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ABSTRACT

Removal of inorganic and organic nitrogen from wastewater prior to recharge of ground and surface waters can be accomplished by judicious land application. This study focused attention upon the feasibility of using sprinkler irrigation as the wastewater delivery system with coastal bermudagrass (*Cynodon dactylon* L., var. coastal) pasture as the wastewater sink. One site was located on a Sawyer soil near El Dorado, while the other was located on a Savannah soil near Malvern. This report is limited to the renovation of surface waters. Results revealed that nitrogen concentration in runoff water from rainfall was substantially less than nitrogen concentration of the wastewater applied to the soil and similar to background levels. Such results support the consideration of land application as a viable wastewater disposal method.

INTRODUCTION

A major goal in the renovation of industrial wastewaters should be to recover and recycle wastewater components which are considered pollutants if discharged directly into surface waters. When these components are plant nutrients, this goal can be achieved by properly integrating wastewater management with conventional cropping systems (Pound and Crites, 1973). Toward this end, site selection, irrigation method, loading rates and crop management must be considered to optimize the renovation process (Pound and Crites, 1973).

The objective of this study was to evaluate the potential of sprinkler irrigation on pasture at two sites in Arkansas as a wastewater renovation procedure. Surface water nitrogen concentrations were the variables used in this evaluation.

METHODS AND MATERIALS

Site 1 was located near El Dorado, Arkansas, on a Sawyer soil (fine-silty, siliceous, thermic, Aquic Paleudult) with 2 to 5 percent slope. In 1975, coastal bermudagrass (*Cynodon dactylon* L., var. coastal) pasture was established at the site and a stationary sprinkler irrigation system installed on three 0.74 ha rectangular plots. Each plot was surrounded by a levee in which a runoff outlet, a V-notch weir, was installed. Sample tubes were connected to the weir in a manner which allowed individual samples (about 1 sample per each 2.5 cm head) to be collected during rising and falling stages of a given runoff event. Runoff volume was measured with a water stage recorder. Runoff results reported here were from rainfall events and not from runoff which may have occurred during irrigation. When irrigation was improperly conducted, the infiltration capacity of the soil was exceeded and runoff occurred. The nitrogen concentrations in the latter were similar to the nitrogen concentrations in the applied effluent (data not shown).

Site 2 was located near Malvern, Arkansas, on a Savannah soil (fine-loamy, siliceous, thermic, Typic Fragiudult) with 0 to 1 percent slope. In 1975, coastal bermudagrass pasture was established and a staionary sprinkler irrigation system installed on three 0.10 ha circular plots. These plots were instrumented and measurements made as described for Site 1 above.

At each site, fertilization, liming, weed and insect control, harvest frequency and the like were representative of the management inputs used by farmers in the site area. Control plots received no management inputs except harvest.

The effluent was applied at weekly or biweekly intervals during the growing season (April to September). At Site 1, three plots received effluent (3 to 9 cm applied) at rates of about 400, 700 and 1100 kg N/ha, respectively, during the growing season. The data reported in Table I are average values for the 3 plots. Control data for Site 1 were obtained from an unirrigated plot identical to the above except that vegetation was native and not coastal bermudagrass. At Site 2, three plots received approximately 300, 600 and 900 kg N/ha/year, respectively, during each season. In 1976, from 7 to 21 cm of effluent were applied, while in 1977, 17 to 46 cm of effluent were applied. The data reported in Table II are average values from the 3 plots. Control data for Site 2 were obtained from an unirrigated plot identical to the plots irrigated with effluent.

Water samples were treated with phenylmercuric acetate and refrigerated prior to analysis. Ammonium, nitrate (plus nitrite) and organic nitrogen were determined by the semi-micro Kjeldahl procedure (Bremner, 1965). Runoff data for Site 1 are volume-weighted averages, while those from Site 2 are unweighted averages. Irrigation data reported for both sites are unweighted averages.

RESULTS AND DISCUSSION

Land application of nitrogenous effluent was evaluated by comparing the nitrogen (N) concentrations in runoff with the N concentrations in: a) effluent used in irrigation, b) runoff from other events, and c) receiving streams. For the purposes of this discussion, it was assumed that runoff did not occur during effluent application and that renovation was shown when a decrease in the N concentrations from input (irrigation) to output (runoff) waters was measured. Thus, renovation considered surface water quality entering and leaving the pasture and did not consider the behavior of nitrogen or water within the pasture itself.

Tables I and II present the average nitrogen concentrations in irrigation and runoff waters for Sites 1 and 2, respectively, during the growing season. In all cases, the nitrogen concentration in the runoff water was substantially smaller than that in the irrigation water. The NH_4-N concentration decreased by 99 percent at Site 1 and from 75 to 83 percent at Site 2. The NO_3-N concentration also decreased at Site 1 (97%), while a 93 to 97 percent NO_3-N decriment was measured at Site 2. Data from Site 2 pointed out that organic-N concentrations decreased by 88 to 95 percent. These reductions in NH_4-N, NO_3-N and organic-N represent a substantial renovation of the original wastewater which equals or surpasses that attainable through conventional or advanced treatment schemes (D. T. Mitchell, *per. comm.*). Conventional water treatment plants do not alter NO_3-N concentrations, while NH_4-N concentrations of somewhat less than 5 ppm result when near optimum methods of NH_4-N removal are employed. Advanced wastewater treatment schemes which have been proposed, but not yet applied on a large scale, would probably achieve concentration reductions similar to those reported here (D. T. Mitchell, *per. comm.*).

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Table I. Summary of irrigation and runoff water quality during the 1976 growing season at site 1.

Water	NH_4-N	NO_3-N
	ppm	
Irrigation	796	380
Runoff*	7	11

*Average NH_4-N plus NO_3-N concentration from the control plot was about 1 ppm.

Table II. Summary of irrigation and runoff water quality during the 1976-77 growing seasons at site 2.

Water	NH_4-N 1976	NH_4-N 1977	NO_3-N 1976	NO_3-N 1977	Org-N 1976	Org-N 1977
			ppm			
Irrigation	6	4	131	59	329	118
Runoff*	1	1	1	4	13	14

*Average NH_4-N, NO_4-N and Org-N concentrations during 1976-77 from the control plot were 1, 1 and 3 ppm, respectively.

Another measure of wastewater renovation was comparison of the nitrogen concentrations in the runoff water with those of other runoff waters. For example, at Site 1 the control plot yielded runoff waters with an average NH_4-N plus NO_3-N concentration of about 1 ppm, while that from the sprinkler irrigated plots averaged 18 ppm. At Site 2, NH_4-N and NO_3-N concentrations in runoff for control and irrigated plots were similar, while organic-N concentrations were about 10 ppm higher in plots receiving effluent as compared to controls. In a Missouri study runoff waters from pastures amended with 170 kg N/ha as NH_4NO_3 averaged 2.5 ppm NO_3-N and 1.3 ppm NH_4-N over a 3 year period (Schuman *et al.*, 1973). These concentrations are intermediate to those reported here which suggests that our results are within the range of those expected for a pasture fertilized in a conventional manner. Schreiber *et al.* (1976) measured about 0.1 ppm NO_3-N and from 0.5 to 1.1 ppm NH_4-N in runoff waters from 5 southern pine watersheds. These results are similar to the data reported here for the control plots. Thus, the concentrations of NH_4-N and NO_3-N in runoff appeared greater than would be expected in a native or control environment, but were similar to that expected for a pasture receiving recommended amounts of nitrogen as fertilizer applied in a conventional manner.

A final comparison used to test renovation efficacy was contrasting the nitrogen concentrations in runoff waters (Table I and II) with those in receiving streams. Only NO_3-N data were available in the STORET computer file of surface water quality data (D. B. Beasley, *per. comm.*) for this comparison. Data from October, 1973 to October, 1977 for Smackover Creek (Sample Station OUA27) and from October, 1971 to October, 1977 for the Ouachita River (station OUA07A), both receiving streams for Site 1, showed NO_3-N concentration averages of 0.2 and 0.5 ppm, respectively. Data from October, 1973 to October, 1977 for the Saline River (station OUA26), the receiving stream for Site 2, yielded an average NO_3-N concentration of 0.2 ppm. Thus, even with the reduction in NO_3-N concentration obtained via sprinkler irrigation, the NO_3-N concentrations in runoff waters were larger than those of the receiving stream.

In summary, substantial reductions in wastewater N concentrations were achieved, and runoff N concentrations were within expected limits. However, NO_3-N levels in runoff were larger than those in receiving streams. These results and attendant discussion point out that land application of nitrogenous effluent by sprinkler irrigation yields surface recharge water (runoff from rainfall) much less likely to measureably increase N concentrations in the receiving stream than direct discharge of the effluent.

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