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QUALITY OF RUNOFF FROM FOUR NORTHWEST ARKANSAS PASTURE FIELDS TREATED WITH ORGANIC AND INORGANIC FERTILIZER

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ABSTRACT. *Long-term land application of animal manures, even at agronomic rates, can promote accumulation of soil phosphorus (P) which can, in turn, contribute to increased P loadings to downstream waters. The objective of this study was to assess the soil and runoff effects of replacing animal manure as a soil amendment with inorganic fertilizer (ammonium nitrate,* NH_4NO_3*) on fields that had been treated previously with animal manures. Runoff from two pairs of small fields (0.57 to 1.46 ha) was sampled from September 1991 to April 1994. All fields had been treated previously with animal manures; after runoff monitoring began, one field of each pair received only* NH_4NO_3*, while the other of each pair continued to receive animal manure. Both soil and runoff P concentrations exhibited statistically significant decreasing trends over the monitoring period. The results demonstrate the potential for positively influencing runoff quality in a relatively short duration by replacing animal manures with ammonium nitrate for fields already having sufficient soil P.*

Keywords. *Runoff, Manure, Fertilizer application, Ammonium nitrate, Soil, Water quality.*

Beneficial impacts of manure application, such as increased crop yields, have been documented by many researchers (Vandepopuliere et al., 1975; Quisenberry et al., 1980; Huneycutt et al., 1988). Land application of manures from confined animal production, however, is a topic of environmental concern in regions with a high density of swine, cattle, poultry, and similar operations. These concerns stem partly from the fact that runoff from large rainfall events that occur soon after manure application can transport manure constituents such as nitrogen (N), phosphorus (P), and other materials into downstream waters. Several studies conducted over the past two decades have demonstrated potential magnitudes of off-site transport of manure constituents and have described how this transport depends on factors such as manure application rate, rainfall intensity, and soil (Westerman et al., 1983; McLeod and Hegg, 1984; Edwards and Daniel, 1993).

Substantiated reports of catastrophic water quality impacts of manure application (e.g., fish kills) at agronomic rates are quite rare and would probably occur only in conjunction with remarkably unfavorable circumstances (e.g., a situation in which rainfall occurs immediately following application to a large area, and the runoff enters directly into a relatively small stream). It is more likely that the water quality impacts of manure application will be relatively subtle. For example, the water quality impacts of animal manure (as well as other fertilizers) are very commonly discussed in the context of accelerated eutrophication of water bodies downstream of land application sites (Sharpley et al., 1993, 1994; Daniel et al., 1994).

Animal manures are particularly challenging from the standpoint of managing their application in such a way as not to promote increased eutrophication. Rates of eutrophication for most inland water bodies are limited by P inputs rather than N inputs (Schindler, 1974, 1977; Sharpley et al., 1994). Land areas with high soil P concentrations can be significant sources of P inputs to downstream waters due to soluble P in runoff and P associated with eroded soil particles. Since animal manure application rates are typically selected to meet plant N requirements, the relative proportions of manure N and P contents most often lead to over application of P and thus can promote P build-up in receiving soils. The most practical way to avoid any detrimental water quality impacts of P accumulation is to prevent the accumulation by matching P application amounts to plant requirements. If P accumulation has already occurred, the most practical remedy would be to withhold P application until soil P levels justify addition of more P. This tactic might require a period of several years to make much difference in terms of soil P concentrations (McCollum, 1991), so runoff quality reports of using this type of corrective activity are rare.

The objective of this work was to assess the effects on both soil and runoff, especially with regard to P concentrations, of replacing animal manure with ammonium-nitrate (NH_4NO_3) fertilizer. This type of research strengthens the demonstrated linkages between fertilizer application practices and runoff quality. This study can also provide information regarding potential water quality effectiveness of fertilizer strategies and the timetables involved in achieving that effectiveness. Potential applications of this information exist in regions having soils with high P concentrations and where confined animal manure may be applied repeatedly to limited land areas at N-based rates.

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PROCEDURES

FIELD SELECTION AND CHARACTERISTICS

Two pairs of fields were monitored for soil composition and runoff quality. The monitored fields were selected by first identifying potential cooperators and then conducting an on-site reconnaissance of these properties. Cooperating landowners' property was inspected for suitable potential monitoring sites that included fields of small to moderate size with well-defined outlets, ease of access, and security of monitoring instruments. Specific pairs of fields were then selected based on similarity of cover, management, and ownership. All fields are located in northwestern Arkansas (vicinity of 36°00′N, 94°25′W) and were designated RM, RA, WM, and WA.

The predominant cover for all fields was "tall" fescue (*Festuca arundinacea* Schreb.). Table 1 lists selected characteristics of the monitored fields. As may be inferred from table 1, there were some differences in field characteristics, particularly with respect to area and soil. Unfortunately, it was not possible to identify identical paired fields, and the final field selections represented several compromises in terms of desirable characteristics.

Table 1. Selected monitored field characteristics

Field	Area (ha)	Soil Texture*	Curve Number†	Average Slope (%)	Slope Length (m)	Erodibility‡ (Mg/ha/year)
RM	1.23	Silt loam	74	3	182	0.99
RA	0.57	Sandy loam	61	2	188	0.54
WM	1.06	Sandy/gravelly loam	64	4	239	0.49
WA	1.46	Loam	79	4	257	0.54

* Harper et al., 1969.
† Soil Conservation Service, 1986.
‡ Soil Conservation Service, 1983.

FIELD MANAGEMENT

Preliminary analysis of soil samples (0 to 15 cm depth) indicated large differences in soil P concentration between fields within a pair. Extractable (Mehlich 3) soil P was found to be 156 and 307 mg P/kg for fields RM and RA, respectively. This finding was consistent with a history of animal manure application at rates exceeding plant P requirements. The lower soil P content for field RM corroborated the landowner's observations that the field was not as trafficable after rainfall as field RA and thus was not fertilized as often. A similar disparity in soil P contents was found for fields WA and WM. Extractable soil P content was initially found to be 630 mg P/kg for field WA and 210 mg P/kg for field WM. The soil testing results again suggested relatively long-term application of animal manures at rates in excess of plant P requirements and were consistent with information from the landowner regarding a large, one-time application of animal manure to field WA. Since soil P levels were sufficiently high for fields RA and WA that further additions of P would not be expected to result in increased forage yields, these fields were chosen to be fertilized with only NH_4NO_3. Fields RM and WM were to continue receiving fertilizer in the forms of poultry manure for RM and poultry litter for WM, as had been the owners' practice.

The schedule of fertilizer applications to the monitored fields is given in table 2. Only one application of poultry manure per year to field RM was possible because of poor trafficability in the field. The application rate for field RA, which received split applications of NH_4NO_3, was adjusted upward in 1993 to better offset leaching and denitrification losses as estimated using Soil Conservation Service (SCS) (1992) methods. Field WA was to also receive split applications of NH_4NO_3, but received only a single application in 1992 because the actual amount applied was greater than the target rate. Field WM received split applications of poultry litter at an approximate gross application rate of 5.6 Mg/ha.

Table 2. Fertilizer application schedule

Field	Date	Application Rate (kg/ha) N	Application Rate (kg/ha) P
RM*	03/15/92	332	119
	07/13/93	451	209
RA†	03/23/92	67	0
	08/14/92	67	0
	04/22/93	116	0
	07/14/93	136	0
WM‡	03/23/92	218	62
	08/13/92	144	59
	04/13/93	158	43
	07/20/93	194	71
	03/29/94	186	71
WA†	03/23/92	138	0
	04/13/93	102	0
	07/20/93	102	0
	03/24/94	101	0

* Fertilized with poultry manure.
† Fertilized with ammonium nitrate.
‡ Fertilized with poultry litter.

All monitored fields were grazed by dairy cattle during the monitoring period. The stocking densities, as determined from information supplied by the landowners, are shown in table 3. In the cases of fields WA and WM, there were differences in grazing strategies during the monitoring period (table 3). The impact of the grazing differences in runoff quality is unknown, but was probably relatively slight and will be discussed in the Results section. While it would certainly have been preferable to have equal grazing densities for fields WA and WM, this was not possible because of the landowner's pasture management strategy.

Table 3. Cattle stocking densities

Month/Year	Field RA/RB	Field WA	Field WB
	------------	(animal units/ha)	------------
9/91-1/92	2.0	0.3	0.3
2/92-3/92	2.0	0.0	1.0
4/92-6/92	0.0	0.0	1.0
7/92-9/92	0.0	0.0	1.7
9/92-12/92	1.5	1.1	1.1
1/93-4/93	1.5	0.0	1.5
5/93	0.0	0.0	1.5
6/93	0.0	0.0	0.9
7/93	0.0	0.0	0.0
8/93-10/93	1.4	1.0	0.0
11/93-1/94	1.4	0.5	0.5
2/94-3/94	0.0	0.5	0.5
4/94	0.0	0.0	1.0

RUNOFF SAMPLING

Each monitored field had instrumentation installed at the outlet to measure runoff rates and to collect runoff samples during storm events. The instruments were enclosed by a barbed wire fence that prevented cattle from getting closer than approximately 3 m. Runoff was channeled into type "H" flumes (Agricultural Research Service, 1979) with flume depths of 30 cm for fields RA and WM and 46 cm for fields RM and WA. Stilling wells were constructed and attached to the flumes. A pressure transducer (model PCDR950, Druck, Inc.) was placed inside each stilling well to measure water height inside the flume. The stilling wells were constructed so that the pressure transducers were approximately 2 cm beneath the flume floor. Pressure transducer output was measured and recorded at 5-min intervals by data loggers (model CR10 measurement and control module, Campbell Scientific, Inc.). Flume rating tables reported by Agricultural Research Service (1979) were used to convert water height inside the flume to discharge rate.

Runoff was sampled by automatic water samplers (model 800SL portable liquid sampler, American Sigma) installed at each flume. Sampler intake holders were constructed from a horizontal wooden base to which wooden blocks were attached to form a narrow channel (2 cm wide, 6 cm deep) with one end (toward the flume) of the channel blocked. The sampler intake holders were positioned and secured just beneath the flume outlets. The sample intake apparatus ensured the collection of well-mixed samples and minimal air pumpage. The water sampler and data logger were interfaced so that when water height inside the flume reached 2 cm, runoff sample (1 L sample volume) collection initiated with samples collected at 5-min intervals until either all 24 sample bottles were filled or flume water height had fallen below 2 cm.

In addition to the runoff measurement and sampling equipment, a tipping bucket rain gage was installed in the vicinity of each pair of fields. All instruments were powered by batteries and were operational on a continuous basis (except for maintenance) over the project duration. The monitoring equipment was installed and operational by 1 September 1991.

Runoff events were sampled from 1 September 1991 to 30 April 1994. Runoff samples were retrieved from the sample collectors within 24 h following each runoff event. The samples were then transported to the Arkansas Water Resources Center Water Quality Laboratory, prepared for analysis, and analyzed for nitrate nitrogen (NO_3-N), ammonia nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), ortho-phosphorus (PO_4-P), chemical oxygen demand (COD), and total suspended solids. Standard methods of analysis (Greenberg et al., 1992) were used in all analyses. Ion chromatography was used in analyses of NO_3-N and PO_4-P. The ammonia-selective electrode method was used to determine NH_3-N. The macro-Kjeldahl method was used in TKN analyses. Total P was determined by the ascorbic acid colorimetric method following sulfuric acid-nitric acid digestion. The closed-reflux, colorimetric method was used for COD determinations.

Due to resource constraints, it was not possible to analyze all runoff samples collected. A subset of runoff samples was selected for analysis from each storm event so that the rising and falling limbs as well as the peak of the runoff hydrograph were represented. Flow-weighted means of analysis parameters were computed based on observed concentrations of the respective parameters and runoff rates.

SOIL SAMPLING

Soil samples (0-15 cm depth) were collected quarterly from five locations in each field. The samples were then transported to the University of Arkansas Agricultural Services Laboratory where they were analyzed for organic matter, pH, ammonium N (NH_4-N), NO_3-N, P (Mehlich 3 extraction), K, and various other constituents. Standard methods (Page et al., 1982) were used in all soil analyses.

RESULTS AND DISCUSSION

RAINFALL

Monthly rainfall observed near fields RM/RA and WM/WA is given in figure 1. Total rainfall observed during monitoring was 3160 and 3550 mm for fields RM/RA and WM/WA, respectively. Rainfall observed at the four fields was higher than historical average amounts recorded for Fayetteville, Arkansas (the nearest weather station with available daily rainfall data). Rainfall observed at fields RM and RA was 14% higher than average, and rainfall at the WA and WM fields was 28% higher than average over the monitoring period.

SOIL SAMPLING RESULTS

Mean concentrations of soil analysis parameters are given in table 4. Most soil analysis parameters demonstrated no significant trends during monitoring (i.e., regressions of analysis parameters against time were not significant). Trends detected in soil analysis parameters were generally attributable to the fertilizer management strategy implemented at the beginning of the project.

Soil pH and soil organic matter content exhibited significant ($p < 0.05$) linear trends with respect to time only for field WA, in which pH decreased from approximately 6.9 to 6.0 and organic matter content decreased from

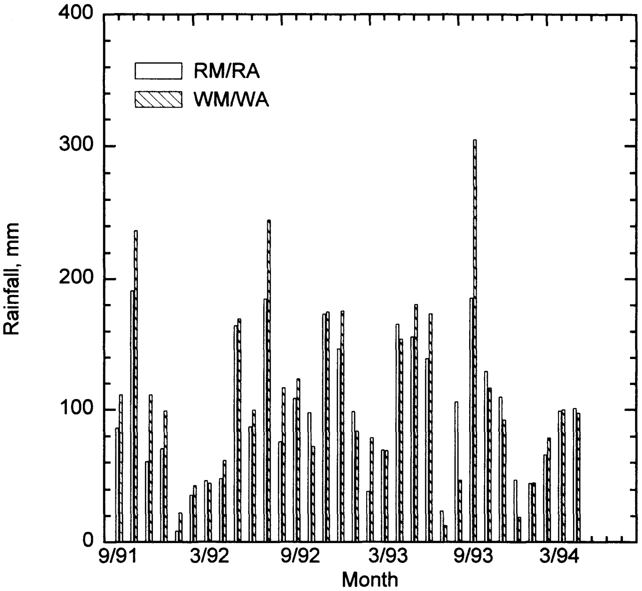

Figure 1–Observed monthly rainfall.

Table 4. Mean* concentrations of soil analysis parameters

Field	pH	OM (%)	NH_4-N (mg/kg)	NO_3-N (mg/kg)	P (mg/kg)	K (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
RM	6.6	2.1	50.7†	8.9	177	102	128	13.3	5.6
RA	6.3	2.5	39.5†	24.2	246†	211†	117	16.8	5.4
WM	6.4	3.0	62.3	13.0	187	230	145	12.2	6.0
WA	6.4†	2.0†	38.8	9.5	364†	142	132	16.5	5.6

* Mean of 55 samples (11 sampling dates, 5 replications per sampling date).

† Significant ($p < 0.05$) decreasing trend with respect to time.

approximately 2.4 to 1.8%. The decreases in soil pH and organic matter content for field WA can be attributed to the addition of only NH_4NO_3, without lime treatment, rather than organic animal manures.

Mean soil NH_4-N content decreased significantly ($p < 0.05$) over time for fields RM and RA but did not change for fields WM and WA. Declines in NH_4-N for these fields might have been the result of fertilization at a high rate shortly prior to the beginning of soil sampling.

Mean soil P concentrations declined significantly ($p < 0.02$) for the fields that were fertilized with NH_4NO_3 (RA and WA; figs. 2 and 3, respectively). Soil P decreased from approximately 300 to 200 mg/kg for field RA and from approximately 450 to 250 mg/kg for field WA. The decreases in soil P concentrations for fields RA and WA were too large to be attributed only to plant uptake and are probably due in part to transformation of soil P into relatively insoluble forms that were not detected during analysis. In any event, the findings with regard to fields RA and WA suggest that soil P concentrations can be reduced (perhaps relatively quickly) by not applying P to soils that already have sufficient P for optimal forage growth. Even though fields RM and WM continued to receive P over the monitoring period in the form of poultry manure and poultry litter, respectively, there were no detectable trends in soil P concentrations in those fields. It appears that the P applied to fields RM and WM was insufficient to cause detectable increases in soil P. The lack of an observed increase in soil P for the manure-treated fields might be due to a relatively high proportion of the supplied P transforming to indetectable forms or, less likely, to P leaching out of the sampled depth due to P saturation. More detailed studies would be required to identify the reason for no detectable increase in soil P for the manure-treated fields.

Mean soil K concentrations changed significantly over time only for field RA (from approximately 250 to 175 mg/kg), again due in part to no K being added to the field over the monitoring period. Mean soil concentrations of Fe, Zn, and Cu demonstrated no linear trends with respect to time over the monitoring period.

RUNOFF SAMPLING RESULTS

An average of 47 runoff events per field were observed over the monitoring period. The total runoff amounts measured were 515, 115, 162, and 466 mm for fields RM, RA, WM, and WA, respectively. Approximately 90, 93, 83, and 88% of all runoff occurring was sampled and analyzed for fields RM, RA, WM, and WA, respectively. The reasons that less than 100% of all runoff occurring was sampled include (a) storms too small to trigger the automatic samplers (i.e., producing less than a 2 cm depth of flow in the flumes), (b) storms occurring when all sample containers were still filled from a storm occurring just previously, and (c) a limited number of equipment malfunctions.

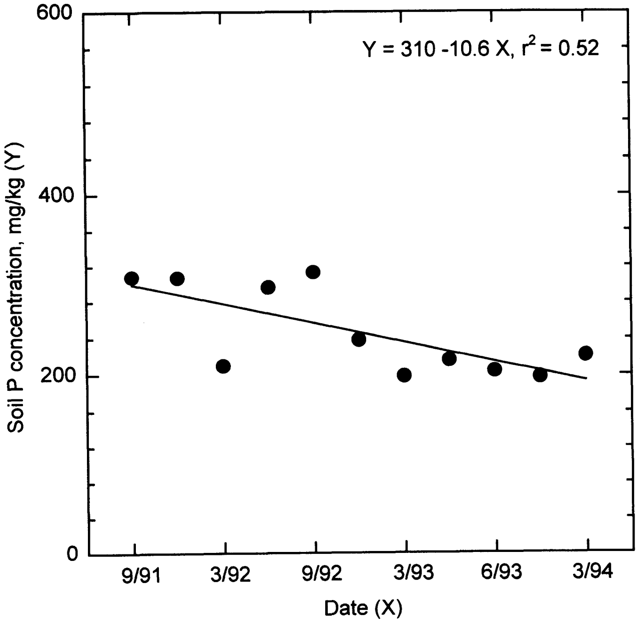

Figure 2–Soil phosphorus (P) concentrations for field RA.

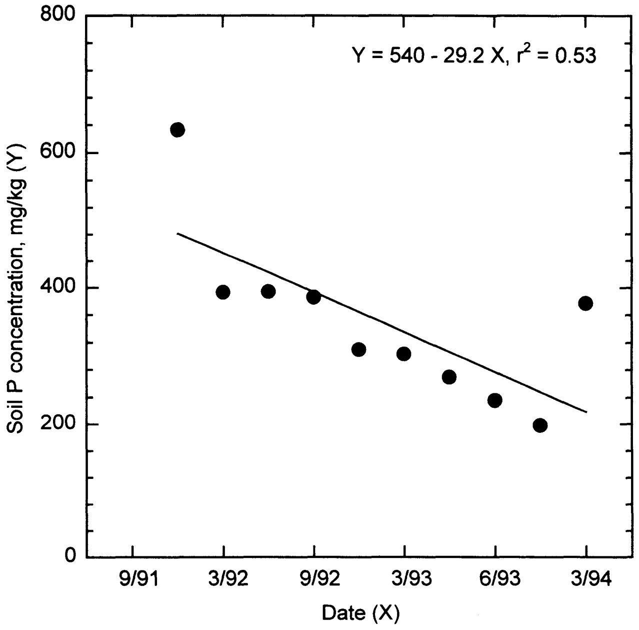

Figure 3–Soil phosphorus (P) concentrations for field WA.

Analysis parameter concentrations. Table 5 contains statistics of flow-weighted mean concentrations of analysis parameters for the four fields for all sampled runoff events.

Concentrations of analysis parameters are generally representative of a pasture/range situation in that mean N, COD, and TSS concentrations are relatively low. Runoff PO_4-P concentrations were relatively high, reflecting the pasture land use and the high soil P concentrations measured throughout the monitoring period.

There was no significant correlation between stocking density of cattle and concentration of any runoff analysis parameter investigated. However, there was a very strong relationship between parameter concentrations and fertilizer application timings. Runoff during storms that occurred soon after fertilizer application usually had much higher concentrations of analysis parameters than during storms preceding fertilizer application. The best recorded example of the linkage between fertilizer timing and runoff quality was the 14 April 1993 storm for Fields WM and WA. This storm consisted of 70 mm of rainfall and occurred only one day following fertilizer application to fields WM and WA. During the first portion of the storm, which produced 1.3 mm of runoff from field WM (treated with poultry litter), flow-weighted mean runoff concentrations of TP and TKN were 24 and 108 mg/L, equivalent to approximately 16 and 21 times the respective mean concentrations. The first part of the same storm caused only 0.3 mm of runoff from Field WA (treated with NH_4NO_3), during which flow-weighted mean runoff concentrations of NO_3-N and NH_3-N were 71 and 42 mg/L, respectively, equivalent to approximately 20 times the respective mean concentrations. These findings clearly indicate a direct runoff quality benefit to avoiding fertilizer application a short time before the occurrence of a runoff-producing storm. Unfortunately, this type of benefit will be difficult to realize without significant improvements in forecasting rainfall amounts and disseminating those forecasts to manure appliers.

Table 5. Statistics of event runoff concentrations of analysis parameters

Parameter	Statistic*	RM (mg/L)	RA (mg/L)	WM (mg/L)	WA (mg/L)
NO_3-N	Mean	0.38	0.97	0.63	3.69
	SD	1.34	1.21	0.83	11.60
	Max	8.53	6.81	5.49	70.74
	Min	0.01	0.12	0.07	0.00
NH_3-N	Mean	0.42	0.73	1.96	1.88
	SD	0.79	0.84	6.36	7.05
	Max	4.12	3.49	40.31	42.00
	Min	0.03	0.04	0.00	0.00
TKN	Mean	5.24	6.89	8.57	5.11
	SD	7.75	8.69	17.80	9.96
	Max	29.84	38.49	108.30	57.44
	Min	0.57	1.01	1.77	0.65
PO_4-P	Mean	2.93	1.69	2.93	1.64
	SD	2.54	0.83	3.71	0.67
	Max	15.65	3.79	24.35	3.23
	Min	0.55	0.60	1.02	0.65
COD	Mean	55.5	77.4	100.79	56.6
	SD	25.7	49.8	115.14	35.0
	Max	118.0	199.0	791.00	192.0
	Min	12.0	5.0	29.00	3.0
TSS	Mean	32.3	101.7	88.1	40.0
	SD	34.2	171.6	107.5	88.1
	Max	154.0	774.0	597.0	458.0
	Min	3.0	8.0	14.0	0.0

* Mean is arithmetic mean, SD is standard deviation, Max is maximum observed value, and Min is minimum observed value.

Both fields that received NH_4NO_3 fertilizer instead of animal manures (RA and WA) experienced significant ($p < 0.02$) decreases in runoff PO_4-P concentrations during the monitored period (figs. 4 and 5). These results are associated with the decreases in soil P concentration that were observed over the monitoring period and discussed earlier. The significance of these findings is that decreases in soil P concentrations were translated directly into runoff quality benefits in the form of decreases in runoff P concentrations.

Runoff concentrations of TKN and TSS decreased significantly ($p < 0.02$) with time for field RA (figs. 6 and 7, respectively). Since there was no decrease in runoff NH_3-N, the decline in runoff TKN concentration may be taken as due primarily to decreasing organic N concentration in runoff. As mentioned in the discussion of soil testing results, applications of animal manure to field RA prior to soil testing might have led to residual, relatively slowly-mineralizable N present near the soil surface that contributed progressively less organic N to the runoff. The decline in TSS concentration is probably due in large measure to the initially high runoff TSS concentrations (fig. 7), which were most likely atypically high due to the recent installation of the flume and associated disturbance of the soil near the flume approach channel. If the two data points having TSS concentrations greater than 600 mg/L are omitted from analysis, then there is no significant linear relationship between TSS concentrations and time.

In addition to PO_4-P, event mean runoff concentrations of COD ($p < 0.03$) and TSS ($p < 0.07$) decreased significantly with time for field WA (figs. 8 and 9,

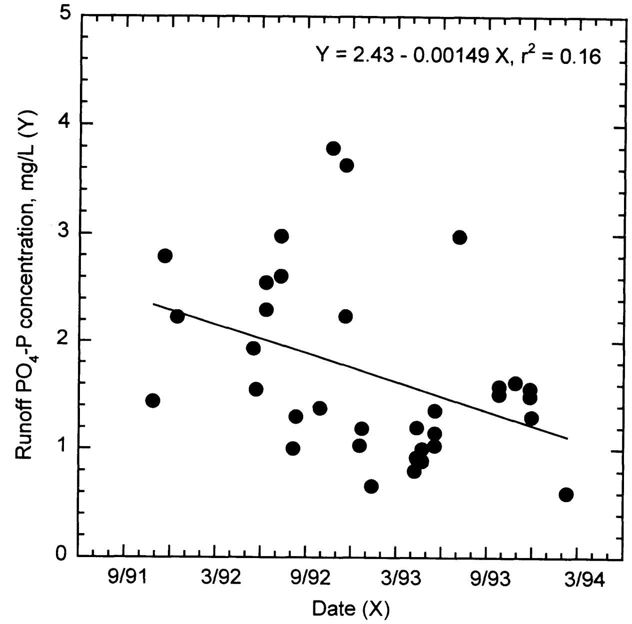

Figure 4–Event runoff ortho-phosphorus (PO_4-P) concentrations for field RA.

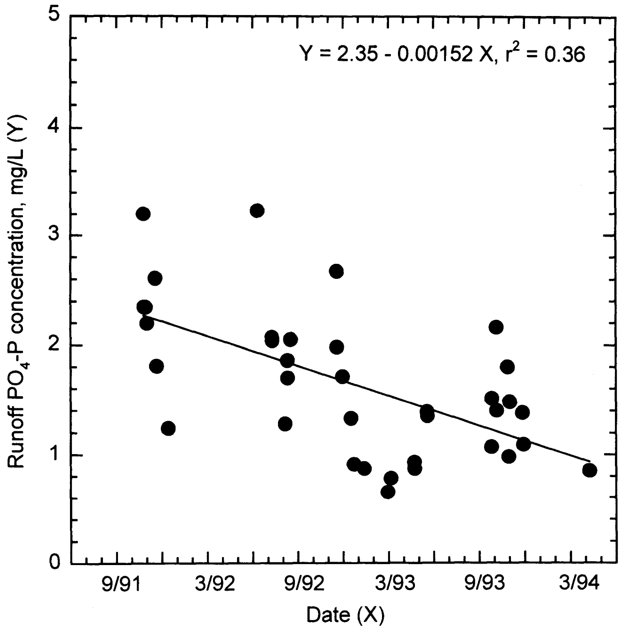

Figure 5–Event runoff ortho-phosphorus (PO_4-P) concentrations for field WA.

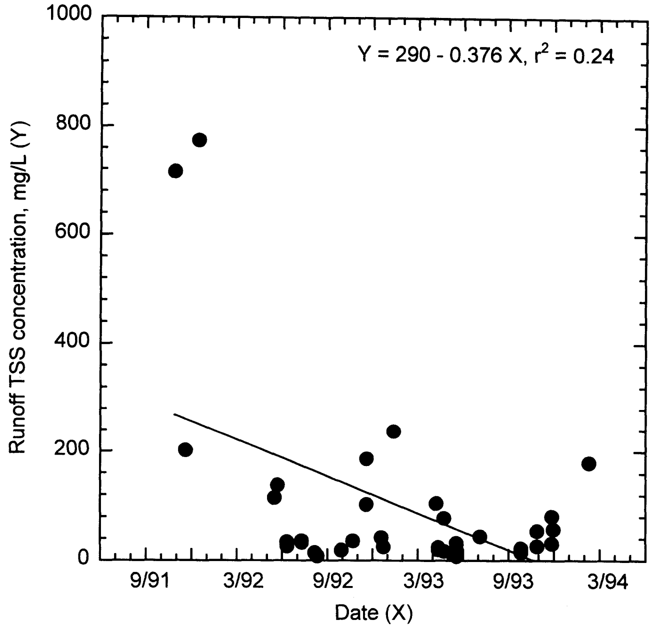

Figure 7–Event runoff total suspended solids (TSS) concentrations for field RA.

respectively). The decrease in runoff COD concentration can be linked in part to a concurrent decrease in soil organic matter content (see earlier discussion). The reasons for the decrease in runoff TSS concentrations are unclear, and even treating the two highest TSS concentrations as outliers leads to a significant ($p < 0.05$) decline in TSS concentrations with respect to time.

There was no trend in concentration of any analysis parameter for the fields that continued to receive animal manure (Fields RM and WM).

Analysis parameter mass transport. Statistics of event runoff mass transport of analysis parameters are shown in table 6. Estimated values of annual mass transport appear in table 7. The values given in table 7 were calculated by multiplying mass transport for sampled events by the ratio of total runoff to sampled runoff and then multiplying by the ratio 12/32 (the reciprocal of sampled years). Event runoff transport of analysis parameters was generally low and was dominated by large runoff events; for example, 44% of all TKN losses from field WA occurring over the monitoring period occurred during only one runoff event (14 April 1993). If such large individual storm event losses can be reduced, by fortuitous timing of fertilizer application or by other practices, then the impact on overall

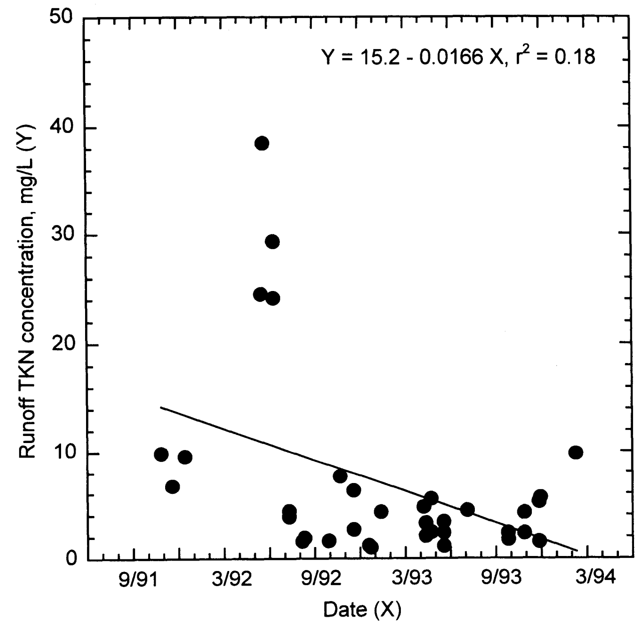

Figure 6–Event runoff total Kjeldahl nitrogen (TKN) concentrations for field RA.

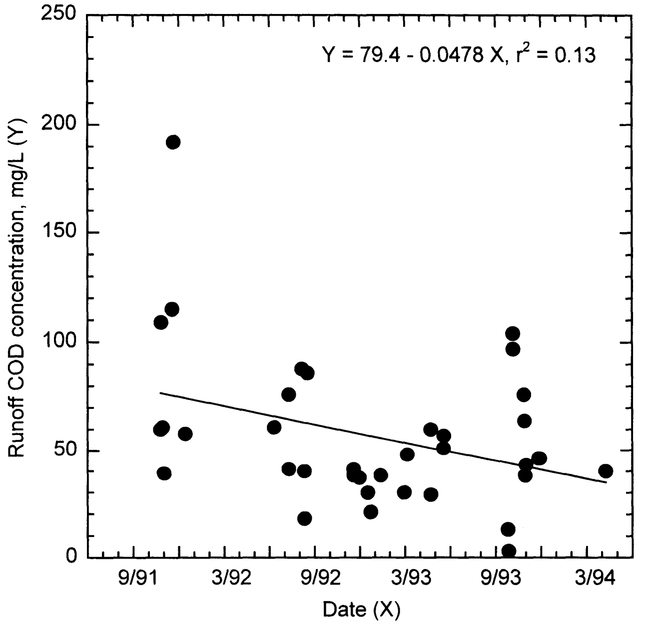

Figure 8–Event runoff chemical oxygen demand (COD) concentrations for field WA.

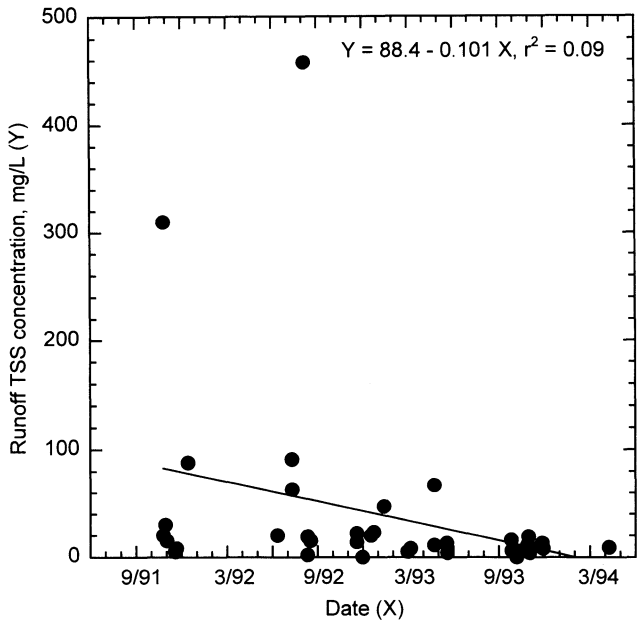

Figure 9–Event runoff total suspended solids (TSS) concentrations for field WA.

Table 6. Statistics of event runoff mass transport of analysis parameters

Parameter	Statistic*	RM (kg/ha)	RA (kg/ha)	WM (kg/ha)	WA (kg/ha)
NO_3-N	Mean	0.02	0.03	0.01	0.22
	SD	0.02	0.06	0.02	0.46
	Max	0.11	0.27	0.09	2.39
	Min	0.00	0.00	0.00	0.00
NH_3-N	Mean	0.02	0.01	0.05	0.08
	SD	0.05	0.02	0.17	0.31
	Max	0.30	0.06	1.02	1.88
	Min	0.00	0.00	0.00	0.00
TKN	Mean	0.32	0.11	0.21	0.39
	SD	0.59	0.13	0.48	0.80
	Max	3.55	0.44	2.61	4.15
	Min	0.01	0.00	0.00	0.00
PO_4-P	Mean	0.26	0.05	0.08	0.17
	SD	0.28	0.06	0.15	0.21
	Max	1.17	0.26	0.79	0.72
	Min	0.01	0.00	0.00	0.00
COD	Mean	5.84	2.05	2.55	5.13
	SD	6.55	2.68	3.76	7.44
	Max	33.37	9.46	15.52	34.05
	Min	0.01	0.00	0.00	0.00
TSS	Mean	4.68	2.10	3.61	7.48
	SD	10.59	5.27	8.80	26.31
	Max	59.07	30.87	46.94	131.46
	Min	0.01	0.00	0.00	0.00

* Mean is arithmetic mean, SD is standard deviation, Max is maximum observed value, and Min is minimum observed value.

losses of analysis parameters could be quite high. Annual mass transport was also relatively low, representing small proportions of nutrients applied via the fertilizers.

Table 7. Estimated* mean annual mass transport of analysis parameters

	Field			
Parameter	RM (kg/ha/year)	RA (kg/ha/year)	WM (kg/ha/year)	WA (kg/ha/year)
NO_3-N	0.27	0.43	0.28	3.38
NH_3-N	0.40	0.20	0.99	1.27
TKN	5.58	1.58	3.91	6.12
PO_4-P	4.34	0.67	1.58	2.71
COD	97.51	28.83	48.12	80.45
TSS	77.72	29.53	68.20	117.42

* Mass transport assumed proportional to runoff when concentration data were unavailable.

Despite the presence of significantly decreasing trends in some cases for analysis parameter concentrations, there was no significant trend in mass transport of any analysis parameter. This result is attributed to the fact that the fields were not perfectly paired and to high variability in storm event runoff amounts, which caused parameter mass transport to have much greater variability than concentrations alone. The lack of trends in analysis parameter losses does not contradict the findings with respect to parameter concentrations. In those cases where significantly decreasing trends in parameter concentrations were detected, runoff mass transport would be expected to eventually (with additional monitoring to overcome runoff amount variability) exhibit similar decreases, unless runoff amounts are statistically nonstationary.

SUMMARY AND CONCLUSIONS

Soil and runoff were sampled for four pasture fields in Northwest Arkansas from September 1991 to April 1994. The objective of the sampling and analysis was to assess the effects on soil and runoff of replacing animal manure fertilizer with only inorganic N fertilizer for fields having high soil P concentrations. The results of the study indicated that the fields receiving only inorganic N fertilizer exhibited decreases in both soil and runoff P concentrations. However, no significant increases in soil or runoff P concentrations were observed for the fields that continued to receive animal manures. The finding of significant decreasing trends in soil and runoff P concentrations during the study period suggests that runoff quality benefits may be realized in perhaps a relatively short time by replacing animal manure with inorganic N on fields that already have sufficient P for crop production.

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