STUDIES ON EPILITHIC ALGAL COMMUNITIES FROM GLASGOW STREAMS IN RELATION TO EPISODIC EVENTS AND DOMESTIC REFUSE

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ABSTRACT: Studies on epilithic algal communities from Glasgow streams in relation to episodic events and domestic refuse. Epilithic algal communities and their primary productivity in running waters of Glasgow streams were examined for 21 months. This work describes a detailed analysis of species diversity, chlorophyll biomass and primary productivity of epilithic algal communities representing unpolluted and polluted sites on the Allander Water and two sites on the Glazert Water. These are tributaries of the River Kelvin of Glasgow, Scotland, U.K. They receive different levels of the domestic effluent from Milngavie sewage works and Lennox Castle Hospital, respectively. Peaks of chlorophyll were found in late spring and early summer in both the waters. Phaeophytin concentration was low in both waters for most of the period and in polluted sites of Allander and Glazert water this represented on average 30%. Primary production reached a peak in May and was insignificant from December to February. Regression and correlation coefficient analysis were used to determine significant relationship of chlorophyll biomass and productivity values between each site during each month. Correlations were performed to indicate relations between these two variables and the results were found to be highly significant.

Key words: Epilithic algae, Allander and Glazert waters, primary production, chlorophyll biomass, Regression analyis.

RESUMO: Produtividade primária por comunidade de algas epiliticas de riachos de Glasgow poluídos pelos esgostos domésticos. As comunidades de algas epilíticas e sua produção primária em um sistema lótico de riacho de Glasgow foram analisadas durante 21 meses. Este trabalho descreve e detalha a diversidade das espécies, biomassa da clorofila e a produção primária das comunidades epilíticas não poluídas e poluídas situadas no Allander Water e no Glazert Water. Estes são tributários do Rio Kelvin em Glasgow, Scotland, U.K. As águas lóticas recebem esgotos domésticos do Milngavie e Hospital de Lennox Castle. A biomassa de clorofila atingiu o nível máximo durante o final da primavera e o início do verão em ambos locais. O nível de feofitina foi baixo nas estações não poluídas durante a maior parte do tempo, embora ela tenha atingido até 30% em média nas estações poluídas de Allander e Glazert. A produção primária atingiu o máximo no mês de maio e foi insignificante entre o meses de dezembro à fevereiro. A análise de regressão e o coeficiente de correlação foram testados estatisticamente a fim de relacionar biomassa de clorofila e produção primária, e foram altamente significativos.

Palavras chave: Algas epilithicas, Águas de Allander e Glazert, produção primária, biomassa da clorofila, Análise regressão.

INTRODUCTION

The distribution of algal communities in lotic ecosystems is determined by several factors, including light, temperature, current velocity, suspended solids, inorganic nutrients and herbivory. In recent years, it was strongly emphasised that an intermediate disturbance such as less light, strong currents and greater loads of suspended and transported matter creating the localised turbulence consequently high turbidity which were collectively responsible for the reduction of species diversity and the rate of primary production. This is especially true for sessile epilithic algal communities because they can-not avoid high-shear-stress and low flow habitats on the river heed. The effects have been very well recorded for lacustrine phytoplankton (Padisak et al., 1993; Reynolds et al.,1993; Calijuri & Dos Santos, 1996) and riverine Phytoplankton (Peterson et al., 1990). The impact of nutrient enrichment on the changing biotic nature of lotic ecosystems is well documented and has been shown to be important in the distribution of algal communities (Whitton & Crisp, 1984) The contribution of filamentous green algae to the biomass of running waters was clearly demonstrated in epilithic form of periphyton (Hynes, 1970). At the same time the development of dense mats of filamentous algae occupying the stony substrata withstand the high shear stress of current velocity without any reduction in chlorophyll biomass and productivity. Morgan (1987) and Carpenter & Durham (1985) found nutrient effect on increased species diversity, Chlorophyll biomass and Primary productivity for periphytic and phytoplanktonic algae in rivers as overwhelming influence. Chellappa (1996) described a detailed analysis of freshwater stream algal communities in relation to different degrees of domestic sewage load on Glasgow streams and demonstrated the reduction of species diversity, chlorophyll *a* content in relation to the quantity of ammonia-nitrogen. A comparison was made only between different sites and different communities.

The aims of our present paper were to understand the species diversity, chlorophyll biomass and primary productivity of algal epilithic communities of Glasgow streams for 21 months and to study how community structure are related to current velocity and discharge rates for short-term changes and nutrients effect emanated from domestic sewage wastes for long-term effect.

DESCRIPTION OF SITES: The Allander and Glazert Water at the study sites are third order streams. The Allander Water was sampled at an upstream site 8Km from the sewage works (AW1) (NGR NS 738 768) and at polluted site (AW2), 2Km below the point source of pollution (NGR NS 575 729). The major cause of pollution in this river is the discharge from Milngavie sewage works. The Glazert Water was sampled at two sites, upstream of the Nailworks Burn (GW1) (National Grid Reference (NGR) NS 619 783) and downstream (GW2) (NGR NS 633 771). Pollution in the Glazert Water arises from the Lennox Castle Hospital, which discharges an organically rich effluent. The map of the sampling stations and the flow characteristics and discharge rates of water for Allander and Glazert are presented in Fig. 1 and Tab. I. The detailed description of sampling stations are given by Chellappa (1996).

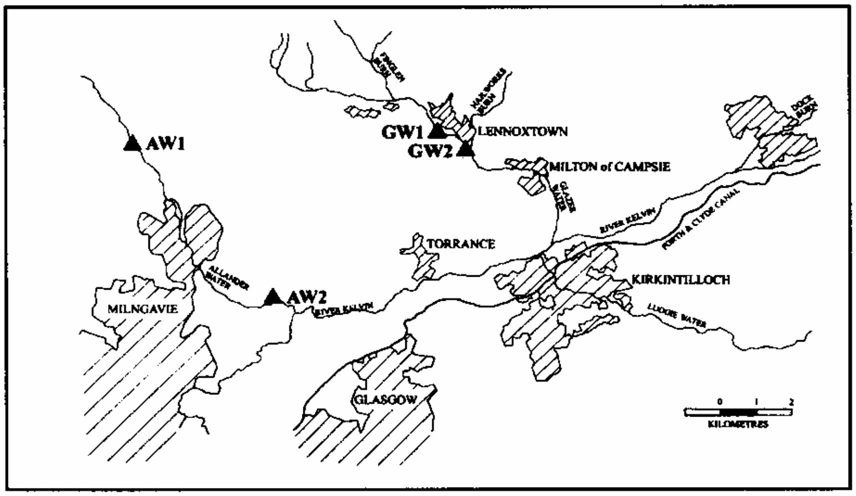

Figura 1. Map of the sampling stations

Table I. Catchment area and flow characteristics of Allander Water and Glazert Water AW1 is situated 8 Km upstream and AW2 2 Km Downstream from the gauging station. GW1 is 2 Km and GW2 1 Km upstream from the gauging station

	Allander Water		Glazert Water	
	Discharge ($m^3 sec^{-1}$)	Mean water velocity ($m\ sec^{-1}$)	Discharge ($m^3 sec^{-1}$)	Mean water velocity ($m\ sec^{-1}$)
Long term average (May-June & Dec – Feb, 1985 & 1986 –10 months data)	1.2	0.36	1.7	0.25
Maximum recorded (Jun/ 85)	53.8	8.3	71.2	6.47
Minimum recorder	0.006	0.005	0.05	0.02
1986 Values:				
average	1.8	0.54	2.5	0.37
maximum	45.2	6.9	54.1	4.9
minimum	0.062	0.05	0.141	0.06
Catchment area (Km^2)	32.8		51.9	
Width of stream (m) at gauging station	6.3		8.6	

MATERIALS AND METHODS

The study was conducted for 21 consecutive months (October 1984 to June 1986). On each occasion temperature and dissolved oxygen were recorded at the sites using Oxymeter LH860. Sampling was done simultaneously and between 9.00-10AM covering a distance of 20 Km. Analytical techniques of physico-chemical parameters followed the titrometric methods those of Mackereth, et. al. (1978). Samples of stone containing with and without (as control) adherence of *Oedogonium* were used for measurement of epilithic algal communities. At all sites the bed of the stream were stony. The sampling sites were chosen to best determine the effects on the epilithic algae of the discharge rate (1.2 $m^3.sec.^{-1}$ for Allander waters and 1.7 $m^3.sec.^{-1}$ for Glazert waters.) Samplings were made from the recommendations used for clumped samplings procedure of community ecology procedures. Clumping suggests that the species be aggregated in more favourable parts and due to environmental heterogeneity (Ludwig & Reynolds, 1988). Samples of algae were scrapped in triplicates from 30 mm^2 (3,0 cm^2) of three different stone surface with a scalpel blade from the unshaded area and the slurry was collected and made up to a known volume (100 ml water previously sterilised). It was then transported to the laboratory in wide mouth glass jars. One ml of suspension of an aliquot of the algal samples were transferred into Sedgwick-Rafter counting cells for quantitative measurements, carefully mixed and the cells in an aliquot counted using a compound microscope and results are expressed as cells mm^{-2}. Identifications were according to Anagnostidis & Komárek (1986), Desikachary, (1959), Hustedt (1930), Lind & Brook (1980) and Prescott (1951). Species diversity measured in the present study included two components a) number of individuals of species in each samplings (diversity) and b) species evenness (species abundance) and were calculated according to Shannon-Weaver (1949) from Log_{10} data. Bicudo (1990) work was used for some aspects of tropical periphytic algal comparisons.

The measurements of chlorophyll *a* for each community were made in triplicates following the recommendations of Riemann (1980) and Marker et al. (1980). The calculation of Lorenzen (1967) was used to obtain the values of chlorophyll a and phaeopigment, expressed as $mg.cm^{-2}$ for epilithic algae. The stones containing epilithic algae collected from triplicates were introduced into the wide mouthed light and dark bottles for radioactive carbon-14 method to estimate primary production in triplicates. Light (3) and dark (3) bottles, each containing stone with algae from the respective site, were filled with water from the site of collection and inoculated with 1 ml ^{14}C ($3mC.ml^{-1}$) in the form of sodium bicarbonate. The bottles were properly incubated at their respective site for a 3 hours. Upon return to lab known areas of rock surfaces were scrubbed with clean distilled water and the total volume of epilithic suspension recorded. Two 5 ml subsamples of the suspension were filtered onto Millipore filters (0,45mm), rinsed with distilled water, dried and the ^{14}C activity determined using a Beckman LS 7000 scintillation

:ounter. The area of rock cleaned was determined by moulding aluminium foil)ver the rock and using an Apple computer to calculate the area of the foil in cm^2. Finally productivity was estimated as mg $C.cm^{-2}$ for epilithic algae. The radioactivity on the filters was determined Glasgow University Radiobiology Unit.

Statistical analyses were performed using Statigraph version 6.0 programme. A simple regression analysis was performed between dependent variable (Chlorophyll *a*) and independent variable (Primary productivity) for epilithic algae. Results were considered significant by applying 99 (0.01) percent levels of probability.

RESULTS

Environmental Parameters

Temperature differences between stations were small, while seasonal variation was very marked ranging from sub-zero temperature in winter to 14.5°C in summer (Fig. 2 a). The sub-zero temperatures in January and February 1985 and 1986 caused ice to be formed on the margins of both Allander and Glazert Waters. pH of Allander Waters range about neutrality (Fig 2b) with means of 7.14 and 7.03 respectively for AW1 and AW2, whereas Glazert Waters (GW2) were acidic (Fig. 2b) (pH means of 6.89 and 6.76 respectively for GW1 and GW2). In both rivers pH was slightly more acidic in winter than in summer.

Dissolved oxygen showed a distinct seasonal variation (Fig. 2c). At the unpolluted sites AW1 and GW1, dissolved oxygen varied from minimum values of 7.5-9.5 to maximum values of 13.5-14.4 mg l^{-1}. At the polluted sites AW2 and GW2, dissolved oxygen was considerably reduced with values as low as 1.7-2.4 and maximum values of only 6.25-7.8 mg l^{-1}. At AW1 oxygen saturation was 90-100% throughout the period of sampling. At GW1 oxygen saturation was 90-100% throughout most of the study period but was reduced to 42-53% during the late summer of 1985. At AW2 and GW2 oxygen saturation was 40-50% in winter and fell to 16-23% in summer.

Biological oxygen demand (BOD) is most widely used when pollution is of organic origin and is useful for evaluating streams perturbed with domestic sewage. At the clean sites of AW1 and GW1 the mean values of BOD were 3.6-3.8 mg O_2 l^{-1} compared with downstream sites (AW2 and GW2) where BOD reached as high as 8.8-10.1 mg O_2 l^{-1}. BOD is strongly influenced by water temperature in both Allander and Glazert Waters (Fig. 2d).

Nitrate-nitrogen concentrations were highest during winter at polluted sites (AW2 and GW2) may be due to leaching from farm land and in the spring, prior to stream algal increase in unpolluted sites (AW1 and GW1). The decline through the spring and summer was gradual at all four sites with the lowest concentrations being in late July. The rise in nitrate over the winter corresponded to minimum biological activity and maximum flow rates (Fig 2e). Increase or decrease of nitrate did not show any correlation with oxygen saturation but showed distinct inverse correlation with orthophosphate concentration. This could be explained with the differential resource utilisation by epilithic algal communities.

The ammonia nitrogen concentration remained low at AW1 throughout the sampling period (range 18-96 $\mu g\ l^{-1}$) with only a small increase in spring (Fig 2f). At AW2 ammonia concentration was very much higher (range 77-1860 $\mu g\ l^{-1}$) with a very rapid increase in March of each year followed by a moderately slow decline throughout the summer. This peak was associated with the onset of a decline of oxygen and in nitrate concentrations which provides evidence that although most of the ammonia must have originated directly from allochthonous sources, some resulted from bacterial reduction of nitrate. The ammonia concentration in GW showed a similar seasonal pattern at both sites , and was roughly similar to AW2, although the seasonal pattern was not so clearly shown.

In both Allander and Glazert Waters (Fig 2g), soluble reactive silicate (SRS) concentrations followed a cyclic seasonal distribution, with high winter values being reduced in spring followed by a gradual increase in summer and a moderate decline in autumn before recovering in winter.

Orthophosphate phosphorus in Allander and Glazert Waters (Fig 2h) was low (gradual decline) in winter (10-25 $\mu g\ l^{-1}$), but increased steadily after summer in the year 1985 to reach a maximum in summer of 1986 (55-107 $\mu g\ l^{-1}$) Autumnal orthophosphate content was low in GW1, moderate in AW1 and GW2 and high in AW2.]

Epilithic algal community

The detailed algal lists of epilithic algae of all four sites have been presented in Tab. II. Since more than 85% of the rocks, stones and pebbles were covered with the filamentous Chlorophyceae, *Oedogonium*, *Stigeoclonium*, *Microthamnion* and *Cladophora*, which limited the growth of the majority of other smaller forms. The collections were restricted to stony substrate where the macrophytes almost absent. The current over the study area was usually slight, excepting on one occasion (June 1985) when a torrential rain and flood episodes was registered. The epilithic algal community developments indicate that horizontally positioned monoraphid forms (*Cocconeis, Achnanthes* and *Navicula*) were first to colonize substrata in both high and low water velocity areas before the domination of filamentous green algae and vertically positioned diatoms (*Gomphonema, Nitzschia* and *Cymbella*) Subsequently, the current velocity reduced the growth of pennate diatoms, and a chrysophyte alga *Dinobryon divergens,* the other representative forms of this community, while permitting a few species to adhere on to the mucilage of *Oedogonium*. The distribution of *Oedogonium* in AW2 was overwhelming, out competing all other algae and producing higher chlorophyll values during summer months. The quantitative data based on number counts in Sedgwick-Rafter cells did-not help much in differentiating the filamentous forms and unicellular forms.

The species abundance in epilithic algal communities was represented by the species diversity index based on the quantitative enumeration. The mean value of the data presented in Fig. 3 of epilithic algae combines both species diversity and evenness into a single value (bits). Diversity in Allander waters (AW1 and

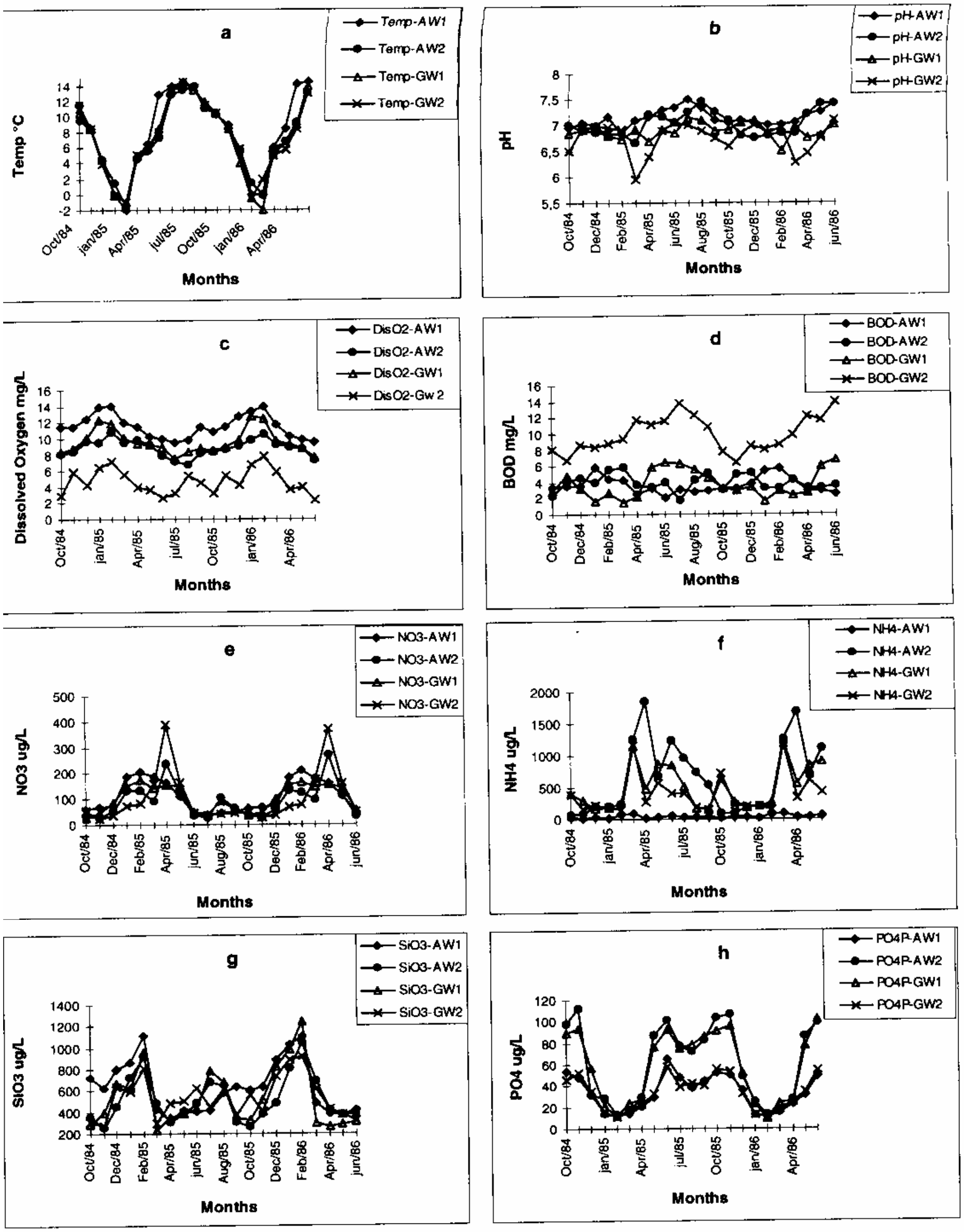

Figure 2: Seasonal variations in water chemistry of Allander (AW1 and AW2) and Glazert Waters (GW1 and GW2). a – Temperature; b – pH; c – Dissolved Oxygen; d – BOD; e – Nitrate-nitrogen; f – Ammoniacal-nitrogen; g – Soluble Reactive Silica (SRS); h – Orthophosphate

AW2) was higher than Glazert Water (GW1 and GW2) with the maxima during June and July in 1986 and the sharp reduction observed in June 1985 in AW2 was associated with flash floods (episodic event). Current velocity and discharge rates have not been recorded at regular intervals. The mean value given in Table 1 represents the pooled average of 8 months which was taken as long-term effects and single value for June 1985 during that time flash flood occurred. The reduction in species diversity observed in site GW2, which stayed between 0.3 to 0.8 was

Table II: List of Epilithic algal species recorded in Allander and Glazert Waters of River Kelvin of Glasgow between October 1984 and June 1986.

Taxon	Site			
	AW1	AW2	GW1	GW2
Bacillariophyceae				
Centrales				
Cyclotella meneghiniana Kutz.	+	+	+	+
Pennales				
Tabellaria fenestrata var. *asterionelloides* Grun.	+	+	+	+
T. flocculosa (Roth) Kutz.	+	+	+	
Fragillaria constuens (Ehr.) Grun.	+	+	+	+
Ceratoneis arcus	+	+	+	+
Synedra ulna (Nit.) Ehr.	+	+		
S. acus Kutz.		+	+	+
Meridion circulare (Grev.) Ag.	+	+	+	+
Amphipleura pellucida Kutz.	+	+		
Navicula cuspidata Kutz.	+	+	+	+
N. elegans Wm.Smith	+	+	+	
Nitzschia linearis Wm.Smith	+	+	+	+
Eunotia exigua (Bréb)Rabh.	+	+	+	
Pinnularia divergentissima (Grun.) Ralf.	+	+	+	+
P. viridis Ag.		+		
P. stauroptera (Grun.) Rabh.	+	+		
Amphora ovalis Kutz.	+	+	+	+
Cymbella prostrata (Berk.) Brun.	+		+	
Gomphonema acuminatum var. *coronata* Rabh.	+	+	+	+
G. intricatum Kutz.		+		
G. parvulum Kutz.		+	+	
Cocconeis pediculus Kutz.	+	+	+	+
C. diminuta Pant.			+	+
Mastogloia smithii var. *lacustris* Grun.		+	+	+
Surirella biseriata Bréb.	+	+	+	+
S. ovata Kütz.	+	+		
Achnanthes lanceolata (Bréb.) Grun.	+	+	+	+
A. brevipes Ag.	+		+	
Gyrosigma kutzingii Grun.	+	+	+	+
Ceratoneis arcus (Ehr.) Kutz.	+	+	+	+
Cyanophyceae				
Stichosiphon regularis Geit.	+		+	+
Oscillatoria sp..	+		+	
Leptolyngbya gloeophila Borzi. (*Plectonema gloeophilum* Borzi)			+	+
Pseudanabaena arcuata Skuja. (*Phormidium arcuata* Skuja)			+	
Chlorophyceae				
Closteriopsis longissima Lemm.	+		+	+
Closterium moniliforme (Bory) Ehr.	+	+	+	+
Staurastrum capitulum Breb.		+		
Cosmarium costatum W & G.S.West	+	+	+	+
Hormidium sp.	+			
Oedogonium sp.	+	+	+	+
Mougeotia sp.	+		+	
Stigeoclonium sp.	+	+		
Microthamnion sp.	+			
Cladophora sp.	+	+	+	
Euglenophyceae				
Euglena sp.		+		+
Trachelomonas sp.			+	+
Chrysophyceae				
Bumilleriopsis sp.	+			
Dinobryon divergens Imhof	+		+	

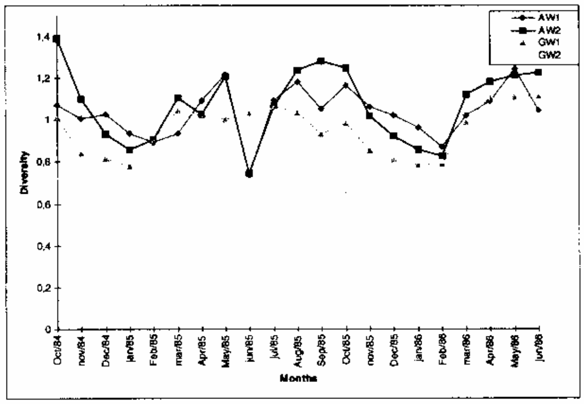

Figura 3: Seasonal Variation in Species Diversity of Epilithic Microalgal of Allander (AW1, AW2) and Glazeert (GW1, GW2) waters of Glasgow Streams

largely due to effects hospital wastes arises from the Lennox Castle hospital.

Figure 4 indicates clearly that both chlorophyll *a* concentrations and primary productivity rates varied greatly during 21 months but their seasonal cycle remained the same with summer maxima and winter minima for all four sites (AW1, AW2, GW1 and GW2) . The higher values obtained in AW1, AW2 and GW2 was due to the predominance of filamentous green alga, *Oedogonium*, which contributed a three to four fold increase during summer. Phaeopigment was also higher during the winter months (26-39%) in the epilithic community. The collapse of the algal flora during summer time (July 1985) was caused by unusually high rainfall around the Glasgow area thus increasing the rate of flow rate enormously and also the turbidity. The decrease was slightly recovered during the month of September. On the contrary, the flow rate was normal in GW1 and therefore did not interfere with chlorophyll and primary productivity

Tabs. III-VI demonstrate that the correlation between chlorophyll biomass and primary productivity data of AW1, AW2, GW1 and GW2 respectively and all of them uniformly confirmed high level of statistical significance (N=21; df = 20; P = 0.000).

DISCUSSION

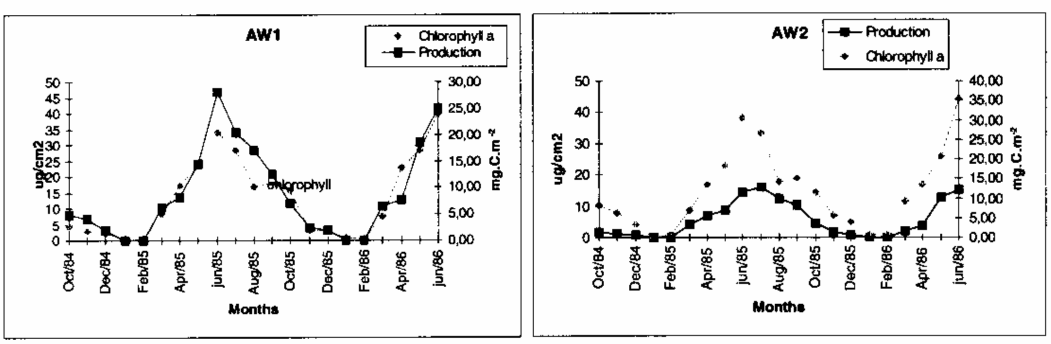

Figura 4a: Seasonal Variation in Epilithic Microalgal Chlorophyll and Productivity of Allander (AW1, AW2) waters of Glasgow streams.

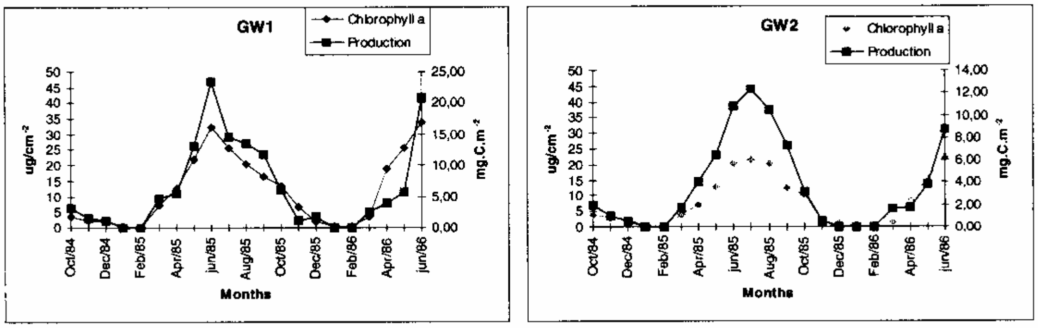

Figura 4b: Seasonal Variation in Epilithic Microalgal Chlorophyll and Productivity of Glazert (GW1, GW2) waters of Glasgow streams.

Table III: Results of regression analysis between Chlorophyll biomass and primary production of Allander water (AW1)

Dependent variable: Chlorophyll biomass		Independent variable: Primary production		
Parameter	Estimate	Standard error	T value	Probability level
Intercept	1.15492	1.32238	0.873369	.39337
Slope	1.36695	0.108227	12.6305	.0000

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	Probability level
Model					.0000
	2753.4123	1	2753.4123	159.529	
Residual					
Total (Corr.)	327.93341	19	17.25965		
	3081.3457	20			

Correlation Coefficient = 0.945291 R — squares = 89.36 percent
Standard Error of Est. = 4.15447 P > 0.000

Table IV: Results of regression analysis between Chlorophyll biomass and primary production of Allander water (AW2)

Dependent variable: Chlorophyll biomass		Independent variable: Primary production		
Parameter	Estimate	Standard error	T value	Probability level
Intercept	2.42308	1.17867	2.05576	.05381
Slope	1.64558	0.149746	10.9891	.00000

Analysis of Variance

Source	Sum of Squares	DF	Mean Square	F-Ratio	Probability level
Model	1756.4738				.00000
		1	1756.4738	120.761	
Residual	276.35572				
Total (Corr.)	2032.8295	19	14.54504		
		20			

Correlation Coefficient = 0.929545 R — squares = 86.41 percent
Standard Error of Est. = 3.8138 P > 0.000

Table V: Results of regression analysis between Chlorophyll biomass and primary production of Glazert water (GW1).

Dependent variable: Chlorophyll biomass		Independent variable: Primary production			
Parameter	Estimate	Standard error		T value	Probability level
Intercept	1.35037	0.789411		1.7106	.10343
Slope	1.8463	0.146721		12.5837	.00000
Analysis of Variance					
Source	Sum of Squares	DF	Mean Square	F-Ratio	Probability level
Model	1122.2972	1	1122.2972	158.351	.00000
Residual	134.66088	19	7.08741		
Total (Corr.)	1256.9581	20			

Correlation Coefficient = 0.944917   R — squares = 89.29 percent
Standard Error of Est. = 2.66222   P > 0.000

Table VI: Results of regression analysis between Chlorophyll biomass and primary production of Glazert (GW2)

Dependent variable: Chlorophyll biomass		Independent variable: Primary production			
Parameter	Estimate	Standard error		T value	Probability level
Intercept	4.22655	1.84297		2.29334	.03340
Slope	1.11735	0.195897		5.70378	.00002
Analysis of Variance					
Source	Sum of Squares	DF	Mean Square	F-Ratio	Probability level
Model	1236.9903	1	1236.9903	32.533	.00002
Residual	722.42785	19	38.02252		
Total (Corr.)	1959.4181	20			

Correlation Coefficient = 0.794547   R — squares = 63.13 percent
Standard Error of Est. = 6.16624   P > 0.000

The results of the present work are discussed within the framework of the questions which we addressed in the introduction as short-term effect of current velocity and discharge rate and the long-term effect of inorganic nutrients on species diversity, chlorophyll biomass and primary productivity. Epilithic microalgal communities provide an excellent model system for studying the pollution effect as well as effects of current disturbance on the structure and function in lotic aquatic ecosystems. Acs & Kiss (1993) working with periphyton on artificial substrates in River Danube showed by principal component analysis that algal abundance is closely correlated with water discharge in a river, with flood episodes of high discharge being most important in dislodging algae. The results of their study are similar to the theory of intermediary disturbance hypothesis, which show high diversity of algal species as a result of intermediary disturbance and low diversity attributed to too low or too high frequency disturbance. However the flow regime experienced by epilithic algae in Allander and Glazert Waters, associated with the substratum of the river where drag effect (where the streams take diverted course) will significantly slow down water velocity even at times of flood, therefore, did not dislodge the filamentous green alga, *Oedogonium* and removed only some of the epiphytic diatoms found attached to this alga. The results partly in agreement with Biggs & Thomsen, (1995) report on perturbation effect on stream periphyton. In this study daily discharge data were not available for analysis, but analysis based on cumulative data provide strong evidence that there was a reduction in species diversity index, chlorophyll biomass and primary productivity during winter months of 1985 and 1986 in all four stations. The flow rate also affected species diversity index of site AW2 in July 1985 during the time when flash flood was recorded in Glasgow area. This change in trophic structure of the community from herbivore based to detritus based in the organically enriched streams lead to further change in different species indicating differing conditions (Turner & Barr, 1989).

We found some algae, such as *Nitzschia linearis*, *Ceratoneis arcus*, *Euglena*, and *Trachelomonas* to be widely distributed at the polluted site (GW2) and at the other three sampling stations. Other algal species, such as *Tabellaria fenestrata* var. *asterionelloides*, *Synedra ulna*, *Gomphonema acuminatus*, *Dinobryon divergens*, and *Oscillatoria sp.* were found repeatedly only at AW1, AW2 and GW1. *Oedogonium*, *Pinnularia*, *Mastogloia*, *Meridion circulare*, *Achnanthes lanceolata* and *Cyclotella meneghiniana* were also distributed more or less throughout the annual cycle except for a brief absence in the winter months. Conversely the following algae are seasonal in their distribution and dominate for a short period in spring or autumn: *Oscillatoria* sp., *Ceratoneis arcus*, *Cymbella ventricosa* and *Amphora ovalis*, *Dinobryon divergens*, and *Fragilaria constuens* appeared during late autumn. The higher silica content in winter and its lower level in spring observed in the present study followed the similar pattern established by Moss (1981) and Goltermann (1975). Silicate depletion in water is primarily the result of diatom productivity in spring (Esteves, 1988). Blue green algae were widely distributed in the streams during summer and autumn with a peak of *Oscillatoria* in late spring to early summer and *Anabaena* and *Coelosphaerium kuetzingianum* as planktonic algae during late summer to autumn; this pattern was similar to Goldman and Horne's (1983) report of blue-greens in Clear Lake, California.

The long-term effects of the epilithic algae of Allander and Glazert waters have been viewed from inorganic nutrients point of view in the present study. Some of the freshwaters in Rio Grande do Norte showed increased nutrients output that originate from anthropogenic activities also contribute to the high and low diversity of microalgal species of shallow tropical waters (Chellappa, 1990) The published data of OECD Co-operative programme (1982) on eutrophication of inland waters pointed out that nitrogen or some other factors, can sometimes outweigh the usual role of phosphorus as the factor limiting algal growth. The results of our study illustrate a linear relationship found between chlorophyll biomass and primary productivity, thus indicate a close correlation between these two factors. Results of this investigation also suggest a some interaction between water discharge and epilithic algal species diversity, chlorophyll biomass and primary productivity but they are inconclusive. On the other hand, our results highlight the important contribution of *Oedogonium*, a typical epilithic alga in Allander Water and Glazert Water makes to the biomass estimated as chlorophyll biomass and primary productivity. We also obtained a very high significant linear relationship between chlorophyll and primary productivity through regression and analysis of variance. Presence of robust filamentous green alga, *Oedogonium* is found throughout annual cycle that showed resistance to the effects to high frequency of intermediary disturbance but it was evident that the summer peak of *Oedogonium* closely follows the nitrate nitrogen decline. Alternatively, the theory of episodic events in relation to ecology and evolution of Boero (1996) that the changes in contribution of the species to the biomass of the community could be fitted to intermediary disturbance of epilithic algal of Glasgow streams.

The hydrological conditions and the stony substrata increase a high development of filamentous green algae on the upstream and down stream faces while more rheophilous diatoms colonise initially but dominated heavily by macroalgal counterparts. The pattern of colonisation on the stones was completely modified under flood condition. The impact of episodic (intermediary disturbance) events on periphytic organisms was increasingly clear in relation to reduction of species diversity, chlorophyll biomass and primary productivity The oscillations in current velocity and discharge rate in Allander and Glazert waters revealed a characteristic reduction of species diversity of epilithic algal communities as short-term effect and the resistance of filamentous green alga, *Oedogonium* to sheer stress was equally evident. The anthropogenic nutrient load through domestic and hospital sewage waste is still overwhelmingly control the species diversity, chlorophyll levels and primary productivity of epilithic algae as long-term effect. The overall reduction observed in species diversity index in Glazert water (GW2) clearly indicates the tendency of organic pollution effect. If we settle down to treat anthropogenic addition as one of the episodic events, the situation then becomes easily be related to disturbance theory for the third order streams of lotic ecosystems.

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