Water quality of Hungarian reach of the River Szamos

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Introduction

„In the thought of progress there was as much ignorance as self-confidence. We felt we were so up that we did not even look round to see whether we were really up or actually down."

(László Németh)

Németh László put down the thought chosen as a motto with the purpose of comparing modern and primitive art. We believe his thought can be considered valid in every walk of life where our activities have been motivated by progress at any cost.

The industrial countries of the west woke up earlier than us, they began to mitigate and eliminate the conflict between production and the condition of the environment. But we must add to this that earlier awakening was forced by pollution manifold greater than our problems ...

Our domestic results dwarfed beside the rehabilitation of the Thames and the Rhine, the decrease of a few percentage points in pollution hardly improved the quality of our waters.

If we look at the data in Table 1. and compare the pollution of the last column, 1995, and the previous one, 1990, we might as well be proud because the decrease is considerable. The only trouble is that we did not achieve it with activities to protect the water quality, but with the collapse of our agricultural and industrial production. This process is not characteristic of only our country, Figures 1-4. may prove it quite convincingly that the situation is similar to ours with our northern and eastern neighbours. We have selected 4 illustrative components: the annual averages of dichromate Chemical Oxygen Demand (COD_{Cr}) indicating organic pollution, ammonium and nitrate ions (NH_4^+ and NO_3^-) indicating plant nutriments and conductivity showing the pollution with mineral salts, which provide a comprehensive description of the changes in the water quality.

	estimated					measured				
tons/day	**1950**	**1955**	**1960**	**1965**	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**
COD_{Cr}	250	400	600	800	1000	1137	1105	964	835	478
Oil/Fat	15	30	40	55	70	90	60	47	49	27
NH_4^+	15	30	36	58	60	65	77	73	59	32
Mineral salt	1000	1500	1700	2000	2200	2417	2727	3059	3055	1812

%				
100	97	85	73	42
100	70	52	54	30
100	118	112	91	49
100	110	126	126	75

Table 1.

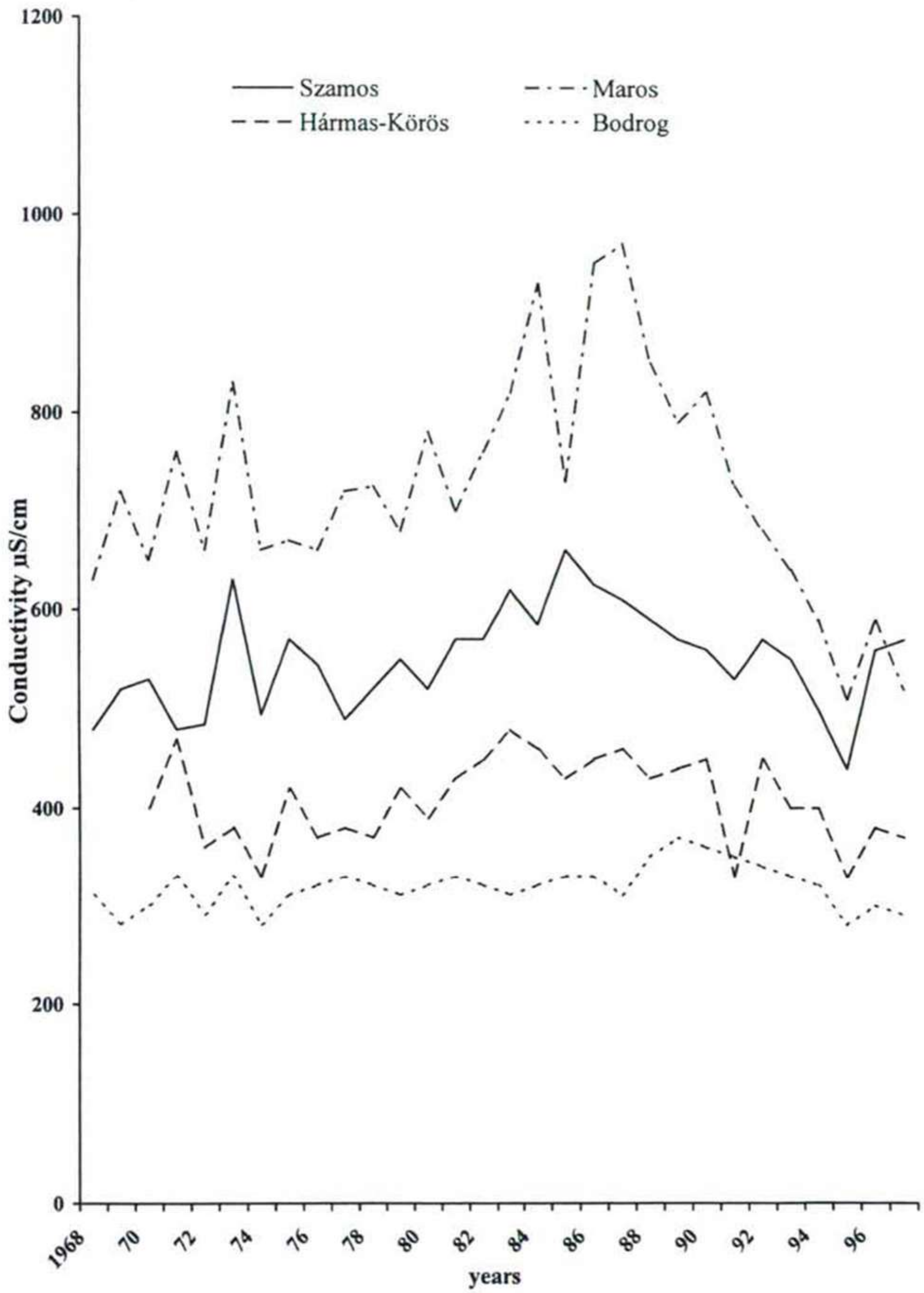

1200
1000
800
600
400
200
0
Conductivity µS/cm
Szamos
Maros
Hármas-Körös
Bodrog
1968
70
72
74
76
78
80
82
84
86
88
90
92
94
96
years

Figure 1.

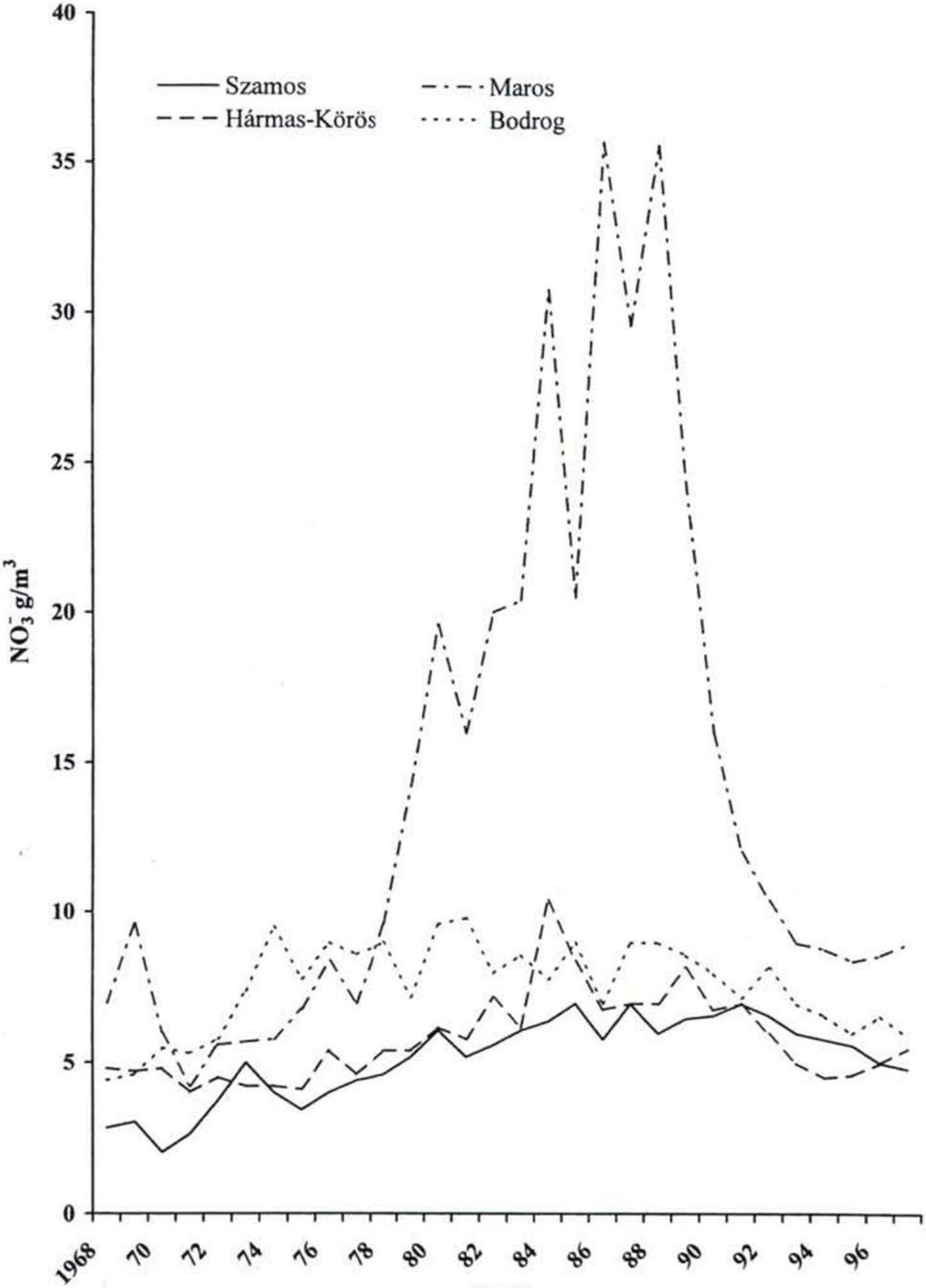
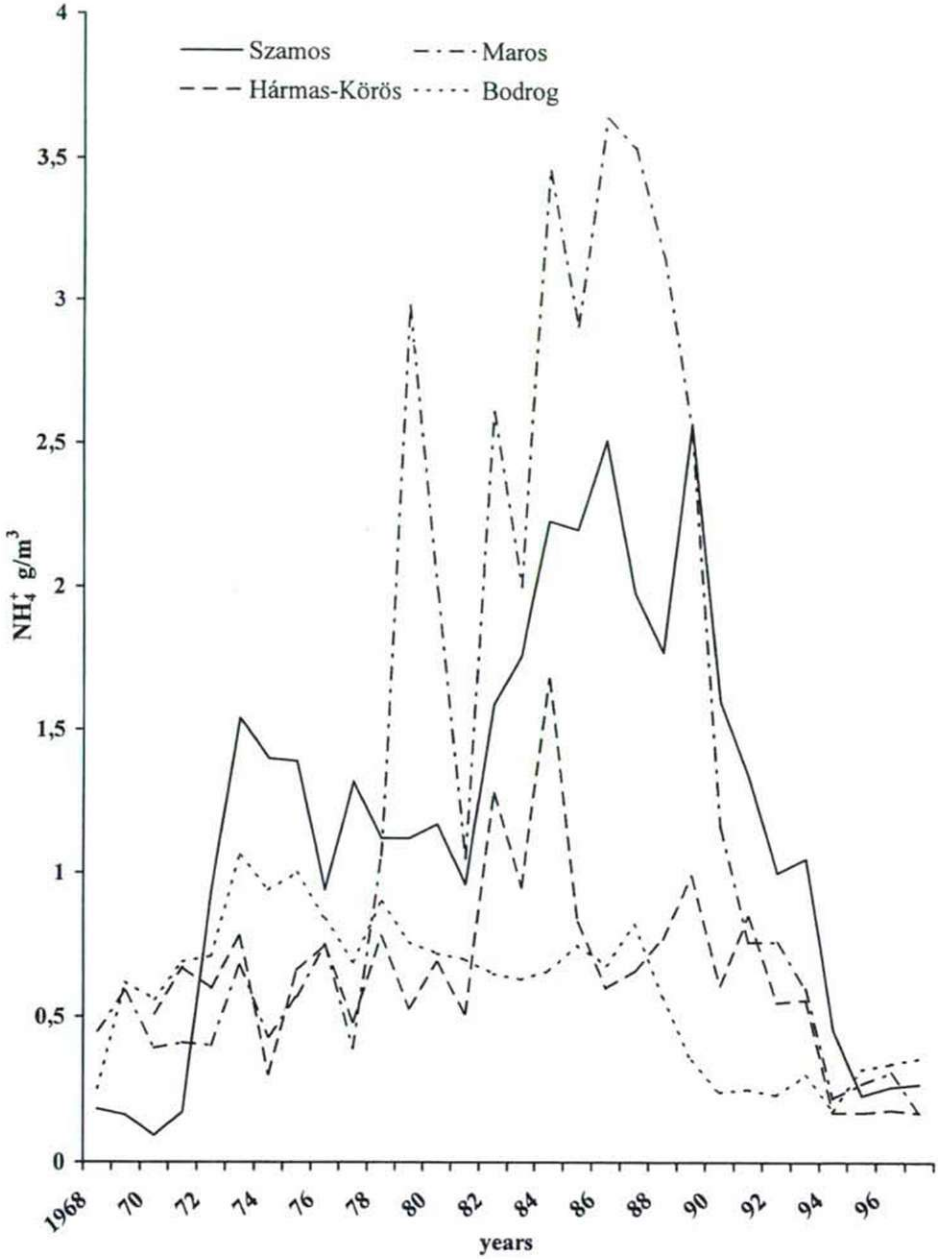
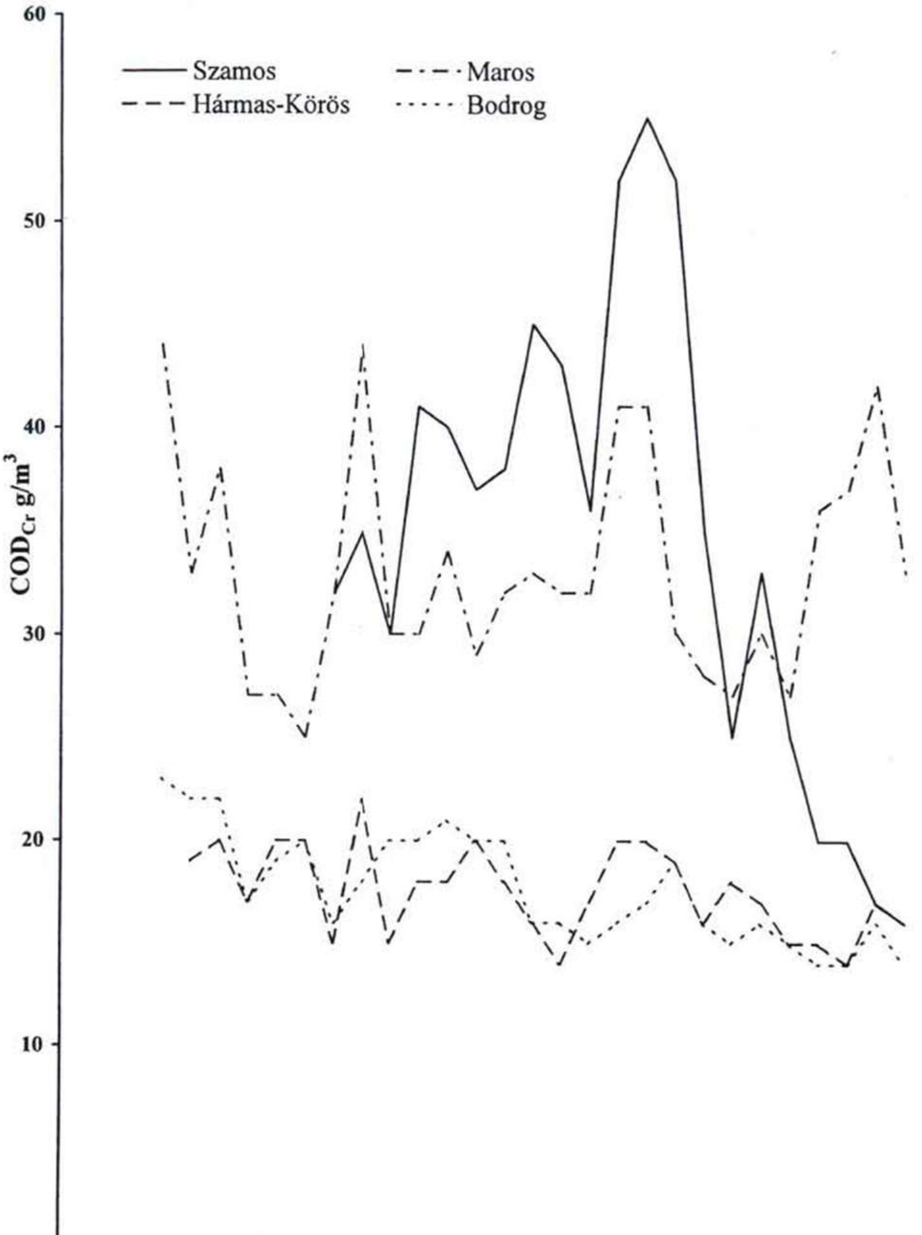

40
35
30
25
20
15
10
5
0
NO_3^- g/m^3
Szamos
Hármas-Körös
Maros
Bodrog
1968
70
72
74
76
78
80
82
84
86
88
90
92
94
96
years

Figure 2.



Szamos
Maros
Hármas-Körös
Bodrog
4
3,5
3
2,5
2
1,5
1
0,5
0
NH$_4^+$ g/m^3
1968
70
72
74
76
78
80
82
84
86
88
90
92
94
96
years

Figure 3.



Szamos
Maros
Hármas-Körös
Bodrog
COD_{Cr} g/m^3
60
50
40
30
20
10
0
1968
70
72
74
76
78
80
82
84
86
88
90
92
94
96
years

Figure 4.

We think we must review the happenings and problems - everyone in their own field - of the past now, at the time of a standstill, of decline. We should do it not for the sake of historical fidelity but, having drawn the conclusions, for being able to avoid the pitfalls.

We must carry out a thorough and profound analysis, because in our opinion there is quite a great chaos, a great deal of impatience and unfounded expectation of a miracle. Here we suspect we do not know well the natural conditions of the water quality, the conditions which has never experienced human activity. According to our system of evaluation watercourses that have not been polluted by humans often prove to be polluted. This is a problem, because we are unable to determine what we actually want to achieve, or because we will search for solutions in the wrong way.

Hydrographical data in the catchment area of the River Szamos

Meteorological observations in Hungary

Within the catchment area of the Szamos there is a meteorological station at Fehérgyarmat and at Jánkmajtis. We did not consider the data of precipitation accessible in hydrographical almanacs worth processing, because of the 411 rkm of the Szamos only 50 rkm are in Hungary and of the drainage basin of 15,880 sq. km only 306 sq. km. The river regime of the Szamos is determined by the hydrometeorological events across the border, whose data, however, we do not possess.

We have found a sequence of data noteworthy for us in the relevant value of the Hydrographical Almanac: the monthly average precipitation (in millimeter) for the confluence of the Szamos counted on the basis of the period between 1901 and 1940.

01	02	03	04	05	06	07	08	09	10	11	12	M
44	39	44	51	78	99	87	82	559	61	53	51	748

The data shown are averages, in the high mountainous areas of the Nagy-Szamos/Someşul Mare[1] the annual mean is 1000-1300 mm, at the spring of the Kis-Szamos/Someşul Mic it is only 800-1000 mm, whereas in the Transylvanian Basin it is about 600 mm.

1.1% of the drainage basin of the Szamos/Someş is high mountains, 24.9% is a mountainous area between the heights of 600-1600 m, 60.4% is a hilly area above 200 m, whereas 13.6% is plain below the altitude of 200 m.

Flowage from the area is determined by the combination of the relief conditions, precipitation, evaporation and the vegetation. In recent years it has also been influenced by reservoirs built in the catchment area. We should also mention that permeation, in other words the water-retaining capacity is medium in the drainage basin.

A consequence of the enlisted factors is that flood waves of a few days may occur after intense showers at any time of the year.

[1] The first name is Hungarian, and the second Romanian

Hydrometric staffs

On the Hungarian section of the Szamos there are 3 hydrometric staffs, run by the Hydrographical Service:

Cserger	47.6 rkm	catchment area 15 283 sq.km
Nábrád	19.0 rkm	catchment area 15 750 sq.km
Olcsvaapáti	4.7 rkm	catchment area 15 876 sq.km

Data concerning water levels can be obtained from the Hydrographical Almanacs, at the Csenger stretch daily water output is also provided.

The hydrometric staff at Csenger has been in operation since 1875. On the basis of the Water Management Institute (WMI)'s processing of the observations between the years 1921 and 1976 we have completed Figure 5., where we illustrate the monthly mean streamflow at various probability. Dinamism of average monthly streamflow shown in Figure 6.

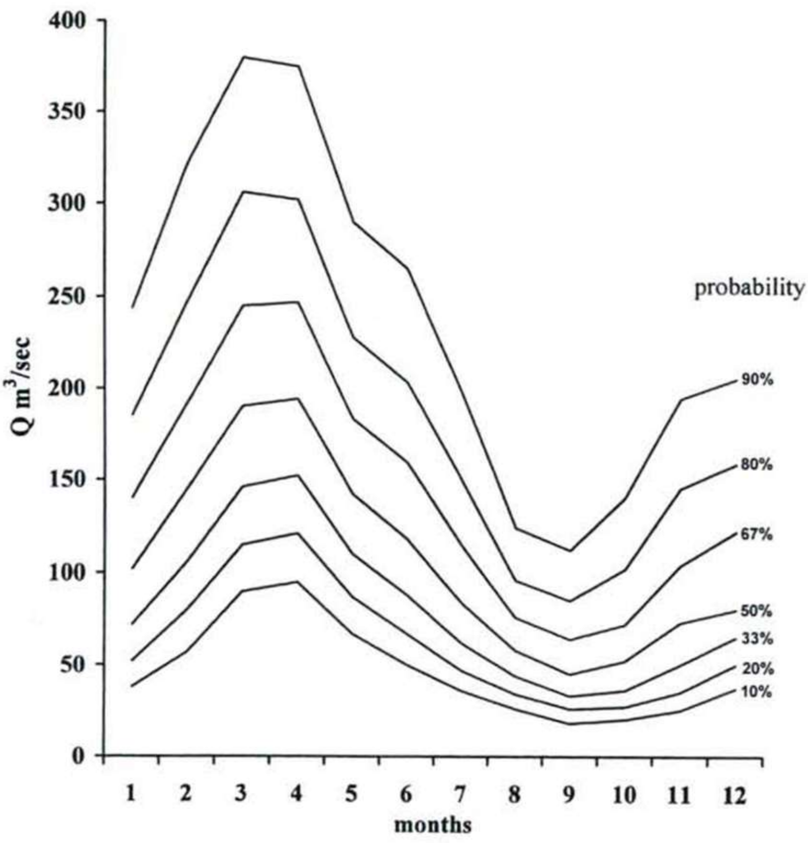


Figure 5.

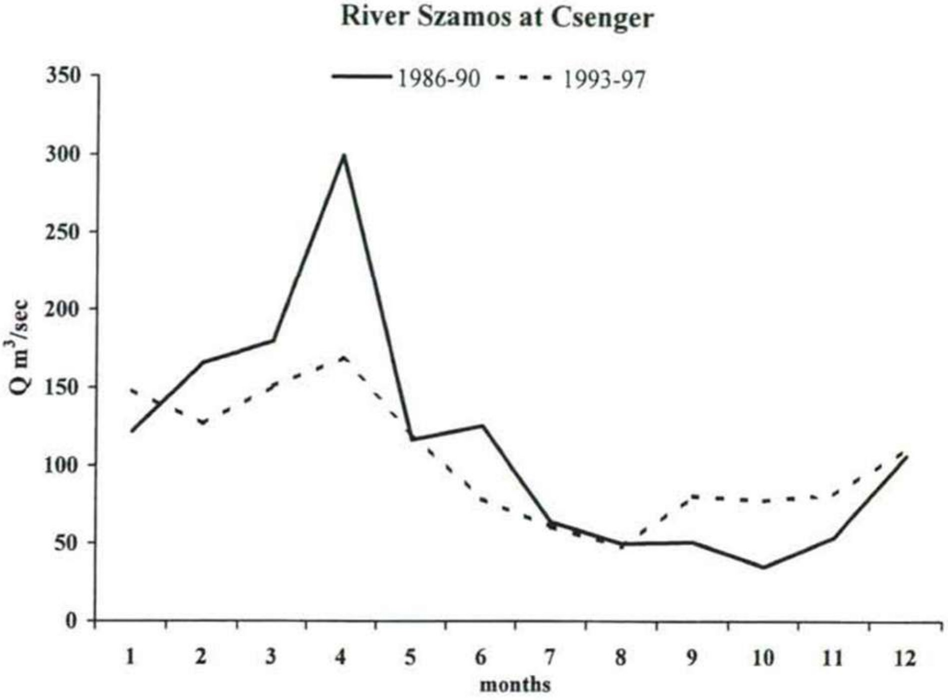


Figure 6.

On counting the stream of mass we noted that the Environment Management Institute (EMI) has recently corrected the data registered at taking the samples; they replace them with the daily average streamflow recorded in the Hydrographical Almanacs. With regards to the insignificant difference this change causes in the stream of mass we have not corrected our former calculations.

Concerning the water quality the accumulation process of the waters flowing down the bed is of vital importance. Water penetrating through impermeable layers is filtered, surface flowage may or does wash pollution of colloidal or coarse disperse phase. Changing water output results in changing speed (stream energy), so settling or stirring occur. Dilution provided by the water mass flowing down is also important here.

The rate of flowage, even the averages counted from data of long periods may vary from day to day. To illustrate the degree of importance of this we show the averages counted from the streamflow measured at the same time as taking the samples, for four 5-year periods: 1. 1976-80, 2. 1981-85, 3. 1986-90, 4. 1993-97.

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Okt.	Nov.	Dec.	average
1	281	277	278	295	242	164	147	103	106	88	105	150	186
2	180	151	261	193	244	142	99	70	41	63	70	207	143
3	122	166	180	300	117	126	63	58	51	35	54	107	114
4	148	127	151	169	121	79	61	48	81	78	82	112	105

Table 2.

So we must remark that our survey of the water quality was conducted while the water output was decreasing, which was seemingly moderated by fluctuation, but was still significant. The trend of the annual Mean Streamflow for the 21-year period between 1976 and '97 is as follows:

$MWD_n=188-4.6n$ $r=0.65$ $M=135\ m^3/sec$

MWD_n is the mean streamflow of the nth year in the time sequence, „n" is the number of years, „r" is the correlation factor, which characterizes the closeness of the relationship determined by the equation.

We would also like to remark that the trend is characteristic only of the time period the calculation included. Extrapolation must not be done, because, for instance, we could easily come to the conviction that the Szamos would completely dry up in about 40 years. With examining long - 40-50-year time sequences of MWD the regression factor usually turns out 0.

Water quality surveys

The first water quality surveys (that we know of) were conducted by VITUKI (Water Research Center for Water Resources Development) in the case of the Szamos in the first half of the 50s, and the results were published in 1957 entitled „Qualitative evaluation of our watercourses".

The condition of the water quality was indicated in 5 sections of the Szamos with 1 sample every season.

The water managament created the network of laboratories examining water quality in the 2nd half of the 60s for every Disctrit Water Authority, and since 1968 the Szamos has been measured at the 46.4 rkm - Csenger - weekly, and at the 19.2 rkm - Tunyogmatolcs - every second week. At the beginning of the 90s the laboratory network was annexed to conservation and examination of the Tunyogmatolcs section ceased on the basis of MSZ (Hungarian Standard) 12749. We should not complain about it because domestic pollution is insignificant, so a fundamental change in the water quality does not occur from Csenger to the confluence of the river with the Tisza at Vásárosnamény.

The watercourse sections to be sampled, frequency sample-taking, the range of components to be examined, methodology to be applied at the evaluation, and the methods of examination were determined by MSZ 10-172/1-83, MI 10-172/2-84 and MI 10-172/3-85 until 1994. Since then the regulations of MSZ 12749 have been compulsory.

Evaluation of the water quality data of the Szamos

At first approach we have reviewed the data sequences of the 1955 measures of VITUKI. We have concluded that concentrations of pollutants of the 4 samples for the 4 sections each - Csenger, Szamossóly, Tunyogmatolcs, Olcsvaapáti - did not reveal significant differences, as it had been expected on the basis of minimal domestic pollution. Here we present mean concentrations for every season:

	Winter	Spring	Summer	Autumn
COD_{Mn} g/m^3	6,60	16,50	14,80	4,60
BOD_5 g/m^3	2,20	2,90	2,70	1,20
O_2 g/m^3	98,00	105,00	99,00	96,00
NH_4^+ g/m^3	157,00	172,00	150,00	288,00
NO_3^- g/m^3	8,20	9,20	4,00	2,60
Conductivity uS/cm	474,00	334,00	420,00	559,00
Na^+ g/m^3	41,00	25,00	-	80,00
Cl^- g/m^3	52,00	272,00	35,00	110,00
Total Hardness $g/CaO/m^3$	122,00	86,00	91,00	112,00
Total suspended matter g/m^3	127,00	241,00	529,00	54,00
pH	6,38	7,62	8,12	7,62
Q m^3/sec	106,00	326,00	180,00	35,00

Table 3.

Judging from the results the water of the Szamos was being polluted even then. It was probably the communal pollution entering the water without purification at Kolozsvár/Cluj and Szatmárnémeti/Satu Mare, though only a small amount yet, of which the biologically decomposable part the watercourse managed to tackle.

Permanganate Chemical Oxygen Demand (COD_{Mn}) points to an important factor: the amount of most probably dissipative organic debris that though biologically not, but chemically is oxidizable, will grow with increasing streamflow.

The mineral indicators changing with streamflow prove a more powerful dilution, which indicates the input of industrial pollution and/or mine waters containing minerals.

Oxygen concentrations did not show any significant pollution.

Nitrate ion concentrations are already surprisingly high - then they may not have come from artificial fertilizer washed in.

Examination of oxygen budget

Of the components of oxygen budget we have got an unbroken time sequence between 1968-97 and 1976-90 concerning 5-day Biochemical Oxygen Demand (BOD_5) and the oxygen saturation; their descriptive statistics already enlisted are summed up in Figures 7-8.

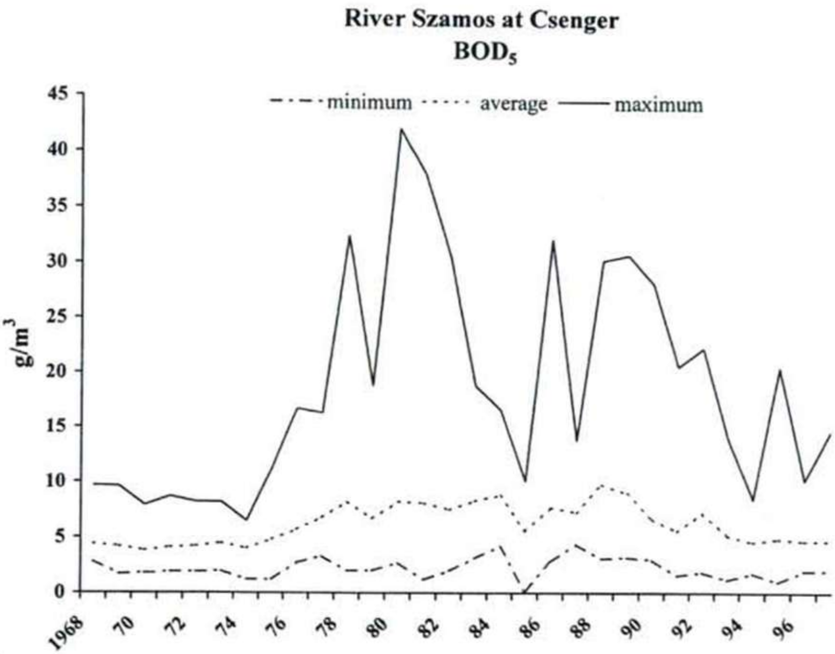


Figure 7.

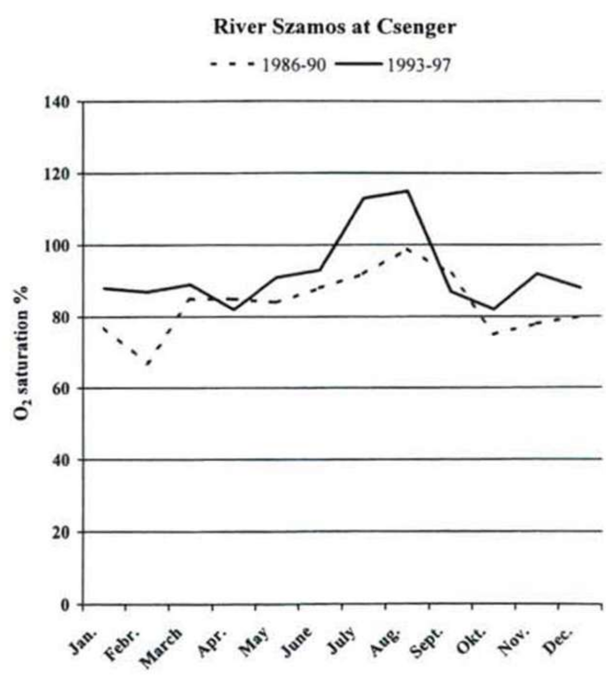


Figure 8.

The 30-year time sequence can be characterized mathematically by the trends below.

BOD_5	Cn= 5.30+0.057n	r=0.28	M=6.88 g/m^3	s=1.76
O_2 Sat. %	Tn=83.6+0.201n	r=0.33	M=86.7%	s=5.22

Where n=number of year, Cn=concentration of n^{th} year, Tn= saturation of n^{th} year, r= correlation coefficiens, M= average value, s=variance

The original (shaken, so containing floating substances, too) BOD_5 have been examined regularly only since 1977 at the Csenger section of the Szamos, so the trends of the four important components between 1977-97 are also determined:

COD_{Cr}	Cn=45.1-0.94n	r=.0.50	M=34.8 g/m^3	s=11.4
COD_{Mn}	Cn=17.1—.39nn	r=0.54	M=12.8 g/m^3	s=4.39
BOD_5	Cn=8.63-0.15n	r=0.60	M=6.93 g/m^3	s=6.15
O_2 Sat. %	Tn=79+0.68n	r=0.67	M=88.5 g/m^3	s=6.15

The characteristic annual statistics of COD_{Cr} in the time sequence between 1977-97 are shown in Figure 9.

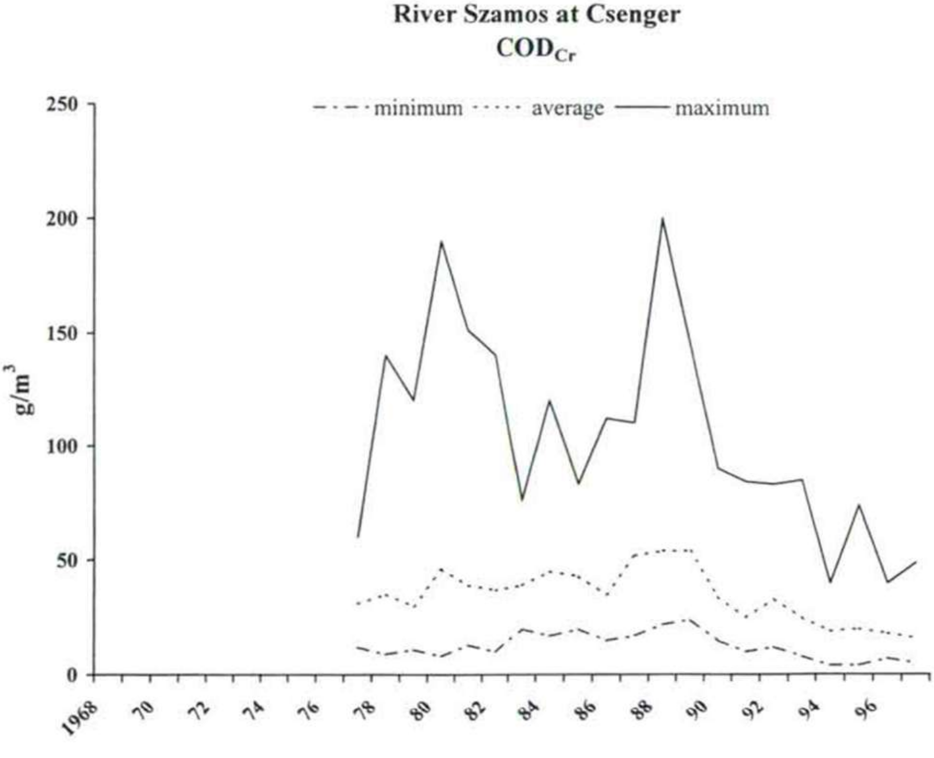


Figure 9.

The picture based on the figure and the four trends are encouraging, but the comparatively low correlation factors of the trends indicate the uncertainly of the change.

Here the problem is the same as the one we mentioned previously, namely that annual fluctuation, ascending and descending trends following each other loosen up the relationship expressed by the equation.

Looking back at the 1955 BOD_5 concentrations we can say that until the commencement of regular measurements in 1968 they nearly doubled. The sequences of the 10-year trends also testify that deterioration was continuous until the period of 1976-85 in a way that the intensity of the increase reached its maximum between 1972-81. At the same time the relationship was closest with a 0.92 correlation factor. After that during four further periods deterioration decreased - and the relationship loosened - and then it began to decrease in an uncertain way, the trend being broken time and again. We found the highest figure of the degree of decrease in the 1988-97 period.

With the slid trends of COD_{Cr} and COD_{Mn} the situation is similar to the previous one with the remark that the first periods are missing here, and the improvement presented itself later, though more markedly then.

Oxygen saturation until 1968 - probably in relation to the increase of biologically decomposable organic pollution (natural purification!) - decreased compared with the 1955 concentrations, but the minimums did not become catastrophic even in that period. Concentrations have increased since 1977-86, but the process became consummate in the 1990s. This phenomenon is not clearly positive, because maximum concentrations show considerable supersaturation, which indicates the commencement of the eutrophication process of the river. *It is to be feared that in summer and early autumn excess growth of algae occurring more and more often in the 90s will contribute to the increase of COD and BOD, and because of the change of the milieu algae dying in the Tisza may or will lead to great lack of oxygen.*

We have already seen at the 1955 examinations that concentrations in different seasons show significant differences. For a more detailed presentation of this we have processed the concentration sequences of the COD_{Cr} for each season and month of the years 1976-90. The results are summed up in Table 4.

In order to get to know the concentration sequences in more detail we have arranged four 3-year sequences, and their total frequency is summed up in Table 4a. The table provides information about the improvement process as well, but it is more important that it informs us about the distribution of elements according to size. The proportion of the minimums and maximums of streamflow is 50-100, of the concentrations it is 15-50.

COD_{Cr} g/m^3

	n	M	s	Cv	min.	80%	95%	max.
Total	725	41	23	0.56	8	54	89	200
winter	178	43	23.5	0.54	11	52	87	200
spring	181	41	26.2	0.64	8	53	90	190
summer	183	40	20.4	0.51	14	52	81	120
autumn	183	40	21.6	0.54	9	55	80	140
January	65	42	20.1	0.48	11	56	76	112
February	555	43	28.2	0.65	15	50	89	200
March	59	44	25	0.57	13	55	92	151
April	58	37	20	0.54	8	48	78	100
May	64	41	31.5	0.76	10	53	90	190
June	559	40	24.4	0.61	14	49	104	120
July	62	40	19.7	0.5	15	55	72	100
August	62	40	17	0.42	15	51	68	92
September	60	40	21.4	0.54	11	54	72	140
October	64	37	18.5	0.49	12	49	70	106
November	59	43	24.6	0.57	9	70	86	120
December	58	45	22.5	0.5	17	57	84	140

Table 4.

Summarized frequency

River Szamos at Csenger

1. 1978-80 **2.** 1981**3.** 1988**4.** 1991-93

	COD_{Cr} g/m3				COD_{Mn} g/m3				BOD_5 g/m3			
	1	2	3	4	1	2	3	4	1	2	3	4
minimum	8	10	15	8	2,4	4	5	2,6	2	1,2	3	6
5%	15	16	19	12	5,9	6,2	5,9	3,8	3,2	3,1	3,4	2
10%	18	20	23	13	6,6	7,3	7,5	4,8	3,9	4	4	2,6
20%	20	24	28	17	7,5	8,4	9,8	5,6	4,3	5,1	4,9	3,6
30%	24	27	31	19	9	9,6	11,2	6,6	5	5,6	5,9	4,2
40%	25	30	36	22	9,8	10,7	12,5	7,2	5,7	6,1	6,8	5
50%	30	33	40	24	10,4	12,5	14,8	8	6,1	6,7	7,1	5,4
60%	33	38	49	26	12,9	13,9	16,8	8,6	6,4	7,7	7,9	6
70%	38	40	55	29	14,8	16,3	18,7	9,4	7,6	8,6	8,9	6,6
80%	46	48	61	36	19,5	19,1	22,7	12,7	9,3	9,9	10,5	7,3
90%	65	60	78	48	26,8	24,5	29,8	15,7	13,3	12	14,9	9,8
95%	88	76	90	52	33,2	30,5	38	22	16,8	16,2	19,6	11,9
maximum	190	151	200	85	102	78,5	86,4	32,4	42	38	30,7	22,3
average	37	38	47	28	14,7	14,8	17,5	9,5	7,7	8	8,5	6

Table 4a.

Looking through these tables it is surprising that although the different figures of streamflow, as we have seen it, are arranged to a certain extent according to the months, we do not encounter excessive differences in the monthly statistics of the oxygen demand.

We suspect the increase of point-like pollutants behind the increase of concentration, or at least a drastic human interference with the natural condition of the drainage basin. After we have seen that streamflow has decreased in the past 10-15 years and that COD's and BOD to a lesser extent change inversely to streamflow we become uncertain at acknowledging the improvement process because it might only be the play of nature: a considerable change in weather can reverse the whole process and after some years have passed we may have to endure a pollution similar to that of the 80s ... This uncertainty has been increased by the examination of the streams of mass, which we defined as the multiplication of concentrations and their respective streamflow. The stream of mass of the three main components, expressed in tons/day dimension:

year	COD_{Cr}	COD_{Mn}	BOD_5
1981	988	500	190
1982	608	225	104
4983	3224	108	67
1984	368	138	64
1985	698	254	83
1986	693	275	148
1987	564	212	69
1988	654	212	117
1989	649	304	128
1990	209	70	39
1991	305	111	70
1992	338	131	89
1993	280	95	51
1994	137	45	31
1995	269	104	64
1996	180	68	45
1997	210	86	63

Table 5.

Trends of average load (L) of pollution of the 17 years:

COD_{Cr}	Ln=757-35.3n	r=0.74	M=440 tons/day	s=234
COD_{Mn}	Ln=312-15.5n	r=0.67	M=173 tons/day	s=112
BOD_5	Ln=128-4.9n	r=0.59	M=84 tons/day	s=41

According to the equations under 17 average daily streams of mass decreased by 600 tons with COD_{Cr}, by 264 tons with COD_{Mn} and 83 tons with BOD_5.

As far as we remember, however, Budapest did not perform daily organic pollution of 600 tons even at the height of industrial production - 48% of the domestic industry was concentrated there! - so, although we do not know the pollution of Transylvania, we doubt

600 tons of daily decrease. The trends do not tell us lies, but they do not separate the changes in pollution caused by nature and those caused by human interference, either.

Our scepticism outlined here is supported by Figure 10., too. They confirm the fact of a change, but the differences of pollution from month to month, their spring maximums and autumn minimums exclude the explanation that decreases in industrial and communal pollution are the causes.

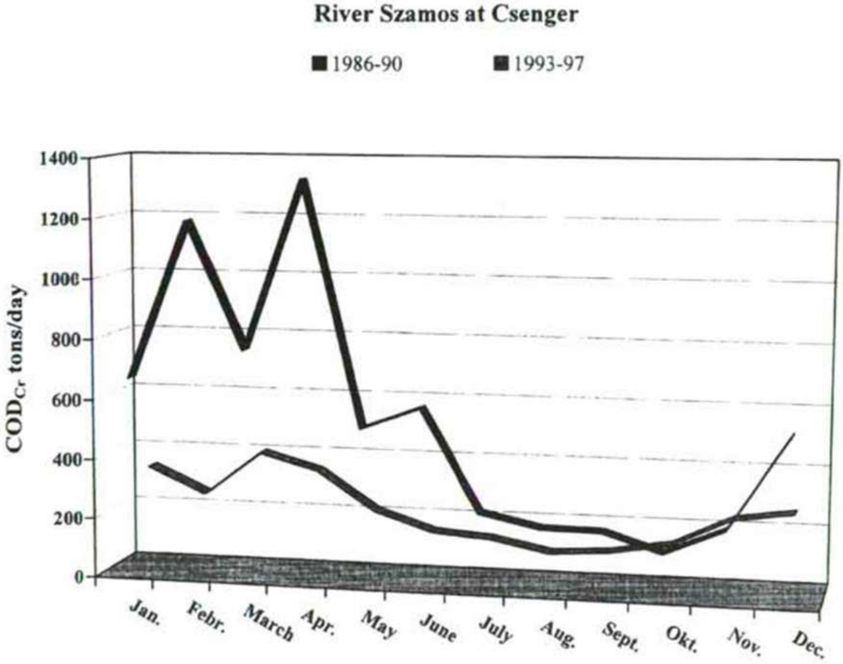


Figure 10.

The fact that the extent of changes expressed by the previous trends is unreal is „known“ by the trends as well, the question should only be put in a different way. The trend of streams of mass determined at or less than 100 m^3/sec streamflow:

COD_{Cr} Ln=194-4.2*2* r=0.48 M=148 tons/day s=52

so decrease is only 71.4 tons/day here for the 17 years.

To analyze the problem more thoroughly we have included in our examinations the time sequences of settled COD_{Cr} and COD_{Mn} that resumed in the 80s with the examination of the Csenger section. (COD of the original, so shaken, sample is proportional to all concentrations of organic matter, that of the settled sample is proportional to the dissolved and colloidal-phase ones, and the difference of the two is proportional to concentrations of organic matter in coarse disperse phase.)

The 7 thus gained concentrations of components characteristic of organic pollution have been arranged into 4-year periods according to the ranges of streamflow, parallel to streams of mass (Table 6.).

Table 6.

River Szamos at Csenger

1982-85			concentration g/m³							stream of mass tons/day						
	n	Q	COD_{Cr}			COD_{Mn}			BOD_5	COD_{Cr}			COD_{Mn}			BOD_5
		m³/sec	total	diss.	susp.	total	diss.	susp.		total	diss.	susp.	total	diss.	susp.	
Q ≤ 50	66	38	44,3	34,4	8,9	14,4	5,9	8,5	9	117	89	28	38	31	7	23
50 < Q ≤ 100	59	70	35,5	23,6	11,9	11,4	7,5	3,9	6,6	214	142	72	69	44	25	40
100 < Q ≤ 150	19	131	42,2	26,8	15,4	13,5	8	5,5	7,7	445	286	159	145	86	59	82
150 < Q ≤ 200	19	177	32,6	20,4	12,2	10,2	6,5	3,7	5,2	500	314	186	156	100	56	77
200 < Q ≤ 400	30	258	39,1	21,5	17,6	15,4	6,8	8,6	6,3	905	468	437	369	147	222	141
Q >400	10	578	57,4	26,4	31	26	10,2	16,1	11,2	3004	1254	1750	1346	498	1298	486

1986-89			concentration g/m³							stream of mass tons/day						
	n	Q	COD_{Cr}			COD_{Mn}			BOD_5	COD_{Cr}			COD_{Mn}			BOD_5
		m³/sec	total	diss.	susp.	total	diss.	susp.		total	diss.	susp.	total	diss.	susp.	
Q ≤ 50	61	34	50,7	40,1	10,6	18	13,6	4,4	8,5	144	118	26	53	40	13	25
50 < Q ≤ 100	80	72	41,5	29,6	11,9	15,3	10,6	4,7	7,5	256	180	76	94	64	30	48
100 < Q ≤ 150	27	127	51,5	22,8	28,7	18,8	8,2	10	6,2	562	248	314	206	96	110	90
150 < Q ≤ 200	7	174	46,2	34,1	12	20,7	8,7	12	6,7	709	526	183	324	128	196	98
200 < Q ≤ 400	18	280	44,6	20,3	24,3	18,6	8,4	10,2	7,9	1120	517	603	490	224	266	201
Q >400	13	639	85	28,5	56,5	31,8	10	21,5	15,8	4767	1593	3174	1812	583	1229	966

1990-93			concentration g/m³							stream of mass tons/day						
	n	Q	COD_{Cr}			COD_{Mn}			BOD_5	COD_{Cr}			COD_{Mn}			BOD_5
		m³/sec	total	diss.	susp.	total	diss.	susp.		total	diss.	susp.	total	diss.	susp.	
Q ≤ 50	85	35	28	17,6	10,4	8,8	5,8	3	5,8	82	50	32	25	17	8	17
50 < Q ≤ 100	65	70	26,7	18,6	8,1	9,1	6	3,1	6,8	167	115	52	56	37	19	36
100 < Q ≤ 150	34	122	28	17,7	10,3	9,3	5,8	3,5	5,8	295	185	110	97	61	36	59
150 < Q ≤ 200	14	172	35,5	18,5	17	14,4	8,2	6,2	8,1	551	275	276	229	118	111	116
200 < Q ≤ 400	2	267	43,8	26	17,8	13,5	7,1	6,4	9	1107	600	507	278	171	107	210
Q >400	5	678	56,5	35,1	21,4	29	10,4	19,4	16,8	3688	1936	1752	1760	613	1147	964

Tables containing the figures of concentration and stream of mass corresponding the ranges of streamflow tell us everything about the relationship between streamflow and pollution, though the facts reflected are to a certain extent distorted.

Distortion is caused by the fact that the figures of concentration and stream of mass are averages of elements characterizes by 30-40% dispersion in time, and like every statistics, the average bears estimation errors. According to the statistics estimation error of the averages is the smallest - $s_M=s/n^{1/2}$ -, but if dispersion (s) is high and the number of elements (n) is low, it may be considerable. Lines 1-3 of the tables provide more or less correct information, but with the streamflow increasing the number of elements decreases, so these lines may have a standard error of 10%.

It is a further problem that, besides streamflow, pollution is influenced by even more circumstances, of which trends are either the opposite of or the same as those of streamflow. What constitutes a change in the water quality are the mass of organic matter produced during eutrophication and degrading in the self-purification processes of the watercourse, daily, seasonal etc. fluctuation of point-like communal and industrial pollution, the characteristics of the hydrometeorological time sequence before the time the examination takes place, etc.

Examination of organic pollution in several watercourses of various streamflow and degree of pollution, according to the ranges of streamflow, however, allows us to draw some general conclusions:

With watercourses of no or insignificant pollution the lowest concentrations of COD and BOD - and the lowest streams of mass - can be detected at low waters.

With the streamflow increasing, oxygen demands in settled samples fluctuate only statistically, rather than change in a predicted direction, the shaken ones increase slightly, but surely.

From streamflow of middle-water mark onwards oxygen demands of both the settled and the shaken samples increase, at high waters dramatically, 2-5 fold. Increase in the stream of mass, naturally, intensifies with increasing streamflow.

Streams of mass of ranges at low waters may be exceeded manifold by those of ranges at high waters - according to the characteristics of the watercourse. With the Danube having more even streamflow this proportion does not reach 10, with the Tisza it exceeds 70. (These proportions are true for the cleanest sections.)

The most sensitive response to point-like pollution is at the ranges of streamflow at low waters. Expressed in percentage points they cause the most significant change in the stream of mass here. So the proportions indicated above usually decrease if pollution increases.

What is important in the above-mentioned conclusions, as far as the water quality of the Szamos is concerned, is that decrease of point-like pollution can be inferred from the decreases of stream of mass in ranges at low and mean stage. On the basis of the periods 1986-89 and 1994-97, therefore, decrease of pollution for every range of streamflow is the following:

	COD_{Cr}	COD_{Mn}	BOD_5
$Q \leq 50$	144-82= 62 t/day	53-23=30 t/day	25-16=9 t/day
$50 < Q \leq 100$	256-90=166 t/day	94-34=60 t/day	48-24=24 t/day
$100 < Q \leq 150$	562-167=395 t/day	206-65=141 t/day	90-46=44 t/day
$150 < Q \leq 200$	709-281=428 t/day	324-105=219 t/day	98-72=26 t/day
$200 < Q \leq 400$	1120-656=464 t/day	490-259=231 t/day	201-172=29 t/day
$Q > 400$	4767-1400=3367 t/day	1799-559=1229 t/day	966-352=614 t/day

Table 7.

Of these, concerning decrease of pollution, the first three lines should be considered. All in all, decrease of organic matter with regard to point-like pollutants can be put at 100-150 tons/day of COD_{Cr}, 50-80 tons/day of COD_{Mn} and 20-30 tons/day of BOD. With the last component, decrease of the pollution measured at the site of its discharge must have been greater, but some of it did in the past and does now already decompose by the time it reaches the site of sampling at the border section.

Figures of organic pollution has decreased, but they still exceed the desired degree significantly. Considering the unavoidable presence of purified industrial and communal sewage, by operating the purifying technologies at a high degree of efficiency a further decrease of 20-30% can be achieved. In ranges at low waters it should stabilize with concentrations at 12 g/m³ of COD_{Cr}, at about 4-5 of COD_{Mn} and at about 3-4 g/m³ of BOD.

At evaluating the Szamos no miracle should be expected. High waters will invariably wash in great amounts of humus and plant debris under humification, so because of COD_{Cr} as well as the other indicators of organic matter, the condition of the water quality will come out IV and V.

Pollution of plant nutriments

Plant nutriments - inorganic nitrogen and phosphorous derivatives (ammonium-ammonia NH_4^+-NH_3, nitrite NO_2^-, nitrate NO_3^- and PO_4^{3-}) - the survey data of all phosphorous and all nitrogen concentrations are only short-term ones. Characteristic annual statistics of the time sequences of the 4 important components are included in Figures 11-14.

Trends of the 25-year averages - 1973-97 - of the 3 important components:

NH_4^+	Cn= 1684-23.7n	r= 0.22	M= 1377 mg/m³	s= 634
NO_3^-	Cn= 4.7+0.071n	r= 0.52	M= 5.6 mg/m³	s= 0.98
PO_4^{3-}	Cn= 303-1.6n	r= 0.21	M= 263 mg/m³	s= 54.5

Table 8.

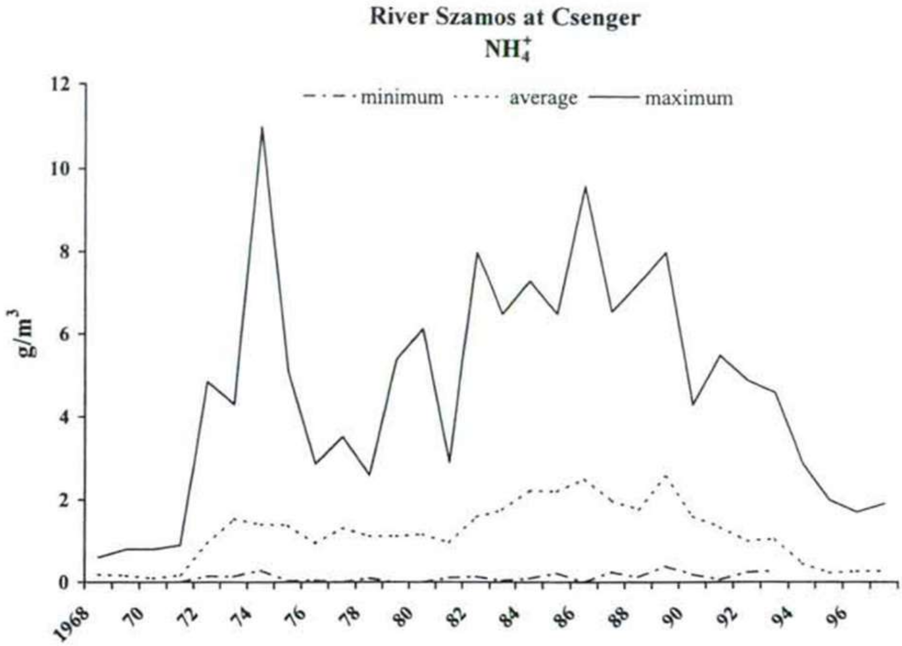


Figure 11.

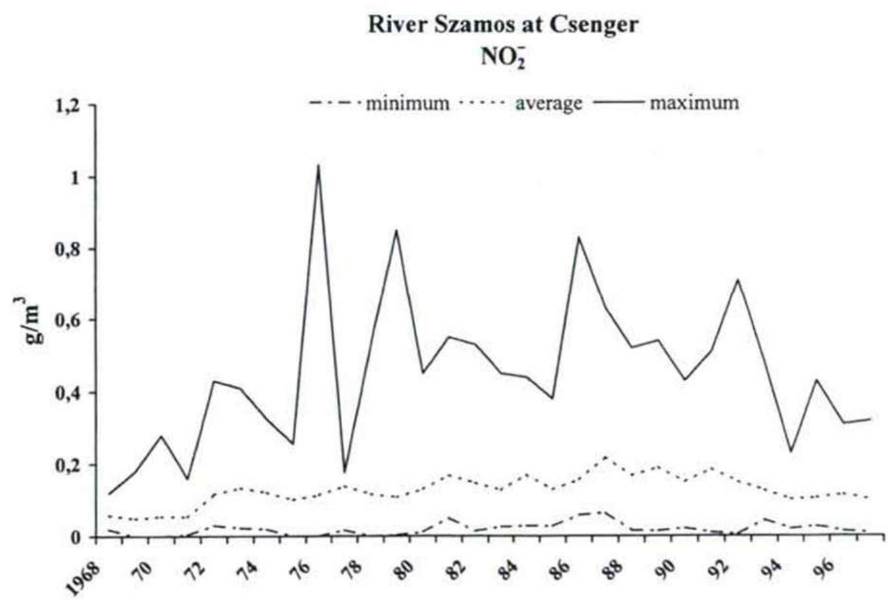


Figure 12.

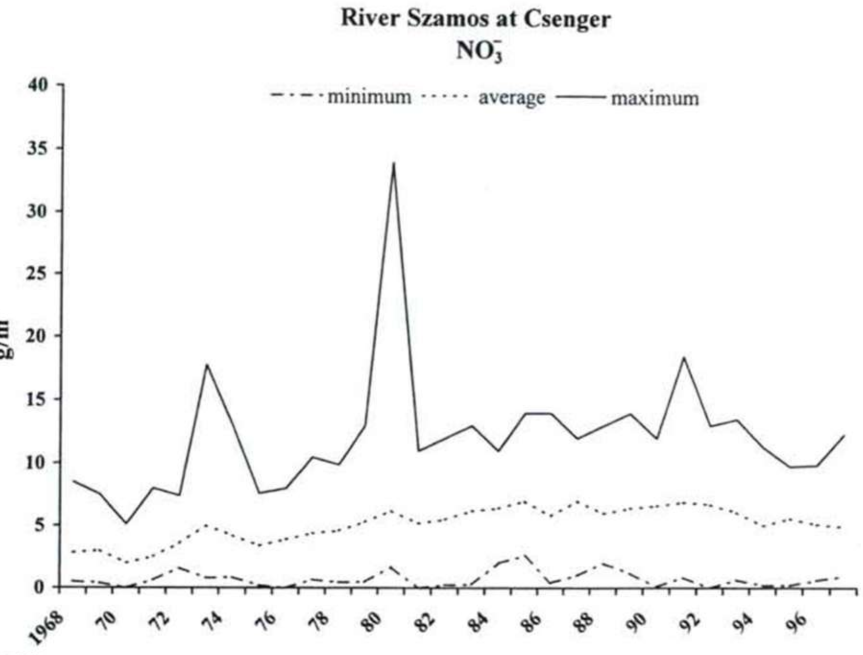


Figure 13.

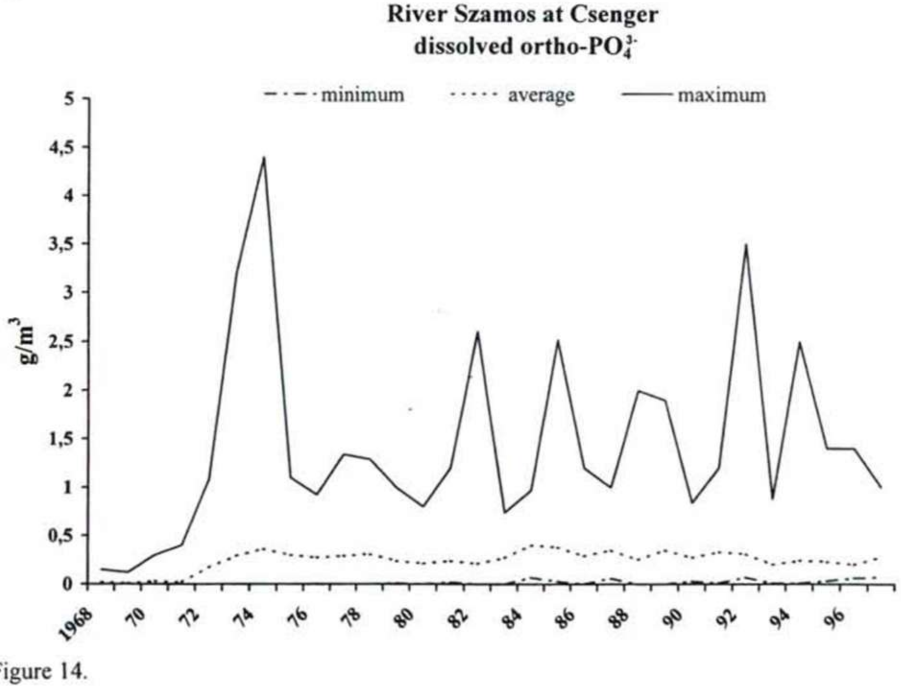


Figure 14.

Correlation factors indicate unstable relationships, which is natural, because there were deteriorations as well as improvements during the 25 years, not considering the loosening caused by natural fluctuation.

Average annual streams of mass have also been completed for the 15-year time sequence of the survey results:

	NH_4^+	NO_3^-	PO_4^{3-}
year	tons/day		
1983	13,1	57,5	1,7
1984	10,5	51,7	2,2
1985	29,8	128,3	4
1986	20,4	101,5	2,5
1987	18,3	76,7	2,8
1988	15,3	79,1	1,8
1989	26,6	78,4	2,8
1990	11,1	43,7	1,6
1991	11,3	69,6	2,7
1992	15,6	63,2	3,2
1993	12,1	64,7	1,7
1994	3,7	43,5	2,2
1995	2,1	58,2	2,3
1996	2,2	47,2	2,4
1997	2,6	52,5	3,3

Table 9.

If we assume that in the drainage basin of the Szamos there are about half a million people who live in areas with sewerage and the collected sewage water is purified at high-power sewage clarification plants decomposing 80-85% of the pollution, then nutriment pollution of the population can be estimated from the specific data. Communal pollution by our estimation can be put at 3500-4000 kg/day of ammonium ion and about the same amount of orthophosphate ion.

Comparing the estimated average pollution with the estimated streams of mass it should be remarked that stream of mass of ammonia-ammonium ions and orthophosphate ions in the last 4 years came primarily from communal sewage water. Great amounts of the previous years flowed into the receiver from food processing plants and animal (primarily swine) farms.

What is mainly responsible for nitrate ion pollution is agriculture, but some of it came from areas without sewerage trickling from nitrated ground water.

Surveying nitrate ion it should be highlighted that its concentrations in the Szamos are usually favourable, since 1968 its maximum has exceeded the limit value of class I only once and has come close to it once. It must, therefore, be assumed that the Hungarian wasteful use of artificial fertilizer was never the case in Transylvania.

The origin of phosphate and ammonium from point-like sources is proven by the fact that their sequences, arranged according to ranges of streamflow decreased with streamflow except for the range of maximum streamflow. The origin of nitrate pollution from diffuse sources is proven by their increase with streamflow, characteristic of dissolution.

Orthophosphate concentrations in themselves would not hurt the interest of those using water, but together with the excess of nitrogen compounds it reaches the degree of concentration which generates eutrophication processes. This situation has been the case for more than a decade, but biological overproduction in the Szamos was detected only in the 90s, primarily in the summer and early autumn seasons.

Determination of a-chlorophyll serves as the measurement of that component - alga production. Unfortunately it has been measured regularly only for the past 4 years - 1994-97. The previous period can be described by the samples of some fragments taken when algal bloom was detected. On the basis of evaluations of other surface waters, however, we know that in our watercourses, considering conditions of flowage within our country, oxygen supersaturation can only be measured if intense primary production, namely algal bloom, occurs. Maximums at times occurred indeed in past years, too, so eutrophication is not a new phenomenon in the Szamos either.

Monthly averages of a-chlorophyll are shown in Figure 15.

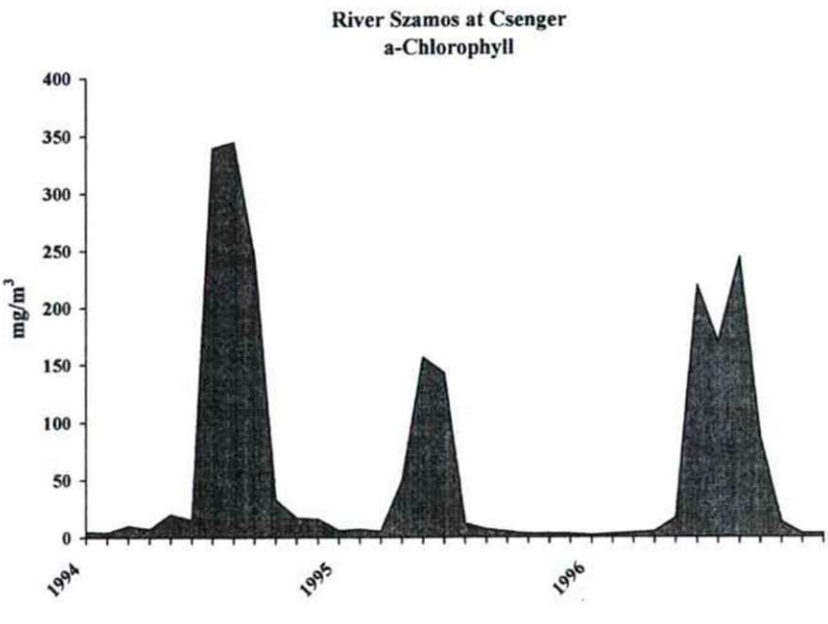


Figure 15.

Eutrophication of the Szamos is an especially dangerous phenomenon because the Upper Tisza is poorer in nutriments, so the conditions of survival of the alga production's great number of specimen is not provided. The biomass of algae dying in the Tisza starts to decompose rapidly, and the process is so intense that it uses up the river's oxygen reserves. The decreased content of dissolved oxygen may cause the destruction of the living world, among others the fish stock ...

This is the reason why it is more and more urgent to reconsider our sewage purification strategy. At our sensitive watercourses - which is not one? - sewage clarification stage III removing phosphorus must be implemented. Our domestic activities in themselves cannot reverse the unfavourable process, because, for instance, domestic pollution of the Szamos is nearly 0, we must therefore persuade our neighbours up the watercourses to undertake the job.

Doing the job should not be started with towns and villages of a couple of hundred inhabitants, which we assume watercourses the size of the Szamos will cope with, but with cities and towns of 5-10 thousand inhabitants.

Mineral salt components

Mineral salt content and composition of surface waters are primarily determined by geochemical features. Content of all salts, and conductivity proportionate to this are determined by specific flowage.

Trend of annual averages of the conductivity in the 30-year time sequence between 1968-97:

$Sn=527+1.6n$ $r=0.26$ $M=551$ uS/cm $s=51.9$

Machua's radial figures - % ratio of ions equivalent- of the Tisza and its main tributaries can be seen in Figure 16. beside which average conductivity between the years 1976 and 1990 is also indicated. From this it is clear that watercourses coming from the Transylvanian Basin - Szamos, Maros - have a comparatively high sodium and chloride ion content, and have high concentrations of salt and conductivity as against the other 3 watercourses.

Considering the drainage basins it is acceptable, but we are convinced that the two watercourses have been polluted, besides natural components, with industrial sewage and mine water containing great amounts of salt, especially common salt, NaCl.

It is proven by, for example, the fact that there are close hyperbolic relations, characteristic of dilution, between streamflow and the specific concentrations. (If there is no point-like pollution, the nature of the relation will remain the same, though, but the correlation factors will be lower.)

Relations established in 1986

Conductivity	$Sn= 231+16594/Q$	$r= 0.93$	$M= 668$ uS/cm
Total dissolved matter	$Cn= 236+9493/Q$	$r=0.92$	$M= 454$ g/m^3
Sodium ion	$Cn= 17.8+2440/Q$	$r=0.94$	$M= 67.3$ g/m^3
Chlorid ion	$Cn= 42.8+2143/Q$	$r=0.77$	$M= 89.7$ g/m^3

Table 10.

According to the results point-like pollution in 1996 decreased, so the established relations became looser:

Conductivity	$Sn=418+9493/Q$	$r=0.57$	$M=568$ uS/cm

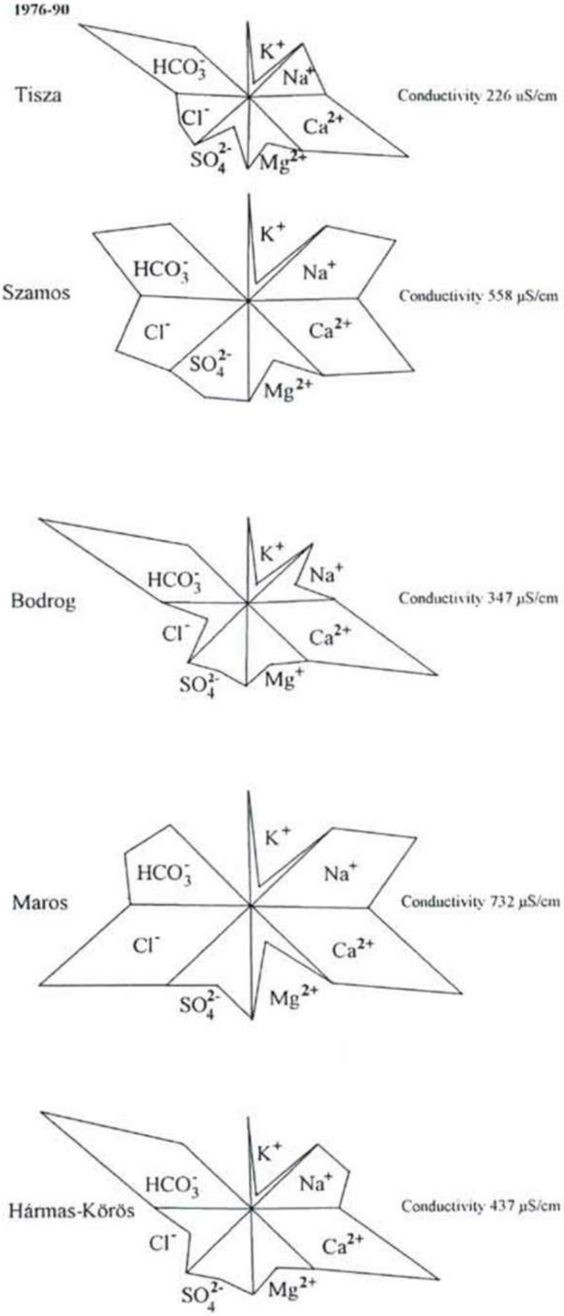

1976-90
Tisza
Conductivity 226 uS/cm
Szamos
Conductivity 558 μS/cm
Bodrog
Conductivity 347 μS/cm
Maros
Conductivity 732 μS/cm
Hármas-Körös
Conductivity 437 μS/cm
HCO_3^-
Cl^-
SO_4^{2-}
K^+
Na^+
Ca^{2+}
Mg^{2+}
Mg^+

Figure 16.

Summary

Water quality of the Szamos between the years 1970-80 was determined by pollution of high contents of organic matter, which may have come partly from communal plants, but mainly from food processing and light industrial - probably paper and cellulose production - plants. Draining off thin manure from animal farms may also have contributed to that. In 1990 a considerable improvement process commenced, definitely at the cost of a decline in industrial production, when major plants stopped operation. Some of the organic pollution is still present, output of point-like sources can be estimated at 25-30 tons/day.

Organic pollution of high waters exceeding 3-400 m^3/sec of streamflow is stable, its cessation cannot be expected because it comes from humus and plant debris under humification washed in the river.

Mainly in the second half of the 80s, considerable amounts of ammonia-ammonium pollution was characteristic of the Szamos. Presumably it came from the draining off of thin manure from animal farms, most of which have stopped operation since then, into the recipient. We hope that in a more reasonable agricultural system this kind of pollution will not reoccur.

Probably from the plants of heavy industry and the mines of Dés and Nagybánya sewage and mine waters containing a high degree of salt, primarily sodium chloride, were received by the Szamos. As even the developed industrial countries have not been able to tackle this kind of pollution economically so far, with a lowered degree of production its decrease but not its termination can be expected.

We believe that our most important problems in the near future will be caused by the eutrophication of the Szamos. We must therefore go to any length to decrease the pollution of phosphorus feeding, generating this process. At our major towns sewage clarification stage III, providing elimination of phosphorus must be implemented, and we must win the countries up the watercourses over to it, too.

For that a sensible, balanced conservation policy should be pursued, because we will not achieve anything with impatience and unjustified demands.

I would like to thank my colleague József Hamar, for his hints.

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