RELATIONSHIPS BETWEEN SURFACE WATER SEDIMENT CONCENTRATION, TOTAL PHOSPHORUS, AND TOTAL KJELDAHL NITROGEN IN MISSISSIPPI DELTA STREAMS

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INTRODUCTION

Surface water quality continues to be a topic of concern for state governments trying to comply with federal mandates for clean water. The U.S. Environmental Protection Agency (EPA) has made significant progress in developing its procedures for mandating control of nonpoint sources of pollution through their Total Maximum Daily Load (TMDL) program (40 C.F.R.). Mississippi Departments of Environmental Quality (MSDEQ) is trying to better define the water quality problems in the state (MSDEQ 1999). Information in this paper could help to focus monitoring and TMDL development efforts.

USDA Natural Resource Conservation Service (NRCS) began a Delta wide study in 1992 to find alternative water supplies for irrigation and environmental quality maintenance during low flow periods. Existing Delta surface water quality needed to be monitored in order to determine how best to address supply and quality concerns. NRCS has conducted monthly surface water quality sampling on the major interior Delta streams starting in 1993 with Deer Creek and expanding by 1994 to the Sunflower River, Bogue Phalia and Quiver River. Data were gathered through 1997 from a total of 22 sites for varying lengths of time (1996 Pennington; USDA NRCS 1999). Examination of this information provides a good picture of seasonal variations in water quality parameters and provides a basis for prioritizing these concerns for improvement through conservation based land use. The patterns followed by sediments and nutrients in these waters were indicative of the nature and seasonality of these parameters. Total phosphorus, total kjeldahl nitrogen, total solids, total suspended solids and turbidity were chosen for further study.

About 3 million of the Delta's 4 million acres are in agricultural production. Agriculture is essential to the economic viability of this part of our state. However, farming in the Mississippi Delta potentially moves more soil than any other activity elsewhere in the state. The opportunities for sediment and nutrient control are plentiful. NRCS has been developing management practices for control of soil erosion and sediment transport for over 60 years. The technology is available to address our environmental concerns. The current challenge is to find the funding and implement these practices in sufficient numbers in strategically located areas using watershed planning to achieve the water resource goals that will be mandated under the TMDL program through the MSDEQ.

MATERIALS AND METHODS

Sampling methods, site locations, and testing were described in references 3 and 4 (Figure 1).

Data were grouped by month and averaged. Linear regression analyses were run using monthly averages for the dependent variables total phosphorus, total kjeldahl nitrogen, and the independent variables total solids, total suspended solids, and turbidity (parameters). The relationship between turbidity and total suspended sediments was also determined.

Data collected for the Sunflower River at the town of Sunflower were used to estimate parameter loads because long-term stage data were available to calculate flow volumes per month. Water quality and flow data were grouped by month for load calculations. Loads for a range of "acceptable" parameter concentrations, based on available published data for water quality standards, were calculated using the same equations. Differences between the actual and desired parameter concentrations were obtained and used along with practice efficiencies to estimate cost of measures to control inputs of the parameters for the Sunflower River watershed.

RESULTS AND DISCUSSION

Linear regression analysis of indicators of sediment load in the surface waters, total solids, total suspended sediments, and turbidity, to both total phosphorus and total kjeldahl nitrogen were performed. Analysis of data averaged by month for all sites showed a strong correlation between indicators of sediment concentration and concentrations of phosphorus and nitrogen in these waters.

Total phosphorus and total kjeldahl nitrogen monthly average concentration correlation with all indicators of water borne sediment were high (Table 1). Total phosphorus coefficients of determination (r^2) were about 0.8. This indicates that all measures of water borne sediment are good predictors of total phosphorus concentration. Interestingly the r^2 values for total kjeldahl nitrogen were about 0.9 suggesting an even better predictive ability. It is probable that soil organic matter makes up part of the total solid load since most nitrogen in the soil is in an organic form. Erosive losses from fields are potentially having a negative impact on soil productivity through the loss of soil, organic matter, and associated nutrients.

Turbidity was strongly correlated to total suspended sediment load, $r^2 = .99$. Either is a good indicator of water sediment load. Turbidity is an easy to perform field measurement which, due to its correlation to nutrient and sediment concentrations, could serve as a monitoring tool for practice efficiency.

Careful examination of the monthly changes in all of these parameters reaffirms the seasonal variations in water quality in the Delta (Table 2). Higher concentrations of all five parameters occur when the soil is bare and are lowest when there is good canopy cover. There is a clear change in concentration of all parameters between June and July. The highest influx of sediments and nutrients occurs during winter and spring.

Lets look at a "typical" year in the Delta. Crops are generally all harvested by the end of October to early November. Weather permitting, this is also a time when soils are prepared for spring planting using several conventional operations from deep tillage to disking. Landforming can be done whenever weather permits, but late fall is often optimum for ground work. These operations leave soil bare for the winter rains. Data in Table 2 indicate that by February there may be sufficient winter cover from natural weed growth to provide some protection from erosion. However, field preparation begins in earnest in March with corn planting and rice ground preparation again exposing bare soil to erosive forces. Crop canopies are well developed by July and continue through harvest in October and early November. Dry ground can decrease runoff events in early November and December, but concentrations of sediment and nutrient parameters begin to increase in December peaking in January and repeating the cycle. The key to water quality is to implement conservation options that address the problems of winter and spring runoff.

Linear regression analysis of both total phosphorus load to total suspended sediment load and total kjeldahl nitrogen load to total suspended sediment load in the Sunflower River at the town of Sunflower (Table 1) predict that sediment control would significantly decrease nutrient levels in the river. Coefficients of determination may reflect the effects of the load calculations. Both parameters are multiplied by flow volume potentially increasing r^2; however, the values still reflect the trend of a relationship of increasing sediment and nutrient concentrations. Methods to limit sediment and nutrient loss from fields have varied efficiencies (Table 3). Conservation tillage and grass filter strips are two practices used in the Delta that could be expanded to many more acres. They are both effective year round and have sediment control benefits during the critical winter and spring time periods.

Gage data from the recorder on the Sunflower River at Sunflower were used to develop monthly average flows at this location. These flows and the monthly average parameter concentrations were used to calculate a monthly load for total phosphorus, total kjeldahl nitrogen and total suspended sediment (Figure 2). Applying conservation practice efficiencies from Table 3 to current Sunflower River nutrient and sediment loads determined the concentration of these parameters which would remain with either or both of these conservation practices in place.

Total phosphorus could be reduced by either practice to less than 0.3 ppm, a potential water quality standard, in all months except January, March, and April. Delta soils are high in native phosphorus. The Mississippi State soils extension specialist, Larry Oldham, reports that 98.5% of all soil tests for rice production are in the high phosphorus range indicating no need for phosphorus fertilizer. This indicates that even without added fertilizers, sediment inputs into streams will be likely to maintain total phosphorus concentrations at higher levels than in other parts of the country. This reemphasizes the need to set standards locally to accurately reflect local limitations.

Neither conservation practice could lower total kjeldahl nitrogen load to less than 1 ppm, also a possible water quality standard, at any time during the year. However, the alternative standard of 2 ppm is met by either practice all year. Again, setting an obtainable standard is essential to the success of a program such as TMDL setting.

The implications of these results for surface water quality are straightforward. Remove or eliminate the source of sediment in the water and the nutrient load will also be reduced. Implementation of both practices over the entire Sunflower River watershed, 852,390 acres, would control all of these parameters at the indicated levels for an estimated cost of 21 to 33 million dollars (Table 4). Costs for the practices are those currently used by NRCS in the Delta and reflect current market values. This is a significant and not really practical, investment covering only the Sunflower River Basin, which is about 1/3rd of the farmland in the Delta. It is obvious that it would be difficult to install conservation tillage or grassed filter strips on every farmed acre in the Sunflower watershed. What is also obvious is that with watershed planning, strategic location of practices on the most susceptible acres could produce significant benefits for the entire area without treating every farmed acre. There are many other conservation practices that should be considered from nutrient management to water control structures with slotted board risers. Some of these, such as conservation tillage and water control structures with slotted board risers, complement each other to produce additive benefits. Careful watershed planning addressing real environmental issues will produce the best use of our conservation dollars no matter where they originate.

REFERENCES

40 C.F.R. § 130.7(b)(5)(iii) Federal Clean Water Act Section 303(d)

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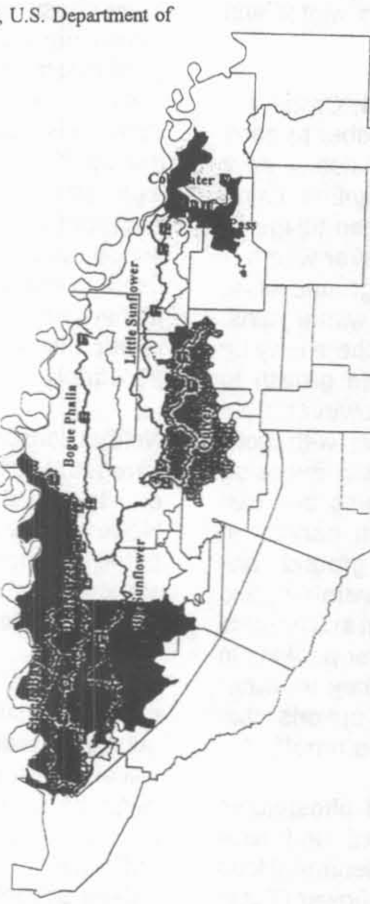

Figure 1: NRCS monthly water quality sampling sites in the Mississippi Delta.

Table 1: Regression Analysis for monthly average parameter concentrations 1-7 and parameter loads 8-9.

	Parameters	Equations	r^2
1	Total Phosphorus to Total Solids	TP = (0.0014 * TS) - 0.0225	0.78
2	Total Phosphorus to Total Suspended Sediment	TP = (0.001 * TS) + 0.2026	0.80
3	Total Phosphorus to Turbidity	TP = (0.0007 * TS) + 0.2669	0.83
4	Total Kjeldahl Nitrogen to Total Solids	TKN = (0.0048 * TP) - 0.1214	0.89
5	Total Kjeldahl Nitrogen to Total Suspended Sediment	TKN = (0.0036 * TP) + 0.6825	0.90
6	Total Kjeldahl Nitrogen to Turbidity	TKN = (0.0025 * TP) + 0.9298	0.87
7	Turbidity to Total Suspended Sediment	Turbidity = (1.4266 * TSS) - 93.869	0.99
8	T Phosphorus to TSS Sunflower River @ Sunflower	TP = (0.001 * TSS) + 14.5922	0.94
9	T Kjeldahl Nitrogen to TSS Sunflower River @ Sunflower	TKN = (0.003 * TSS) + 31.5782	0.98

Table 2: Monthly average concentration values for water quality parameters.

Month	Total	Total Solids	Turbidity	Total	Total Suspended
	ppm	ppm	NTU	ppm	ppm
1	0.56	444	450	1.86	378
2	0.36	353	285	1.85	284
3	0.63	514	542	2.49	453
4	0.76	500	549	2.25	442
5	0.48	329	241	1.40	233
6	0.43	306	235	1.29	211
7	0.36	253	97	1.14	116
8	0.31	277	66	0.94	122
9	0.24	267	60	1.04	114
10	0.34	267	67	1.43	117
11	0.38	286	121	1.27	152
12	0.45	266	135	1.24	163
Average 1 to 6	0.53	408	384	1.86	333
Average 7 to 12	0.35	269	91	1.18	131

Table 3: Conservation practice efficiencies.

Practice	Sediment	Nitrogen	Phosphorus
		% Controlled	
Conservation Tillage	75	45	55
Grass Filter Strip	85	75	50

Table 4: Conservation practice costs for the Sunflower River watershed.

Practice	Acres	Cost per acre	Total Cost
Conservation Tillage	852,390	17 to 32	\$15 to \$27 million
Grass Filter Strip	852,390	7	\$6 million
Total	852,390	24 to 39	\$21 to \$33 million

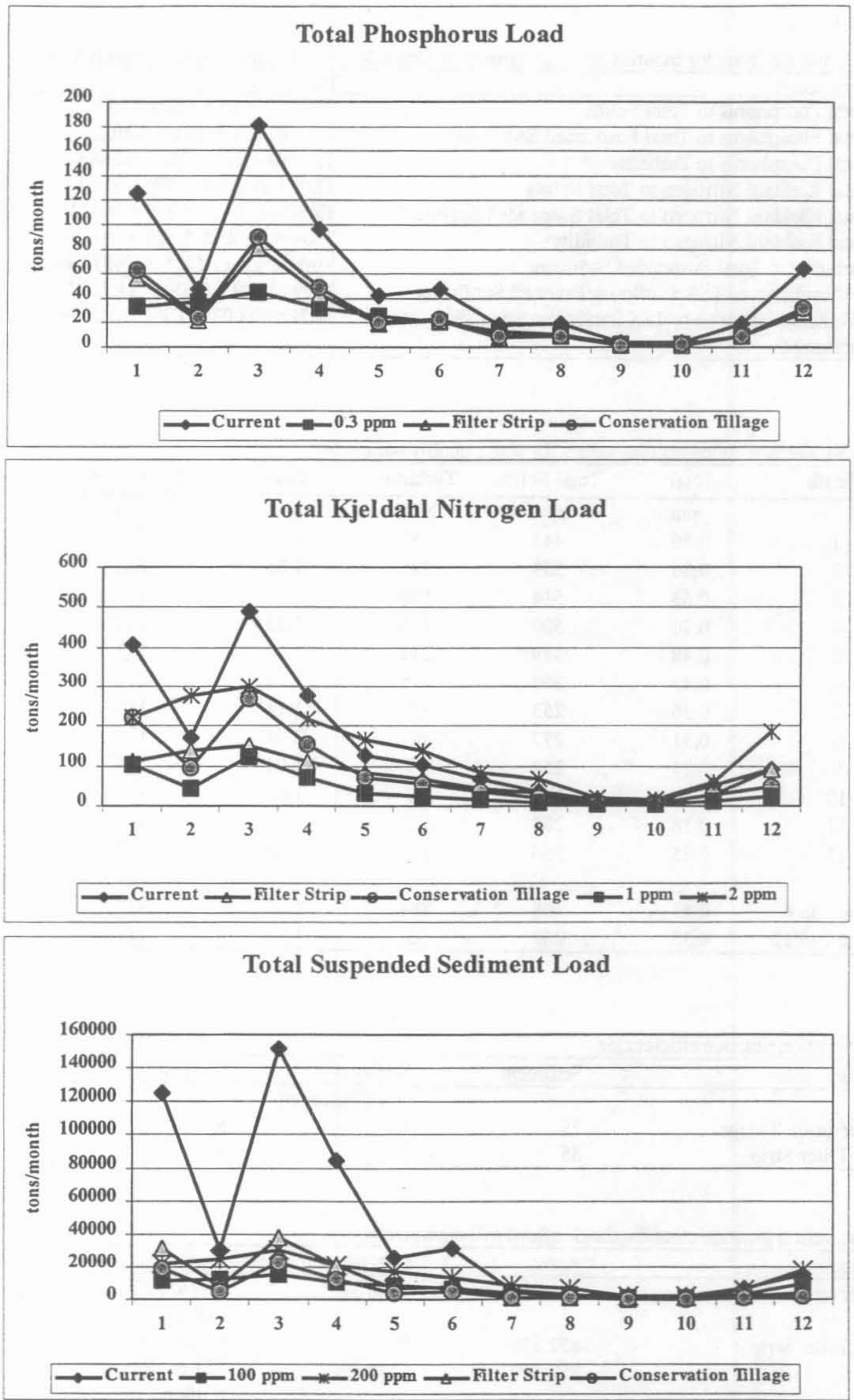

Figure 2: Nutrient and sediment loads for the Sunflower River at the town of Sunflower 1994 - 1996 predicted using efficiencies of the conservation practices, conservation tillage and grassed filter strips.