POLLUTION STATE OF SEDIMENTS DREDGED FROM THE SULINA DISTRIBUTARY AND THEIR INFLUENCE TO THE DANUBE DELTA FRONT AREA

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Abstract: The Sulina Canal and mouth bar are dredged for better navigation conditions. The dredged sediments contain important quantities of heavy metals (e.g. Pb, Cd, Cr). The same heavy metals were found in lower concentrations in the sediment samples collected from the geoecological monitoring stations from the Romanian Black Sea shelf. The dredged sediments are discharged two nautical miles SE of the Sulina protection jetties. These contribute to the local pollution of the Danube Delta Front area, thus showing the important role of the Danube River as polluting agent. The presence of heavy metals in high contents in some areas of the Romanian Black Sea shelf indicates a significant anthropic contribution that disturbed the marine ecosystems.

Key words: Danube River, Sulina mouth bar, Black Sea, sediment fluxes, dredged sediments, heavy metals

1. INTRODUCTION

The Danube is the second European river with a total length of 2850 Km. Its drainage basin is extended on 817.000 Km.^{2} on the territories of 15 Central and Eastern European countries (Fig. 1)

The multiannual mean water discharge is about 6000 m^3s^{-1} (Bondar *et al.*, 1996). The length of the Danube Romanian watershed is 1075 Km, between the confluence of the river with the Nera tributary and the Black Sea.

The natural flowing regime of the Danube River has been disturbed by anthropic activities (e.g. river

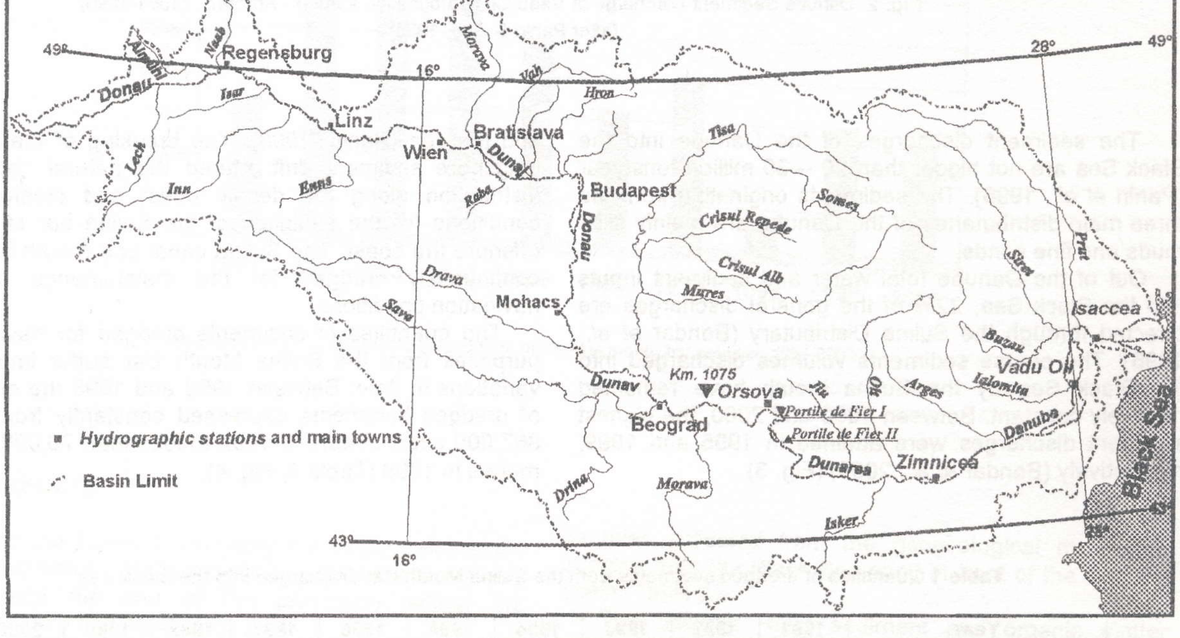

Fig. 1 Hydrographic basin of the River Danube (km 1075 - Black Sea Romanian section of the river)

damming, embankments, dredging of the Sulina Distributary for navigation, meandering cut-off works). After the building of the dams from the Iron Gates I and II hydroelectric power plants, the river sediment load has decreased by 50 – 70% compared to the mean value of pre-damming sediment flux regime (Fig. 2).

The cutting of the meanders of the Sulina Distributary and the construction of jetties that flank the Sulina mouth for the protection of the navigation canal have influenced the natural equilibrium between the river

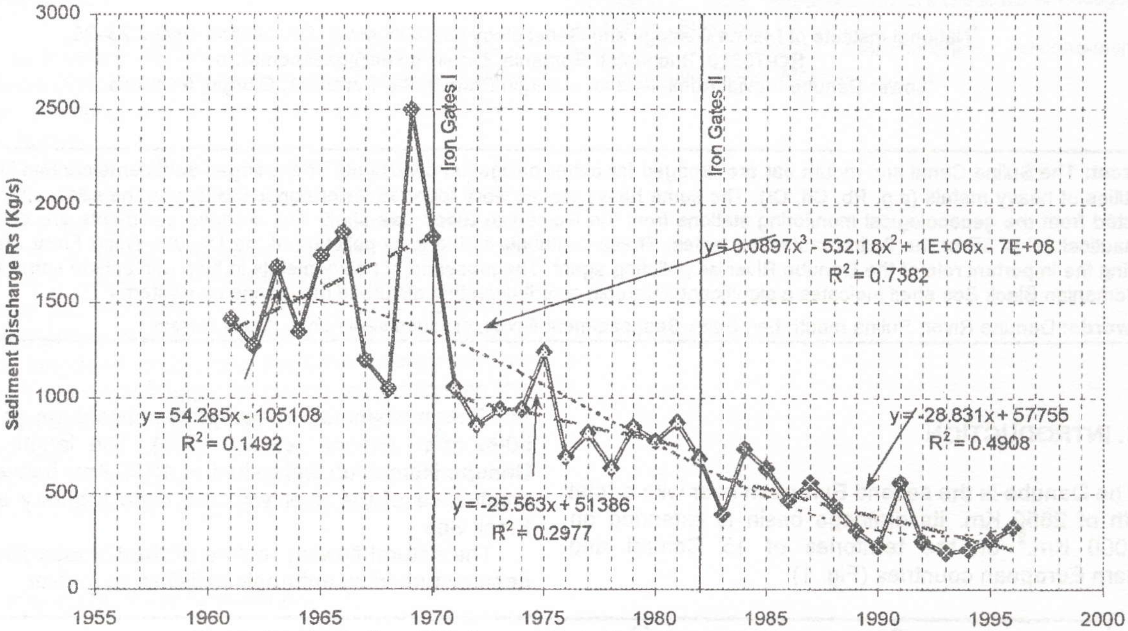

Fig. 2 Danube Sediment Discharge at Vadu Oii hydrographic station - Km.247 (1961-1996) (after Panin & Jipa, 1998)

The sediment discharges of the Danube into the Black Sea are not bigger than 20 – 30 million tons/year (Panin *et al.*, 1996). The sediments originating from the three main distributaries of the Danube are mainly silts, muds and fine sands.

Out of the Danube total water and sediment inputs into the Black Sea, 22% of the general discharges are directed through the Sulina Distributary (Bondar *et al.*, 1996). The coarse sediments volumes discharged into the Black Sea by the Sulina mouth have remained relatively constant. Between 1990 and 2000, the highest sediment discharges were attained in 1995 and 1999, respectively (Bondar *et al.*, 2000) (Fig. 3)

and the sea (Panin, 1998). The breaking of the littoral longshore sediment drift altered the natural sediment distribution along the deltaic coast and created the conditions for the evolution of the Sulina bar at 8 km offshore the coast. The Sulina canal and mouth bar are continuously dredged for the maintainance of the navigation conditions.

The quantities of sediments dredged for navigation purposes from the Sulina Mouth Bar suffer important variations in time. Between 1992 and 1998 the quantity of dredged sediments decreased constantly from over 867,000 cubic meters in 1992 to less than 70,000 cubic meters in 1998 (Table 1, Fig. 4).

Table 1 Quantities of dredged sediments from the Sulina Mouth Bar discharged into the Black Sea

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Quantity of discharged sediments (cubic meters)	330343	867057	710221	633204	502085	328800	395844	66401	303990	277348

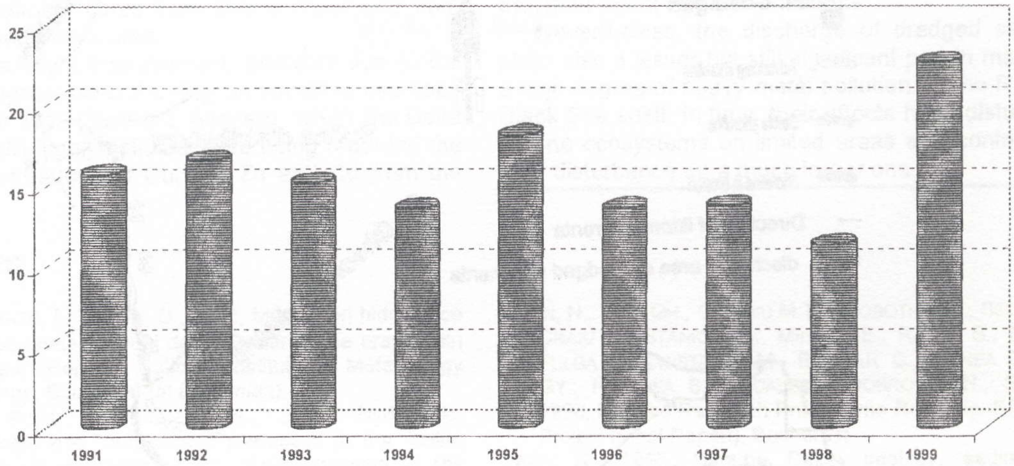

Fig. 3 Mean coarse bottom sediment inputs at the Sulina mouth

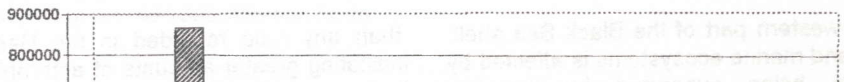

Fig. 4 Quantity of sediments dreged from the Sulina mouth bar between 1991-2000

2. RESULTS

Along the Sulina Distributary the bottom sediments are mainly sandy. At the mouth (e.g. between the Sulina harbor and the end of the protection jetties) the sediments are fine sand to mud.

Heavy metals contents in the superficial bottom sediments are higher for Pb, Cd and Cr (Oaie *et al.*, 1998). The values are similar to those from the sediments dredged from the Sulina Mouth Bar that are discharged two Nautical Miles SE of the mouth of the Sulina Jetties (Fig. 5). These values are higher in comparison with those measured in the bottom sediment samples collected from the geoecological monitoring stations from the Black Sea shelf in front of the Danube Delta (Table 2).

The Danube River sediment and organic matter discharges into the Black Sea are of about 11.000 t/day (Gomoiu *et al.*, 1998). The Phyto- and zooplankton represent 8.9% and 0.2% of the solid suspension discharge. Expanding the data for an entire year, the total suspended solids and biomass discharges are of about 4000x10^3 t/year, suspended solids, out of which 35x10^3 t/year phytoplankton and 7x10^3 t/year zooplankton (Gomoiu *et al.*, 1998). These compounds

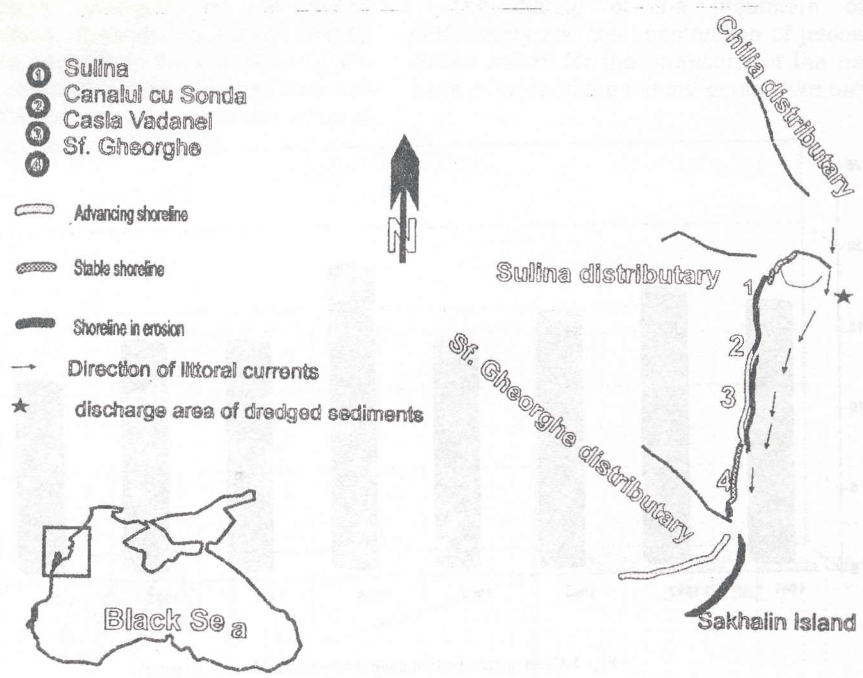

Fig. 5 Sulina-Sf. Gheorghe littoral zone (Black Sea-Danube Delta front); evolution of beach sectors, positions of littoral currents, discharge area of dredged sediments.

influence the north-western part of the Black Sea shelf. The state of fluvial and marine ecosystems is affected by pollution, this fact being supported by the low biodiversity and predominance of a few species.

The sediment core from Hm 72 Sulina (GPS coordinates: 45^0 08' 843" N lat.; 29^0 45' 761" E long., with a length of 91 cm.) contains intervals with high concentrations of Cu, Pb and Zn at 35 cm depth and Pb at 73.2 cm. From top to bottom, the core sediments vary from medium to fine silts, the clayey fraction representing 8.27 to 15.19% from fine silt 8.89 to 13.56% from medium silt (Rădan in Panin *et al.*, 1996). The bottom layers of the core consist of fine sand. The heavy mineral fraction from coarser sediments (garnets, opaques, amphiboles) vary between 1 and 6 % (Fulga, in Panin *et al.*, 1996), the main source being the fossil beach ridges. The heavy metals contents vertical distribution is important, as the dredging reach depths of 2 meters in the sediments from the Sulina mouth bar. At the same time, the heavy metals to Fe_2O_3 ratios for dredged sediments are, with a single exception, higher than any ratio recorded in the Danube Delta Front, indicating greater amounts of anthropic heavy metals in their constitution. For Pb and Cd the difference reaches one order of magnitude.

CONCLUSIONS

The pollutants discharged by the Danube River into the Black Sea are adsorbed on the fine fraction. This is transported either as suspended or bed load and redistributed on the Black Sea shelf by the normal littoral-marine currents (Fig. 5). Another means of transportation is also due to the storms period, when finer sediments are redistributed by storm waves and currents from the shallower areas to deeper sedimentary environments. Thus, the dredged sediments contribute to the local pollution of the Danube Delta Front between Sulina and Sf. Gheorghe, supplying especially great quantities of Pb and Cd, two of the most toxic heavy metals.

Table 2 Pollutant contents in dredged sediments from Sulina mouth bar and from the geoecological monitoring stations on the Black Sea shelf in front of the Danube Delta

No.	Location	Superficial bottom sediments	Pollutant content (ppm)								
			Cu	Pb	Zn	Ni	Cd	Cr	Fe * (%)	MnO* (%)	V
1	Hm 72 Sulina Distr.	Silt	32	67.8	73.2	46.6	6.63	76.1	2.4	0.107	61.6
2	S1 (marine monitoring station)	Clayey silt	79	21	123	84	0.41	112	5.50	0.138	84
3	S2 (marine monitoring station)	Silt	60	24	117	93	0.41	115	5.87	0.142	96
4	BS3 (marine monitoring station)	Clayey silt	48	51	48	37	1.20	16	2.05	0.060	12

GeoEcoMar studies show that the contents of heavy metals in superficial bottom sediments taken from the Sulina Canal and Danube Delta Front decrease in time. This fact is supported by the results obtained analyzing the superficial bottom sediments collected between 1995 and 2000, sediment cores from Sulina Canal and from the dredged sediments area.

Although a slight improvement, probably due to the economical regression of the riparian countries has been observed after 1990 (Secrieru, Secrieru, 1998), the Delta front area is still highly polluted, here being recorded the highest concentrations of Cu, Pb, Zn and Cd from the entire Romanian continental shelf (Table 2). The presence in the Danube Delta Front of the highest concentrations of several heavy metals, with significant anthropic contributions (Secrieru, Secrieru, 2000), confirms the role of the Danube River as the main transport agent for most pollutants.

Nevertheless, the discharge of dredged sediments plays also a lesser but still significant part in maintaining a high degree of heavy metal pollution on the Romanian Black Sea shelf. In time, their effects have disturbed the marine ecosystems on limited areas and contributed to their disturbance on a much larger one.

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