Interrelationship of Pollution Indicators in Streams Flowing into the Indian River

by D. D. WOODBRIDGE and W. R. GARRETT
University Center for Pollution Research of Florida Institute of Technology

As vital as the problem of pollution is to mankind, there are still many facets of the interrelationships of various aspects of pollution that are only guessed at on a gross scale. Thus, the purpose of the described research program was to investigate the time dependent relationship between nitrate and phosphate concentrations, bacterial pollution and rainfall. Data was collected and analyzed by different groups of high school teachers during the summer of 1967, 1968, and 1969 under the sponsorship of the Cooperative College-School Science Program, of the NSF. The results herein presented are only indicators of concentrations that have been found in all of the primary freshwater tributaries of the Indian River estuary and its principal subestuary, the Banana River.

Measurement Program

Initial samples were obtained from Crane Creek only; however, as the program expanded the Banana River estuary was also investigated. These waterways are located in east-central Florida near Cape Kennedy, and are tributaries of the Indian River estuary which accounts for a major portion of fresh water flow into the Indian River north of the Sebastian Inlet.

Physical, chemical, and biological data were obtained from several measurement sites on each of the waterways. Individual rain gauges were placed at each measurement location so that accumulated rainfall data could be determined. Water temperature, rate of flow, and depth were recorded at each time water samples were obtained. Air temperature, wind velocity and wind direction were also recorded. Water samples were obtained in a cleaned and autoclaved glass bottle for bacteriological analysis, and in cleaned plastic bottles for chemical analysis.

Bulletin of Environmental Contamination & Toxicology,
Vol. 6, No. 4, 1971, published by Springer-Verlag New York Inc.

Data acquisition locations were chosen at the mouth of each waterway and at upstream positions. In the Banana River two data acquisition sites were located on opposite sides of the river, approximately one-quarter mile up the river from where it becomes an integral part of the Indian River estuary.

Nearly all the samples were taken during the month of July. In 1967 and 1968 daily water samples were acquired. During 1969, samples were taken only twice a week.

Data Analysis

Analytical methods were developed that could be utilized by the teachers in their high school classrooms. Results were required to possess scientific value, and not just to be used as classroom demonstrations. All analyses were performed according to standard methods (1).

Coliform bacteria were used as one indicator of pollution as they are accepted almost universally as the indicator organism (2). The coliform group includes all the aerobic and facultatively anaerobic, gram-negative, non-sporulating bacilli that produce acid and gas from the fermentation of lactose. The Millipore Filter Technique was utilized to analyze the water samples for coliform bacteria (1). Sample dilutions of 1/10, 1/100, 1/1000, 1/10,000, and 1/100,000 were used.

Nitrate and phosphate indicators of pollution were analyzed utilizing the Hach Direct Reading Engineer's Laboratory equipment. (This equipment was used as a training device as it was made available to the teachers for their training in the high schools by the National Science Foundation.) The Cadmium Reduction Method with 1-Naphthylamine - Sulfanilic Acid was used for nitrate determination and the Molybdate Method with stannous reduction was used for phosphate determination (3).

Program Results

Data from three summers of measurement programs show a complex relationship between nutrients, bacteria, and rainfall in the tributaries of the Indian River. At times, nearly an inverse relationship exists between the phosphate and nitrate concentration in the streams, while at other periods a direct relationship occurs. An interesting example

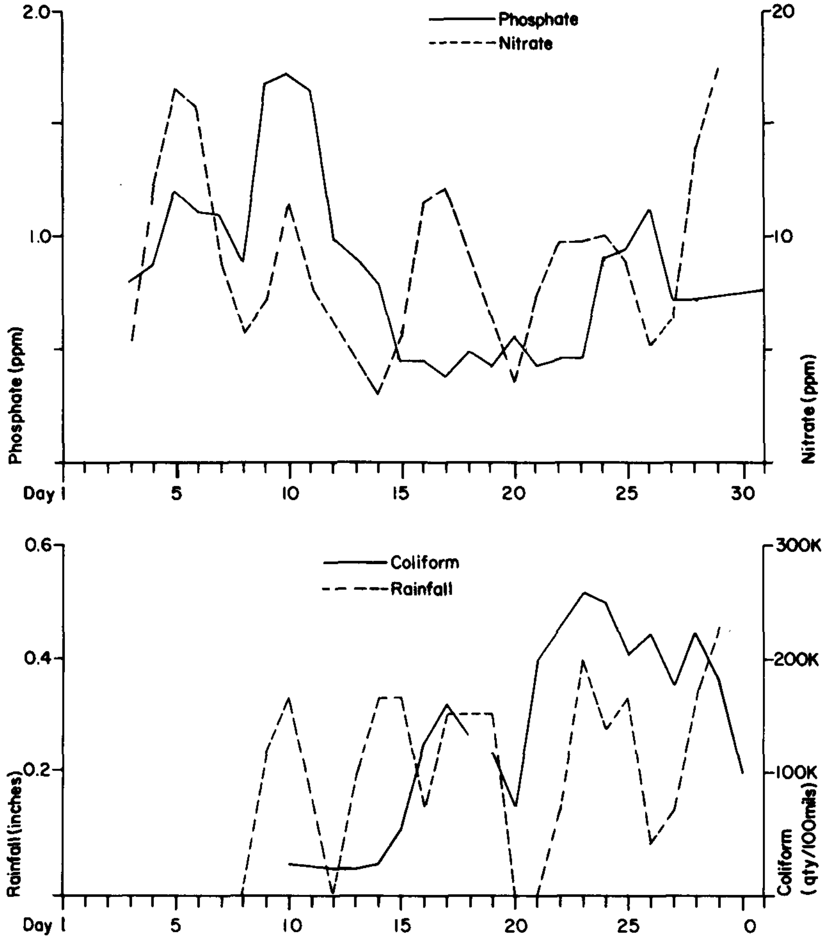

Figure I
Relationship of Pollution Indicators in
Crane Creek for July 1967

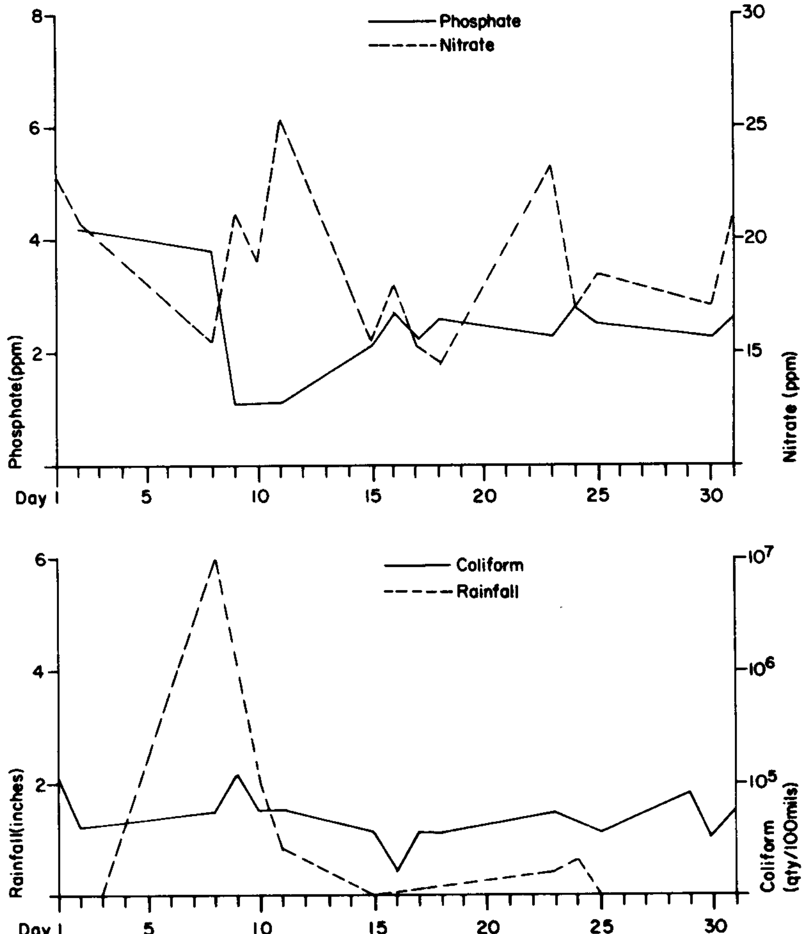

Figure 2
Relationship of Pollution Indicators in
Crane Creek for July 1968

of this complex relationship is shown in Figure 1, which shows the time variation of nitrate, phosphate and rainfall for July, 1967 in Crane Creek. At the beginning of July a dry period of several weeks had existed and the nitrate-phosphate relationship appears to be in phase. The first rain on the 9th and 10th of July coincided with an increase in both phosphate and nitrate. With continuing rains the nitrate-phosphate relationship reverted to an inverse correlation. Similar effects were noted at the other measurement sites.

The total coliform count in the stream did not show a marked increase until 1.45 inches of rain had fallen in the previous week. The lower part of Figure 1, shows the total coliform count for each day of the month of July, 1967 for Crane Creek. The cessation of rain for two days on the 20th and 21st of July is also evident in a reduction in the coliform count at that time.

Similar relationships were observed during the 1968 and 1969 programs. Figure 2 shows the relationship for nitrate, phosphate, total coliform count and rainfall in Crane Creek for July, 1968. A definite inverse relationship appears between nitrate and phosphate following occurrence of heavy rains on the 8th and 9th of July. A marked increase in total coliform count was observed with the onset of heavy rains on the 8th of July. A decrease in total coliform bacteria occurred on the 16th of July that was associated with a cessation of rainfall. This decrease in coliform bacteria was also observed at other measurement sites. As rainfall increased after the 17th, an increase in coliform bacteria is again noted. Increases in coliform bacteria, such as that on the 29th, that are not related to rainfall have previously been noted by Woodbridge and Garrett (4).

Figure 3 shows the variation with time between nitrate, phosphate, total coliform, and rainfall for Crane Creek during July, 1969. Again, the inverse relationship between nitrate and phosphate appears following rather heavy rains. Also a marked increase in coliform bacteria occurs nearly in phase with the sudden rains near the end of the month.

Data acquired at other measurement sites have displayed only minor variations from the Crane Creek data shown in the above figures. Figure 4 shows the relationship between nitrate, phosphate, total coliform bacteria and rainfall for the Banana River during July, 1969 presented as a comparison with the results from Crane Creek.

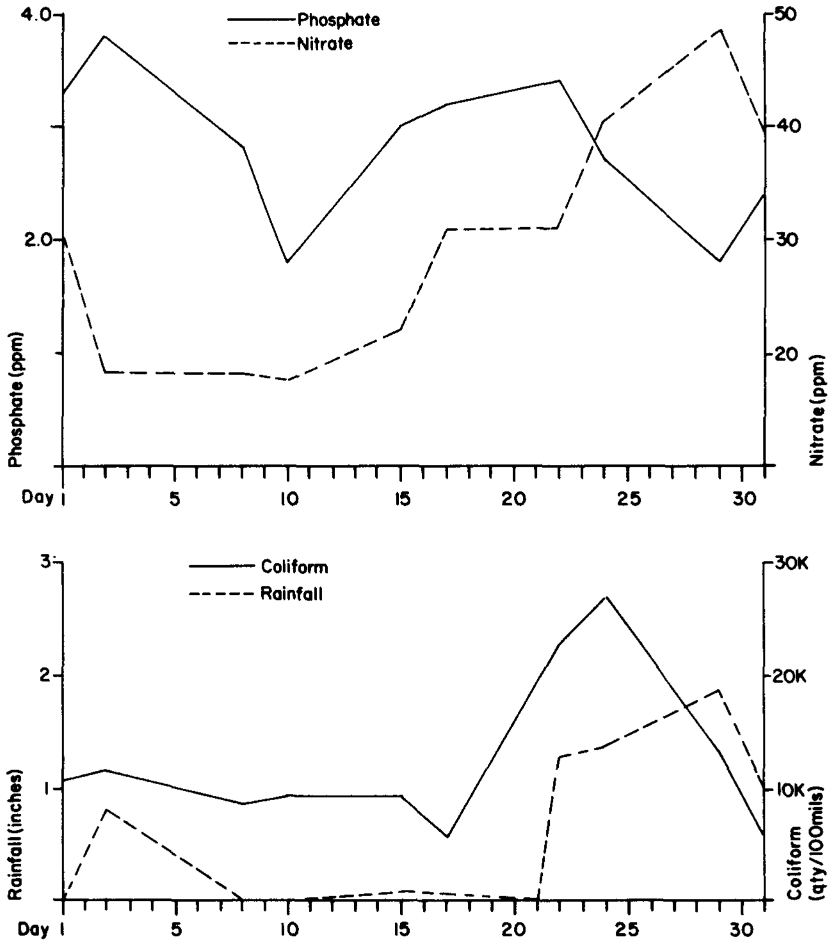

Figure 3
Relationship of Pollution Indicators in Crane Creek for July 1969

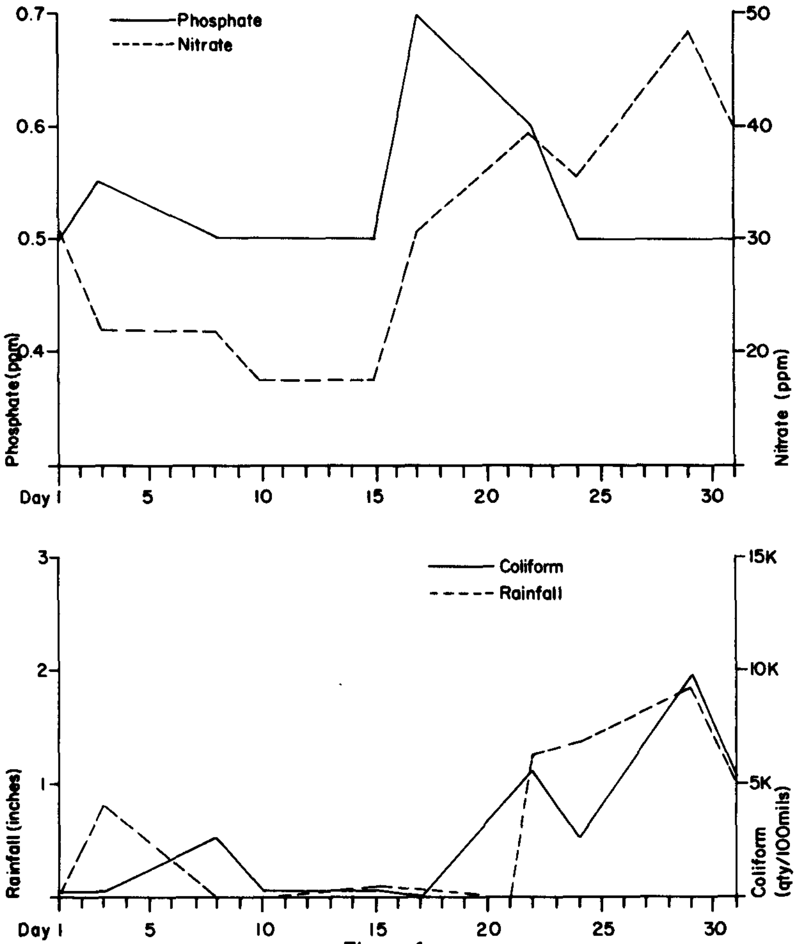

Figure 4

Relationship of Pollution Indicators in The Banana River for July 1969

Discussion

Results of the study for the three July measurement programs indicate certain relationships and complexities between nitrate, phosphate and total coliform bacteria. These relationships appear to be related to rainfall. However, deviations from a direct correlation are also evident.

Under proper conditions a definite inverse relationship between nitrate and phosphate appears. However, under some physical conditions a rather independent relationship appears to exist between the nutrients and at other times a direct relationship appears to exist. The data indicates that approximately one-inch of rain may be necessary to establish the inverse relationship between nitrates and phosphates.

Sharp increases in bacteria were observed whenever more than one-inch of rain fell within five days preceding the acquisition of data. However, increases in coliform bacteria can also be observed to occur at times when no sizeable rainfall has been measured. The relationship between rainfall and coliform bacteria and between rainfall and the nitrate-phosphate inverse relationship may indicate a relationship between coliform bacteria and the relative nitrate-phosphate concentration.

Acknowledgement

This work was performed under National Science Foundation grants: GW-4090, GW-3042, GW-1766.

References

1. Am. Pub. Health Assoc.; Am. Water Works Assoc.; Water Poll. Control Fed. Standard Methods for the Examination of Water and Wastewater. Twelfth Ed: American Public Health Association, Inc. 1962, New York.

2. M.J. Pelczar and R.D. Reid, Microbiology, "Food and Water Infection of Man, "McGraw-Hill, New York, 1965, p. 428.

3. ______________________, Hach DR-EL "Direct Reading" Portable Engineer's Laboratory Methods Manual, Fifth Edition, Hach Chemical Company 10-66-M, pp. 32-40.

4. Woodbridge, D.D. and Garrett, W.R., "Relationship Between Bacteria, Nutrients and Rainfall in Selected Bodies of Fresh Water", Bull. of Environ. Con. & Tox., Vol. 4, No. 5, 311-19, 1969.