Soil Loss and Microbiological Quality of Runoff from Land Treated with Poultry Litter[1]

JOEL GIDDENS AND A. P. BARNETT[2]

ABSTRACT

Because large amounts of poultry wastes are often applied to hilly land in the southeastern United States, information is needed on the environmental hazards of this practice. A rainfall simulator was used to study the effect of application of poultry litter (manure plus wood residues) on runoff water quality and soil loss, on moderately sloping (7%) land. Increasing rates of litter were surface-applied on fallow soil and grassland and also incorporated in the fallow soil. Runoff and soil loss were drastically decreased by litter application on fallow soil, and runoff was reduced on the grassed soil. The grassed soil had little soil loss with or without litter application. The coliform bacterial content of runoff water from plots receiving the higher application rates of surface-applied litter was appreciable afterward. Incorporating litter into soil generally reduced coliforms during the later stages of runoff. Moderate applications of poultry manure to sloping land (especially grassland) should not create a major water quality problem, unless excessive rainfall occurs.

Additional Index Words: **coliforms, pollution, erosion, washoff, manures, animal wastes.**

Giddens, J., and A. P. Barnett. 1980. Soil loss and microbiological quality of runoff from land treated with poultry litter. J. Environ. Qual. 9:518–520.

The application of poultry manure to pasture and cropland, often at high rates, is a very common practice in the southeastern United States (8). This practice can result in wash-off and, hence, stream pollution, especially at the higher application rates and on sloping land. Much of the manure plus wood residues (hereafter, called *poultry litter*) from the broiler houses is surface-applied to land near the poultry houses.

Kunkle (3) reported that fecal coliform counts in runoff water from grazed pastures in Vermont were greatly influenced by rainfall and storm events. Fecal coliforms were better indicators of animal pollution than total coliforms in these studies. Malaney et al. (5) showed that the bacteriological water quality of Ohio farm ponds fed by runoff from agricultural land was good enough for watering animals and for domestic purposes with relatively minor purification. Smith and Douglas (10) found that fecal streptococci and microorganisms incubated at 20°C were higher in drainage water than in irrigation water from the Snake River in Idaho. Otherwise, bacteriological quality of the irrigation water was not significantly changed by using it for irrigation. Long et al. (4) found that incorporating 45 metric tons/ha of cattle manure into sandy soils near Auburn, Ala. for 3 years did not result in runoff biological oxygen demand (BOD) values exceeding those of untreated soil, nor did it increase nitrate (NO_3-N) levels in runoff water. Meiman and Kunkle (6) reported that bacterial groups were a better indicator of the land-use impact on water quality than were suspended sediment or turbidity. They also found storms to be very important in increasing natural levels of sediment, turbidity, and organisms in streams of Colorado.

The purpose of this study was to determine the possible pollution hazards from using poultry litter on sloping land and to show the effect of using poultry litter on soil erosion.

[1] Contribution from the Southern Piedmont Conserv. Res. Center, USDA, SEA, Watkinsville, Ga., and the Dep. of Agron., Univ. of Georgia, Athens, GA 30602. Received 26 Nov. 1979.

[2] Professor of Agronomy, Univ. of Georgia, and Agricultural Engineer (retired), Southern Piedmont Conservation Research Center, USDA, SEA-ARS, respectively.

MATERIALS AND METHODS

The study was carried out at the Southern Piedmont Conservation Research Center, USDA, Watkinsville, Ga. in August 1966. The treatments consisted of surface applying 0, 5.6, 11.2, 22.4, 67.2, and 89.2 metric tons/ha of poultry litter to fallow soil surface and applying 11.2 and 22.4 metric tons/ha of poultry litter to fallow soil and incorporating it to a depth of about 10 cm, and surface applying 0, 5.6, 11.2, and 22.4 metric tons/ha of litter to coastal bermudagrass (*Cynodon dactylon*) sod. The soil was a Cecil sandy loam (clayey, kaolinitic, thermic Typic Hapludults) on a slope of 7%. Plots were 1.8 m wide by 10.7 m long.

The poultry litter consisted of broiler chicken manure plus wood shavings that had accumulated in the broiler house for about 25 weeks. The litter contained about 25% moisture, 1.7% N, 0.8% P, and 1.3% K (8).

Water was applied uniformly to two plots simultaneously with a rainfall simulator (7) at the rate of 6.35 cm/hour for 120 min. This was equivalent to a severe storm. Water and sediment were collected at 1- to 5-min intervals, after runoff began depending upon the runoff rate. The soil moisture content prior to simulated rainfall was less than field capacity. Total microbial counts were made by dilution plating, using soil extract agar (9) and total coliforms were counted by the membrane filter technique using M-Endo medium (1), with four replications. Runoff and soil loss were determined by collecting aliquots of runoff water, measuring the volume, evaporating the water, and drying and weighing the sediment. All measurements were made in duplicate. Water used in the runoff study contained 1 coliform/ml.

RESULTS AND DISCUSSION

Runoff and Soil Loss

Figure 1 shows the time for runoff to start after water application was begun. Runoff began in about 7 min from the fallow, no-liter plots. Increasing rates of poultry litter on the soil surface delayed runoff, with runoff for the 89.2 metric tons/ha treatment occurring after 53 min of simulated rainfall. This indicated that runoff would occur only during more intense storms when high litter rates were applied. Although the highest litter rates were not incorporated, incorporating the 11.2 and 22.4 metric tons/ha rates decreased the time for runoff to start. Runoff from the 11.2 metric tons/ha litter-incorporated treatment started 7 min after water application started and for the same litter rate surface applied, surface runoff began after 11.5 min. Runoff from the incorporated and surface-applied litter, 22.4 metric tons/ha rate started after 15 and 21.5 min, respectively. Runoff from the grass plots started after 67, 72.5, 80, and 98 min for the 0, 5.6, 11.2, and 22.4 metric tons/ha litter treatments, respectively.

The soil loss after 120 min of 6.35 cm/hour simulated rainfall is shown in Fig. 2. Soil loss from the no-litter fallow plot was 30.2 metric tons/ha. Surface-applied litter applications reduced soil loss with the application of 11.2 metric tons/ha litter resulting in somewhat less soil loss than incorporated litter (18.7 vs. 22 metric tons/ha, respectively). Soil loss was reduced 23% when the surface applied litter rate was doubled from 11.2 to 22.4 metric tons/ha. For the 67.2- and 89.2-metric tons/ha surface-applied litter rates, the soil losses were 0.92 and 1.64 metric tons/ha, respectively. This was a drastic reduction which resulted from litter forming a good cover on the soil. Essentially no soil was lost from the grassed plots at any rate of litter application.

Not only was the soil loss greatly reduced by the poultry litter, but runoff water was greatly reduced. Of the 12.7 cm of water applied during 120 min of simulated rainfall, 9.96 cm were collected as runoff from the bare fallow plots; 6.35 cm from fallow with 22.4 metric tons/ha litter on surface; 8.3 cm from fallow plus 22.4 metric tons/ha litter incorporated into soil; 3.9 cm from 89.2 metric tons/ha litter on surface of fallow soil; 2.24 cm from untreated grass plots; and 0.44 from grass plots receiving 22.4 metric tons/ha litter.

On the grassed plots, water was reapplied 1 day later. The soil loss was still insignificant, but the amount of runoff was increased. For example, where 11.2 metric tons/ha litter were applied, the total runoff after 120 min was 2.5 cm at the first application and 7.75 cm when reapplied.

Microbial Runoff

Total microorganisms in the runoff water initially and after 120 min are shown in Fig. 3. Runoff was delayed for various periods of time, depending upon the

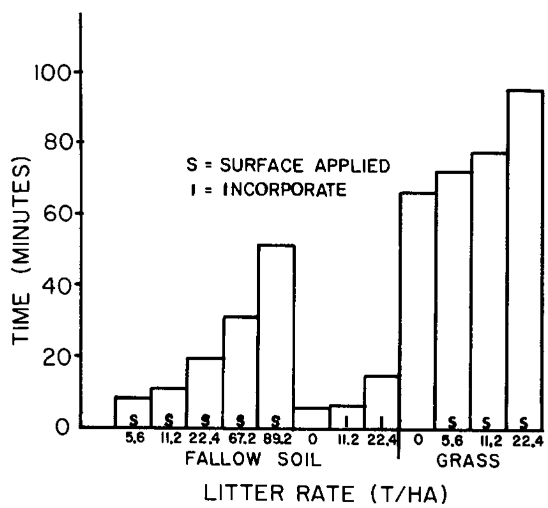

Fig. 1—Time for runoff to start after simulated rainfall began on poultry litter plots. S = surface-applied litter; and I = litter incorporated into soil.

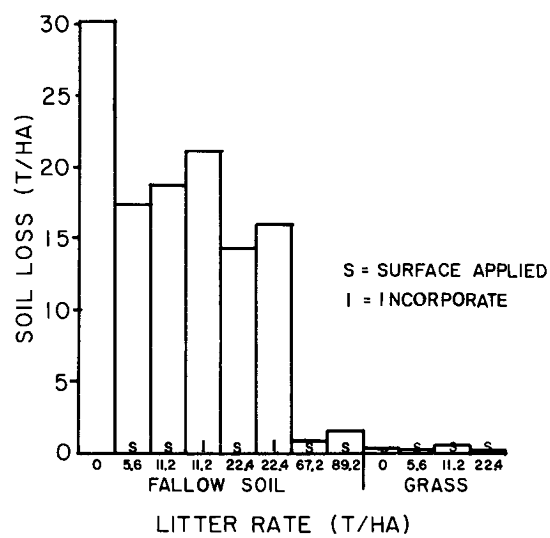

Fig. 2—Soil loss from plots receiving simulated rainfall. S = surface-applied litter; and I = litter incorporated into soil.

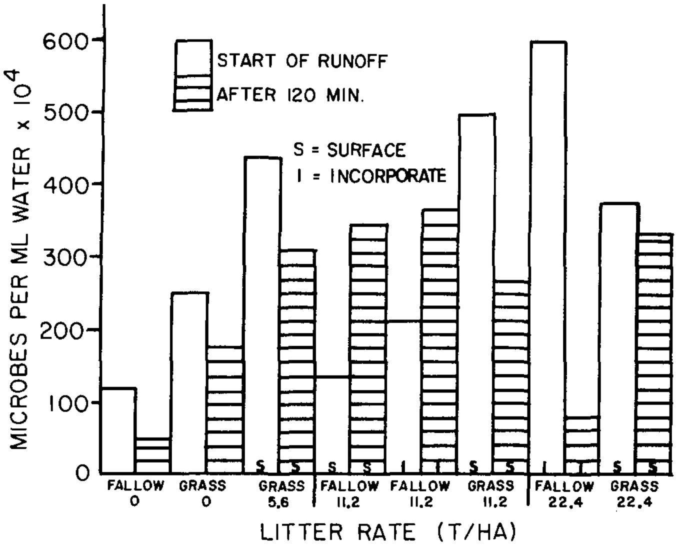

Fig. 3—Microbes in runoff water from plots receiving simulated rainfall. S = surface-applied litter; and I = litter incorporated into soil.

litter application rate and the soil treatment. Therefore, data on microorganisms in runoff water, as related to manure application and soil treatment, should be interpreted taking this into consideration. Only runoff water at both 11.2 metric tons/ha manure application rates on fallow soil (surface applied and incorporated) contained more total microbes after 120 min runoff than at the start (Fig. 3). The highest microbial runoff occurred in initial runoff from the 22.4 metric tons/ha litter rate on fallow soil.

Total coliforms (Table 1) in runoff water from plots receiving litter were not extremely high. Total coliforms in runoff water were higher for 22.4 metric tons/ha surface litter application on fallow soil than for the lower or higher application rates. Coliform counts in runoff were low for the 67.2 and 89.2 metric tons/ha litter application rates (except for the 60-min runoff period for the highest litter rate). Coliform counts were generally lower in runoff water after 120 min of water application than at the beginning. Litter applied to grassland at the lowest rate (5.6 metric tons/ha) resulted in a greater initial washoff of coliforms than did the 11.2 or 22.4 metric tons/ha rates. The coliform washoff decreased immediately to near zero after the first few minutes of runoff from grassland.

Doran and Linn (2) reported that runoff from both grazed and ungrazed parts of a cow-calf pasture in eastern Nebraska generally contained bacteriological counts that exceeded the recommended water-quality standards. The fecal coliform group was a better indicator of the impact of grazing than total coliforms or fecal streptococci. In our report, total coliforms seemed to be a good indicator of possible water pollution from poultry litter since those plots not receiving litter contained practically no coliforms in runoff water. Total coliform counts recommended for recreational partial-contact water are 50 coliforms/ml and for public water supply 100 coliforms/ml (2). Coliform counts in runoff

Table 1—Total coliforms in runoff water from plots treated with poultry litter.

Poultry litter treatments, metric tons/ha	Total coliforms/ml (× 1000) Minutes after runoff starts					
	2	20	40	60	80	110
	Surface application on fallow soil					
0	1±1	0	5±3	0	0	4±4
5.6	9±7†	21±7	2±1	–‡	--	6±2
11.2	4±2	5±2	0	0	0	0
22.4	33±7	--	--	37±11	--	38±10
67.2	5±7	--	--	0	--	26±10
89.2	4±2	--	--	99±31	--	2±1
	Plowed-in on fallow soil					
11.2	15±3	10±8	3±4	19±5	1±1	4±4
22.4	23±8	24±11	18±5	0	5±4	5±3
	Surface application on grassland					
0	0	5±3	0	–§	--	--
5.6	33±5	1±0	0	--	--	--
11.2	3±3	9±3	6±2	--	--	--
22.4	0	2±1	--	--	--	--

† Standard deviation.
‡ Determinations not made.
§ Simulated rainfall persisted for 120 min but runoff did not start until after 67 min.

water from the poultry litter plots exceeded these amounts. If the runoff water is allowed to flow some distance over grassed waterways, however, its pollution potential should be greatly reduced. Therefore, moderate amounts of surface-applied poultry manure to sloping lands, especially those grassed, should not be a major water quality problem unless excessive amounts of rainfall occur.

LITERATURE CITED

1. American Public Health Association. 1965. Standard methods for the examination of water and waste water. 12th ed. Am. Public Health Assoc. Publ., Inc., New York.
2. Doran, J. W., and D. M. Linn. 1979. Bacteriological quality of runoff water from pastureland. Appl. Environ. Microbiol. 37: 985–991.
3. Kunkle, S. H. 1970. Concentrations and cycles of bacterial indicators in farm surface runoff. p. 49–60. *In* Cornell Waste Manage. Conf. Proc., Rochester, N.Y., 19–21 Jan. 1970. Sponsored by the New York State College of Agriculture of the State University of Cornell Univ., Ithaca, N.Y.
4. Long, F. L., Z. F. Lund, and R. E. Hermanson. 1975. Effect of soil-incorporated dairy cattle manure on runoff water quality and soil properties. J. Environ. Qual. 4:163–166.
5. Malaney, G. W., H. H. Weiser, R. O. Turner, and M. Van Horn. 1962. Coliforms, enterococcus, thermodurics, thermophiles, and psychrophiles in untreated farm pond waters. J. Appl. Microbiol. 10:44–51.
6. Meiman, J. R., and S. H. Kunkle. 1967. Land treatment and water quality control. J. Soil Water Conserv. 22:67–70.
7. Meyer, L. D. 1960. Use of the rainulator for runoff plot research. Soil Sci. Soc. Am. Proc. 24:319–322.
8. Perkins, H. F., M. B. Parker, and M. L. Walker. 1964. Chicken manure—its production, composition and use as a fertilizer. Georgia Agric. Exp. Stn. Bull. NS. 123.
9. Pramer, D., and E. L. Schmidt. 1964. Experimental soil microbiology. Burgess Publ. Co., Minneapolis.
10. Smith, J. H., and C. L. Douglas. 1973. Microbiological quality of surface drainage water from three small irrigated watersheds in southern Idaho. J. Environ. Qual. 2:110–112.