commercial fertilizers coupled with the production of large quantities of animal waste provides a potential for nitrogen and phosphorus contamination of surface and ground water. The initial phase of the joint project has been to evaluate the effect of current agricultural management practices on stream and ground water quality within the watershed.

Methods

Groundwater monitoring wells were established on ten farms in the watershed. These farms exemplify the agricultural practices used in the watershed. Ground water monitoring wells were installed using a SIMCO 2800[1] trailer-mounted drill rig equipped with 108-mm (4.25-in) i.d. hollow stem augers. The well casings and screen were 50-mm (2-in) i.d. threaded schedule 40 PVC, and well screens were 1.5 m (5 ft) in length. Well bottoms were placed on an impermeable layer or to a depth of 7.6 m (25 ft) if the impermeable layer could not be located above that depth. Water table depths in the watershed are generally 1.5 to 3 m (5 to 10 ft) from the soil surface.

Surface water sampling stations were established in August, 1990, at three sites within the watershed. Site 1, Red Hill, was located at the stream outlet from the watershed. Site 2, Herrings Marsh Run Tributary, was located along a tributary downstream from intensive swine and poultry operations. Site 3, Herrings Marsh Run Main, was located along the main stream run flowing through woodlands. Site 4, Red Hill tributary, was installed in August, 1991, to provide additional information about the eastern portion of the watershed. Isco 2700 automated water samplers were installed at each site. Sample collection was continual from October 1990 to the present time. The water samplers combines hourly samples into a daily composite. The samples were collected weekly and transported to the laboratory for analysis. All water samples were transported to the USDA-ARS, Soil and Water Conservation Research Center in Florence, SC, for analysis using a TRAACS 800 Auto-Analyzer. Water samples were analyzed for nitrate-nitrogen, ammonium-nitrogen, Total Kjeldahl Nitrogen, ortho-phosphorus, and total phosphorus using EPA Methods 353.2, 350.1, 351.2, 365.1, and 365.4, respectively (4). EPA-certified quality control samples were routinely analyzed to verify results.

Results and discussion

Groundwater nitrate-nitrogen concentrations for the monitored sites are presented in Table 1. Nitrate-nitrogen concentrations in groundwaters at Farm A consistently exceeded 10 mg/L. In addition, the mean nitrate-nitrogen concentrations in stream water at site A were 8 mg/L. It appears likely that sites A is being affected by point sources of nutrient contamination. At farm B, the elevated nitrate-nitrogen concentrations is believed to be directly related to the land application of swine wastewater that has been an on-going operation since 1986. The spray field for the waste application is undersized due to expansion of the swine operation since its original design. Prior to 1991, the spray field had no permanent grass cover; row

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[1] Mention of a trademark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by USDA and does not imply its approval to the exclusion of other products or vendors that may also be suitable.

crop or weed fallow served as the ground cover. Additionally, it is suspected that the overloading may be degrading the performance and efficiency of nutrient removal in the lagoon.

The slightly elevated nitrate-nitrogen concentrations at sites B and C are likely related to nonpoint sources of nitrogen because only commercial fertilizer is used. It appears that improved nutrient management will be helpful. Sites D and E appear to have appropriate nutrient management since the nitrate-nitrogen concentrations are less than 10 mg/L.

Nitrate-nitrogen concentrations in the surface water are presented in Figure 1. Mean nitrate-nitrogen concentrations of water leaving the watershed at the exit, Red Hill (Site 1), and at HMR tributary (Site 2) were two- and four-fold higher, respectively, than background concentrations as represented by HMR main (Site 3). Daily mean nitrate-nitrogen concentrations at the HMR tributary sometimes exceeded 10 mg/L. Over- application of waste water and overloaded lagoons are likely contributors to the elevated nitrate-nitrogen concentrations in the HMR tributary. However, the mass load calculations indicated that there are other sources, probably nonpoint sources nitrate-nitrogen contribution on this tributary.

Stream flow data were integrated with the stream monitoring data to calculate the mass loading of nitrate-nitrogen. The mass nitrate-nitrogen leaving the watershed (Red Hill) averages approximately 30 kg/ha per day. The HMR tributary monitoring site has approximately 20 kg/ha per day leaving that sub-watershed.

Results from the initial phase of the five-year project indicate that most of the streams and groundwaters of the watershed have acceptable water quality. However, it appears that traditional agricultural management practices on the watershed have had a significant adverse impact on the quality of surface and groundwater at specific sites. Further, these data indicate that improvements in specific agricultural management practices on the watershed could produce measurable improvements in water quality.

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Table 1.Mean nitrate-nitrogen concentrations in groundwater monitoring wells located within the North Carolina demonstration watershed.

Sampling period	A	B	C	D	Farm E	F	G	H	I
					mg/L				
Oct. - Dec. 1991	79	8							
Jan. - Mar. 1992	47	8							
Apr. - Jun. 1992	75	12	16	5	7				
Jul. - Sep. 1992	87	12	19	7	6				
Oct. - Dec. 1992	81	13	18	6	8	7	11	5	6
Mean	74	11	18	6	7	7	11	5	6

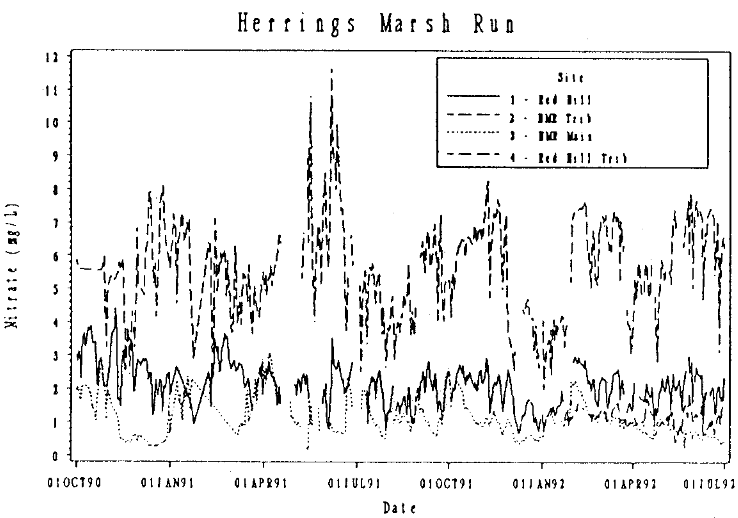

Figure 1. Nitrate-nitrogen concentrations in the surface water.