Case Study on Race Horse Manure

Introduction

This section describes a case study of pollutant levels in water discharged from a horse race track. The case study provides a demonstration of water contamination that can result from direct discharge from animal operations concentrated in a relatively small area. The data show high concentration levels of pollutants in the water that would be associated with direct discharge of untreated manure. In particular, an enterococci and fecal coliform contamination rate were the highest among the pollutants. Furthermore, the concentration levels of pollutants can be elevated during the wet weather.

This section provides some background on the case study, descriptions of the data, descriptive statistics, and graphics that provide some insight into the data and conclusions.

Background

In 1990, New Jersey Department of Environmental Protection (NJDEP) discovered that two horse race tracks in New Jersey had been discharging horse wash down water into the waters of the State without a Pollutant Discharge Elimination System Permit authorizing the discharge. Particularly, one horse racetrack had approximately 30 barns housing approximately 20 horses each. The animals and their stalls were cleaned daily during the season, and the discharge from this activity went directly into the Cooper river and the sanitary sewer system. Upon discovering this situation, NJDEP issued the Administrative Consent Order that included the water quality monitoring program. The program required that the grabsamples be collected and anlalyzed monthly by a New Jersey certified laboratory.

Data

Between 1991 and 1997, water samples were collected monthly at various discharge points at the race track facility. During this period, the facility did not have any kind of treatment management plan. The reported data were the measurements of the following anaytes in the water samples:

Analytes	Explanation (unit)
DO	Dissolved Oxygen (mg/l)
BOD5	Biological Oxygen Demand-five days (mg/l)
COD	Chemical Oxygen Demand (mg/l)
ENTEROCOCCI	Enterococci (colony/100ml)
FECAL COLIFORM	Fecal Coliform (colony/100ml)
NH3-N	Ammonia Nitrogen (mg/l)
pH	pH (SU)
TSS	Total Suspended Solids (mg/l)

Whether the horses were at the track or not at the time of the measurement was also recorded as well as the weather condition.

The grabsamples were collected from various locations within the facility. Two of the locations discussed in this study are:

(1)A direct discharge point from the stable area (“001A”).

(2) A final discharge point from the racetrack into surface water (“004A”).

Discharge from 001A flows in the direction of 004A.

Summary

The following provides a summary of descriptive statistics and graphics that characterized the data.

C Descriptive statistics of the data including the number of data points (N), mean, minimum, maximum, and range are reported.

C In order to determine a progressive reduction in raw discharge from 001A in seven years, the annual mean values are reported.

C The characteristics of the horse manure and the bacterial pollutants from the horse manure were compared with other animal species.

C The water quality during the presence and the absence of horses at the track are compared using Wilcoxon Rank Sum Test. Similarly, the water quality during the wet and dry weather are compared. The absence or presence of animals on site and weather condition are suspected to be related to the increase the contamination levels of pollutants.

C The measured amounts of each substance are plotted in time series graphs in the appendix. The data points are plotted by the sample locations. Thus, the contamination levels from all samples are presented comprehensively comparing both locations .

Exploratory Data Analysis

From Table 1 we can see that the means from 004A are smaller than those from 001A, which indicates that the water samples from 004A were diluted. Also, enterococci and fecal coliform are critically high. The mean amount of toxic substance in Table 2 had decreased over the years as bacteria content remained high.

Table 1 Descriptive Statistics: Garden State Park Race Track Data

	Location:001A				
Analyte	N	Mean	Min	Max	Range
BOD5	53	39.74	2	180	178
COD	53	109.56	11	390	379
DO	53	4.85	1.3	9.4	8.1
Enterococci	53	166768.74	10	1000000	999990
Fecal Coliform	53	247457.17	50	1000000	999950
NH3	53	2.43	0.1	8.9	8.8
pH	53	6.89	6	8.9	2.9
TSS	53	70.38	4	580	576
Location:004A					
Analyte	N	Mean	Min	Max	Range
BOD5	65	6.30	2	36.3	34.3
COD	65	32.51	20	82.3	62.3
DO	65	6.83	2.8	10.2	7.4
Enterococci	65	14896.49	12	180000.00	179988
Fecal Coliform	65	53298.12	48	390000.00	389952
NH3	65	0.38	0.1	3.6	3.5
pH	65	7.10	6.5	7.9	1.4
TSS	65	23.03	4.0	260	256

Table 2 Sample Location 001A Annual Means

Year	BOD5	COD	DO	ENTER.	FECAL.	NH3	pH	TSS
1991	46.75	157.25	4.4	74275	773000	2.24	6.63	194
1992	92.22	206.78	3.69	308766.7	364555.6	3.46	6.64	77
1993	20.72	65	3.96	82802	240410	1.14	6.68	101
1994	48.8	105.86	3.49	215998.6	349708.6	2.88	6.9	61.57
1995	24.76	97.49	5.18	88450	295437.5	2.33	7.1	58
1996	88.6	100.11	6.04	28963.64	44491.82	3.19	7.03	52.55
1997	8.92	41.04	6.03	15182.56	26590	1.04	6.99	31.44

In order to examine the characteristics of pollutants from horse manure, Table 3 offers the comparisons to other animal species. Previously, the racetrack data showed high concentration level of enterococci, a subgroup of a total streptococcus. The mean number of colonies of total streptococci from horse manure in Table 3 is within the range of the means from layer and swine manure. On the other hand, the mean concentration level of fecal coliform in the horse manure is extremely low compared with the other animal species as shown in Table 3, although the concentration level from the racetrack data was critically high. This suggests quite a magnitude of fecal coliform concentration level in the manure of other animal species.

Table 3 Fresh Manure Production and Characteristics per 1000 lb live animal mass per day

Parameter	Unit	Statistics	Dairy	Beef	Swine	Horse	Layer	Broiler
Total Manure	lb	Mean	86	58	84	51	64	85
		Std	17	17	24	7.2	19	13
Density	lb/ft^3	Mean	62	63	62	63	60	63
		Std	4.0	4.7	1.5	5.8	2	2.4
Total Solids	lb	Mean	12	8.5	11	15	16	22
		Std	2.7	2.6	6.3	4.4	4.3	1.4
BOD	lb	Mean	1.6	1.6	3.1	1.7	3.3	*
		Std	0.48	0.75	0.72	0.23	0.91	*
Total Streptococcus	colonies†	Mean	42	14	240	26	7.4	*
		Std	63	21	130	27	3.3	*
Fecal Coliform	colonies†	Mean	7.2	13	8.0	0.042	3.4	*
		Std	13	12	5.4	0.013	0.91	*

*Data not found.

† Mean bacteria colonies per 1,000 lb animal mass multiplied by 10^{10}.

Source: ASAE Standards.

The graphs in the Appendix are the amounts of analytes in the samples plotted in chronological sequence. They show the decrease in variation since critically high levels of concentration diminish gradually over time. Also, the concentration levels seen in these plots provide visual illustration of the results from the descriptive statistics. The concentration levels from 004A are not as critical as 001A, which is reasonable since 004A is downstream of 001A.

The Comparison Between the Two Populations

In order to determine the impact of the animals on site and the weather condition, Wilcoxon Rank Sum Tests were performed. Wilcoxon Rank Sum Test is a nonparametric technique that compares the probability distributions of two populations. In this analysis, the two pairs of populations of interest are the following: the measurements made in the presence of animals vs. the absence of horses, and the measurements made under the wet weather vs. dry weather. The comparisons between the presence and the absence of horses at the time of measurement were made strictly during the dry weather in order to eliminate the variation caused by the weather conditions. Similarly, the comparisons of the wet verses dry weather condition were made only in the presence of horses.

Table 5 shows the z-statistics from the tests. The negative sign of z-statistics indicates that the probability distribution of population A is located on the left side of that of population B. Based on the samples from the location 001A, it appears that the presence of horses at the track is associated with amounts of TSS that larger than those associated with the absence of horses. An unexpected result from 004A was that there was significant evidence that the probability distribution of fecal coliform in the absence of horses was shifted to the right of the distribution in the presence of horses. In other words, the amounts of fecal coliform measured in the absence of horses tend to be larger than those measured when horses were present. This result might be contributed to the manure management practice at the facility where the stalls might have been cleaned when the horses were removed. Consequently, the old manure might have been washed into the sampling path.

The probability distributions of some analytes under the wet weather condition were significantly different from the distributions under the dry weather condition. For COD, enterococci, and TSS from 001A, the probability distributions under the wet weather condition were significantly shifted to the right of the distributions under the dry weather condition. From 004A, COD, enterococci, and TSS showed the same results. Additionally, the probability

distribution of DO under the dry weather condition was significantly shifted to the right of the distribution under the wet weather condition.

Table 5. Wilcoxon Rank Sum Z-Test Statistics (P-Value).

	Pop. A : The absence of horses Pop. B : The presence of horses		Pop. A : Wet weather Pop. B : Dry weather	
Analyte	001A	004A	001A	004A
BOD5	-1.72623(0.0843)	-0.372516(0.7095)	1.01714(0.3091)	1.89068(0.0587)
COD	-1.33821(0.1808)	0.528927(0.5969)	2.1294(0.0332)*	2.09164(0.0365)*
DO	1.47615(0.1399)	-1.35889(0.1742)	-0.62851(0.5466)	-2.28191(0.0225)*
Enterococci	-0.487206(0.6261)	1.147080.2513)	2.3349(0.0195)*	2.52844(0.0115)*
Fecal Coliform	0.250857(0.8019)	2.56926(0.0102)*	1.8917(0.0585)	1.95096(0.0511)
NH3	-0.697169(0.4857)	-0.508283(0.6113)	0.131924(0.8950)	1.53911(0.1238)
PH	0.910922(0.3623)	0.074012(0.9410)	-0.856435(0.3918)	-0.644382(0.5193)
TSS	-2.46462(0.0137)*	0.832832(0.4049)	2.88175(0.0040)*	2.78355(0.0054)*

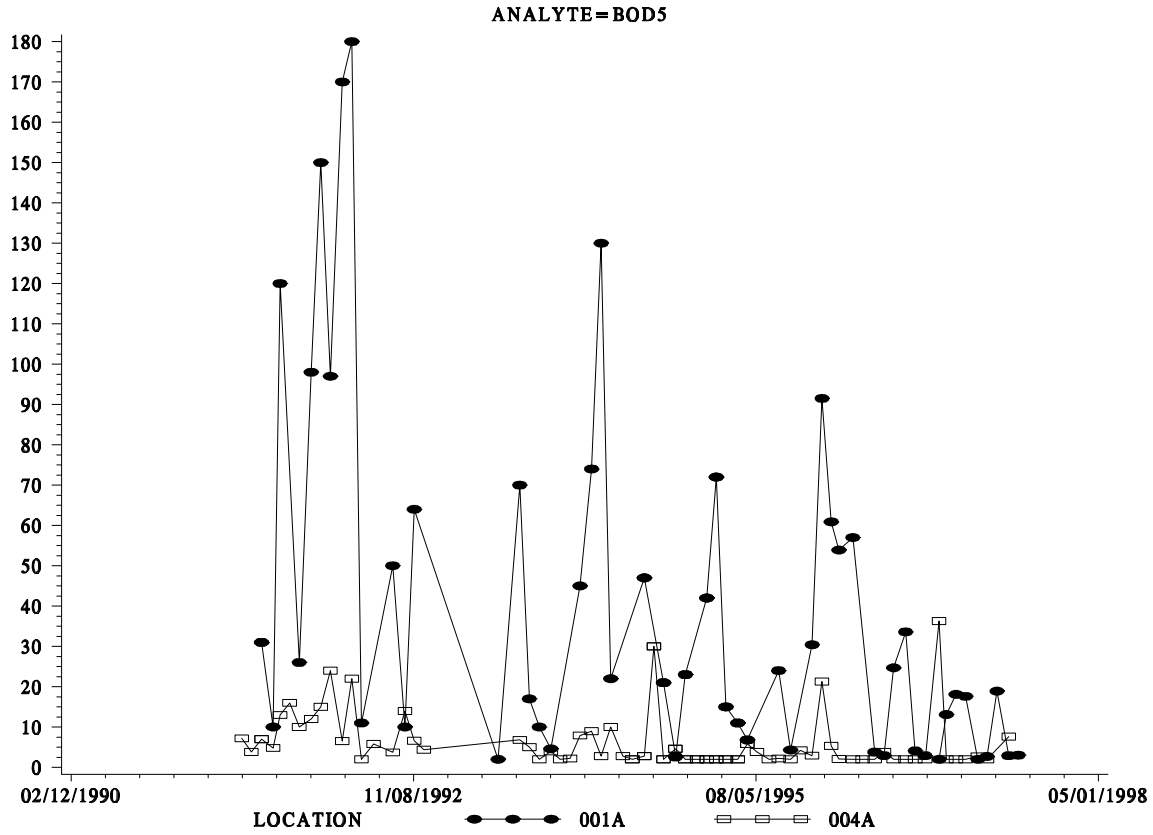
*a significant statistic
Note: The tests are the two-tailed tests at the significance level 5%.

Conclusions

The data showed the high concentration levels of pollutants in the water as a result of direct discharge of raw horse manure. Particularly, bacterial contamination levels shown by enterococci and fecal coliform were especially high. The graphical displays of the data also provide visual illustration of the excessive amounts of contaminants present in the samples. Also, in the event of precipitation, the concentration levels increased significantly. This case study provides an example of water contamination can result from the discharge of untreated animal manure.

Appendix

Time Series Graphs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11/08/1992
08/05/1995
05/01/1998
LOCATION
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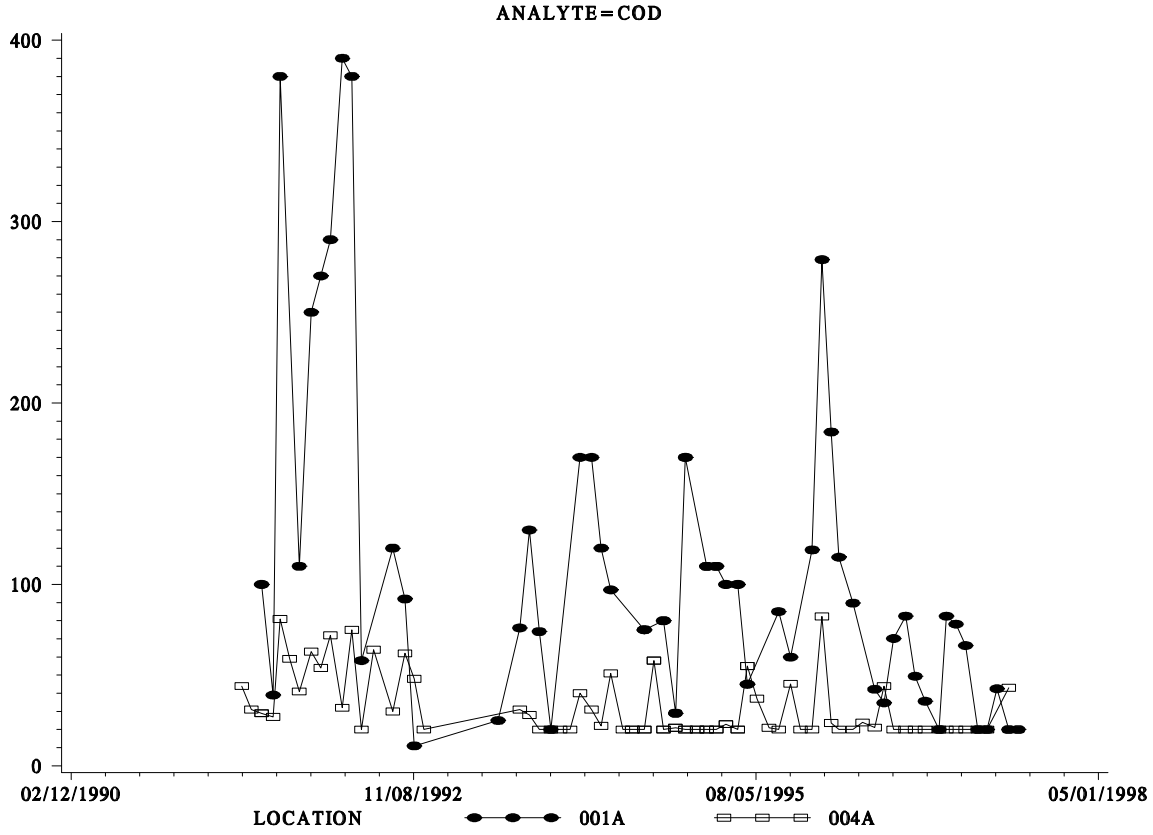
004A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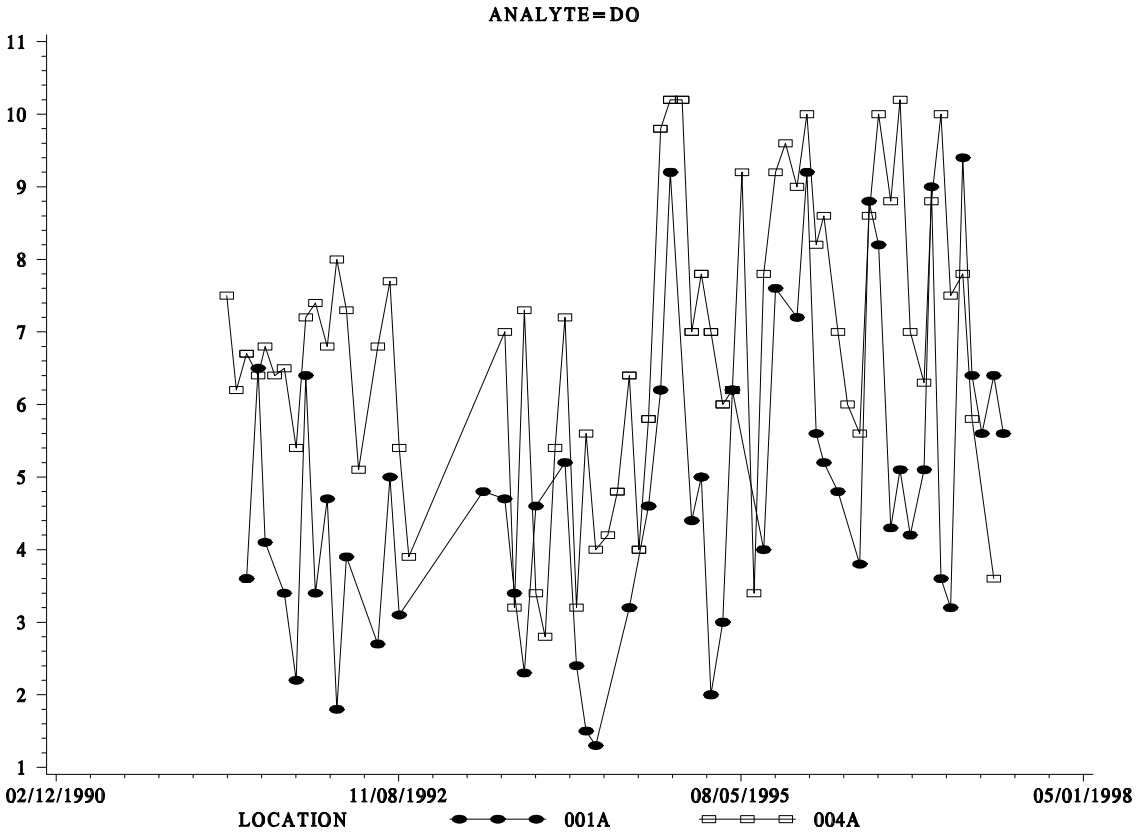
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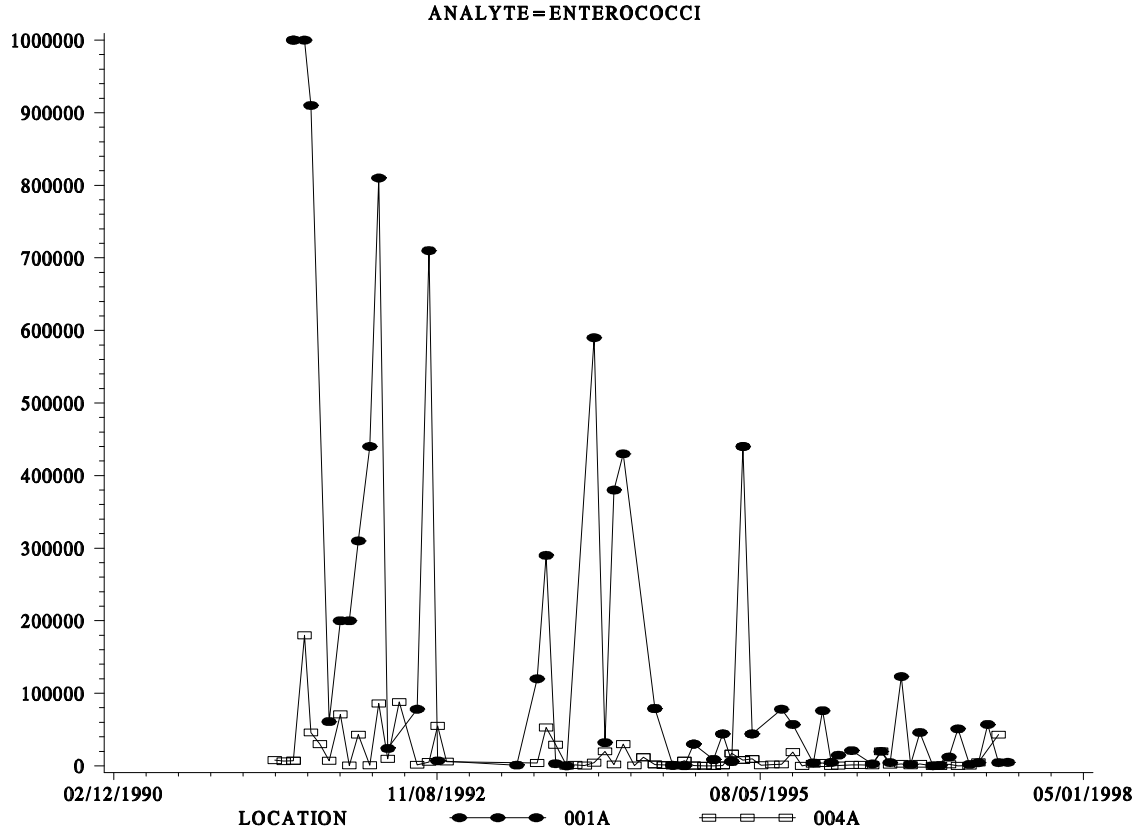
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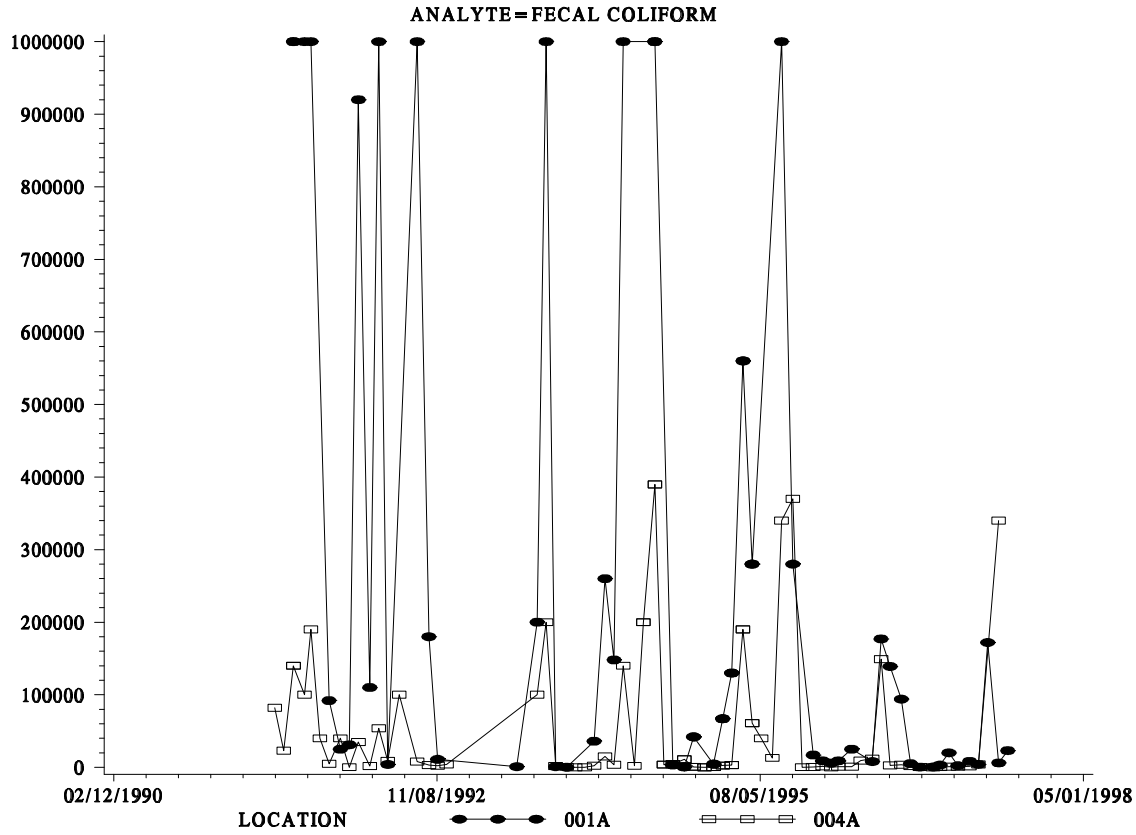
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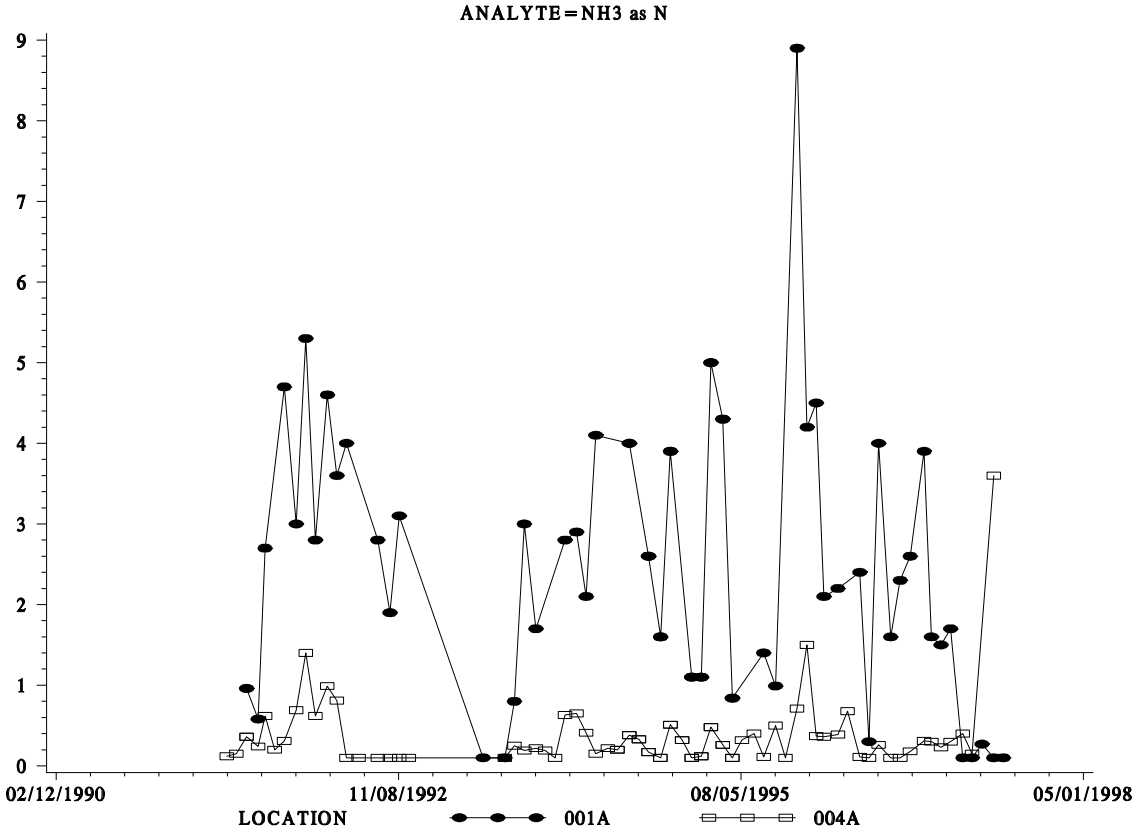
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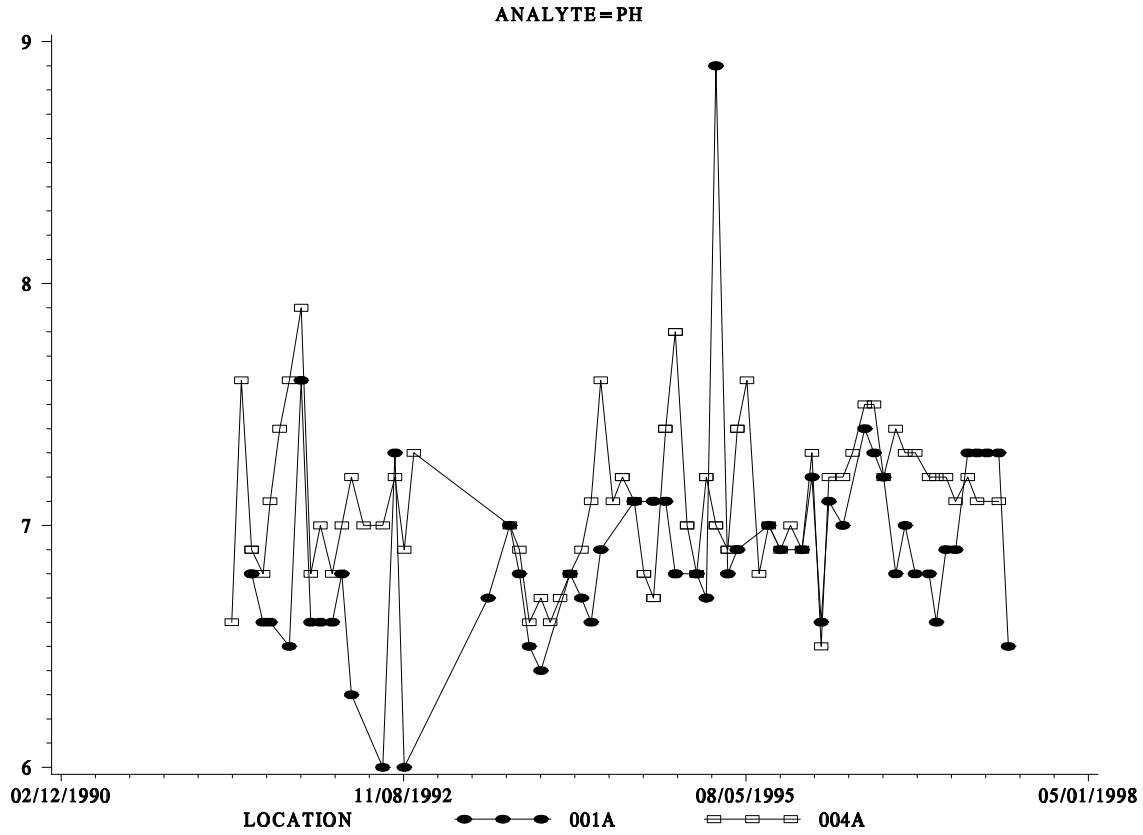
004A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001A
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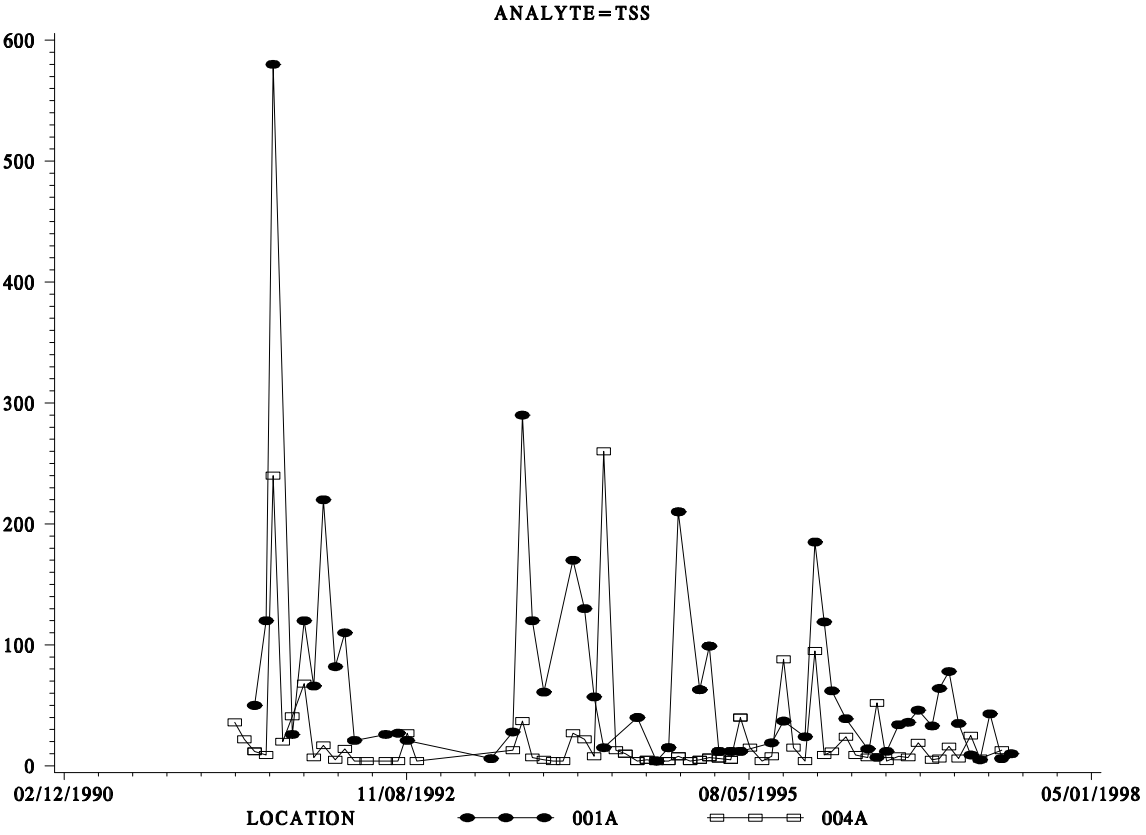
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001A
004A