Integrating Geospatial and Temporal Data for Water Quality Monitoring in Southwest Mississippi

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Abstract - Monitoring water quality and identifying the location and magnitude of existing and potential pollution sources and impacts are important activities to ensure clean and adequate supply of this natural resource. We used remote sensing and geographic information systems (GIS) to assess land use/land cover influence on water quality of streams in the Coles Creek watershed. Eleven monitoring stations were established in the watershed to quantify water quality. At each station, dissolved oxygen, turbidity, pH, specific conductance, total coliform and E. coli were measured. The data was incorporated into the GIS database for the entire watershed. Preliminary results showed spatial and temporal variability in the parameters measured. Rainfall events significantly influenced all water quality parameters measured (p<0.05).

Keywords: GIS, Remote Sensing, watershed, classification, streams, land use and landcover.

1. INTRODUCTION

The contamination of streams through non-point source water pollution is well documented (Mallin et al., 1997; Mawdsley et al., 1995) and has become a critical concern in many areas of watershed units of which South West Mississippi is no exception. These concerns has prompted the Environmental Protection Agency of the United States to entrust support to help exhibit improved stream water quality through realization of best management practices (BMPs). Currently, in Mississippi silvicultural best management practices (BMPs) have been widely accepted as an effective management tools to minimize non-point source (NPS) pollution associated with forest management activities.

In this study, remotely sensed data was used to identify and assess the impact of land use and land cover as well as land use management practices on water quality. To help quantify the impact of land use and land cover on water quality, eleven locations were appropriately established using global positioning system. The main objective of this study was to assess the quality of major streams in the Coles Creek watershed. Increase in concentrations of nutrients and bio-contaminants in water can alter the function and stability of many riparian and aquatic ecosystems. In the past, intensive fertilization has contributed to the accumulation of nutrients in many wetland and aquatic environments (Koch and Reddy, 1992; Lebo and Sharp, 1993; David and Gentry, 2000; Edwards et al., 2000; Sharpley et al., 2000).

2. MATERIALS AND METHODS

2.1 Satellite Imagery Classification

The Coles Creek watershed (1300 km^2) is located in the Southern Mississippi Valley Silty Uplands, major land resource area 134. The watershed lies between latitude 31.38^0 and 31.92^0 north and longitude 90.87^0 and 91.47^0 west. Our investigation utilized Landsat 7 Enhanced Thematic Mapper (LANDSAT 7 ETM^+) (Fig. 1) data covering the study watershed. The satellite data was examined using the standard image processing software ERDAS Imagine 8.7 version. The unsupervised image classification technique using ISODATA (Iterative Self-Organizing Data Analysis Technique) algorithm (Schowengerdt, 1997) was used to cluster imagery into spectrally similar categories. This classification was used over another method, supervised classification using the maximum likelihood parametric method **(**Jensen, 2003**)** to derived a highly accurate Land use and Land cover categories (Fig. 2). Groundtruthing data were used for final classification. The result of the raster data were converted to vector data and used in the Geographic Information system.

2.2 Sample Collection

Locations of water quality monitoring stations were identified using the interpreted imagery and global positioning system. A total of eleven monitoring stations were identified and marked. Water samples were collected prior to and after rainfall events (only two sampling times will be presented in this paper). The YSI Sonde model 6600-M coupled with the YSI model 650-MDS was used to measure dissolved oxygen, turbidity, pH, specific conductance, and temperature. Water samples were collected in pre-sterilized bottles and analyzed for total coliform and *Escherichia coli* (*E. coli*) using colilert® substrates. Samples were enumerated by the presence or absence in Quanti-Tray® cells and the data expressed as most probable number (MPN) per 100 mL. All data collected were incorporated into the GIS database for the watershed.

2.3 GIS and Water quality parameters Analysis

Geographic Information System (GIS) was used to organize both spatial and temporal data and presented graphically the water quality parameters data for the watershed. The spatial relationship between the water quality parameters (DO, turbidity, pH, specific conductance, total coliform and *E. coli.*) and the land use and land cover was correlated and the overlay technique (Arnold et al., 1987) used to display spatial patterns.

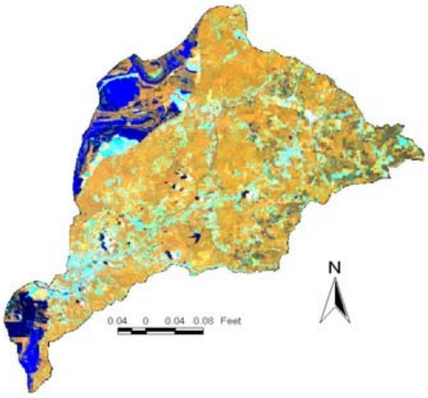

Fig. 1. Lansat 7 Enhanced Thematic Mapper imagery (05/28/2003) of the Coles Creek Watershed

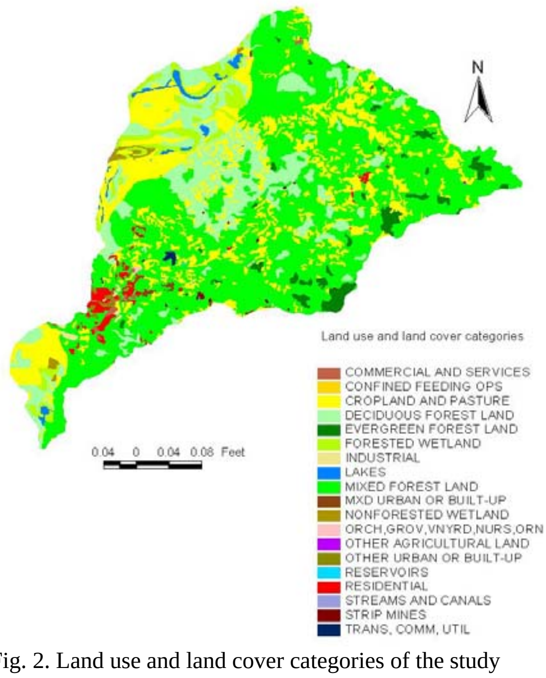

Fig. 2. Land use and land cover categories of the study watershed.

3. RESULTS

Preliminary analysis and results showed spatial and temporal variability in the parameters measured (Figs. 4, 5, 6 and 7). Results also showed that irrespective of land use/land cover, rainfall events significantly influenced all water quality parameters measured ($p<0.05$). The parameters measured were superimposed on the land use and land cover categories to establish relationships. Tables 1 and 2 depict water quality parameters taken at the eleven monitoring locations.

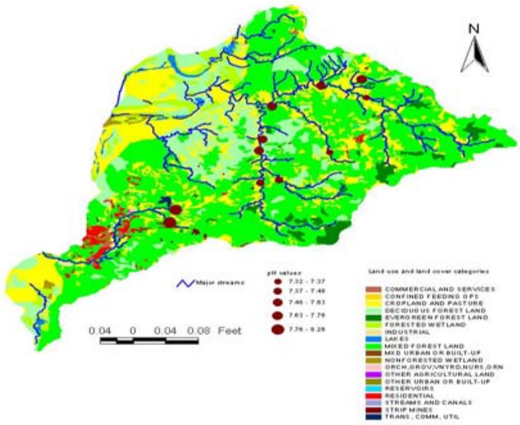

Fig.3. Variability of stream pH in the study watershed.

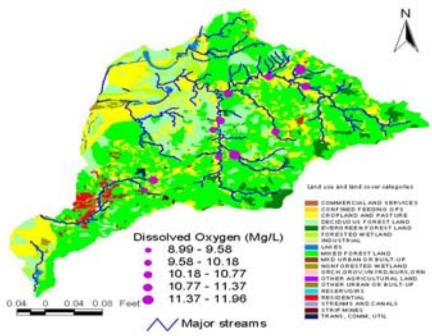

Fig. 4. Dissolved oxygen in stream segments in the study watershed.

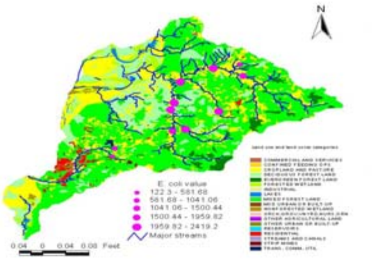

Fig. 5. Distribution of *E. coli* in streams in the study watershed.

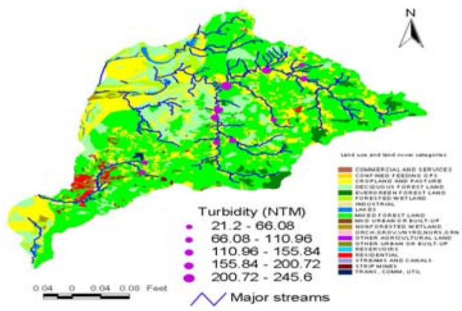

Fig. 7. Turbidity of stream segments in the study watershed.

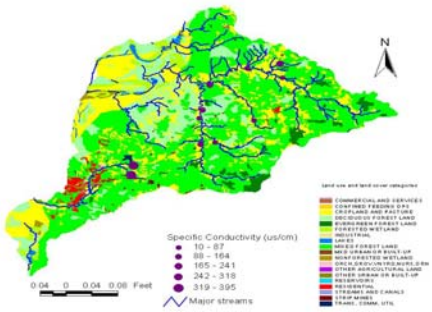

Fig. 6. Spatial distribution of Specific Conductance in the study watershed.

TABLE 1. VALUES OF WATER QUALITY PARAMETERS MEASURED TWO DAYS AFTER A 15-CM RAINFALL.

STA_N	LONG_X	LAT_Y	Time	Temp (^{o}C)	Specific Cond. (us/cm)	DO (mg/L)	Depth (ft)	pH	Turb+ (NTM)	Baro. pressure (mmHg)	E. coli (MPN/100 mL)
1	-91.29329	31.58114	11:56	29.29	395	8.99	0.656	8.09	44.5	762.6	114
2	-91.27951	31.59985	12:14	24.45	395	11.29	0.681	8.26	40	763.7	85
3	-91.18261	31.64242	12:40	27.31	121	10	0.473	7.48	93.8	763.3	457
4	-91.15909	31.64660	1:13	25.44	74	11.64	1.625	7.43	108.9	767.9	457
5	-91.09743	31.69026	1:26	25.34	79	10.68	0.376	7.37	21.2	765.9	830
6	-91.05257	31.77561	1:43	26.03	53	11.27	1.447	7.32	103.1	765.3	870
7	-91.06089	31.80723	1:55	24.78	188	11.96	0.715	7.76	60.8	763.6	1011
8	-91.10805	31.79331	10:17	22.39	62	10.55	1.146	7.63	156.8	762.2	1011
9	-91.16786	31.76082	10:42	22.54	105	10.48	2.045	7.57	245.6	766.1	960
10	-91.17928	31.71054	11:13	24.06	99	10.29	2.142	7.55	180	768.3	914
11	-91.19121	31.69338	11:31	24.78	10	10.14	1.062	7.63	146.1	764.6	870

TABLE 2. VALUES OF WATER QUALITY PARAMETERS 21 DAYS AFTER A 15-CM RAINFALL.

STA_N	LONG_X	LAT_Y	Time	Temp (^oC)	Specific Cond. (us/cm)	DO (mg/L)	Depth (ft)	pH	Turb. (NTM)	Baro. pressure (mmHg)	E. coli (MPN/100 mL)
1	-91.29329	31.58114	12:52	31.77	487	10.93	0.386	8.35	28.2	761.2	196.8
2	-91.27951	31.59985	12:41	27.47	592	11.99	1.12	8.41	7.2	760.4	191.8
3	-91.18261	31.64242	1:16	31.24	419	11.02	0.665	7.78	8.4	763.7	1203.3
4	-91.15909	31.64660	1:27	30.15	288	12.66	2.258	7.67	10.3	763.5	1299.7
5	-91.09743	31.69026	1:41	29.24	188	11.32	0.79	8.07	16.5	761.1	183.5
6	-91.05257	31.77561	2:37	33.48	151	11.47	0.365	8.44	9.9	765.7	249.5
7	-91.06089	31.80723	2:48	27.84	363	11.71	1.125	8.09	10.1	763.3	58.1
8	-91.10805	31.79331	11:29	27.36	218	10.48	0.687	7.97	16.1	760.9	84.2
9	-91.16786	31.76082	11:45	26.94	465	10.35	2.833	8.19	9	762	88.6
10	-91.17928	31.71054	12:02	28.34	374	10.62	0.51	7.93	7.1	761.9	56.1
11	-91.19121	31.69338	12:16	29.05	398	11.23	0.351	8.04	7.4	761.7	125.4

4. CONCLUSION

Preliminary analysis revealed that rainfall played key role in contaminants found at some sample locations. Subsequent analysis will be done to identify the source(s) of these contaminants and to establish a relationship if any with any category of land use/land cover. Further laboratory analysis will be conducted to quantify phosphate, nitrate, total coliform and *E. coli*. This will enable researchers address and inform decision makers within the study watershed on issues concerning water quality.

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