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CHAPTER 37

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The role of stormwater as nutrient for the growth of algae was investigated. Samples during storm events were collected at discrete time intervals from a channel draining an urbanized watershed. Concentrations of nitrogen and phosphorus were determined by Technicon Autoanalyzer. Bioassays, with *Selenastrum capricornutum* as the test alga, were performed using the 1969 U.S. Environmental Protection Agency procedure. Nitrogen and phosphorus concn increased and decreased with channel flow during two storm events. Urban stormwater did not stimulate algal growth; nitrogen limited algal growth in most of the water samples collected. One urban sample was either toxic to the test alga or deficient in nutrients other than nitrogen and phosphorus. Similar studies indicate that phosphorus rather than nitrogen is the nutrient most limiting to algal growth during periods of low flow.

INTRODUCTION

Nutrient enrichment of aquatic ecosystems poses a serious problem in water quality management. Inorganic nutrients, in excessive quantities, often accelerate the natural process of eutrophication and enhance the growth of aquatic flora. Among inorganic nutrients which have been implicated in increasing eutrophication, nitrogen and phosphorus are usually considered the primary stimulants of algal growth in impounded waters.

Significant quantities of these elements may be transported to aquatic ecosystems by surface runoff from watersheds. Since surface drainage is a major component in the hydrologic linkage between aquatic and terrestrial ecosystems, it is an important ecological parameter. If the watershed is used for urban purposes, then this linkage becomes ecologically more critical. That urbanization generally increases the amount of nutrients discharged to surface waters has been shown by several investigators (Keup 1968; Stewart 1968; Sylvester 1961; Wiebel et al. 1964).

However, the role of urban runoff in stimulating algal growth seems to be unsettled. For example, Goldman and Armstrong (1969) showed that nutrients in streams entering Lake Tahoe from urbanized areas have a stimulatory effect on algal growth, while Shannon and Brezonik (1972) indicated that urban runoff is not a major source of enrichment for lakes in Florida. Emery et al. (1973) also concluded that streams which drain urbanized areas have little effect on the productivity of Lake Sammamish, Washington.

This paper deals with an investigation of the role of stormwater runoff from an urban area near Houston (eastern), Texas, in contributing nitrogen and phosphorus to streams. Chemical analyses were used to determine the concn of these nutrients in water samples which were collected at discrete intervals during the courses of two storm events. Bioassays were used to determine the stimulatory effects of these discrete samples on algal growth.

Materials and Methods

Description ⸝ *udy area.* The Hunting Bayou watershed is located on the northeastern ..de of Houston near the intersection of Highways 59 and 610. The area is characterized by extremely low land slopes (0.1%), impermeable soils with high clay content, and approx. 45 inches of rain annually. Land usage in the area is varied, with approx. 80% devoted to residential and 20% to commercial and industrial development. Few storm sewers are present within the area and the major portion of the watershed is drained by roadside, grass-lined swales.

The two main channels of Hunting Bayou are essentially trapezoidal with low-flow channels. The banks and channel beds are earthen and lined with vegetation which varies in density from moderate to very heavy. The area is, in general, poorly maintained and the channels are often used as dumping areas for waste materials.

Collection and preservation of samples. Water samples were collected at the U.S. Geological Survey (U.S.G.S.) Fall Street gauging station during two storm events. Samples for chemical analyses were taken at 15-min intervals for a period of 3 h during the first storm event (March 20-21, 1974) and at hourly intervals during the 10-h course of the second storm event (April 11-12, 1974). These samples were collected manually in precleaned, glass-dissolved oxygen bottles which were packed in ice for transport to the laboratory. In the laboratory, portions of each sample were filtered through 0.5-μm Millipore "cellotate" filters and preserved with mercuric chloride (40 mg/liter). Samples were refrigerated at 4 C until the time of analysis. All analyses were completed within the time period recommended by the U.S. Environmental Protection Agency (1971).

Water samples for bioassays were collected at approx. 60-min intervals during the first storm event and at 170 to 245-min intervals during the second storm. These samples were collected in precleaned, 3.7-liter glass bottles and processed immediately upon arrival at the laboratory. Preservatives were not added to these samples.

In order to be prepared for storm events, weather patterns in the Houston vicinity were monitored on a regular schedule. When a storm front entered the area, personnel were deployed and samples were collected at the first indication of rainfall. Sampling continued until there was a decline and "leveling off" in discharge.

Analytical procedures. Instantaneous discharge was determined from the U.S.G.S. hydrograph at the Fall Street site. Analyses of NO_3-N, NO_2-N, NH_4-N, O-PO_4, and total-PO_4 were conducted with a Technicon Autoanalyzer.

Methods used in the batch culture bioassays were similar to those described by the Joint Industry/Government Task Force on Eutrophication (1969). Water samples were filtered aseptically with 0.45-μm Gelman filters which had been prewashed with sterile, deionized water. Forty milliliter portions of each filtrate were transferred to sterile 125-ml Erlenmeyer flasks, and 9 or 12 flasks were prepared for each sample. Three flasks were used as controls (no added nutrients), while other sets of three flasks were spiked with nitrogen (1 mg/liter N as $NaNO_3$) and/or phosphorus (0.05 mg/liter P as KH_2PO_4). The prepared samples were seeded with *Selenastrum capricornutum* and initial cell concn were adjusted so each flask contained 1×10^3 cells/ml. Cotton plugs were used as closures for the flasks and each flask was shaken daily for mixing. Algal yields were determined gravimetrically with a Mettler balance after incubation for 21 days.

Results and Discussion

Stream discharge. Maximum discharge was achieved in the first hou ... the March 20-21 st... event (Fig. 1) and at hour 9 in the April 11-12 storm event ...g. 2). Achievemen... maximum discharge in the latter storm was delayed primarily by drier antecedent wea... debris in drainage channels, and less intense initial rainfall. Other factors, such as the den... of land vegetation, presence or absence of leaves in street gutters, and frequency of st... sweeping probably also influenced discharge during these storms. Concomitantly, these fac... also influence the amounts of nitrogen and phosphorus which are transported to stream... surface runoff (Sylvester 1961).

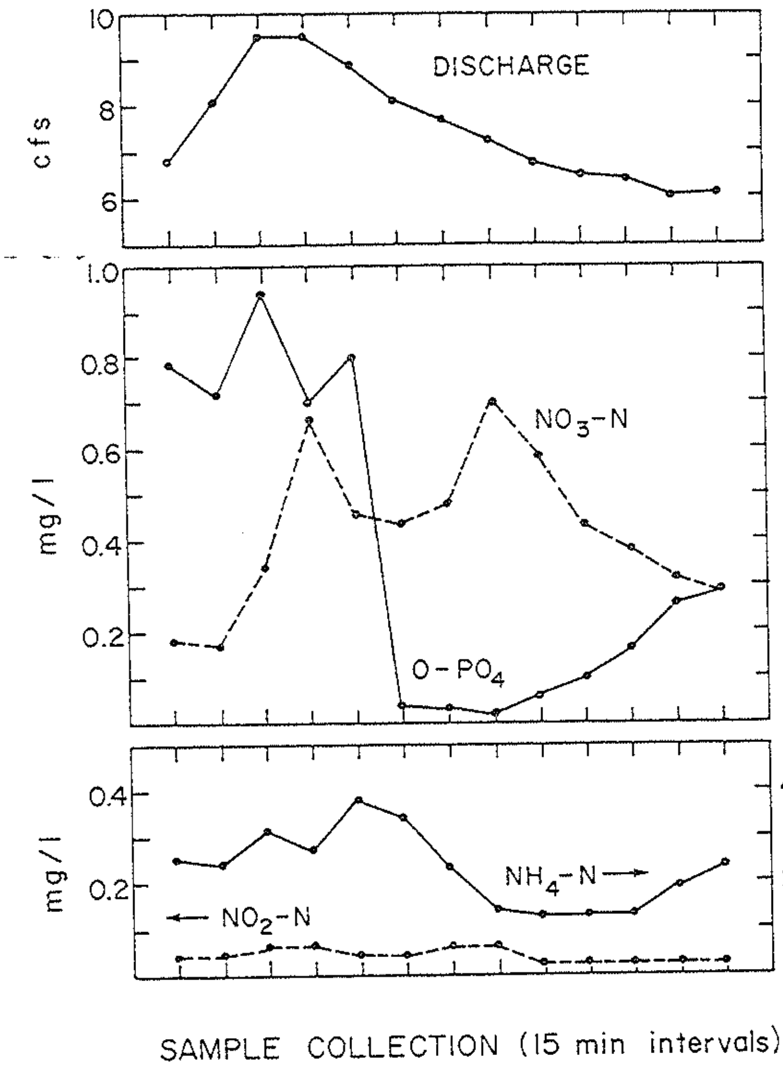


FIG. 1. Discharge and chemical composition of Hunting Bayou water samples collected during the ... 20-21 storm event.

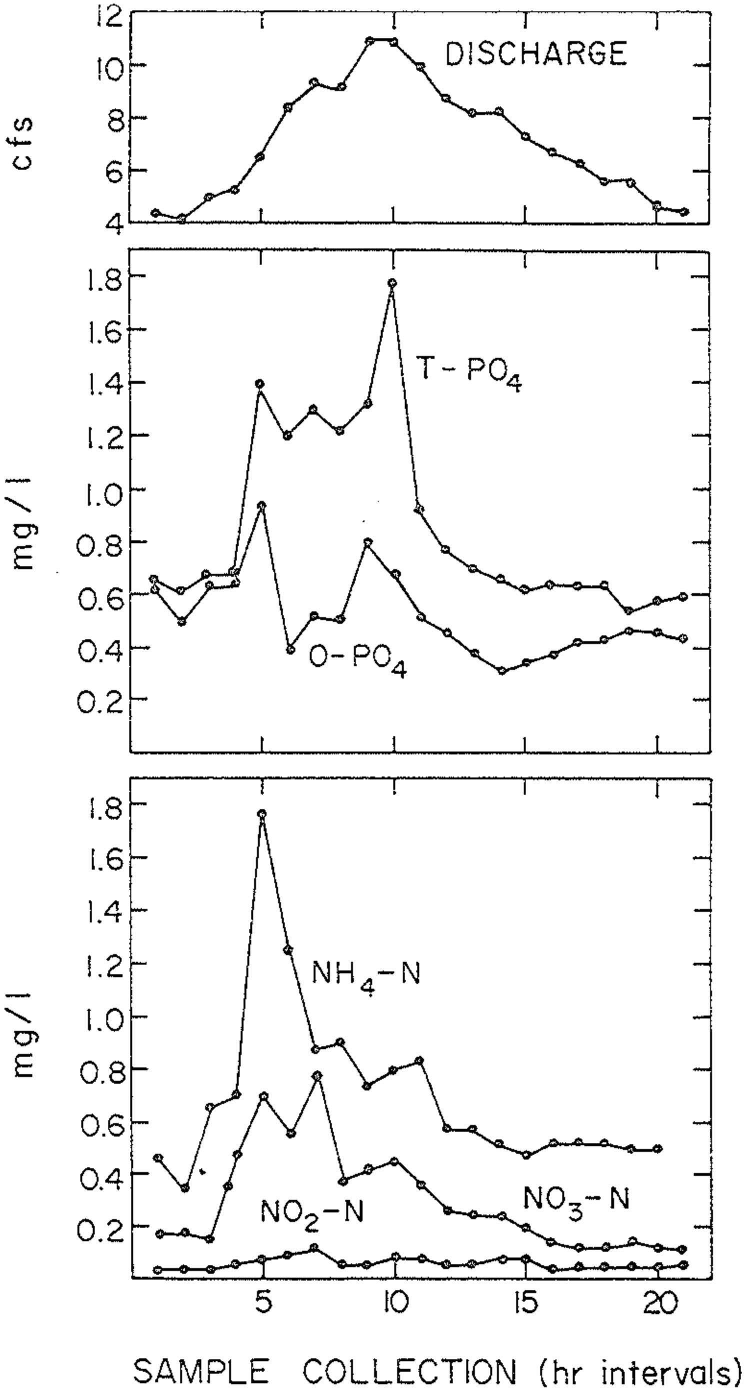


FIG. 2. Discharge and chemical composition of Hunting Bayou water samples collected during the April 11-12 storm event.

Chemical analyses. Concentrations of NO_2-N did not vary significantly throughou events, while there were significant fluctuations in concn of NO_3-N, NH_4-N, and 1 and 2). Influxes of these latter elements increased during periods of increased d decreased with declining discharges. These fluctuations were probably due, in intermittent entrance of water from small lateral drainage channels. During the in of the storms, phosphorus may also have been released from bottom sedime nutrient load of the stream as shown by Connell (1965) for other Texas strean with declining flow rates, phosphorus may again be stored temporarily in botto (Keup 1968). This latter process, along with initial washout and dilution of the e probably responsible for the reduction in soluble nutrient concn as discharges dec

Soluble concn of nitrogen and phosphorus in running water can be reduced b these elements to particulate matter (Brezonik 1972; Keup 1968). With decreasin the velocity, turbulence, and carrying capacity of a stream are reduced and th materials, along with their sorbed elements, become incorporated into botton Soluble nitrogen and phosphorus may also be removed from stormwaters b assimilation. Aquatic vascular plants and attached algal communities have been being primary sources of rapid uptake of nutrients from streams (Ball and H Brezonik 1972). Nitrogen and phosphorus bound to particulate materials or fixed tissues were not determined for samples collected during these storm events. forms of nitrogen and phosphorus were measured.

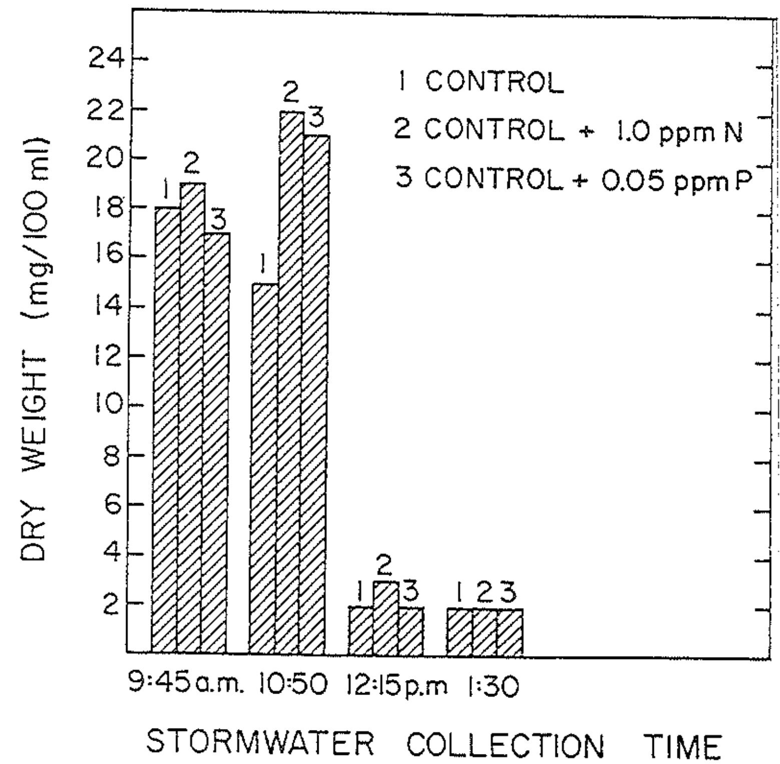
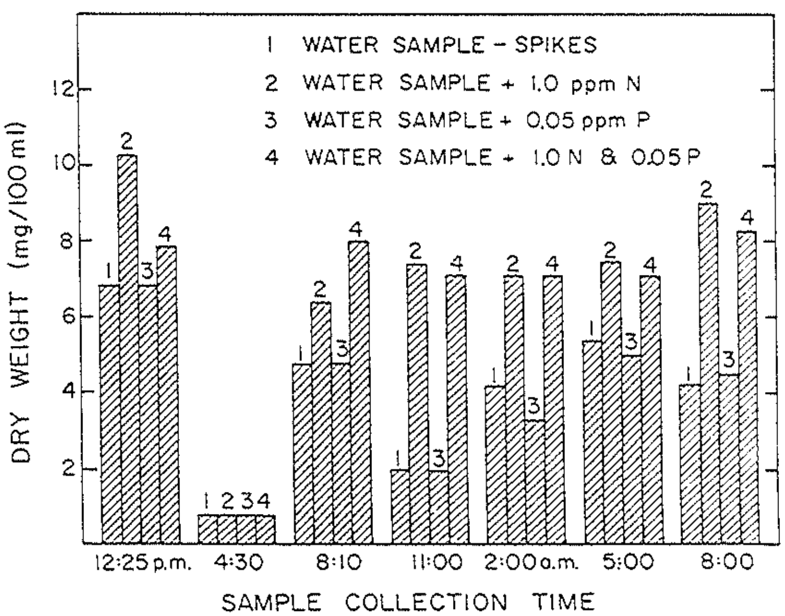


FIG. 3. Yields of *S. capricornutum* obtained from bioassays with stormwaters collected f Bayou during the March 20-21 storm event.

Bioassay – March 20-21 storm event. Algal growth was stimulated by the addition of nitrogen to the first water sample and by nitrogen or phosphorus additions to the second water sample collected during this storm (Fig. 3). However, algal growth was not enhanced by the addition of nutrients to samples collected during the latter portions of the storm. This reduction in growth capacity could have been caused by nutrient limitations or by some toxic substance(s) which was washed into the stream. Unfortunately, combined nitrogen and phosphorus spikes were not made with these samples, thus the effects of combined nutrient enrichment were not recorded. If a toxic substance was present, it inhibited *Selenastrum* in small quantities or was present in sufficiently high concn to prevent dilution to a noninhibitory concn. Reduced growth may also have been due to a deficiency in some trace element which was essential for algal growth. Even so, the data indicate that there was a definite variation in the capacity of the stormwater runoff to support algal growth.

Bioassay – April 11-12 storm event. With the exception of the 4:30 p.m. sample, there was a definite stimulation of algal growth with additions of nitrogen or both nitrogen and phosphorus to the water samples, and slight or no stimulation with spikes of phosphorus only (Fig. 4). The marked reduction in algal growth, even with combined nitrogen and phosphorus spikes, in the 4:30 sample could again have been due to the presence of some toxic agent or the absence of some essential trace element.

The data (Fig. 3 and 4) indicate that discrete samples of stormwater runoff from Hunting Bayou did not have a stimulatory effect on algal growth. Instead, as both storms progressed, algal yields decreased. Nitrogen was the limiting factor for algal growth in most of the surface runoff samples. Algal yields were not increased in some samples by the additions of nitrogen and phosphorus; thus, these elements were not the only algal growth-limiting factors



encountered in stormwater runoff. The total nutrients present in stormwater w determined because particulate materials were removed by filtration. Thus, total concn in the stormwater samples were probably underestimated. Only those nutrien were readily available for biological assimilation were assayed in this investigation.

This study demonstrates that algal bioassay techniques can be used to characte nutrient potential of impounded stormwaters to support nuisance algal growths. A knowledge of inorganic nutrient loads, primarily nitrogen and phosphorus, are esse proper lake management, other factors such as season, temperature, light pen presence of toxic materials, and detention time may, at any point in time, cont growth and the establishment of bloom conditions. Similar studies in an unde watershed in eastern Texas indicate that stormwaters stimulate algal growth and sufficient nutrients to support blooms if other environmental conditions are favorable management strategies for recreational lakes receiving stormwater runoffs shou depending on the primary source(s) of surface flow.

Acknowledgments

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