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Study of surface water mercury contamination in river Nura (2001-2002)

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The necessity of conducted study is caused by the absence of reliable data on level of contamination of surface water in river Nura throughout the year. This data are essential in relation to the program of World Bank including the risk assessment for the population living downstream from the main location of depositions of bank ash and bottom sediments containing mercury. This is also needed for the feasibility study of the remediation actions. The study of mercury in river water was also added with a small-scale study of mercury levels in fish caught in the river Nura downstream of Temirtau.

Historical data

There exist contradictory data on mercury contamination of surface water of rivers Nura and Ishim. During last decade (including the period after cessation of acetaldehyde production in AO Karbid at 1997) the record indicating contamination of river Nura more than Maximum Acceptable Concentration for drinking water (MAC_{dw}=0.5 μg/l) appeared several time. Such contamination was registered not only for the section near Temirtau but also for the Preobransky dam, Kurgaldzhino lakes and even for the section of river upstream Samarkand reservoir. Cases of exceeding MAC_{dw} were registered for the surface water of Nura-Ishim Canal as well as for the river Ishim in Astana. These facts were used more than once to approve the limited usage of this canal.

First independent study of mercury contamination of river Nura water was conducted in September 1975 by Institute of Experimental Meteorology (city of Obninsk) in the frame of the task of USSR Construction Committee /1/. One-stage study found the following concentrations of mercury for 11 sampling points: river Nura upstream of Samarkand reservoir (village Petrovka) – 0.5 μg/l; Samarkand reservoir (village Tokarevka) – 0.1 μg/l; 1 km upstream of wastewater outfall – 0.2 μg/l; 500 m downstream of wastewater outfall (village Chkalovo) – 2.7 μg/l (5 MAC_{dw}); 1 km downstream of wastewater outfall – 2.2 μg/l (4 MAC_{dw}); village Gagarinskoye – 1.6 μg/l (3 MAC_{dw}); bridge near village Tegiz-Zhol – 0.9 мкг/л (2 MAC_{dw}); village Rostovka – 0.6 μg/l; village Molodetskoye – 0.5 μg/l; village Samarka – 0,4 μg/l; village Kievka – 0.5 μg/l.

In the beginning of 80th when acetaldehyde plant of AO Karbid was still in operation Kazhydromet /2/ registered maximal levels of total mercury in river Nura in 0.5 km downstream of Main drain outfall as 50-100 μg/l (i.e. 100-200 MAC_{dw}) when the average annual concentration was 2-4 μg/l (4-8 MAC_{dw}); in village Rostovka – 4-9 μg/l (8-18 MAC_{dw}) when the average annual concentration was 0.6-0.8 μg/l (1-2 MAC_{dw}); in village Samarka – 2 μg/l (4 MAC_{dw}) when the average annual concentration was 0.3-0.6 μg/l (1 MAC_{dw}). Even for the river section near village Kievka the maximal concentrations were registered as 5-6 μg/l (10 MAC_{dw}) when the average annual concentration was about 0.5 μg/l (1 MAC_{dw}). However, the concentration of total mercury as high as 0.5 μg/l (1MAC_{dw}) was registered for the hydrostation in village Sergiopolskoe (upper reach of Samarkand reservoir) as well as for the hydrostations in villages Proletarskoe and Bes-Oba that are located in the significant distance upstream of Temirtau.

In August 1987 E.P. Yanin /3-7/ was conducted daily sampling of surface water from Main drain and river Nura along its 30-km section downstream of Main drain. He utilised pre-filtering under vacuum through membrane filters with 0.45-μm pore size to separate dissolved and suspended mercury species. The dissolved mercury in filtrate was trapped by polymeric thioether. The filter with suspended solids and sorbent were analysed separately using atomic-absorption spectrometer in main laboratory in Moscow. For the Main drain the average concentration of dissolved mercury was 2.88 μg/l (maximal – 5.3 μg/l) and suspended mercury – 1.31 μg/l (maximal – 1.6 μg/l); for the section in 0.5 km downstream of Main drain outfall concentration of dissolved mercury was 0.87 μg/l (maximal – 1.2 μg/l) and suspended mercury – 0.89 μg/l (maximal – 2.1 μg/l); for village Rostovka concentration of dissolved mercury was 2.9 μg/l (maximal – 4.1 μg/l) and suspended mercury – 0.08 μg/l (maximal – 0.2 μg/l). The concentrations of dissolved/suspended mercury for the cross-sections of village Molodetskoye, upper reach of Intumak reservoir, outfall of Intumak reservoir and Samarka dam were correspondently: 0.44 μg/l /0.12 μg/l; 0.82 μg/l /0.07 μg/l; 0.80 μg/l /0.08 μg/l; 0.9 μg/l /0.07 μg/l. For Samarkand reservoir the average concentrations of mercury were 0.94 μg/l for dissolved species and 0.12 μg/l for suspended species.

The data described above could be regarded as most reliable. However the values of concentration of mercury in natural water at the level of 0.5 μg/l and below should be used with caution because this level lies near the realistic detection limit of the atomic-absorption analytical techniques used in USSR for the determination of mercury in water in 70-90th.

The report of USSR Construction Committee study /1/ also contains the only data on mercury in fish measured in Soviet period. 8 samples of crucian carp were caught in Samarkand reservoir; their weight was in the range of 100-150 g. The following mercury contents were found in these samples: 0.60 mg/kg; 0.32 mg/kg; 2.80 mg/kg; 0.93 mg/kg; 0.60 mg/kg; 0.60 mg/kg; 0.42 mg/kg; 2.20 mg/kg. This is in the range from 1 to 7 MAC_f (MAC_f for the freshwater non-predatory fish species is 0.3 mg/kg wet weight).

The data of INCO-Copernicus study IC15-CT96-0110

The study conducted in 1997 in the scope of INCO-Copernicus research program IC15-CT96-0110 proposed the investigation of seasonal variations of total mercury content in river Nura water as a sub-task. Unfortunately this task was not completely done because the analyses of water were carried out by local analytical laboratories using outmoded facilities. The only reliable result of this study is that concentration of total mercury in Nura water downstream of Molodetskoye was less than 0.5 μg/l (1 MAC_{dw}) during spring, summer and autumn of 1997 and

spring of 1998. In September 1998 in the scope of the same project the team of KazGU carried out the sampling and analysis of 9 water samples taken from Nura in the section between Samarkand reservoir and bridge near village Tegiz-Zhol using atomic-absorption spectrophotometer AGP-1 installed in the field laboratory. Samples were filtered under pressure through the membrane filters with 0.45-μm pore size. Concentration of dissolved mercury in all samples was below detection limit (i.e. 0.1 μg/l) and the content of suspended mercury varied from 0.03 to 0.19 μg/l.

In 1998 46 samples of crucian carp and lake perch were caught. 17 specimens caught in Samarkand reservoir and upstream contained less mercury than MAC_f. 11 specimens of crucian carp from Intumak reservoir and river section of 5 km downstream had mercury concentrations in the range from 0.1 to 0.3 mg/kg, which is also below MAC_f. 18 specimens of lake perch were caught in Intumak and Samarkand reservoirs: 8 specimens contained mercury in concentrations from 0.1 to 0.3 mg/kg (i.e. below MAC_f) and 10 specimens – 0.3-1.5 mg/kg (i.e. 1-5 MAC_f). Therefore, a third of fish specimens caught downstream of Samarkand reservoir contained more mercury than MAC_f but maximal concentration did not exceed 1.5 mg/kg, i.e. 5 MAC_f.

Sampling and pre-treatment techniques

Water samples were taken to determine the concentrations of total mercury, dissolved mercury, suspended mercury and content of suspended solids.

Typically river water was sampled from the main river channel (usually from the bridge or dam) using the basket-type sampler (bathometer). The disposable 1 or 2 l bottle (Coca-cola or BonAqua bottle) was put into the sampler and it was used for sampling only once. The sampler was evenly moved from the bottom of river to its surface and back until the bottle was filled. The sampling bottle was rinsed with river water three times before the first sampling.

In case of the determination of total mercury the water from the sampling bottle was poured into the label 0.5-liter plastic storage bottles (also Coca-cola or BonAqua bottles) which were rinsed 3 times with sample before. The storage bottle has a sign indicating 0.5 l volume and it was used for the storage and following analysis only once and then was disposed. In case the sampling from the bridge or dam was impossible it was carried out from the river bank using the storage bottle which was immersed into the river to 0.5 m depth. All samples were taken in 2 replicates.

In case of sampling for determination of dissolved and suspended mercury the river water was filtered immediately after sampling. The filtration was done under pressure through the membrane filter with 0.45-μm pore size using specially cleaned plastic filtration unit equipped with a funnel with a scale division and pressure cap. Compressed nitrogen from a cylinder was used to create a pressure. The funnel was filled with river water from sampling bottle and filtrate was collected directly to the storage bottle up to the volume of 0.5 l. Filters were changed when the next portion of water was completely filtered. The number of filters used for one sample was usually more than one. Filters for the same sample were put into labelled zipped plastic bag.

After filtration the unit was dismantled and put into the capped plastic container for cleaning and storage. Washing was done by filling container with clean water (content of mercury < 2 ng/l) and shaking. Depending on the expected concentration of mercury in the previous sample this procedure was repeated 3-5 times. After final rinse the rinsing water was collected into the separate storage bottle and further analysed as a washing control.

All water samples were preserved immediately after sampling with concentrated hydrochloric acid (5 ml of HCl per 1 l sample). The purity of acid (in terms of mercury content) for preservation and other reagent used for analysis was controlled by blank sample.

During sampling for determination of suspended solids the known volume of water (usually 0.5 l) from sampling bottle was filtered through weighted and labelled dense paper filter (GF/C). The separate plastic filtration unit with scale divisions and pressure cap was used for this and it was rinsed three times with sample water beforehand. Filters were changed after the next portion of water was completely filtered; filtrate was discarded. Filters with suspended solids from the same sample were put into labelled zipped plastic bag.

Analytical techniques

Concentration of mercury in the samples was determined utilising atomic-fluorescence spectrophotometer (AFS) Millennium Merlin (PS Analytical, UK) by cold vapour technique. There were used 3% solution of tin (II) chloride purged with the air to remove the residues of mercury as a reductant and bromide-bromate mixture as an oxidizing agent which was usually used for decomposition of natural waters.

Immediately after delivery of samples to the laboratory the volume of sample was reduced to 450 ml by discarding of water using the measuring cylinder. The rest of the sample was digested by adding 60 ml of 33% solution of hydrochloric acid, 4.5 ml of 0.2M KBr solution and 4.5 ml of 0,2M $KBrO_3$ solution. Samples were set acid for overnight for complete digestion. After that they are ready for analysis and could be stored for at least a month without loss of mercury from the solution. The excess of bromide-bromate mixture in the solution was reduced by adding 12% solution of hydroxylamine (300 µl per 500 ml of sample) right before the determination.

The calibration of instrument has been done daily at the day of determination. Two working solutions (with concentrations of 50 and 100 µg/l) were prepared by dilution of standard solution (BDH Spectrosol, concentration 1 g/l). Then these working solutions were used for daily preparation of calibration solution by dilution with laboratory blank solution. Laboratory blank solution was daily prepared by digestion of distilled water using exactly the same technique as for analysed samples. Laboratory blank was also used if the dilution of analysed samples was needed. In order to estimate the contribution of mercury contained in the reagents to the accuracy of analysis the field blank solution was prepared at the day of sampling. This blank is distilled water preserved in field with the same acid that was used for samples and then digested by the same way as samples. The result of field blank analysis was used to correct the result of instrumental determination of mercury in analysed water samples. The correction of the results of instrumental analysis was also carried out to consider the dilution after adding chemicals for preservation and digestion. The quality control and quality assurance (QC/QA) included application of the method of standard spike for 10% of analysed samples in accordance with the standard method of EPA 1631. Beside this once in several days the certified reference water sample (ORMS-2, Canada) was analysed. The procedures described above correspond to the standard method of the manufacturer of AFS instrument.

The content of mercury in suspended solids was measured by analysis of filters. Filters of one sample were put into 100 ml glass beaker and then treated with 1 ml of concentrated sulphuric acid. The mixture was heated on the water bath at 70 ^{0}C until the filters were completely dissolved. The obtained solution was quantitatively transferred into 0.5-liter disposable plastic bottle. Then 75 ml of 33% hydrochloric acid, 10 ml of 0.2M KBr solution and 10 ml of 0.2M

$KBrO_3$ solution were added and the volume was made to 0.5 l with distilled water. Samples were set aside for overnight for complete digestion. Then the solution was analysed by exactly the same way as described above for water samples.

The concentration of suspended mercury species was attributed not only to the volume of water sample (ng/l) but also to the weight of suspended solids (mg/kg).

The content of suspended solids in water sample was determined by difference in the weights of filter dried to the constant weight after and before filtration. The drying was done at 105 ^{0}C.

The concentration of total mercury in fish meat was also determined using CV-AFS technique. The weighted sample from the vertebral part of the fish (about 1 g) was put into 100-ml glass beaker and then 5 ml of concentrated sulphuric acid and 3 ml of concentrated nitric acid were added. The mixture was heated on the water bath at 100 ^{0}C during 2 hours until the solution became clear. Then the solution was chilled and diluted with distilled water to 100 ml. The obtained mixture was quantitatively transferred into 0.5-liter disposable plastic bottle where 150-200 ml of distilled water were added beforehand. 25 ml of concentrated hydrochloric acid, 10 ml of 0.2M KBr solution and 10 ml of 0.2M $KBrO_3$ solution were added and the volume was made to 0.5 l with distilled water. Samples were set aside for overnight for complete digestion. Then the solution was analysed by exactly the same way as described above for water samples. The QC/QA included the analysis of certified reference material DORM-2 (the specified concentration of total mercury is 4.64±0.26 mg/kg) in order to check the rate of recovery.

The age of fish was determined by counting the number of rings on the scale.

Observation cross-sections, water levels and flows in river Nura at November 2001 and during the spring flood of 2002

The sampling of surface water of river Nura was done in one stage in late autumn of 2001 (Nov 4-6) and in three stages during the spring flood of 2002: Apr 7-13, Apr 17-22 and Apr 29 – May 5. Each stage of sampling assumed that the team was going by car along the river Nura from Karaganda to Kurgaldzhino lakes and taking samples in scheduled sampling points. Table 1 contains the description of observation cross-sections (sampling points) in wastewater treatment plant of AO Karbid, Main drain, river Nura, river Oshagandy (Nura tributary) and river Ishim that were investigated in the scope of present study.

Table 2 contains the data on average flows of water in river Nura in the outfall of Samarkand reservoir. This data was provided by Environmental Protection Departments of industrial enterprises of Temirtau. It allowed calculation of the water flow in the river at 4th and 5th of November 2001 for the cross-section “Bridge # 2”. The flow of Samarkand reservoir outfall is approximately equal to the flow of river Nura in the cross-section “Bridge # 1”. Table 3 contains the data on discharge of water from Samarkand reservoir during the flood of 2002. This data as well as the data of Table 2 allowed calculation of the water flow in river Nura for the cross-section “Bridge # 2” during the flood and the results are presented in Table 3. Table 3 also contains the information of Karaganda Hydromet about levels and flows of water in river Nura at the hydrostation Zakharovka for the same period.

Absolute levels of water at 4-5 of November 2001 that were measured in cross-sections “Bridge # 1”, “Bridge # 2”, Bridge # 3” and “Bridge # 4” corresponded to the regular summer levels: 476.14; 474.93; 468.64; 457.47 m (by Baltic system of altitudes). During the first stage of

sampling of the program of flood-2002 absolute levels of water measured in cross-sections "Bridge # 1", "Bridge # 2", Bridge # 3" and "Bridge # 4" corresponded to 477.61; 476.95; 469.64; 459.33 m (by Baltic system of altitudes) that indicated the rise of water level by 1.45; 2.02: 1.00; 1.86 m correspondently. During the second and third stages of sampling the level of water in cross-sections "Bridge # 1", "Bridge # 2", Bridge # 3" and "Bridge # 4" returned to the regular summer level.

In cross-section of hydrostation Zakharovka the highest relative summer level of water is 5.40 m [8]. According to the Table 3 the relative levels of water at the dates of sampling (Apr 11, Apr 22 and May 2) had the values 7.76; 6.89 and 6.53 m correspondently, i.e. these levels exceeded the summer level by 2.36; 1.49 and 1.13 m, correspondently.

It should be noted that the peak of flood-2002 occurred on Mar 15 in the cross-section of Temirtau and on Mar 31 in the cross-section of hydrostation Zakharovka, so it took place before the conduction of present sampling program. The delay of sampling was 3 weeks for the cross-section in Temirtau and 1 week for the cross-section in Zakharovka. In first case the water flow was 3 times less than maximal and in the second – almost in 2 times and water level was less than maximal by 2.79 m.

According to [8] the peak of flood passes the distance from Zakharovka to Romanovka in 3-4 days. That is why even near Sabyndy first sampling of water (at Apr 12) was done in a week later than the peak of flood occurred. First lakes of Kurgaldzhino located upstream of village Kurgaldzhino detain and smooth the peak of flood [9]. According to our observations the maximal level of water for this cross-section took place during the third stage of sampling (May 5) and water level at that time was higher by 1.5-2 m than the one observed during the first stage of sampling (at Apr 12).

Results of study of mercury contamination of river Nura surface water conducted at November 2001

The results of autumn campaign are presented in Table 4 and in brief in Table 5. The taken water was very clear and contained no algae. The temperature of water outside of Main drain was 6-8 ^{0}C, and in Main drain – 18 ^{0}C. No exceeds of MAC_{dw} (500 ng/l) were registered for any of cross-sections of river Nura. Concentration of mercury in Main drain water slightly exceeded this value. It also should be noted that concentration of mercury in Main drain increased along the channel from the cross-section "Bridge near village Gagarinskoye" to the cross-section "Inlet of Main drain into river Nura". The reason for that is high level of mercury contamination of technogenic silts covering the bed and banks of Main drain in this section. High temperature of water also plays its role. At 4-5 Nov 2001 the rate of dilution at the entering of water from Main drain into the river was 15. However, the level of mercury in the river only dropped in 2 times. This is also connected to the high level of mercury contamination of the river Nura bed in the section downstream of Main drain outfall. However, the low temperature of water and absence of high water flow leaded to significant decrease of mercury concentration in the section between "Bridge # 2" and "Mill dam". This section is known by the highest level of mercury contamination of technogenic silts deposited on the bed and banks. The slight increase of mercury concentration in water between "Mill dam" and "Bridge # 3" is probable caused by relatively high slope of river on this section and related to that increase of water flow. The concentration of mercury in water dropped in 7 times after passing the Intumak reservoir. Concentration of mercury downstream cross-section "Bridge near village Kievka" was below detection limit (i.e. <2 ng/l). The water of Samarkand reservoir was 2 times more contaminated

than water from the river at the reach to this reservoir, however, that was 2 orders of magnitude less than MAC_{dw}.

The results of study of mercury contamination of river Nura surface water conducted during spring flood-2002

The results of analysis of surface water samples taken in spring are shown in Table 6. The water was cloudy and had no algae. The temperature of water outside of Main drain was: at the first stage of sampling 1-5 ^{0}C, at second – 4-7 ^{0}C, at third – 8-13 ^{0}C. The temperature of water in Main drain was 18 ^{0}C. The level of mercury concentration in Main drain was lower than in autumn approximately in 3 times. However the same trend of increase of concentration from "Bridge near Gagarinskoye" to "Inlet of Main drain into river Nura" was observed. The only exception was the first stage of sampling when the inlet of Main drain into river was filled with river water due to its high level.

MAC_{dw} (500 ng/l) was exceeded in surface water of the river (maximal exceed was in 2 times) only during the first stage of sampling and it was registered only for the section of river between "Kalininskoye" and "Mill dam". On Apr 13 the dilution of Main drain water in river Nura reached the ration of 50 times. However, despite the concentration of mercury on outfall of Main drain dropped in 2 times, it increased again on "Bridge # 2" almost in 3 times and continued to rise up to the cross-section "Gagarinskoye". It indicates that the perturbation of technogenic silts containing mercury occurs in this river section. The rise of mercury concentration in this section was also observed during the second stage of sampling when the level of water dropped almost to the summer level. Only during the third stage of sampling the length of section where contamination of river water by perturbed deposits of technogenic silts took place was decreased, i.e. concentration of mercury dropped along the section between "Kalininskoye" and "Gagarinskoye" that was caused by dilution and sedimentation of technogenic silts.

Even during the third stage when the water level dropped to the summer level the content of total mercury in surface water of the river in the section between "Bridge # 2" and "Mill dam" was 2 times higher than in autumn 2001. During the first stage of sampling the concentration of mercury in river Nura water was higher than detection limit of analytical method all along the river section downstream of Samarkand reservoir. The level of mercury concentration in outfall of Intumak reservoir remained constant (6-8 ng/l). On Apr 9 and Apr 18 the concentration of mercury dropped in 5 times after passing this reservoir and on Apr 30 the drop was in 3 times.

The concentration of dissolved species of mercury in surface water of river Nura did not exceed 10 ng/l and dropped together with the recession of the flood. The transport of mercury was occurred in suspended form together with redistributed technogenic silts (ash) by more than 90% and that was correct even for Main drain. Meanwhile, the concentration of mercury in perturbed suspended solids from the most polluted section of river was significantly lower (in 5 and more times) than the concentration of mercury in technogenic silts of riverbed and riverbanks depositions.

The results of mercury contamination in fish of river Nura

140 specimens of river fish belonged to the species most popular among local amateur fishermen (i.e. gudgeon, bream, roach, perch and ide) were caught in the river section between Main drain and village Sabyndy. The results of analysis of 20 samples of fish meat for total mercury are presented in Table 7. Except only 1 case all specimens contained mercury in concentrations

exceeding MAC_f (from 1 to 4 times more). The highest contents are registered for the samples from "Mill dam" and also for the reservoir of Samarka dam which is in agreement with the results of study conducted at 1998.

Conclusions

1. In autumn period the surface water of river Nura contains less mercury than MAC_{dw} all along the channel. However, the section of river contaminated with mercury in most extent is characterized by continuous leaching of mercury by surface water leading to the mercury movement downstream.
2. During the spring flood the level of mercury contamination of river Nura surface water increases and for some sections concentrations are higher than MAC_{dw}. The length of river section where the movement of mercury can be observed becomes extended as well.
3. During the spring flood the transport of mercury mainly occurred (by not less than 90%) in suspended form together with technogenic silts (ash).
4. Intumak reservoir is an effective settling pond even in its current conditions. It prevents the spread of mercury pollution downstream of the river Nura.
5. Despite the fact that level of mercury pollution is likely to be acceptable during the most periods of the year the content of mercury in fish of river is higher than sanitary standards for at least 150-kilometer section of the river downstream of Temirtau. The borders of this section are not defined.

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ANNEX

Table 1. Observation cross-sections (sampling points) investigated in the scope of the study of mercury contamination of surface water of river Nura basin in 2001-2002

Observation cross-section	The distance along the river Nura downstream from Samarkand dam (km)
1. Bridge on the Karaganda-Pavlodar motorway	Upstream 33
2. Bank of Samarkand reservoir, the city beach near telecom centre	Upstream 4.5
3. Bridge in Temirtau (bridge # 1)	1
4. Sedimentation lagoons of AO Karbid	
5. Main drain, outfall of AO Karbid wastewater pipe	
6. Main drain, the discharge of wastewater from sludge lagoons of AO Karbid	
7. Main drain, road bridge near village Chkalovo	
8. Main drain, inlet into river Nura	
9. Bridge on Karaganda-Astana motorway (bridge # 2, new)	5.3
10. Bank of river Nura near village Kalininskoye	8.1
11. Bank of river Nura near village Gagarinskoye	11.9
12. Bank of river Oshagandy near pumping station of village Andrennikovka	
13. “Mill” dam downstream of Oshagandy inlet	17.7
14. Bridge on Karaganda-Kievka motorway near village Tegiz-Zhol (bridge # 3)	21.6
15. Bank of river Nura near the school of village Rostovka	33.5
16. Bridge on Molodetskoye-Shakhan motorway (bridge # 4)	56
17. Bank of river Nura in the place of its cross with oil pipeline Pavlodar-Shymkent	74
18. Outfall of Intumak dam	90
19. Outfall of Samarka dam	130
20. Bank of river Nura, ford near village Tassuat	185
21. Road bridge near village Kievka (bridge # 5)	210
22. Bank of river Nura near village Akhmet-aul (former Entuziast)	260
23. Road bridge near village Romanovka (bridge # 6)	285
24. Outfall of Preobrazhenka dam	300
25. Bank of river Ishim, center of Astana	
26. Road bridge near village Birlik bridge # 7)	340
27. Outfall of dam near village Sabyndy bridge # 8)	375
28. Road bridge near village Kurgaldzhino (bridge # 9)	455

Table 2. Average water flows in Main drain and river Nura in 2001-2002 basing on the data of AO Karbid, Ispat-Karmet and KarGRES-1

Observation period	Water flom (m^3/s)				
	Main drain			Samarkand reservoir dam	Total in the cross-section of bridge # 2 (calculation)
	Discharge of Ispat-Karmet	Discharge of Karbid + sludge lagoons	Total (calculation)		
October 2001	0.821	0.097	0.918	3.000	3.9
November 1-10, 2001	1.042	0.075	1.117		
November 4-5, 2001				15.000	16.1

November 2001	1.032	0.101	1.133		
March 2002	0.966	0.076	1.041		
April 2002	1.060	0.076	1.136		
May 2002	0.948	0.076	1.024		

Table 3. Average water flows and water levels on river Nura at 2002

Observation date	Samarkand dam, data of KarGRES-1	Bridge # 2 (road Karaganda-Astana), calculated values	Hydostation Akmeshyt (former Zakharovka), data of Karaganda Hydromet	
	Average water flow (m3/s)			Water level (m)
01.03.2002				534
02.03.2002				535
03.03.2002				536
04.03.2002				538
05.03.2002			***9.0***	571
06.03.2002				580
07.03.2002			15.6	603
08.03.2002			49.3	656
09.03.2002			126.2	777
10.03.2002			133.2	788
11.03.2002			128.8	781
12.03.2002			125.6	776
13.03.2002			126.9	778
14.03.2002			129.4	782
15.03.2002			118.6	765
16.03.2002			109.7	751
17.03.2002			107.8	748
18.03.2002			79.2	703
19.03.2002			65.2	681
20.03.2002			***55.4***	674
21.03.2002			***67.5***	741
22.03.2002			***101.0***	774
23.03.2002			130.7	784
24.03.2002			***124.0***	791
25.03.2002			***147.0***	804
26.03.2002			***162.0***	829
27.03.2002			163.1	835
28.03.2002			170.1	846
29.03.2002			211.4	911
30.03.2002			267.3	999
31.03.2002			302.9	1055
01.04.2002	14.688	15.8	279.4	1018
02.04.2002	4.392	5.5	233.0	945
03.04.2002	1.944	3.1	199.3	892
04.04.2002	1.728	2.9	199.3	892
05.04.2002	1.728	2.9	194.2	884
06.04.2002	5.688	6.8	185.3	870
07.04.2002	6.048	7.2	181.5	864
08.04.2002	6.048	7.2	163.1	835

09.04.2002	6.048	7.2	***146.0***	808
10.04.2002	1.134	2.3	135.8	792
11.04.2002	0.432	1.6	125.6	776
12.04.2002	0.432	1.6	116.7	762
13.04.2002	4.212	5.3	107.8	748
14.04.2002	4.752	5.9	***119.0***	724
15.04.2002	4.752	5.9	81.7	707
16.04.2002	1.35	2.5	***68.9***	699
17.04.2002	0.54	1.7	75.4	697
18.04.2002	0.243	1.4	76.0	698
19.04.2002	0.216	1.4	75.4	697
20.04.2002	0.216	1.4	***86.8***	697
21.04.2002	0.216	1.4	72.8	693
22.04.2002	0.216	1.4	70.3	689
23.04.2002	0.216	1.4	68.4	686
24.04.2002	0.216	1.4	65.8	682
25.04.2002	0.216	1.4	***76.0***	675
26.04.2002	0.216	1.4	62.7	677
27.04.2002	0.216	1.4	58.8	671
28.04.2002	0.216	1.4	56.3	667
29.04.2002	0.216	1.4	55.7	666
30.04.2002	1.098	2.2	53.1	662
01.05.2002	1.728	2.8		
02.05.2002	1.728	2.8	***58.1***	653
03.05.2002	1.728	2.8		
04.05.2002	1.728	2.8		
05.05.2002	1.728	2.8		
06.05.2002	1.728	2.8		
07.05.2002	1.728	2.8		
08.05.2002	1.728	2.8		
09.05.2002	1.728	2.8		
10.05.2002	1.728	2.8		

Notes:

1. Measured values in column C are highlighted with bold-italic, the rest is calculated values.

2. The average water flow for the bridge # 2 is calculated basing on the data of Table 1.

Table 4. The results of total mercury analysis of the Nura and Ishim rivers surface water samples in November of 2001

N	Sampling location	Sampling date	1st sample ID	Total mercury in 1st sample (ng/l)			2nd sample ID	Total mercury in 2nd sample (ng/l)			Average concentration of total mercury (ng/l)	Notes
				1	2	Average		1	2	Average		
1	Bridge on the road Karaganda-Pavlodar	4.11.2001	H1	<2	<2	<2	H2	<2	<2	<2	<2	Sampling with bathometer from the bridge
2	Samarkand reservoir, near centre of telecommunication	5.11.2001	H19	3.601	3.112	3.357	H20	2.750	2.662	2.706	3	Sampling with bathometer from the boat station berth, 45 m from the bank
3	Bridge #1 (Temirtau)	4.11.2001	H3	2.888	2.088	2.488	H4	2.744	3.234	2.989	2	Sampling with bathometer from the bridge
7	Main drain, bridge near Chkalovo	5.11.2001	H15	523.8	522.7	523.3	H16	631.1	628.7	629.9	577	Sampling with bathometer from the bridge
8	Main drain, inlet into Nura	5.11.2001	H17	655.2	656.0	655.6	H18	647.2	663.4	655.3	655	Sampling with bathometer from the right steep bank
9	Bridge #2 (new)	4.11.2001	H11	350.9	347.0	348.9	H12	379.5	379.7	379.6	364	Sampling with bathometer from the bridge
10	Kalininskoe	5.11.2001	H13	111.6	111.7	111.6	H14	141.1	138.6	139.9	126	Sampling with bathometer from the right steep bank, 1m from the bank
11	Gagarinskoe	4.11.2001	H5	110.9	110.4	110.7	H6	114.7	114.8	114.7	113	Sampling with bathometer from the right steep bank near the pumping station, 3m from the bank

13	Mill dam	4.11.2001	H7	82.26	81.21	81.74	H8	76.88	77.38	77.13	79	Sampling with bathometer from the left bank. Outlet of rock dam.
14	Bridge #3 (Tegiz-Zhol)	4.11.2001	H9	96.06	95.51	95.78	H10	94.03	94.29	94.16	95	Sampling with bathometer from the bridge
15	Rostovka	5.11.2001	H21	41.82	41.84	41.83	H22	43.68	43.47	43.57	43	Sampling with bathometer from the right steep bank, 1m from the bank
16	Bridge #4 (Molodetskoe)	5.11.2001	H23	29.34	28.56	28.95	H24	26.76	27.21	26.98	28	Sampling with bathometer from the bridge
17	Oil pipeline	5.11.2001	H25	19.45	19.33	19.39	H26	20.56	19.41	19.98	20	Sampling with bottles from the right flat bank, 2m from the bank
18	Outfall of Intumak reservoir	6.11.2001	H27	4.010	3.358	3.684	H28	2.948	2.539	2.744	3	Sampling with bathometer from the small bridge on the discharge canal.
19	Outfall of Samarka reservoir	6.11.2001	H29	3.929	4.013	3.971	H30	3.234	3.398	3.316	3	Sampling with bathometer from the dam bridge.
21	Bridge # 5 (Kievka)	6.11.2001	H31	<2	<2	<2	H32	<2	<2	<2	<2	Sampling with bathometer from the bridge
23	Bridge # 6 (Romanovka)	6.11.2001	H33	<2	<2	<2	H34	<2	<2	<2	<2	Sampling with bathometer from the bridge
24	Dam of Preobrazhenka reservoir	6.11.2001	H35	<2	<2	<2	H36	<2	<2	<2	<2	The canal is out of order. Water level is low. Sampling with bathometer from the sluice dam.

25a	River Ishim in the inlet of Nura-Ishim canal near village Telmana, upstream of Astana	6.11.2001	H37	<2	<2	<2	H38	<2	<2	<2	<2	Sampling with bottles out of water stream runing out of the discharge pipe of the dam.
25	River Ishim, center of Astana	6.11.2001	H39	<2	<2	<2	H40	<2	<2	<2	<2	Sampling with bathometer from the small berth of boat station in the park on the left bank, 10 m from the bank.

Table 5. Levels of mercury concentration in river Nura water in November 2001

Sampling point ID	Sampling point location	Conventional distance from Samarkand dam downstream the river (km)	Sampling date	Average concentration of total mercury (ng/l)
1	Bridge on the road Karaganda-Pavlodar	-33	4.11.2001	<2
2	Samarkand reservoir, near centre of telecommunication	-4.5	5.11.2001	3
3	Bridge #1 (Temirtau)	1	4.11.2001	2
7	Main drain, bridge near Chkalovo		5.11.2001	577
8	Main drain, inlet into Nura		5.11.2001	655
9	Bridge #2 (new)	5.3	4.11.2001	364
10	Kalininskoe	8.1	5.11.2001	126
11	Gagarinskoe	11.9	4.11.2001	113
13	Mill dam	17.7	4.11.2001	79
14	Bridge #3 (Tegiz-Zhol)	21.6	4.11.2001	95
15	Rostovka	33.5	5.11.2001	43
16	Bridge #4 (Molodetskoe)	56	5.11.2001	28
17	Oil pipeline	74	5.11.2001	20
18	Outfall of Intumak reservoir	90	6.11.2001	3
19	Outfall of Samarka reservoir	130	6.11.2001	3

21	Bridge # 5 (Kievka)	210	6.11.2001	<2
23	Bridge # 6 (Romanovka)	285	6.11.2001	<2
24	Dam of Preobrazhenka reservoir	300	6.11.2001	<2
25a	River Ishim in the inlet of Nura-Ishim canal near village Telmana, upstream of Astana		6.11.2001	<2
25	River Ishim, center of Astana		6.11.2001	<2

Table 6. Levels of mercury concentration in river Nura water during the flood in April-May 2002

Sampling point No.	Sampling point location	Conventional distance from Samarkand dam downstream the river (km)	Sampling date	Average concentration of total mercury (ng/l)	Average concentration of total dissolved mercury (ng/l)	Average concentration of mercury in suspended solids (ng/l)	Average content of suspended solids (mg/l)	Average concentration of mercury in suspended solids (mg/kg)	pH	Temperature of water (^{0}C)	Temperature of air (^{0}C)
	First sampling replicaion										
1	Bridge on the road Karaganda-Pavlodar	-33	10.04.2002	2.00						4	5
2	Samarkand reservoir, near centre of telecommunication	-4.5	07.04.2002	2.56			28.1				
3	Bridge #1 (Temirtau)	1	13.04.2002	5.78			17.0			2	3
7	Main drain, bridge near Chkalovo		10.04.2002	260.28	4.02	184.00	9.8	18.8	7.26	18	
8	Main drain, inlet into Nura	3.5	13.04.2002	128.47							
9	Bridge #2 (new)	5.3	08.04.2002	304.39	10.50	203.50	14.8	13.8	7.24		
10	Kalininskoe	8.1	13.04.2002	894.46							
11	Gagarinskoe	11.9	13.04.2002	1043.56							
12	r. Oshagandy, near Andrennikovka		08.04.2002	4.18			83.6		7.06	3	
13	Mill dam	17.7	13.04.2002	824.17						2	3
14	Bridge #3 (Tegiz-Zhol)	21.6	08.04.2002	451.25	5.02	383.50	34.7	11.1	7.46	3	
15	Rostovka	33.5	09.04.2002	377.67							
16	Bridge #4 (Molodetskoe)	56	09.04.2002	161.96	4.40	116.50	34.6	3.4	7.56	3	
17	Oil pipeline	74	09.04.2002	38.20							
18	Outfall of Intumak reservoir	90	09.04.2002	7.93	2.33	11.50	28.8	0.4	7.46	2	

19	Outfall of Samarka reservoir	130	11.04.2002	12.79							
20	Ford near Tassuat	185	11.04.2002	8.70							
21	Bridge # 5 (Kievka)	210	11.04.2002	5.45					7.63	7	1
22	Akhmet-aul	260	11.04.2002	6.29							
23	Bridge # 6 (Romanovka)	285	11.04.2002	4.08			36.4			5	1
24	Dam of Preobrazhenka reservoir	300	11.04.2002	6.98							
25	river Ishim, center of Astana		12.04.2002	2.00							
26	Bridge # 7 (Birlik)	340	12.04.2002	4.74							
27	Bridge # 8 (Sabyndy)	375	12.04.2002	7.38							
28	Bridge # 9 (Kurgaldzhino)	455	12.04.2002	3.86							
	Second sampling replication										
1	Bridge on the road Karaganda-Pavlodar	-33	19.04.2002	2.00						4	0
2	Samarkand reservoir, near centre of telecommunication	-4.5	21.04.2002	2.00							
3	Bridge #1 (Temirtau)	1	21.04.2002	2.21							
7	Main drain, bridge near Chkalovo		20.04.2002	180.35	22.36	125.50	11.5	11.0			
8	Main drain, inlet into Nura	3.5	21.04.2002	444.24							
9	Bridge #2 (new)	5.3	20.04.2002	153.72	4.95	122.50	11.7	10.5		7	2
10	Kalininskoe	8.1	19.04.2002	253.53						7	-1
11	Gagarinskoe	11.9	19.04.2002	343.50						6.5	-1
12	r. Oshagandy, near Andrennikovka		19.04.2002	2.00						4	-1
13	Mill dam	17.7	19.04.2002	205.80						6.5	-1
14	Bridge #3 (Tegiz-Zhol)	21.6	20.04.2002	121.93	2.00	118.00	10.4	11.4		5	2
15	Rostovka	33.5	18.04.2002	110.30							
16	Bridge #4 (Molodetskoe)	56	18.04.2002	91.83	4.76	89.50	23.5	3.8		6	8
17	Oil pipeline	74	18.04.2002	27.54							
18	Outfall of Intumak reservoir	90	18.04.2002	5.45	2.00	7.15	11.7	0.6		4	8
19	Outfall of Samarka reservoir	130	22.04.2002	7.74			48.6			5	9
20	Ford near Tassuat	185	22.04.2002	3.07						6	14
21	Bridge # 5 (Kievka)	210	22.04.2002	2.00			18.9			6	13
22	Akhmet-aul	260	22.04.2002	3.44						6	13
23	Bridge # 6 (Romanovka)	285	22.04.2002	2.11			56.0			6	10
24	Dam of Preobrazhenka reservoir	300	22.04.2002	2.26							
25	river Ishim, center of Astana		22.04.2002	2.00						7	12
26	Bridge # 7 (Birlik)	340	17.04.2002	2.00							

27	Bridge # 8 (Sabyndy)	375	17.04.2002	2.00			32.0			7	7
28	Bridge # 9 (Kurgaldzhino)	455	17.04.2002	2.00			262.4			5	10
	Third sampling replication										
1	Bridge on the road Karaganda-Pavlodar	-33	29.04.2002	2.00						9	11
2	Samarkand reservoir, near centre of telecommunication	-4.5	29.04.2002	2.00							
3	Bridge #1 (Temirtau)	1	29.04.2002	2.00						7.5	13
4	Sedimentation lagoons of Karbid			228.77							
5	Main drain, Karbid discharge			998.60							
6	Main drain, discharge of sludge lagoon			125.27							
7	Main drain, bridge near Chkalovo		29.04.2002	159.28	12.75	118.50	8.2	14.4		18	16
8	Main drain, inlet into Nura	3.5	29.04.2002	496.72							
9	Bridge #2 (new)	5.3	29.04.2002	120.96	2.13	146.35	9.3	15.8		10	11
10	Kalininskoe	8.1	29.04.2002	291.61						10	13
11	Gagarinskoe	11.9	29.04.2002	198.82						10	12
12	r. Oshagandy, near Andrennikovka		29.04.2002	2.00						9	12
13	Mill dam	17.7	30.04.2002	259.44						10	19
14	Bridge #3 (Tegiz-Zhol)	21.6	29.04.2002	153.39	3.22	150.00	13.2	11.4		11	20
15	Rostovka	33.5	30.04.2002	87.55							
16	Bridge #4 (Molodetskoe)	56	30.04.2002	63.50	3.72	53.00	13.5	3.9		9	16
17	Oil pipeline	74	30.04.2002	17.94							
18	Outfall of Intumak reservoir	90	30.04.2002	6.20	2.17	6.30	10.9	0.6		9	17
19	Outfall of Samarka reservoir	130	02.05.2002	8.24			22.9			10	17
20	Ford near Tassuat	185	04.05.2002	3.36						11	21
21	Bridge # 5 (Kievka)	210	04.05.2002	2.94			19.3			11	22
22	Akhmet-aul	260	04.05.2002	2.58						12	22
23	Bridge # 6 (Romanovka)	285	04.05.2002	2.41			58.5			13	23
24	Dam of Preobrazhenka reservoir	300	04.05.2002	2.93							
25	river Ishim, center of Astana		04.05.2002	2.00						15	20
26	Bridge # 7 (Birlik)	340	05.05.2002	2.00						11	13
27	Bridge # 8 (Sabyndy)	375	05.05.2002	2.00			15.0			12	18
28	Bridge # 9 (Kurgaldzhino)	455	05.05.2002	2.00			16.0			11	15

Table 7. Levels of mercury concentration in fish of river Nura caught in April-May 2002

Sample ID	Sampling date	Sampling location	Conventional distance from Samarkand dam downstream the river (km)	Species	Linear size of fish (length of body without tale/full length of body) (mm)	Weight (g)	Age (years)	Concentration of mercury in 1st sub-sample, (mg/kg)	Concentration of mercury in 2nd sub-sample, (mg/kg)	Average concentration of mercury, wet weight (mg/kg)
8	10.04.2002	Main drain inlet	3.5	bream	170/215	94.9	7	0.352	0.436	0.394
18	10.04.2002	Nura near main drain inlet	3.5	roach	165/201	100.4	5-6	0.070	0.076	0.073
23	10.04.2002	Nura near main drain inlet	3.5	bream	185/240	138.6	8	0.424	0.421	0.423
44	10.04.2002	Nura near main drain inlet	3.5	gudgeon	98/117	17.2	3	0.398	0.411	0.404
48	10.04.2002	Nura near main drain inlet	3.5	gudgeon	103/123	24.0	3-4	0.241	0.268	0.255
68	01.05.2002	Mill dam	17.7	perch	115/140	34.7	6	1.081	1.109	1.095
69	01.05.2002	Mill dam	17.7	perch	120/145	38.1	8	0.676	0.696	0.686
70	01.05.2002	Mill dam	17.7	perch	137/161	42.3	8	1.162	1.128	1.145
71	01.05.2002	Mill dam	17.7	perch	117/133	26.3	5	1.082	1.166	1.124
72	01.05.2002	Mill dam	17.7	perch	118/133	37.2	5-6	0.460	0.637	0.549
1	08.04.2002	Bridge # 3	21.6	roach	177/220	169.5	5-6	0.405	0.399	0.402
4	08.04.2002	Bridge # 3	21.6	roach	140/176	63.9	7	0.167	0.371	0.269
6	08.04.2002	Bridge # 3	21.6	roach	151/192	91.0	7	0.497	0.569	0.533
81	30.04.2002	Spillage of Intumak reservoir	90	perch	113/121	16.6	6	0.557	0.549	0.553
83	30.04.2002	Spillage of Intumak reservoir	90	perch	122/143	38.6	10-11	0.377	0.359	0.368
87	30.04.2002	Spillage of Intumak reservoir	90	perch	150/170	54.2	12	0.563	0.556	0.559
89	30.04.2002	Spillage of Intumak reservoir	90	perch	136/161	48.3	7-8	0.497	0.555	0.526
104	02.05.2002	Spillage of Samarka reservoir	130	perch	180/215	106.4	7-8	0.842	0.875	0.858

110	02.05.2002	Spillage of Samarka reservoir	130	perch	142/173	55.6	5	0.413	0.476	0.445
115	02.05.2002	Spillage of Samarka reservoir	130	perch	125/148	38.7	5-6	0.556	0.562	0.559