Relationship between Bacteria, Nutrients and Rainfall in Selected Bodies of Fresh Water

by DAVID D. WOODBRIDGE and WILLIAM R. GARRETT
University Center for Pollution Research
Florida Institute of Technology
Melbourne, Florida

The problem of the pollution of small man-made lakes is becoming increasingly more evident by the number of no swimming, boating, or fishing signs posted around them. These lakes vary in size usually ranging from 2 to 5 acres. Many small lakes are created by excavating fill dirt during the development of land for housing projects, highways, recreational parks and other projects.

The excavations are allowed to fill with water, the banks are then landscaped, and the lake is stocked with different varieties of fish. The lake is then ready to be used for swimming, boating, fishing and other recreational activities.

The small lakes also serve as a catchment basin for run-off water from the surrounding land area. Many of these lakes are located in surburban areas without any sewage systems, thus relying on septic tanks as a means of sewage disposal. During heavy rainfall, bacteria laden effluent from the septic tanks is washed into the lakes, along with large quantities of nutrients in the form of fertilizer from lawns. In many of the lakes there is no provision for drainage away from the lake by streams or canals, therefore, the lakes act as an accumulation point for bacteriological pollutants, chemical

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pollutants, and nutrient material.

The St. Johns river, a natural drainage for a large water shed, was selected as a control for this study. The river, up stream from the sample site, is in a wild state, boardered on either side by large marsh areas. There are no inhabited areas along this stretch of the river. Approximately 5 miles down stream from the sampling site the river flows into lake Washington, from which several municipalities draw their raw water. The St. Johns River, for this study, was designated as sampling site #1.

The selection of two small lakes for this study was based upon the conditions existing in the adjacent land areas. A small lake located in a wooded area, about ¼ mile distant from the nearest dwelling, was selected and designated as sample site #II. The second lake is encompassed on two sides by a housing development and by business establishments on the other two. There are canals that flow through the housing development into the lake. This lake was designated as sample site #III.

Data Acquisition and Methods of Analyzing

Samples were taken at each site one day per week at approximately the same time each sample day for a period of 24 weeks, resulting in 24 bacteriological samples and 24 chemical samples for each sample site. The water temperature was taken at the time of each sampling. An average of the rainfall for the six day period preceeding each sample day was calculated.

All sampling and methods of analyses of samples were performed using standard methods as adapted for the Hach model DR-colorimeter and reagents by Hach Chemical Co. Ames Iowa. The analyses performed and the methods used are as listed.

1. Dissolved Oxygen - The method for analysis of dissolved oxygen is a titrametric procedure employing the standard Wrinkler method with the Alsterberg modification. The Alsterberg modification substitutes the stable reagent phenylarsene oxide for the titration of iodine in the standard Wrinkler method, in place of unstable Sodium thiosulfate reagent.
2. Nitrate nitrogen - The method for analysis of nitrate nitrogen is a colorimetric procedure using the cadmium reduction method with 1-napthylamine-sulfanific acid.
3. Ortho Phosphate - The analysis for phosphate is a colorimetric procedure using the molydate mehtod with stannous reduction.
4. Bacteriological analysis - These analyses were performed using the millipore filters technique. A sterile membrane is placed in a sterile millipore filter holder and the bacteria are collected by passing the water sample through membrane with the aid of a partial vacuum. The membrane and the side of the funnel are rinsed with a small volume of sterile distilled water. The membrane is removed aseptically and placed on an absorbent disk previously saturated with culture medium and contained in sterile petri dish. The incubation time and temperature are specified for the organism to be grown and medium used. The medium used was MF-endo broth. On this medium, cell organisms that produce dark (purplishgreen) colonies with a metallic

sheen in 20± 2 hours at 35°C are classified as members of the coliform group.

Results

Figure 1 shows the variation of temperature of each of the three bodies of water, from which samples were obtained, as a function of time. The normal seasonal trend of the water temperature is very evident from figure 1 with a minimum temperature in January of about 14°C and a maximum near 30°C in June.

Figure 2 shows the six days accumulation of rainfall prior to the day to taking sample. Two periods of rainfall are of significance. These periods are the last half of February and from the middle of April through the first part of June. Between the period of considerable rainfall were periods of dryness. Both chemical and bacteriological pollution conditions can be corralated with the periods of extensive rain.

Figure 3 shows the occurance of phosphate in each of the bodies of water as a function of time. There appears a fairly excellant correlation of phosphate with rainfall except for one peak in the latter part of January. The six days of rainfall before the February 20 data acquisition resulted in a small increase in phosphate at all three stations and the continued rain throughout the latter period of February and the first of March provided varying amounts of phosphate being washed into the St. Johns river, and the lakes. During the summer of 1968, with the onset fairly heavy, rains in the middle of April a marked increase in phosphate occured both in the St. Johns River and in lake #II. Both of these bodies of water received run-off water from an uninhabited area. Lake #III near a large number of homes and businesses did not show the increase in phosphate until several weeks after the onset of the summer rains.

Figure 4 showing nitrate-nitrogen content of each of the bodies of water during the first half of 1968. Direct correlation of the nitrate-nitrogen content of the water is very difficult to relate directly to rainfall. However, the peak of rainfall just before the February 20 date acquistion shows a small increase in nitrogen in each of the bodies of water. The large increase in nitrate-nitrogen that occured on the 9th of April cannot be accounted for by an increase in rainfall. Occurance of the relatively high peak amount of nitrate-nitrogen in lake #II is indicative of the conditions that existed in the area before the lake was formed.

Figure 5 shows the total coliform as measured in bacteria per hundred mililiters of water in each of the 3 bodies of water in which samples were acquired. A surprising correlation appears between the total coliform count and the nitrate-nitrogen, in lake #III except for a few isolated points. In general, the correlation between total coliform and nitrate-nitrogen is much greater than the generally accepted relationship between total rainfall and coliform in bodies of water.

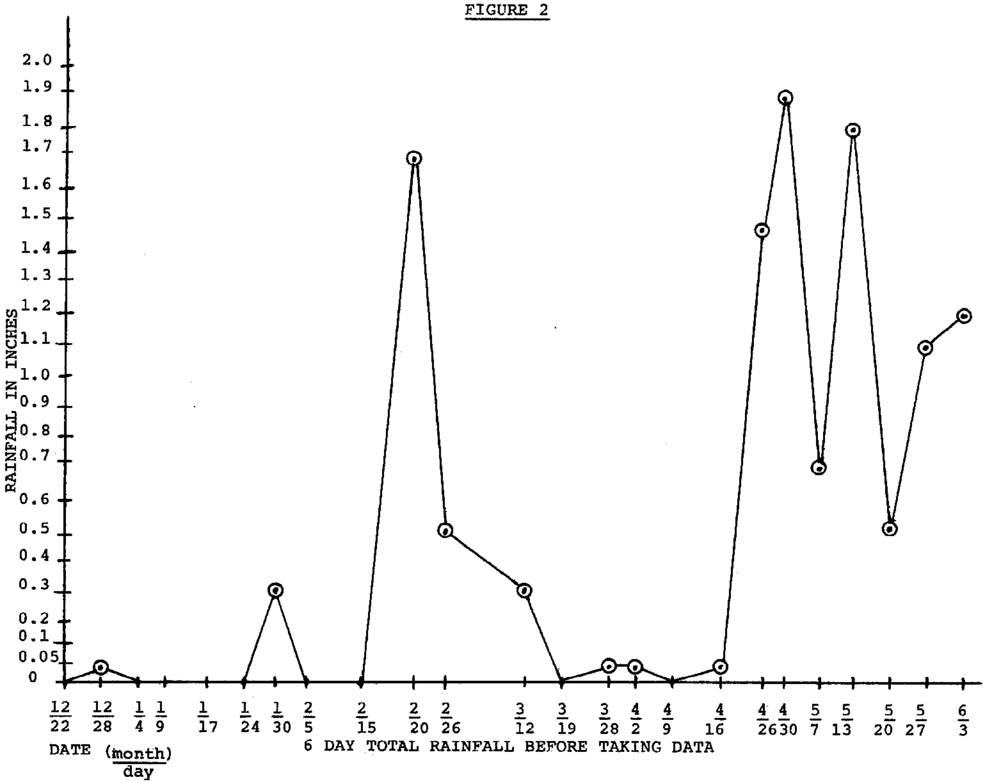
The peaks in coliform, in the St. Johns River, also follow increases in the phosphate in the river. However, the total coliform count in the remote lake #II does not correlate with the occurance of either phosphate or nitrate in the lake. However, the increase in coliform that occured at all stations in April follow the increase in both phosphate and nitrate in these water.

Discussion

Results of the study indicates that the relationship between dissolved nutrients such as phosphate and nitrate and the indicator bacteria (total coliform) are not simple or direct. Under particular conditions in specific bodies of water a direct relationship may be shown. However, the variability in the data with time and in different bodies of water raises doubts as to the direct relationship between chemical and bacterial pollutants.

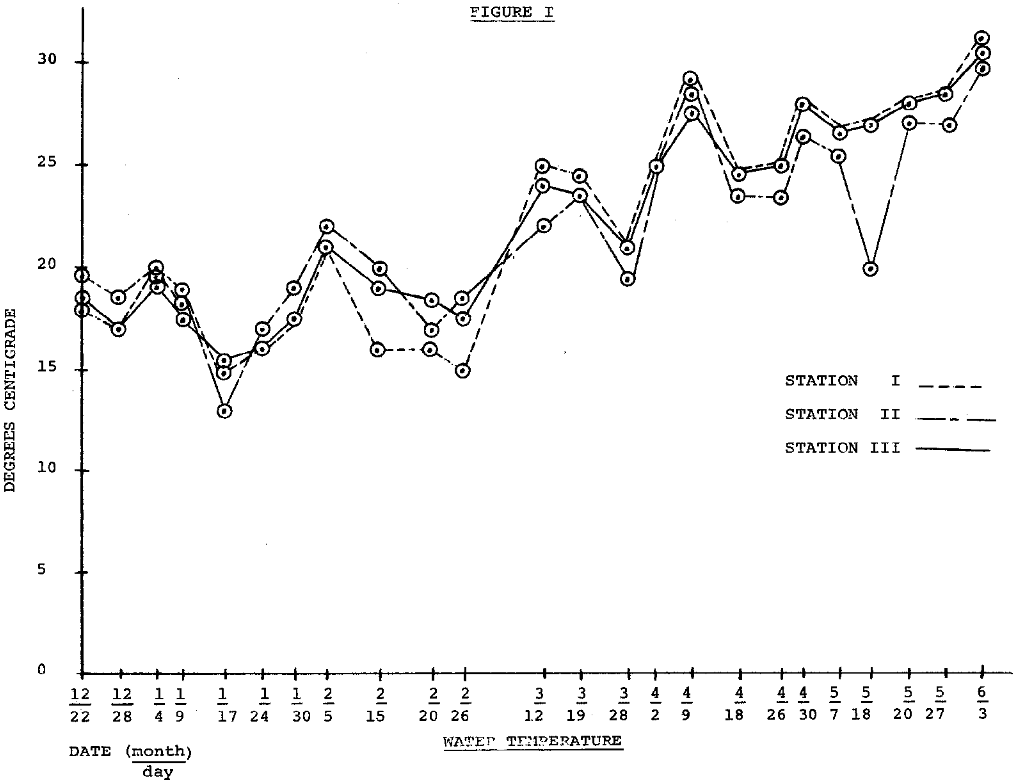
Sharpe increases in total coliform occured in both of the lakes that were not related to rainfall in the area. In the St. Johns River the total coliform correlate much closer to the rainfall. Even in the river several sharpe increases in total coliform count occured that were not obviously related to an increase in rainfall.

FIGURE 2



6 DAY TOTAL RAINFALL BEFORE TAKING DATA

FIGURE I



WATER TEMPERATURE

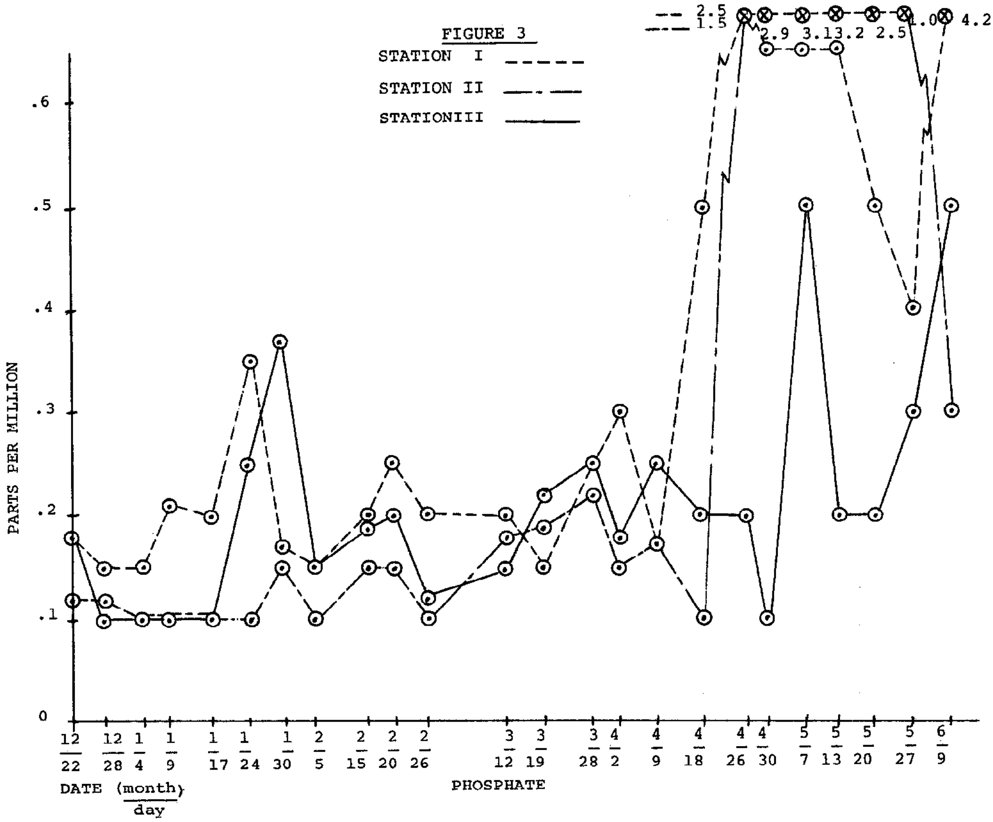


FIGURE 3
STATION I
STATION II
STATIONIII
2.5
1.5
2.9
3.1
3.2
2.5
1.0
4.2
PARTS PER MILLION
.6
.5
.4
.3
.2
.1
0
DATE (month/day)
PHOSPHATE

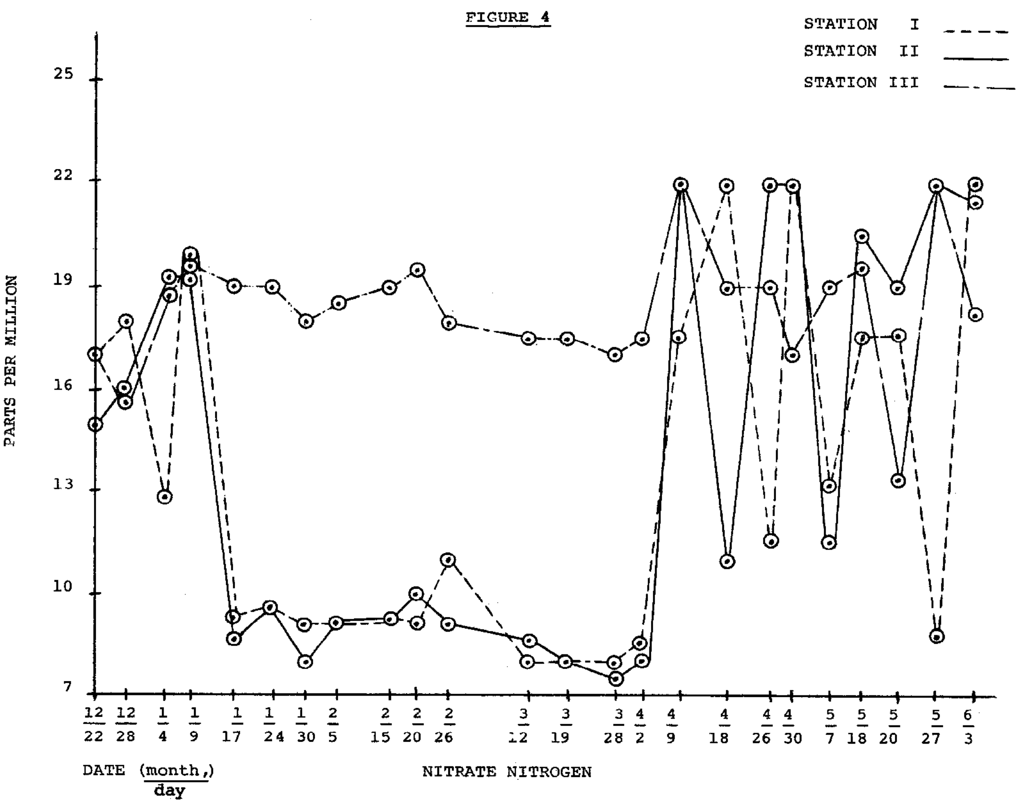


FIGURE 4
STATION I
STATION II
STATION III
PARTS PER MILLION
25
22
19
16
13
10
7
DATE (month,/day)
NITRATE NITROGEN

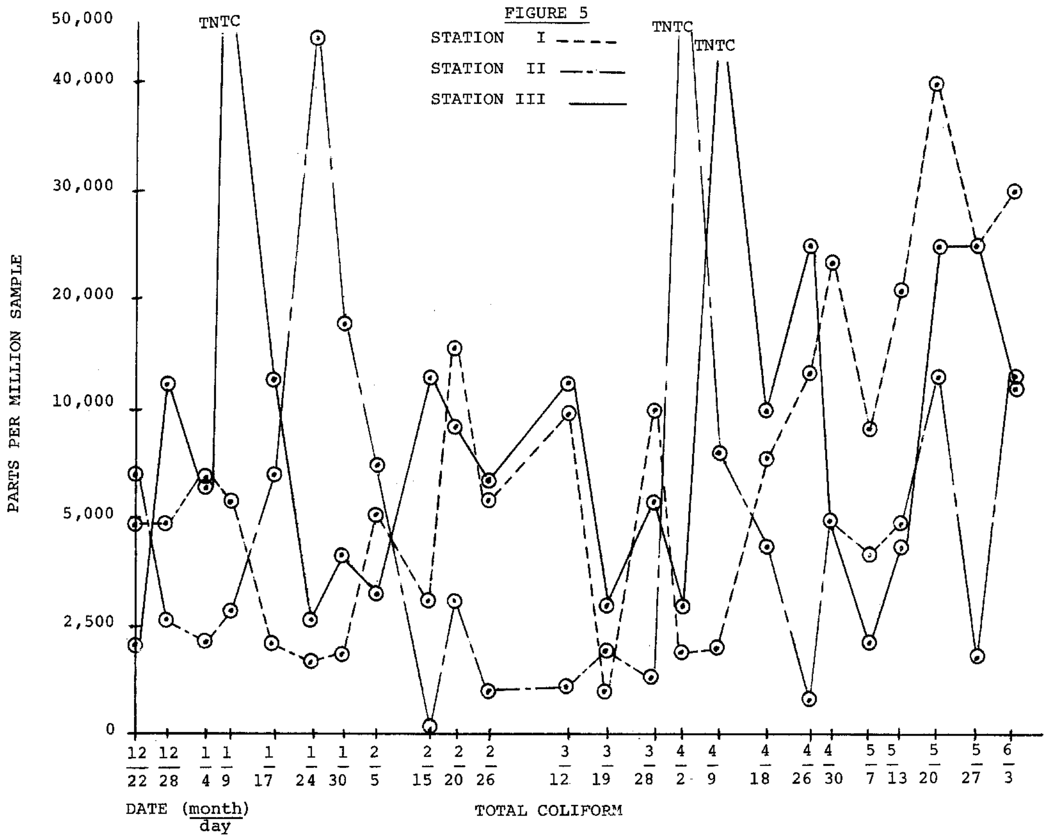


FIGURE 5
STATION I
STATION II
STATION III
TNTC
TNTC
TNTC
50,000
40,000
30,000
20,000
10,000
5,000
2,500
0
PARTS PER MILLION SAMPLE
12/22 12/28 1/4 1/9 1/17 1/24 1/30 2/5 2/15 2/20 2/26 3/12 3/19 3/28 4/2 4/9 4/18 4/26 4/30 5/7 5/13 5/20 5/27 6/3
DATE (month/day)
TOTAL COLIFORM