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RELATIONSHIP BETVEEN THE CHEMICAL OXYGEN DEMAND, SUSPENDED MATTER CONTENT AND ALGAL COUNT IN THE EASTERN MAIN CANAL (HUNGARY)

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Abstract

The Eastern Main Canalis a 100 km long artificial stream conducted from the Tisza river at Tiszalök (535 river km) with the rate of flow 30—50 m^3/s. The investigations were carried out in the Eastern Main Canal at the section between Tiszalök and Balmazújváros 1968—1975. The amount of suspended matter changed from 5—700 mg/l, the values of chemical oxygen demand (COD) varied from 3—15 mg/l and that of the algal count from 30 thousand — 20 million individuals per liter. The changes of theese values depended on the floods of the Tisza river and on the current velocity of the Eastern Main Canal.

The present paper wishes to report on the degree to which the COD values were altered by the suspended matter content, and modified by the algal count, respectively (here, that organic material of suspended matter and algae should be taken into account, which are oxidizable in acidic with potassium permanganate, since the suspended matter also comprises the algae). With the help of path-analysis it was concluded that in case of high suspended matter content — when the algal count is low — the COD is determined by the amount of suspended matter in 40—70%, and by the algal count in 0,5—0,6%. Besides low suspended matter content — when the algal count is high — the values of the chemical oxygen demand are determined in 4—10% by the amount of suspended matter content, and in 15—20% by the algal count.

Introduction

Apart from the dissolved organic matter, the chemical oxygen demand of flowing waters is determined by the formed (living, dead) organic matter of the suspended matter. The suspended matter content in river waters — which substantially increases at the time of floods — manifests essential influence on the chemical oxygen demand. In the case of the Hungarian rivers this had been analysed by several authors (PÁSZTÓ 1963, ÁDÁMOSI et *al.* 1974, VÉGVÁRI 1976, 1977, KOZMA 1976—77, ÁDÁM M., VÁRDAY 1977, BANCSI et *al.* 1978). As the consequence of the enhancing eutrophization of the rivers, phytoplankton communities of high individual number (several million ind/l) appear in the low-water periods. In such case the biomass of the phytoplankton increases the organic matter content of the water to such an extent that its effect on COD is well demonstrable (VÖRÖS 1976).

Parallel with the regular algal studies at the Eastern Main Canal between 1968—1975, the analysis of a few chemical parameters was also performed (KISS, K. T. et *al.* 1974, KISS, K. T., TÓTH 1975). The quantity changes of certain components as well as the development of the quantity relations of the phytoplankton communities stand connection with each other. Here we will report on the relationship between the chemical oxygen demand, the suspended matter content and the algal count.

Methods of sampling and analysis

For the chemical and algological examinations the water samples were taken weekly at Tiszalök (0,4 riv. km), Tiszavasvári (4,7 riv. km) and Balmazújváros (44,5 riv. km), from beneath the water surface, from the current line. Taking into account the current velocity of the Eastern Main Canal, the sampling at Balmazújváros was accomplished 2—7 days following the samplings at Tiszalök and Tiszavasvári, so that according to possibility the water samples would originate from the same mass of water. The water samples taken from the Eastern Main Canal at Tiszalök could be regarded as Tisza-water, since the water of the redammed up bed-section of the Tisza river at Tiszalök reaches this sampling place without any difficulty. More detailed data on the sampling places and the used methods can be read in the earlier papers by KISS, K. T. (1974*b*, 1975).

The suspended matter content and the chemical oxygen demand (COD) measured in acidic medium with potassium permanganate were determined according to the instructions of FELFÖLDY (1974). The quantitative analysis of the phytoplankton communities was carried out using the method of UTERMÖHL (LUND et *al.* 1958). The correlation calculation and path-analysis were carried out on the basis of the average data of the monthly 4 samplings (SVÁB 1973).

Results

The suspended matter content of the Eastern Main Canal depends on the floods of the Tisza river and the water amount supplied through the lock at Tiszavasvári. In general, more seston is found in the water at the Tiszalök—Tiszavasvári section than at Balmazújváros (Fig. 1). If there is no flood at the Tisza river, the suspended matter content in Winter in the frozen canal water is 5—6 mg/l, which may rise to several hundred mg-s on the occasion of floods in Spring and early Summer (KISS, K. T. et *al.* 1974.). With the subsiding of the floods the water becomes settled in the periods at the end of Summer — early Autumn, and the seston amount decreases to 20—30 mg per liter. Algal communities with large species- and individual numbers appear in the settled water and the development of phytoplankton blooms can frequently be observed (KISS, K. T. 1974a, b, 1975).

The chemical oxygen demand of the water at the Eastern Main Canal generally ranges between 4—6 mg/l. The lowest values (2,2—2,5 mg/l) were measured in Winter at the icecovered Main Canal at Balmazújváros, and in the August period at Tiszalök, respectively. At the time of the floods in Spring and early Summer there is a rise in the COD value, which is firstly the result of increased seston-quantity of the water. During the course of our studies so far, the highest values were measured in 1970 on the occasion of the great flood at the Tisza river (May 18, 1970; Tiszalök 781 mg/l). Advancing from Tiszalök towards Balmazújváros the chemical oxygen demand shows a decrease in general, which can first of all be brought into connection with the decrease in seston content.

The correlation between the suspended matter content and the chemical oxygen demand can be approached the most precisely with a linear equation (Fig. 1).

Correlation coefficient values:

At Tiszalök	r=0,7076 (significant at 0,1 %)
At Tiszavasvári	r=0,6849 (significant at 0,1 %)
At Balmazújváros	r=0,3130 (significant at 3,0%)

Equation of linear regression:

At Tiszalök	Y'=3,86+0,0110 x
At Tiszavasvári	Y'=3,58+0,0113 x
At Balmazújváros	Y'=3,50+0,114 x

It can be determined from the regression equation, the measured data, as well as from Figure 1, that the higher suspended matter content values come nearer to the straight line obtained on the basis of the regression equation than the values of

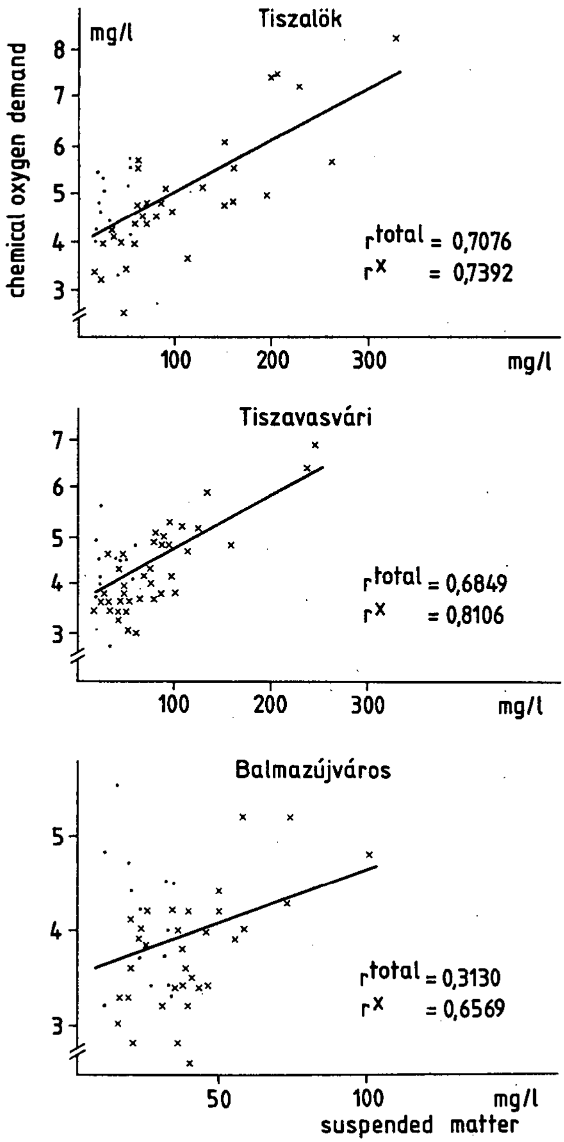

Fig. 1. Correlation between the suspended matter content and the chemical oxygen demand (the values belonging to the higher suspended matter content — lower algal count are indicated by x; interpretation is given in the text).

the low suspended matter content. The cause of this ist hat by low suspended matter content, the COD is influenced by the number of plankton algae, and in periods with high suspended matter content rather by the abioseston. In the interest of proving this assumption, further calculations were carried out.

The coefficient values of the Brawais' correaltion between the COD and the algal count are:

The coefficient values of the Bravais' correaltion between the COD and the algal count are:

At Tiszalök	r=0,0084
At Tiszavasvári	r=0,1109
At Balmazújváros	r=0,3077

According to the correaltion coefficients there is no relationship between the algal count and COD at the upper canal section, and the correaltion is very loose at Balmazújváros.

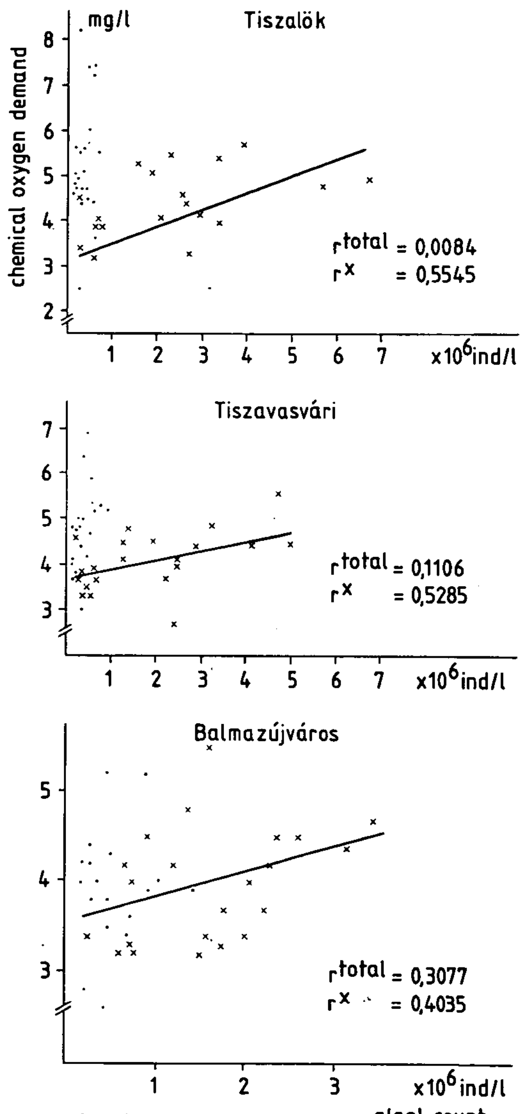

Fig. 2. Correlation between the algal count and the chemical oxygen demand (the values belonging to the lower suspended matter content are indicated by x, the equation of the straight line was also calculated on this base and the straight line was drawn accordingly; interpretation is given in the text).

It is striking firstly on the basis of the data gained from Tiszalök that the COD values belonging to the algal number lower and higher, respectively, than 1 million ind./l are separated from each other (Fig. 2). Namely, the essence of the correlations pisnedout better if the correlation ccul itoalatinos aer accomplished with t edahat

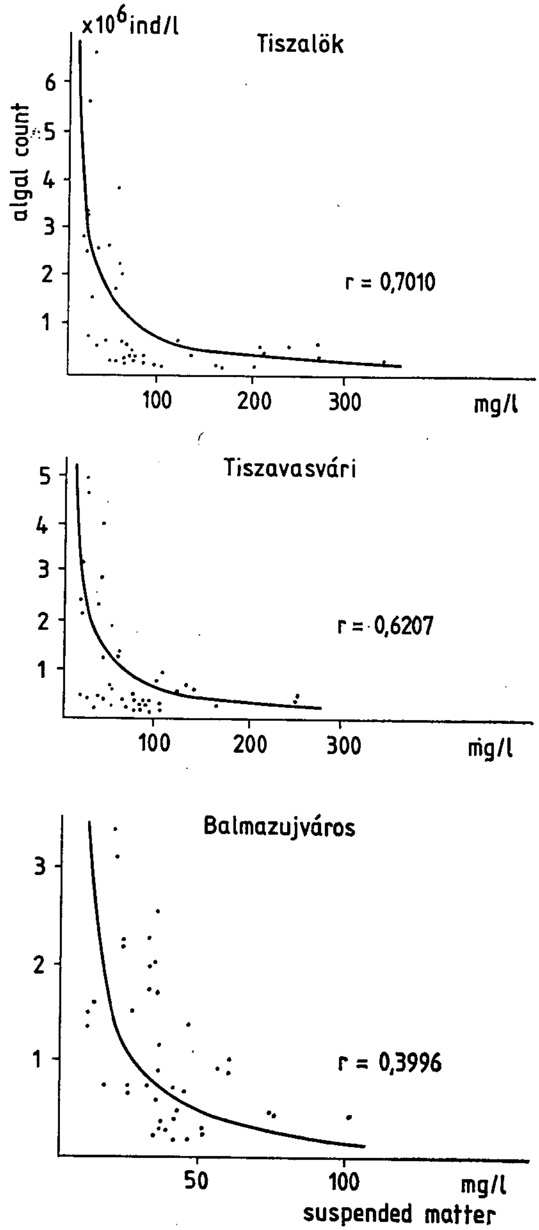

Fig. 3. Correlation between the suspended matter content and the algal count.

standing below and above this limit value, respectively. The result of this is the following (the r_{total}=correlation coefficient) counted on the basis of the total data):

At Tiszalök:		
<1 million ind./l	r=0,2061	(r_{total}=0,0084)
>1 million ind./l	r=0,5545	(significant at 1,5%)
At Tiszavasvári:		
<1 million ind./l	r=0,3334	(r_{total}=0,1109)
>1 million ind./l	r=0,5285	(significant at 1,5%)
At Balmazújváros:		
<1 million ind./l	r=0,0658	(r_{total}=0,3077)
>1 million ind./l	r=0,4035	(significant at 6,5%)

It can be concluded that there is no relationship between the algal count and the COD — or it is very loose, resp. — in the case of algal numbers lower than 1 million ind./l. When the algal number is higher than 1 million ind./e the correlation is moderate. The relationship is all the tighter, the higher the algal number. This is the reason why the tightness of the correlation decreases from Tiszalök towards Balmazújváros.

The distinguishing of these two provinces is by all means reasonable even when

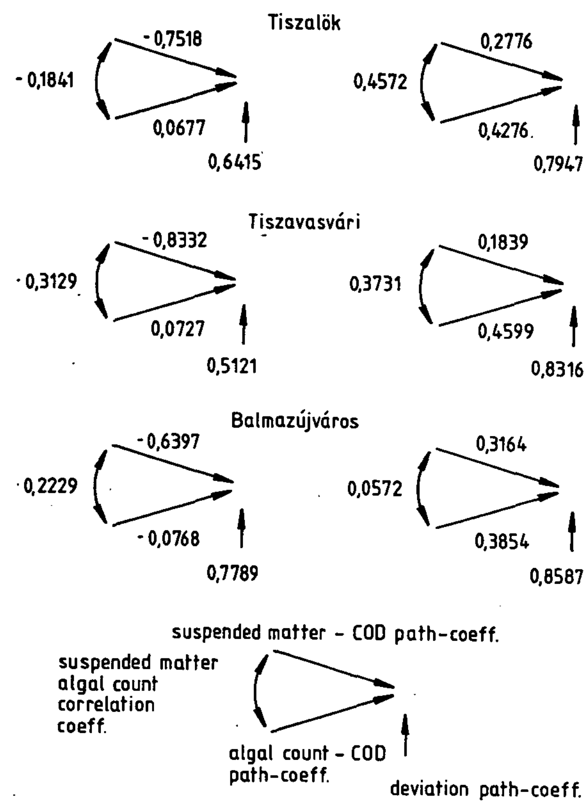

Fig. 4. Path-diagram of the correlation between the suspended matter content, the algal count, and the chemical oxygen demand (the left column comprises the larger suspended matter domain, and the right column the smaller suspended matter domain).

studying the relationship between the suspended matter content and the chemical oxygen demand. The mode of distinction was by finding on the joint diagram of the suspended matter content and algal count that suspended matter limit value, above which the algal count doesn't rise — or only rarely — rises over 1 million ind./l. This limit was found to be 60 mg/l suspended matter content at Tiszalök and Tiszavasvári, and 35 mg/l at Balmazújváros (Fig. 3). Performing the correlation calculations according to this, the following results were obtained:

At Tiszalök:
>60 mg/l $r=0{,}7392$ (significant at 0,1%)
<60 mg/l $r=-0{,}0820$ ($r_{total}=0{,}7076$)
At Tiszavasvári:
>60 mg/l $r=0{,}8106$ (significant at 0,1%)
<60 mg/l $r=-0{,}0123$ ($t_{total}=0{,}6849$)
At Balmazújváros:
>35 mg/l $r=0{,}6569$ (significant at 0,5%)
<35 mg/l $r=-0{,}2937$ ($r_{total}=0{,}3130$)

It can be concluded on the basis of the correlation coefficients that besides suspended matter content higher than 60 and 35 mg/l, resp. (algal count lower than 1 million ind./l) the correlation is tighter than in case of r_{total}. This is particularly striking at Balmazújváros. In the case of suspended matter content lower than 60 and 35 mg/l, resp., (algal count higher than 1 million ind./l) there is no relationship between the suspended matter content and the chemical oxygen demand, or it is very loose and of negative tendency.

To decide the degree to which the chemical oxygen demand is influenced by the suspended matter content and the algal count, furthermore, to determine the degree of the common effect of these, path-analysis was carried out (applying the "r" values of the above distinguished two value domains). The values of the path-coefficients are demonstrated on Figure 4. Only the disintegration of the R^2 multiple determination coefficient is presented in detail, with the help of the following Table. (p_1^2=suspended matter — COD determination coefficient; p_2^2=algal count — COD determination coefficient; P_{ind}=suspended matter+algal count — COD path-coefficient; P_e=determination coefficient of other, not studied effects):

	At Tiszalök		At Tiszavasvári		At Balmazújváros	
	>60 mg/l	%	>60 mg/l	%	>35 mg/l	%
p_1^2	0,5652	56,5	0,6942	69,4	0,4093	40,9
p_2^2	0,0046	0,5	0,0053	0,5	0,0059	0,6
p_{ind}	0,0187	1,9	0,0379	3,8	0,0219	2,2
p_e	0,4115	41,1	0,2626	26,3	0,5848	58,5
		100,0		100,0		100,0
	<60 mg/l	%	<60 mg/l	%	<35 mg/l	%
p_1^2	0,0770	7,7	0,0338	3,4	0,1001	10,0
p_2^2	0,1829	18,3	0,2115	21,2	0,1486	14,9
p_{ind}	0,1085	10,9	0,0633	6,3	0,0140	1,4
p_e	0,6316	63,1	0,6916	69,1	0,7373	73,7
		100,0		100,0		100,0

On the basis of the Table it can be concluded that at the upper canal section by suspended matter content more than 60 mg/l, the suspended matter content has the decisive role in the values of the chemical oxygen demand (56—69%). The effect of the algal count is negligible, and even the indirect effect is not essential. Other cffects influencing the COD have a role in 26—41%. In the smaller suspended matter content domain the direct effect of the suspended matter in low (3—7%). The algal eount determines the COD in 18—21%, and the indirect effect should not be neglected either (6—10%). The role of other non-studied effects becomes considerable, in whole becoming determinative (63—69%).

At Balmazújváros the role of p_1^2 is substantial the larger suspended matter domain (40%), but is not so considerable as at the upper canal section. The effect of the algal count and also the indirect effect are both negligible, since here, it is the other effects which play decisive role. In the smaller suspended matter domain the value of COD is determined by the algal count in 14%, and by the amount of suspended matter in 10% (in whole this is almost as high as the effects of the suspended matter and the algal count at the upper canal section). The indirect effect is insignificant (lower than at the upper section). The other effects become determinative (73%).

Summarising, it can be concluded that the effect of the suspended matter content is the most important in the development of the COD amount by high value of suspended matter content. The decisive role of the algal count comes into the foreground by lower suspended matter content nevertheless, the other effects play a more important role after all, than the studied factors.

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A kémiai oxigénigény, a lebegőanyag-tartalom és az algaszám összefüggése a Keleti Főcsatornán

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Kivonat

A Keleti Főcsatorna Tiszalök—Balmazújváros közötti szakaszán 1968—75. között, a heti mintavételek eredményei azt mutatták, hogy a víz lebegőanyag-tartalma 5—6 mg-tól 500—700 mg-ig, a kémiai oxignéigény (KOI_{sMn}) értékei 3—15 mg között, az algaszám 30—50 ezertől 15—20 millió egyedig változott literenként.

Dolgozatunkban azt kívántuk bemutatni, hogy a KOI értékeket milyen mértékben alakította a lebegőanyag-tartalom, hogyan módosította az algaszám. Path-analízist végezve megállapítottuk, hogy nagy lebegőanyag-tartalom esetén — amikor kicsi az algaszám — a KOI-t 40—70%-ban a lebegőanyag mennyisége, 0,5—0,6%-ban az algaszám határozta meg. Kis lebegőanyag-tartalom mellett — amikor nagy az algaszám — a kémiai oxigénigény értékeit 4—10%-ban a lebegőanyag-tartalom mennyisége, 15—20%-ban az algaszám határozta meg. Nagy lebegőanyag-tartalomnak Tiszalök—Tiszavasvárinál a 60 mg/l, Balmazújvárosnál a 35 mg/l-nél nagyobb értékeket, kis lebegőanyag-tartalomnak az ennél kisebbeket tekintettük. Kis algaszámnak az 1 millió ind./l alatti, nagy algaszámnak az e fölötti értékeket tartottuk.

Зависимость между химической потребностью в кислороде, содержанием взвешенных веществ и числом водорослей в Восточном Главном Канале

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Резюме

Результаты проб, которые еженедельно брались из воды Восточного Главного Канала на участке между Тисалёк-Балмазуйварош в течение 1968—75 гг., показали, что содержание взвешенного материала колеблется от 5—6 мг до 500—700 мг, показатели химической потребление в кислороде (ХПК) — между 3 и 15 мг, а число особей водорослей — от 30—50 тысяч до 15—20 мил. на 1 литр.

В своей работе мы хотим показать, в какой степени влияли на ХПК содержание взвешенных веществ и количество водорослей. Проделав анализ Патх, мы установили, что в случае высокого содержания взвешенного материала и низкого количества водорослей ХПК на 40—70% определяет количество взвешенного материали и лишь на 0,5—0,6% — содержание водорослей.

В случае же невысокого содержания взвешенного материала и большого числа водорослей химическую потребность в кислороде на 4—10% определяет содержание взвешенного материала и на 15—20% — число водорослей. Высоким содержанием взвешенного материала на участке Тисалёк—Тисавашвари мы считали показатель свыше 60 мг/л, а в Балмазуйвароше — свыше 35 мг/л, низким содержанием — показатели соответственно ниже приведенных. За небольшое число водорослей принимали показатель ниже 1 мил/л, а за высокое — превышающие 1 мил. показатели.

Zavisnost broja algi, hemijske potrošnje kiseonika i lebdeće mase u Keleti Főcsatorna

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Abstrakt

Na deonici Istočnog Kanala (Keleti Főcsatorna) izmedju Tiszalök—Balmazújváros, u periodu 1968—1975. godine, nedeljni uzorci su pokazali da se lebdeće materije u vodi kreću od 5—6 mg do 500—700 mg, vrednosti hemijske potrošnje kiseonika (HPK) su od 4—15 mg, dok se broj algi kretao od 30—50 hiljada do 15—20 miliona jedinki po jednom litru.

U radu je prikazano u kojoj meri je lebreći materijal i broj algi uticao na HPK. Path-ovom analizom je utvrdjeno da je u slučaju velike količine lebdećeg materijala- kada su alge malobrojne — HPK je u 40—70% ovisna od lebdeće mase, a u 0,5—0,6% od broja algi. U slučaju male količine lebdećeg materijala — kada su alge malobrojne HPK u 4—10% odredjuje lebdeći materijal, a u 15—20% broj algi.

Pod velikom količinom lebdeće mase smatrali smo veće količine od 60 mg/l kod deonice Tiszalök—Tiszavasvári, a kod deonice Balmazújváros veće količine od 35 mg/l. Količinu ispod ovih vrednosti smatrali smo malom količinom lebdećeg materijala. U odnosu na količinu algi vrednost ispod jednog miliona ind/l uzeli smo kao malu brojnost, a iznad kao veliku brojnost.