MONITORING WATER QUALITY AT A FOOD WASTE COMPOSTING SITE

By

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INTRODUCTION

In 1993, the Georgia Diagnostic and Classification Prison (located near Jackson, GA) initiated an on-site composting operation to convert food waste into a useable by-product. Each week, inmates compost about 20 tons of food waste, which are mixed with ground cardboard, hay, yard leaves, or wood products. The operation takes place on a 1.2-ha site (3 acres) that drains towards a small, perennial stream. Because of the potential for contaminating surface and ground waters with nutrients derived from the compost, we initiated a study in 1997 to monitor the quality of surface runoff and groundwater at the site.

MATERIALS AND METHODS

The composting pad was properly graded and bermed so that most of the surface runoff would drain towards one end of the pad (Allen, 1994; Block, 1997). During the study, all composting windrows were placed perpendicularly to the slope of the pad to slow surface runoff. A 45-cm (1.5-ft) H-flume and an ISCO 2100 sampler (ISCO, Inc., Lincoln, NE) were installed at the lower end of the composting pad to monitor surface runoff. The height of water in the flume was continuously measured with a pressure transducer, with average water heights recorded every 5 minutes in a Campbell Scientific CR10 datalogger (Campbell Scientific Inc., Logan, UT). Rain data were collected with a tipping bucket rain gauge connected to the same datalogger. The ISCO sampler was activated every time water in the flume reached a height of 17 mm (0.7 inches). When activated, the sampler took a 500-mL sample every 20 minutes, storing each sample in a separate bottle. Surface runoff from the site was monitored from December 2, 1997, through May 4, 1998.

To monitor groundwater at the site, we installed a 5-cm diameter (2 in), 5.4-m deep (18 ft) well downslope from the pad, at a surface elevation of about 3 m (10 ft) below the surface of the composting pad. The bottom 1.5 m (5ft) of the well was screened. Since water in the well was found at a depth of 3.6 m (12 ft), the groundwater was at approximately 6.6 m (22 ft) below the surface of the composting pad. Before taking a monthly 1-L sample, the well was purged 10 times with a submersible, electrical pump. Groundwater was monitored from October 2, 1997 through June 22, 1998.

Groundwater and surface runoff samples were brought to the laboratory and kept refrigerated at 4°C (40° F) until analyzed. Groundwater samples were analyzed as collected, but surface runoff samples were filtered through 0.45 µm membranes. All samples were analyzed for inorganic N and phosphorus with colorimetric procedures implemented on an Alpkem RFA-300 Autoanalyzer (O-I- Analytical, Wilsonville, OR). Ammonium-N was determined by the salicylate-hypochlorite method (Crooke and Simpson, 1971, and (nitrite+nitrate-N) by the Griess-Ilosvay procedure, after reduction of nitrate to nitrite with a Cd column (Keeney and Nelson, 1982). Orthophosphate-P was determined with the molybdate-blue method of Murphy and Riley (1962).

The 5-minute averages of water height in the flume were used to calculate flow, which was integrated with time to estimate the cumulative volume of surface runoff at which each sample was taken. The measured concentrations of ammonium-N, (nitrate+nitrite)-N, and orthophosphate-P were in turn integrated with cumulative volume to

calculate the total mass of each species lost in each runoff event. To calculate the flow- weighted concentration of each chemical species, we divided the total mass loss by the total volume of surface runoff.

RESULTS AND DISCUSSION

Between December 2, 1997, and May 4, 1998, there were 54 rain events that provided 871 mm of rain and caused 36 runoff events totalling 429 mm of runoff (Fig. 1). The volume of surface runoff, expressed as a percentage of the rain, ranged from 7 to 76% for the individual runoff events, with an overall average of 49%. As expected, the large runoff events were observed with large rains that fell on a wet composting pad. The difference between rain and surface runoff in each event was either retained by the composting windrows or infiltrated into the soil.

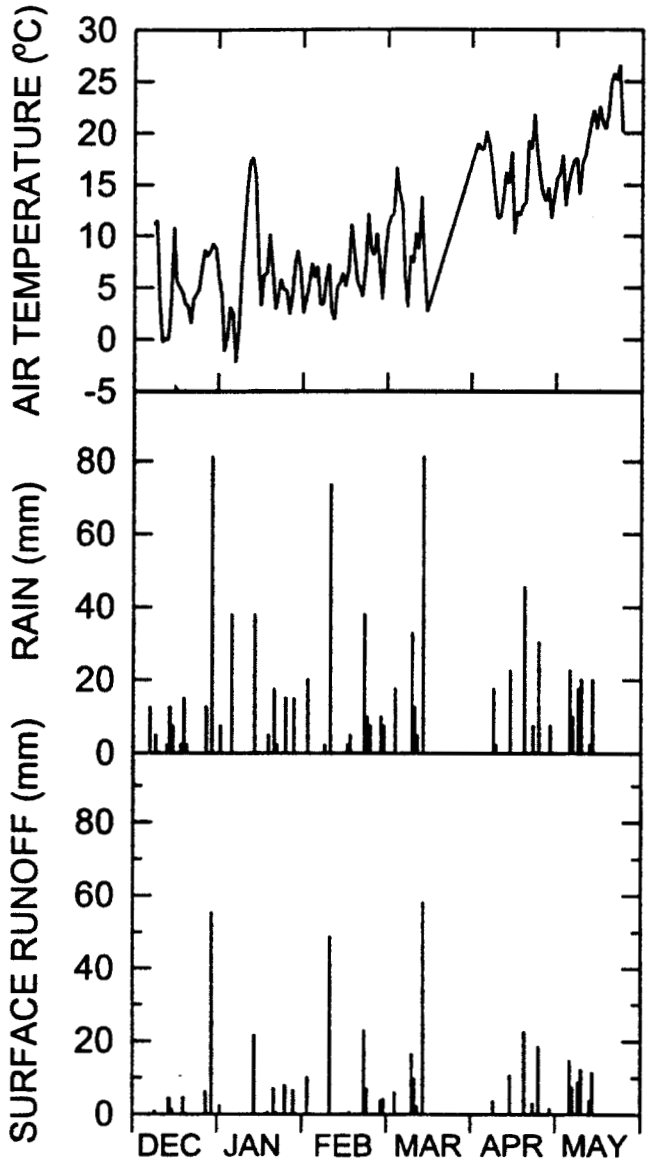

Figure 1. Average daily temperature, rain, and surface runoff from December 1997 through May 1998.

Table 1. Date, rain, runoff, and flow-weighted concentrations of ammonium, nitrite+nitrate, and orthophosphate.

DATE	RAIN	RUNOFF	NH_4-N	(NO_2+NO_3)-N	PO_4-P
	-- mm --	% of rain	---------- mg/L ----------		
3 December 1997	5.1	14.6	3.22	0.00	0.09
8 December 1997	6.9	6.7	5.72	0.00	0.10
22 December 1997	7.6	21.4	6.42	0.00	0.20
7 January 1998	12.7	26.0	4.32	0.00	0.13
13 January 1998	5.1	15.3	1.63	0.00	0.08
14 January 1998	10.2	27.8	9.45	0.06	0.33
11 February 1998	5.1	9.3	0.83	0.28	0.06
16 February 1998	12.7	40.2	6.66	0.12	0.11
22 February 1998	10.2	28.4	0.43	0.06	0.06
11 April 1998	23.0	44.9	7.68	0.01	0.11
14 April 1998	46.0	44.4	3.22	0.17	0.05

We collected and analyzed runoff samples in 11 of the 36 runoff events observed. In general, the concentrations measured were low at the beginning of a runoff event, and increased with cumulative runoff (Fig. 2). The range of nutrient concentrations in the individual samples was 0.17 to 24.85 mg N L^{-1} for ammonium, 0.00 to 4.82 mg N L^{-1} for nitrate+nitrite, and 0.02 to 1.22 mg P L^{-1} for orthophosphate.

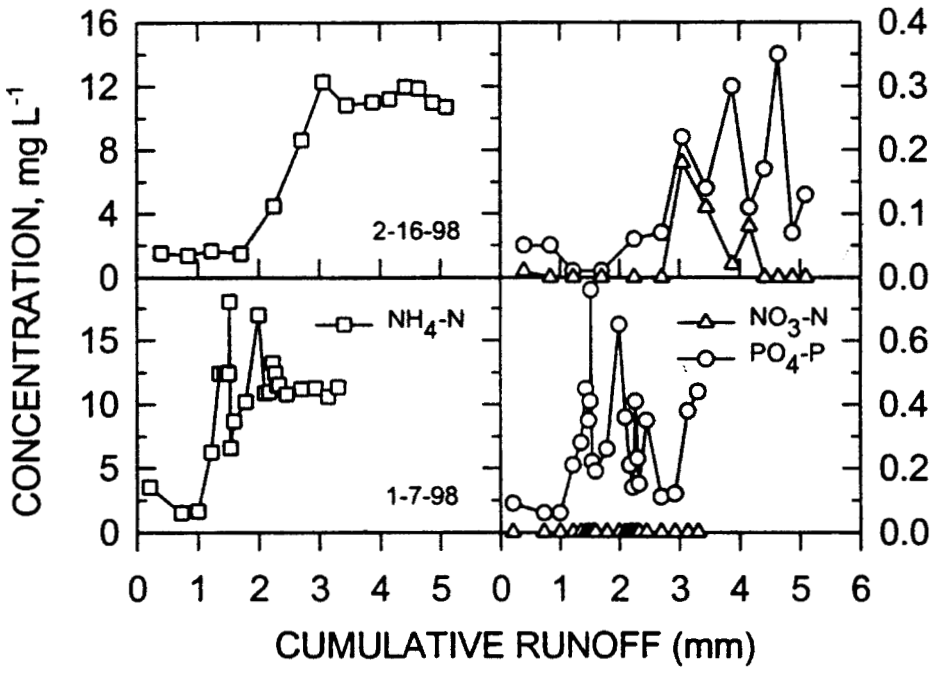

Figure 2. Concentrations of ammonium-N, (nitrite+nitrate)-N, and orthophosphate-P as a function of cumulative runoff in runoff events of January 7 and February 16, 1998.

The flow-weighted concentrations in individual runoff events ranged from 0.43 to 9.45 mg N L^{-1} for ammonium, from 0.00 to 0.28 mg N L^{-1} for nitrite+nitrate, and from 0.05 to 0.33 mg P L^{-1} for orthophosphate (Table 1). In most cases, the concentrations of nitrite+nitrate were low, with the exception of a runoff event on April 14, 1998, in which the values were relatively high (Fig. 3). The low concentrations of nitrite+nitrate in most runoff events were probably due to the average temperature being below 10°C, which is considered to be the threshold temperature for nitrification. At the beginning of April, daily temperatures increased to about 15°C, favoring nitrification (Fig. 1) and resulting in higher nitrite+nitrate concentrations in the runoff of April 14.

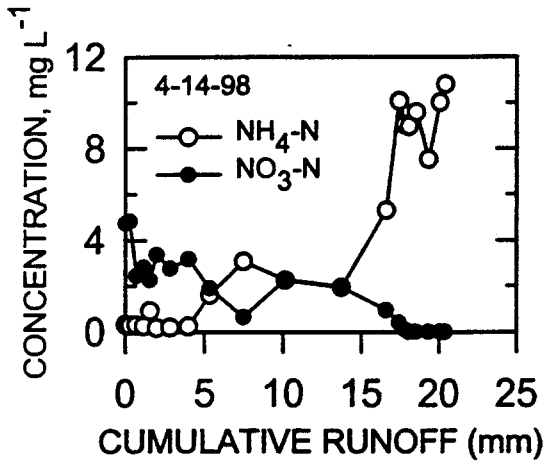

Figure 3. Concentrations of ammonium-N and nitrite+nitrate-N in the runoff event of April 14, 1998.

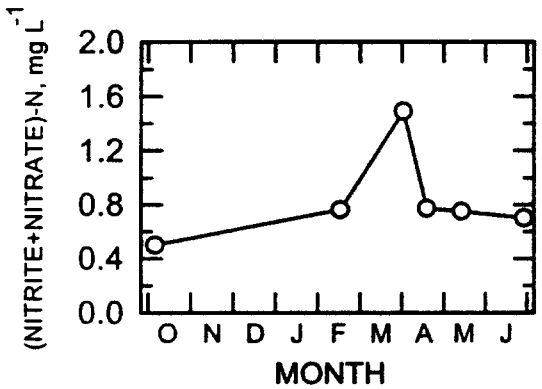

Figure 4. (Nitrite+nitrate)-N concentration in groundwater samples taken from October 1997 through June 1998.

The overall flow-weighted concentrations for the 11 runoff events were 4.87 mg N L^{-1} for ammonium, 0.09 mg N L^{-1} for nitrite+nitrate, and 0.10 mg P L^{-1} for orthophosphate. These concentrations of nitrite+nitrate and orthophosphate are low and not likely to cause environmental problems in surface waters. In contrast, the concentration of ammonium is rather high and may lead to eutrophication problems in surface waters in which N is the limiting nutrient. It should be noted, however, that the significance of a high concentration of ammonium at the edge of the composting pad depends on the dilution that may occur from the edge of the pad till the point where the surface runoff enters the nearby stream. If the watershed contributing to the nearby stream is relatively large, there may be enough dilution of the ammonium concentrations to decrease or eliminate the potential for eutrophication. Thus, the next step in the evaluation of the potential of this site for contamination of surface waters would be to conduct a study in which the quality of surface runoff from the composting pad is monitored simultaneously with the quality of water in the nearby stream.

Nitrite+nitrate concentrations in groundwater ranged from 0.50 to 1.49 mg N L^{-1} during the measurement period (Fig. 4). A peak observed on March 27, 1998, may have been due to nitrate leaching from the composting pad. Nevertheless, the concentrations were at all times well below the 10 mg N L^{-1} drinking water standard established by the USEPA. Considering that this site has been in operation since November 1993, these results suggest that nitrate leaching from the composting pad does not appear to be contaminating groundwater.

CONCLUSIONS

The flow-weighted concentrations of (nitrite+nitrate)-N and orthophosphate-P in surface runoff from the composting pad were relatively low and not likely to cause environmental problems. In contrast, ammonium-N concentrations were rather high, suggesting the need for additional studies to determine the amount of dilution that occurs before runoff water from the composting pad enters the nearby stream. Groundwater (nitrite+nitrate)-N concentrations were at all times well below 10 mg N L^{-1}, suggesting that nitrate leaching from the composting pad does not pose a threat to groundwater quality.

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