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Effect of Turbidity on Algal Growth

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ABSTRACT

A comparative study was made to determine the effect of water turbidity on algal growth. The growth of algae in Illinois River water which is characterized by turbid conditions and generally void of algal blooms was compared with algal growth in Fox River water which is generally clear except during periods of frequent algal blooms.

Bi-weekly water samples were taken from the Illinois River at Peoria and the Fox River at Oswego and at Dayton. Half of each sample was filtered through 0.45 micrometer membrane filter to remove all particulate matter. The filtered portion and the remaining unfiltered sample were separately inoculated, and the algal growth potential of each fraction was determined under various incubation conditions.

The experimental results suggest that high turbidity conditions retard algal growth, a light-inhibition effect. In some cases, however, particulate matter appeared to stimulate algal growth.

INTRODUCTION

The Illinois River is a nutrient-enriched stream. It contains phosphorus levels reportedly among the highest in the U. S. Public Health Service's nationwide stream monitoring system.[1] The river is also abundant in various forms of nitrogen and other plant nutrients.[2] Under optimum laboratory conditions, Illinois River water consistently supports algal growth densities unrivaled by other river water samples in the state.[3] Yet the stream is conspicuously lacking in significant numbers of aquatic vascular plants and algal blooms. It appears muddy and barren, reflecting a typical stream of low biological productivity. The question posed is: Why does the river appear sterile, without signs of vegetative life, when it contains abundant quantities of plant nutrients? Many hypotheses have been advanced, including the lack of seed organisms, presence of toxic substances, and light inhibition.

The Fox River, a tributary to the Illinois River, is also a nutrient-enriched stream. The chemical qualities of its water are not unlike that of the Illinois River; however, it frequently supports algal blooms of nuisance proportions during the summer months.

The headwaters of the Fox River consist basically of the notoriously eutrophic Fox Chain of Lakes, a glacial lake system. The Fox Chain of Lakes is a source of algae for the Fox River that is sustained and indeed propagated throughout its entire length. The Illinois River, in turn, does not sustain the algal densities emitted to it by the Fox River. It is obvious that the lack of algal blooms in the Illinois River is not caused by scarcity of seed organisms.

Mathis and Cummings[4] investigated the distribution of heavy metals in the Illinois River near Peoria. They analyzed copper, nickel, lead, chromium, lithium, zinc, cobalt, and cadmium from sediment, clams, tubificid worms, fish, and water. They found that the chromium concentration in Illinois River water was two orders of magnitude higher than that in other rivers in the United States, lithium and cobalt were one order of magnitude higher, and lead about the same order of magnitude. Copper, nickel, and cadmium were one order of magnitude lower. The effect of heavy metals on algal growth is little understood, and what role these metals play in the Illinois River situation is unknown.

Apparently there are some limiting factors other than plant nutrients and seed organisms which inhibit the growth of algae in the Illinois River. A likely factor is turbidity, particularly since the Illinois River is laden with silt and clay particles and its water exhibits a typical muddy appearance year-round. Cheng[5] reported that algal productivity in Lakes Sorell and Crescent, Australia, was strongly influenced

by water turbidity. Mathis and Myers[6] studied the community metabolism in Peoria Lake, a wide sector of the Illinois River, and found that the lowest photosynthetic efficiency occurred during more turbid conditions. The gross photosynthesis ranged from 1.6 g/m^2/day O_2 on June 28-29, 1968 (water turbidity 135 Jtu) to 13.8 g/m^2/day O_2 on June 6-7, 1968 (water turbidity 40 to 50 Jtu). The chlorophyll ranged from 0.03 g/m^2 on June 28-29 to 0.23 g/m^2 on June 6-7. McDonald and Schmickle[7] found plankton organisms to be lowest in early spring when the water turbidity was highest. Claffey[8] found the largest numbers of plankton in clear water, fewer numbers at intermediate turbidity (25 to 50 mg/1), and the least number at higher turbidity. Butler[9] reported that summer productivity in a clear pond (12 g/m^2/day O_2) exceeded that in a turbid pond (4 g/m^2/day O_2). The ratio of gross productivity to community respiration (P/R ratio) exceeded 1 in the clear pond but was less than 1 in the turbid pond. Many other investigators[10,11,12] have reported on the influence of turbidity on aquatic plant growth. Thus it seemed prudent to examine the effect of turbidity on algal growth, and this was done by comparing the waters from the Illinois and the Fox Rivers.

Acknowledgments

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METHODS

The three stream sampling stations designated for this study were Oswego and Dayton on the Fox River and Peoria on the Illinois River. Oswego is approximately 30 miles upstream from Dayton, and Dayton is 4 miles upstream of the juncture where the Fox River flows into the Illinois River. This 4-mile distance is considered safe from occasional backwater from the Illinois River into the Fox River. The Peoria station is located about 80 miles below the confluence of the Fox and Illinois Rivers.

At 2-week intervals, grab samples were obtained at the water surface of each sampling site. As soon as they were delivered to the laboratory, they were divided into two equal portions. One half was filtered through an 0.45 micrometer (µm) membrane filter. The other half remained unfiltered but was autoclaved. The filtered and unfiltered fractions of each sample were refrigerated until needed.

The algal inoculum was obtained from the Illinois River. A portion of the river water was filtered through a crepe filter paper to remove most of the silt and zooplankton. The filtrate in a quart Mason jar was placed on a reciprocating shaker at 100 strokes per minute and illuminated at an intensity of 100 footcandles for 7 days. Because of the richness of the natural plant nutrient present, the algal inoculum always developed successfully. Periphyton as well as phytoplankton developed. After 7 days incubation, the vessel was scraped with a rubber policeman, then directly attached to a blender, and the contents mixed at a low speed for 20 seconds. The inoculum culture was then visually homogeneous and ready to use.

Filtered and unfiltered water samples from each of the sampling stations were individually placed in quart Mason jars and inoculated with approximately 500,000 cells/ml. A 100-ml portion of a subsample was taken from each jar and its initial organic biomass was determined as initial weight. Many laboratory experiments were run with water subsamples of varying degrees of turbidity. This was accomplished by mixing various portions of filtered and unfiltered samples. The Mason jars were covered with polyurethane foam and then placed for shaking and illumination. After a week of incubation, each water sample was individually mixed in the blender and the final organic biomass was determined. The organic biomass was measured as follows.

An 0.45 µm membrane filter was prewashed with 0.5 N hydrochloric acid and then washed with doubly deionized water. The filter was dried in an oven at 90 C for 1 hour and the tare weight was determined to 0.01 mg by an electrobalance. This preweighed filter was used to retain the particulate matter above 0.45 µm. The filter with residue was again heated in an oven at 90 C for 1 hour and weighed. This residual weight represents organic biomass and inorganic calcium carbonate. To remove the inorganic fraction, the residue was washed with 0.5 N hydrochloric acid. The filter was rinsed, dried, and weighed as usual. The final residue represented organic biomass only. The increase of organic biomass from before and after incubation was defined as algal growth. Detailed procedures for algal growth measurements and their reliability have been previously reported.[3]

In addition, algal growth experiments were conducted

with bottled samples suspended in two 32-gallon round plastic water tanks (22-inch-diameter, 24-inch height). One tank was filled with tap water and the other with Illinois River water having a turbidity of 104 Jtu. Water in the river water tank was circulated by a centrifugal pump at a rate of 10 gallons per minute(gpm). The circulation arrangement provided an inlet at the bottom and an outlet at the top of the tank. The purpose of this was to keep the suspended material in the water from settling. To prevent algal growth in the tank water, copper in the form of copper sulfate was added to insure a concentration of 2 mg/1 in each tank. Hardware cloth was used as hangers to suspend the test specimens in BOD bottles at 4, 12, and 20 inches below the surface. The length of incubation was 14 days. The algal growth was determined on duplicate samples as described previously.

Algal growth was also determined in the field. Water samples were collected from the Fox River at Dayton and the Illinois River at Peoria. Filtered and unfiltered fractions of each sample were inoculated in triplicate, for a period of 14 days, in both the Illinois and Fox Rivers. In the Illinois River the samples were suspended from a navigational buoy in a hardware cloth basket about 12 inches below the water surface; in the Fox River the basket was anchored 12 inches below the water surface on a flat concrete block located in the river bed.

Other measurements included in this report are turbidity, alkalinity (titrated electrochemically to pH 4.5), hardness (titrated with EDTA and Eriochrome black T as indicator[13]), silica (molybdosilicate method[13]), ammonium,[14] nitrate,[15] and orthophosphate (some modification of molybdenum blue method[16]). Particle size analysis was performed according to Rukavina and Duncan.[17]

For the purpose of this report the three methods of incubation, i.e., on a shaker, in tanks, and in the two streams, are considered laboratory, tank, and field procedures, respectively.

RESULTS

Typical characteristics of the water samples examined are shown in table 1. There was no great difference in pH among the three stations. Turbidity was drastically different between the two rivers. While the Fox River was reasonably clear (13 Jtu at Oswego and 10 Jtu at Dayton), the Illinois River was much more turbid (86 Jtu). Alkalinity and hardness were expectedly very high, and the major nutrients, nitrogen, phosphorus, and silica, were in sufficient quantities to support algal growth in all samples.

Table 1. Typical Characteristics of Water Samples (Sample of 2/25/1972)

	Fox-Oswego	Fox-Dayton	Illinois-Peoria
PH	8.12	8.20	7.92
Turbidity, Jtu	13	10	86
Alkalinity, *mg/l*	283	291	208
Hardness, *mg/l*	383	384	326
Silica, *mg/l*	6.66	7.41	8.65
NH_3-N, *mg/1*	1.48	1.90	3.85
NO_3-N, *mg/l*	2.54	2.75	3.12
Ortho-p, *mg/l*	0.73	1.04	0.50

Laboratory Results

During laboratory incubation the algal growth in filtered samples fluctuated considerably ranging from 34.8 to 191.4 mg/1 for the Fox at Oswego, 21.0 to 169.8 mg/1 for the Fox at Dayton, and 58.7 to 202.0 mg/1 for the Illinois at Peoria. Because of this fluctuation, it was suspected that the algal growth data were geometrically distributed. To confirm this, data from the Fox River at Dayton and the Illinois River at Peoria were plotted on log-probability paper. Figure 1 shows that the filtered-sample data are geometrically distributed (plot is linear) and that values for central tendencies and dispersion should be in geometric terms. The geometric mean (M_g) of algal growth for the Fox River at Dayton was 56.9 mg/1 and that for the Illinois River was 103.9 mg/1. Data for the unfiltered samples were handled in a similar manner, as shown in figure 2. Both the Fox and the Illinois Rivers showed the same trend, with geometric means of 81.5 mg/1 for the Fox River and 103.5 mg/1 for the Illinois River.

A t-test was made to determine if there was a significant difference between the Fox River and the Illinois River samples for supporting algal growth. Since the algal growth potential of each river was geometrically distributed, the algal growth was converted to a logarithmic expression for the t-test. The t value of the filtered samples was 2.808 (>P 0.01, df 24), indicating that the filtered waters were significantly different in their capability to support algal growth. The capability of the filtered Illinois River water to support algae exceeded that of the filtered Fox River water. A t-test for the unfiltered samples was also performed. A t value of **1.152** was found (<P 0.05, df 22). This indicated there was no significant difference in the algal growth potential of the unfiltered waters of the two streams.

The algal growth in the filtered and unfiltered samples for both streams is shown in figure 3. If turbidity did not affect the algal growth in the unfiltered sample, the results in figure 3 would have fallen on the 1:1 ratio line. The fact

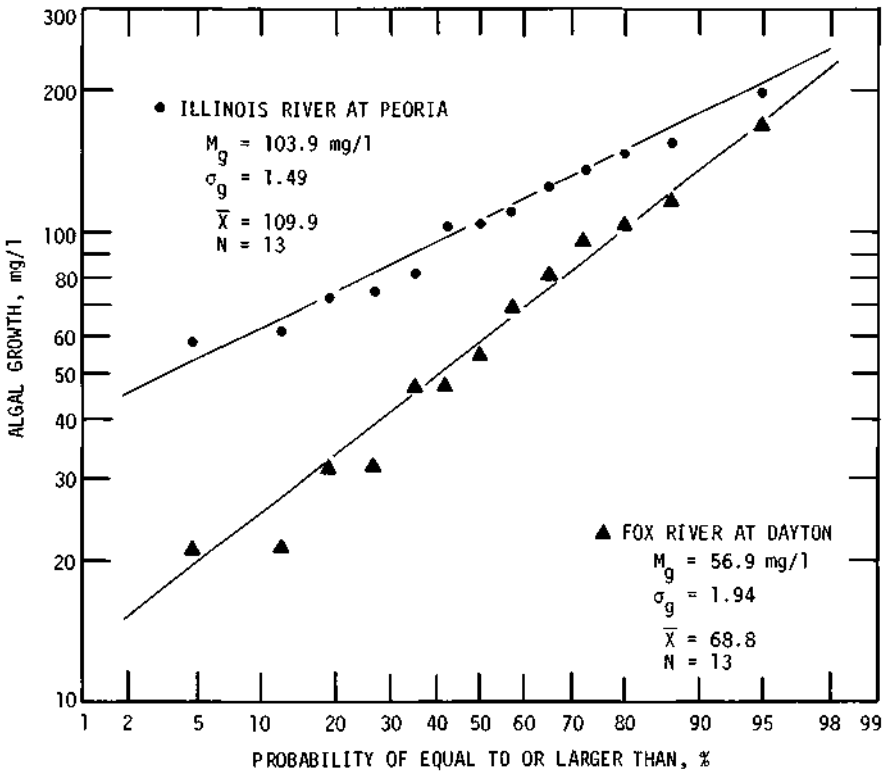

Figure 1. Algal growth for filtered samples

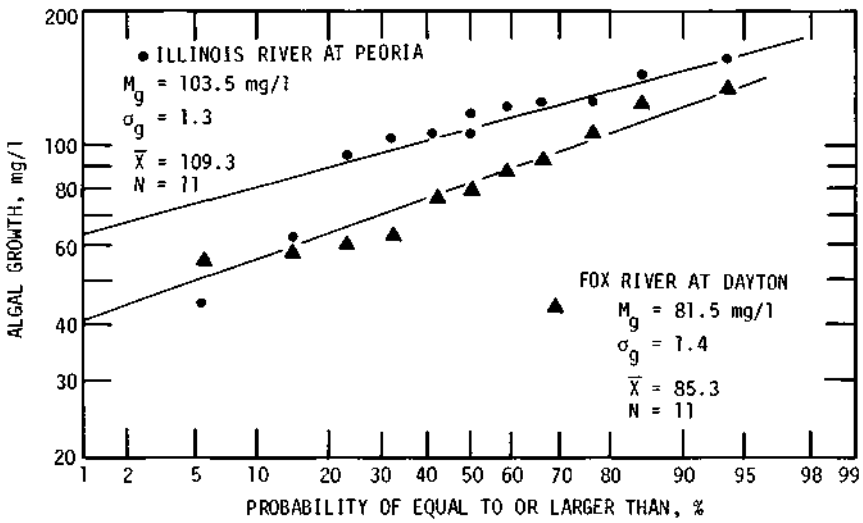

Figure 2. Algal growth for unfiltered samples

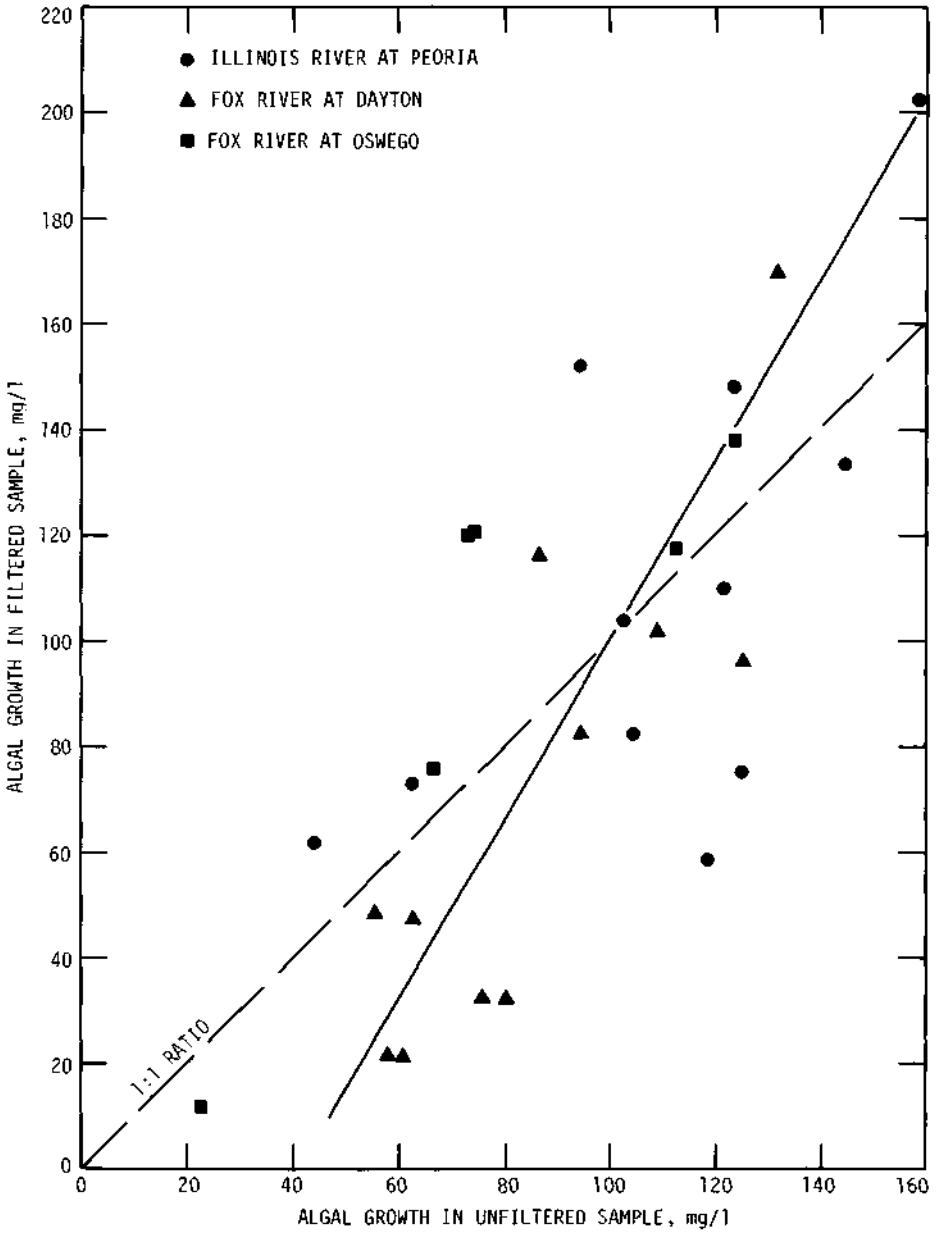

Figure 3. Algal growth in filtered samples versus unfiltered samples

that this hypothetical line was not the line of best fit indicates that turbidity was influencing algal growth. An algal growth of about 100 mg/1 appeared to be the turning point. Below 100 mg/1 most of the data points were below (right side) the hypothetical line, indicating algal growth in the unfiltered samples exceeded that in the filtered ones. When the algal growth was over 100 mg/1, the opposite trend was found.

The interpretation of this intriguing result is simply conjecture. The high algal growth occurred primarily in winter and early spring before spring rains. There was superrichness of plant nutrients in the water samples. Under optimum laboratory conditions, water turbidity might simply act as a light inhibitor and the shadowing effect thus reduce the algal growth in the unfiltered sample compared to the filtered one. The lower algal growth occurred in late spring and summer. During this period, higher water flow combined with higher biological activity in warm weather reduced plant nutrients dramatically. As previously mentioned, the unfiltered samples were autoclaved. This process may have resulted in a significant increase in plant nutrients and thus an increase of algal growth.

Some specific examples are depicted here to show the trend of algal growth along with turbidity. Three samples

Table 2. Algal Growth with Various Treatments

(Sample of 5/19/1972)

Sample	Treatment	Algal growth *(mg/l)*
Fox-Dayton	filtered	32.0
	unfiltered	80.0
	filtered + N+P*	31.0
	unfiltered + N+P*	184.8
	unfiltered + EDTA†	99.0
	unfiltered + cysteine†	95.0
Illinois-Peoria	filtered	73.0
	unfiltered	62.8
	filtered + N+P*	25.2
	unfiltered + N+P*	199.9
	unfiltered + EDTA†	81.9
	unfiltered + cysteine†	93.1

• Addition of 15 mg/l N and 2 mg/1 P
† Addition of 1 mg/l EDTA and cysteine

were obtained on February 8, 1972, well before spring rains (figure 4). The water turbidity in the Fox River was very low and there appeared to be little or no effect of algal growth with turbidity. In the Illinois River the turbidity was 10 times greater and a clear trend of decreasing algal growth with increasing turbidity occurred. On March 21, 1972, the algal growth in the filtered samples was even greater. As shown in figure 5, a sharp decrease of algal growth occurred with increasing turbidity in samples from both streams. On April 11, 1972, an opposite trend was observed. As shown in figure 6, a clear trend of increasing algal growth with increasing water turbidity occurred. On this occasion, the algal growth of the filtered sample was very low, as were soluble plant nutrients.

The effect of turbidity was also tested by spiking water samples with nutrients. For a specific case, as summarized in table 2, it was found that the addition of 15 mg/1 N and 2 mg/1 P did not enhance the algal growth in filtered samples, yet it greatly increased the algal biomass in the unfiltered sample. This phenomenon should be further studied before a meaningful conclusion can be reached. EDTA and cysteine were added with the idea that there might be a toxic material present in the unfiltered sample. Apparently this was not the case.

Tank Study Results

The results of the tank procedures are shown in figures 7 and 8. In the 2-week incubation period June 28 to July 12, 1972, the water temperature varied from 25 to 26 C in the 'river water' tank and from 23 to 25 C in the 'tap water' tank. There was no significant thermal stratification through the tank water depths. No visible algal growth was seen in the tank water, suggesting an effective suppression of algae by copper. In the 'tap water' (figure 7), there was a general trend of a gradual decrease in algal growth with depth. All four water samples depicted a near-parallel trend. This is probably due to the shadowing effect by the walls of the water tank. In other words, the deeper the location of the sample in the tank, the less light and the less algal growth.

In the river water tank (figure 8), the algal growth at the 4-inch depth was substantial, though not as high as that for a comparable depth in the tap water unit. At the 12-inch depth, the algal growth was reduced drastically, but was still measurable. At 20 inches, the algal growth stopped. Apparently the top 12 inches was the euphoric zone, even though the water turbidity was 104 Jtu.

The conditions for algal growth in the laboratory (table 2) were different from those in the tap water tank at the 4-inch depth (figure 7). The laboratory samples were illuminated continuously for 1 week, while the tank was subject to diurnal change for a period of 2 weeks. Nevertheless, for the same samples the algal growth results were comparable, as shown in table 3. The slight decrease of algal growth in the tap water tank compared with that in the laboratory can be expected because of variations in temperature, light intensity, incubation time, and light attenuation.

Field Results

As mentioned earlier, incubation of water samples under field procedures involved placing the samples in the Fox and Illinois River at a depth of 12 inches for 14 days. The field procedure was carried out during July 7-21, 1972. During this incubation period the turbidity in the Illinois River ranged from 78 to 87 Jtu, while the Fox River turbidity was considerably less, i.e., 20 to 35 Jtu. The results obtained were compared (table 4) with the 'river water' tank procedure

Table 3. Comparison of Algal Growth in Tap Water Tank (4-inch depth) and in Laboratory

(Sample of 5/19/1972)

Sample	Algal growth *(mg/l)* Tank	Laboratory
Fox, filtered	21.1	32.0
Fox, unfiltered	58.0	80.0
Illinois, filtered	61.6	73.0
Illinois, unfiltered	44.2	62.8

Table 4. Comparison of Algal Growth in River Water in Tank and in Rivers

(Sample of 5/19/1972)

Sample	Algal growth at 12-inch depth *(mg/l)* River tank	Illinois R.	Fox R.
Fox, filtered	0	5.8	4.7
Fox, unfiltered	15.5	8.2	25.8
Illinois, filtered	2.0	6.4	14.1
Illinois, unfiltered	7.0	9.9	29.3

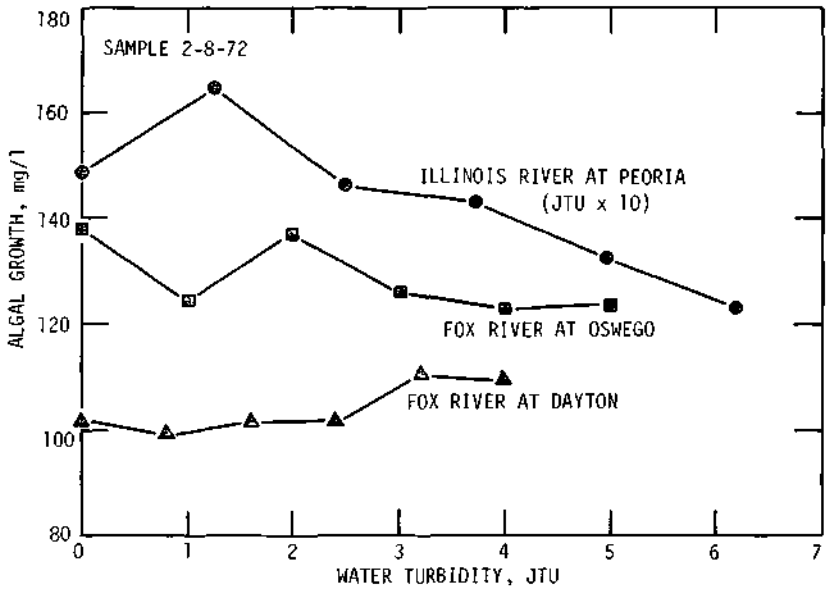

Figure 4. Algal growth in various water turbidities, sample of February 8, 1972

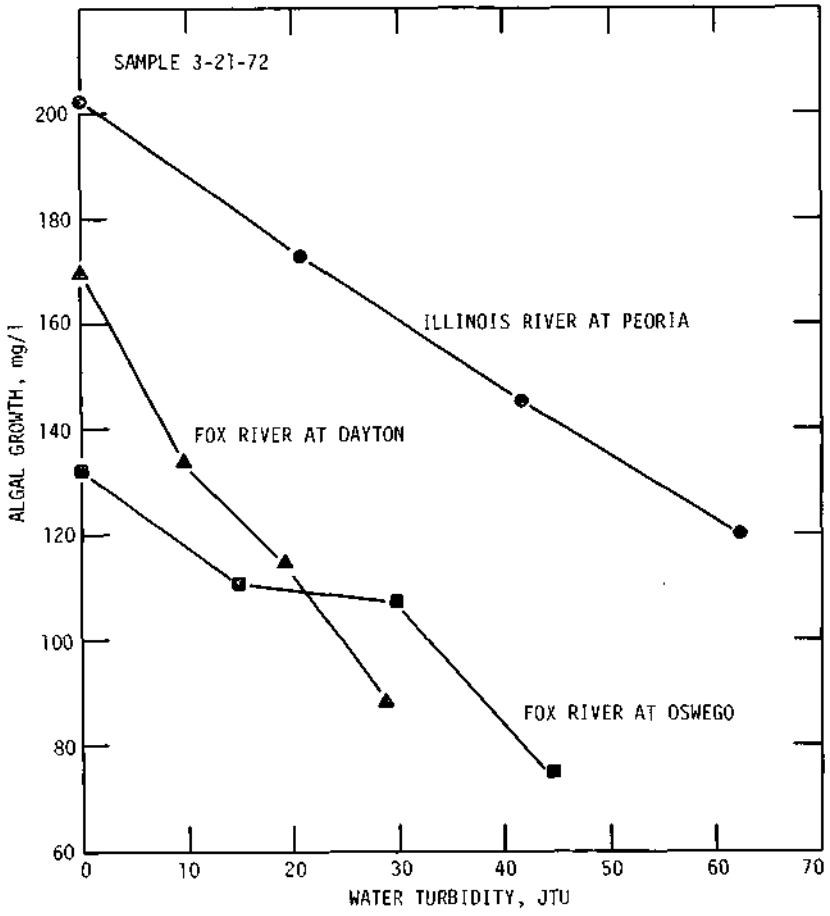

Figure 5. Algal growth in various water turbidities, sample of March 21, 1972

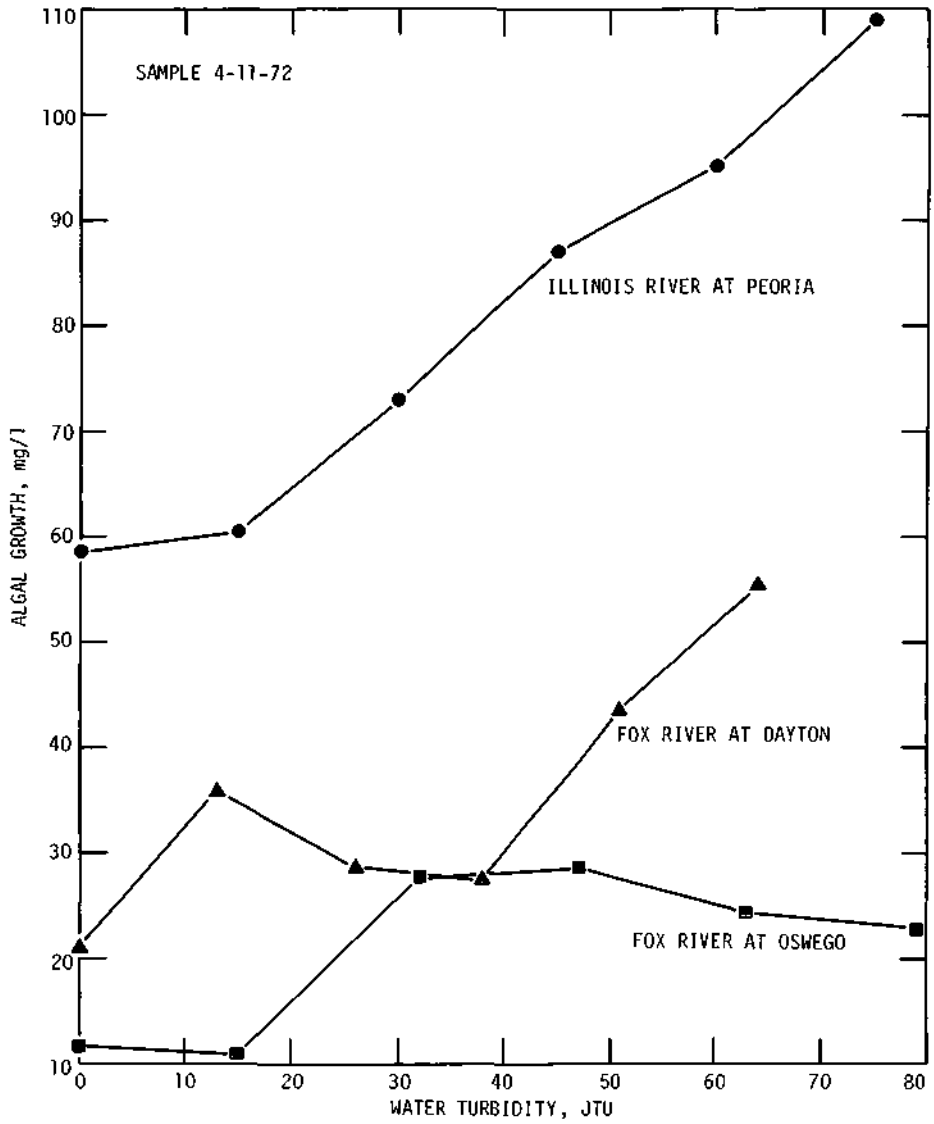

Figure 6. Algal growth in various water turbidities, sample of April 11, 1972

Table 5. Texture of Particulate Matter in River Water

(Sample of 3/21/1972)

	Particle size (μm)	Concentration suspended solids *(mg/l)*
Fox-Dayton	>63	0
	4-63	30
	0.45-4	50
	<0.45	400
Illinois-Peoria	>63	10
	4-63	0
	0.45-4	60
	<0.45	500

at the 12-inch depth. Except for the filtered Fox River sample, algal growth of the remaining samples was substantially greater, double to triple, in the Fox River than in the Illinois River. This quantitative difference in algal growth can only be due to the differences that existed in the turbidity of each stream. The slightly lower algal growth observed in the 'river water' tank compared to that *in situ* in the Illinois River was probably due to the shadowing effect of the tank wall and the higher water turbidity in the tank sample, i.e., 104 Jtu vs 78 to 87 Jtu.

The particle size distribution for the two rivers was determined by the method of Rukavina and Duncan[17] (table 5). The major fraction of particulate matter was in the range of

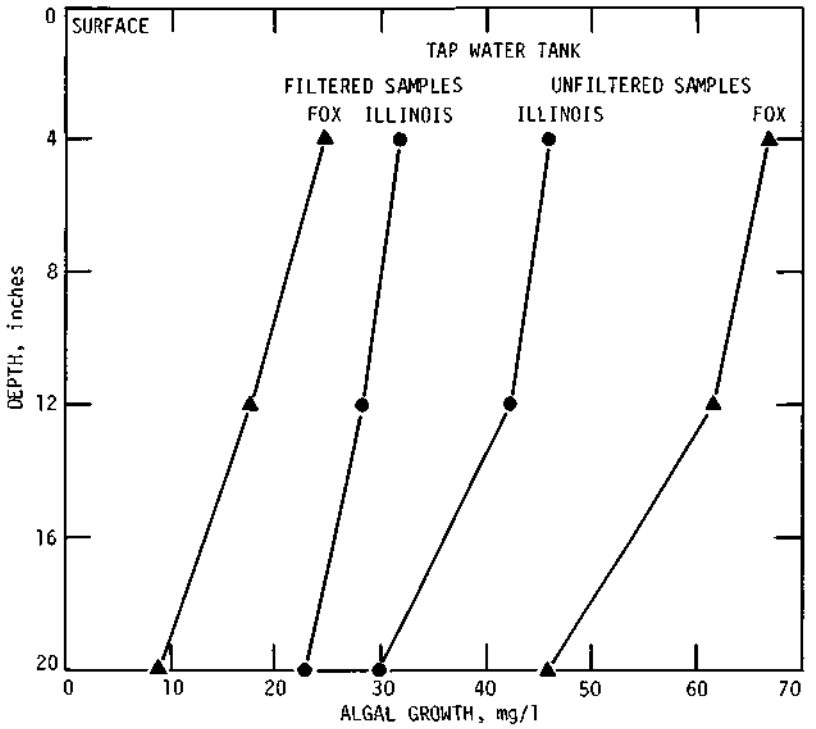

Figure 7. Algal growth in tap water tank, sample of May 19, 1972

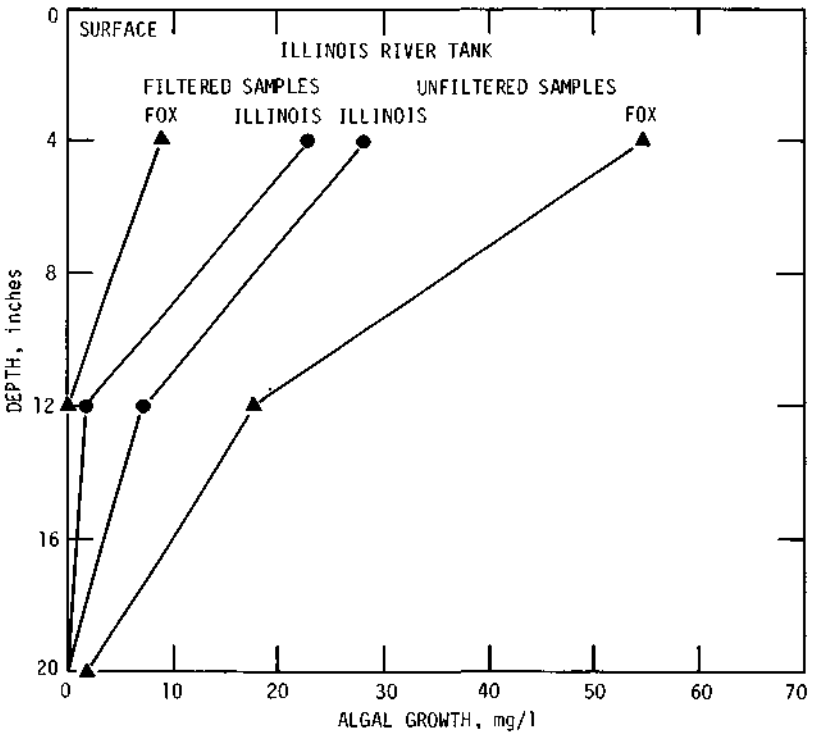

Figure 8. Algal growth in river water tank, sample of May 19, 1972

0.45 to 4 μm, coarse clay size particles. The Fox River contained a significant amount of silt, particle size 4 to 63 μm, while the Illinois River contained a small fraction of sand, particle size > 63 μm. The filtrate from a 0.45 μm membrane filter contained dissolved solids as well as fine clay size particles, 0.01 to 0.45 μm.

DISCUSSION

The major ecological effects of particulate matter[10] are 1) mechanical or abrasive action, 2) blanketing action or sedimentation, 3) reduction of light penetration, 4) surface habitat for growth of bacteria, fungi, etc., 5) adsorption and/or desorption of various chemicals, and 6) reduction of temperature fluctuation. Of these, light inhibition is considered the most important effect that particulate matter may exert on phytoplankton. This contention is based primarily on the results of *tank* and *field* experiments which clearly show here that the more turbid the water, the less the algal growth (figures 7 and 8 and table 4).

These results offer some explanation as to the differences in the occurrence of algal bloom in the Fox and the Illinois Rivers. Since both are flowing waters there is mixing of the waters generally from the surface to the bottom. In the case of the Illinois River, the obvious absence of an algal bloom does not mean there is no algal activity. On the contrary, there is some algal population in the surface euphotic zone.[18] In the absence of mixing, algae in the euphotic zone could continue to multiply to nuisance proportions. In reality, however, the euphotic zone is constantly being mixed and diluted with less algae populated waters from the deeper water strata, the aphotic zone. This mechanism lessens the probability of algae blooms. The Fox River, on the other hand, is less turbid and consequently has a deeper euphotic zone. The mixing of the water mass does not dilute the algal population to the extent that it does in the Illinois River. Thus a continuous growth of algae can and does occur in the Fox River.

It is known that certain toxic heavy metals are adsorbed on particulate matter. For example, the Illinois River sediment contains 19.1 mg/1 copper.[4] A hypothesis has been suggested that the adsorbed heavy metals may inhibit algal growth in the Illinois River, thus making the river void of algal bloom. This hypothesis is rejected from the following experimental results: 1) the addition of EDTA and cysteine did not significantly affect algal growth (table 2); 2) the addition of 15 mg/1 N and 2 mg/1 P greatly increased the algal growth in the unfiltered sample (table 2); and 3) in both *tank* and *field* experiments, the unfiltered sample showed an impressive algal increase under sufficient light (table 4).

Hynes[12] indicates that flow rate is an important ecological factor in a stream. "If the river flow greatly exceeds the planktonic multiplication rate, then there is no chance for plankton to accumulate simply because the algae are swept away faster than they can reproduce." This is not the case for the Illinois River. The river is a navigational system consisting essentially of 8 pools. In the summer during low flow, the water movement is sluggish and almost imperceptible compared with flows in the Fox River near Dayton and Oswego. This suggests the fallacy of the river flow as a controlling factor for algal growth in the Illinois River.

The following comparisons can be made between the Fox and Illinois Rivers. The Fox River is reasonably clear, while the Illinois River is always turbid. The Fox River has algal blooms and rooted plants in summer, while the Illinois River does not. Larvae Trichopetra and Dipetra are abundant in the Fox, but do not exist in the Illinois. The water color appears brownish and rich in organic and humic substance in the Fox, and appears typical clayish gray in the Illinois.

In an 8-month survey[19] of the Illinois River at Peoria Lake, mean turbidity values varied from 105 Jtu in the inlet to 89 Jtu at the outlet. The Secchi disc reading varied between 5 and 10 inches. In the tank experiment, the turbidity of the river water was 104 Jtu and the euphotic zone was found to be 12 inches. This value compares favorably with the euphotic zone of 13 inches that was determined by the light and dark bottle method in a water turbidity of 130 Jtu. The results from tank experiments (figure 8) strongly suggest a highly stratified biological structure in the water column. For example, the algal growth at a 12-inch depth is less than one-half that at the 4-inch depth, and at 20 inches, algal growth is practically zero.

There is evidence that particulate matter, under certain conditions, stimulates algal growth instead of retarding it. The membrane filtration of the Fox River water resulted in a sharp decrease of algal growth (table 2). The decrease is not due to the change of major nutrients, nitrogen and phosphorus, since supplementary additions of these nutrients did not have any effect. Cheng[5] demonstrated the same effect. He postulated that the particulate matter may be a source of micronutrients and organic matter because the addition of micronutrients restored the algal growth potential. Martin and Pfister[20] reported that particulate matter larger than 0.45 μm was stimulatory to certain microorganisms while particulate matter smaller than 0.45 μm was stimulatory in all cases. It should be mentioned that the

stimulation of algal growth by fine particulate matter is limited to a minute quantity of the particles.

The preceding discussion indicates that the experiments in *tank* and *field* should be put in a perspective different from experiments in the laboratory. Incubation of samples in the laboratory study was in an open system in which air could pass through the porous polyurethane foam plug into the Mason jar. In the tank and field experiments, incubation was performed in a closed system in which the closed bottles were submerged in water. The distinctively different results shown in figures 7 and 8, between the same water samples, can only be due to the effect of turbidity on algal growth. For example, the unfiltered Fox River water at 4, 12, and 20 inches supported algal growth of 66.8, 61.8, and 45.8 mg/1 in 'tap water' and 54.6, 17.6, and 1.8 mg/1 in 'river water.' In the laboratory experiment, the comparison between filtered and unfiltered samples may reflect an interaction between the shadowing effect of particulate matter as well as the possibility of other effects.

If the high turbidity of natural waters can effectively depress algal growth, this suggests a possible alternative for curbing nuisance algal blooms. Fitzgerald[21] suggested the use of aerobic lake muds for removal of phosphorus from lake water. A concurrent effect of applying lake muds will be the increase of water turbidity which may result in depressing algal growth. In fact, carbon black has been tested for the sole purpose of increasing water turbidity.[22] Other possible materials include clay, flyash, and dyestuff.

SUMMARY

The Fox and Illinois Rivers are excellent examples for a comparative algal growth study. Both are hypereutrophic, yet the Illinois is turbid and void of algal bloom while the Fox is clear and supports occasional algal blooms.

Under laboratory incubation, both river waters normally supported significant growth of algae. The unfiltered sample showed less algal growth than the filtered sample. This suggested a shadowing effect of particulate matter in the unfiltered sample. On the other hand, during a low nutrient period, the particulate matter in the unfiltered sample stimulated algal growth rather than retarded it. This suggests that the effect, inhibitory or stimulatory, may be related to the quantity of available nutrients in solution.

A tank experiment was made to compare algal growth in bottles immersed in tap water and river water. The retardation of algal growth by turbidity was clearly demonstrated in the 'river water' tank.

The algal growth in bottles incubated in the Fox River was two to three times greater than that for a similar arrangement in the Illinois River, except in one instance. This again demonstrated that water turbidity has an influence on algal growth.

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