Rochester Committee
for Scientific Information
Rochester, NY

RCSI Bulletin 122

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June 1971

THE ROCHESTER COMMITTEE FOR SCIENTIFIC INFORMATION
P. O. Box 5236, River Campus Station
Rochester, New York 14627

Bulletin #122 (W)
Water Pollution

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Summary

High concentrations of phosphate were found in Irondequoit Creek and especially in its major tributaries, Allen and Thomas Creeks. Phosphate concentrations increased substantially at periods of low rainfall in August. Substantial amounts of nitrogen occur in the lower regions of the Creeks. A significant portion of the nitrogen occurs in the form of organic nitrogen, ammonia and nitrite, which indicates that the streams are unable to oxidize nitrogenous wastes completely. There is enough phosphate,nitrogen, carbon, silicate and sulfur to support additional plant growth. Moderate reductions of phosphate from increased sewage treatment or use of detergents of lower phosphate content will probably not affect the creek system at the present time, but may benefit the waters of Lake Ontario and may speed recovery of the creek system after sewage diversion occurs.

Background

Irondequoit Creek is the principal tributary of Irondequoit Bay. The total effective drainage basin for Irondequoit Creek and its tributaries is 144 square miles, of which the Thomas Creek basin constitutes 19% and the Allen Creek basin constitutes 20%. Flow data measured during a low flow period in November, 1954, show a flow of 46.4 cfs in Irondequoit Creek at Browncroft Boulevard (1). At that time, Irondequoit Creek above the confluence with Thomas Creek contributed 48% of the total flow; Thomas Creek contributed 17% of the flow; and Allen Creek contributed 20% of the flow. Thomas and Allen Creeks each receive variable flows from the Barge Canal. The standard stream classifications of Irondequoit, Thomas and Allen Creeks are "B" (Best use: bathing; Minimum dissolved oxygen: 4.0 mg/l; Maximum coliform bacteria (MPN): 2,400 per 100 ml; ammonia: 1.65 mg/l as N). The upper portions of Irondequoit Creek are classified as trout waters (minimum dissolved oxygen: 5.0 mg/l).

Irondequoit Creek and its tributaries receive effluent from nine sewage treatment plants, including the Brighton Allen Creek Sewage Treatment Plant (STP), which discharges into Allen Creek, and the Village of Fairport and Perinton-Thomas Creek STP's, which discharge into Thomas Creek. Water from the Barge Canal, which receives effluent from five STP's, is used for flow augmentation of Thomas and Allen Creeks.

Pollution of Irondequoit Creek by organic matter was cited as early as 1913 (2). Using biological oxygen demand (BOD_5) and coliform measurements (MPN) as criteria of pollution, the NYS Department of Health reported in 1954 (1) that Irondequoit Creek

This study was performed as part of the development of a Water Quality Analysis laboratory course at the University of Rochester. Funds for this study were provided by the College of Arts and Sciences. Grateful acknowledgement is made to all those who participated in sampling and to Mr. George Ireland of the Monroe County Department of Health, who provided helpful discussion and data on the water quality of Thomas Creek.

was polluted to just above Blossom Road. At this time fishing was noted as far down Irondequoit Creek as Browncroft Boulevard. In the same report Thomas Creek was cited as "slightly polluted" in the region below White Brook and as "natural" in the upper portions of the creek.

The Monroe County Department of Health has sampled Irondequoit Creek at six points and Thomas Creek at five points on an approximately biweekly basis during each summer since 1966. Dissolved oxygen, BOD_5, chloride, pH, turbidity, color and coliform measurements are made, but phosphate and nitrogen are not determined.

In an R.C.S.I. study of ortho-phosphate concentrations in waters of the Rochester area conducted in April and May of 1967 (3), an average of 2.2 mg/l PO_4 was found in Irondequoit Creek at Washington Street and an average of 2.7 mg/l in lower Irondequoit Creek (below Penfield Road). Measurements made in May and June of 1968 (4) showed a similar level of 2.5 mg/l PO_4 in lower Irondequoit Creek. Phosphate measurements performed in November, 1968 (5) showed ortho-phosphate concentrations of 2.2 mg/l in Irondequoit Creek at Washington Street, 3.3 mg/l in Thomas Creek near Baird Road and 4.2 mg/l in Allen Creek below the Allen Creek STP. Phosphate concentrations determined in September, 1969 (5) were generally similar to those found in 1968, except that Allen Creek contained 5.8 mg/l.

Nutrients and Eutrophication

In order for an algal cell to grow about 20 elements must be acquired from the environment. Carbon (35%), nitrogen (2.3%), sulfur (1.6%), and phosphorus (0.6%) are utilized to the greatest extent by typical algae (6). In the case of a severe deficiency of any necessary element, plant growth will be hindered. Occasionally, shortage of metals may limit algal growth, but generally algal growth seems to be limited by nutrient stresses of phosphorus, nitrogen or carbon. The importance of carbon has been stressed by Kuentzel (7). Substantial amounts of carbon and nitrogen are available from natural sources, but most phosphorus arises from the activities of man. Hence, control of phospharus input has generally been considered the most practical method of limiting nuisance plant growth and the resulting deterioration of water quality. The National Technical Advisory Committee to the Secretary of the Interior has recommended maximum levels of total phosphate of 0.3 mg/l in flowing streams and maximum of 0.15 mg/l where the stream enters lakes or reservoirs (6).

Reduction of phosphorus input can cause dramatic improvement in the quality of eutrophied water as can be seen from studies done on Lake Washington, near Seattle (8). Between 1963 and 1968 the effluent from eleven STP's were diverted from the Lake; it was estimated that 56% of the phosphate input to the Lake came from sewage in 1958. There was noted an appreciable drop in algal growth and in turbidity as the sewage was being diverted. After diversion of sewage, the phosphate levels decreased 72% relative to values observed in 1963; simultaneously the summer chlorophyll content of the surface phytoplankton dropped by 80% and the Secchi Disk Transparence improved from 1 m to 2.8 m. The mean winter nitrate concentrations have decreased slightly to 80% of the 1963 value and the alkalinity (bicarbonate) has increased 20%. Thus, for this lake, the diversion of slightly more than half of the phosphorus load resulted in dramatic improvement in the quality of the lake water. In the light of the planned installation of tertiary treatment for Monroe County sewage and the diversion of sewage from Irondequoit Bay and its tributaries, the Lake Washington study is of particular relevance.

Results and Discussion

Figure 1 shows the dissolved phosphate concentrations in Thomas Creek and in Irondequoit Creek below the confluence with Thomas Creek. At one time the phosphate level of Thomas Creek exceeded the recommended maximum value for phosphate in flowing streams by a factor of 46. This peak is part of a general rising trend which follows periods of little or no rain in the later summer months.

The principal source of the phosphate of Thomas Creek is the Village of Fairport STP (0.41 million gallons per day average flow rate). The phosphate concentration near Baird Road (0.5 miles below the Village of Fairport STP) was typically eight times that above the STP. A sample of the effluent from the STP contained 33.0 mg/l PO_4, which is typical of municipal sewage. On the basis of the phosphate concentrations, it is estimated that the effluent from the Fairport STP constituted at least one-third of the total flow of the Creek in mid-August.

It was observed that in general the concentration of total phosphate (unfiltered samples) decreased with distance in regions between phosphate inputs. In certain regions where the water was deep and turbid, rooted and attached plants were not abundant; hence, these cannot account for reduction in the phosphate concentrations. It is suggested that the decrease in phosphate in the creek is a consequence of incorporation of particulate matter into the organic sediments on the creek bottom (9).

Figure 2 shows total dissolved phosphate and oxidized nitrogen levels in Irondequoit Creek. The largest increases in phosphate concentration occur below Thomas Creek, below Allen Creek, and below the Rich's Dugway STP. Allen Creek exhibited the highest contentration of phosphate in the creek system. Typically 80% of the total dissolved phosphate was in the form of ortho-phosphate. Taking 3.0 mg/l as the average phosphate concentration in Irondequoit Creek at its mouth, one can estimate that the Irondequoit Creek watershed contributes 725 lb PO_4 per day or 260,000 lb PO_4 per year to Irondequoit Bay.

The nitrogen concentration in Irondequoit Creek increased substantially below Fairport Road. In general, in regions of the Creek where nutrient inputs did not occur the concentration of nitrogen compounds decreased with distance; inputs from the STP's served to keep the nitrogen above 1 mg/l N. In the lower regions of the Creek, 20-40% of the nitrogen was in the form of ammonia and 6-10% of the nitrogen was in the form of nitrite. This is in contrast to the upper regions of the Creek, where ammonia and nitrite were negligible and indicates that nitrogenous wastes are not being oxidized adequately. In Allen Creek, substantial amounts of organic nitrogen were present. For example, on October 10, 1970, ammonia in Allen Creek was 0.32 mg/l N, nitrite was 0.040 mg/l N, organic nitrogen was 0.38 mg/l N, and nitrate was 0.55 mg/l N. Thus, at the time less than half of the total nitrogen was in the form of nitrate.

The Barge Canal contained lower concentrations of phosphate and coliform bacteria than Thomas Creek and had similar concentrations of nitrate and bicarbonate. Thus, until sewage diversion from Thomas Creek occurs as part of the Pure Waters Master Plan, flow augmentation from the Barge Canal serves to improve the quality of water in Thomas Creek by dilution of the nutrients. The waters of Allen Creek have high concentrations of phosphate and substantial amounts of nitrogen even in times of high flow; hence, flow augmentation from the Barge Canal is beneficial.

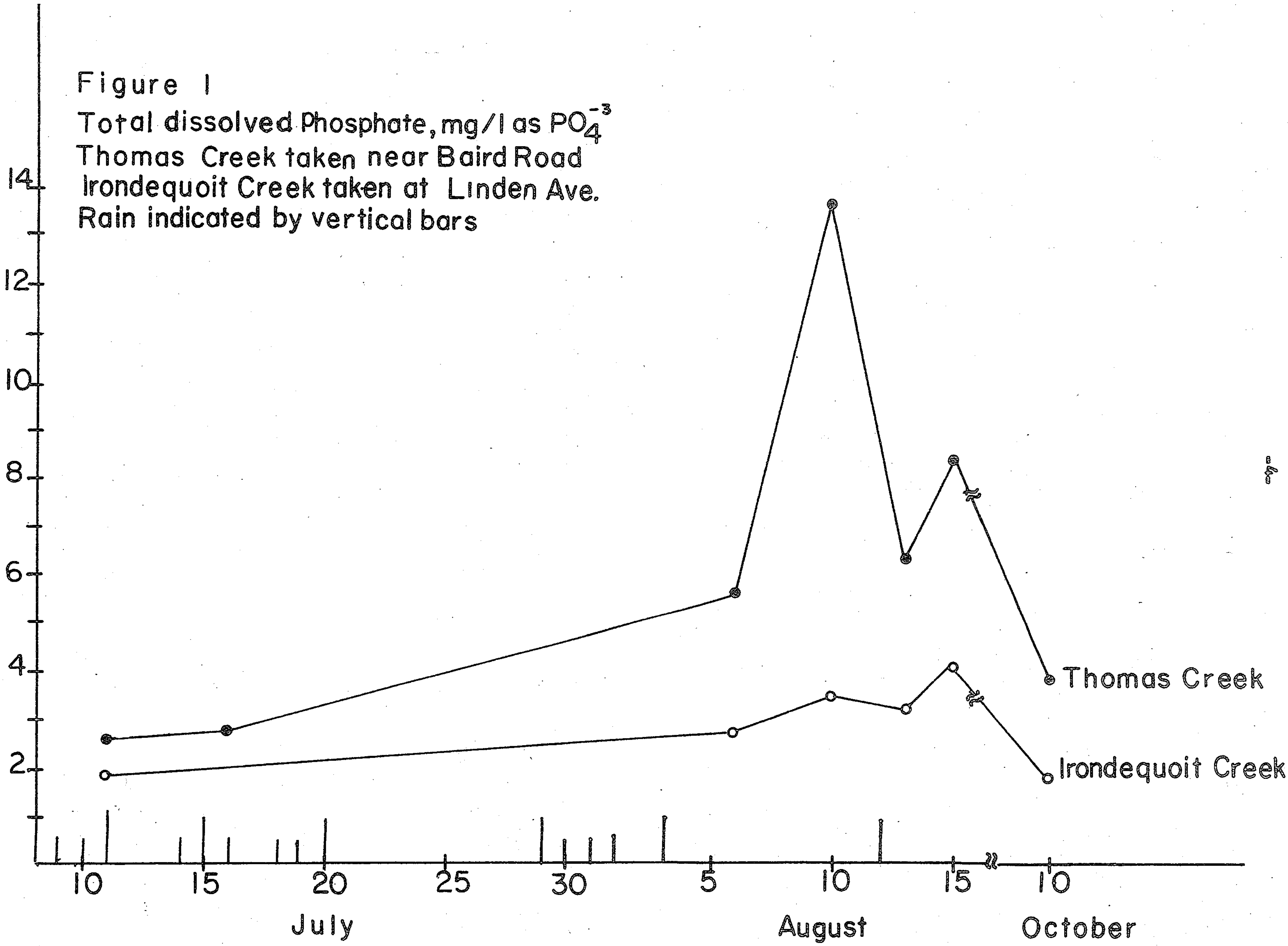

Figure 1
Total dissolved Phosphate, mg/l as PO_4^{-3}
Thomas Creek taken near Baird Road
Irondequoit Creek taken at Linden Ave.
Rain indicated by vertical bars

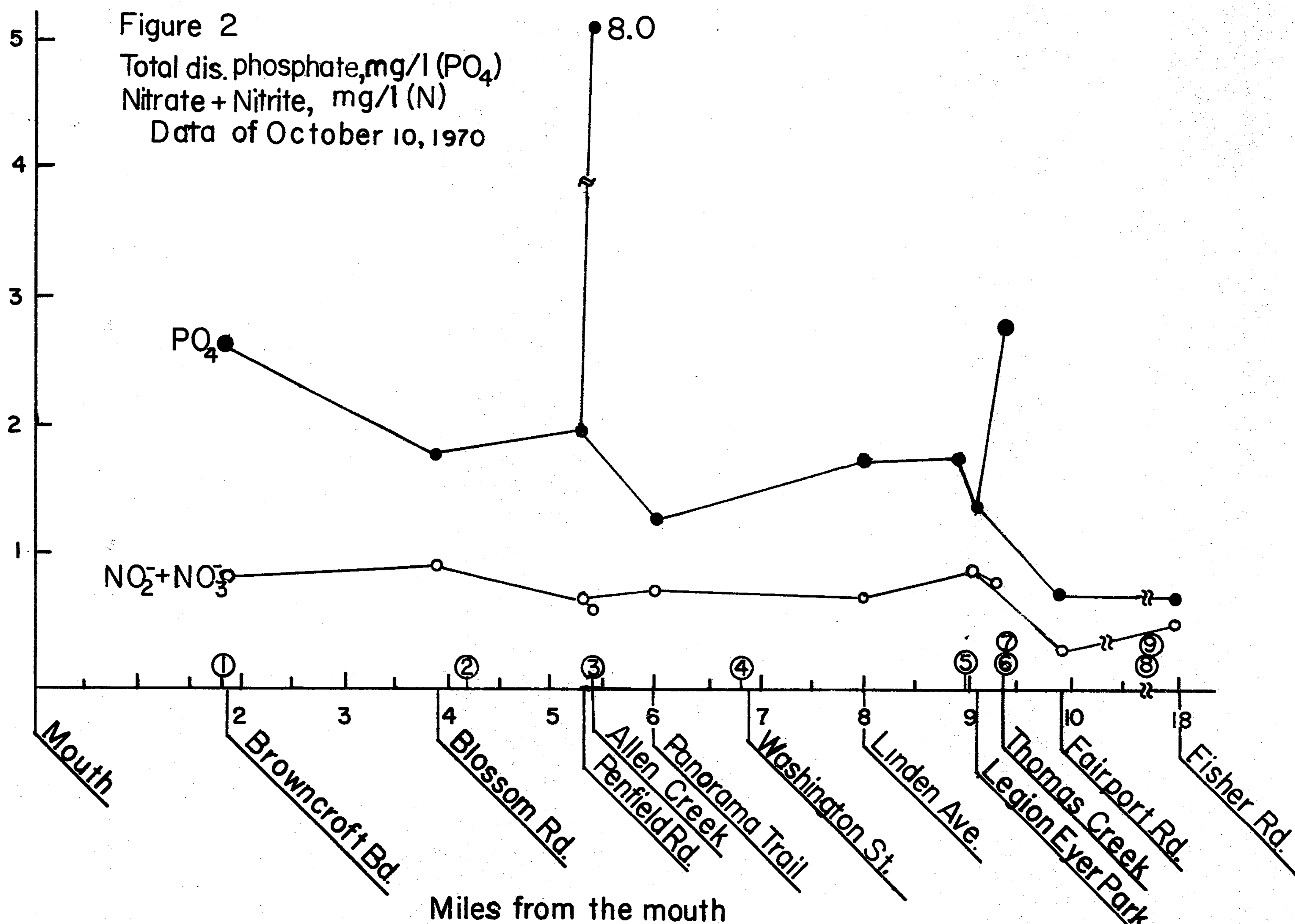

Figure 2
Total dis. phosphate, mg/l (PO_4)
Nitrate + Nitrite, mg/l (N)
Data of October 10, 1970
8.0
PO_4
$NO_2^- + NO_3^-$
5
4
3
2
1
Mouth
2
3
4
5
6
7
8
9
10
18
Browncroft Bd.
Blossom Rd.
Penfield Rd.
Allen Creek
Panorama Trail
Washington St.
Linden Ave.
Legion Eyer Park
Thomas Creek
Fairport Rd.
Fisher Rd.
Miles from the mouth

Dissolved oxygen measurements for Thomas Creek at Baird Road made by the Monroe County Department of Health over the last five years averaged 7.3 mg/l O_2. This value is unexpected, since nitrite concentrations were appreciable, indicating active decomposition is taking place and hence oxygen is being consumed. We attributed these high dissolved oxygen concentrations to reaeration, since the sampling point is just below a riffle area. Measurements made at the start of the riffle area gave values as low as 3.8 mg/l O_2. These measurements were made in bright sunlight, when photo-synthesis contributes substantial amounts of oxygen to the water. Thus, it appears that dissolved oxygen concentration in the lower portion of Thomas Creek is substantially lower than measurements at Baird Road indicate.

Of the forms of carbon in waters, generally only carbon dioxide is readily available for plant growth. However, bicarbonate and organic material usually provide large reservoirs of carbon, except under conditions of high pH or low bacterial activity, respectively. The bicarbonate concentrations in the creeks were fairly constant at 180-200 mg/l CO_2, and the pH was generally near 8; thus, carbon dioxide is freely available. Furthermore, bacterial degradation of organic matter from sewage and from food processing wastes should provide an additional source of carbon dioxide.

Sulfate was about 120 mg/l, which is quite adequate for algal growth. Soluble silicate was typically 2-4 mg/l SiO_2.

During the summer Thomas Creek below the Fairport STP and in the lower regions of Irondequoit Creek became heavily overgrown with attached algae, principally Cladophora. Fish were present in the upper regions of Thomas and Irondequoit Creeks, but in the lower region of Thomas Creek no fish were observed. Isopods, snails, and insect larvae were abundant in this region of the Creek. Seinings in the region of Irondequoit Creek just below Allen Creek have been reported (10) to have yielded no fish.

Based on the above data, it can be seen that more phosphate than can be assimilated by plant growth is entering the Irondequoit Creek system from municipal sewage. Furthermore, there appear to be adequate amounts of carbon, nitrogen, silicon, and sulfur to support additional plant growth. Thus, the growth of algae in the lower portions of the Irondequoit Creek system is not limited by the availability of major nutrients, but rather either by the availability of micronutrients, the presence of toxic materials, the activity of organisms, or utilization and availability of sunlight. The authors favor the latter explanation, since algal growth appeared to be substantially heavier in open regions of the Creek than in shaded or turbid regions.

At the present time, a moderate decrease in phosphate input to the creek system, such as from the use of nonphosphate detergents instead of high-phosphate detergents, would probably have negligible effect on the quality of water in Irondequoit Creek and probably also Irondequoit Bay. Reduction in phosphate at the present time could, however, be beneficial for several reasons. First, the water from Irondequoit Creek eventually goes into Lake Ontario, and hence any phosphate not utilized within Irondequoit Creek or Bay will enter the Lake. Since in Lake Ontario waters the addition of phosphate serves to stimulate algal growth (11), any reduction in phosphate input should tend to improve the condition of the Lake. Secondly, sediments presently being deposited are expected to act as a reservoir of nutrients after sewage diversion occurs. Thus, continued phosphate inputs at the present time may tend to retard the process of recovery of the creek system when sewage diversion is complete.

Methods

Water samples were generally grab samples taken from bridges or canoes. For the data of Figure 2, the samples were composites of six to ten samples taken over a period of ca. one-half hour.

Ortho-phosphate was determined colorimetrically by the stannous chloride method (13). Total phosphate analyses were performed by hydrolysis of filtered samples of water by wet ashing in concentrated sulfuric and nitric acids (12) followed by determination of the phosphate by the stannous chloride-molybdate method. The method of Mullin and Riley (13) for determination of nitrates was modified by increasing the temperature to 70°. Nitrite was determined by distillation at pH 7.4 followed by Nesslerization. Dissolved oxygen was determined by the Winkler method with azide modification or with a YSI dissolved oxygen meter. Other analyses were performed as described in Standard Methods of Water Analysis (12).

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