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QUALITATIVE AND QUANTITATIVE STUDIES ON THE PERIPHYTON (BIOTECTON) OF REED IN LAKE BALATON

Abstract

The authors report on the results of examination carried out on the reed-periphyton complex in three characteristic reed stands of Lake Balaton.

The measured quantities of reed and periphyton and the results of the chemical analysis provide data to the exploration and assessment of the littoral zone, especially the periphyton settled on reeds, playing an important role in the water quality regulation of the lake.

The quantities of nitrogen and phosphorus measured in periphyton in the case of the Bay of Keszthely are particularly remarkable: 2.4 gN.m^{-2} and 0.25 gP.m^{-2} of reed stands.

Considering the 480 hectare reed stand of the bay, the quantity of nitrogen and phosphorus is estimated at 8000 kg N and 900 kg P.

Introduction

Our waters are endangered by eutrophication nowadays and Lake Balaton is no exception. The menace to the healthy state of the lake comes from two directions. One is the large quantity of plant nutrients an waters entering the lake, the other is the increased utilization of its immediate environment which speeds up the process of cultural eutrophication (TÓTH 1974). The littoral zone is a conspicuous and diverse and, perhaps, the most interesting habitat of Lake Balaton (ENTZ and SEBESTYÉN 1942), and in a large part of this area reed stands are found with periphytic organisms covering the submerged reed stems in most places.

ALLEN (1971), MICKLE and WETZEL (1978,1979), WETZEL and ALLEN (1972) provide data on the role of the littoral zone in the material circulation in lakes. Relying on research findings in Hungary we can say that the reed-periphyton complex is significant in checking and buffering influences coming from the shore while also indicating them (DINKA et al, 1979; KÁRPÁTI et al, 1980; LAKATOS 1975; TÓTH 1972).

In the present paper we report on the results of our study concerning in role of reed-periphyton complex in the framework of the "Research Project on the Littoral Zone of Lake Balaton" started in 1979 and carried out under the guidance of senior research associate, Dr.Béla Entz. For the purposes of our undertaking we have relied on earlier findings concerning the reed stands and their periphyton in the littoral zone (CHOLNOKY 1929; ENTZ and SEBESTYÉN 1942; MESCHKAT 1934; etc.).

Material and methods

On three occasions in 1979 (May 28-30, July 10-12 and October 2-4) water surface samples (to depth of 50 cm) and deep underwater periphyton samples were taken from young and old reed, moreover, young and old reeds were collected in the case of the former. Sampling was repeated 3-5 times from young (y) and old (o) reeds at every sampling point. At the time of reed and periphyton sampling, water samples were also taken and water depth as well as transparency were measured. The measurement of pH, dissolved ortho-phosphate, the total phosphorus and total inorganic nitrogen content in the samples were done in the laborotories of the Biological Research Institute in Tihany, while the rest of the analysis and processing of periphyton was carried out at the Ecological Institute at L. Kossuth University, Debrecen.

The description of the methods for determining the orthophosphate and total inorganic nitrogen content is to be found in FELFÖLDY 1974 work. The determination of cations from water, reeds, sediment and periphyton was done (after combustion and digestion) with help of atomic absorption spectrophotometry UNICAM SP 1900 instrument.

From the periphyton and reed samples wet weight was determined and the dry weight as well after drying at 105 C^o. The chlorophyll-a content was determined by way of meteanol dissolution and then the quantity of ash was ascertained after burning at 600 C^o. The nitrogen, phosphorus and cation contents (Na, K, Ca, Mg, Fe, Mn, Cu, Zn) were also determined from the periphyton, reed and sediment samples. The transects of the studied reed stands in Lake Balaton are given in Figure 1 with the indication depth of water at sampling points. About the applied methods of periphyton analysis LAKATOS (1975) gives a detailed account.

Explanation of abbreviations

Ww= wet weight

Dw= dry weight (105 C^o)

Ow= ash free dry weight (organic matter weight) 600 C^o

Chl= a= Chlorophyll-a

AI= autotrophic index (WEBER 1973)

$$AI = \frac{\text{Ow mg m}^{-2}}{\text{Chl-a mg m}^{-2}}$$

cf= concentration factor (HUTCHINSON 1972)

$$cf = \frac{\text{element content of periphyton in ppm related to dry weight}}{\text{element content in water in ppm}}$$

Results and discussion

During the cours of research on the littoral zone of Lake Balaton we have studied the periphyton settled on reeds in the reed stands in the bays at Bozsa, Keszthely and Paloznak. The relevant parameters of water sample taken of periphyton sampling site are given in Table 1. The findings of chemical analysis of water match well with the values published by ILOSVAY (1898), ENTZ (1953), KOVÁCS and TÓTH (1979), PÁSZTÓ (1963), TÓTH (1972). In a biological sense the reed stands in the Bay of Bozsa are perhaps the only relatively less disturbed one in the littoral zone of present-day Lake Balaton, and one which can be regarded as an ideal reed stock in the Little Balaton region. Human activity has left rather visible traces in the reed stands in the Bay of Paloznak. The reed stands in the Bay of Keszthely are the most nutrient-rich areas of the lake.

Table 2 contains the biomass and the quantity of biogenic elements of underwater part of young reed and the periphyton on it measured in spring. On the basis of our results for 1sq. meter surface of the reed belt of the lake the underwater biomass of reeds and the quantity of periphyton on it was the greatest in the case of reed stands in the Bay of Keszthely.

By applying t-statistic to the analysis of the quantity of periphyton on young reed, we got a significant ($P < 1\%$) difference between the Bay of Bozsa and the Bay of Keszthely, while a less marked difference ($P < 10\%$) was registered between the Bay of Bozsa and the Bay of Paloznak. It can be stated that the periphyton in the reed stands of the three bays are of different chemical composition. In the rich periphyton found in the Bay of Keszthely a large quantity of nitrogen, phosphorus, potassium, magnesium and calcium as well as a large concentration of iron from among the micro-elements is characteristic (Figure 2).

As to the phosphorus content, significant (P 1 %) difference was found between the periphyton in the Bay of Keszthely and the Bay of Paloznak on the one hand and the Bay of Boza and the Bay of Paloznak on the other. A large nitrogen and phosphorus concentration is characteristic of the periphyton in the Bay of Keszthely; the periphyton collected from the Bay of Bozsa has moderate nitrogen and slight phosphorus content while the periphyton of the Bay of Paloznak is characterized by small nitrogen and phosphorus contents (Figure 3).

In Figure 4, the seasonal changes of periphyton collected from young reed are presented and the increase is visible by autumn. Apart from young reed, the analysis of periphyton on old reed was also done. The substrate role of old, wintered reed is significant because it becomes possible for some organisms in its periphyton to survive the unfabourable season and thus they retain a part of stabilized nutrients in their bodies from matter circulation.

The different element content of reed and weed on the side near the open water and near the shore has long been known (BUTTEREY and LAMBERT 1965, MOCHNACKA-LAWACZ, ROSS 1979, etc.). Less known, howewer, is the difference in periphyton depending on the distance of reed from the open water. The t-statistics was applied to the analysed parameters of the periphyton collected from the reed transect near the shoreline and from the one near the open water to reveal the difference.Significant difference was not obtained for the periphyton expressed in dry weight, but for ash content significant difference was found. The N, P and K concentration near the shoreline significantly differs from concentration near the open water (Figure 5). Only slight difference was found in the case of Ca, Mg and Fe contents while significant (P 5%) difference was observed in Mg, Cu, Zn that is, the periphyton of reeds near the shoreline builds in plant nutrients arriving from the shore and accumulates micro-elements.

The role of periphyton settled on reed stands and their underwater substrates is proved by our results, that is, the complex plays a role in buffering influences coming from the shore, in taking up and storing micro-elements while it is also active near the open water as a results of mechanical and physico-chemical processes (ALLEN 1971, ALLANSON 1973, KELLY and EHLMANN 1980, MICKLE and WETZEL 1978, OTSUKI and WETZEL 1973, etc.). The above statements are supported by results of the chemical analysis of the water, the values of the chemical analysis of periphyton and the calculated concentration factors of elements (Table 3).
The element concentration factors were identical with the data published by KÁRPÁTI et al. (1980), KOVÁCS (1978, 1979), KOVACS and TOTH (1979) and the only difference was found in the case of nitrogen, since the total inorganic nitrogen concentration of water was taken into consideration as against the total organic nitrogen:

N 10^5	Na 10^2	Ca 10^3	Fe 10^4	Cu 10^4
P^x 10^4	K 10^3	Mg 10^3	Mn 10^4	Zn 10^4

x for the dissolved ortho-phosphate content of water Figure 6 convinces us that there is positive correlation between certsin element contents of young reed and its periphyton. This was not found in old reed and its periphyton. The close positive correlation found in many cases between the micro-elements concentrations of water and periphyton suggests the accumulation processes in periphyton.

The strong positive correlation between the sodium content and the copper and zink concentration of periphyton in the Bays of Keszthely and Bozsa deserve special mention. Though not very strong the concentration with calcium content and, to a lesser degree, with magnesium found in periphyton suggest adsorption processes taking place (CUSHING 1967, CUSHING and ROSE 1970, KELLY and EHLMANN 1980, etc.) We did not succeed in proving the possibility of coprecipitation of calcium and phosphate published by OTSUKI and WETZEL (1973) with the help of regession analysis of findings.for periphyton yet, the large calcium content (Ca% 10) of periphyton, or, more exactly, by virtue of the calcium carbonate incrustation (ALLEN 1971, ALLANSON 1978, WETZEL and ALLEN 1972, etc.) the physico-chemical processes taking place in/on the periphyton (MICKIE and WETZEL 1978, 1979) also deserve attention.

The dependence of nitrogen content of periphyton (as target variable) on the nitrogen content of water, sediment and young reed can be attributed in 57,2 % to the inorganic nitrogen concentration of water on the basis of the Path scheme (Figure 7). Apart from the presence of remarkable quantity of other factors, the variance of zink content is determined through the direct Path by the zink content in young reed.

Figure 8 presents ratios of dry weight, nitrogen and phosphorus content of young reed and its periphyton calculated for 1 m^2 area of reed. the percentage share of periphyton for the analysed parameters was the smallest in the Bay of Bozsa and the greatest in the Bay of Keszthely. The share of periphyton in total dry weight is surpassed by the ratio of nitrogen and phosporus, and the quantity of nitrogen and phosphorus is particularly large in the reed stand of the Bay of Keszthely: 2.4 $gN.m^{-2}$, 0,25 $gP.m^{-2}$. The nitrogen and phosphorus quantity for the 490 hectare reed stand of the bay is estimated at 8000 kg N and 900 kg P.

The water quality improving role of the littoral zone, especially the reeds and the periphyton settled on the underwater part of reed substrate must be put to better use. In the case of Little Balaton to be reconstructed in the future, periphyton together with plants and substrate, is important for it contributes significantly to the retention of plant nutrients in the future reservoir and to their removal thus decreasing the load on Lake Balaton. The filter role of periphyton is not limited to holding up nutrients, but it extends to the acitve processing, although - for the time being - we are familiar with some parts of the process only.

Summary

This paper reports on the results of the study carried out on the reed-periphyton in three characteristic reed stands of Lake Balaton. This study is part of the research project of the Biological Research Institute of Hungarian Academy of Sciences at Tihany on the littoral zone of Lake Balaton.

The results of the water chemical examinations can be used as important background data to the analysis of the role of reed-periphyton complex and suggest the effect of reed on water-quality changes.

The measured quantity and the chemical analysis provide data to the exploration and assessment of the littoral reed zone and especially the periphyton settled on reed playing a significant role in regulating water quality in the lake.

It can be stated that, except for the Bay of Keszthely the concentration of micro-elements in periphyton is a 10^4 value for water and it is greater near the shore than near the open water. The biological element content in periphyton is smaller in the case of N, P, Na, K ions while the other elements contents, Ca, Mg, Fe, Mn, Cu, Zn, can be several times greater than those measured in the underwater part of reed.

The nutrient stabilizing fuction of periphyton of young and old reed is proved since 23 % of the 10,4 $g.m^{-2}$ stabilized nitrogen and 45,8 % of the 0,6 $g.m^{-2}$ phosphorus in the periphyton of the Bay of Keszthely was measured in the periphyton of the Bay of Keszthely was measured in the periphyton of the underwater part of reed. Futhermore, the nature of periphyton as a good indicator of the state of water quality also deserves mention.

The role of the littoral zone in the life of the lake can be explored and quantified only by further series of studies to which goal the present paper is a contribution.

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Table 1.

Chemical results of water analysis

Parameters	Sampling site				
	Bay of Bozsa	Bay of Keszthely			Bay of Paloznak
	28.05.	29.05.	10.07.	02.10.	30.05.
pH	7.65	8.33	-	8.2	8.1
Na	21.0	20.1	22.3	26.5	21.2
K	5.9	5.3	5.5	5.6	6.0
Ca	41.5	43.8	42.4	35.3	33.3
Mg $mg \cdot dm^{-3}$	48.8	44.5	41.1	40.9	51.1
Fe	0.201	0.202	0.165	0.166	0.239
Mn	0.025	0.046	0.071	0.056	0.039
Cu	0.030	0.035	0.020	0.021	0.030
Zn	0.065	0.093	0.135	0.178	0.092
ortho-PO_4 P $mg \cdot dm^{-3}$	0.00	0.12	-	0.40	0.07
total-inorganic-N $mg \cdot dm^{-3}$	0.17	0.64	0.28	1.98	0.61

Table 2.

Biomass and quantity of biogenic elements of underwater part of young reed /to depth of 50 cm/ and periphyton on it in the investigated bays of Balaton, May of 1979.

	Bay of Bozsa		Bay of Keszthely		Bay of Paloznok	
	underwater part of reed	periphyton	underwater part of reed	periphyton	underwater part of reed	periphyton
Ww $g \cdot m^{-2}$	169.6	20.2	299.2	44.8	270.5	19.7
Dw $g \cdot m^{-2}$	121.0	3.1	194.4	7.5	104.9	2.4
N $mg \cdot m^{-2}$	1464.1	106.2	2507.8	339.6	1101.5	67.4
P "	193.6	7.7	311.0	30.2	118.8	5.3
Na "	60.5	8.4	97.2	26.7	62.9	8.5
K "	1476.2	16.6	3168.7	58.4	1279.8	11.3
Ca "	33.9	469.0	70.0	1110.2	28.3	382.1
Mg "	36.3	46.9	83.6	86.7	42.0	40.4
Fe "	6.0	56.3	8.0	110.9	2.6	23.4
Mn "	1.6	3.8	3.6	6.9	1.6	3.8
Cu "	0.4	0.9	0.5	1.9	0.4	1.0
Zn "	0.6	1.9	0.7	10.6	0.7	2.5

Table 3.

Concentration factors of some important elements in periphyton collected from young reed, May of 1979.

	N	P	Na	K	Ca	Mg	Fe	Mn	Cu	Zn
Bay of Bozsa	$x10^5$	$x10^4$	$x10^2$	$x10^3$	$x10^3$	$x10^2$	$x10^4$	$x10^4$	$x10^4$	$x10^4$
1	1.7	-	1.0	1.2	3.9	5.4	16.3	10.6	3.5	1.4
2	2.1	-	1.3	1.0	3.0	2.0	10.6	5.6	0.7	1.4
3	2.0	-	1.4	1.0	3.3	3.0	6.9	6.4	0.5	1.0
4	2.4	-	1.6	0.8	3.7	3.4	6.9	2.3	0.6	0.7
5	1.9	-	1.4	0.6	4.3	1.5	9.8	2.4	2.0	0.3
Mean	2.0	-	1.3	0.9	3.6	3.1	10.1	5.5	1.5	1.0
Bay of Keszthely										
6	1.4	5.3	1.5	1.6	2.0	1.4	3.7	2.4	1.7	1.9
7	1.3	5.8	1.5	1.6	2.9	1.5	5.6	2.5	1.4	2.0
8	0.8	1.8	2.0	1.5	3.4	2.7	8.9	2.7	1.0	1.5
9	0.6	3.6	1.8	1.2	3.6	2.2	7.9	1.5	0.6	1.3
10	0.3	2.4	1.5	1.7	4.0	4.1	11.5	2.5	0.4	0.6
Mean	0.9	3.8	1.7	1.5	3.2	2.4	7.5	2.3	1.0	1.5
Bay of Paloznak										
11	0.6	5.9	2.8	1.3	4.8	7.4	4.9	7.1	2.0	1.4
12	0.4	3.8	1.8	0.8	5.7	5.2	4.0	5.0	1.6	1.4
13	0.4	3.0	2.7	1.1	4.5	5.0	9.6	2.3	2.8	2.5
14	0.4	2.8	1.1	0.5	3.5	1.9	2.3	3.0	0.4	1.0
15	0.5	2.5	1.2	0.6	6.0	1.6	4.9	5.8	1.5	0.8
Mean	0.5	3.6	2.0	0.9	5.0	4.2	5.1	4.6	1.7	1.4

Fig.1. Sampling sites of Lake Balaton, 1979

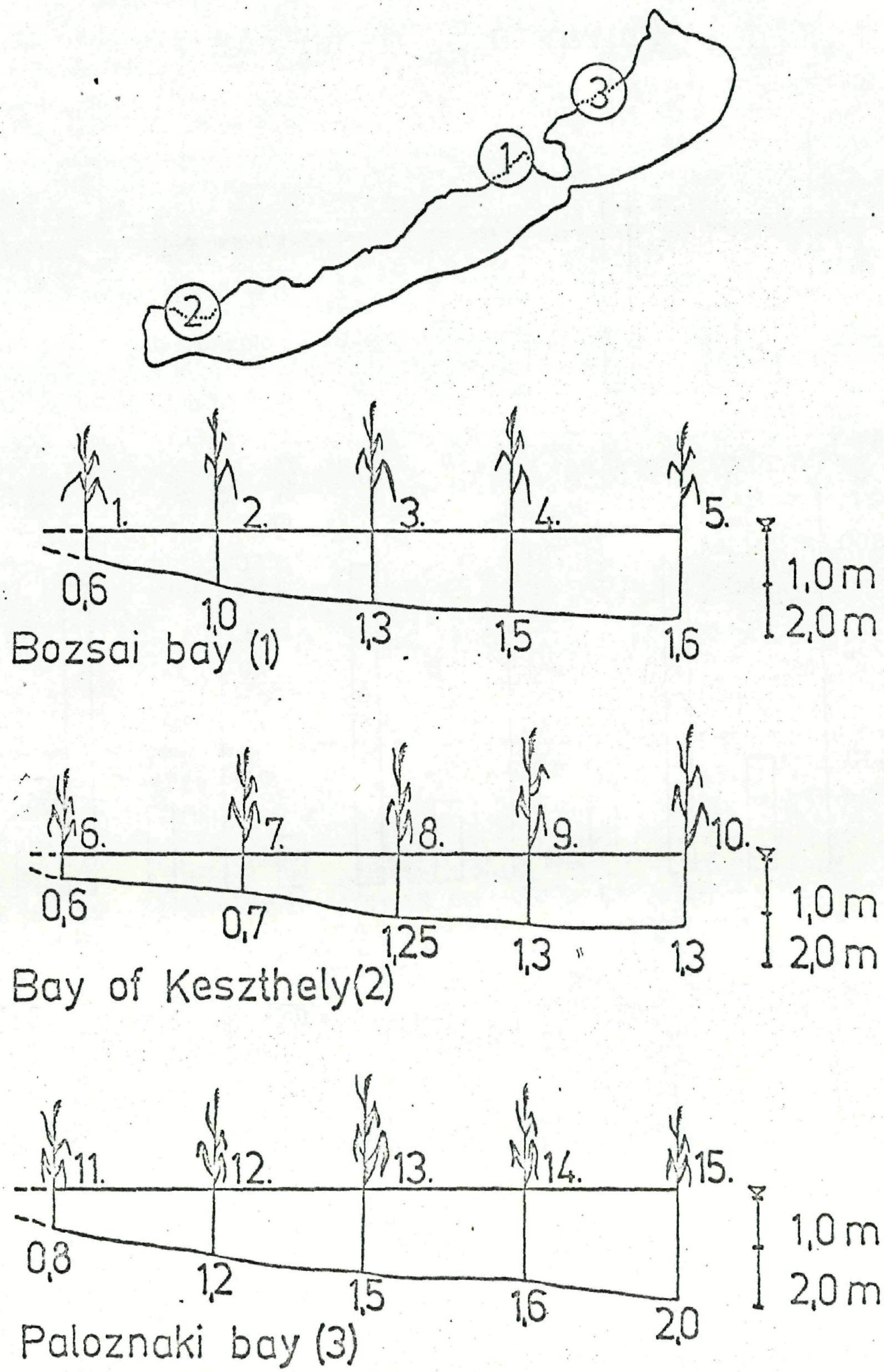


Fig.2.

Dry weights and element contents of periphyton (biotecton) collected in bays of Lake Balaton (down to 50 depth water)

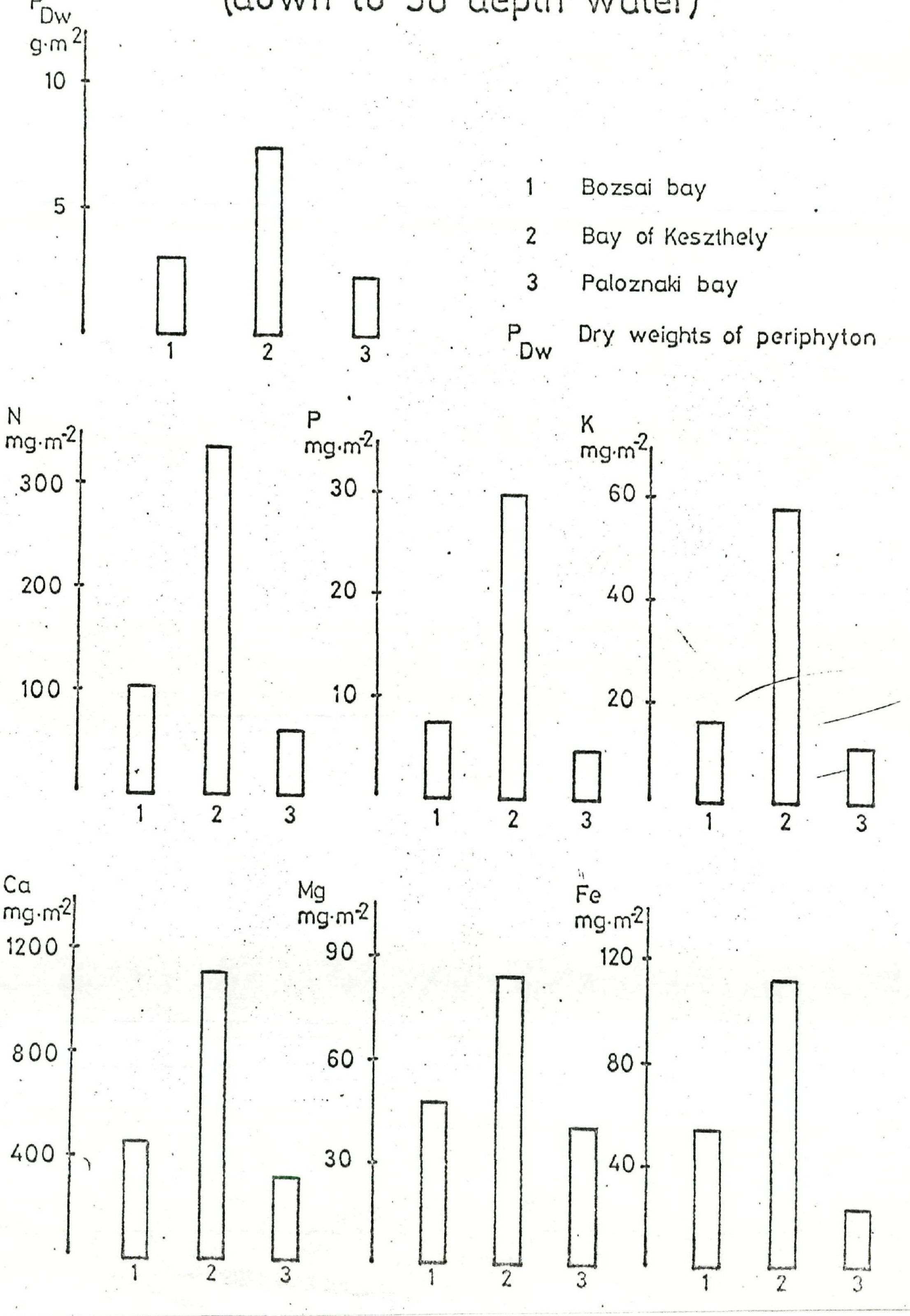


Fig.3. Relationship between N and P concentration of periphyton collected on the bays of Lake Balaton

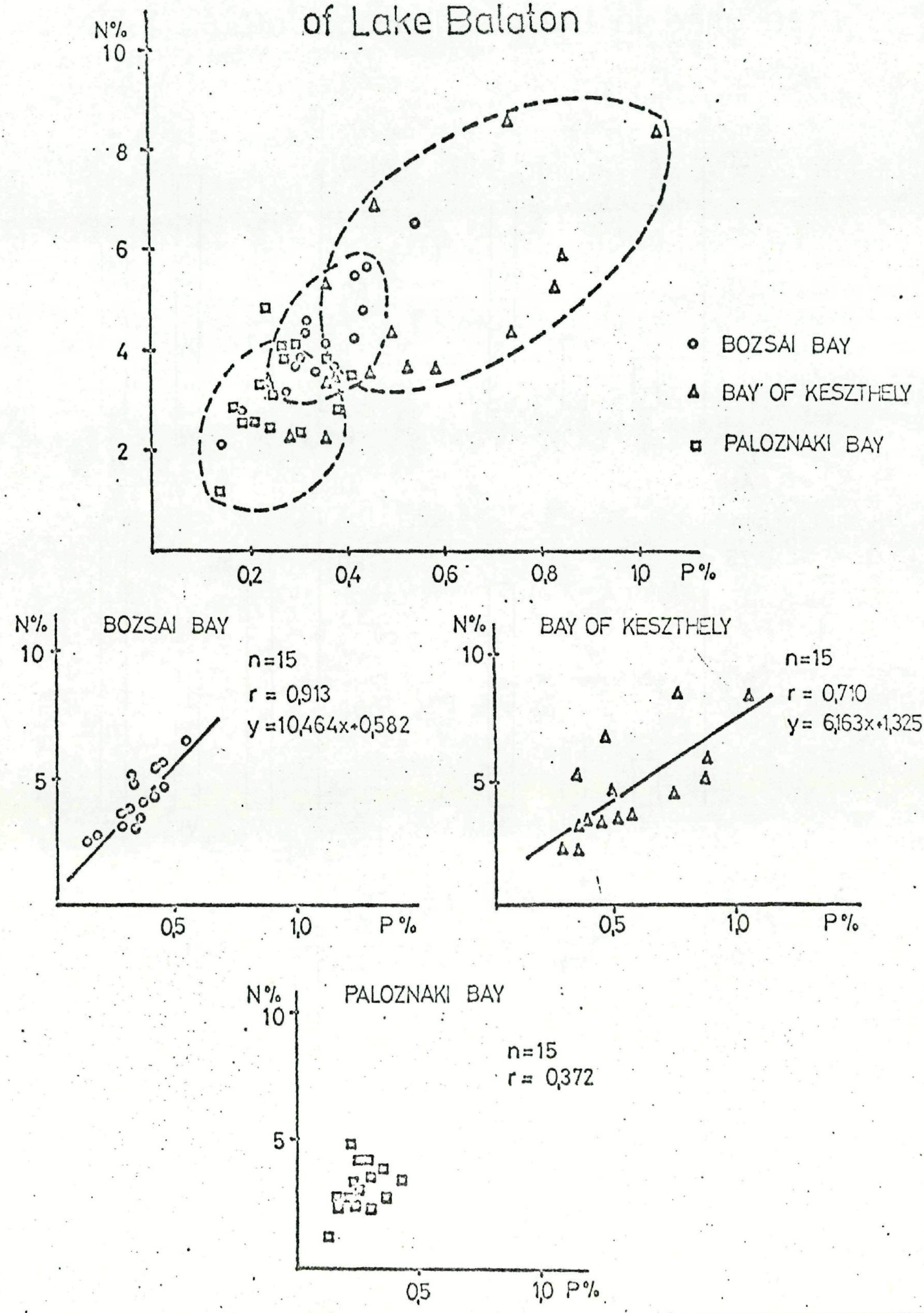


Fig. 4.

Seasonal changes of some parameters measured in the periphyton, Balaton, 1979

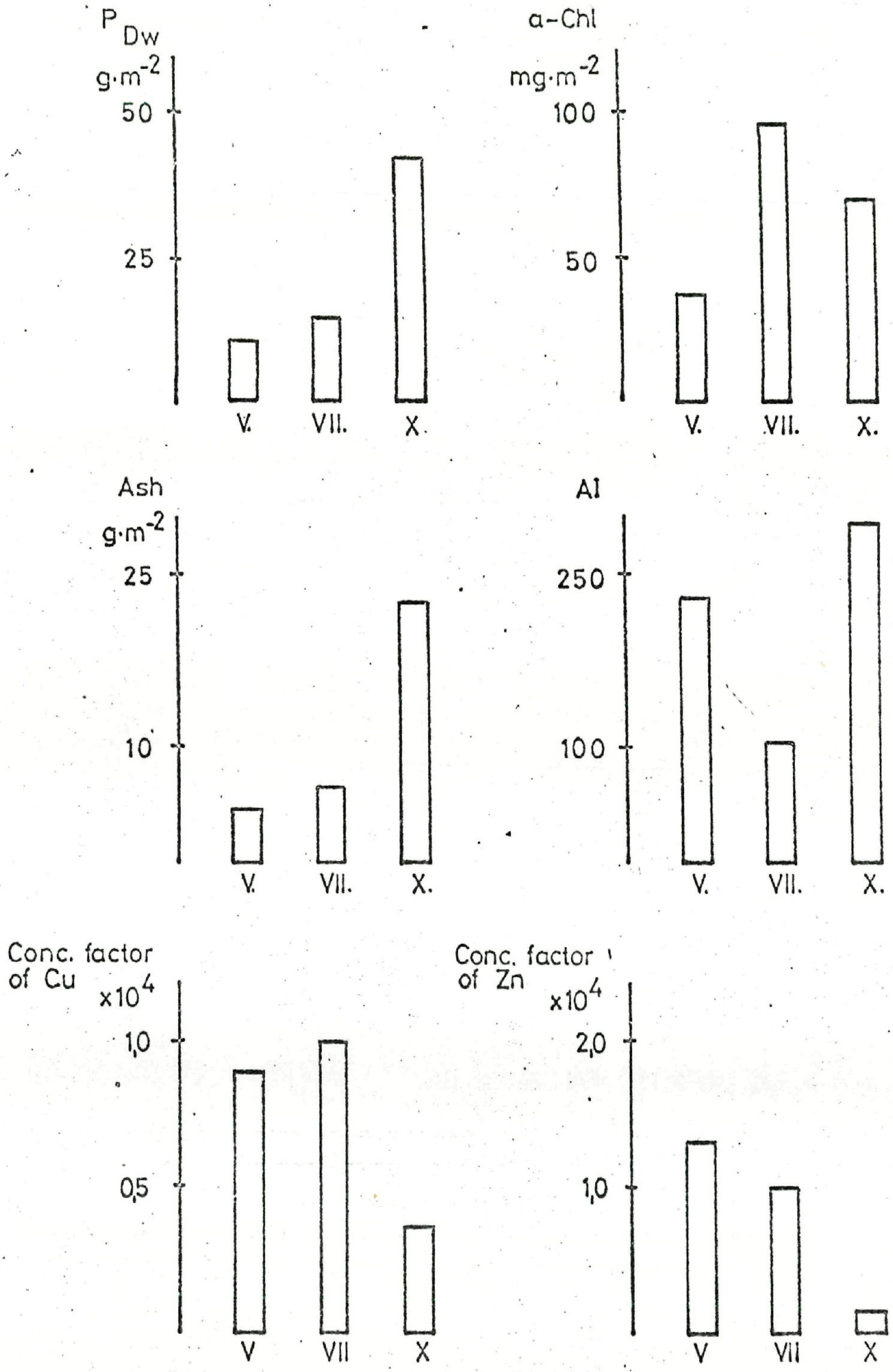


Fig.5.

	Periphyton on reed collected near the bank	Periphyton on reed collected near the open water
N%	5,520	2,770
P%	0,545	0,292
Cu%	0,048	0,020
Zn%	0,106	0,050
Al	116,4	171,5

Fig.6. Relationship between element contents of young reed and its coating (periphyton)

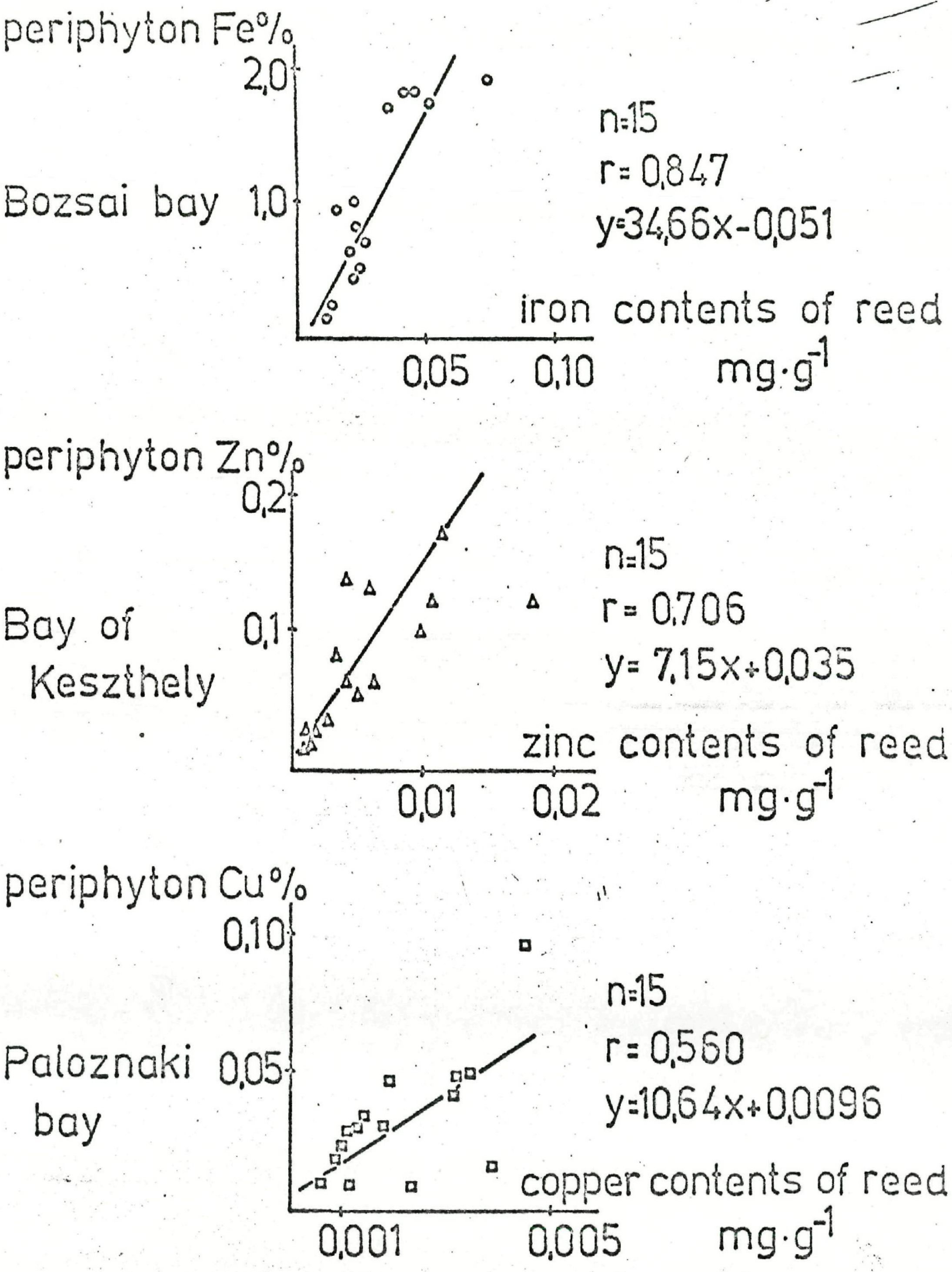
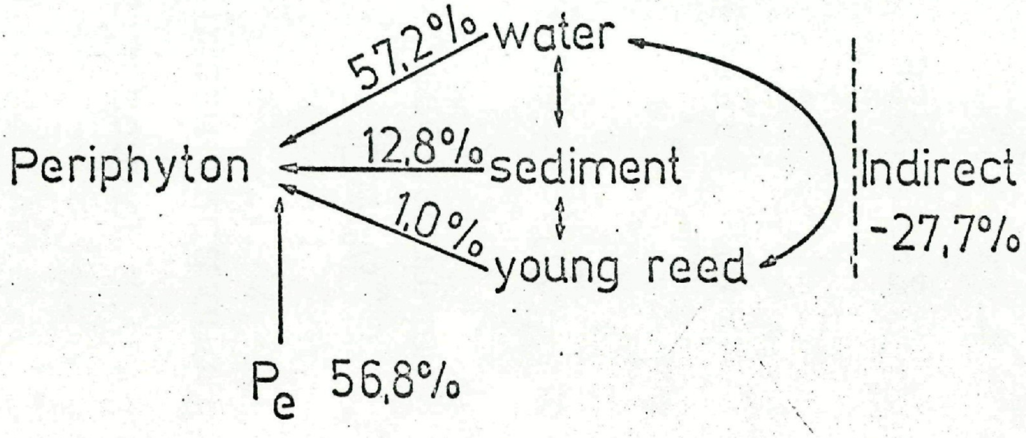


Fig.7.

Diagram of Path analysis

(With the percentage distribution of direct and indirect Path)

For N content



For Zn content

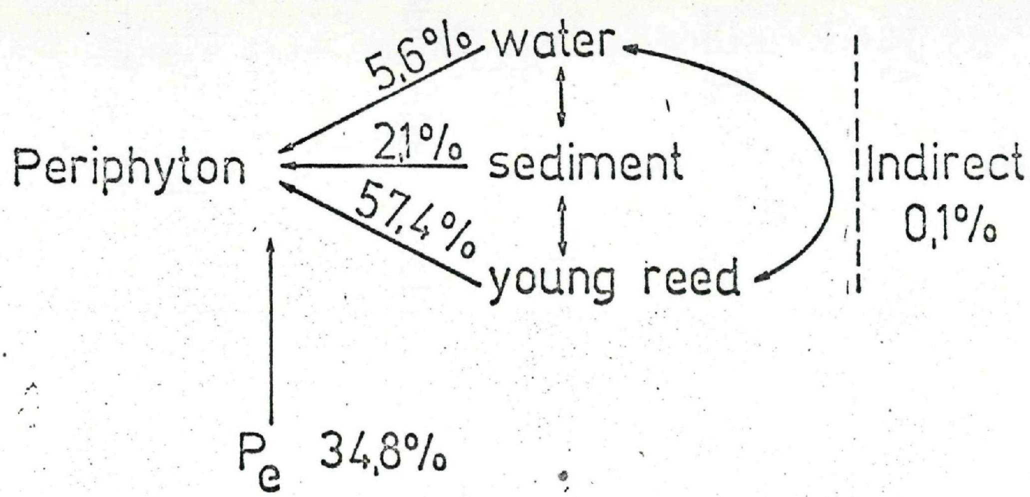


Fig.8.
The percentage distribution of dry weight, N and P content estimated in the green reed and its coating (periphyton)

	Dw %		N %		P %	
	reed	periphyton	reed	periphyton	reed	periphyton
Bozsai bay	99,3	0,7	97,1	2,9	97,1	2,9
Bay of Keszthely	92,8	7,8	77,0	23,0	54,2	45,8
Paloznaki bay	93,8	6,2	85,3	14,7	85,2	14,8

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