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ASBESTOS IN WATER SOURCES OF THE BAZHENOVSKOYE CHRYSOTILE ASBESTOS DEPOSIT

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Abstract. The paper provides measurements of asbestos fiber levels in water sources from the area of the Bazhenovskoye chrysotile asbestos deposit. All study water samples contained asbestos fibers at concentrations one to three orders below the values standardized in the USA ($7 \cdot 10^6$ fibers/liter). All the identified fibers belonged to chrysotile asbestos and no amphibole asbestos, such as tremolite asbestos, has been identified. The anthropogenic load of asbestos fibers in Asbest City's environment is increasing in the volume of $5.770 \cdot 10^{14}$ fibers/liter or 10.2 kg of chrysotile asbestos.
The authors consider it advisable to continue studies to measure asbestos levels in the water sources in the areas located in the vicinity of other Russian asbestos deposits.

Key words:
Bazhenovskoye chrysotile asbestos deposit, Water source, Chrysotile asbestos, Fiber concentrations

INTRODUCTION

The presence of asbestos in the waters of Canadian cities was first reported in 1971 [1]. Since then the surveys of asbestos concentrations in various water supplies have been conducted in Canada [2–4], Germany [5,6], the United Kingdom [7], the USA [8–10] and other countries. Until recently, Russia did not carry out such research, despite the fact that our country has first-rate sources of asbestos in the world. Just in the Urals more than hundred deposits and developments of chrysotile and amphibole asbestos are prospected [11]. The world first-rate Bazhenovskoye, Kiembaiskoye and Dgetygarinskoye chrysotile asbestos deposits are mined.

At a first stage the Bazhenovskoye chrysotile asbestos deposit was selected as a subject of investigations (Sverdlovsk region). In this article there are cited preliminary results of determination of asbestos in the waters of the deposit region.

MATERIALS AND METHODS

The sampling was made from the water-supply of Asbest City, situated near the deposit of asbestos; the groundwater in the place of fault of the asbestos pit's pumping shaft; the superficial water from the spring and the river in the suburbs of Asbest City; and the pit-face of deep horizons of the quarry. The tap and distilled water of Ekaterinburg was taken for comparison.

Depending on water turbidity from 50.0 to 200.0 ml of investigated water was filtered through the cellulose ester membrane filters (Millipore MF, 0.45 micrometer pore

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size). Dried filters were bisected. One half of the filter was used for counting and sizing of mineral fibers which were enumerated using phase contrast optical microscopy (PCOM) (LEICA DMLS) according to AIA Counting Criteria (Recommended Technical Method No 1, RTM 1). The second half was used to identify mineral fibers by scanning electron microscopy (SEM) (JEM-2000 EX) combined with X-ray microanalysis system (LINK AN-10000).

Thirty one determinations of number concentrations of asbestos fibers, and 19 determinations of size distribution of suspended particles were carried out with the PCOM method. Qualitative structures of 19 samples were also studied with the SEM method.

RESULTS

The investigation revealed that all study water sources of the Bazhenovskoye deposit region concentration fibrous particles related to chrysotile asbestos by their mineral composition. Amphibole asbestos, including tremolite asbestos, was found in none of the studied samples. The concentration of asbestos fibers varied within a wide range from 0.098 • 10^5 fibers/liter (the river near Asbest City) to 4.800 • 10^5 fibers/liter (Asbest City tap water) (Table 1). The concentration of fibers longer than 5 μm ranged from below the limit of detection, using the PCOM method (the drainage of "North" pit) to 4.800 • 10^5 fibers/liter (Asbest City tap water). The concentration of asbestos fibers with length up to 5 μm (respirable fraction) in two superficial sources (the river and the pit-face of a quarry, depth mark – 43 m) was from zero to 0.753 • 10^5 fibers/liter (the drainage of "Central" pit). The concentration of respirable asbestos fibers in water samples from Asbest City water supply varied from 2.700 • 10^5 fibers/liter to 4.800 • 10^5 fibers/liter; the mean values was 3.433 • 10^5 fibers/liter. In the water of Ekaterinburg the values ranged from 0.159 • 10^5 fibers/liter to 0.220 • 10^5 fibers/liter with the average of 0.184 • 10^5 fibers/liter. Asbestos was not found in distilled water.

The studies of dispersive constitution revealed that the majority of particles suspended in water were represented mainly by granular particles (99.06–99.86%); among them there were particles sized up to 5 μm (96.27–99.70%). The concentration of fibrous particles was very low in all study water sources. Fibers formed 0.14–0.55 % of all suspended particles in groundwater of drainage pits. In surface waters (the river and the spring near Asbest City) they made 0.19% and 0.26%, respectively. And only in water samples from the pit-face the concentration of fibers reached 0.94%. The concentration of fibers longer than 5 μm varied within a wide range: in water samples from underground sources it ranged from 9.82 to 44.58%; in surface waters (pit-face and the river) it was 100.00%, and in the spring water it accounted for 41.55 % (Table 2).

Table 1. Number concentrations of asbestos fibers, × 10^5 fibers/liter

Source	Fibrous particles (μm)					
	<5		>5		Total	
	Range	Average	Range	Average	Range	Average
The pit-face of a deep horizons of the quarry, depth mark – 43 m	Not detected		0.196–0.441	0.319	0.196–0.441	0.319
"North" drainage pit	0.147–0.392	0.245	0.000–0.049	0.025	0.147–0.441	0.270
"Central" drainage pit	0.715–0.753	0.734	0.245–0.260	0.255	0.960–1.013	0.989
"South" drainage pit	0.196–0.294	0.229	0.049–0.098	0.082	0.245–0.392	0.310
The river in the suburbs of Asbest City	Not detected		0.098–0.125	0.106	0.098–0.125	0.106
The spring in the suburbs of Asbest City	0.147–0.961	0.172	0.098–0.147	0.123	0.246–0.343	0.294
Asbest City tap water	Not determined		2.700–4.800	3.433	Not determined	
Ekaterinburg City tap water			0.159–0.220	0.184		
Distilled water			Not determined			

Table 2. Size distribution of asbestos fibers in water (%)

Source	Percent of fibrous particles	Fibrous particles (μm)						
		<5	5–10	10–20	20–30	30–40	40–50	>50
The pit-face of a deep horizons of the quarry, depth mark – 43 m	0.94	—	49.08	15.74	20.37	7.41	3.70	3.70
"North" drainage pit	0.34	90.18	3.57	—	—	6.25	—	—
"Central" drainage pit	0.55	74.10	—	4.23	6.67	10.83	4.17	—
"South" drainage pit	0.14	55.42	41.46	—	—	3.12	—	—
The river in the suburbs of Asbest City	0.19	—	66.67	—	16.67	–	16.67	—
The spring in the suburbs of Asbest City	0.26	58.45	16.88	8.44	5.41	8.44	—	2.38

Table 3. Contents of asbestos pumped out from three drainage pits

Drainage pit	Fibrous particles (mm)					
	<5		>5		Total	
	Number of fibers (10^{14}/year)	Mass of fibers (kg/year)	Number of fibers (10^{14}/year)	Mass of fibers (kg/year)	Number of fibers (10^{14}/year)	Mass of fibers (kg/year)
"North"	0.482	0.3	0.049	0.2	0.531	0.5
"Central"	3.144	1.9	1.092	6.7	4.236	8.6
"South"	0.738	0.3	0.265	0.8	1.003	1.1
Total	4.364	2.5	1.406	7.7	5.770	10.2

From three drainage pits ("North", "Central" and "South") about 10 million cubic meters of water were pumped out annually, which contained $5.770 \cdot 10^{14}$ fibers or 10.2 kg of chrysotile asbestos (Table 3). The amount of chrysotile asbestos fibers longer than 5 μm was $1.406 \cdot 10^{14}$ fibers or 7.7 kg of chrysotile asbestos.

DISCUSSION

The Bazhenovskoye chrysotile asbestos deposit consists of distinguished by size and shape asbestos deposits and lumps of non-asbestos strata. Asbestos is mined in open pit-faces at a depth of about 300 m (depth mark – 70 m). Waters, formed by snow thawing, rains and subsoil waters accumulate in pit-faces of deep horizons of the quarry. Superficial and ditch waters come by drains through sumps and funnels to the water intake pits, and then to the lodgment. Drainage from the lodgment goes to the surface. Drainage pits "South", "North" and "Central" are used for dehumidification of the quarry. The deposit is found at 280 m over the sea level, so the water sampling was made from depth (horizon); 360 m (horizon –80 m); 400 m (horizon –120 m); and 270 m (horizon +10 m) from the surface of deposit.

As evident from the data cited earlier, summary asbestos concentrations in water of the pit-face deep horizons of drainage pits "South" and "North" were about the same and made up $0.319 \cdot 10^5$, $0.310 \cdot 10^5$ and $0.270 \cdot 10^5$ fibers/liter, respectively. All fibers from the pit-face water samples were longer than 5 μm, while the fibers from the drainage pits mentioned earlier were mostly up to 5 μm (55.42–90.18%). It is necessary to mention that the concentration of asbestos fibers was 2.8–6.7 times lower in overflowed waters of drainage pits, passing through the rocks. It is likely that fibers longer than 5 μm impeded to a greater extent. At the same time, the concentration of asbestos fibers in waters of the "Central" pit, collecting water in the zone of active asbestos mining, was 3.1 times higher than that in the pit-face water samples, with concurrent 1.7 times lower of total fibre concentration in a number of particles suspended in water.

The river in the suburbs of Asbest City rises from a marsh, in which rocks free from asbestos, are falling. That is why

asbestos concentration in it is about 3 times lower than in the water of drainage pits. The concentration of asbestos fibers was 2.7 times lower in the spring than in the river, but on the whole at the expense of up to 5μm fibers.

For Asbest City water supply groundwater is used. To the district of the city, where water samples were taken, water comes from drains through the asbestos rocks. That is why the asbestos concentration in tap water is high.

CONCLUSIONS

1. All studied superficial and groundwater sources of the Bazhenovskoye deposit district contain chrysotile asbestos fibers.
2. All study water samples were found to contain longer than 5 μm asbestos fibers at concentrations one to three orders below the values standardized in the USA ($7 \cdot 10^6$ fibers/liter) [12].
3. Taking into consideration the resolution of PCOM method by which about 2.4% of all fibers could be determined, the actual concentrations can be as much on the whole at the expense of up to 5 μm fractions [13].
4. The anthropogenic load of asbestos fibers in the environment of Asbest City is increasing in the volume reaching $5.770 \cdot 10^{14}$ fibers/liter or 10.2 kg of chrysotile asbestos.
5. The authors consider it advisable to continue studies to measure asbestos levels in the water sources in the areas located in the vicinity of other Russian asbestos deposits.

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