ENVIRONMENT CHANGES IN THE DANUBE DELTA CAUSED BY THE HYDROTECHNICAL WORKS ON THE SF.GHEORGHE BRANCH

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Abstract: The hydrotechnical works carried out along the River Danube and its tributaries as well as within the Danube Delta have significantly influenced the river water and sediment discharge and consequently the particle flux in the North-Western Black Sea. Thus, after 1970, when the Portile de Fier dam was completed, the sediment discharge, particularly the bed-load flux, of the River Danube diminished by 25-35 %. In the last eight years, a program of short-cuts of the Sf.Gheorghe distributary meander belts has been undertaken in order to shorten this waterway by about 35 Km, to activate the sediment flux and to enlarge the supply of coarse sandy sediments into the delta shore zone for limiting the very active beach erosion. The present paper presents the environmental impact on the Sf.Gheorghe meander belts cut-off after the completion of the digging works in 1993. The water and sediment discharge (in particular the saltation bed load) have been assessed during 1988-1994 period by yearly direct measurements in 35 cross-sections placed along the Sf.Gheorghe and Sulina distributaries as well as along the cut-off canals. The simultaneous measurement of water velocity and depth in continuous vertical profile allows the automatic computation of the liquid discharge and makes evident some dynamic characteristics of water flux such as: structure of the turbulent flow, density stratification of the water masses in the river mouth Sulina with a pronounced salt wedge; propagation of the eddies in the water mass; training or stopping superior layers by the wind and direct showing of the acceleration field associated to velocities. The analysis of liquid discharge and bed-load measured during the yearly campaigns before and after completion the rectified working in 1993 shows the distribution of the water fluxes and bed-load between Chilia branch and Tulcea at Ceatal Ismail, between Sulina and Sf.Gheorghe branch at Ceatal Sf.Gheorghe and between the meanders and rectified canals on Sf.Gheorghe branch. A special attention was paid to Mahmudia system where the rectified canal approaches to 7.5 m depth in 1990 and evolved to 20-24 m in 1996. Simultaneously the depth of the former meander at Km 83 decreased from 18 m to 9.5 m.

Keywords: environmental changes, liquid discharge, Sf.Gheorghe branch, rectification, Danube Delta, bed-load.

INTRODUCTION

The published data in the specialized literature show that the flow of the water and sediments in the Delta's distributaries has changed in time. One of the most aggressive factors which generate these changes is represented by the different hydrotechnical works on the Danube's course or in the Danube Delta. At the beginning of the century, the Danube water and sediment supply when penetrating the Delta was divided as follows: 72% on Chilia branch and 28% on Tulcea branch (7% of them was on Sulina branch).

The completion of the rectification works on Sulina branch made by the European Commission of the Danube between 1856-1902 led to the shortening of the branch with 21 Km a consequence, the quantity of water taken by the Sulina branch has increased at 12% in 1921, 14% in 1929 and 17% in 1960. This increase was accompanied by increasing the weight of Tulcea branch with 9%, detrimental to the weight of Chilia (5%). An example of the varied distribution of the mean water discharge among the main Danube Delta distributaries is presented by Almazov et al., (1973) (Table 1).

Table 1.The discharge distribution during 1928-1960

Distributaries	1928-1929			1958-1960		
	Q (m^3/s)	%from QD	%from QT	Q (m^3/s)	%from QD	% from QT
Danube	6300	100.0		6300	100.0	
Chilia	4135	65.6		3940	62.5	
Tulcea	2165	34.4	100.0	2360	37.5	100.0
Sulina	888	14.1	41.0	1065	16.3	45.0
Sf.Gheorghe	1277	20.3	59.0	1295	20.6	55.0

Q = liquid discharge; QD = Danube discharge; QT = Tulcea discharge

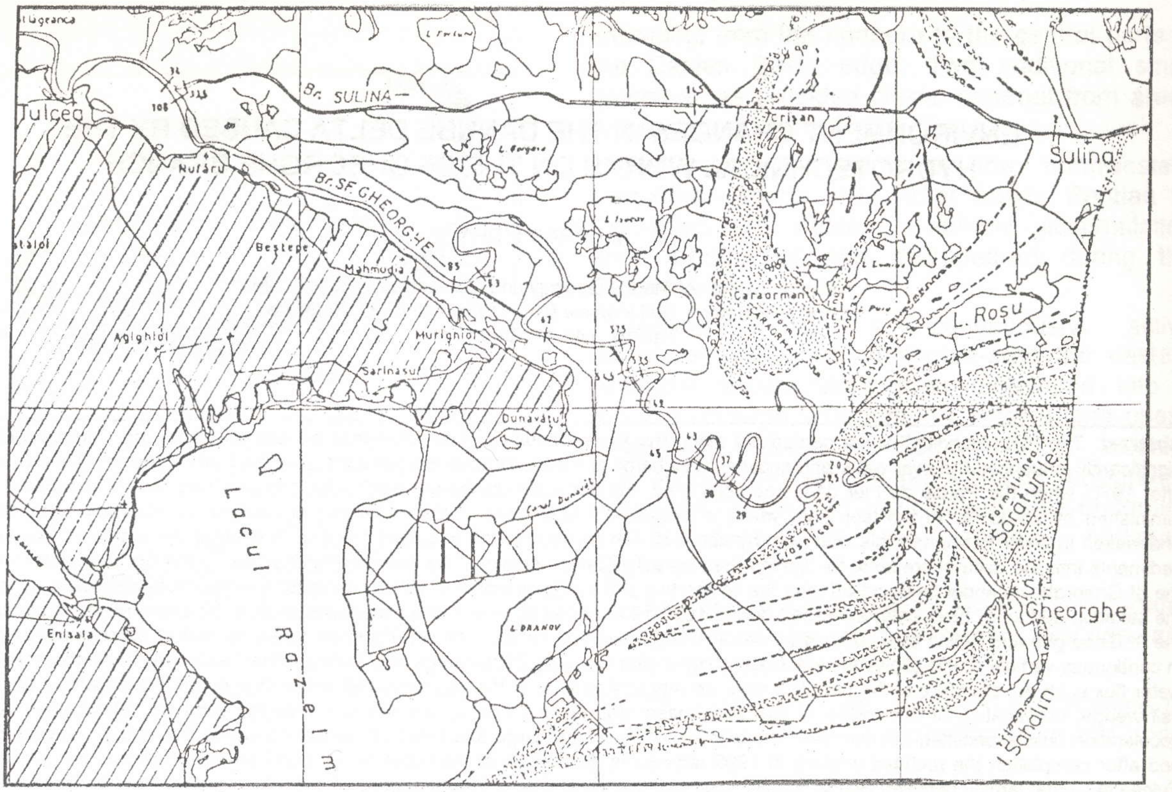

Fig.1 General structure of meander zone of Sf.Gheorghe branch and location of measure cross-sections.

After the construction of "Portile de Fier I and II" dams (1970), the water flow and sediments on the Danube branches has decreased appreciably. In order to protect the navigation on Sulina branch, at Ceatal-Sf.Gheorghe it was built a spur, which increased the amount of water on Sulina branch. Till the beginning of the rectification works on Sf.Gheorghe branch, the distribution of the water flow on Tulcea branch became almost equal between Sulina and Sf.Gheorghe branches, the former often taking over a bigger amount of water and sediments than the latter one.

Major hydrotechnical works were carried out in the Danube Delta in between 1983-1989, in accordance with the provisions of a program meant for "entirely changing and exploiting the Danube Delta". Those works have strongly affected negatively the environmental balance of this area unique in Europe.

One of the works in the program was the cut-off of the Sf.Gheorghe meander belts by digging several canals with a maximal depth of 7-8 m and a width of 75-100 m. Its goal was to shorten this water way with about 32 km in order to ease the navigation. The following canals were dug: Mahmudia (km. 84-64), Dunavatul de Sus (km. 58-55), Dunavatul de Jos (km. 54-50), Dranov (km. 44-39), Erenciuc (km. 38-30) and Ivancea (km. 20-16), the last one was finished in 1993.

It was expected that this work should lead to

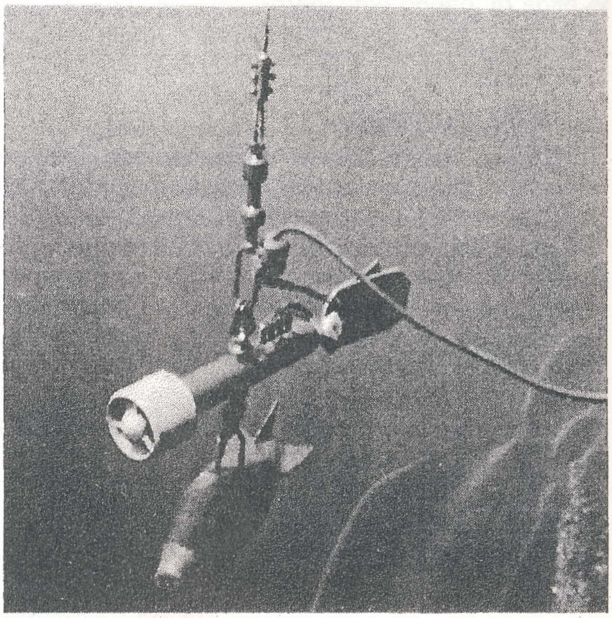

Fig.2 Automatic complex system for simultaneous measurement of the water flux velocity and depth.

some major changes in the water and sediments flowing system on Sf.Gheorghe branch and, consequently, in the sedimentary balance of the river mouth area with direct implication on the Black Sea coast. Consequently, in the year 1988 it was initiated a complex study on the possible morphological, geological, hydrological, pedo-

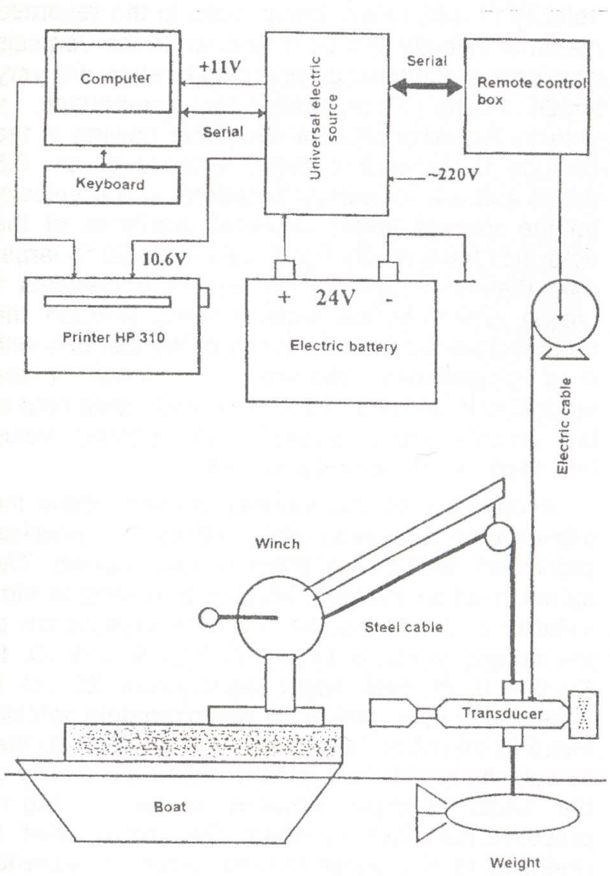

Fig.3 Block-scheme of the apparatus for flowing water discharge measurement.

logical changes in the deltaic area crossed by Sf.Gheorghe branch and in the littoral beaches between Sulina and Cape Midia was initiated in 1988. In the first period, the one of cutting and finishing the canals, during 1988-1993, the main research objectives were mainly sedimentological and hydrodinamical. After 1993, when the hydrological objectives were finished, the research added some supervising objectives upon the water and sediment flux system on Sulina and Sf.Gheorghe branches. Its goal was to estimate the environmental changes tendencies in each of the six rectified systems "branch-meander-canal" by the time of their appearance

EXPERIMENTAL PROGRAM AND WORK METHODOLOGY

Experimental objectives

The rectification works determined different changes in the flow characteristics of Sf.Gheorghe branch water and sediments. It was also affected the distribution of the liquid and solid fluxes between Sulina and Sf.Gheorghe distributaries. For this reason, the organized measurements on Tulcea, Sulina and Sf.Gheorghe branches, in 1990-1997, aimed at:

a. determining the characteristic parameters of the water flux: flow velocity, liquid discharge and procentual distribution of water masses between Tulcea distributaries and between meanders and rectified canals on Sf.Gheorghe branch;

b. estimating the transport of coarse, sandy sediments by measuring the "bed-load" (contact load and saltation load);

c. determining the environmental parameters: morphology (width and bathymetric profile of riverbed in measured section)

d. determining the multiple correlation coefficients among the measured parameters;

e. hydrometrology (water level, velocity and direction of wind, etc.);

f. determining the multiple correlation coefficients among the measured parameters;

g. collecting sediment samples from the bed-load and from the upper layer of the river bed and their analysis from the chemical, textural /structural, mineralogical point of view.

Experimental methodology

The measurements were made on 31 sections of the branches, meanders, natural channels and rectified canals (Fig.1). Each section included 6-10 stations, with the exception of the canals, where were carried out only 3 stations. In each station it was determined the distance to the left bank, carried out the continuous recording of the flow velocity profile and collected bed-load and sediment samples from the upper layer of the river bed.

The following equipment was used to reach each objective were:

- for the determination of the liquid discharge a portable computerized system installed on the shipboard was used (Fig.2). This system is built by "BIOTRON S.A." company, Bucharest, by the engineer Vlad Teodorescu. The components of the system are presented in Fig.3. This Biotron equipment realized: the simultaneous measurements of velocity and depth of the water (using a sensor based on Hall effect for velocity and another one based on the differential pressure for depth); the computer recordings of all these values; the selection of the extreme values of water velocity (maximum and minimum velocity in each station and section - Fig.4); the computing of mean velocity on station and on section and the integration of all values of velocity on section to obtain the characteristic liquid discharge of the respective section (Fig.5). Because the system allows the practically instantaneous measure-ment of the flow velocity (it records almost 100 values per second), it is possible to determine the acceleration field

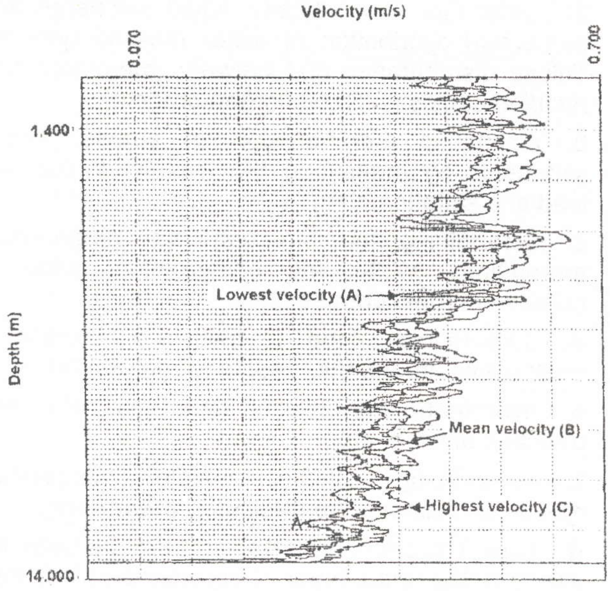

Fig.4 Water velocity-depth profile (Sulina, 2.09.1995)

associated to velocities as (Vmax - Vmin)/second;

• the bed-load was determined using a sediment trap, the weight of the capture being used to compute the specific discharge of the bed-load (g/cm^2/5 min). Integration of the values for each station realizes the mean determination of a mean discharge of the bed-load (RT) on section measured in Kg/day;

• drawing of the sample collection from the upper layer of the bottom of river bed was performed using a boden-greiffer;

• the chemical analyses were realized by Roentgen Spectroscopy in order to establish the content in Fe_2O_3, TiO_2, MnO, Ba, Sr, Ni, Zn, Cr, Zr, V;

• the grain size analysis was made by sieving for the bed-load samples and by sieving and sedimentation for the samples from the superior layer of the river bed;

• the mineralogical analysis was performed on arenitic granoclastes especially for heavy minerals.

RESULTS

1. Utilization of the computerized system for the simultaneous measurements of the depth and the velocity of water allowed the collection of a several thousands of flowing velocities both on the Danube and also in the Danube Delta. Analyzing the records from the last two years some dynamical characteristics of flowing regime are revealed. Figure 6 presents a typical profile of flowing for the Danube: the whole water volume with depth of 8 m. flows homogeneously, the mean velocity of 0.82 m/sec being close to the recorded maximal velocity of 1.04 m/sec, while the verticals gradients of the velocity and acceleration are very small. Figure 7 presents, for comparison, a velocity typical profile for the water flowing in the Danube Delta, with a mean velocity of ca. 0.5 m/sec and with pulsatory variations of the velocity on the vertical profile. Vertical gradients of the velocities have much bigger values (to 20 % larger than the mean velocity value). Fig.8 presents a typical profile of the water flowing through the natural channels in the mouths of the Danube with a homogeneous character at small mean velocities (0.35 m/sec) and with small gradients of the velocity and acceleration (a constant value less than 1% of the mean values).

Recordings of the velocity profiles show the interaction between the different physical processes, which take place simultaneously. The influence of air masses, which are moving at high velocity in the sense, or in the reverse sense of the flowing water is shown in Figs 9 and 10. In Fig.9 a 7 m thick water layer (from 22 m) is accelerated by a wind at an approximately velocity value of 20 m/sec in the sense of flowing, so that its velocity is with 50% greater than the velocity of the water masses situated under it. Fig.10 presents the case in which the strong wind is reversed to the water flowing sense, a superior layer (of ca. 6 m of 14 m) being strongly braked (its velocity representing 30% of the inferior layer velocity). Fig.11 (which presents a recording of velocity profile at Sulina, at 2 Hm distance from the sea shore) reveals the superposition of a fresh water layer of Danube with a thickness of 7 m over a bed layer of ca. 3 m thick as a result of the mixed fresh water with salt sea water. The vertical velocity gradient at the interface of the two layers in this case exceeds the mean velocity value.

The turbulent character of the flow, both on the natural way of the branch and also on the rectified canals is shown in Fig.12. This figure reveals the flow on the rectified canal Mahmudia way of an eddy which takes in the rotation movement of a water layer of about 4 m thick, situated between the surface and deep waters. After this recording, 10 sections of measurement of the liquid discharge, at 100 m distance one from another in a total time interval of 30 min were recorded. The synoptic Table of the discharge values (Fig.13) recorded in this way along the first kilometer of the rectified canal Mahmudia shows the pulsatory character of the flowing, the amplitude of the pulsating discharge reaching 15% from the mean value (440 m^3/sec). This turbulence flowing of water masses is probably the natural cause of the canal bed river modeling (Fig.14).

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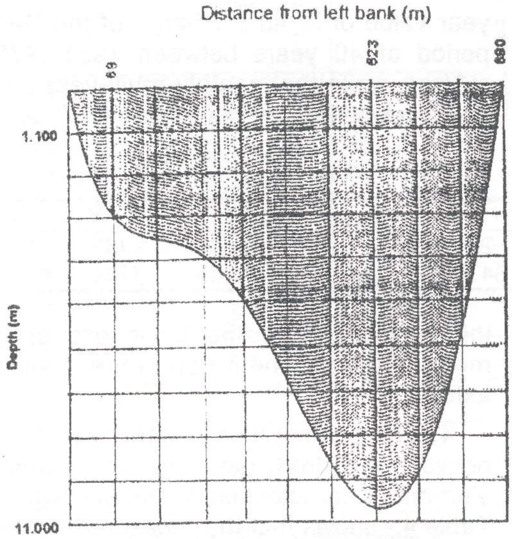

Fig.5 - River-bed configuration and liquid discharge value for cross-section Zimnicea measurement (23.06.1996)

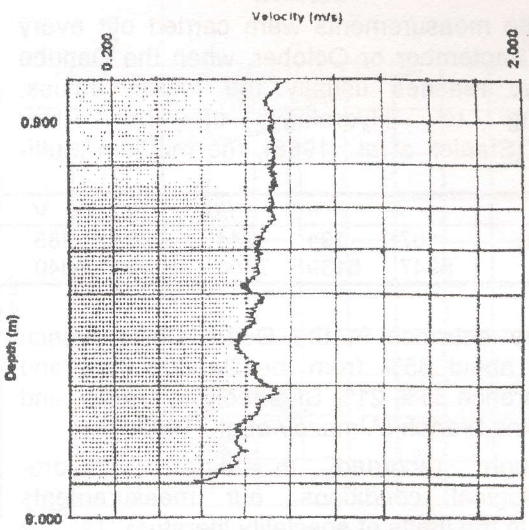

Fig.6 - Water velocity-depth profile on the upstream Danube (Turnu Măgurele, 23.06.1996)

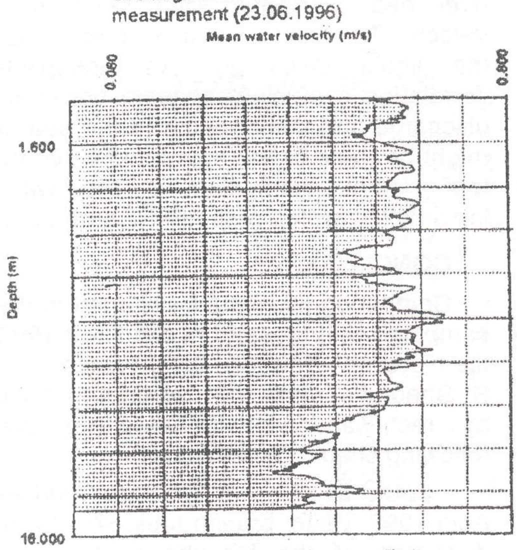

Fig.7 - Water velocity-depth profile in the deltaic zone (St.George Branch, km 38, 14.09.1995)

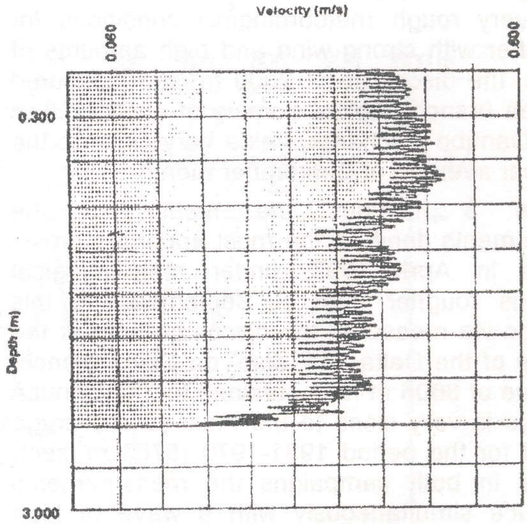

Fig.8 - Water velocity-depth profile on the natural channel Turcu (24.09.1996)

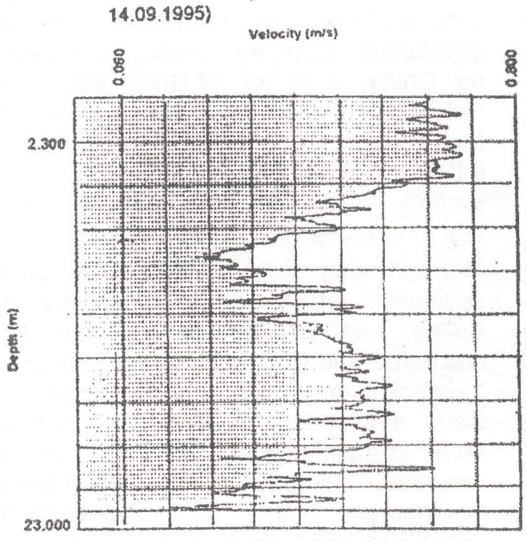

Fig.9 - Water velocity-depth profile on St.George Branch at km 19.5 (the wind sense of the flowing - 23 09.1996)

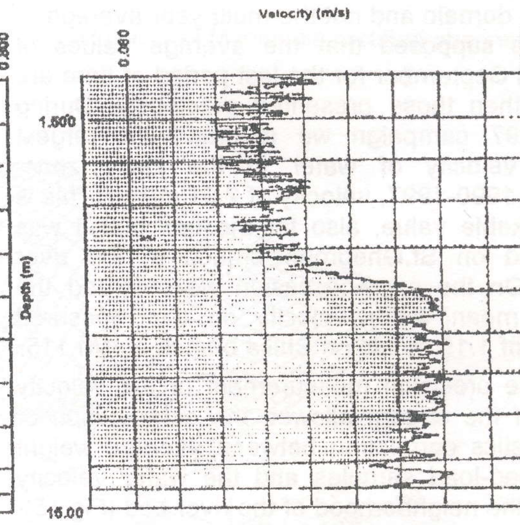

Fig.10 - Water velocity-depth profile on St.George Branch at km 19.5 (the wind in opposite sense of the flowing - 23.09.1996)

2. The measurements were carried out every year in September or October, when the Danube discharge reaches usually the lowest values. According to "Hydrology of the River Danube"(Stanick et al., 1988), the medium multi-year value of liquid discharge of the Danube for a period of 40 years between 1931-1970 is 6550 m3/sec, while the monthly multi-year averages for the same period are the following:

Month	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*
km^3/year	187	194	244	276	285	267	230	176	147	133	154	182
m^3/sec	5947	6139	7750	8783	9040	8477	7311	5579	4657	4218	4895	5764

At the entrance in the Delta, Chilia branch takes in about 65% from the Danube flow, and Tulcea branch 35%-21% Sf.Gheorghe branch, and 14% Sulina branch (Almazov et al., 1963).

Although recorded in different hydro-meteorological conditions, our measurements situated in the limits of speciality literature. Table 2 presents the results obtained in September 1996 campaign for all the 31 sections of measurement. Under very rough meteorological conditions for September with strong wind and high amounts of rainfalls, the discharge of 2000 m^3/sec measured at Tulcea branch implies a value of 4650 m3/sec for the Danube discharge, value very close to the multi-year average of September month.

Table 3 includes the results of the measurements done on the most important cross-sections in April 1997, under meteorological conditions rougher than in September. In this campaign we measured the discharge both at the entrance of the Delta and, also, on Chilia branch. The value of 8605 m^3/sec obtained for the Danube discharge is very close to the multi-year average for April for the period 1931-1970 (8783 m^3/sec). Because in both campaigns the measurements took place simultaneously with a wave of high flood, the value of liquid discharge would have been expected to reach the superior limit of variation domain and not the multi-year average. It might be supposed that the average values of April and September for the last period of time are smaller then those presented previously. During April 1997 campaign we recorded the largest flowing velocity of water in the Delta zone, between 1990-1997, velocity of 2.01 m/sec. This is a remarkable value, also for the fact that it was measured on Sf.Gheorghe branch at the river mouth. On the same occasion we recorded the biggest mean water velocity on the measured section, of 1.15 m/sec on Chilia branch at Km 115.

3. The precision measurement of the velocity profile of the stream allowed the computation of the statistics correlation between average weight of the bed-load samples and the water velocity close to the neighborhood of the river bed (Fig.15). We can notice that the measurements of correlation coefficients do not exceed 0.5 for any of the used analytical functions. An explanation of this fact might be the looseness of orientation mode of the sediment trap in the flowing saltation axle.

4. The computation of the multiple correlation between hydrodynamical and morphological elements characteristic to Sf.Gheorghe branch - Table 4 - shows that the measured liquid and solid discharge are best correlated with the width of the river bed, with the water level and transport velocity. The solid discharge depends obviously on the liquid discharge. An unexpected small correlation coefficient appears between the liquid discharge and the distance to the sea shore. This might be owed to the high flood wave that marked the normal distribution of the water in the longitudinal profile of the Sf.Gheorghe branch.

CONCLUSIONS

Comparing the results obtained in the last year campaign with those from the 1989-1993, in which the system formed by Tulcea - Sulina - Sf.Gheorghe might be considered as unaffected by rectification of Sf.Gheorghe branch, the following should be remarked:

- in the situation of the high flood recorded in April 1997, Chilia branch took 57% from the liquid discharge of the Danube measured at Ceatal Ismail, 24% went on the Sf.Gheorghe branch, and 19% on the Sulina branch. These values differ significantly from the average repartition of 65% for Chilia, 21% for Sf.Gheorghe, and 14% for Sulina, mentioned by Almazov et al. (1963). This fact can be explained either by the rectification influence of Sf.Gheorghe branch on the deltaic system, or by the homogenization tendency of high flood propagation waves.

- following the evolution of water fluxes and sediments repartition of Tulcea branch between Sulina and Sf.Gheorghe (Table 5; Q=liquid discharge and RT=bed-load) we observe that until 1994, Sulina branch took a greater quantity of water and sediments from Tulcea branch, while after completion of the rectifying works the repartition changed, so that beginning with 1995, Sf.Gheorghe branch took a greater quantity of water and bed-load from Tulcea branch than the Sulina branch.

- the same type of analysis applied to

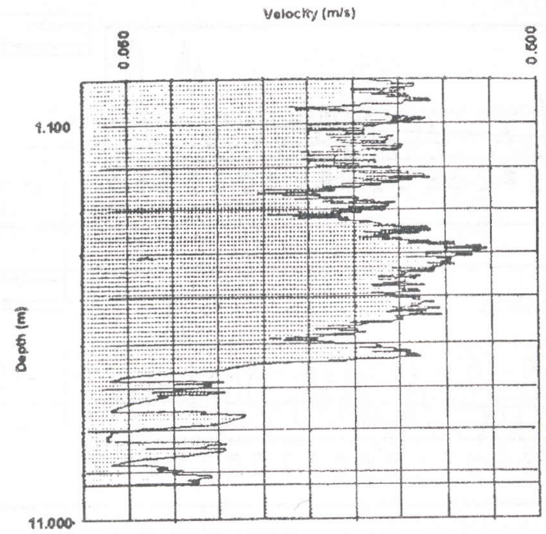

Fig.11 - Water velocity-depth profile on Sulina Branch, Hm 2; 5.09.1996 (pronounced salt wedge)

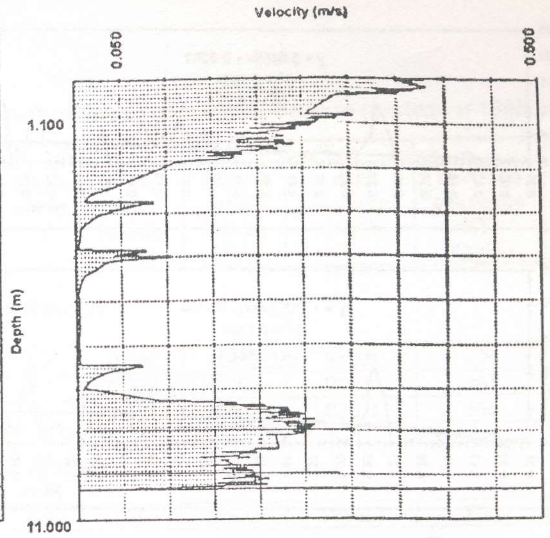

Fig.12 - Water velocity-depth profile on the Mahmudia rectified channel (7.09.1995; displacing between water layers edge)

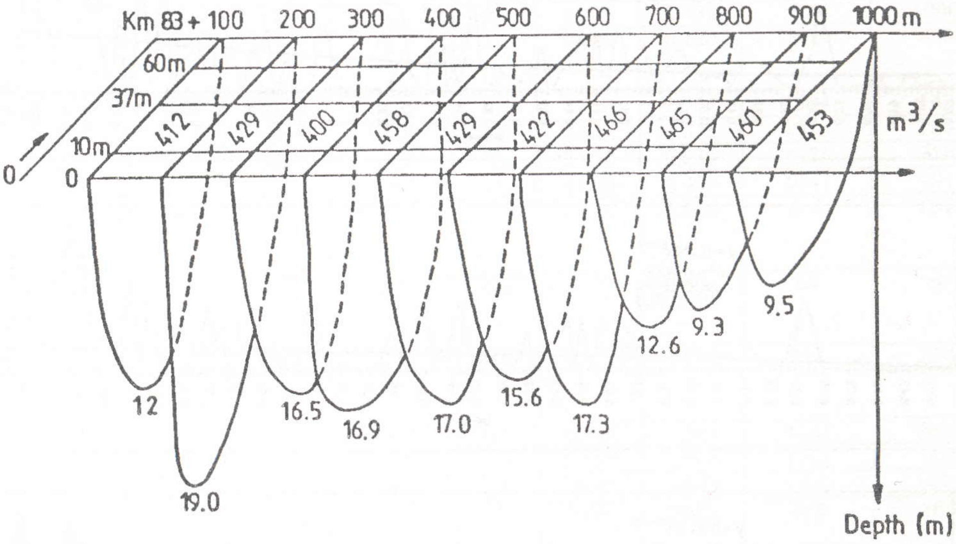

Fig.13 - Liquid discharge values recorded on the first sector of Mahmudia rectified channel

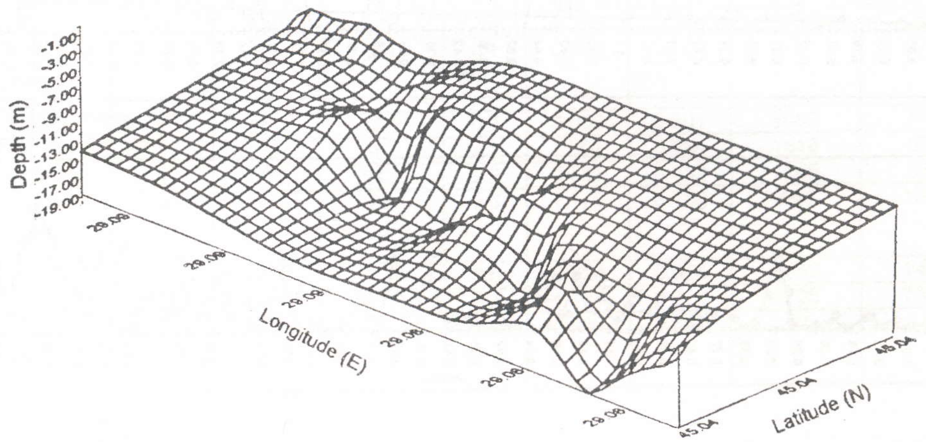

Fig.14 - River-bed bottom configuration on the first sector of Mahmudia rectified channel

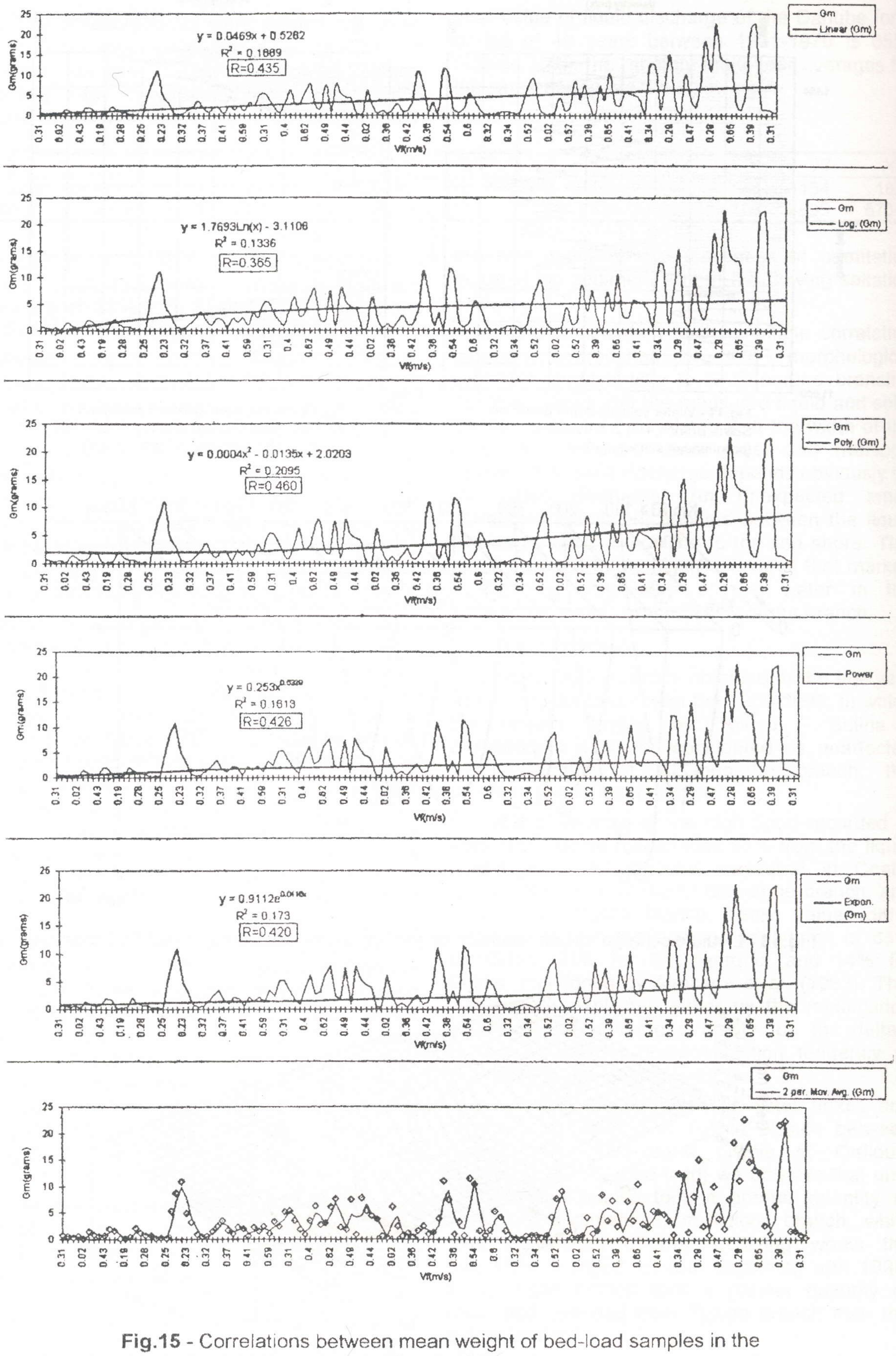

Fig.15 - Correlations between mean weight of bed-load samples in the neighborhood of the river-bed bottom

Table 2. Hydrodynamic and morphodynamic parameters measured on the cross-sections (September 1996)

Sampling Date (Sept.)	Cross section's site	Wind velocity (m/s)	Breadth (m)	Maximum depth (m)	Mean depth (m)	Max. water velocity (m/s)	Mean. water velocity (m/s)	Liquid discharge $Q-m^3/s$	Bed-load discharge RT-Kg/day	Water level (cm) St. George
Sulina Branch										
5	Mila 2		170	13.2	6.3	0.801	0.447	914.5	204	86
6	Mila 14		170	12.1	5.1	0.936	0.603	902.0	391	86
7	Mila 33		170	17.0	6.7	0.901	0.633	836.0	368	86
Tulcea Branch										
8	Mila 34		375	17.2	6.8	0.895	0.649	1988.0	700	88
St. George Branch										
8	Km 108	9	320	11.9	5.3	0.811	0.613	1395	1936	88
11	Km 85	9	340	9.6	4.3	0.852	0.560	1263	4030	110
11	Km 83	9	196	9.4	3.8	1.201	0.757	603	1086	110
11	Cn. Mahmudia Km 83.3	9	77	16.7	7.8	0.934	0.700	675	470	110
13	Km 62	24	310	9.3	4.4	0.836	0.569	1364	142	130
14	Km 58	16	289	11.8	5.0	0.822	0.575	1316	268	141
14	Km 57.5	16	261	12.7	5.0	0.856	0.575	1224	318	141
15	Km 54.5	10	305	15.8	6.0	0.839	0.480	1643	291	140
14	Cn. Dunavăt de Sus (R)	16	79	6.5	3.1	0.718	0.586	202	602	141
15	Cn. Dunavăt (N)	10	47	3.2	1.6	0.777	0.494	64	88	140
15	Cn. Dunavăt de Jos (R)	10	76	9.5	3.8	1.027	0.712	324	338	140
16	Km 53.5	10	173	14.6	5.7	0.845	0.607	1047	2632	140
16	Km 49	10	210	16.7	7.3	0.927	0.588	1327	303	140
17	Km 44.5	8	200	14.8	6.9	0.887	0.547	1480	1416	144
17	Cn. Dranov (R)	8	78	11.2	4.1	0.994	0.663	378	168	144
17	Cn. Dranov (N)	8	36	2.3	1.4	0.471	0.339	25	20	144
17	Km 43	8	177	16.1	6.5	0.904	0.589	991	184	144
18	Km 38	8	272	17.0	6.8	0.944	0.566	1376	1706	156
18	Km 37.5	8	180	17.5	7.1	0.868	0.583	1050	157	156
18	Cn Erenciuc (R)	8	80	9.4	4.1	0.940	0.709	418	134	156
22	Km 29	7	212	19.2	6.7	0.956	0.601	1488	2407	185
23	Km 20	20	353	9.7	4.1	1.091	0.584	1618	600	208
23	Km 19.5	20	177	24.2	9.9	0.731	0.432	1255	337	208
25	Cn Ivancea (R)	8	71	7.1	3.5	1.170	0.739	444	1064	230
24	Km 6	20	423	7.2	3.6	0.924	0.674	1742	1403	229
24	Km 5	20	263	13.0	5.4	1.167	0.716	1725	7329	229
24	Cn. Turcului (N)	20	62	3.7	1.9	0.509	0.361	62	145	229

(N) - natural channel;
(R) - rectified channel

Table 3. The hydrodynamic elements of the Danube liquid flow at the beginning of EROS 21 cruise (13-18.04.97)

Profile	Location	Date/hour	L(m)	V_{AX}(m/s)	V_{ied}(m/s)	H_{MO}(m)	H_{md}(m)	Q (m^3/s)
Ceatal Ismail	M 44	13.04.97 h13	455	1.83	1.15	21.6	9.5	8605
Chilia	Km 115	13.04.97 h14	500	1.61	0.93	19.4	6.0	5872
Tulcea	M 34	13.04.97 $h17^{30}$	390	1.74	1.02	17.4	5.9	4340
Sulina	M 33	14.04.97 h17	115	1.69	1.24	19.5	8.5	1945
Sf.Gheorghe	Km 108	13.04.97 $h16^{30}$	345	1.51	0.92	10.7	4.0	2375
Sulina	M 2	15.04.97 h12	183	1.72	0.89	14.5	6.2	2009
Sf.Gheorghe	Km 6	15.04.97 h16	400	2.01	0.86	7.6	3.0	1995

Table 4. Correlation coefficients between hydrodynamic characteristics measured on Sf.Gheorghe branch (September 1996)

	level Tulcea (cm)	level Sf.Gh. (cm)	distance (km)	width (m)	max.depth. (m)	mean depth. (m)	Vmax (m/s)	Vmean (m/s)	Q (mc/s)	RT (kg/day)	Vwind (m/s)
Level Tulcea(cm)	1.000000										
Level Sf.Gh.(cm)	0.989433	1.000000									
distance(km)	-0.945568	-0.935594	1.000000								
width(m)	-0.020085	0.027489	0.071975	1.000000							
max.depth.(m)	-0.070746	-0.057845	0.022338	0.261596	1.000000						
Mean depth.(m)	-0.090582	-0.071118	0.053780	0.264709	0.977769	1.000000					
Vmax(m/s)	0.110422	0.114980	-0.023898	0.230775	0.223042	0.198296	1.000000				
Vmean(m/s)	-0.066906	-0.065449	0.164455	0.086963	0.088705	0.093246	0.865314	1.000000			
Q (m^3/s)	0.088608	0.117533	-0.059511	0.893596	0.579235	0.582311	0.313088	0.112667	1.000000		
RT(kg/day)	0.447393	0.478517	-0.389188	0.721067	0.069729	0.089266	0.253850	0.191648	0.659600	1.000000	
Vwind(m/s)	0.387621	0.476604	-0.372921	0.374695	-0.142751	-0.103054	-0.134566	-0.183260	0.271584	0.475709	1.000000

Table 5. The percentage distribuiton of water and bed-load fluxes at Ceatal Sf.Gheorghe

Date	Tulcea Branch (NM 34)	Sulina Branch (NM33)	Sf.Gheorghe Branch (Km 108)
20-22.10 1990	Q = 1800 m^3/s	Q = 54% RT = 58%	Q = 46% RT = 42%
13.08.1992	Q = 1210 m^3/s	Q = 63% RT = 60%	Q = 37% RT = 40%
07.08.1993	Q = 3072 m^3/s	Q = 54% RT = 41%	Q = 46% RT = 59%
31.08.1994	Q = 1480 m^3/s	Q = 49% RT = 37%	Q = 51% RT = 63%
10.10.1994	Q = 1255 m^3/s	Q = 52% RT = 82%	Q = 48% RT = 18%
05.09.1995	Q = 1574 m^3/s	Q = 46% RT = 45%	Q = 54% RT = 55%
04.09.1996	Q = 2230 m^3/s	Q = 38% RT = 47%	Q = 62% RT = 53%

Q = liquid discharge (m^3/sec), R_T = bed-load discharge (Kg/day)

Table 6. The percentage weight of liquid and solid discharge assumed by the rectified canals from Sf.Gheorghe branch total discharge.

Liquid discharge (Q)	Year	Rectif. cn. Mahmudia (Km 84)	Rectif. cn. Dunavătul de Sus (Km 58)	Rectif. cn. Dunavătul de Jos (Km 54)	Rectif. cn. Dranov (Km 44)	Rectif. cn. Erenciuc (Km 38)	Rectif. cn. Ivancea (Km 20)
Q_{canal}% from $Q_{Sf.Gh.}$	1996	54.0	13.0	24.0	27.0	28.0	27.0
	1995	56.0	8.3	28.0	21.8	19.31	21.5
	1994	45.6	12.4	19.2	21.5	12.9	16.8
	1993	39.3	16.7	13.5	21.7	14.7	14.5
	1992	30.5	11.0	11.0	16.8	-	19.6
	1991	15.7	8.4	18.8	15.2	-	19.0
	1990	21.0	15.0	9.0	-	-	9.0
	1989	20.5	9.7	14.9	-	-	14.0

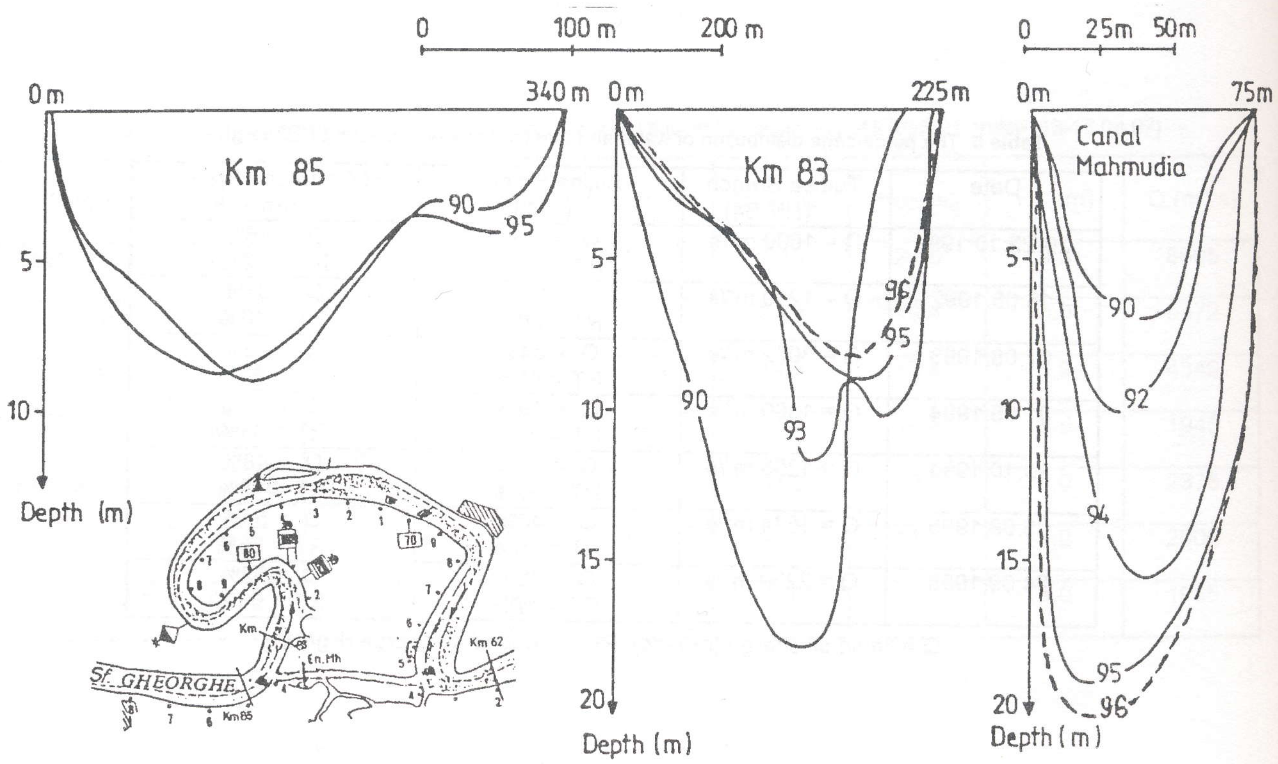

Fig.16 River-bed evolution in the Mahmudia rectified system (Kms 85-62)

Sf.Gheorghe branch for each of the 6 rectified systems "branch-meanders – rectifying canal". Starting with 1993 all the rectified canals take more and more water from the branch (Table 6). In the last 2 years, the rectified canal from Km 84 (Mahmudia zone) which is the first completed one, took a quantity of water greater than the natural meander.

- another category of modifications induced by rectifying Sf.Gheorghe branch refers to the remodeling of the morphological and bathymetrical configuration of the river bed, especially in the rectified zones. As the rectified canals were completed, the appearance of some erosional processes of the canal beds was observed, simultaneously with the appearance of some clogging processes in some areas of the short-cutted meanders. An example in this sense is the evolution of the rectified system Mahmudia (Km 84) in which the canal river bed was strongly eroded. The maximal depth of the reference profile was in 1990 of 7.5 m while in 1996 it was of 20 m (Fig.16). Bathymetrical longitudinal and transversal profiles performed on this canal evidentiated the existence of some zones with 24m depths. In the same time, the river bed of the first sector (Km 83) of the meander suffered a clogging process, maximal depth of reference profile being of 18 m in 1990 and only 9.4 m in 1996. The process seems to be developing and in extension, this fact recommending the hydrological and sedimentological research of the environmental zone of Sf.Gheorghe until a new hydrologic equilibrium would be established.

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