BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, April 2015. Vol. **12**(1), 119-132

Research on Water Quality of the Transboundry ILI River and Its Tributaries

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DOI: http://dx.doi.org/10.13005/bbra/1642

(Received: 06 February 2015; accepted: 08 March 2015)

The basin of the Ili River and its tributaries within Kazakhstan is limited from the south with Trans-Ili Alatau and Kungei Alatau, from the west with north-eastern spurs of the Chu-Iliysk mountains (Aitau), from the north with the Balkash lake (delta of the Ili River) and the valley of the Karatal river, from the north-east with the Zhungar Alatau, but from the east and the south-eat with the Ketmen ridge and the Terskey Alatau. We studied pollution of the Ili River run-off from the border with the People's Republic of China – (river station of the Dubun' village) to the Balhash lake – river station of the Ushzharma village. For this purpose we processed data on river stations of the Dubun' pier, 164 km higher than Kapshagai HPP (hydroelectric power station), Kapshagai, Ushzharma. Available data on pollution of the Republican State Enterprise "Kazgidromet" rivers run-off is mainly presented on copper and iron. The quality monitoring network for land surface waters include gauging stations of the National Hydrometeorological Service. The main criteria for water quality according to hydrochemical parameters are values of maximum permissible concentration (MPC) of pollutants for waters bodies of fishery, potable and household water use. The level of land surface waters pollution is estimated according to a value of the complex water pollution index (WPI), which is used to compare and identify dynamics of change in water quality.

Key words: Run-off, tributaries, river basins, water quality.

The Ili River is the main waterway of the Balhash lake basin. It originates in the Muzart glaciers in the Central Tanirtau (Kazakhstan) with the Tekes river source. Then it flows on the territory of China, where it merges with the rivers Kunes and Kash, at the 250th km from the confluence point it enter the Republic of Kazakhstan again and at the 1001st km it runs into the Balhash lake. The total length of the river is 1439 km, within Kazakhstan – 815 km. The total area of the Ili River basin is – 140 thousand sq. km (approximately 75% of the catchment area of the Balhash lake, from which 44400 sq. km – on the territory of the Republic of Kazakhstan. The river flow forming part of the basin is situated in China, where the hydrographical network is sufficiently developed (from 0.6 to 3 km/sq. km). 30% of the water resources of the Ili River are formed in Kazakhstan. Besides the Sharyn and Shelek rivers, a series of mountain rivers join the Ili River in the left-bank part of the basin: Turgen', Issyk, Talgar, Kaskelen with the tributaries of Small and Big Almatinka, Kurty, which form a flow on the northern slope of the Trans-Ili Alatau. In the right bank part the largest tributaries of the Ili River are Horgos, Usek and Borohudzir, flowing down from the

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southern slopes of Zhungar Alatau (Figure 1)[1,2]. Most of the tributaries, including Turgen, Talgar, Borohudzir, due to large flow losses in the foothills for filtration and catchment for irrigation, do not bring their waters to the Ili River. Tables 1 and 2 show the average annual and maximum losses of the Ili River and its tributaries.

The natural complex of the Ili River delta is quite variable and is highly vulnerable to anthropogenic influence. Even the smallest changes in the river network primarily affect the delta mode. The reason for this is that the delta of the Ili River ecosystem is in a very unstable state[3, 4]. Therefore, the uniqueness of natural resources of the Ili River delta and its vulnerability to anthropogenic influence should be taken into account during planning and conducting water management activities in the basin.

The main pollutants of water bodies in the basin within Kazakhstan are industrial facilities, discharge of municipal wastewater of settlements (mainly industrial cities, especially Almaty, where fecal water goes through Sorkol), agriculture, particularly, irrigated agriculture. In this regard, the hydrological regime of many rivers in the basin does not meet sanitary requirements for fisheries, recreation, drinking, and contaminated run-off, in its turn, worsens ecological conditions of river deltas and the Balhash lake. The lake "Sorkol'" – wastewater storage of the Almaty city and annexed territories is the source of groundwater pollution with manganese, lead, nitrates, cadmium, bromine, fluorine, beryllium. The maximum concentration values are documented in the coastal zone, as the distance from the lake-storage increases, there is a clear direct correlation of the concentrations of polluting components, groundwater level with the volume of wastewater in the storage[5,6].

Table 1 shows parameters of the annual run-off of the Ili River in natural conditions, and Table 2 shows parameters of the maximum losses of spring floods.

MATERIALS AND METHODS

Tables 3 and 4 show the data on the index of water pollution and maximum allowable concentrations of the Ili River and its tributaries according to the RSE "Kazgidromet" data for 2010-2012, and using this data the diagrams were constructed (Fig. 2-7) [4]. As can be seen from the diagram, in recent years the highest WPI 4.16 was observed in the third quarter of 2010 and refers to pollution of the 5th class and after that there is a decrease of WPI to 1.39 in 2012 and pollution refers to the class 3. The highest 9.6 MAC (maximum allowable concentration) value of copper was observed in 2010, and by 2012 a decrease to 3.5 MAC was observed, and run-off contamination of total iron in these years had not changed and remained within 1.3-1.5 MAC.

RESULTS

According to Tables 5 and 6 we constructed a dependence diagram SCu=f(L) and SZn =f(L), i.e. an attempt was made to establish influence of distances on the self-cleaning capacity of the Ili River (Figures 4 and 5).

As shown in Figures 4 and 5, dependence of copper concentration from distances is pretty good, the correlation coefficient is 0.833, and the equation describing this relationship $Y=0.0035^{0.001x}$ is obtained, but the dependence of zinc concentration from distance is weak, because the correlation coefficient is 0.57, the equation describing this relationship is $Y=0.0095^{0.001E}$. At this stage, we processed a limited amount of data, further this data will be complemented.

DISCUSSION

As can be seen from Table 3 for the Tekes river, the maximum 3.71 WPI was observed in the 3rd quarter of 2010 and by pollution it refers to the class 4 and the minimum 0.84 WPI is noted in the 3rd quarter of 2011 and it is the class 2 by pollution, in the 4th quarter of 2012 WPI amounted to 1.14 and referred to the third class of pollution.

Heavy metal pollution of the Tekes River is determined by copper and total iron. The highest copper pollution in 10.2 MAC is noted in 2010, in 2011 it amounted to 4.36 MAC, in 2012 it made up to 3.2 MAC, thus, we can observe reduction of the Tekes river run-off pollution with copper. Total iron pollution was determined in 2010 and amounted to 1.9 MAC and in 2012 – 0.9 MAC.

The maximum 3.45 WPI in the Turgen' river was observed in the first quarter of 2011 and referred to the 4th class pollution, the minimum

Table 1. Parameters of the Ili River annual run-off in calculated cross-sections in natural conditions

Index of a region,area	River	Cross-section	Average long-term parameters				Estimated amount of run-off, million m3		
			Qo, m3/sec	Wo, million m3	Cv	Cs	50%	75%	95%
	Ili	pier Dubun’	395	12474	0.24	3.0 Cv	12117	10333	8274
	Ili	164 kilometres up the Kapshagai HPP	460	14512	0.18	4.0 Cv	14193	12600	10773
	Ili	stow of Kapshagai (a tributary to the Kapshagai Reservoir)	473	14928	0.18	4.0 Cv	14621	13023	11181
	Ili	settlement of Yatmatu	356	11235	0	4.5 Cv	11200	10100	887
06-03-03-1	Ili	village of Ushzharma	427	13500	0	4.0 Cv	13200	11600	9900
06-03-02-1	Tekes	village of Tekes	8.58	271	0.23	3.0 Cv	263	226	182
06-03-02-2b	Horgos	village of Baskunchi	16.4	518	0.17	2 !v	514	458	385
06-03-02-3	Sharyn	2 kilometres lower of the mouth of Ulken-Naldybulak river	28.3	893	0.22	5.0 Cv	858	748	642
	Sharyn	cross-section of the Bestyubinsk Reservoir dam	29.0	915	0.22	5.0 Cv	879	766	658
	Sharyn	stow of Sarytogai	37.7	1190	0.24	3.5 Cv	1150	981	802
06-03-02-4	Shilik	village of Malybai to 1982	31.9	1007	0.09	2.0 Cv	1000	944	862
	Shilik	cross-section of the Bartogaisk Reservoir	32.5	1140	0.12	0.0 !v	1030	943	824
06-03-02-4	Turgen’	village of Tauturgen’	7.06	223.0	0.2	4.0 Cv	219.0	197.0	171.0
06-03-02-4	Issyk	town of Issyk	4.81	152.0	0.2	5.0 Cv	148.0	133.0	117.0
06-03-02-4	Kaskelen	town of Kaskelen	4.12	130	0.19	2.2 Cv	128	112	92.5
06-03-02-4	Malaya Almatinka	City of Almaty [15]	1.78	56.2	0.24	2.0 Cv	54.91	46.71	35.98
	Bolshaya Almatinka	1.1 kilometres up the Big Almaty lake	4.98	157.2	0.14	-0.20	156.2	139.2	116.5
06-03-03-2	Kurty	Leninskiy bridge	4.94	156	0.33	2.0 Cv	150	119	82

Table 2. Parameters of spring floods maximum losses

Water resources region	River	Cross-section	Average long-term parameters: Q,m³/sec	Cv	Cs	Calculated costs of various water coverage, m³/sec: 0.1%	1%	2%	5%	10%
Natural run-off										
06-03-03-1	Ili	stow of Kapshagai (a tributary to the Kapshagai Reservoir)	1378	0.21	2.0 CV	2450	2140	2050	1890	1760
06-03-02-3	Sharyn	2 kilometres down the mouth of Ulken-Naldylbulak (a tributary to the Kapshagai Reservoir)	119	0.33	3.0 CV	296	237	222	193	172
06-03-02-3	Sharyn	stow of Sarytogai	145	0.35	3.0 CV	378	300	280	240	213
06-03-02-4	Shilik	Malybai (a tributary to the Bartogai Reservoir)	146	0.18	3.0 CV	248	217	209	193	181
06-03-02-4	Ul'ken Alamaty	2 kilometres up the mouth of the Prohodnaya river	9.55	0.36	4.0 CV	21	19.4	18.5	16.2	14.7
06-03-03-2	Kurty	Leninskiy bridge (a tributary tothe Curtin Reservoir)	52	1.25	2.5 CV	524	318	272	180	124
Domestic wastewater										
06-03-02-1b	Ili	the Dubun' pier	1310	0.23	2.0 Cv	2440	2110	2020	1840	1710
06-03-02-1á	Ili	164 kilometres up the Kapshagai HPP	1277	0.18	2.0 Cv	2100	1870	1810	1680	1580
06-03-03-1	Ili	stow of Kapshagai (a tributary tothe Kapshagai Reservoir)	835	0.2	2.0 Cv	1450	1270	1220	1130	1060
06-03-03-1	Ili	village of Ushzharma	625	0.17	4.0 Cv	1060	923	888	818	766
06-03-02-1	Tekes	village of Tekes	28.7	0.38	1.8 Cv	73.1	59.3	55.7	48.5	43.2
06-03-02-4	Shilik	village of Malybai	114	0.14	4.0 Cv	176	158	152	142	135
06-03-02-4	Turgen'	village of Tauturgen'	42.6	0.41	3.5 Cv	132	100	92.1	76.5	66
06-03-02-4	Issyk	town of Issyk	19.1	0.4	3.5 Cv	58	44.1	40.6	33.9	29.3
06-03-02-4	Malaya Almatinka	City of Almaty	11.8	0.7	3.0 Cv	61.7	42	37.3	28.4	22.5
06-03-02-4	Ul'ken Alamaty	1.1 kilometres up the Big Almaty lake	8.99	0.26	4.0 Cv	19.7	16.1	15.2	13.4	12.1
06-03-02-4	Kaskelen	town of Kaskelen	21.8	0.31	4.0 Cv	54.7	43.2	31.1	34.8	30.9

Table 3. Water pollution index of the Ili River and its tributaries in 2010-2012

No.	Name of a water body (administrative area)	Water pollution index (WPI) – characteristic of water quality											
		2010				2011				2012			
		1st quarter	2nd quarter	3rd quarter	4th quarter	1st quarter	2nd quarter	3rd quarter	4th quarter	1st quarter	2nd quarter	3rd quarter	4th quarter
1	the Ili River	1.12 (class 3)	2.09 (class 3)	4.16 (class 5)	2.18 (class 3)	3.52 (class 4)	1.50 (class 3)	1.14 (class 3)	1.55 (class 3)	1.40 (class 3)	1.60 (class 3)	1.07 (class 3)	1.41 (class 3)
2	river Tekes	1.44 (class 3)	2.96 (class 4)	3.71 (class 4)	1.71 (class 3)	2.30 (class 3)	1.3 (class 3)	0.84 (class 2)	0.90 (class 2)	1.05 (class 3)	1.28 (class 3)	1.50 (class 3)	1.14 (class 3)
3	river Turgen	0.83 (class 2)	1.70 (class 3)	2.03 (class 3)	1.24 (class 3)	3.45 (class 4)	1.43 (class 3)	1.11 (class 3)	0.73 (class 2)	1.22 (class 3)	0.64 (class 2)	0.82 (class 2)	0.70 (class 2)
4	river Sharyn	1.05 (class 3)	2.17 (class 3)	5.03 (class 5)	0.92 (class 2)	4.59 (class 5)	1.69 (class 3)	0.97 (class 2)	1.33 (class 3)	1.05 (class 3)	1.18 (class 3)	1.69 (class 3)	0.66 (class 2)
5	river Shilik	1.41 (class 3)	2.36 (class 3)	3.55 (class 4)	1.28 (class 3)	4.27 (class 5)	1.76 (class 3)	0.91 (class 2)	1.25 (class 3)	1.32 (class 3)	1.28 (class 3)	1.30 (class 3)	1.38 (class 3)
6	river Korgas	1.10 (class 3)	2.14 (class 3)	3.16 (class 4)	2.32 (class 3)	3.76 (class 4)	1.16 (class 3)	0.75 (class 2)	0.89 (class 2)	0.97 (class 2)	1.07 (class 3)	1.04 (class 3)	0.71 (class 2)
7	river Issyk	1.26 (class 3)	2.42 (class 3)	3.04 (class 4)	1.59 (class 3)	3.39 (class 4)	1.2 (class 3)	0.72 (class 2)	1.31 (class 3)	1.16 (class 3)	1.32 (class 3)	1.40 (class 3)	0.63 (class 2)
8	river Kaskelen	1.08 (class 3)	1.58 (class 3)	3.98 (class 4)	1.37 (class 3)	5.84 (class 5)	1.76 (class 3)	1.47 (class 3)	1.45 (class 3)	2.39 (class 3)	1.52 (class 3)	1.29 (class 3)	1.30 (class 3)
9	the Kapshagai Reservoir	1.22 (class 3)	2.89 (class 4)	3.36 (class 4)	2.21 (class 3)	3.24 (class 4)	1.26 (class 3)	1.00 (class 2)	1.40 (class 3)	1.55 (class 3)	1.62 (class 3)	1.53 (class 3)	1.01 (class 3)
10	the Curtin Reservoir	1.69 (class 3)	3.00 (class 4)	6.16 (class 6)	1.91 (class 3)	4.69 (class 5)	2.74 (class 4)	2.34 (class 3)	2.90 (class 4)	1.65 (class 3)	3.47 (class 4)	3.04 (class 4)	2.98 (class 4)
11	the Bartogai Reservoir	1.43 (class 3)	1.91 (class 3)	3.62 (class 4)	1.25 (class 3)	2.82 (class 4)	1.65 (class 3)	0.83 (class 2)	1.31 (class 3)	0.90 (class 2)	0.71 (class 2)	1.16 (class 3)	1.08 (class 3)
12	river Kishi Almaty	1.46 (class 3)	1.48 (class 3)	1.25 (class 3)	1.81 (class 3)	4.08 (class 5)	1.84 (class 3)	1.45 (class 3)	2.02 (class 3)	2.16 (class 3)	2.35 (class 3)	1.44 (class 3)	1.85 (class 3)
13	river Ulen Almaty	1.36 (class 3)	1.74 (class 3)	1.31 (class 3)	1.63 (class 3)	3.06 (class 4)	1.27 (class 3)	1.11 (class 3)	1.40 (class 3)	1.20 (class 3)	1.16 (class 3)	1.04 (class 3)	1.04 (class 3)

Surface water quality criteria by WPI

Class of quality	Characteristic of water quality	WPI value	1	Very clean	d” 0.3	2 Clean	0.31 – 1.0
3	Moderately polluted	1.01 – 2.5	4	Polluted	2.51 – 4.0	5 Dirty	4.01 – 6.0
6	Very dirty	6.01 – 10.0	7	Extremely dirty	> 10.0		

Table 4. Maximum and general concentrations of heavy metals in the Ili River water and in water of its tributaries

Name of a water body	Ingredients	Content of pollutants exceeding MAC					
		2010		2011		2012	
		Medium concentration, mg/dm^3	Repetition factor of MAC excess	Medium concentration, mg/dm^3	Repetition factor of MAC excess	Medium concentration, mg/dm^3	Repetition factor of MAC excess
the Ili River	Copper (2+)	0.0096	9.6	0.0067	6.6	0.0032	3.2
	Total iron	0.14	1.4	0.15	1.5	0.15	1.5
river Tekes	Copper (2+)	0.0102	10.2	0.0044	4.36	0.035	3.5
	Total iron	0.19	1.9			0.087	0.9
river Turgen	Copper (2+)	0.0045	4.5	0.0048	4.8	0.0016	1.6
	Total iron	0.14	1.4				
river Sharyn	Copper (2+)	0.0088	8.8	0.0070	7.01	0.0035	3.5
	Total iron	0.12	1.2				
river Shilik	Copper (2+)	0.0089	8.9	0.0067	6.68	0.0032	3.2
	Total iron					0.098	1.0
river Korgas	Copper (2+)	0.0098	9.8	0.0065	6.68	0.0028	2.8
	Total iron					0.066	0.7
river Issyk	Copper (2+)	0.0084	8.4	0.00458	4.58	0.0037	3.7
	Total iron	0.16	1.6			0.045	0.4
the Kaskelen river	Copper (2+)	0.0064	6.4	0.00705	7.05	0.0026	2.6
	Total iron			0.14	1.4		
the Kapshagai Reservoir	Copper (2+)	0.0101	10.1	0.00631	6.31	0.0039	3.9
the Curtin Reservoir	Copper (2+)	0.0121	12.1	0.008	7.97	0.007	7.0
the KapshagaiReservoir	Copper (2+)	0.0075	7.5	0.005	4.96	0.0022	2.2
	Total iron					0.085	0.8
The Kishi Almaty river	Copper (2+)	0.0043	4.3	0.007	7.0	0.0037	3.7
the Ulken Almaty river	Copper (2+)	0.0049	4.9	0.0063	6.25	0.0024	2.4
	Total iron					0.08	0.8

Table 5. The copper content in the water of the Ili River from 2001 till 2007 mg/dm^3

River stations	2001	2002	2003	2004	2005	2006	2007
The Dubun’ pier	0.024	0.0129	0.0185	0.0133	0.0152	0.01	0.004
146 kilometre up the Kapshagai HPP	0.01	0.008	0.0069	0.007	0.0068	0.006	0.006
Stow of Kapshagai	0.013	0.003	0.004	0.003	0.004	0.007	0.005
Village of Ushzharma	0.002	0.004	0.004	0.015	0.004	0.008	0.005
Village of Kuigan	-	-	-	-	-	-	0.004

Table 6. The zinc content in the water of the Ili River from 2001 to 2007 mg/dm^3

River stations	2001	2002	2003	2004	2005	2006	2007
the Dubun' pier	0.015	0.0194	0.021	0.019	0.016	0.003	0.04
146 kilometre up the Kapshagai HPP	-	-	-	-	-	0.002	0.04
stow of Kapshagai	0.008	0.01	0.018	0.009	0.01	0.001	0.02
village of Ushzharma	-	-	-	-	-	0.002	0.02
village of Kuigan	-	-	-	-	-	-	0.02

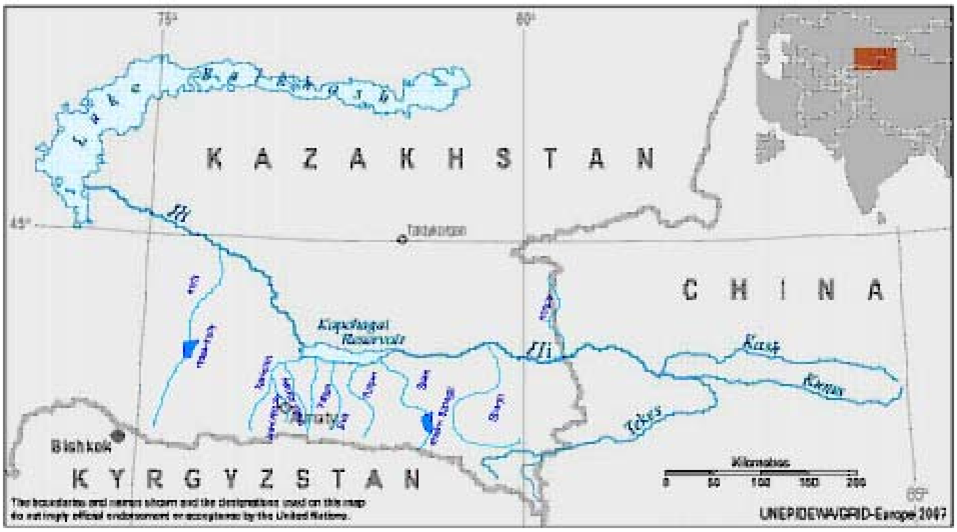


Fig. 1. Scheme of complex use and protection of water resources in the Ili River basin and its tributaries

0.73 WPI in the 4th quarter of 2011 and referred to the 2nd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 0.70 and referred to the 2nd class pollution.

The highest copper pollution 4.8 MAC of the Turgen’ River was observed in 2011, and in 2010 it amounted to 4.5 MAC, in 2012 it made up to 1.6 MAC. Total iron in 2010 amounted to 1.2 MAC.

The Sharyn River had the maximum 5.01 WPI in the 3rd quarter of 2010 and referred to the 5th class pollution, the minimum 0.66 WPI was observed in the 4th quarter of 2012 and referred to the 2nd class pollution, in the 4th qurter of of 2012 WPI amounted to 0.66 and referred to the 3rd class pollution.

The highest copper pollution of the Sharyn River was noted in 2010 and amounted to 8.8 MAC, in 2011 it amounted to 7.01 MAC, but in 2012 it amounted to 3.5 MAC, i.e. reduction of the copper pollution of the Sharyn river run-off is observed. Total iron pollution was determined in 2010 and amounted to 1.2 MAC and in 2012 – 1.0 MAC.

The maximum 4.27 WPI in the Chilik River

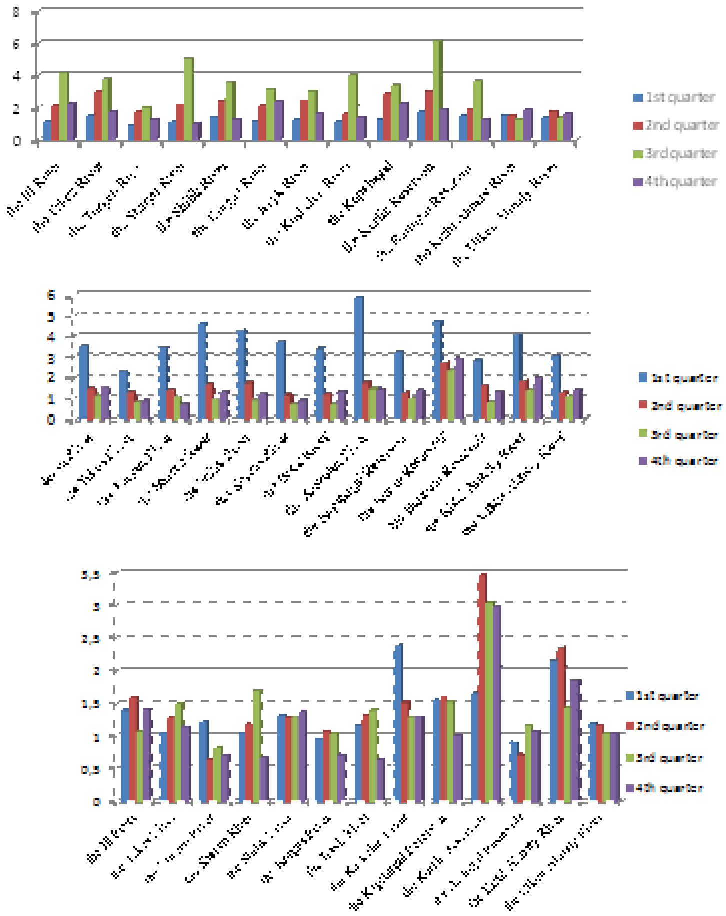
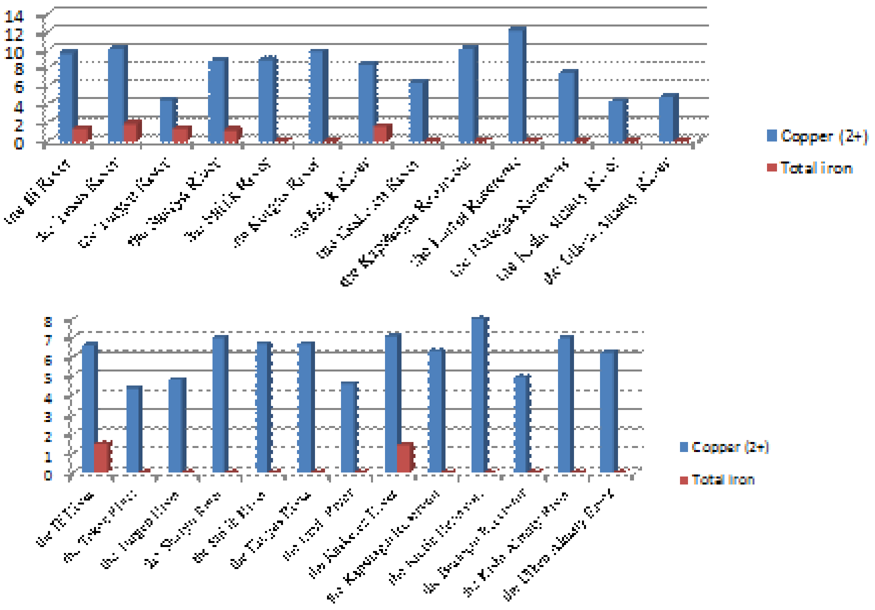


Fig. 2. Water pollution index of the Ili River in 2010-2012. *a –2010, b –2011, c –2012*



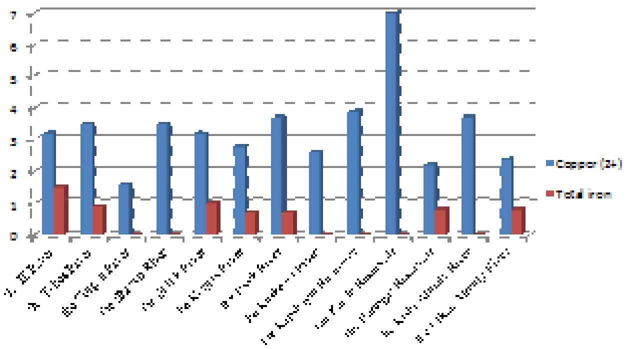


Fig. 3. MAC of copper and iron of the Ili River in 2010-2012

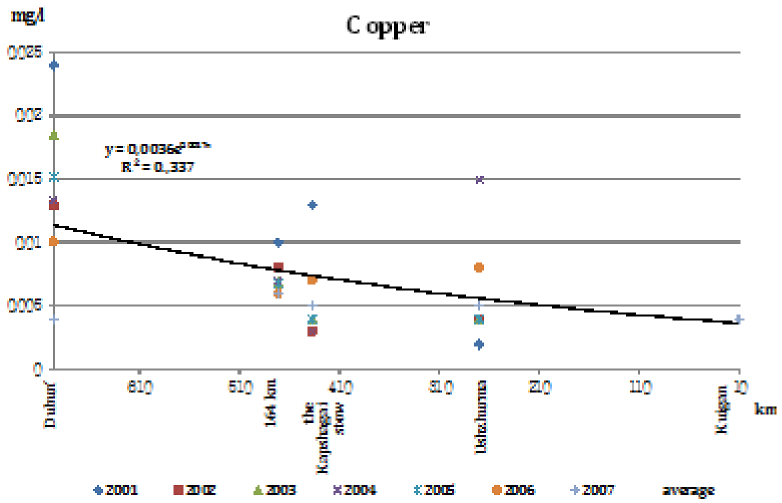


Fig. 4. Diagram of copper concentration dependence from distances S_{Cu}=f(L)

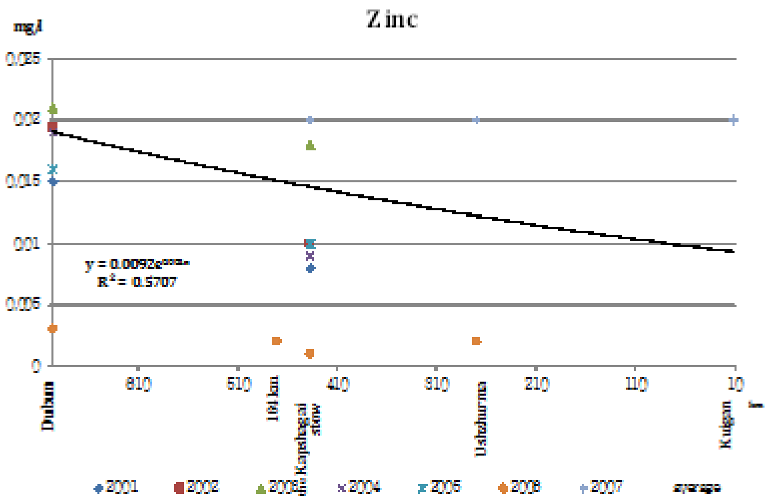


Fig. 5. Diagram of zinc concentration dependence from distances S_{Zn}=f(L),

was observed in the first quarter of 2011and referred to the 5th class pollution, the minimum 0.91 WPI in the 3rd quarter of 2011 ad referred to the 2nd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 1.38 and referred to the 3rd class pollution.

The highest copper pollution 8.9 MAC of the Chilik River was observed in 2010, and in 2011 it amounted to 6.68 MAC, in 2012 it made up to 2.8 MAC, i.e. reduction of the copper pollution of the Chilik river run-off is observed. Total iron in 2012 amounted to 1.0 MAC.

The maximum 3.76 WPI in the Korgas River was observed in the first quarter of 2011and referred to the 4th class pollution, the minimum 0.71 WPI in the 4th quarter of 2012 ad referred to the 2nd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 0.71 and referred to the 3rd class pollution.

The highest copper pollution 9.8 MAC of the Korgas River was observed in 2010, and in 2011 it amounted to 6.68 MAC, in 2012 it made up to 2.8 MAC, i.e. reduction of the copper pollution of the Korgas river run-off is observed. Total iron in 2012 amounted to 0.7 MAC.

The maximum 3.39 WPI in the Issyk River was observed in the first quarter of 2011and referred to the 4th class pollution, the minimum 0.63 WPI in the 4th quarter of 2012 ad referred to the 2nd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 0.63 and referred to the 2nd class pollution.

The highest copper pollution 8.4 MAC of the Issyk River was observed in 2010, and in 2011 it amounted to 4.58 MAC, in 2012 it made up to 3.7 MAC, i.e. reduction of the copper pollution of the Issyk river run-off is observed. Total iron in 2010 was 1.6 MAC, but in 2012 – 0.4 MAC.

The maximum 5.84 MAC was observed in the Kaskelen River in the 1st quarter of 2011and referred to the 5th class pollution, the minimum 1.08 WPI in the 3rd quarter of 2010 and referred to the 3rd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 1.30 and referred to the 3rd class pollution.

The highest copper pollution 6.4 MAC of the Kaskelen River was observed in 2010, and in 2011 it amounted to 7.05 MAC, in 2012 it made up to 2.6 MAC, i.e. reduction of the copper pollution of the Kaskelen river run-off is observed. Total iron in 2011 amounted to 1.4 MAC.

The maximum 3.36 WPI was in the Kapshagai Reservoir was observed in the 3rd quarter of 2011and referred to the 4th class pollution, the minimum 1.00 WPI in the 3rd quarter of 2011 ad referred to the 2nd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 1.01 and referred to the 3rd class pollution.

The highest copper pollution 6.4 MAC of the Kapshagai Reservoir was observed in 2010, and in 2011 it amounted to 6.31 MAC, in 2012 it made up to 3.9 MAC, i.e. reduction of the copper pollution of the Kapshagai Reservoir run-off is observed.

The Curtin Reservoir had the maximum 3.36 WPI in the 3rd quarter of 2010 and referred to the 6th class pollution, the minimum 1.65 WPI in the 3rd quarter of 2012 and referred to the 3rd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 2.98 and referred to the 4th class pollution. The highest copper pollution 6.4 MAC of the Curtin Reservoir was observed in 2010, and in 2011 it amounted to 7.97 MAC, in 2012 it made up to 7.0 MAC, i.e. reduction of the copper pollution of the Curtin Reservoir run-off is observed.

The maximum 3.62 WPI was observed in the Bartogai Reservoir in the 3rd quarter of 2010 and referred to the 4th class pollution, the minimum 0.71 WPI in the 2nd quarter of 2012 ad referred to the 2nd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 1.08 and referred to the 3rd class pollution.

The highest copper pollution 7.5 MAC of the Bartogai Reservoir was observed in 2010, and in 2011 it amounted to 4.96 MAC, in 2012 it made up to 2.2 MAC, i.e. reduction of the copper pollution of the Bartogai Reservoir run-off is observed. Total iron in 2012 amounted to 0.8 MAC.

The Kishi Almaty River had the maximum 4.08 WPI in the 1st quarter of 2011 and referred to the 5th class pollution, the minimum 1.25 WPI in the 3rd quarter of 2010 and referred to the 3rd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 1.85 and referred to the 3rd class pollution.

The highest copper pollution 4.3 MAC of the Kishi Almaty River was observed in 2010, and in 2011 it amounted to 7.0 MAC, in 2012 it made up to 3.7 MAC, i.e. reduction of the copper pollution of the Kishi Almaty river run-off is observed.

The Ulken Almaty River had the maximum 3.06 WPI in the 1st quarter of 2011and referred to the 4th class pollution, the minimum 1.04 WPI in the 3rd quarter and the 4th quarter of 2012 and referred to the 3rd class run-off pollution, in the 4th quarter of 2012 WPI amounted to 1.04 and referred to the 3rd class pollution. The highest copper pollution 4.9 MAC of the Ulken Almaty River was observed in 2010, and in 2011 it amounted to 6.25 MAC, in 2012 it made up to 2.4 MAC, i.e. reduction of the copper pollution of the Ulken Almaty run-off is observed. Total iron in 2012 amounted to 0.8 MAC.

Due to development of industry, chemicals used in agriculture, population growth and sizes of urban areas, influence of human economic activity on the natural environment as a whole and, in particular, on land surface waters increased dramatically. Along with the increasing use of water resources, there is a deterioration of water quality, pollution increases. In these conditions the most important challenge of hydrology is to develop effective measures to fight against pollution. To solve this problem it is necessary to study the formation of water masses quality in rivers, lakes and reservoirs that happened to be in the area of anthropogenic influence, to find ways to objectively assess a pollution level of water bodies, to develop calculation methods and prediction of water quality in water bodies and stream flows.

Flow of industrial, domestic and agricultural waste water substantially affects chemical and biological mode of land water bodies. The process of changing composition and properties of natural waters, as a result of human activity, leading to deterioration of water quality for water use and disruption of biological processes, is called water pollution. Often, poor water quality may be due to natural processes. In this case, the term "natural water pollution" is sometimes used [7-9].

In places where waste water flows into water bodies, water masses are affected by pollutants and discharged together with waste water. Regulatory documents limit amounts of waste water substances, which are called limiting substances. If concentration of the limiting substances in waste water exceeds the established norms of water use conditions (maximum allowable concentrations – MAC), then a pollution bubble is formed at the place of discharge. The outer boundary of this zone is a concentration contour line, corresponding to the MAC for this limiting substance, amount of which mostly exceeds the MAC in waste water.

Pollution processes in rivers and reservoirs oppose a self-cleaning process, which refers to a set of hydrodynamic, physical, chemical and biological processes that lead to a decrease in the concentration of pollutants in the water, and during full self-cleaning – to restoration of natural water quality. A hydrodynamic factor – dilution of waste water under the influence of turbulent mixing, plays a decisive role in the self-cleaning process of rivers and flowing water bodies. In stagnant and slowly flowing waters other of the above factors become also relevant. Thus, a very significant decrease in concentration is due to chemical and biological processes of transformation and decomposition of substances [10-12].

Requirements for water quality by different sectors of the economy are quite different, that's why water quality standards for different water users are of great importance. Currently existing norms of water composition and properties are developed and approved only for water bodies of the sanitary and domestic, and fishing industry.

General requirements to the quality of water used for these purposes are based on the following indicators of physical condition, chemical and biological composition of water: temperature, suspended solids, mineralization (dry residue), chlorides, sulphates, dissolved oxygen, pH, BOD, pathogens, toxins, odours, flavours, colouring [13-15].

The criterion of water pollution established in the rules is deterioration of water quality due to changes in its organoleptic properties and appearance of substances harmful to humans, animals, birds, fish, forage and commercial organisms (depending on the type of water use), as well as an increase in a water temperature, which changes normal life conditions for aquatic organisms. All normalized substances are divided into three groups by the limiting health hazard indicator (LHHI) according to the nature of their impact on the human body and internal water body biological processes. There are the general sanitary, sanitary-toxicological and organoleptic health hazard indicators. It is necessary to take into account to which specific group according to LHHI a chemical compound belongs in order to monitor compliance with the following requirements of the Regulations[16, 17]:

$$\sum_{i=1}^{n} \frac{S_i}{MAC_i} \quad ...(1)$$

where S_i – average concentration of one substance belonging to the examined LHHI group; ***MAC*** – maximum allowable concentration of the same substance; ***?*** – total amount of substances of this LHHI group in the water of the examined water object

Objective quantitative assessment of rivers and water bodies' pollution, identifying trends of its change under the influence of economic activity and hydrometeorological factors, operational control of a pollution level – all these tasks can be solved only on the basis of well-organized network observations. Planning a network of observation (control) points is the most important task of the study of surface water quality [18].

The general principle of spatial distribution of observation points is to meet the requirements of representativeness: representativeness by the scale and types of sewage pollution and compliance of physical and geographic characteristics with natural conditions of a catchment point (or its locally-homogeneous area) [19].

A structure and amount of work in observation points and pollution control should meet the requirements for information on water quality and its mode of economic, design and water conservation organizations, government bodies, cultural and community facilities and other water users in relation to an existing or projected use and protection of an examined water body. All points must determine indicators related to the general requirements for water quality for sanitary and domestic and commercial fishing water use: water temperature, suspended and floating substances, mineralization, colour, pH, dissolved oxygen, BOD, odours. As a rule, a mandatory program of work should include determining common pollutants like oil, detergents, and phenols.

In 1971 the State Hydrological Institute published "Practical recommendations on hydrological study of pollution and self-purification of rivers, lakes and reservoirs" [20], which give specific suggestions for widespread adoption of a comprehensive method of studying pollution of water bodies and self-cleaning processes occurring in them.

Studies of self-purification and pollution of rivers and water bodies consist of two main types of work: 1) monitoring stream flow and a water body as a whole; 2) study of formation of pollution zones and zones of influence under different factors. Performance of main types of works precedes visual reconnaissance surveys, allowing selecting specific areas for organization of detailed stationary observations, to establish the nature, composition and quantity of discharged waste water and so on. The general background for stationary studies are network observations performed by the Hydrometeorology state committee [21, 22].

We tried to study pollution of the Ili River run off from the border with the People's Republic of China – (river station of the Dubun' village to the Balhash lake – river station of the Ushzharma village). For this purpose we processed 2001-2007 data on river stations of the Dubun' pier, 164 km higher than the Kapshagai HPP, the Kapshagai stow, the village of Ushzharma. Available data on pollution of the Republican State Enterprise "Kazgidromet" rivers run-off is mainly presented on copper and iron. The data shown in Tables 1 and 2 from 2001 to 2007 are the data "Kazgidromet" RSE, and data for 2007 were obtained by the authors by working in RSE "KazRDIEC" MEP RK.

CONCLUSION

As the results of our study show, the water pollution index of the Ili River varies considerably both quarterly and year to year. The most heavy metals polluted river station is the river station of the Dubun' pier, i.e. run-off from China comes polluted with both copper and zinc. Copper concentrations decrease from the top river station to the bottom one, i.e. to the source of the river Ili, where the correlation coefficient was 0.833 and the equation describing this relationship was obtained, and the zinc concentration dependence is weak, as the correlation coefficient is 0.57, the equation describing this relationship was also obtained. It should be noted that at this stage we processed a limited amount of data that will later be complemented.

The water pollution index both of the Ili River and its tributaries varies significantly across both quarterly and year to year from 2 to 6 WPI (Table 3). The excess MAC of copper of the Ili River and its tributaries was observed from 1.6 (the Turgen river 2012) to 12.1 (the Kurty river 2010).

It should be noted, one of the goals of our study is to further identify sources polluting the Ili River and its tributaries run-off with heavy metals, to develop measures aimed at preventing tributaries run-off pollution and their flow to the Ili River.

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