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A Comparison of Periphyton Growth on Artificial and Natural Substrates in the Upper Spokane River

Abstract

The purpose of the study was to determine preferences of periphyton for glass or natural substrates. Colonization of benthic samplers (baskets) was conducted in the Spokane River from December 1979 to November 1981. Standing crops of periphyton were estimated by ash-free dry weight, chlorophyll *a* density, and microscopic enumeration. Samples from rock substrate showed higher absolute values of chlorophyll *a* and ash-free dry weight (56 percent and 76 percent, respectively) than those collected from the glass substrate. Dominant periphytic genera were *Fragilaria* and *Synedra* of the Bacillariophyta, *Microspora* of the Chlorophyta, and *Lyngbya* of the Cyanophyta.

Introduction

The Spokane River originates at the mouth of Coeur d'Alene Lake and flows west to the Columbia River. This study encompassed an area along the course of the river in the eastern portion of the Spokane River valley (Fig. 1). Ten sampling stations were established along this reach of the upper Spokane River, from Harvard Road to the inflow of Hangman Creek. Each station was selected as representing some land-use aspect of the river. Harvard I and Harvard II stations were in areas used for animal grazing and farming. Barker, Sullivan, Euclid, Plantes Ferry, and Upriver stations represent portions of the river that run through the suburbs of the City of Spokane. The stations at Greene Street, Gonzaga University, and Hangman Creek are located within Spokane city limits.

The study was conducted between December 1979 and November 1981 as part of a larger investigation of the water quality of the Spokane River (Funk *et al.* 1983, Gibbons *et al.* 1984). Ranges of water quality conditions are shown in Table 1. Individual measurements are on computer file at the Environmental Engineering Section at Washington State University. Phytoplankton and macroinvertebrates also were intensively monitored during the investigation, and discussion of those communities can be found in Notestine (1982) and Duffner (1983).

Periphyton (attached algae) represent the algae of a river system. According to Round (1964), probably over 90 percent of all algae species grow in an attached form. Periphyton are also relatively fixed with regard to their position in a river and there-

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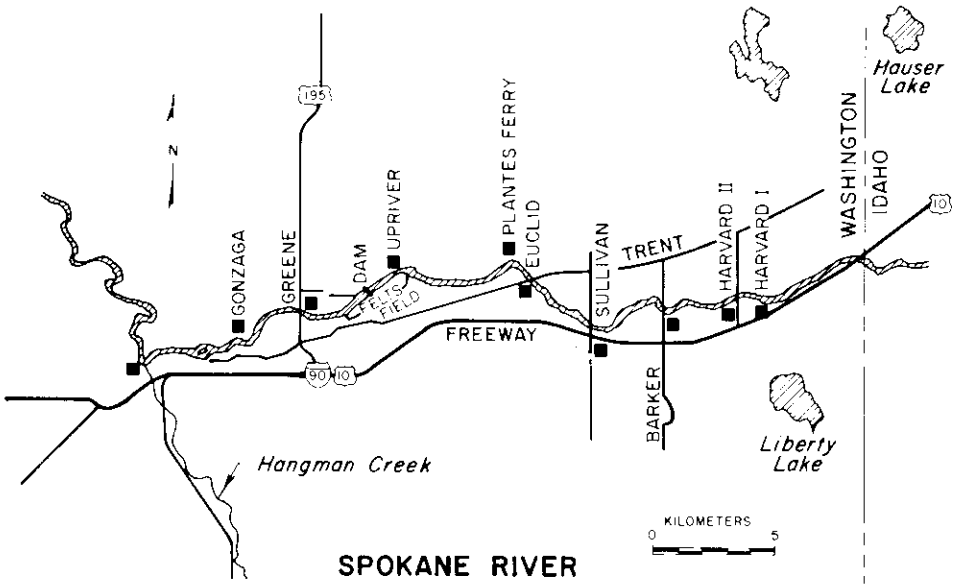

Figure 1. Upper Spokane River, from the Washington-Idaho stateline to Hangman Creek, with sites of sampling stations.

fore are more easily monitored than plankton, which are constantly being carried in and out of a study area by currents.

Periphyton are commonly regarded as indicators of water quality. They are valuable in these studies because they readily respond to changes in the aquatic environment. Chemical or physical measurements are useful parameters for describing water quality at a specific time, but an interpretation of the biomass and structure of a periphyton community exposed constantly to that water reflects the state of the environment on a long-term basis.

A number of studies have been conducted to compare periphyton growth on artificial (glass) and natural (rock) substrates. The conclusions regarding which substrate represents the better growing conditions for attached algae in a natural environment are

TABLE 1. Ranges of water quality parameters on the upper Spokane River, December 1979 to March 1981 (all values are mg/ℓ except as noted).

Parameter	Minimum	Maximum
Total Alkalinity (methyl orange alkalinity)	16.0	90.0
CO_2	0	3.0
Water Temperature (°C)	4.0	23.
Flow (ft^3/S)	20.0	620.0
NO_2-N	0.01	0.01
NO_3-N	0.02	0.88
NH_3-N	0.01	0.01
Total Phosphorus	0.01	0.05
BOD	<1.0	4.8
Total Copper (µg/ℓ)	<1.0	8.0
Total Nickel (µg/ℓ)	<5.0	22.0
Total Cadmium (µg/ℓ)	<1.0	7.0
Total Lead (µg/ℓ)	<5.0	70.0
Total Zinc (µg/ℓ)	25.0	235.0

often conflicting. Siver (1977) and Tett *et al.* (1978) contended that glass slides are colonized by different species of periphyton, with different densities, than the natural substrates; hence, glass slides used for periphyton colonization do not reflect the composition of naturally occurring algal communities. Patrick *et al.* (1954) stated that glass slides collected a representative sample of the species of diatoms of a river, and McIntire (1966) found similar species of algae on glass and rock substrates. Wetzel (1975) believed that the number of discrepencies found between algal populations on natural and artificial substrata were sufficiently large to necessitate a thorough evaluation for each study.

The primary objective in studying the periphyton of the upper Spokane River was to determine if periphyton demonstrated a preference in colonizing rock or glass substrates. In addition, an assessment was made of the potential impact of the substrate on the ecological condition of the periphyton community by examining chlorophyll *a*, ash-free dry weight concentrations, and algae associations.

Methods and Materials

The responsiveness of periphyton to glass and rock substrates and to the water quality conditions of the Spokane River was measured by chlorophyll *a* analysis, ash-free dry weight and community structure by identification-enumeration. Substrates for the periphyton growth were provided by placing three glass rods and one or two flattened rocks into barbecue baskets that were set in the river at a depth of one meter. The glass rods were 8 cm in length with an outside diameter of 10 mm. A surface area of 25 cm^2 was provided. When the baskets were retrieved, the three glass rods were scraped and the periphyton rinsed into sampling bottles, one each to be analyzed for chlorophyll *a*, ash-free dry weight, and identification-enumeration.

The rocks in the baskets were gathered from the immediate vicinity of the site and were considered to be representative of rocks that periphyton would colonize. Rocks were chosen that were flat on one side and about 10 cm wide and up to 20 cm in length. A plexiglass ring with a neoprene seal was used to delineate an area of 11 cm^2 on the rocks. From these areas the periphyton were scraped, rinsed and siphoned as a slurry via a vacuum flask into three test tubes, to be analyzed in the same manner as the samples from the glass rods (Fig. 2).

The baskets were retrieved every 6 weeks during the warmer months (May to September) and every 12 weeks during the colder months (October to April). Such time periods are deemed sufficient to allow for the development of stable communities (American Public Health Association 1976).

Results and Discussion

The most common algal group sampled on either substrate was diatoms. The dominant diatom was the genus *Synedra*; it was found in concentrations as high as 21,000 cells/mm^2 in the winter months and was present during all seasons. The second most common periphytic form, *Fragilaria*, was found in densities of up to 16,000 cells/mm^2 in the late summer and winter, although it occurred throughout the entire year.

Other common diatoms encountered in the Spokane River were *Achnanthes*, *Amphora*, *Asterionella*, *Cymbella*, *Diatoma*, *Gomphonema*, *Melosira*, *Navicula*, and *Tabellaria*. All but *Asterionella* and *Melosira* are known to be stalked or to affix to the sub-

strate by various attachment mechanisms (Smith 1933; Prescott 1962, 1978; Patrick 1966). The presence of *Asterionella* and *Melosira*, plankton diatoms, among the attached algae can be attributed to the cells settling out on the substrate during periods of declining populations and quiescent water.

Diatoms often are grouped by genera into associations. Common associations include *Gomphonema-Diatoma* (Hynes 1970) and *Achnanthes-Gomphonema Synedra* (Round

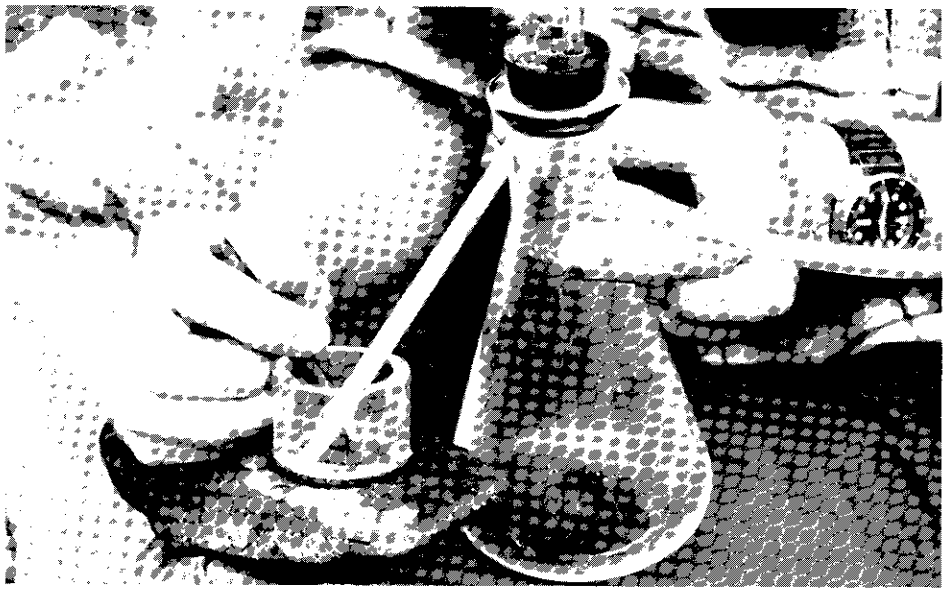

Figure 2. Aspirating device to remove periphyton from rock surfaces.

1965). The data presented in this study suggest that no associations exist between these genera in the Spokane River. This may be caused by the scouring of the river during high flow, the relatively high concentration of metals, or a combination of both factors.

Blue-green algae were the second most numerous group of algae encountered among the periphyton. The highest densities at all stations occurred during the summer months. On many occasions, *Lyngbya* was the only blue-green algae encountered, and when other blue-greens were present, *Lyngbya* made up the majority of cells.

Microspora was the most frequently encountered genus of the green algae found on the Spokane River. Other green algae observed included *Cladophora, Rhizoclonium* and *Ulothrix*.

According to Hynes (1970), green algae are expected to be a dominant periphyton group during the summer in a lotic environment. However, they were observed infrequently on the upper Spokane River. The high zinc concentrations encountered throughout the study period may have had an effect on the expected seasonal growth pattern of the Chlorophyta; further investigations are warranted. Earlier studies by Bartlett *et al.* (1974) showed complete inhibition of the test alga, *Selenastrum capricornutum,* by trace amounts of zinc.

Comparisons were made on the ash-free dry weight, chlorophyll *a* values, and the numbers of cells/cm^2 in the Bacillariophyta (diatom), Chlorophyta (green algae), and

Cyanophyta (blue-green) algae groups to determine if a preference was demonstrated for rocks or glass substrate. In addition, paired t-test (Huntsberger and Billingsley 1977) were conducted; the null hypothesis was that no selectivity for rocks or glass substrate was observed at the 95 percent confidence level except that to be expected by chance (Table 2). All data were normalized by base 10 logarithms (Bliss 1967).

TABLE 2. Summary of paired t-test for substrate preference.

Parameter Tested	Mean Difference	Variance	n	Calculated t	Table t	Reject Null Hypothesis
Ash-free dry weight	3.56 mg/cm²	2.07	62	5.42	2.00	Yes
Chlorophyll[a]	0.48 µg/cm²	1.39	65	2.13	2.00	Yes
Diatoms	-0.196 cells	2.22	55	-0.96	2.01	No
Green algae	-206 cells	10.55	48	-0.92	2.01	No
Blue-green algae	-918 cells	12.31	49	1.29	2.01	No

The densities of algae cells were higher on the rock substrate than on the glass substrate in 51 percent of the Cyanophyta samples, in 45 percent of the Bacillariophyta samples, and in 41 percent of the Chlorophyta samples. The paired t-test indicated that no significant difference was demonstrated in the numbers of cells of the major algae groups colonizing the rock or glass substrate. The rock substrate was observed to have higher chlorophyll *a* and ash-free dry weight concentrations than the glass substrate in 56 percent and 76 percent of the samples, respectively. The null hypothesis of the paired t-test was rejected for chlorophyll *a* and ash-free dry weight. These results indicate that periphyton colonized the substrates in a random fashion, but once established, they were better able to carry on primary production on the rock substrate than on the glass, as demonstrated by the higher ash-free dry weight and chlorophyll *a* values. The significantly greater amounts of ash-free dry weight and chlorophyll *a* on the rock substrate seems to indicate that the rougher rock substrate provides a more productive habitat for the algae. Periphyton can attach more easily to the rough rock than to the smooth glass, and interstices in the rock provide better havens from the scouring action of the current than the smooth glass. Horner and Welch (1981) found that growth increased with increased current until the velocity caused a severe shearing of the periphyton.

The periphyton measurements reinforce the results of earlier studies on the effect of flow on algal production. A dam creates a lentic situation at the Upriver station; at the other nine stations the river is characterized by a moderate to swift flow. At the Upriver station the rock substrate had more ash-free dry weight than the glass substrate on 61 percent of the samples; the chlorophyll *a* values were greater on the rock substrate in only 42 percent of the samples. At all other stations the rock substrate had higher ash-free dry weight and chlorophyll *a* concentrations than the glass substrate in 78 percent and 58 percent of the samples, respectively. That is, at a station where flow was not as great, there was less difference in periphyton production on rock versus glass substrates.

Summary

The study, conducted on the upper Spokane River to determine algae selectivity for artificial or natural substrate, indicated that the periphyton showed no definable difference in density between the algae colonizing glass and natural rock substrate. How-

ever, once the periphyton were attached to the rock substrate, they were able to attain a greater ash-free dry weight and chlorophyll *a* level than the same density of algae on the glass substrate. Hence, the periphyton on the rock substrate had an advantage over the periphyton on the glass substrate in the process of primary production. It appears that consideration of artificial substrate composed of glass would lead to underestimation of periphyton productivity in flowing waters.

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