THE EFFECT OF IRRIGATION WITH PRETREATED WASTEWATER ON GROUNDWATER QUALITY AND ELEVATION AT CLAYTON COUNTY, GEORGIA

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INTRODUCTION

Municipal wastewater has been irrigated at a 1460 hectare land treatment system in Clayton County, Georgia since October 1982. The system was designed to renovate secondarily treated wastewater and augment water supplies by irrigation 11 km upstream from the drinking water intake for Clayton County. The pretreated wastewater is pumped from the Flint River Basin, where most of the wastewater is produced, to the land treatment site in the Ocmulgee River Basin which contains the raw water reservoir.

The irrigation site is divided into seven sections of about 145 hectares. Each section is irrigated once a week with 6.4 cm of wastewater. The concentrated hydraulic loading is designed to promote denitrification by providing a period when the soil is saturated or nearly saturated followed by a period when the soil is allowed to dry. The site is planted in loblolly pine and harvested on a 20-year rotation to promote vegetative uptake of nitrogen (Nutter, 1986).

Groundwater quality and elevations have been monitored since December 1979 to obtain background data and to evaluate system performance. This paper will address the effectiveness of the wastewater renovation by analyzing groundwater quality for trends in nitrate-nitrogen (NO_3-N), phosphate (PO_4), chloride (Cl), specific conductivity and selected metals. We will also use groundwater monitoring well elevations as indicators of increased recharge that would augment streamflow and the Clayton County drinking water supply.

METHODS

Groundwater samples were collected and well elevations measured by the staff of the Clayton County Water Authority (CCWA). Chemical analyses were performed at the CCWA laboratory using procedures from Standard Methods for the Examination of Water and Wastewater (1985).

Groundwater monitoring wells were grouped by location into Interior wells (Wells 3, 8, 10, 11 and 18 within the irrigation area), Outflow wells (Wells 13, 14 and 15 at the downgradient edge of the site), Sub-watershed wells (Wells 16 and 17 downgradient from a subwatershed at the site), a Seepage well (Well 19 below the holding ponds), and a Control well (Well 1 outside the irrigated area). Data collected from December 1979-September 1982 represents pre-irrigation water quality and elevations, while data collected from October 1982-December 1987 represents post-irrigation water quality and elevations. Missing data precluded a monthly statistical analysis, so quarterly means were calculated for each parameter of each well. A two-tailed Mann-Kendall (M-K) trend test (alpha = 0.05) was used to test the hypothesis that there were no groundwater quality trends. The non-parametric test was chosen because the data set contained missing values and below detection limit values which precluded other time series analysis (Gilbert, 1987). Below detection limit values were assigned half the detection limit for statistical analysis because the test relies on the relative differences between values rather than the values themselves. Several M-K statistics were larger than the table value given for zero probability. The out of range values were probably due to the number of ties in the data associated with below detection limit numbers. The results of the M-K trend test were validated by inspecting plots of the parameters over time.

Pre- and post-irrigation means were calculated for the metal concentrations as data were collected infrequently and were only available for most wells since the summer of 1980. Means were calculated with half the detection limit substituted for below detection limit values. The M-K trend test was not appropriate due the extreme number of ties in the data.

Plots of groundwater elevations over time were inspected for trends, and groundwater elevation means were used to compare treatment wells with the control during the pre- and post- irrigation periods.

RESULTS

Groundwater Quality

Nitrate-nitrogen concentrations in the groundwater generally exhibited no significant trends for any of the well groups. Results of the M-K trend test were insignificant for all wells except Interior Well 10 and Outflow Well 13. Both Well 10 and Well 13 had a negative M-K statistic indicating a downward trend. Plots of

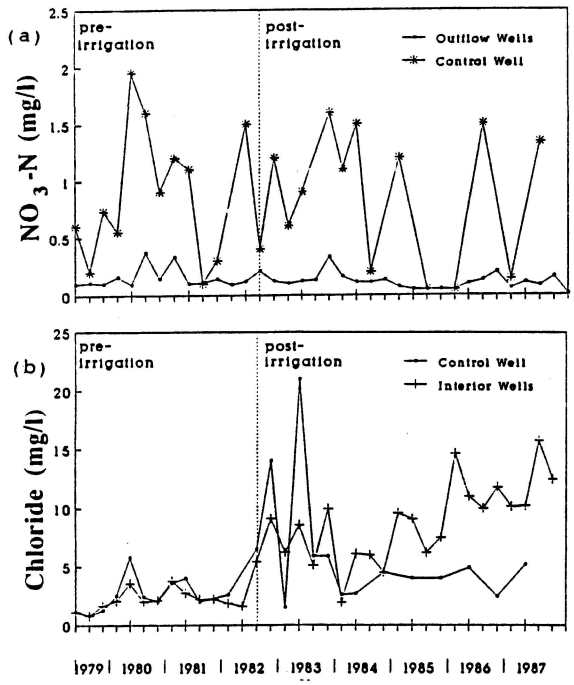

Figure 1. Control Well and Mean Outflow Well Concentrations over Time at the Clayton County Land Treatment Site. (a) Nitrate-nitrogen. (b) Chloride.

the quarterly means confirmed the results of the M-K test. Nitrate-nitrogen in the Control well samples was higher than in either Interior, Outflow, Sub-watershed, or Seepage well samples (Figure 1a).

Phosphate showed significant downward trends in two Outflow wells (Wells 13 and 14), the Sub-watershed wells, and the Control well. The downward trend was evident in both the M-K trend test and the plots. Interior wells and the Seepage well did not show trends either in the M-K trend or the plots. The overall mean of PO_4 in the Control Well was within the same range or slightly higher than that of the treatment wells.

In contrast to NO_3-N and PO_4, Cl exhibited a significant upward trend in the Interior, Sub-watershed, Seepage, and Control wells. Plots of Cl over time confirmed the upward trend (Figure 1b). The Outflow Well 15 also shows a significant upward trend. The overall mean of the Control Well Cl was within the range of the treatment wells.

Specific conductivity did not exhibit any consistent trends. Two Interior wells and the Seepage well had a significant upward trend, but the Outflow wells were not significant or showed a significant decreasing trend by the M-K test.

A comparison of pre- and post-irrigation means of cadmium (Cd), lead (Pb) and mercury (Hg) found no differences between the pre- and post-irrigation periods. Mean cadmium levels in the Control Well were greater than those of the treatment

Table 1. A Comparison of Pre- and Post-irrigation Cadmium and Lead Groundwater Concentrations.

	Cd		Pb	
	mg/l			
	mean	s.d.	mean	s.d.
Pre-irrigation				
Interior	0.007	0.002	0.13	0.10
Outflow	0.007	0.004	0.13	0.07
Control	0.017	0.005	0.11	0.07
Post-irrigation				
Interior	0.006	0.002	0.07	0.11
Outflow	0.006	0.002	0.08	0.14
Control	0.018	0.018	0.06	0.07
Drinking Water Standard	0.01		0.05	

wells (0.02 versus 0.01 respectively). Lead levels in the Control Well samples were within the range of the treatment wells. The means of all the monitoring wells except Interior Well 10 exceeded the drinking water standard for lead. Mercury concentrations in all wells were at or below 0.001 mg/l which is below the drinking water standard of 0.002 mg/l.

Groundwater Elevations

Plots of Outflow Well elevations showed small decreases or remained relatively constant while control well elevations decreased after the 1985 drought (Figure 3). The difference between pre- and post-irrigation means for Well 14 was positive indicating an increase in the well elevation during the post-irrigation period. Differences between pre- and post-irrigation means were negative for Wells 13 and 15 (-0.3 and -1.5 respectively), but the decrease was smaller than that of the Control Well (-2.2).

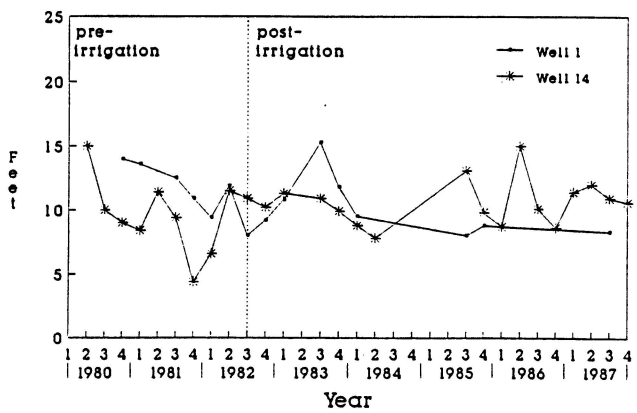

Figure 2. Control Well and an Outflow Well Elevations over Time.

DISCUSSION

The monitoring data indicated groundwater quality at the Clayton County site has not been adversely affected by irrigation with pre-treated wastewater. There has not been a significant increase in NO_3-N concentrations in any of the well groups. Plots of NO_3-N over time for the Outflow Wells along with the predominately negative M-K statistics, suggested a slight dilution effect may have occurred. Phosphate concentrations in the Outflow Wells also exhibited a downward trend. The decreases in PO_4 concentrations were present in the Control well and began occurring before irrigation in the Outflow wells. This suggests the PO_4 decrease was independent of the land treatment system effects. The contrasting upward trend of Cl in the Interior, Subwatershed and Seepage wells was also present in the Control Well. Again, this suggests the increases in Cl were independent of irrigation. There was no evidence of increases for specific conductivity or for the metals Cd, Pb and Hg.

Performance of a land treatment system is judged by the quality of groundwater leaving the site. Based on the results of this study, the Clayton County system has met the water quality performance goals established by the Georgia EPD and US EPA regulations. Further, the lack of significant trends for groundwater quality indicated that continued compliance with the performance goals can be expected.

The groundwater elevation data were difficult to interpret because the monitoring wells are widely spaced over the site and range in location from the ridge to the valley bottom. The data suggested there were small increases in groundwater elevations in the Outflow Wells in recent years. The increases in groundwater elevations may have been obscured by the persistent drought which started in 1985.

CONCLUSIONS

The results of the groundwater monitoring program at the Clayton County land treatment site indicate no adverse effects to groundwater quality due to irrigation. Groundwater elevations experienced small increases, however, interpretation was complicated by the extended period of drought conditions.

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