The influence of dredging on the quality of water in the Kiliya delta branches

Important is to estimate maximal predictable gain of polluting admixtures at the section of executing dredging at the period of the hydraulic dredges work.

Such calculation was done for the work at one section of two dredges with nameplate capacity 1000 m^3 of soil per hour for each hydraulic dredge. The volume of simultaneously extracted soil was accepted 1200 m^3/hour subject to their non-synchronous operation and wear and tear. Calculated consumption of water is accepted as a minimal yearly consumption at 95% provision equalling 1350 m^3/sec in section line of Kiliya and minimal consumption of 850 m^3/sec observed at this section of riverbed. Content of calculated substances in extractive ground is accepted in accordance with the data in the report of Institute of Hydrobiology. Alternatively the most pessimistic assumption is that all polluting and biogenic substances, which were in the mass of soil lost during loading, remain in the water thickness. In calculations the density of preliminary loosened soil is accepted 1,6 g/cm^3.

Results of the calculation made regarding the change in contents of pollutants on average throughout the whole cross-section of water flow in the Kiliya branch are presented in Annex 33.

They are the evidence that out of the biogenic substances the greatest relative gain (by 16,2% at consumption of the river water at 1350 m^3/sec) can be reached for gross content of phosphorus compounds in water. In case of permanent action the given factor can lead to a corresponding increase in eutrophication degree eutrophication of water objects of the Danube delta, however calculated increase of concentration could occur only for a short duration. For duration, corresponding to the cycles of biological productive processes (24 hours and more), average increase of phosphorus concentration in water is predicted a one order lower received during the calculation and can’t essentially influence the level of trophicity of the below sections of the delta. Increase in concentration of total nitrogen in water will make slightly over 0,1% in calculations and can’t influence the processes of eutrophication.

Total content of organic substance during execution of dredging (by indexes of Biochemical Oxygen Demand$_5$ and Chemical Oxygen Demand) can increase for a short time by 5–6%, concentration of oil products by 9%.

The greatest growth of heavy metals concentration predicted for manganese is up to 11,5%. Increases in concentration of other metals and toxic organic substances will not exceed 2,5%. From this analysis one can conclude that increase of the polluting concentration in water at the construction period can only result in short-time and local impacts on the water quality, not changing on the whole the existing sanitary-toxicological situation in the Kiliya delta of the Danube and in its separate branches .

Regarding the suspended substances themselves the predictable calculation shows that near the working hydraulic dredge their addition can reach a few tens of mg/dm³, however, as the cloud of dredge throughout the whole width of the flow as far as it is spreading and sedimentation of large fractions the content of the suspended substance in water drops abruptly.

If to take that the loss dredge coming in to a water consists only out of small fractions making 5% of the bottom sediment and does not further go for sedimentation, then at the consumption of 1350 m³/s the addition to a background content of the suspended substances will make 0,4 mg/dm³ on average in a cross-section of the flow and at the consumption of 800 m³/c it will be 0,68 mg/dm³. At that even in the case when the background of the suspended substances will turn out to be less than 30 mg/dm³, the requirements of Sanitary Project and Norms (СанПиН (SanPiN) 4630-88) are observed according to which the content of the suspended substances in the points of cultural-everyday water use should not increase more than by 0,75 mg/dm³.

Increase in concentration of polluting admixtures on average cross section of the current can characterise impact of dredging on quality of water current in the case, when the source of impact is located at considerable distance from the control section line. From the viewpoint of protection of water medium on the territory of DBR the most important control section lines are the ones before the forks of the Ochakov-Starostambulskiy and the Bystry – Starostambulskiy branches, as the spreading of pollutants throughout the system of watercourses of the Kiliya branch delta depends on distribution of pollutants throughout the width of watercourse in the given section lines.

For conditions of carrying out dredging on the rifts, being at comparatively small distance from these section lines and the absence of full mixing in the check section lines (КС №1, КС №2), fig. 1, calculation of pollutants distribution in the current for four variants of the places of carrying out dredging on the rifts is done: in the section lines 20.5 km, 24 km, 32 km and 36 km – variants 1-4 accordingly.

Location of the hydraulic dredge in width of the water current was chosen as much close to the left bank as possible, depending on the rift configuration, and constitutes: for option 1 – 230 m from the left bank, for option 2 – 50 m from the left bank, for option 3 and 4 – in the middle of the branch.

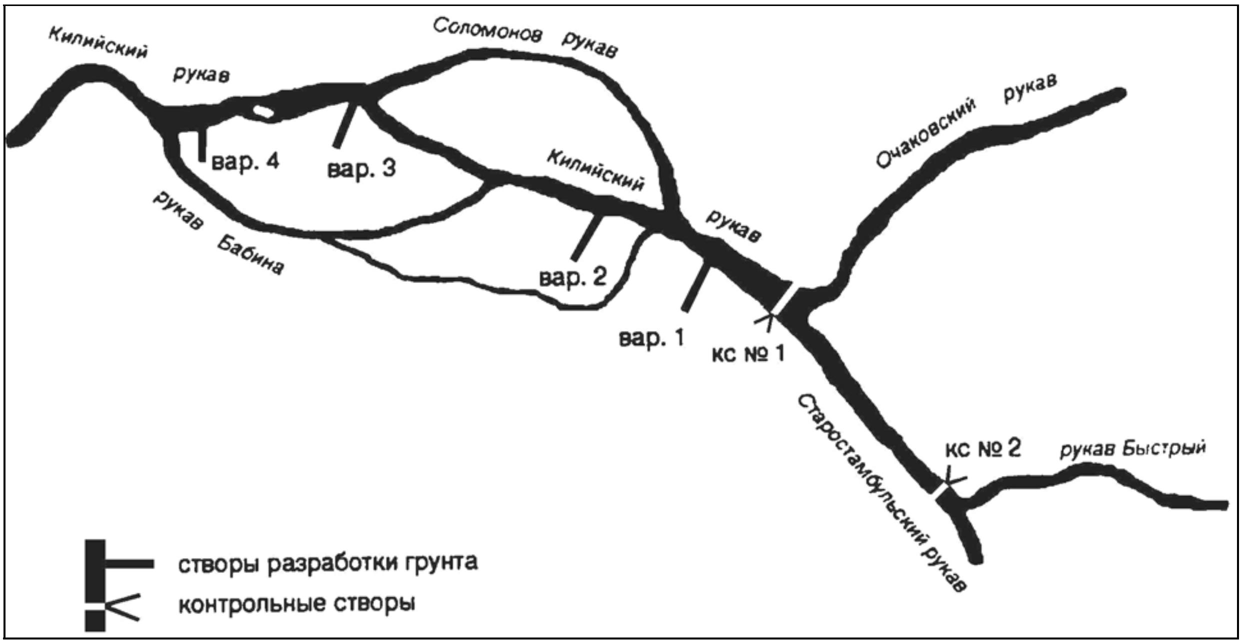

Fig. 1

The calculation was done for the low-water current conditions of 95% provision in the section line of the town of Kiliya (Q=1350 m³/s) that corresponds to the most unfavourable situation. Technological conditions and amount of losses corresponded to the mentioned above, all polluting substances coming into the water of the Danube was considered as conservative and the possibility of re-sedimentation of small fractions of suspended substance was not taken into account. Consumption of water in the branches per the year for 95% provision is presented in the table 1.

Table 1 – Consumption in the branches of the Danube river for a year with 95% provision

Branch	Outflow portion, % of **Q**	Consumption of water, m³/s
The Kiliya (the town of Kiliya)	100	1350,0
The Solomonov	50,9	687,2
The Ochakov	27,4	369,9
The Bystry	33,2	448,2
The Babina	16.9	

Quality of water in the foul part of the current was calculated method, based on analytical solution of the equation of turbulent diffusion.

Background concentrations of pollutants in the Danube river and in the bottom sediment are presented in table. 2.

Table 2 – Background concentration of pollutants in the Danube river and in bottom sediment

No.	Index	Background concentration mg/dm³	Average content in bottom sediment, μg/g	Volume concentration in bottom sediment, mg/dm³	Maximum Allowable Concentration p/x, mg/dm³
1.	Suspended substances (small fractions)	30	50000	80000	background+0.75
2.	Nitrogen general	7.6	1200	1920.0	–
3.	Phosphorus general	0.126	2600	4160.0	–
4.	Manganese	0.1173	1770	2832.0	0.01
5.	Zinc	0.0598	225	360.0	0.01
6.	Copper	0.0479	128	204.8	background+0.001
7.	Lead	0.0308	108	172.8	0.1
8.	Cadmium	0.002	3.3	5.3	0.0033
9.	Chrome	0.086	176	281.6	0.001
10.	Oil products	0.08	920	1472.0	0.05
11.	ПАУ (Surface Active У.)	0.00037	1	1.6	–
12.	DDT	0.000051	0.032	0.051	–
13.	hexachlorcyclohexane	0.00017	0.01	0.016	–

In figures 2–5 graphs of concentrations areas for suspended substances along check section lines No. 1 and No. 2 are presented. (For visualisation the abscissa axis is represented as a percentage of water consumption in KC Q_{KC} from the left bank to the right one.) As the process of blending the river water and dredge is identical for all substances, the presented graphs characterise the picture of pollution for all indexes.

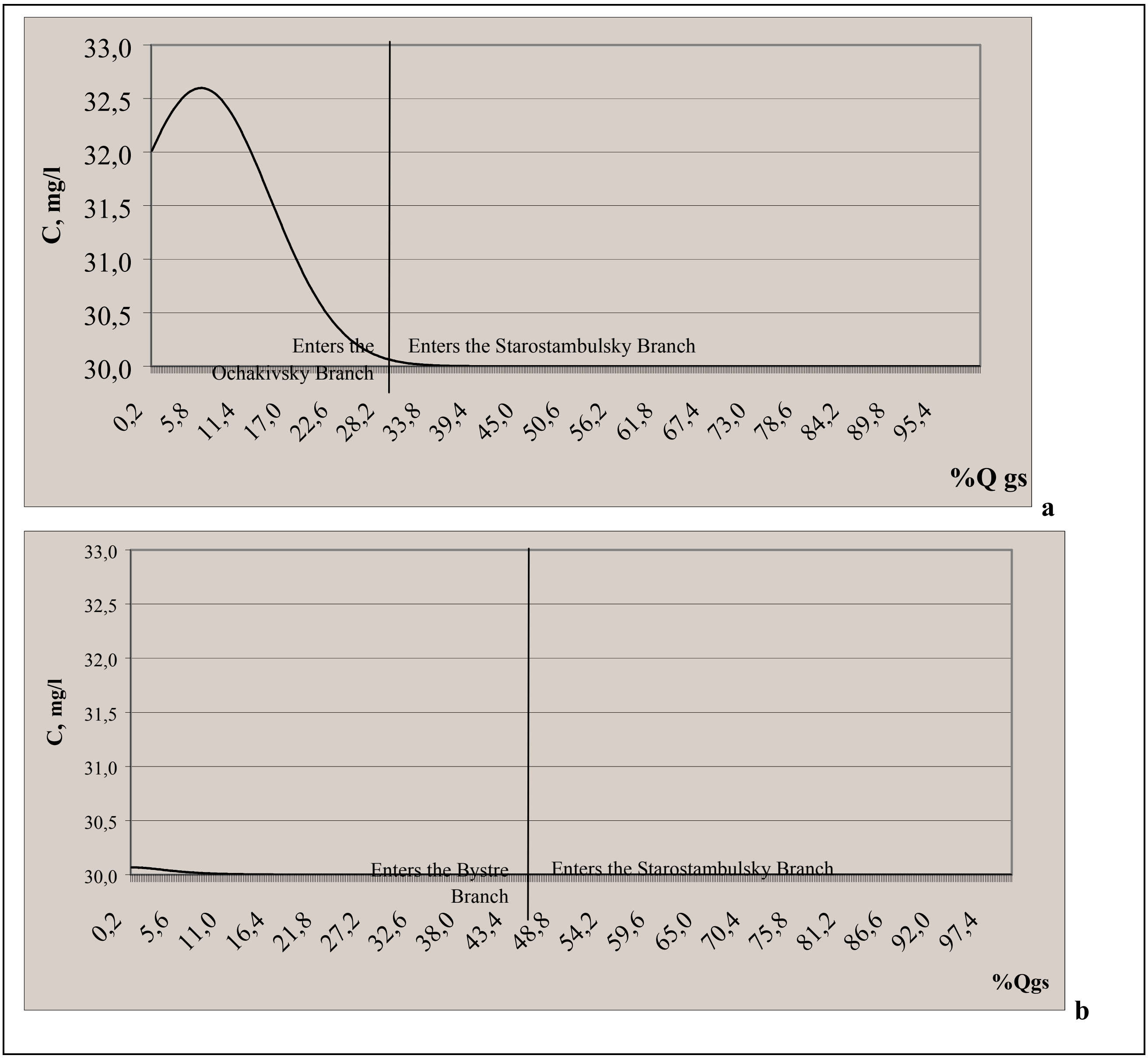

Figure 2. Concentration Ranges for Suspended Substances under Option 1 at the Gauging Stations No. 1 (a) and 2 (b)

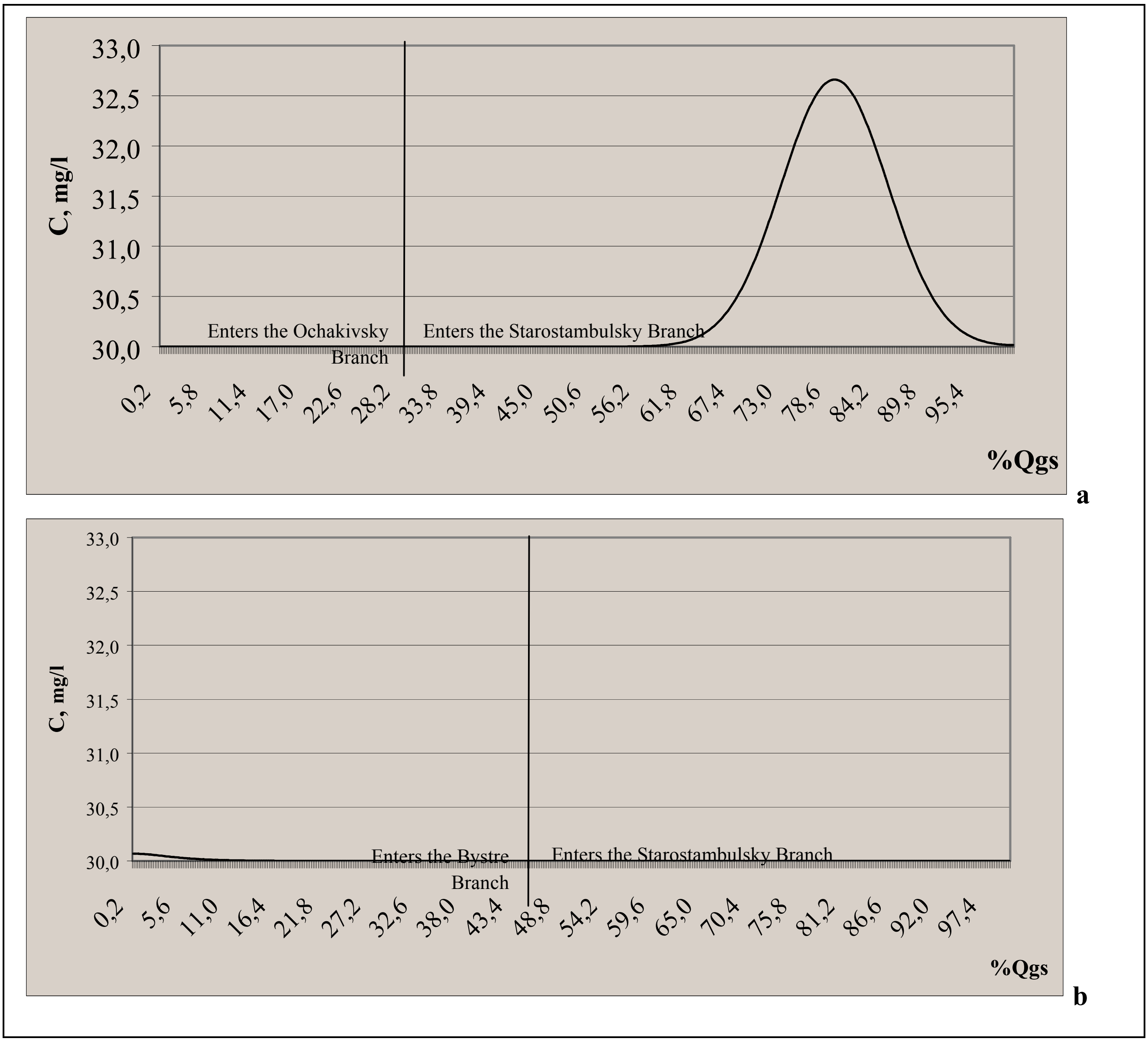

Figure 3. Concentration Ranges for Suspended Substances under Option 2 at the Gauging Stations No. 1 (a) and 2 (b)

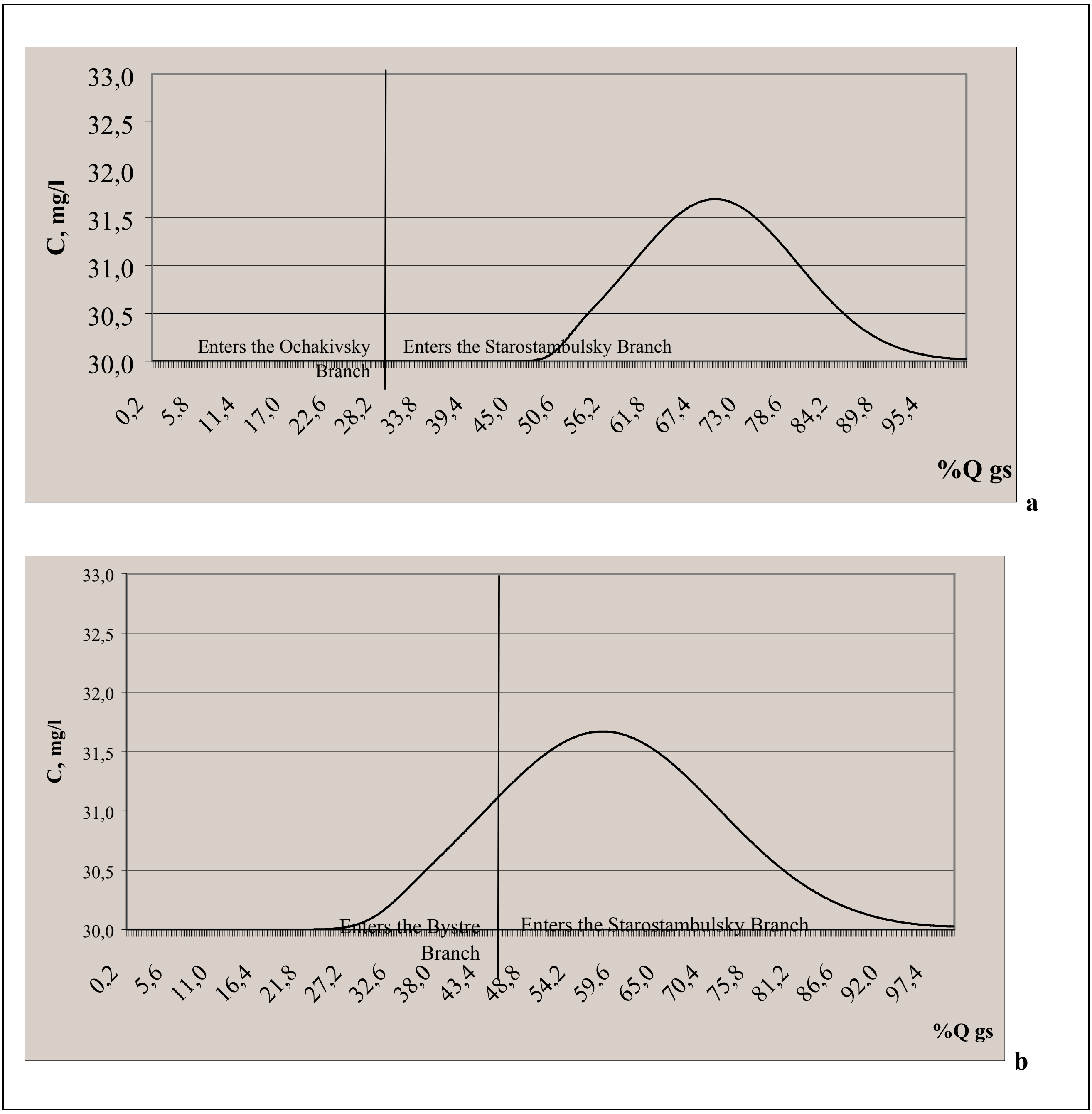

Figure 4. Concentration Ranges for Suspended Substances under Option 3 at the Gauging Stations No. 1 (a) and 2 (b)

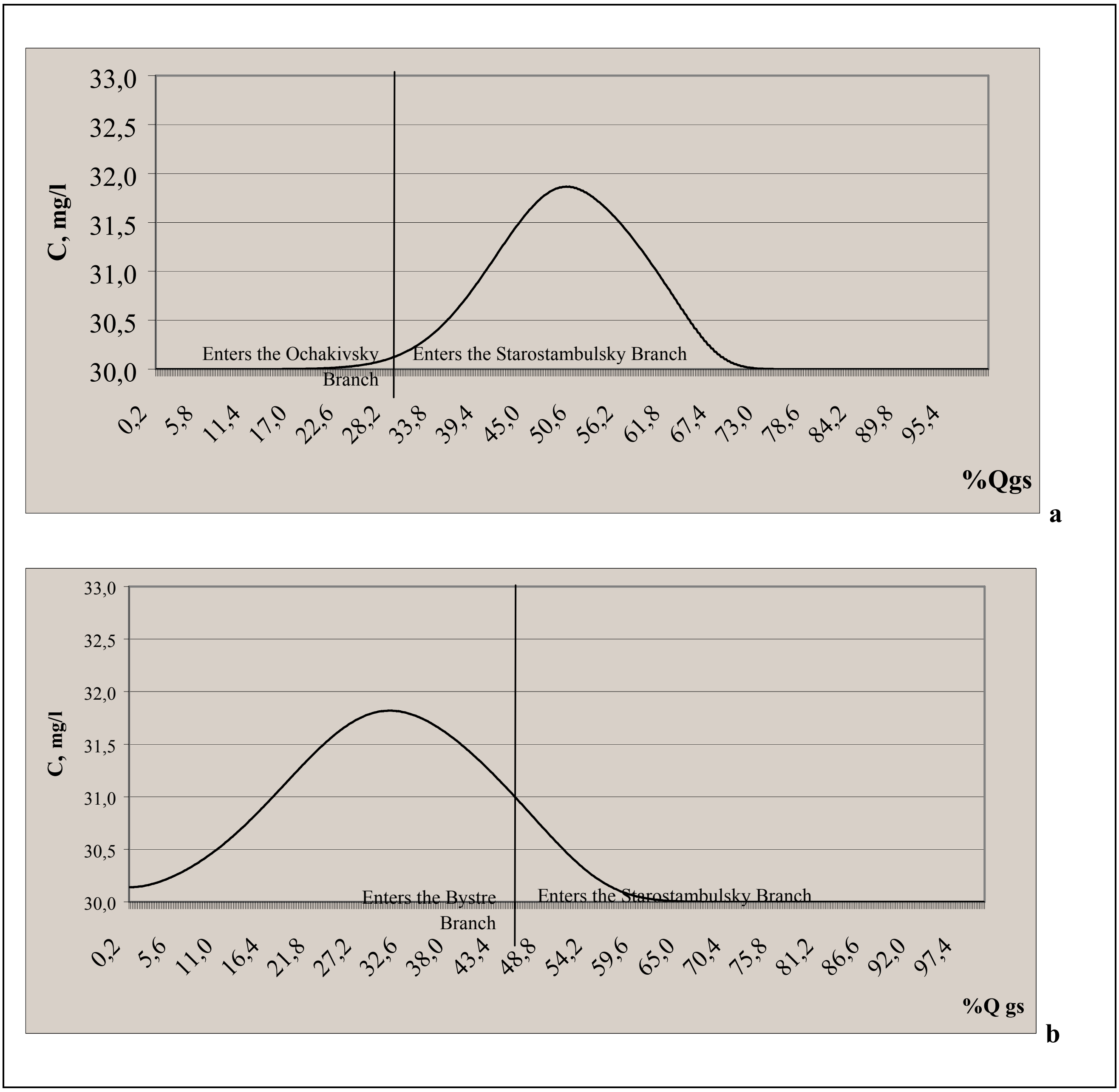

Figure 5. Concentration Ranges for Suspended Substances under Option 4 at the Gauging Stations No. 1 (a) and 2 (b)

The results of this estimate indicate that the increment in SS concentration relative to the background level may be at about 20 mg/l (at the width of contaminated jet of about 10 m) at a distance of several tens of meters downstream of a dredging location. The maximum SS concentration progressively decreases as the jet spreads in the downstream direction as a result of turbulent diffusion, and at a distance of 600 m downstream the increment in SS concentration is only at 5 mg/l.

The process slows down as one moves further downstream, and the maximum increment in SS concentration at a distance of 4 km is about 2 mg/l. At this distance, the width of contaminated water jet, where the increment in SS concentration exceeds the admissible increment limit set for fishing waters (0.25 mg/l), increases up to 150 m, i.e. is at about 1/3 of the total stream width. This may adversely affect the aquatic inhabitants passively carried with river flow (including fish larvae carried from the spawning areas).

Depending on the locations of dredges across the shallow section, the major proportion of suspended matter of technogenic origin may enter either the Ochakivsky Branch (under Option 1) or the Bystre Branch (under Option 4), or remain in the Starostambulske Branch (under Options 2 and 3). The increment in the average SS concentration would be at about 1.5 mg/l in the Ochakivsky Branch and 1.0 mg/l, which exceeds the admissible increment limit set for fishing waters (0.25 mg/l) by 6 and 4 times respectively, and this would require the implementation of control measures. In particular, **during the low-water period the intensity of dredging activities in the shallow section of the Chilia Branch would need to be limited on the basis of operational monitoring data and specific characteristics of a dredging location.**

On the basis of analysing the graphs of concentration areas the conclusion was made of existence of a man-caused influence of dredging on the quality of water in the Ochakov and the Bystry branches (table 3).

Table 3 – The influence of dredging on the quality of water in the Ochakov and the Bystry branches.

Option	Increment in SS Concentration (ΔC_p), mg/l		Exceedance relative to Admissible Limit (background level + 0.25 mg/l), times
	Ochakivsky Branch	Bystre Branch	
1	1,5	–	**6,0** (in the Ochakivsky Branch)
2	–	–	–
3	–	0,03	–
4	0,01	1,0	**4,0** (in the Bystre Branch)

Calculated values of the quality of water in the branches in the presence of a man-caused influence are presented in table 4

Table 4 – Estimated Changes in Water Quality in the Ochakivsky Branch and Bystre Branch due to Dredging Operations in the Chilia Branch

No.	Parameter	Background concentration, mg/l	Average concentration in bottom sediments, μg/g	Volume concentration in bottom sediments, mg/l	Conversion ratio, % (according to ad-hoc standard VBN B.1.1.31-96)	MAC for fishing waters, mg/l	Option 1, Ochakivsky Branch			Option 4, Bystre Branch		
							Mean concentration in waters, mg/l	Absolute increment in background levels, mg/l	Relative increment in background levels, %	Mean concentration in waters, mg/l	Absolute increment in background levels, mg/l	Relative increment in background levels, %
1.	Nitrogen total	7,6	1200	1920,0	–	–	7,88	0,28	3,7	7,76	0,16	2,1
2.	Phosphorus total	0,126	2600	4160,0	–	–	0,153	0,027	21,3	0,150	0,024	19,4
3.	Manganese	0,1173	1770	2832,0	–	0,01	0,1367	0,0194	16,5	0,1345	0,0172	14,7
4.	Zinc	0,0598	225	360,0	1,87	0,01	0,0639 0,0637	0,0041 0,0039	6,8 6,4	0,0628 0,0626	0,0030 0,0028	5,1 4,8
5.	Copper	0,0479	128	204,8	1,31	Background + 0,001	0,0507 0,0503	0,0028 0,0024	5,9 5,0	0,0499 0,0495	0,0020 0,0016	4,2 3,3
6.	Lead	0,0308	108	172,8	2,50	0,1	0,0328 0,0330	0,0020 0,0022	6,6 7,2	0,0323 0,0325	0,0015 0,0017	4,9 5,5
7.	Cadmium	0,0020	3,3	5,3	0,95	0,0033	0,00210 0,00208	0,00010 0,00008	5,0 4,2	0,00207 0,00205	0,00007 0,00005	3,3 2,6
8.	Chromium	0,0860	176	281,6	–	0,001	0,0906	0,0046	5,3	0,0891	0,0031	3,7
9.	Oil products	0,080	920	1472,0	14,5	0,05	0,091 0,137	0,011 0,057	13,4 71,8	0,089 0,135	0,009 0,055	11,6 69,1
10.	PAH	0,00037	1	1,6	–	–	0,000392	0,000022	5,9	0,000386	0,000016	4,2
11.	DDT	0,000051	0,032	0,051	–	–	0,000053	0,000002	4,1	0,000052	0,000001	2,5
12.	HCCH	0,00017	0,01	0,016	–	–	0,000176	0,000006	3,6	0,000173	0,000003	2,0

So the impacts on the environment that occur during dredging are controllable and may be restricted to the acceptable level subject to proper organisation of the works and control of the quality of water.

First of all it refers to determining of the conditions of the works performed, choice of the storage places and working out measures to avoid pollution of river waters with return waters from dumps. In the project the suspension of the works is provided during fish spawning and young fish motion for one month. The restrictions can also be brought in on dredging at extremely low flow rate waters and on the basis of result of monitoring the water quality.

In the areas of carrying out dredging, of dumping soil to channel dumps and in check sections, control of water quality is foreseen by the following parameters: the content of suspended substances, of dissolved oxygen, mineralisation, pH, ammonium nitrogen, nitrites, nitrates, phosphates, oil products, heavy metals. Regular control over changing of biomass and of biological diversity of bacterioplankton and of bacteriobenthos, of phytoplankton, of zooplankton, of macrozoobenthos.

The mentioned restrictions on carrying out works and directions on carrying out monitoring refer both to the dredging during the period of construction and at to operational scraping of the ground, smaller volumes of which as compared to with the works of the construction period enable to reduce the intensity of ground extraction in conformity with ecological requirements.