International Project "Caspian Environment Programme"

UNDP/GEF Project "Implementation of Convention and Action Plan on Caspian Sea Environment Protection – Phase II"

United Nations Office for Project Services (UNOPS)

State Oceanographic Institute (SOI)

of Federal Service on Hydrometeorology and Monitoring of Environment

(Roshydromet)

REPORT

PROJECT Ref. 00034997/ 2006/004

"A Desk Study Project to determine the fluxes of major contaminants from the Terek River into Caspian Sea"

Moscow, 2007

ABSTRACT

In the frame of the current Project the estimation on contents of nutrients, petroleum hydrocarbons, phenols and heavy metals in water and bottom sediments in the basins of rivers Terek, Sulak and Samur over the last years was carried out. Research was conducted within a framework of the State Monitoring Programme on Roshydromet in the central and lower parts of the Terek delta. The data of Roshydromet standard investigations was used to assess the concentration of pollutants, namely petroleum hydrocarbons, heavy metals, phenols, detergents, nutrients (nitrites, nitrates, ammonium and total nitrogen) and silicates, and also expenditure of river water during the estimation of their flows at hydrological Karagalinsky hydro system and Alikazgan stations in the Terek delta. The Roshydromet data cover the period 2002-2005.

Additionally archive data of scientific expeditions of State Oceanographic Institute of Roshydromet during period 2002-2004 were used. The expedition data covered both water and bottom sediment.

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Abbreviations

BOD	biochemical oxygen demand
bs	bottom sediments
CEP	Caspian Environment Programme
DagCHMC	Dagestan Center on Hydrometeorology of Roshydromet
MAC	maximum allowed concentration
PC	permissible concentration for bottom sediments (“Netherlands lists”)
PHs	petroleum hydrocarbons
Roshydromet	Federal Service on Hydrometeorology and Monitoring of Environment
SAP	Strategic Action Programme for the Caspian Sea
SOI	State Oceanographic Institute of Federal Service on Hydrometeorology and Monitoring of Environment (Roshydromet)
UNDP	United Nations Development Programme
UNOPS	United Nations Office for Project Services

CONTENT

CHAPTER 1.
SEASONAL AND INTERANNUAL VARIABILITY IN POLLUTANTS CONCENTRATION AND FLOWS IN THE TEREK WATERS ROSHYDROMET MONITORING

1.1. MATERIAL AND METHODS

The data of Roshydromet standard investigations was used to assess the concentration of pollutants, namely petroleum hydrocarbons, heavy metals, phenols, detergents, nutrients (nitrites, nitrates, ammonium and total nitrogen) and silicates, and also expenditure of river water during the estimation of their flows at hydrological stations in the Terek delta. The measurements of water expenditure and the concentration of chemical substances in the main branch of the Terek delta, Novy Terek, at the hydrological station on Karagalinsky hydrosystem, placed 108 km from the sea, and the hydrological station Alikazgan, placed 21 km from the sea (fig.1), were realized by Dagestan CHMS (Center of Hydrometeorological Service) of North Caucasian DHMS (Department of Hydrometeorological Service). The complete year's set of data on the expenditure of water and suspended solids is available for Karagalinsky hydrosystem for years 2002-2005, but for the hydrological station Alikazgan only for the year 2005. The complete year's set of data on the concentration of substances in water for years 2002-2005 and the first 3 quarters of the year 2006 is available for the both mentioned hydrological stations. The measurement of flow is carried out not rarer than once in 10 days, and the samples of water are taken once in a month several times in a year.

The interpolation of data on the concentration of substances in water between the months, when the samples of water were taken, is groundless. Thus a quarter was taken as the time interval for averaging concentrations of substances in water, because there is not less than one sampling in every quarter. The flow of pollutants for the whole five years (2002-2005) can only be defined according to the data from Karagalinsky hydrosystem. And the data from the hydrological station Alikazgan can only be used to define the flows of pollutants in the year 2005.

The data sets of concentrations of pollutants streams, averaged for quarters are given in Tables 1-5, and the averaged data sets of water expenditure for the same years are listed in tables 7-11. The changes of pollutants concentration for separate months is shown by the example of petroleum hydrocarbons (TPHs) changes at the hydrological station on Karagalinsky hydrosystem and the hydrological station Alikazgan (Fig. 2,3).

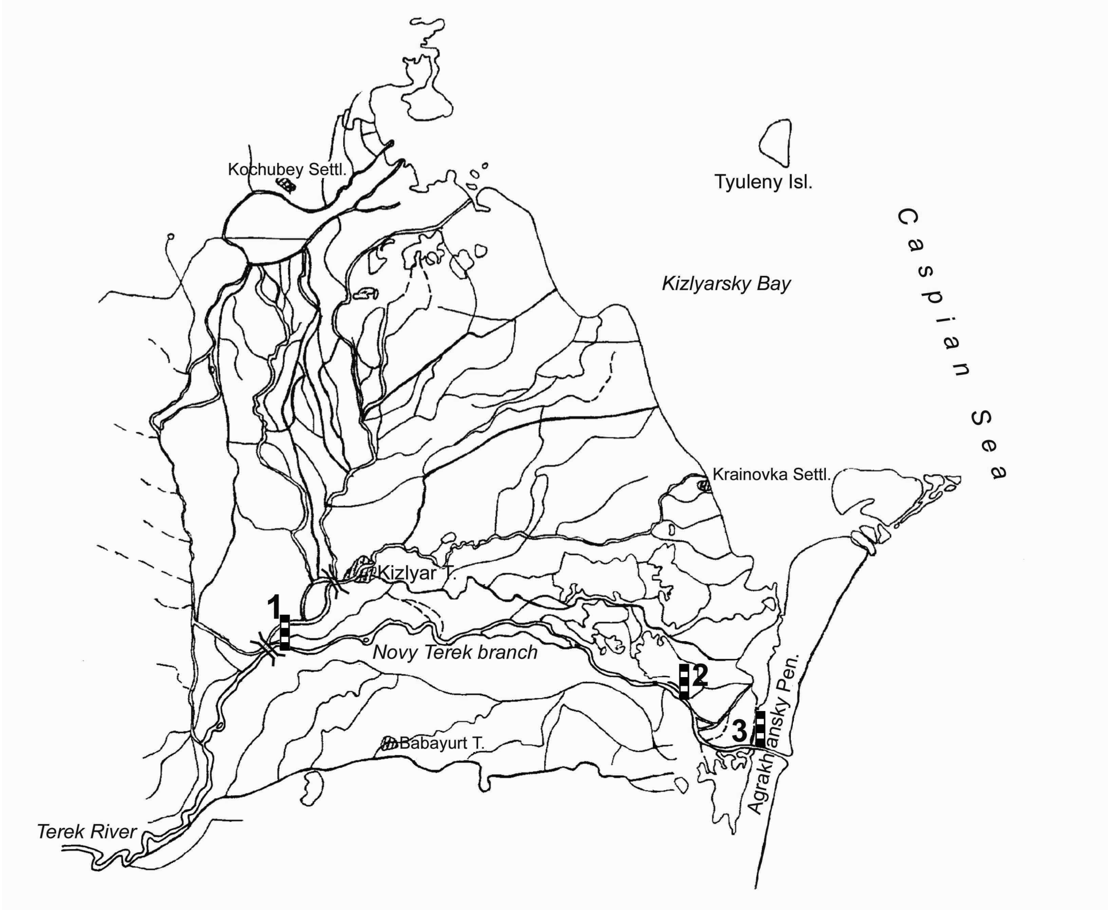


Fig. 1. Terek delta: 1-3 are DHMC gauge-stations: 1 - Karagalinskiy HU, 2 – Alikazgan, 3 -Dam.

1.2. RESULTS

Table 1. The concentration of pollutants (mg/l) at the hydrological station on Karagalinsky hydrosystem in 2002.

Ingredients, mg/l	1 quarter	2 quarter	3 quarter	4 quarter
1	3	6	9	11
Suspended matter	**1,2**	**14,1**	**4,55**	**0,17**
BOD5	**0,96**	**1,06**	**1,34**	**1,36**
Ammonia nitrogen	**0,035**	**0,03**	**0,02**	**0,015**
Nitrite nitrogen	**0,006**	**0,00**	**0,01**	**0,004**
Nitrate nitrogen	**1,204**	**0,90**	**0,29**	**0,926**
Total nitrogen	**1,245**	**0,93**	**0,32**	**0,945**
Phosphates	**0,018**	**0,01**	**0,00**	**0,006**
Silica acid	**4,8**	**4,40**	**3,35**	**4,9**
Magnesium	**20,3**	**15,15**	**11,4**	**14,8**
Total iron	**0**	**0,03**	**0,13**	**0,07**
Copper, µg/l	**5**	**-**	**3**	**6**
Zinc, µg/l	**6**	**-**	**12**	**8**
Phenols	**0,002**	**-**	**0**	**0,001**
Petroleum hydrocarbons	**0,04**	**0**	**0**	**0,07**
Detergents	**0**			**0**

Table 2. The concentration of pollutants at the hydrological station on Karagalinsky hydrosystem in 2003.

Ingredients, mg/l	1 quarter	2 quarter	3 quarter	4 quarter
1	3	6	9	11
Suspended matter	0,08	1,24	2,94	0,37
BOD5	1,54	1,31	2,94	1,71
Ammonia nitrogen	0,087	0,03	0,03	0,063
Nitrite nitrogen	0,062	0,01	0,01	0,04
Nitrate nitrogen	2,49	1,99	0,75	0,949
Total nitrogen	2,64	2,03	0,79	1,05
Phosphates	0,033	0,03	0,00	0,005
Silica acid	5,3	4,7	3,50	5,7
Magnesium	25,9	26,2	31,2	13,9
Total iron	0,05	0,02	0,03	0,05
Copper, μg/l	5,0	5,0	7,5	7,0
Zinc, μg/l	11,0	11,0	9,0	10,0
Phenols	0,002	0	0,002	0,002
Petroleum hydrocarbons	0,18	0	0,09	0,06
Detergents	0		!	

Table 3. The concentration of pollutants at the hydrological station on Karagalinsky hydrosystem in 2004.

Ingredients, mg/l	1 quarter	2 quarter	3 quarter	4 quarter
1	3	6	9	11
Suspended matter	0,56	3,52	1,66	0,25
BOD5	1,73	1,37	1,67	1,11
Ammonia nitrogen	0,03	0,05	0,14	0,09
Nitrite nitrogen	0,041	0,02	0,01	0,011
Nitrate nitrogen	2,059	2,13	0,77	1,19
Total nitrogen	2,13	2,20	0,91	1,29
Phosphates	0,001	0,02	0,00	0,002
Silica acid	6,9	5,90	3,90	5,7
Magnesium	24	17,30	8,75	18,7
Total iron	0,06	0,02	0,05	0,04
Copper, μg/l	3	6,5	6,5	5,0
Zinc, μg/l	7	8,5	9,0	8,0
Phenols	0	0,007	0,002	0,015
Petroleum hydrocarbons	0,03	0,20	0,75	0,54
Detergents				

Table 4.The concentration of pollutants at the hydrological station on Karagalinsky hydrosystem in 2005.

Ingredients, mg/l	1 quarter	2 quarter	3 quarter	4 quarter
1	3	6	9	11
Suspended matter	0,55	3,42	2,21	0,67
BOD5	0,78	1,40	2,59	1,63
Ammonia nitrogen	0,064	0,23	0,09	0,074
Nitrite nitrogen	0,006	0,07	0,02	0,006
Nitrate nitrogen	1,94	1,79	0,86	1,08
Total nitrogen	2,01	2,10	0,96	1,16
Phosphates	0,002	0,01	0,00	0,009

Silica acid	**7**	**6,40**	**5,10**	**6,1**
Magnesium	**21,2**	**18,15**	**9,45**	**15,2**
Total iron	**0,34**	**0,32**	**0,16**	**0,07**
Copper, µg/l	**5,0**	**2,7**	**2,7**	**9,8**
Zinc, µg/l	**5,0**	**8,5**	**8,9**	**10,4**
Phenols	**0,002**	**0,002**	**0,005**	**0,00**
Petroleum hydrocarbons	**0,15**	**0,06**	**0,17**	**0,12**
Detergents	**0,01**	**0,01**	**0,01**	**0,014**

Table 5. The concentration of pollutants at the hydrological station Alikazgan in 2005.

Ingredients, mg/l	**1 quarter**	**2 quarter**	**3 quarter**	**4quarter**
1	3	6	9	11
Suspended matter	**0,55**	**1,09**	**1,09**	**0,53**
BOD5	**1,12**	**1,66**	**2,5**	**0,81**
Ammonia nitrogen	**0,068**	**0,082**	**0,24**	**0,128**
Nitrite nitrogen	**0,007**	**0,046**	**0,02**	**0,007**
Nitrate nitrogen	**1,713**	**2,114**	**0,87**	**1,013**
Total nitrogen	**1,788**	**2,244**	**1,13**	**1,148**
Phosphates	**0,003**	**0,008**	**0,004**	**0,008**
Silica acid	**8**	**5,3**	**4,7**	**5,7**
Magnesium	**16,1**	**16,95**	**10,65**	**14,1**
Total iron	**0,2**	**0,045**	**0,08**	**0,03**
Copper, µg/l	**4**	**2,2**	**1,65**	**3,1**
Zinc, µg/l	**6**	**10,5**	**9,75**	**10,2**
Phenols	**0,004**	**0,002**	**0,003**	**0**
Petroleum hydrocarbons	**0,12**	**0,87**	**0,12**	**0,06**
Detergents	**0,012**	**0,014**	**0,054**	**0,008**

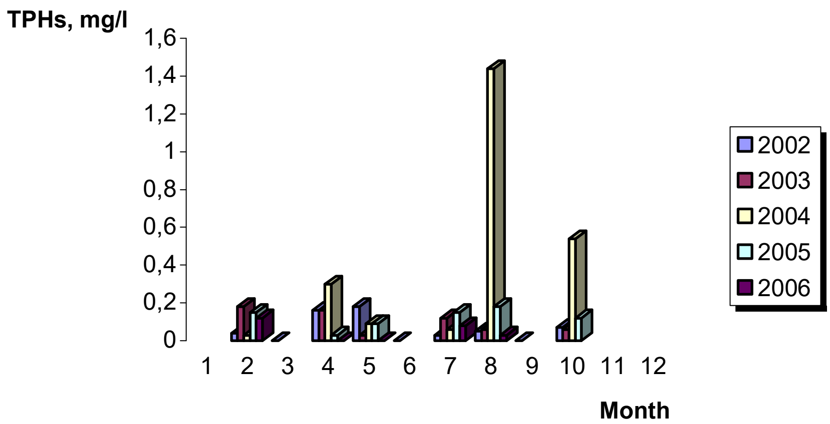


Fig. 2. The concentrations of petroleum hydrocarbons at the hydrological station on Karagalinsky hydrosystem in the Terek delta in 2002 – 2006.

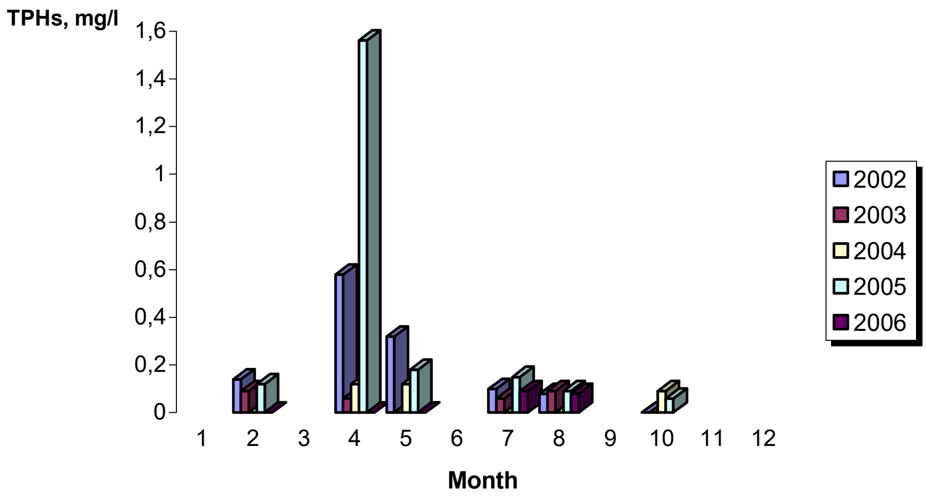


Fig. 3. The concentrations of petroleum hydrocarbons at the hydrological station Alikazgan in the Terek delta in 2002 – 2006.

The concentration of the suspended matter (turbidity) was changing from 0,08 mg/l in the first quarter of the year 2003 to 14,1 mg/l in the second quarter of the year 2002 and averaged 2,34 mg/l (5 MAC) during the period from 2002 till 2005.

The concentration of total nitrogen was changing from 0,32 mg/l in the third quarter of 2002 to 2,64 mg/l in the first quarter of 2003 and averaged 2,01 mg/l during the period from 2002 till 2005. And the concentration of nitrate nitrogen was varying from the minimum of 0,29 mg/l in the third quarter of the year 2002 to the maximum of 2,49 mg/l in the first quarter of the year 2003 and averaged 1,92 mg/l during the whole period from 2002 till 2005. The concentration of nitrite nitrogen was changing from the minimum of 0,03 mg/l in the second quarter of the year 2002 to the maximum of 0,07 mg/l in the second quarter of the year 2005 and averaged 0,02 mg/l during the period from 2002 till 2005.

Ammonia nitrogen was changing from 0,02 mg/l in the first and second quarters of the year 2002 to 0,23 mg/l in the second quarter of the year 2005 and averaged 0,07 mg/l during the period from 2002 till 2005.

The concentration of phosphates was changing from the minimum of 0,32 mg/l in the third quarter of the year 2002 to the maximum of 2,64 mg/l in the first quarter of the year 2003 and averaged 2,01 mg/l during the period from 2002 till 2005.

The concentration of silica acid was changing from 3,4 mg/l in the third quarter of the year 2002 to 7,0 mg/l in the first quarter of the year 2005 and averaged 5,23 mg/l during the period from 2002 till 2005.

The concentration of heavy metals was changing:

- Magnesium – from 8,8 mg/l in the third quarter of the year 2004 to 31,2 mg/l in the third quarter of the year 2003 and averaged 18,2 mg/l during the period from 2002 till 2005.

- Iron - from 0,02 mg/l in the second quarter of the years 2003 and 2004 to 0,32 mg/l in the second quarter of the year 2005 and averaged 0,09 mg/l during the period from 2002 till 2005.
- Copper - from 0,003 mg/l in the third quarter of the year 2005 to 0,01 mg/l in the fourth quarter of the year 2005 and averaged 0,005 mg/l during the period from 2002 till 2005.
- Zinc - from 0,005 mg/l in the first quarter of the year 2002 to 0,012 mg/l in the third quarter of the year 2002 and averaged 0,009 mg/l during the period from 2002 till 2005.

The concentration of phenols was changing from the minimum of 0,001 mg/l in the fourth quarter of the year 2002 to the maximum of 0,015 mg/l in the fourth quarter of the year 2004 and averaged 0,003 mg/l during the period from 2002 till 2005.

The concentration of petroleum hydrocarbons (TPHs) was changing from 0,03 mg/l in the first quarter of the year 2004 to 0,75 mg/l in the third quarter of the year 2004 and averaged 0,17 mg/l during the period from 2002 till 2005.

Table 6. Averaged, maximum and minimum concentration of pollutants at the hydrological station on Karagalinsky hydrosystem in the Terek delta in 2002 – 2005.

Ingredients, mg/l	Concentration of pollutants in 2002-2005											
	1 quarter			2 quarter			3 quarter			4 quarter		
	Averaged	Max	Min	Averaged	Max	Min	Averaged	Max	Min	Averaged	Max	Min
Q, m^3/c	202	205	197	351	554	139	371	487	201	229	268	202
Q_{max}, m^3/c	-	**401** 8.03. 2004	-	-	**1170** 10.05 .2005		-	**888** 9.07. 2005		-	**832** 22.10 2005	
Q_{min}, m^3/c	-	-	**163** 17.01. 2004	-		**44,5** 3.07. 2003	-		**36,5** 16.09. 2003	-		**91,8** 1.10. 2003
Suspended matter	0,59	1,15	0,08	5,570	14,10	1,24	2,84	4,55	1,66	0,37	0,67	0,17
BOD5	1,25	1,73	0,78	1,284	1,40	1,06	2,13	2,94	1,34	1,45	1,71	1,11
Ammonia nitrogen	0,05	0,087	0,03	0,084	0,23	0,03	0,07	0,14	0,02	0,06	0,09	0,02
Nitrite nitrogen	0,03	0,062	0,006	0,026	0,07	0,00	0,01	0,02	0,01	0,02	0,04	0,00
Nitrate nitrogen	1,92	2,488	1,204	1,702	2,13	0,90	0,67	0,86	0,29	1,04	1,19	0,93
Total nitrogen	2,01	2,637	1,245	1,813	2,20	0,93	0,75	0,96	0,32	1,11	1,29	0,95
Phosphates	0,01	0,033	0,001	0,016	0,03	0,01	0,00	0,00	0,00	0,01	0,01	0,00
Silica acid	6,00	7,0	4,8	5,350	6,40	4,40	3,96	5,10	3,35	5,60	6,10	4,90
Magnesium	22,9	25,9	20,3	19,200	26,20	15,15	15,18	31,15	8,75	15,65	18,7	13,90
Total iron	0,11	0,34	0	0,094	0,32	0,02	0,09	0,16	0,03	0,06	0,07	0,04
Copper	0,004	0,005	0,003	4,733	-	-	4,91	7,50	2,65	6,95	9,80	5,00
Zinc	0,01	0,011	0,005	9,333	-	-	9,59	11,50	8,85	9,10	10,40	8,00
Phenols	0,002	0,002	0	0,003	-	-	0,003	0,005	0,002	0,005	0,02	0,000
Petroleum hydrocarbons	0,10	0,18	0,03	0,130	0,20	0,06	0,26	0,75	0,04	0,20	0,54	0,06
Detergents												

The estimation of the annual variability of pollutants at the hydrological station on Karagalinsky hydrosystem (according to the average quarter results) during the period from 2002 till 2005 is shown in table 6 and is illustrated in figure 3. The maximum turbidity was marked in the second quarter and the minimum in the fourth one. The maximum pollution (according to the data of BOD5) fell on the third quarter, and the minimal pollution – on the second quarter. The pollution of petroleum hydrocarbons also is changing during the year. The maximum pollution by nutrients is caused by nitrate nitrogen in the first quarter and by phosphates in the second. The maximum pollution by phenols is in the fourth quarter and the minimum is in the first. Magnesium contributes to the greatest pollution by heavy metals. The maximum magnesium pollution is in the first quarter, the minimum is in the third – silica acid is the same. The concentration of copper and zinc is maximum in the fourth quarter and minimum in the third.

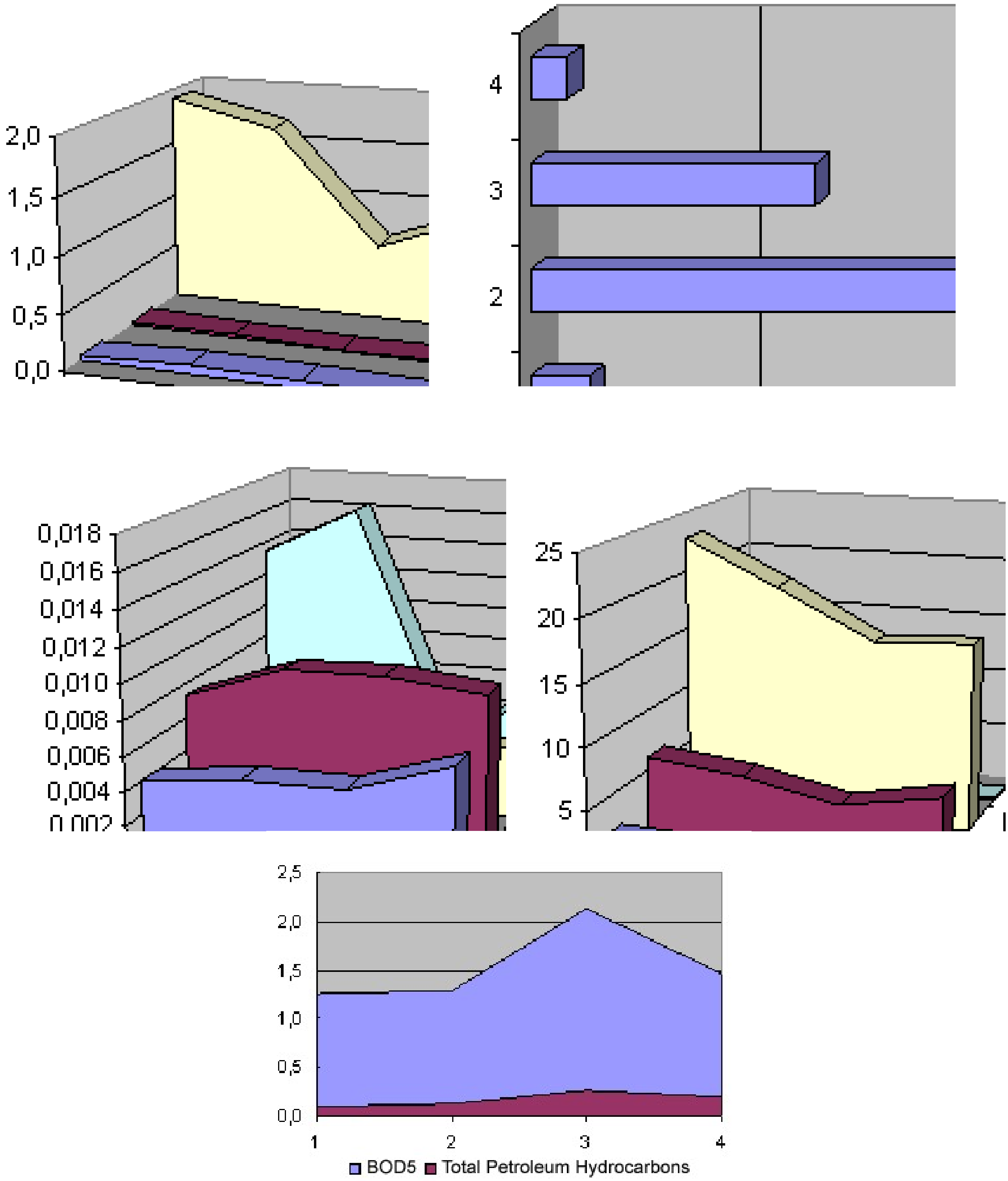


Fig. 4. Annual variability of the pollutants concentrations (mg/l) during the quarters 1, 2, 3 and 4 at the hydrological station on Karagalinsky hydrosystem in 2002-2005.

The results of the estimation of the streams at the hydrological station on Karagalinsky hydrosystem are brought out in tables 7-10, and the data on the hydrological station Alikazgan is shown in table 11.

Table 7. The streams of pollutants at the hydrological station on Karagalinsky hydrosystem in 2002.

Ingredients, mg/l	Top of the Terek delta - Karagalinsky hydrosystem											
	1 quarter			2 quarter			3 quarter			4quarter		
	Expenditure of water, м^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, м^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, м^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, м^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones
Suspended matter	203	1,15	1,8	399	14,10	44,2	487	4,55	17,42	233	0,17	0,3
BOD 5	203	0,96	1,5	399	1,06	3,3	487	1,34	5,11	233	1,36	2,5
Ammonia nitrogen	203	0,035	0,1	399	0,03	0,1	487	0,02	0,09	233	0,015	0,0
Nitrite nitrogen	203	0,006	0,0	399	0,00	0,0	487	0,01	0,03	233	0,004	0,0
Nitrate nitrogen	203	1,204	1,9	399	0,90	2,8	487	0,29	1,12	233	0,93	1,7
Total nitrogen	203	1,245	2,0	399	0,93	2,91	487	0,32	1,24	233	0,95	1,7
Phosphates	203	0,018	0,0	399	0,01	0,02	487	0,00	0,01	233	0,01	0,0
Silica acid	203	4,8	7,7	399	4,40	13,80	487	3,35	12,83	233	4,9	9,0
Magnesium	203	20,3	32,4	399	15,15	47,53	487	11,35	43,46	233	14,8	27,1
Total iron	203	0,00	0,0	399	0,03	0,09	487	0,13	0,48	233	0,07	0,1
Copper, µg/l	203	0,005	0,01	399			487	0,003	0,01	233	0,006	0,01
Zinc, µg/l	203	0,006	0,01	399			487	0,012	0,04	233	0,008	0,01
Phenols	203	0,002	0,003	399			487	0,00	0,01	233	0,001	0,002
TPHs	203	0,04	*0,06*	399	0,17	*0,53*	487	0,04	*0,15*	233	0,07	0,1
Detergents	203			399			487			233		

Table 8. The flow of pollutants at the hydrological station on Karagalinsky hydrosystem in 2003.

Ingredients, mg/l	Top of the Terek delta - Karagalinsky hydrosystem											
	1 quarter			2 quarter			3 quarter			4quarter		
	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones
Suspended matter	197	0,08	0,12	139	1,24	1,4	201	2,94	4,65	213	0,37	0,620

BOD 5	197	1,54	2,39	139	1,31	1,4	201	2,94	4,64	213	1,71	2,864
Ammonia nitrogen	197	0,087	0,13	139	0,03	0,0	201	0,03	0,05	213	0,063	0,106
Nitrite nitrogen	197	0,062	0,10	139	0,01	0,0	201	0,01	0,01	213	0,04	0,067
Nitrate nitrogen	197	2,49	3,85	139	1,99	2,2	201	0,75	1,19	213	0,949	1,589
Total nitrogen	197	2,64	4,08	139	2,03	2,21	201	0,79	1,25	213	1,05	1,762
Phosphates	197	0,033	0,05	139	0,03	0,03	201	0,00	0,00	213	0,005	0,008
Silica acid	197	5,3	8,21	139	4,7	5,14	201	3,50	5,53	213	5,7	9,546
Magnesium	197	25,9	40,12	139	26,2	28,63	201	31,15	49,23	213	13,9	23,278
Total iron	197	0,05	0,08	139	0,02	0,02	201	0,03	0,04	213	0,05	0,084
Copper, μg/l	197	0,005	0,01	139	0,005	0,01	201	0,008	0,01	213	0,007	0,012
Zinc, μg/l	197	0,011	0,02	139	0,011	0,01	201	0,009	0,01	213	0,010	0,017
Phenols	197	0,002	0,00	139	0,00	0,00	201	0,002	0,003	213	0,002	0,003
TPHs	197	0,18	*0,28*	139	0,10	*0,10*	201	0,09	*0,14*	213	0,06	0,100
Detergents	197			139			201			213		

Table 9. The flow of pollutants at the hydrological station on Karagalinsky hydrosystem in 2004.

Ingredients, mg/l	Top of the Terek delta - Karagalinsky hydrosystem											
	1 quarter			2 quarter			3 quarter			4quarter		
	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones
Suspended matter	205	0,56	0,90	313	3,52	8,66	380	1,66	4,96	202	0,25	0,40
BOD 5	205	1,73	2,79	313	1,37	3,37	380	1,67	4,97	202	1,11	1,76
Ammonia nitrogen	205	0,03	0,05	313	0,05	0,13	380	0,14	0,43	202	0,09	0,14
Nitrite nitrogen	205	0,041	0,07	313	0,02	0,06	380	0,01	0,01	202	0,011	0,02
Nitrate nitrogen	205	2,059	3,32	313	2,13	5,23	380	0,77	2,29	202	1,19	1,89
Total nitrogen	205	2,13	3,43	313	2,20	5,42	380	0,91	2,73	202	1,29	2,05
Phosphates	205	0,001	0,002	313	0,02	0,05	380	0,00	0,01	202	0,002	0,003
Silica acid	205	6,9	11,12	313	5,90	14,5	380	3,90	11,7	202	5,7	9,05

Magnesium	205	24	38,68	313	17,30	42,6	380	8,75	26,1	202	18,7	29,7
Total iron	205	0,06	0,10	313	0,02	0,04	380	0,05	0,15	202	0,04	0,06
Copper, µg/l	205	0,003	0,00	313	0,007	0,02	380	0,01	0,02	202	0,005	0,01
Zinc, µg/l	205	0,007	0,01	313	0,009	0,02	380	0,01	0,03	202	0,008	0,01
Phenols	205	0,0	0,00	313	0,007	0,02	380	0,002	0,006	202	0,015	0,02
TPHs	205	0,03	0,05	313	0,20	0,48	380	0,75	2,24	202	0,54	0,86
Detergents	205			313			380			202		

Table 10. The flow of pollutants at the hydrological station on Karagalinsky hydrosystem in 2005.

Ingredients, mg/l	Top of the Terek delta - Karagalinsky hydrosystem											
	1 quarter			2 quarter			3 quarter			4quarter		
	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones
Suspended matter	204	0,55	0,88	554	3,42	14,90	416	2,21	7,23	268	0,67	1,41
BOD 5	204	0,78	1,25	554	1,40	6,10	416	2,59	8,47	268	1,63	3,43
Ammonia nitrogen	204	0,064	0,10	554	0,23	0,98	416	0,09	0,28	268	0,074	0,16
Nitrite nitrogen	204	0,006	0,01	554	0,07	0,31	416	0,02	0,05	268	0,006	0,01
Nitrate nitrogen	204	1,94	3,12	554	1,79	7,81	416	0,86	2,83	268	1,08	2,28
Total nitrogen	204	2,01	3,23	554	2,10	9,13	416	0,96	3,15	268	1,16	2,45
Phosphates	204	0,002	0,003	554	0,01	0,06	416	0,00	0,01	268	0,009	0,019
Silicica acid	204	7,0	11,23	554	6,40	27,9	416	5,10	16,7	268	6,1	12,9
Magnesium	204	21,2	34,00	554	18,15	79,1	416	9,45	30,9	268	15,2	32,0
Total iron	204	0,34	0,55	554	0,32	1,37	416	0,16	0,52	268	0,07	0,15
Copper, µg/l	204	0,005	0,01	554	0,003	0,0	416	0,003	0,0	268	0,010	0,02
Zinc, µg/l	204	0,005	0,01	554	0,009	0,0	416	0,009	0,0	268	0,010	0,02
Phenols	204	0,002	0,00	554	0,002	0,01	416	0,005	0,015	268	0,000	0,00
TPHs	204	0,15	0,24	554	0,06	0,26	416	0,17	0,54	268	0,12	0,25
Detergents	204	0,01	0,02	554	0,01	0,04	416	0,01	0,03	268	0,014	0,03

Table 11. The flow of pollutants at the hydrological station Alikazgan.

Ingredients mg/l	In the Terek delta - hydrological station Alikazgan											
	1 quarter			2 quarter			3 quarter			4quarter		
	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones	Expenditure of water, m^3/sec	Concentration, mg/l	Stream of pollutants, thousand tones
Suspended matter	198	**0,55**	**0,86**	278	**1,09**	**2,38**	218	**1,09**	**1,87**	260	**0,53**	**1,08**
BOD 5	198	**1,12**	**1,74**	278	**1,665**	**3,64**	218	**2,495**	**4,28**	260	**0,81**	**1,66**
Ammonia nitrogen	198	**0,068**	**0,11**	278	**0,0825**	**0,18**	218	**0,2395**	**0,41**	260	**0,128**	**0,26**
Nitrite nitrogen	198	**0,007**	**0,01**	278	**0,046**	**0,10**	218	**0,025**	**0,04**	260	**0,007**	**0,01**
Nitrate nitrogen	198	**1,713**	**2,67**	278	**2,114**	**4,62**	218	**0,87**	**1,49**	260	**1,013**	**2,07**
Total nitrogen	198	**1,788**	**2,78**	278	**2,2445**	**4,91**	218	**1,1345**	**1,94**	260	**1,148**	**2,35**
Phosphates	198	**0,003**	**0,005**	278	**0,0085**	**0,02**	218	**0,004**	**0,01**	260	**0,008**	**0,016**
Silicica acid	198	**8**	**12,5**	278	**5,3**	**11,6**	218	**4,7**	**8,1**	260	**5,7**	**11,7**
Magnesium	198	**16,1**	**25,1**	278	**16,95**	**37,0**	218	**10,65**	**18,3**	260	**14,1**	**28,8**
Total iron	198	**0,2**	**0,31**	278	**0,045**	**0,10**	218	**0,08**	**0,14**	260	**0,03**	**0,06**
Copper, µg/l	198	**0,004**	**0,01**	278	**0,0022**	**0,005**	218	**0,002**	**0,003**	260	**0,003**	**0,01**
Zinc, µg/l	198	**0,006**	**0,01**	278	**0,0105**	**0,023**	218	**0,010**	**0,017**	260	**0,010**	**0,02**
Phenols	198	**0,004**	**0,01**	278	**0,0025**	**0,01**	218	**0,003**	**0,005**	260	**0**	**0,00**
TPHs	198	**0,12**	**0,19**	278	**0,87**	**1,90**	218	**0,12**	**0,21**	260	**0,06**	**0,12**
Detergents	198	**0,012**	**0,02**	278	**0,0135**	**0,03**	218	**0,054**	**0,09**	260	**0,008**	**0,02**

The allocation of the pollutants torrents in thousand tons in the entry area of the Terek delta is shown in table 12 and in figures 4-8. The concentration of the pollutants (table 12) and indices of the pollutants at the hydrological station Alikazgan in regard to the concentrations and indices of the pollutants at the top of the Terek delta decrease or change insignificantly, except the concentrations of ammonia nitrogen, zinc and phenols, which increased by 20%, 10% and 20% accordingly. The concentrations of detergents and petroleum hydrocarbons increased by a factor of 2 and 4, e.g. the flow of petroleum hydrocarbons and indices of detergents increased by 87% and 31% correspondingly. Total amount of pollutants and BOD5 decreased by the percentage from 30% to 75%.

Table 12. The variability of concentration and flow of pollutants in the area of the Terek delta.

n/n	Ingredients, mg/l	Concentrations of pollutants		Ratio of concentrations	Flow of pollutants		Ratio of the pollutants flow
		hydrological station on Karagalinsky hydrosystem	hydrological station Alikazgan		hydrological station on Karagalinsky hydrosystem	hydrological station Alikazgan	
1	2	3	4	5	6	7	8
1	Suspended matter	**1,713**	**0,815**	0,5	**24,4**	**6,2**	0,25
2	BOD5	**1,600**	**1,523**	1,0	**19,3**	**11,3**	0,59
3	Ammonia nitrogen	**0,112**	**0,130**	1,2	**1,52**	**0,96**	0,63
4	Nitrite nitrogen	**0,025**	**0,021**	0,9	**0,38**	**0,17**	0,44
5	Nitrate nitrogen	**1,422**	**1,428**	1,0	**16,0**	**10,8**	0,68
6	Total nitrogen	**1,559**	**1,579**	1,0	**18,0**	**12,0**	0,67
7	Phosphates	**0,007**	**0,006**	0,8	**0,09**	**0,05**	0,50
8	Silicica acid	**6,150**	**5,925**	1,0	**68,6**	**43,7**	0,64
9	Magnesium	**16,000**	**14,450**	0,9	**176**	**109**	0,62
10	Железо общ.	**0,221**	**0,089**	0,4	**2,59**	**0,61**	0,23
11	Copper µg/l	**0,005**	**0,003**	0,6	**0,05**	**0,02**	0,41
12	Zinc µg/l	**0,008**	**0,009**	1,1	**0,09**	**0,06**	0,69
13	Phenols	**0,0020**	**0,0024**	1,2	**0,021**	**0,011**	0,50
14	TPHs	**0,124**	**0,293**	2,4	**1,29**	**2,42**	1,87
15	Detergents	**0,011**	**0,022**	2,0	**0,12**	**0,16**	1,31

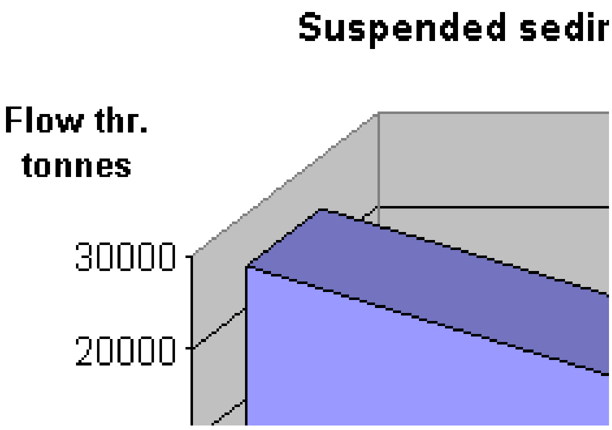
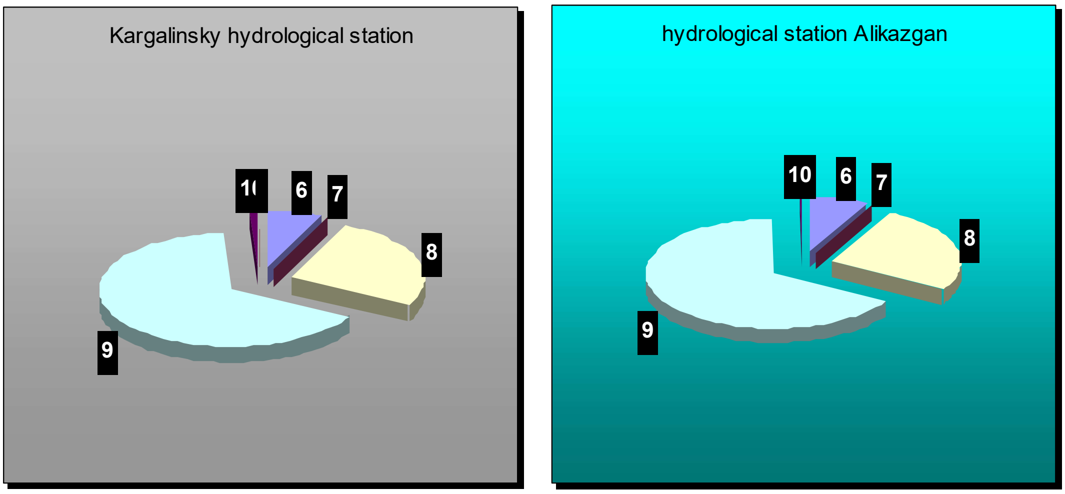


Fig. 5. The variability of the suspended matter flow in the Terek delta from the hydrological station on Karagalinsky hydrosystem to the hydrological station Alikazgan in 2005.

There was a 75% decrease in the flow of suspended matter in the Terek delta from the hydrological station on Karagalinsky hydrosystem to the hydrological station Alikazgan.



Nutrients and metals: 6 – total nitrogen, 7 – phosphates, 8 - silica acid, 9 – magnesium, 10 – total iron.

Fig. 6. Nutrients and metals flow at hydrological stations in the Terek delta.

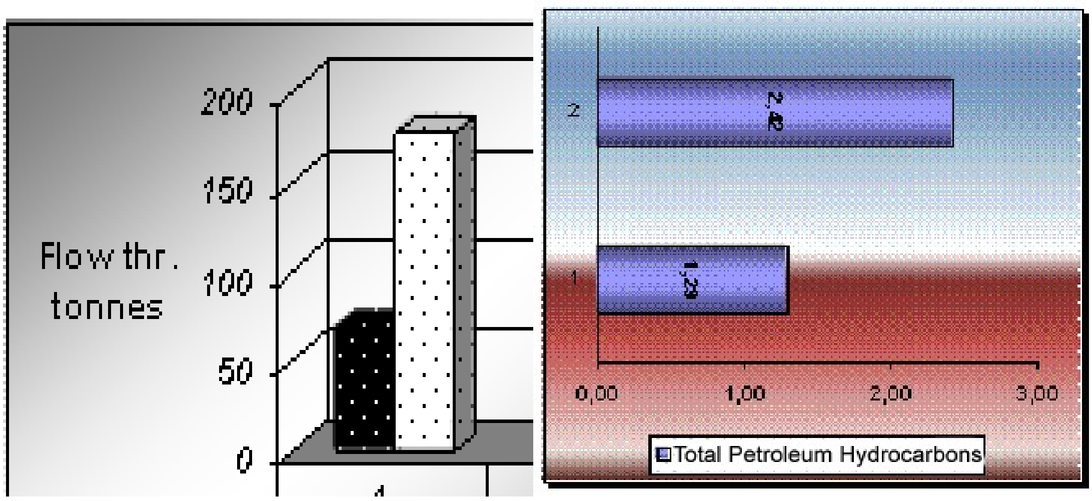


Fig. 7. The flow of magnesium and silica acid (a) and Total Petroleum Hydrocarbons (b) in 2005.

1 - hydrological station on Karagalinsky hydrosystem 2 - hydrological station Alikazgan

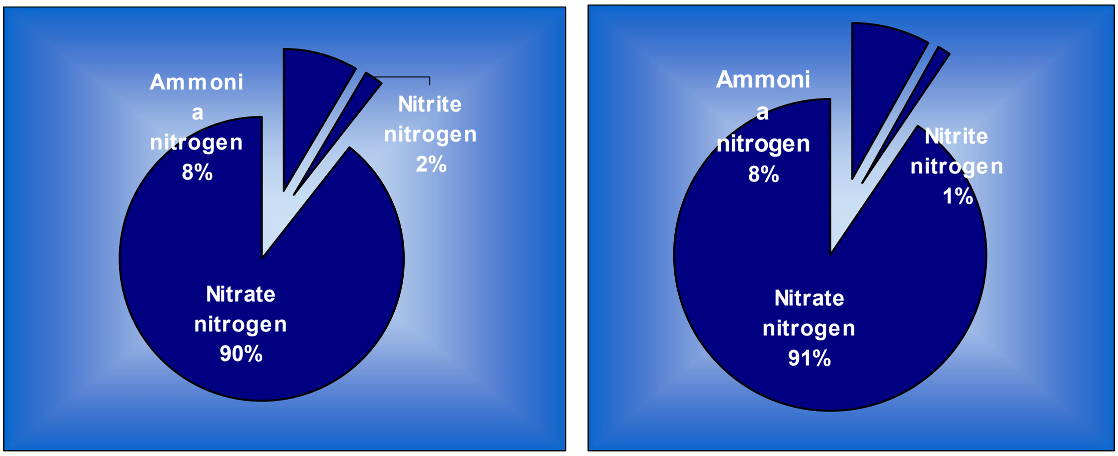


Fig. 8. Ratio of the single nitrogen forms in its total flow in 2005 at hydrological station on Karagalinsky hydrosystem (a) and hydrological station Alikazgan (b).

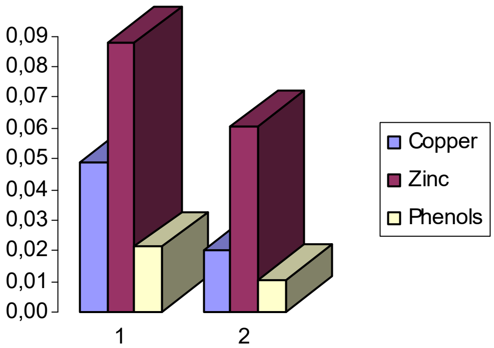


Fig. 9. The flow of some pollutants in the Terek stream at the hydrological station on Karagalinsky hydrosystem (1) and at the hydrological station Alikazgan (2) in 2005.

CHAPTER 2.
SPATIAL VARIABILITY OF POLLUTANTS CONCENTRATION IN THE TEREK BASIN
SOI EXPEDITIONS 2002-2004

2.1. MATERIAL AND METHODS

The data were received during the special expeditions of State oceanographic Institute into the Terek basin from Karagalinsky hydrosystem in the upper stream to estuarine region eastwards of Prores' during the period of 2002 - 2005. The whole investigated area were shared into 9 large parts (regions) of the river stream: 1 – Karagalinsky, 2 - Upper Terek, 3 - Medium Terek, 4- Grass Reservour, 5 - Lower Terek, 6 - Southern Agrakhan, 7 - Northern Agrakhan, 8 – Prorez, 9 - Estuary of the Terek (Fig. 1). Under the number 10 and 11 marked stations in the Sulak and Samur basins correspondingly.

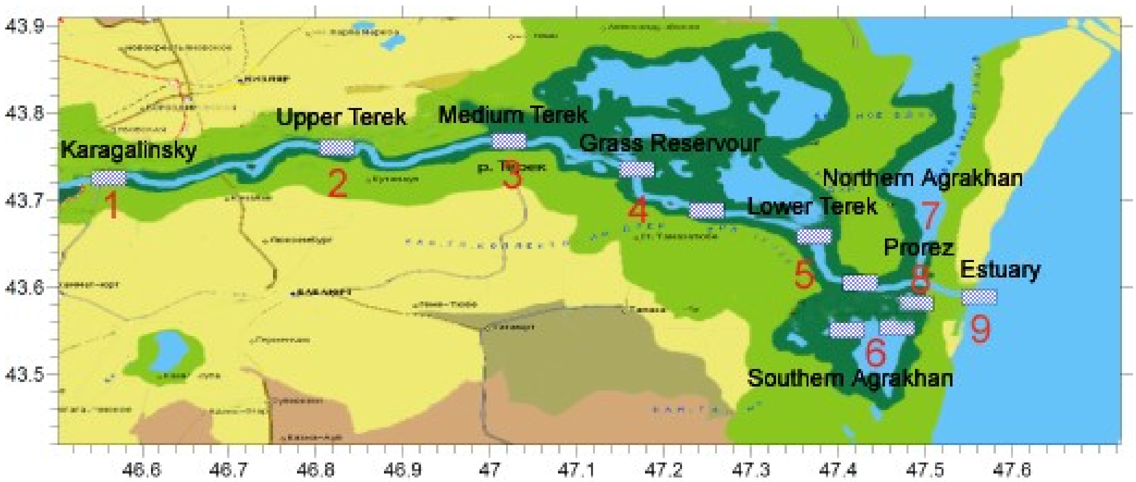


Fig. 1. The large regions in the river Terek stream.

The data for each expedition were averaged for these regions of the Terek basin. In each period of investigation the complex of parameters cover the pollution of water or bottom sediments (Tab. 1)

Table 1. Parameters of water and bottom sediments investigated in different expeditions.

Year	Month	Water	Number of stations	Bottom sediments	Number of stations
2002	October	Petroleum hydrocarbons (InfraRed)	15	Petroleum hydrocarbons (InfraRed), Metalls: V, Cd, Ni, Cu, Pb, Cr	22 + 6 (Sulak)
2003	November	Metalls: Al, Fe, As, Cd, Ni, Cu, Pb, Cr, Suspended Solids	8 + 7 (Sulak)	Petroleum hydrocarbons (InfraRed), Metalls: Al, As, Cd, Ni, Cu, Pb, Cr	25
2004	May	Metalls: Al, Fe, As, Cd, Ni, Cu, Pb, Cr	7 + 5 (Sulak) + 4 (Samur)	Petroleum hydrocarbons (InfraRed), Metalls: Al, As, Cd, Ni, Cu, Pb, Cr	18 + 2 (Sulak) + 1 (Samur)
2004	November	Metalls: Al, Fe, As, Cd, Ni, Cu,	7	-	-

Pb, Cr

The samples of water for petroleum hydrocarbons were extracted by hexane just after sampling and transported into lab for analysis within one day. The samples of bottom sediments were taken by grab ZZZ and then placed into frozen chamber for storage and transportation into laboratory for analysis.

2.2. BOTTOM SEDIMENTS

2.2.1. PETROLEUM HYDROCARBONS

2002

The concentration of petroleum hydrocarbons was studied by Infra-Red spectroscopy. The results were obtained as average of 2 or 3 parallel measurements and standard deviation on these sets were not exceeded 20%.

The concentration of PHs in the bottom sediments varied in the vide range from analytical 0 to 135 μg/g. Maximum exceed the Maximum Allowed Concentration (MAC) for bottom sediments used in the Netherlands (Neue Niederlandische Liste. Altlasten Spektrum 3/95) almost 3 times (MAC = 50 μg/g) and was marked in the Southern Agrakhan. In general, the four Agrakhan stations were polluted by petroleum hydrocarbons (the average number is 86.5 μg/g) much higher then all other investigated area of the Terek Basin (Tab. 2). Without Agrakhan stations the average PHs concentration for the whole investigated area was 14.5 μg/g.

Unequal distributions of PHs in the bottom sediments of the Terek could not be explained by the large content of the small fractions in the Southern Agrakhan. Practically over the whole investigated area the concentration of small particles in the bottom sediments was rather uniform (Tab. 2). Exception were the bottom sediments in Prorez and Estuarine region of the Terek that allow call them as “sandy mud”. In the highly polluted Southern Agrakhan the ratio of surface of all particles in 1 cm^3 of bottom sediments was 0.0977 m^2/cm^3. That is in the range of other sites. In contrary with this case in the Estuarine region the percentage of small fraction reached the maximum and ratio of total surface of all particles in 1 cm^3 jumped up to the level 0.3944 m^2/cm^3. Despite this the petroleum hydrocarbons in the bottom sediments in Estuarine was at moderate level and in Prorez was not determined at all. This fact is in contradiction with general opinion of strong correlation between organic pollution and size of particles.

Table 2. The average concentration of petroleum hydrocarbons (μg/g), metals (μg/g) and Surface of Suspended Solids (m^2/cm^3) in the bottom sediments of the Terek river basin in October 2002.

Region	1	2	3	4	5	6	7	8	9	10	11
PHs	30	17	14.3	6.5	2.5	86.5	-	0	20.5	24.5	0
SurfSS*	0.0975	0.0948	0.0968	0.0940	0.0950	0.0977	-	0.1165	0.2437	0.1302	-
Vanadium	25.3	18.6	23.3	26.4	29.1	11.7	-	30.8	33.6	28.4	-
Chromium	26.3	21.0	20.4	33.1	95.9	67.6	-	16.5	18.9	35.2	-
Nickel	24.6	50.8	49.8	88.6	45.4	31.9	-	17.4	27.3	31.6	-
Copper	19.1	8.7	8.9	10.8	7.8	10.9	-	5.0	7.4	20.4	-
Cadmium	0.19	0.09	0.16	0.06	0.05	0.05	-	0.06	0.05	0.10	-
Lead	9.1	6.1	4.0	10.3	9.4	6.0	-	2.3	3.7	6.0	-

SurfSS* - Surface of Suspended Solids of bottom sediments, m^2/cm^3

2003

The average concentration of petroleum hydrocarbons in the bottom sediments from 8 stations was 4.1 µg/g and varied between 0 and 12 µg/g.

2004

In May 2004 the bottom sediment investigation covered the Lower Terek and Estuarine region. In the first site the average concentration for 4 stations was 7.5 µg/g, and the range from 5 to 13 µg/g; in the second it was 3.7 µg/g within the range 0-10 µg/g.

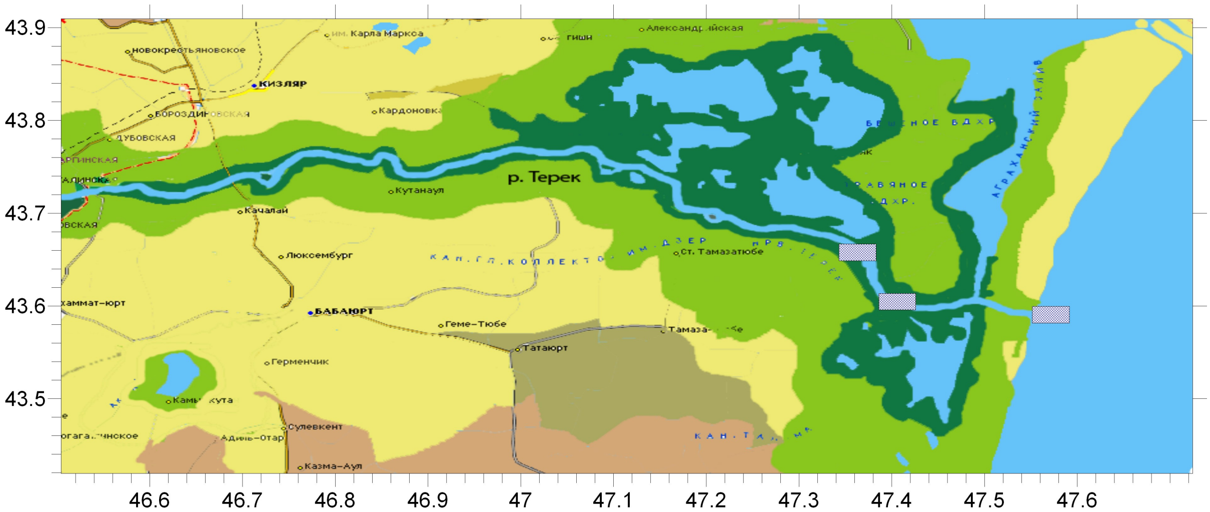


Fig. 2. The sites of bottom sediments investigations in the river Terek stream in May 2004.

At the same month the pollution of bottom sediments by petroleum hydrocarbons in the Sulak stream including Chirkey Reservoir and in estuarine region varied from 0 to 43 µg/g with average meaning 15.6 µg/g for 7 stations.

For Samur site the only at one station from four studied the petroleum hydrocarbons concentration differed from zero and has 6 µg/g.

2.2.2. HEAVY METALS

October 2002

Vanadium. In October 2002 the concentration of vanadium in the bottom sediments along the Terek stream varied from 3.0 to 34.6 µg/g and average mean was 22.4 µg/g. The spatial heterogeneity of vanadium was rather low with slight increasing tendency towards Estuarine.

In Sulak site the level of vanadium concentration was practically the same.

Chromium. The variation of chromium concentration was very wide, from 11.4 µg/g in the Upper Terek to 148.3 µg/g in the Southern Agrakhan (1.5 MAC, Tab. 3). The mean concentration was 38.7 µg/g, but without the single maximum data the average could be 32.9 µg/g. In general, the high concentration was marked in Medium and Agrakhan regions, but in Prorez and Estuarine were significantly less then average.

In the Sulak area the average was 35.2 µg/g and maximum reached 79.5 µg/g.

Nickel. The average level of nickel concentration in the bottom sediments was 44.7 µg/g. The minimum was found in Prorez (17.4 µg/g); the maximum was at one station in the Grass Reservoir (150.9 µg/g, 4 times over then MAC). It wonders that other station here has level close to minimum, the only 26.2 µg/g. It is important underline that bottom sediments in lower stream of the Terek, e.g. Agrakhan, Prorez and Estuarine, in general had less concentration of nickel then upper stream of the river.

In Sulak area the average was 31.6 µg/g with the maximum as high as 75.3 µg/g (2 MAC).

Copper. The concentration of copper in the bottom sediments varied from 3.0 μg/g to 23.9 μg/g. The average was 9.5 μg/g. The minimum and maximum registered in Agrakhan. In general the copper distributed rather patchy but the stations with low and high concentration sometimes were neighbors.

In Sulak stream area the average meaning of copper concentration was rather high (20.4 μg/g) and maximum reached level 51.9 μg/g.

Cadmium. The maximum cadmium concentration exceed the minimum 42 times, 0.42 to 0.01 μg/g. The average was 0.09 μg/g. The maximum was more then 5 times higher then MAC (0.8 μg/g). The maximum was registered in Medium Terek region. In lower part of the river stream including Estuarine the numbers never exceed the average level.

In Sulak area the data was practically uniform and varied from 0.06 to 0.13 μg/g at six stations, the average was 0.10 μg/g.

Lead. The lead concentration varied from 0.8 to 15.6 μg/g, the average meaning was 6.1 μg/g. The maximum was found in Grass Reservoir, but picks of high concentrations were recorded practically everywhere. In general the concentration was much lower then MAC (85 μg/g).

In the Sulak area the average level was 6.0 μg/g with maximum 9.3 μg/g.

Table 3. The Maximum Allowed Concentration of metals in the bottom sediments (Neue Niederlandische Liste. Altlasten Spektrum 3/95).

Metals	MAC
Cadmium, μg/g	0,8
Mercury, μg/g	0,3
Copper, μg/g	35
Nickel, μg/g	35
Lead, μg/g	85
Zinc, μg/g	140
Chromium, μg/g	100
Arsenic, μg/g	29
Cobalt, μg/g	20
Molybdenum, μg/g	10
Tin, μg/g	20
Barium, μg/g	200

November 2003

Chromium. In November 2003 the concentration of chromium in the bottom sediments of the Terek river varied from 8 to 93 μg/g and average mean was 25.3 μg/g.

Nickel. The minimum concentration of nickel in the bottom sediments was 13.4 μg/g; the maximum was 38.1 μg/g. The average level was 21.2 μg/g.

Arsenic. The concentration of arsenic in the bottom sediments varied from 0.2 to 8.3 μg/g and average was 1.3 μg/g.

Copper. The concentration of copper in the bottom sediments varied from 1.0 μg/g to 37.1 μg/g. The average was 11.4 μg/g.

Cadmium. The cadmium concentration varied from 0 to 2.04 µg/g (about 3 MAC). The average was 0.2 µg/g.

Lead. The lead concentration varied from 0.9 to 30.5 µg/g, the average was 10.2 µg/g.

May 2004

Chromium. In May 2004 the concentration of chromium in the bottom sediments of the Lower Terek river was very high and varied from 45.9 to 87.9 µg/g and average for 4 stations was 68.9 µg/g. In the Estuarine region six station were taken and concentration varied between 31.6 and 74.1 µg/g, the mean was 47.4 µg/g.

In the Sulak region the variance within seven taken stations covered the range 42.4 – 108.0 µg/g (1 MAC), the average was 63.0 µg/g.

In the Samur region the level of chromium concentration in the bottom sediments varied from 41.1 to 78.0 µg/g and mean was 58.2 µg/g.

Nickel. At the stations in the Lower Terek region the minimum concentration of nickel in the bottom sediments was 3.4 µg/g; the maximum was 69.6 µg/g; the average level was 46.3 µg/g. In Estuarine region these numbers were 6.2; 45.2 and 33.1 µg/g correspondingly.

In the Sulak area the concentration of nickel in bottom sediments was somewhat higher, the minimum – 24.4 µg/g, maximum – 98.1 µg/g (almost 3 MAC), the mean – 39.3 µg/g.

In the Samur area the data was 22.7 – 36.1 µg/g, the mean was 28.0 µg/g.

Arsenic. The concentration of arsenic in the bottom sediments of Lower Terek region varied from 6.0 to 9.3 µg/g and average was 8.3 µg/g. In Estuarine region the minimum was 3.4 µg/g, the maximum – 12.0 µg/g, the average was 7.4 µg/g.

In the Sulak region these numbers were 6.0; 15.0 and 8.8 µg/g correspondingly.

In the Samur River region the data was rather close: 4.6 – 7.4 µg/g, the mean was 5.8 µg/g. All numbers were significantly less then 1 MAC.

Copper. The concentration of copper in the bottom sediments of Lower Terek varied from 17.1 µg/g to 44.2 µg/g. The average was 26.9 µg/g. In Estuarine region these numbers were 11.7; 78.3 (2 MAC) and 27.9 µg/g.

In the Sulak region their level were 9.9; 21.4 and 15.4 µg/g.

In the Samur 7.9; 19.6 and 11.2 µg/g correspondingly.

Cadmium. The cadmium concentration in Lower Terek varied from 0 to 0.90 µg/g (1 MAC), the mean was 0.34 µg/g. In Estuarine region they were 0; 0.03 and 0.01 µg/g.

In the Sulak region minimum, maximum and mean were 0.01; 0.30 and 0.10 µg/g correspondingly.

In the Samur region they were 0.01; 0.49 and 0.16 µg/g correspondingly.

Lead. The lead concentration in Lower Terek varied from 6.7 to 16.0 µg/g, the mean was 11.5 µg/g. In Estuarine region they were 4.7; 23.0 and 12.7 µg/g.

In the Sulak region minimum, maximum and mean were 14.0; 17.0 and 16.1 µg/g correspondingly.

In the Samur region was practically the same level - 14.0; 17.0 and 16.4 µg/g correspondingly. All data was significantly less then 1 MAC.

Conclusion

The high concentration of metals in the bottom sediments that exceeds 1 MAC **in October 2002** were marked for chromium in the Upper Terek (1.5 MAC); for nickel in the Grass

Reservoir (4 MAC) and Sulak (2 MAC), for copper in Sulak (1.5 MAC) and cadmium in Medium Terek (5 MAC).

In **November 2003** the high concentration were found for nickel (1 MAC), copper (1 MAC) and cadmium (about 3 MAC).

In **May 2004** the concentration of chromium in the bottom sediments was high in Sulak region (1 MAC); of nickel in the Lower Terek (2 MAC, average exceeds 1 MAC), Estuarine region of the Terek (1 MAC), Sulak area (almost 3 MAC) and Samur area (1 MAC), for copper in Lower Terek (1 MAC) and in Estuarine region (2 MAC), for cadmium in Lower Terek (1 MAC).

2.3. WATER POLLUTION

2.3.1. PETROLEUM HYDROCARBONS

October 2002

In October 2002 the concentration of petroleum hydrocarbons in the Terek River waters changed from analytical zero to 0.12 mg/l (2.4 MAC of Russian regulations for fresh and marine waters). Despite the large range of variation the only in 3 samples the level of pollution was lower then 1 MAC. In other 12 samples the PHs concentration exceeded this level and therefore the average meaning was 0.07 mg/l (1.4 MAC).

In the Upper Terek region the average level for four stations was 0.11 mg/l (Fig. 1), in Medium Terek somehow less (0.06 mg/l). In the Grass Reservoir the average level of PHs concentration was practically the same (0.07 mg/l). In Lower Terek and Southern Agrakhan at two stations the concentration was 0.08 mg/l, but on another one PHs was not detected at all. In Estuarine region the level of petroleum hydrocarbons was 0.05 mg/l.

2.3.2. HEAVY METALS

November 2003

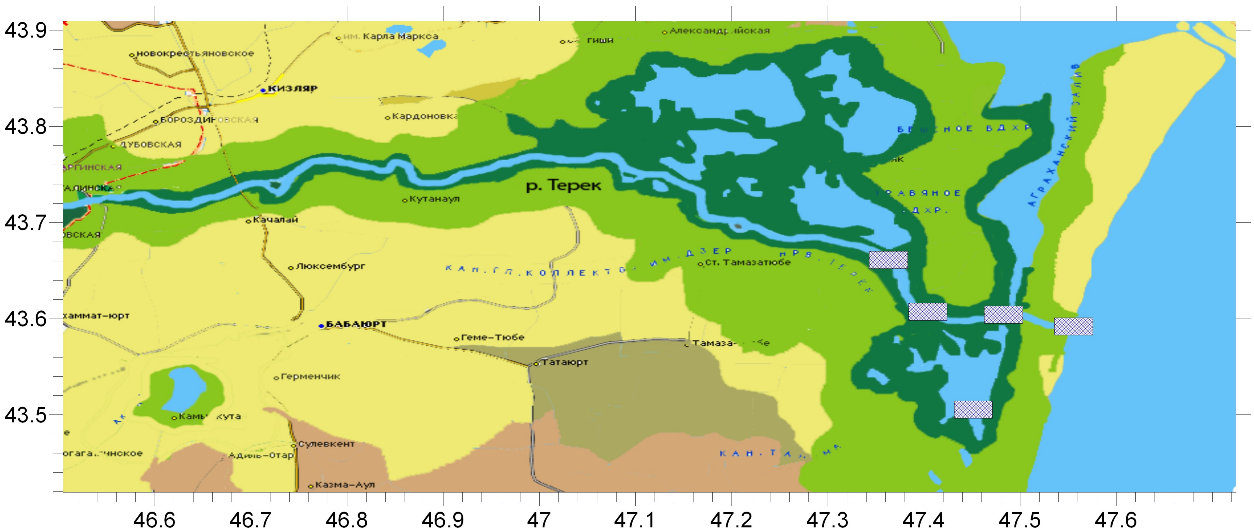


Fig. 3. The sites of water sampling in the Terek River in November 2003.

Chromium. In November 2003 the concentration of chromium in the Terek waters varied from 2.3 to 32.3 µg/l and mean was 13.0 µg/l (Fig. 3).

In the Sulak region these numbers were 1.4; 5.6 and 3.1 µg/l. The level of chromium concentration in the waters was significantly less then 1 MAC (Tab. 4).

Nickel. At five stations the nickel concentration in the waters was very low and close to analytical zero. But at three stations the level reached 37/47 µg/l and 104.7 µg/l (10 MAC). Due to this very high numbers the average (24.8 µg/l) exceed MAC about 2.5 times.

In the Sulak region almost all stations the nickel was not detected in the water. But at two stations the level of it concentration reached 1 and 3 MAC.

Copper. The concentration of copper in the Terek waters in general was very high. The maximum reached number 43,7 µg/l (almost 44 MAC), the minimum was 1.4 µg/l. The average was 18.5 µg/l.

In the Sulak waters the concentration of copper was even higher. The data for 7 stations varied between 4.7 and 59.4 µg/l with mean 16.6 µg/l.

Cadmium. The cadmium concentration varied in the vide range from 0 to 4.54 µg/l (about 1 MAC). The average was 1.8 µg/l.

In the Sulak region the only data from three stations was above zero and reached 1.2 µg/l only.

Lead. The lead concentration varied from 0 to 21.9 µg/l (about 3.7 MAC), the average was 8.4 µg/l.

In five samples from Sulak waters the lead was not determined or close to zero. The only at single station the concentration was very high as 26.2 µg/l (4 MAC).

Iron. The concentration of iron in the Terek waters was very high and varied from 31918 to 968189 µg/l. The mean number was high as 295314 µg/l, mainly due to three outstanding picks.

In the Sulak region this characteristics were significantly less: 34133; 139797 and 69154 µg/l correspondingly.

Aluminum. The aluminum concentration in the Terek waters varied from 6132 to 38458 µg/l, the mean was 19832 µg/l.

In the Sulak region these numbers were 6256; 20362 and 10443 µg/l correspondingly.

Table 4. The Maximum Allowed Concentration of metals in the fresh waters ("The List of fisheries norms: Maximum Allowed Concentration…", Moscow, VNIRO, 1999).

Cadmium	Cd	5 µg/l
Copper	Cu	1 µg/l
Arsenic	As	50 µg/l
Nickel	Ni	10 µg/l
Lead	Pb	6 µg/l
Chromium	Cr^{3+}	70 µg/l
Iron	Fe	100 µg/l

May 2004

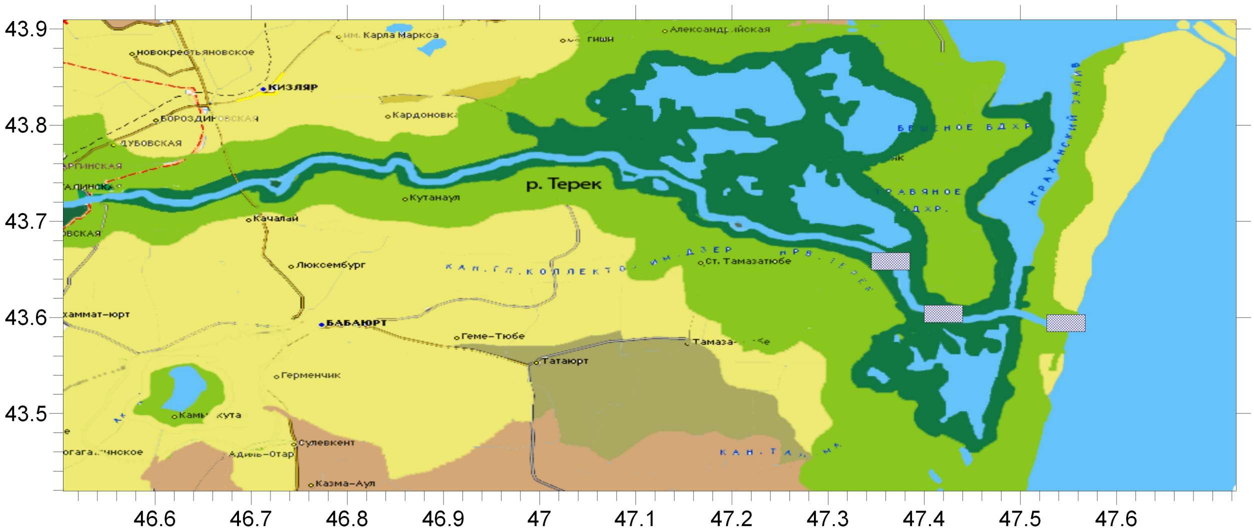


Fig. 4. The sites of water sampling in the Terek River in May and November 2004.

Chromium. At the six stations in the Terek waters the concentration of chromium in varied in very narrow range from 0.5 to 3.8 μg/l and mean was 1.7 μg/l.

In the Sulak region at six stations the chromium was at very low level in the water – from 0.3 to 0.8 μg/l.

The same situation was recorded for the Samur waters. At four stations the chromium concentration in the waters varied from 0.3 to 2.8 μg/l.

Nickel. At all six stations the nickel concentration in the Terek waters differs from the zero. It was very low at two stations and close to 3 MAC at the others. The maximum was 33.8 μg/l and mean was 19.4 μg/l.

In the Sulak region at four stations the nickel was in range 1.3 – 1.6 μg/l, but at two it was close 1 MAC (9.4-10.5 μg/l).

In the Samur waters the nickel concentration varied from 1.9 to 69.9 μg/l (7 MAC), the mean was 30.8 μg/l. It was a very high level despite the only four stations were observed.

Copper. The concentration of copper in the Terek waters was very high in comparison with MAC. The maximum reached number 68.5 μg/l (almost 69 MAC), the minimum was 11.3 μg/l. The average was 48.1 μg/l.

In the Sulak waters the concentration of copper was significantly less. At 6 stations the copper content in the water varied between 9.1 and 29.8 μg/l, the mean was 15.8 μg/l.

In the Samur waters the maximum reached level of 75.0 μg/l (75 MAC) and minimum was 8.7 μg/l, the average of four stations was 42.1 μg/l.

Cadmium. The cadmium concentration varied from 0 to 1.3 μg/l, the mean was 0.9 μg/l.

In the Sulak region the the cadmium content in the waters was very low, the maximum was 0.2 μg/l only.

In the Samur waters the situation was close to the Sulak River waters. The maximum was 0.4 μg/l.

Lead. The lead concentration at six stations in the Terek region varied from 2.7 to 36.5 μg/l (6 MAC), the average was 23.4 μg/l.

At six samples from the Sulak waters the lead concentration was significantly lower. The minimum, maximum and mean were 0.4; 9.2 and 3.8 μg/l.

In the Samur waters its concentration varied from 0.6 to 49.9 μg/l and mean was 23.9 μg/l.

Aluminum. The aluminum concentration in the Terek waters varied from 2761 till 110798 μg/l, the mean was 45932 μg/l.

In the Sulak region these numbers were strongly less: 27; 21195 and 5517 μg/l correspondingly.

In the Samur waters the aluminum occurred in the water at four stations in concentration from 29 to 99870 μg/l. The mean was 51478 μg/l.

November 2004

Chromium. At seven stations in the Terek waters the concentration of chromium varied in very narrow range from 4.6 to 8.1 μg/l and mean was 6.2 μg/l.

Nickel. The maximum of nickel concentration in the Terek waters was 42.8 μg/l, the minimum was 0 and mean was 21.4 μg/l.

Copper. The concentration of copper in the Terek waters varied from 1.7 to 35.9 μg/l (36 MAC). The average was 22.0 μg/l.

Cadmium. The cadmium concentration varied from 0 to 1.2 μg/l, the mean was 0.6 μg/l.

Lead. The lead concentration at seven stations in the Terek region varied from 2.6 to 22.7 μg/l (4 MAC), the average was 11.0 μg/l.

Aluminum. The aluminum concentration in the Terek waters varied from 57 till 37589 μg/l, the mean was 13602 μg/l.

CONCLUSIONS

It is clear from the single observation in October 2002 the general level of pollution by petroleum hydrocarbons of waters of the Terek River was rather high (Tab. 5). Even the mean concentration exceeded the Russian standard Maximum Allowed Concentration. It have to be taken into account that methods used could not cover all fraction of petroleum hydrocarbons but only aliphatic part. So, the total estimation for sure would give much more level of pollution. It was very clear the Upper part of the Terek stream could be considered as more polluted then Lower regions on the river.

One could wonder the results of SOI expedition completely coincide with data from routine State Monitoring system of Roshydromet (Chapter 1, Table 1). Their measures for October 2002 showed the average level of petroleum pollution in Upper Terek (Karagalinsky hydro system) as 1.4 MAC (0.07 mg/l). That it just what obtained during SOI field investigations. Rather interesting that this level was not high during 2002. In April (0.16 mg/l) and May (0.18 mg/l) the concentration of petroleum hydrocarbons in the waters was several times higher, probably due to spring flood.

Taking into account all available data it could be postulated a very high level of Terek pollution by petroleum hydrocarbons. The monitoring system registered the PHs concentrations as high as 1.44 mg/l (29 MAC) in August 2004 (Chapter 1, Table 3). It looks as common concentration in the Terek waters usually in range one - ten MAC over the whole year.

Table 5. Maximum and mean concentration (MAC = Maximum Allowed Concentration) of some pollutants in waters of rivers Terek, Sulak and Samur in 2002-2004.

Region	Terek		Terek		Terek		Terek	
Expedition	October 2002		November 2003		May 2004		November 2004	
	Max	Mean	Max	Mean	Max	Mean	Max	Mean
PHs	**2.4**	**1.4**						
Chromium			< 1	< 1	< 1	< 1	< 1	< 1
Nickel			**11**	**2.5**	**3.4**	**1.9**	**4.3**	**2.1**
Copper			**44**	**19**	**69**	**48**	**36**	**22**
Cadmium			**1.0**	< 1	< 1	< 1	< 1	< 1
Lead			**3.7**	**1.4**	**6.0**	**4.0**	**3.8**	**1.8**

Region	Sulak		Sulak		Samur	
Expedition	November 2003		May 2004		May 2004	
	Max	Mean	Max	Mean	Max	Mean
PHs						
Chromium	< 1	< 1	< 1	< 1	< 1	< 1
Nickel	**3.1**	< 1	**1.1**	< 1	**7.0**	**3.1**
Copper	**59**	**17**	**30**	**16**	**75**	**42**
Cadmium	< 1	< 1	< 1	< 1	< 1	< 1
Lead	**4.4**	< 1	**1.5**	< 1	**8.3**	**4.0**

From the metals in the water a very high concentration was marked for copper. It seems that range 17-75 MAC for copper in the Dagestan rivers depends upon the high natural background concentration of this metal and, therefore, could not be considered as results of human pollution.

About ten times less in concentration occurred in the water the lead and nickel. Usually they were slightly exceeded a few MAC.

Among investigated metals the chromium and cadmium were in concentration much less then 1 MAC practically everywhere.