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Project Summary

Evaluating Swine Drylot Runoff Impact on a Coastal Plain Stream

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The objectives of this study were: 1) to establish sampling methodologies for intensive monitoring of the environmental impact of animal feedlot runoff on in-stream water quality, 2) to determine chemical changes in stream water quality as a result of rainfall runoff from swine drylots on deep sands by comparing these resultant stream concentrations with those from a background reach of stream, and 3) to determine any changes in the stream biota as a result of the drylot runoff.

A drylot unit was selected for investigation which annually markets approximately 4000 hogs on dirt lots with deep sandy soils and which typifies physical and management factors common to Coastal Plain swine production. Stream samples were collected at sites above, adjacent to, and downstream of the drylots and analyzed for chemical oxygen demand (COD), total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO_3-N),total phosphorus (TP), and chlorides (Cl) over a 40-month period. These measurements as well as dissolved oxygen (DO) and stream flow were taken under low-flow conditions by grab sampling techniques while stream samples were collected under rainfall conditions by instrumented sampling stations. Biological surveys of the stream flora and fauna were also conducted. These results are discussed as well as the study approach, site selection, and sampling methodologies.

Field results indicated that approximately 2% of the nutrient and organic load of the defecated swine wastes are transported from the sandy drylot surface during rainfall runoff. The constituent levels of this lot runoff are further reduced 20- to 40-fold by swamp and vegetative buffer filtering action prior to stream input. Background stream constituent concentrations were very similar to levels measured in geographically similar well-drained Coastal Plain watersheds. Nutrient levels, except for phosphorus, below the drylot were similar to background levels under low-flow conditions. Nitrogen and chloride stream levels were approximately doubled by rainfall runoff from the drylot while phosphorus was elevated approximately 5-fold. Despite these nutrient level increases, however, no significant alteration of the stream biology was detected. It would appear from this study that more emphasis should be placed on the actual in-stream biological changes that may occur as a result of point-source and nonpoint-source inputs to reinforce conclusions drawn from nutrient and organic measurements.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Effluent from farm animal production areas is proclaimed as a significant contributor to surface water pollution. Different climatic, geographic, soil, and vegetative conditions, as well as management practices, however, profoundly affect the quality and amount of rainfall runoff and resulting stream impact from these animal production units. Concerns

arise, then, over the implementation of uniform national criteria for effluent guidelines and limitations for concentrated animal feeding operations as designated in the Federal Water Pollution Control Act Amendments of 1972 and the March 18, 1976 *Federal Register*. Regulatory criteria should be responsive to the needs and desire of the indigenous population as it supports national goals. The prudent balance between comprehensive regulations and criteria that are regionally responsive to both quality environment and food production must be maintained.

Decisions concerning control of rainfall runoff from animal production units in a specific location should include an evaluation of whether the constituents adversely affect the quality of a particular receiving water. It would be a misuse of resources to attempt complete control of any of these sources where they do not have an adverse effect or where such control will not produce a positive effect on water quality. Such decisions require more factual information on the magnitude of the waste inputs to a stream, the chemical and biological effects on in-stream water quality, and benefits and costs associated with control possibilities.

Open swine production facilities (drylots) on soils not supporting vegetation are classified as concentrated animal feeding operations subject to the criteria outlined in the National Pollutant Discharge Elimination System (NPDES) guidelines. Approximately 45% of the 3.1 million swine in North Carolina are grown on such drylot units since they represent the minimum housing investment. A large majority of these drylots are on deep sandy soils in the Coastal Plain section of eastern North Carolina. Since a producer may be able to finish up to three times as many hogs in an open lot system as he could afford in confined housing, he may have several hectares (ha) of drylots with stocking densities ranging from 500-1250 market hogs per ha. Stocking densities in this range quickly denude lots of vegetation and will eventually kill any trees within the confined area. Manure buildup and soil compaction are minimal since animal activity tends to keep the wastes well mixed with the sandy surface of the well-drained soils.

Drylots are rotated after one year's production to control disease and parasites and to allow rejuvenation of the soil surface. These lots are then seeded to grasses or allowed to remain fallow for at least 2 years before being put back into production. Large swine drylots characteristic of the Coastal Plain are usually located on sloping topography but separated from a drainageway or stream by a wooded or vegetated buffer strip. These streams are ill defined and often traverse through low-lying wet areas. The actual control of runoff contaminants is to a large extent affected through proper site selection and management practices.

The major objectives of this study were:

1. to establish sampling methodologies for intensive monitoring of the environmental impact of animal feedlot runoff on in-stream water quality.
2. to determine chemical changes in stream water quality as a result of rainfall runoff from swine drylots on deep sands by comparing these resultant stream concentrations with those from a background reach of stream.
3. to determine any changes in the stream biota as a result of the drylot runoff.

Conclusions

The results of 40 months of intensive field monitoring of a Coastal Plain stream receiving rainfall runoff from a swine drylot have indicated that although stream nutrient levels are elevated during rainfall events, the drylot is having minimal impact on the receiving stream biology.

1. Approximately 2% of the defecated swine wastes is transported from the sandy drylot surface during rainfall runoff. Nutrient and organic constituent levels of lot runoff are further reduced 20- to 40-fold by swamp and vegetative buffer filtering action.

2. Background stream constituent concentrations were very similar to levels measured in geographically similar well-drained Coastal Plain watersheds. Nutrient levels, except for phosphorus, below the drylot were similar to background levels under low-flow conditions.

3. Surface runoff and tile drainage from row-crop land appears to have an equal or greater impact on stream nitrogen levels under low-flow conditions than drainage from the swine drylot. Nitrogen concentrations cycled seasonally with peaks during the wet winter months of low evapotranspiration and an additional spike shortly after spring fertilizer application.

4. Nitrogen and chloride stream levels were approximately doubled by rainfall runoff from the drylot while phosphorus was elevated approximately 5-fold Despite these nutrient level increases, however, no significant alteration of the stream biology was detected through biological analyses.

5. Acquisition of flow data from sluggish, unstable Coastal Plain streams proved to be very difficult, costly and time-consuming rendering the cost benefits of obtaining such data questionable.

6. Benefits have already accrued from the cooperative effort of this investigation with the state regulatory agency. It has enhanced the working relationship between educational and regulatory agencies, and the livestock producer resulting in more logical implementation of regulations which are responsive to local conditions and needs, yet compatible with national water quality goals.

Major Findings

In-stream flow measurements proved to be very difficult to obtain due to the sluggishness and unstable organic bottom of this Coastal Plain stream. Consideration should be given in similar related studies to the importance of mass transport and just how flow data will be used before expending the efforts necessary to obtain such information.

Average and extreme constituent concentrations are listed in Table 1 for the primary sampling sites on the receiving stream under low-flow conditions. Only a very slight dissolved oxygen sag occurs in the receiving stream at the point of maximum drylot impact, but this DO concentration recovers and exceeds background levels through a downstream reach. The minimum measured DO throughout the 40-month period of study was 4.0 mg/l which still met water quality standards applicable to the surface waters of North Carolina.

Highest stream total nitrogen levels, particularly nitrate nitrogen, under low-flow conditions were measured near the headwaters. This was probably due to tile drain inputs from an adjacent row-crop field since a seasonal cycling trend emerged with the nitrogen peak concentrations occurring around January through March with an additional spike in May. This would indicate that during the growing season nitrogen losses are reduced due to crop uptake and less moisture for soil-water transport, but after harvest more nitrogen becomes available due to residue decomposition and less evapotranspiration resulting in greater soil-water transport. The additional spike in May occurs after spring fertilizer applications. Nitrogen levels below the drylot, although elevated, were still comparable to a geographically similar North Carolina watershed free of point source inputs.

Table 1. *Mean Constituent Concentrations of Receiving Stream Under Low-Flow Conditions*

Water Quality Parameter		Sampling Site			
		Headwaters	Background	Below Drylot	Recovery
DO,	mg/l	4.3*	6.2	7.0	9.4
		1.2-10.2**	3.2-11.9	4.0-12.1	6.1-15.2
COD,	mg/l	27.12	23.02	44.80	39.48
		11.76-75.10	3.93-49.43	15.81-100.97	15.75-75.10
TKN,	mg/l	1.37	1.11	1.73	1.60
		0.45-4.35	0.34-4.97	0.49-5.55	0.42-6.20
NO_3-N,	mg/l	1.46	0.27	0.49	0.50
		0.23-4.33	0 -2.00	0 -2.60	0 -2.48
TP,	mg/l	0.13	0.07	0.41	0.38
		0.02-0.43	0.02-0.15	0.09-1.35	0.12-0.78
Cl,	mg/l	7.2	5.9	7.0	7.1
		5.0-12.1	4.0-8.5	2.6-12.6	2.7-12.9
Flow,	cfs	0.099	0.207	0.404	0.458
		0.021-0.260	0.009-0.768	0.076-1.062	0.091-0.923

*Mean of approximately 50 sampling dates over a 40-month study period.
**Range of values.

Stream phosphorus levels were substantially higher below the drylot under low-flow conditions than background levels. Visual inspection of the stream channel indicates that most of the sediment transported from the lot in runoff is settled or trapped by a swamp buffer before it reaches the stream. Organic wastes leaving the lot surface probably also settle in the swamp where the phosphorus content of that waste is gradually and continually released to the stream through drainage and subsurface flow.

The average coefficient of variation for organic, nitrogen, and phosphorus stream levels during individual rainfall runoff events was 30%. Table 2 gives the mean constituent concentrations of the receiving stream as well as drylot runoff under rainfall runoff conditions. Organic concentrations of lot runoff decreased by approximately 20-fold when compared to stream concentrations indicating the filtering capability of the swampy buffer. In terms of mass transport based on five runoff events, approximately 2% of the wastes defecated by the animals actually left the lot surface during runoff.

Total nitrogen levels of lot drainage during rainfall runoff events decreased by 40-fold when compared to stream levels indicating the effects of swamp filtering, denitrification, and stream dilution. Total N stream levels below the drylot were approximately double background levels.

Stream phosphorus levels during rainfall runoff indicated a 40-fold decrease in the lot runoff levels. An average phosphorus stream concentration of 0.74 mg/l below the drylot represented a 6-fold increase over background levels.

Biological surveys of stream periphyton and stream benthos under low-flow and rainfall runoff conditions yielded no variations between sampling sites for the specific biological evaluation techniques employed in this study. Examination of the biological data indicated that the impact of drainage from the drylot on the stream biota is minimal over the period of time studied, however instream nutrient and organic concentrations increased as a result of drylot runoff.

Table 2. *Mean Constituent Concentrations of Drylot Runoff and Receiving Stream Under Rainfall Runoff Conditions*

Water Quality Parameter		Sampling Site			
		Headwaters	Background	Below Drylot	Drylot Runoff
COD,	mg/l	26.77*	48.28	78.08	1521.
		3.90-180.54**	10.00-166.03	29.00-577.00	403-3946.
TKN,	mg/l	1.12	1.46	2.61	105.
		0.15-4.59	0.45-4.88	0.75-21.01	49 8-204.
NO_3-N,	mg/l	1.36	0 49	1.77	7.25
		0 -3.70	0 -2 76	0 -8.60	0.03-26.80
TP,	mg/l	0.10	0.13	0.74	31.00
		0 04-0.50	0.04-0.53	0.16-10.13	8.40-54.00
Cl,	mg/l	7.76	6.37	10.13	96.6
		3.00-14.40	4.00-10.90	4.00-19.00	50.6-169.

*Mean of approximately 40 rainfall runoff events over a 30-month study period.
**Range of values.

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***R. Douglas Kreis** is the EPA Project Officer (see below).*
The complete report, entitled "Evaluating Swine Drylot Runoff Impact on a Coastal Plain Stream," (Order No. PB 83-263 699; Cost: $13.00, subject to change) will be available only from:
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