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STORMWATER RUNOFF QUALITY OF A LOUISIANA LOG STORAGE AND HANDLING FACILITY

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ABSTRACT

Very little attention has been paid to the stormwater runoff quality from log storage and handling facilities. This project determined the concentrations of conventional parameters such as BOD_5, COD and TSS, and 123 priority pollutants of stormwater runoff samples from a log storage and handling facility in Louisiana. No significant levels of priority pollutants were found and only about 1 to 13 % of COD was biodegradable. COD followed closely with TSS, suggesting that effective control of TSS will control COD as well. The pollutant strength resulting from summer to fall storms did not vary much.

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INTRODUCTION

The forest industry is very important in Louisiana. Timber is first in annual harvest value with respect to all other agricultural crops (Jacob et al., 1990). Louisiana has a well-developed primary industry, which includes pulp/paper mills, sawmills, plywood mills and other panel mills. Log storage and handling facilities serve as places to house the logs until they are required for conversion at a mill. These yards are typically close to the mills to keep transportation costs low.

In the past, pulp/paper mills typically had satellite woodyards wherein shortwood (8 feet long or less) was gathered from local pulpwooders and loaded on rail cars to be transported to pulp/paper mills. Today, the shortwood yards have been replaced by chip mills, wherein pulpwood logs are delivered tree-length, de-barked and chipped into pieces roughly 8 cm. long and 1 cm. thick. The chips are then transported by truck, rail or barge to pulp/paper mills. Chip mills still keep enough logs on hand to assure constant operability. Mills in the southern U.S. typically like to have enough logs in inventory to supply operations for one week to one month, depending on the season.

Although there has been considerable attention by industry and environmental regulators on the topic of stormwater runoff, much of it concerns urban runoff. Surprising little published data can be found on log yard stormwater runoff. A study in Oregon investigated the effects of log yards on water quality (Schuytema and Shankland, 1976), but the yards were significantly different from yards found in the southern states. Each of the yards utilized stream water that flowed through or near the yard on a continual basis. There was no effort to measure stormwater runoff.

The U.S. Environmental Protection Agency (EPA) and the Louisiana Department of Environmental Quality (DEQ) are concerned about the stormwater runoff quality from log storage and handling facilities. The chemicals leached out from the bark of the stored logs may contribute to a higher chemical oxygen demand (COD) and a lower pH value, and some of them may even be harmful. The higher COD levels may result from the fact that a significant portion of the compounds present in bark are oxidized completely, one example being lignins (Sawyer et al., 1994). Lignins, however, are more of a common concern in a mill, rather than a log storage area, where concentrated acids are used to remove them before any processing occurs (Fengal and Wegener, 1984).

The pH of water is also of concern since bark has more acidic compounds than does the wood of the same tree (Fengal and Wegener, 1984). The pH is generally lower in the outer bark than in the inner bark. Southern pines were found to have the most acidic pHs with values ranging from 3.1 - 3.8, but it must be kept in mind that some of the pH tests were run with hot water treatment, which would give a lower pH than a cold water treatment (Fengal and Wegener, 1984).

This paper presents the quality of the stormwater runoff from the log yard of a typical chip mill. Permit discharge levels, established by DEQ, differ from one log storage facility to another. However, with the data collected in this project, the governmental agencies will be able to compile typical values for various chemical parameters, allowing them to establish a set of fair discharge levels for stormwater coming from log storage areas which can be applied uniformly. The forest products industries will also benefit from having this set of data, since they can immediately see how their operation measures up to other similar facilities. If these industries find that their levels are above the typical range, they can learn from the storage sites with low discharges and utilize similar control measures to bring their discharge levels within range.

METHODS AND MATERIALS

Stormwater runoff samples

All stormwater runoff data were collected from a chip mill log yard in north- central Louisiana. The study drainage area was about 4 hectares in size and contained a large portion of the active log handling area and short-term log storage yard. The debarker and infeed deck of the chip mill were also in within the drainage area, but it is not believed that this affected the results measurably. No chemicals were used in the entire process other than lubricants typical of any industrial mechanical process.

A portable automatic stormwater runoff sampler (Isco Model #3700) was placed in the yard's stormwater ditches. The sampler was hooked in series to a rain gauge and a flowmeter to allow respective readings of inches of rain and flow passing through a V-notch weir flow-measuring device. The sampler was programmed to collect a total of eight separate points in time. The first group of samples, or the first flush group, occured immediately after an adequate water level had been reached in the v-notch weir. A fifteen minute delay would then follow until the sampler began collection of the next set of 3 bottles. For every bottle set after the second one, there would again be a 15 minute delay between each collection until the eighth set. Since the sampler held twenty-four 1-L bottles, this gave a total of three liters for each point in time. Three liters were collected for each point to ensure that enough stormwater runoff was captured to perform all of the chemical analyses.

All samples were iced during shipment and preserved at a temperature of 4°C or lower. The samples were analyzed within 6 hours of collection. When this was not possible, they were analyzed within 24 hours, this being the absolute maximum storage time. When samples were sent to an EPA approved analytical laboratory for priority pollutants analysis, excluding heavy metals, the preservation techniques of that lab were specifically followed. For the heavy metals test, samples were brought down to a $\text{pH} \leq 2$ with nitric acid. With this preservation technique, the samples could be stored up to a month before analysis.

Water Quality Analysis

Both conventional and priority pollutants were measured. The priority pollutant analyses, except heavy metals, were handled by Analytical Environmental Testing, Inc., a commercial analytical laboratory located in Baton Rouge, LA. The heavy metals analysis was conducted by the LSU Wetlands Biogeochemistry Laboratory, the LSU Agricultural Chemistry Lab, or the Baton Rouge commercial laboratory, depending on which was less busy. All these laboratories followed the approved EPA methods for the analysis of priority pollutants.

The conventional parameters (BOD_5, COD, TSS, and TDS) were analyzed at the LSU Department of Civil and Environmental Engineering Water Quality Laboratory. All tests were run in triplicate. In addition, pH and temperature (Orion Model 250A) of the samples were recorded on site. The conventional parameters were analyzed according to the procedures stated in Standard Methods (Eaton et al., 1995). Sections 5210B and 5220D (Closed Reflux, Colorimetric Method) of Standard Methods were used to measure BOD_5 and COD, respectively. TSS and TDS were determined according to Sections 2540D and 2540C of Standard Methods, respectively.

RESULTS AND DISCUSSION

Overall stormwater runoff quality characteristics

The overall BOD_5, COD, and TSS values during the period from June to November 1996 ranged from 0 - 48.4 mg/L, 0 - 14,723.8 mg/L, and 6.7 - 20,077.8 mg/L, respectively. The amount rainfalls during this period ranged from 0.1 to 1.53 inches. The pH of the runoff samples was rather stable and neutral, ranging from 6.7 to 8.1. Tables 1, 2, 3 and 4 show that all priority pollutants, i.e., volatiles, acids, bases, neutrals, and pesticides, were found to be below the standard detection limits, except for methylene chloride, chromium, thallium and zinc. The concentration of Methylene chloride, a common solvent chemical, was 15.4 μg/L, just slightly above the 5.0 μg/L detection limit. The concentrations of other metals were also low enough not to cause serious environmental concerns.

Seasonal and time variations of runoff quality

Time series data for BOD_5, COD and TSS are shown in Figures 1, 2 and 3, respectively. Sample collection took place from June 20, 1996 to November 1, 1996, thus giving a sufficient number of samples from both the summer and fall seasons. Initially, we expected to observe the strength of pollutants dissipate during rainfall. The BOD_5 levels were rather constant throughout the rainfalls ranging from 0.1" to 1.53" except the 11/1/96 samples as shown in Figure 1. For the 11/1/96 data, we suspect that the standing water in contact with bark for a long period of time was not adequately flushed out before taking the first sample due to very small rain and flow. It also may explain the unusually high COD concentration of 14,724 mg/L COD and 52,316 mg/L TSS for the first samples (these data are not shown in Figures 2 and 3).

In Figure 1, the BOD_5 levels for the summer storm (7/10/96) ranged from 4.5 - 39.1 mg/L, while the levels for the fall storm (9/27/96) were essentially the same with values spanning from 7.7 - 30.7 mg/L. The summer CODs (7/10/96) were anywhere from 156.0 - 3022.7 mg/L, while the fall CODs (9/27/96) were 85.6 - 1777.8 mg/L (Figure 2). Obviously, these CODs were somewhat lower, but the question must be asked whether this was due to some other variable, such as the differing rainfall totals of 0.64" and 1.53". According to Figure 3, the concentrations of TSS ranged from 352.2 - 2861.7 mg/L for the summer storm (7/10/96) and from 260.0 - 3301.7 for the fall storm (9/27/96). Figures 1, 2 and 3 show that there were not any easily identifiable relationships among BOD_5, COD, and TSS with respect to seasons.

Table 1
Priority Pollutant Concentrations of the Stormwater Runoff Water Samples (EPA Method 625)

Compounds	Result (ug/L)	DL[*] (ug/L)	Compounds	Result (ug/L)	DL[*] (ug/L)
4-Chloro-3-Methylphenol	BD[@]	20.0	Chrysene	BD	10.0
2-Chlorophenol	BD	10.0	Dibenzo (A, H) Anthracene	BD	10.0
2, 4-Dichlorophenol	BD	10.0	Di-N-Butylphthalate	BD	10.0
2, 4-Dimethylphenol	BD	10.0	1, 2-Dichlorobenzene	BD	10.0
2, 4-Dinitrophenol	BD	50.0	1, 3-Dichlorobenzene	BD	10.0
2-Methyl-4, 6-Dinitrophenol	BD	50.0	1, 4-Dichlorobenzene	BD	10.0
2-Nitrophenol	BD	10.0	3, 3'-Dichlorobenzidine	BD	20.0
4-Nitrophenol	BD	50.0	Diethylphthalate	BD	10.0
Pentachlorophenol	BD	50.0	Dimethylphthalate	BD	10.0
Phenol	BD	10.0	2, 4-Dinitrotoluene	BD	10.0
2, 4, 6-Trichlorophenol	BD	10.0	2, 6-Dinitrotoluene	BD	10.0
Acenaphthene	BD	10.0	Di-N-Octylphthalate	BD	10.0
Acenapthylene	BD	10.0	Fluoranthene	BD	10.0
Anthracene	BD	10.0	Fluorene	BD	10.0
Benzidine	BD	10.0	Hexachlorobenzene	BD	10.0
Benzo (A) Anthracene	BD	10.0	Hexachlorocyclopentadiene	BD	10.0
Benzo (B) Fluoranthene	BD	10.0	Hexachloroethane	BD	10.0
Benzo (K) Fluoranthene	BD	10.0	Indeno (1, 2, 3-CD) Pyrene	BD	10.0
Benzo (A) Pyrene	BD	10.0	Isophorone	BD	10.0
Benzo (G, H, I) Perylene	BD	10.0	Napthalene	BD	10.0
Benzylbutylphthalate	BD	10.0	Nitrobenzene	BD	10.0
Bis (2-Chloroethyl) Ether	BD	10.0	N-Nitrosodimethylamine	BD	10.0
Bis (2-Chloroethoxy) Methane	BD	10.0	N-Nitrosodi-N-Propylamine	BD	10.0
Bis (2-Ethylhexyl) Phthalate	BD	10.0	N-Nitrosodiphenylamine	BD	10.0
Bis (2-Chloroisopropyl) Ether	BD	10.0	Phenanthrene	BD	10.0
4-Bromophenyl Phenyl Ether	BD	10.0	Phenol	BD	10.0
2-Chloronaphthalene	BD	10.0	Pyrene	BD	10.0
4-Chlorophenyl Phenyl Ether	BD	10.0	1, 2, 4-Trichlorobenzene	BD	10.0

[@] Below detection limit [*] Detection limit

Table 2
Priority Pollutant Concentrations of the Stormwater Runoff Water Samples (EPA Methods 608/625 Pesticides)

Compounds	Result (ug/L)	DL* (ug/L)
Aldrin	BD[@]	1.0
Alpha-BHC	BD	1.0
Beta-BHC	BD	1.0
Delta-BHC	BD	1.0
Gamma-BHC	BD	1.0
Chlordane	BD	1.0
4, 4'-DDD	BD	1.0
4, 4'-DDE	BD	1.0
4, 4'-DDT	BD	1.0
Dieldrin	BD	1.0
Endosulfan I	BD	1.0
Endosulfan II	BD	1.0
Endosulfan Sulfate	BD	1.0
Endrin	BD	1.0
Endrin Aldehyde	BD	1.0
Heptachlor	BD	1.0
Heptachlor Epoxide	BD	1.0
PCB-1016	BD	1.0
PCB-1221	BD	1.0
PCB-1232	BD	1.0
PCB-1242	BD	1.0
PCB-1248	BD	1.0
PCB-1254	BD	1.0
PCB-1260	BD	1.0
Toxaphene	BD	1.0

[@] Below detection limit

[*] Detection limit

Table 3
Priority Pollutant Concentrations of the Stormwater Runoff Water Samples (EPA Methods 624 Volatiles)

Compounds	Result (ug/L)	DL* (ug/L)
Benzene	BD[@]	5.0
Bromodichloromethane	BD	5.0
Bromoform	BD	5.0
Bromomethane	BD	10.0
Carbon Tetrachloride	BD	5.0
Chlorobenzene	BD	5.0
Chloroethane	BD	10.0
2-Chloroethylvinyl Ether	BD	50.0
Chloroform	BD	5.0
Chloromethane	BD	10.0
Dibromochloromethane	BD	5.0
Dichlorodifluoromethane	BD	5.0
1, 1-Dichloroethane	BD	5.0
1, 2-Dichloroethane	BD	5.0
1, 1-Dichlorethene	BD	5.0
trans-1, 2-Dichloroethene	BD	10.0
1, 2-Dichloropropene	BD	5.0
cis-1, 3-Dichloropropene	BD	5.0
trans-1, 3-Dichloropropene	BD	5.0
Ethylbenzene	BD	5.0
Methylene Chloride	15.4	5.0
1, 1, 2, 2-Tetrachloroethane	BD	5.0
Tetrachloroethene	BD	5.0
Toluene	BD	5.0
1, 1, 1-Trichloroethane	BD	5.0
1, 1, 2-Trichloroethane	BD	5.0
Trichloroethene	BD	5.0
Trichlorofluoromethane	BD	10.0
Vinyl Chloride	BD	10.0

[@] Below detection limit

[*] Detection limit

Table 4
Priority Pollutant Concentrations of the Stormwater Runoff Water Samples (Metals, Cyanide and Phenol)

Compounds	Result (ug/L)	DL[*] (ug/L)
Antimony	BD[@]	9.0
Arsenic	BD	23.0
Beryllium	BD	3.0
Cadmium	BD	3.0
Chromium	3.5	2.0
Copper	BD	2.0
Lead	BD	12.0
Mercury	BD	0.2
Nickel	BD	9.0
Selenium	BD	31.0
Silver	BD	3.0
Thallium	8	5.0
Zinc	23	4.0
Cyanide	BD	20.0
Phenol	BD	50.0

[@] Below detection limit [*] Detection limit

Relationship between rainfall totals and water quality

One other interesting point was observed for the stormwater data. The conventional parameter levels were not directly related to the rainfall totals. It was initially suspected that higher rainfall totals would cause higher conventional parameter levels. However, as can be seen in Figures 1, 2, and 3, the rainfall totals actually did not have a bearing on the levels of the BOD_5, COD, and the TSS parameters. For instance, in Figure 2, the 1.3" rain (6/20/96) produced the lowest COD levels, while a 0.21" rain (7/14/96) caused the next highest levels of COD. It might be hypothesized that lower rainfall totals produce higher COD levels, but the 0.64" rainfall, which produced the highest levels, rules out this possibility. This indicates that there are certainly other variables affecting the conventional parameter levels. Some of the variables may include: the size of yard, the number of stored logs, the amount of bark and wood debris present within the yard, the amount of vehicle traffic, the type of stormwater management plan in use, the rainfall intensity, the length of time between rains, the soil type within the yard, the percentage of the yard which is paved, and the wood species stored or processed in the yard.

Relationship between BOD_5 and COD

An approximate range of 0.01 to 0.13 was observed for the BOD/COD ratios for all points in time or sampling locations. This, in turn, indicates that only 1 - 13% of the COD is biodegradable, and the COD fractions from log yards consist primarily of non-biodegradable organic matter. These BOD_5/COD ratios demonstrate that BOD_5 is not a major concern in a log yard. Thus, the dissolved oxygen levels of streams and rivers to which this runoff empties should not be affected. The high CODs found in a log storage area should not affect the environment in a negative fashion either, since the chemicals which contribute to these COD totals are not toxic as seen in Tables 1, 2, 3 and 4, but rather are found naturally in bark and wood. There may be some question, however, about the potential chemicals in stormwater runoff from a log processing yard where the runoff has had an opportunity to pick up a portion of the mill water effluent.

Relationship between COD and TSS

After viewing the time series data (Figures 1, 2 and 3), a curious relationship between COD and TSS was found to exist. The same general trend was observed in both parameter curves; that is, when the COD goes up, so does the TSS, and when the COD goes down, so does the TSS as showing in Figure 4. This trend indicates that most of the COD inherent in the water is a result of the TSS content. Thus, to effectively control the COD, the TSS must first be controlled. This could more than likely be accomplished with sedimentation or filtration, processes which are known to reduce suspended solids.

CONCLUSIONS

We investigated the stormwater runoff quality from a log storage and handling facility in Louisiana. The BOD_5 levels were not significant compared to COD and TSS. Most priority pollutants were not found, and a few were detected only in trace amounts that will not cause any serious environmental concerns. The stormwater runoff quality varied little from summer to fall. The rainfall totals did not correlate to the pollutants' strength. Only about 1% to 13 % of COD was biodegradable. It appears that much of the COD resulted from TSS, which suggests that COD can be removed if TSS is controlled.

ACKNOWLEDGMENTS

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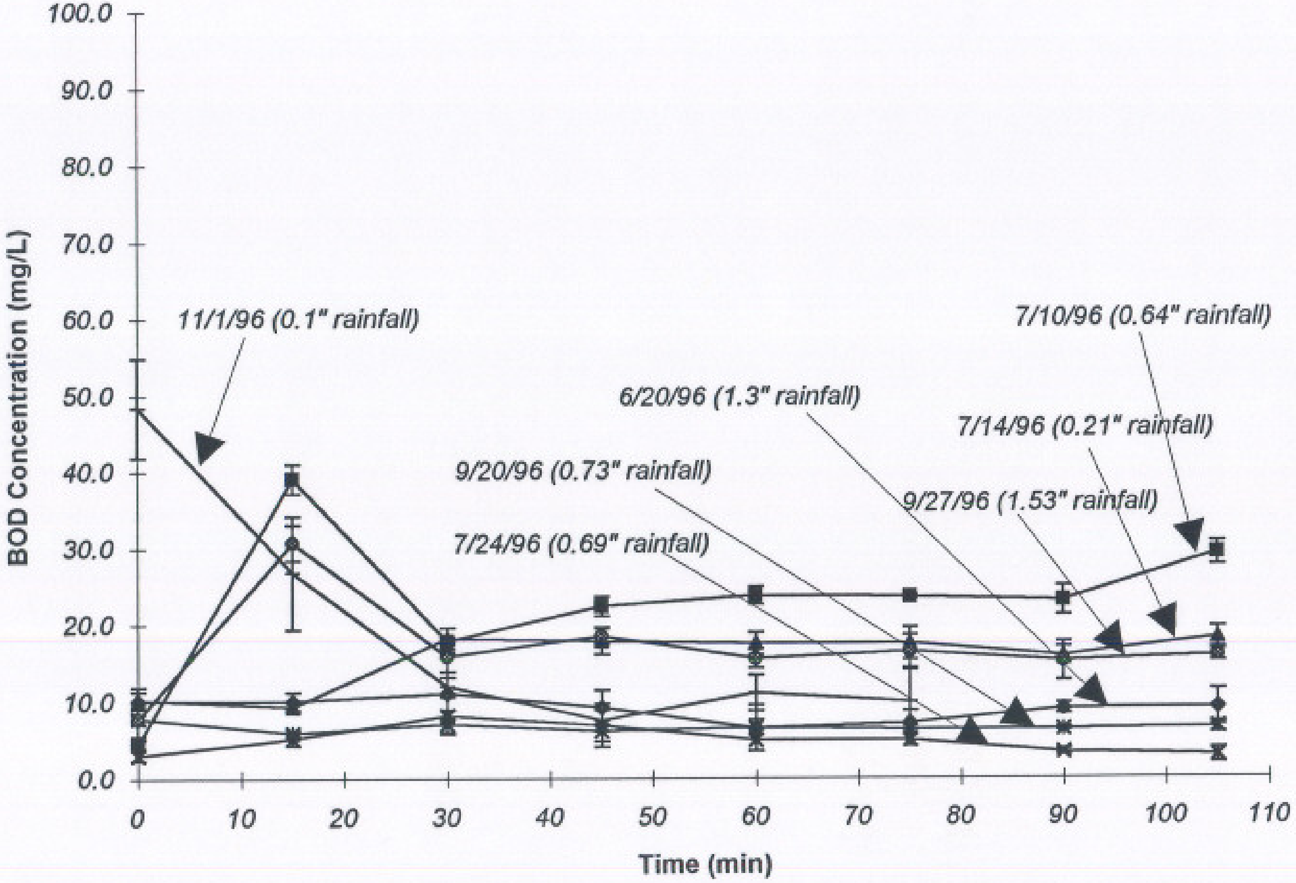

Figure 1- Stormwater Runoff BOD

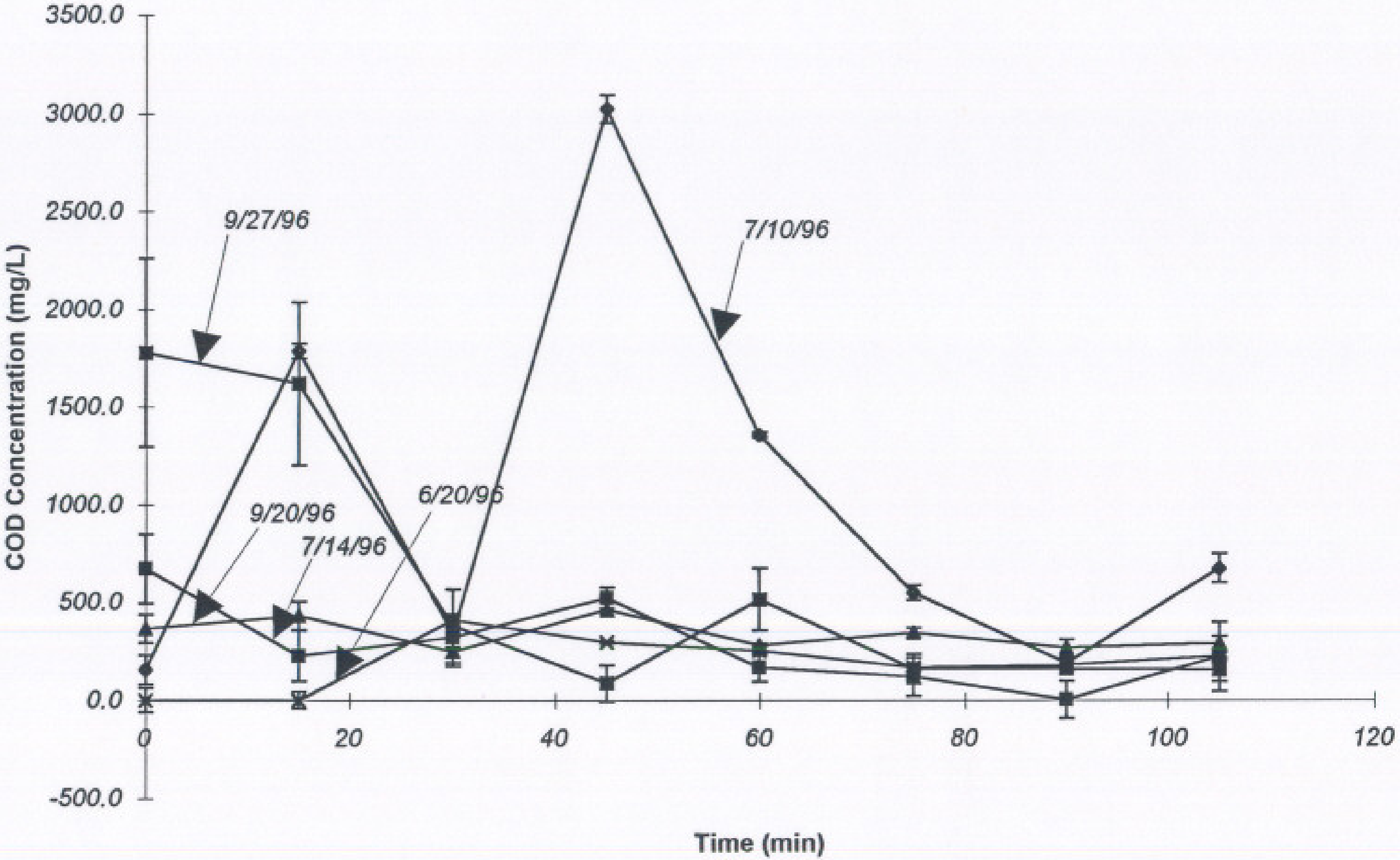

Figure 2 - Stormwater Runoff COD

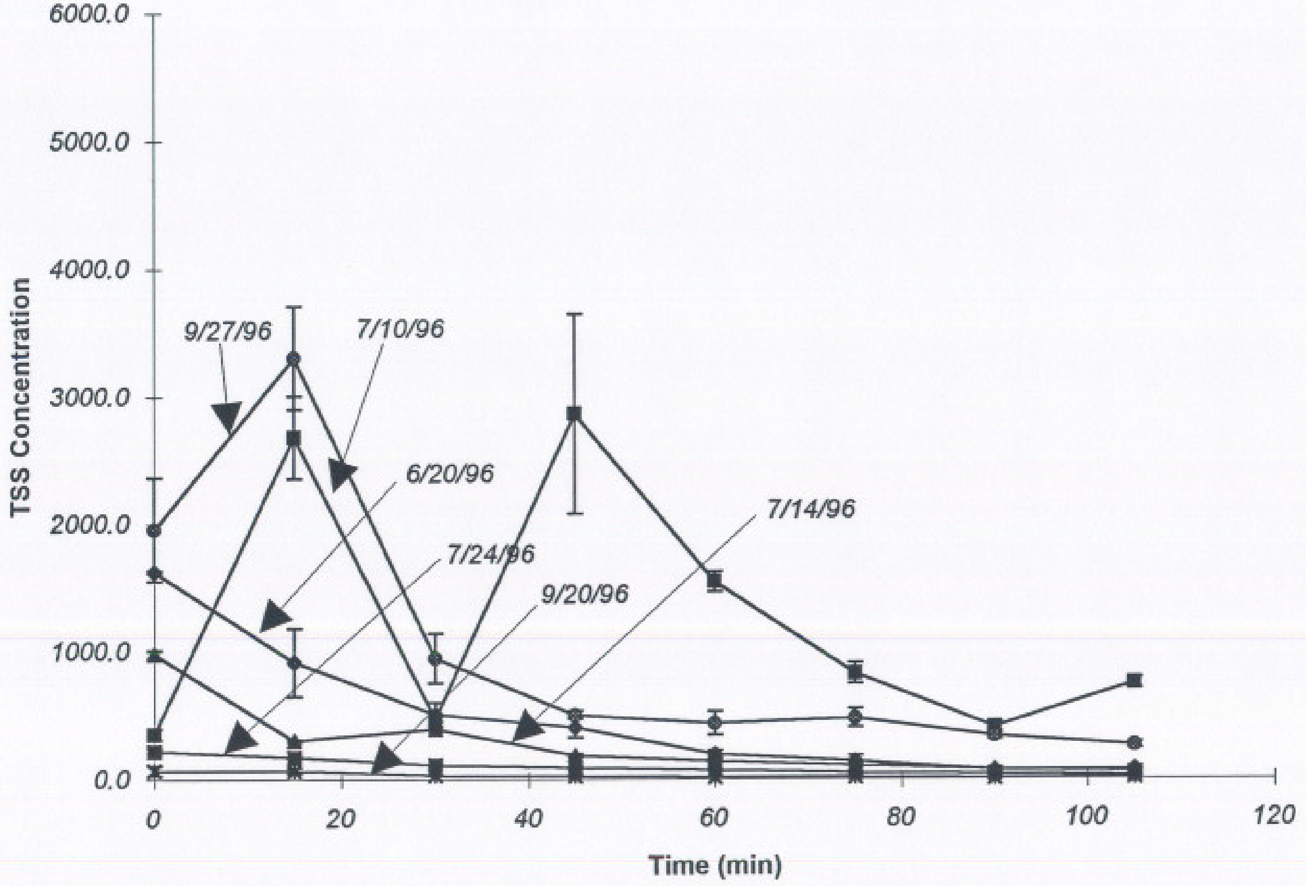

Figure 3 - Stormwater Runoff TSS

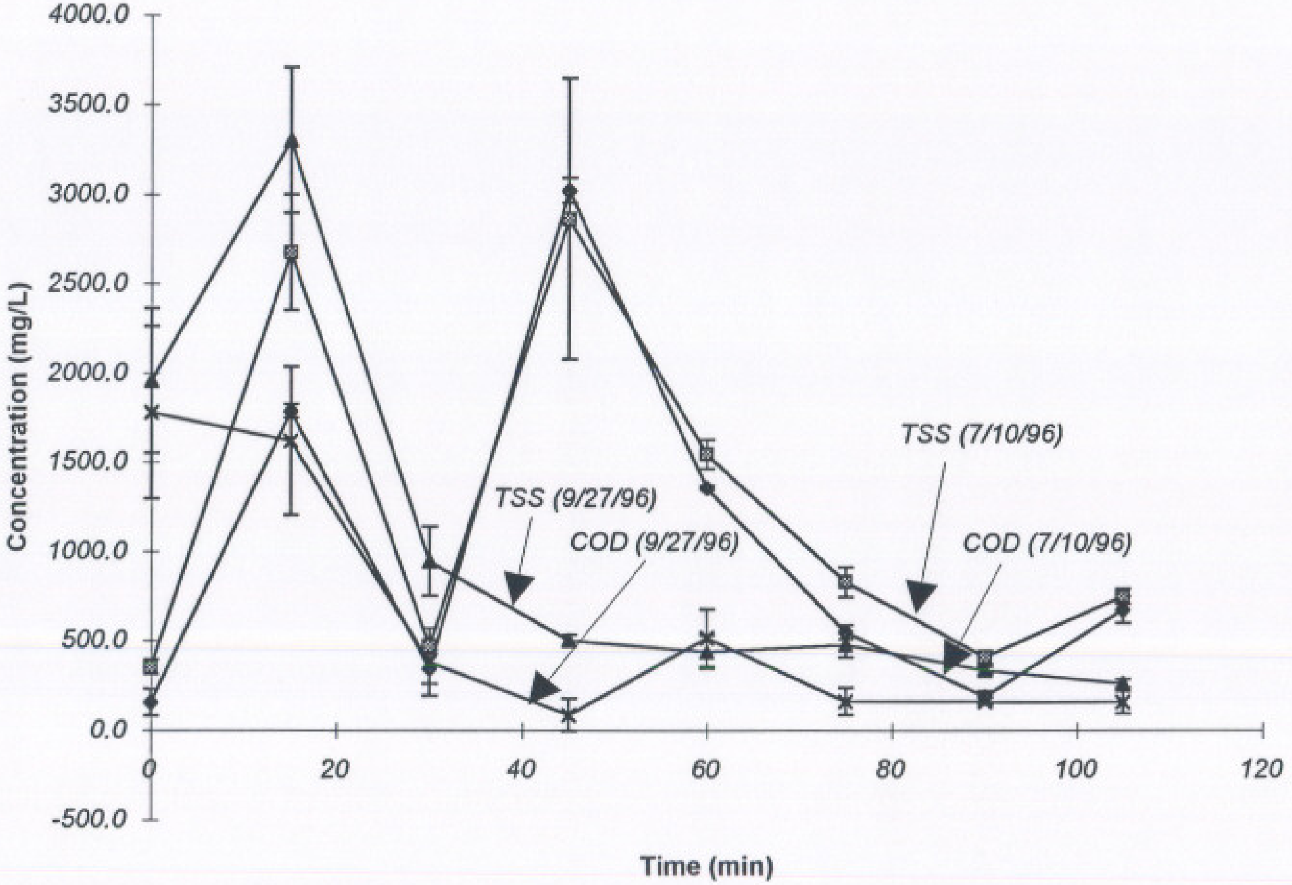

Figure 4 - COD and TSS Tend to Have a Close Relationship