Journal of Environmental Sciences (China) Vol. 3, No. 3, pp. 105–112, 1991 ISSN 1001–0742

Mercury pollution and control in China

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(Received November 2, 1990)

Abstract——Before 1970s the Second Songhua River and Ji Canal of China had been polluted seriously by mercury. During peak pollution period, mercury levels in water, sediment and fish body of these rivers were close to or even higher than that of famous Minamata Bay of Japan. Some residents who live near to the polluted rivers were affected and the methyl mercury values in their blood, hair and urine were higher than normal people obviously. Since the fish had decreased even vanished in these rivers, so the food chain that transfers mercury to human also was out off almostly. However, nervous symptoms of Minamata disease were discovered among fisherman who had eaten more fishes. This report relates the stories about the mercury pollution of the Second Songhua River and Ji Canal.

Keywords: mercury pollution; Minamata disease; food chain.

Most serious mercury polluted areas in China are the Second Songhua River and Ji Canal. The comparison of mercury levels of water, sediment and fish body among the Second Songhua River, Ji canal and Minamata Bay of Japan is as Table 1. This report mainly introduces the situation of pollution and control on Second Songhua River and Ji Canal.

The Second Songhua River is the biggest branch of Songhua River. This river accepts waste water which is discharged from carbide workshop and dye workshop of Jilin Chemical Industrial Company. The waste water of these workshops had been the biggest mercury sources of this river, and 93.6% of total mercury and 100% of methylated mercury had been discharged by these workshops. About 500 km of lower reaches from these workshops had been polluted in different levels. From 1958 to 1973, about 100 tons of mercury had been discharged to the river, and most parts of the mercury were settled with sediment on the river bed, and are transported by water continuously. The position of the reach from Jilin to Harbin of Songhua River is as Fig. 1

Since 1958, mercury acceptance of the Second Songhua River was increasing, and in the period 1969–1976, mercury acceptant values of total mercury and methyl mercury

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increased up to theirs peak values that are 30 kg / day and 1500 g / day, respectively. After 1977 mercury pollution was decreasing, during 1977 – 1982, total mercury and methyl mercury acceptant values of this river were about 3 kg / day and 200 g / day, respectively. The main pollution source was shut off at 1983, after it total and methyl mercury acceptant values decreased to 0.2 kg / day and 3 g / day, respectively.

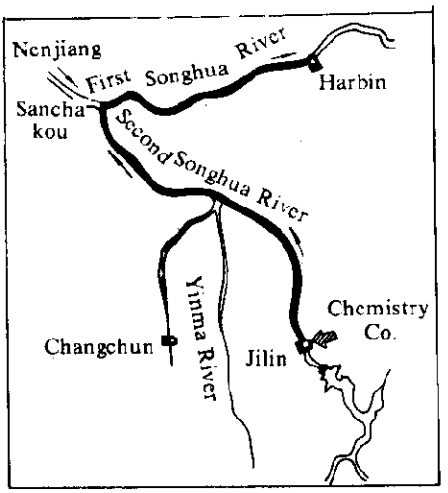

Fig. 1 The position of the reach from Jilin to Harbin of Songhua River

Table 1 Comparison of mercury level among the Second Songhua River, Ji Canal and Minamata during peak pollution period

Samples	Second Songhua River	Hangu Reach of Ji Canal	Minamata Bay of Japan
In water			
Total mercury, μg / L	2.3 – 55.0	0.24 – 23.5	1.6 – 3.6
Methyl mercury, μg / L	0.03 – 0.70	0.002 – 0.064	
In sediment			
Total mercury, mg / kg	7.7 – 440.0	1.8 – 845.0	7.2 – 801.0
Methyl mercury, mg / kg	– –	– –	
In fish body			
Total mercury, mg / kg	0.03 – 3.24	0.29 – 3.40	1.00 – 29.89
Methyl mercury, mg / kg	0.022 – 1.62	0.21 – 2.55	0.062 – 0.440

Mercury level in river water of course related to mercury discharge. During the peak pollution period total and methyl mercury were 55 μg / L and 0.7 μg / L respectively near to the discharge exit. In a 23 km lower reach of the river from the discharge exit, total and methyl mercury were 2.3 −20 μg / L and 0.03 −0.13 μg / L (Pan, 1982). Total mercury values were higher than the values 1.6 −3.6 μg / L of Minamata Bay.

In a 3 km reach lower to the discharge exit, maximum mercury contained in sediment was 440 mg / kg; average of it was 100.6 mg / kg (Pan, 1982). Mercury polluted sediment had extended to Harbin that is located about 500 km lower reach from Jilin.

The fishery of this river was destroyed by mercury pollution. Many fishing grounds closed down; fisherfolk changed their professions. Such as in a fishing ground which is located 150 km lower to Jilin, fish product of 1977 was only 0.25% of that of 1958. During the peak period of pollution, fish had decreased to the vanishing point. The vanishing of fish cut off the food chain almostly, so the opportunity of methyl mercury transferring to human body also decreased greatly. However, almost all living fish were toxic fish, although the fish were so few. According to a report of 1975, maximum and average total mercury in fish body of Second Songhua River were 3.24 mg / kg and 0.74 mg / kg; and maximum and average of methyl mercury were 1.62 mg / kg and 0.44 mg / kg (Pan, 1982). Methyl mercury contained in carnivorous fish which are caught at 110 −300 km away from pollution source was 14 times higher than the control fish which are caught from clean researvoir. Omnivorous fish was 9 times highter than the control fish. Herbivorous fish was 32 times higher than the control fish (Wang, 1983).

Residents who live along the river were suffered from the mercury pollution. Some residents who live 300 −400 km lower reaches to the pollution source and have eaten river fish were affected by the mercury. Methyl mercury values in their blood, hair and urine were higher than normal people several decade times and even hundred times.

Five fishermen were examined systematically by Jilin Medical University during Dec. 1975 to Jan. 1976 (Pan, 1982). These fishermen had eaten some more river fish. Four of them appeared light nervous symptoms that are like to chronic Manamata disease.

Since 1976, mercury pollution of Second Songhua River was paid attention by more government cadres. Some control measures were adopted, and mercury pollution of this river has been improved step by step.

Important measures are pollution source controls. Since 1976, waste water which contains mercury was treated by Na_2S precipitation, Fe, Cu power reduction, and actived carbon adsorption. As well as process improvement was also adopted. During 1977, mercury discharge was decreasing. After 1978, waste water was treated with coke filtration and treating apparatus were improved and entended. Purification effect on inorganic mercury was apparent, but was not so good on methyl mercury. In 1982, at last the new process which does not use mercury was adopted, the sources of mercury pollution was

cut off.

After 1983, total mercury of river water had decreased to light level or no pollution level (Wang, 1986), and methyl mercury of river water had decreased to 0.1 −0.4 ppt level. Shoals of fish appeared again. Methyl mercury value of fish body had also decreased to < 100 ppb. Total mercury of sediment that near by discharge exit decreased to 12 ppm. Average methyl mercury in sediment of the whole lower reaches decreased to less than 1 ppb.

Mercury in sediment and fish body decreasing considerably fast indicated that there is certain self-purification ability in nature. However, according to the transport mechanism, experts estimate 10 −20 years of time is necessary for mercury in sediment vanishing completely by natural self-purification. Some people suggest cleaning the sediment of polluted reaches by dredge engineering. But the cost of dredge and the cost of sludge treatment are tremendous, so it is difficult to realize.

Appearing of fish shoals also recovers the potential passage which mercury transports from fish body to human body. So the monitoring work of river water, sediment and fish body is strengthened, and epidemic mercury disease surveying is carried extensively in the residents lived along the river, to supervise the developing situation of the polluted reaches.

The lower reach of Ji Canal is coastal plain region called Hangu Region. Here Ji Canal is a tidal river, gentle and meandering, and the water flows slowly. At 1968, a tide control gate was constructed at estuary, then the water flows more impededly, and the river became a half closed water body. This situation makes the mercury pollution which is caused by a chlorine-alkaline workshop of Tianjin Chemical Company is limited in a 30 km reach. The position of polluted reach of Ji Canal is as Fig. 2.

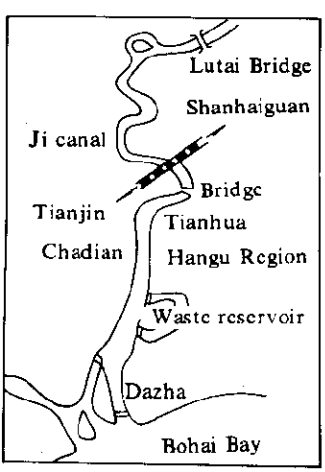

Fig. 2 The polluted reach of the lower reach of Ji Canal

The variation of mercury level distribution in sediment sampled along the upper reach and the lower reach of discharge exit of the chlorine-alkaline workshop is as Fig. 3 (Lin, 1984). The chlorine-alkaline workshop started at 1958. Before 1971 all wastes includes waste water contained mercury and waste sludge contained mercury were discharged into Ji Canal. After 1972, waste sludge that contains mercury has not been discharged to the Ji Canal. From 1977, a water treating system that separates clean and dirty water is operated, mercury pollution of Ji Canal has been improved.

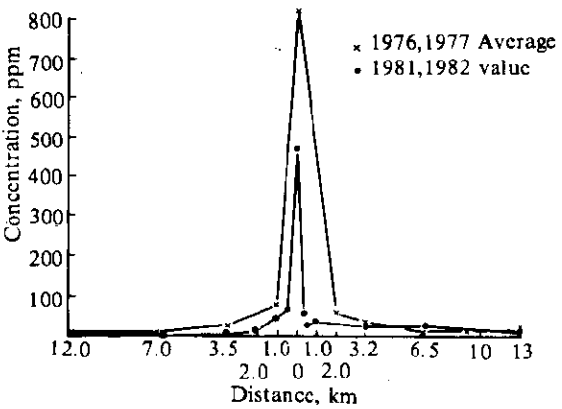

Fig.3 Variation of mercury level distribution in sediment of the lower reach of Ji Canal

During 1957 to 1977, about 200 tons of mercury had been discharged into Ji Canal. In the peak pollution period, average total mercury value in water of whole Hangu Region reach was 5.1 μg / L, and maximum value at the discharge exit of Tianjin Chemical Company was 23.5 μg / L (Zhang, 1981). The thickness of polluted sediment that near the discharge exit was about 1.5m. Maximum mercury value in sediment was 800 ppm. Mercury levels in water and sediment had approached or surpassed the levels of Minamata.

Total mercury values in fish body were 0.29 – 3.40 mg / kg, and 70% of total mercury was methyl mercury (Tang, 1984). Mercury values in fish body had gone beyond the standard of China three times. So the Tianjin Municipal Government prohibits catching fish in Hangu Region. Mercury contained in plants which grow in the serious polluted flood land was quite increased. But on the crops which grow in the farm, no bad effect had been discovered.

There is not professional fisherman in Hangu Region. Some floating fishermen came to Hangu Region caught and ate fish some short time. Some of fishermen's hair was examined. Mercury values of their hair were related to their staying and fish catching time in Hangu Region. In 1978 and 1979, hair mercury of residents lived in Hangu Region were examined. Mercury levels in their hair were higher apparently than the control region. In 1980, and 1981, health

check had been done for residents of Hangu Region, no apparent effect had been discovered.

Since eliminating the pollution of the Ji Canal was suggested by the State Council, three fields of work were carried forward, that are (1) controlling pollution sources, decreasing pollutant emission; (2) Construction of waste water pool and other treating apparatus, separating clean and dirty water; (3) Investigation on the measures that reduce the pollutant in river sediment.

Table 2 Partial examination results of 5 fishermen (Pan, 1982)

Name	Sex	Age	Fishery standing, year	Hair style	Total hair mercury before hospitalizing, Oct., 1975, ppm
Pan Yunxian	Male	56	30	Long parted	98.0
Chang Wanzai	Male	51	28	Bareheaded	76.0
Chang Shizai	Male	55	9	Bareheaded	68.0
Chen Jenlin	Male	45	4	Bareheaded	41.5
Ho Enzai	Male	58	25	Short parted	53.0

Name	Date of hair Sampling	Hair mercury, ppm		
		Total mercury	Methyl mercury	Organic mercury
Pan Yunxian	Dec. 31, 1975	70.0	51.5	
	Jan. 23, 1976	84.0		64.0
Chang Wanzai	Dec. 31, 1975	90.0	69.0	
	Jan. 23, 1976	74.0		54.0
Chang Shizai	Dec. 31, 1975	84.0	64.5	
	Jan. 23, 1976	52.0		38.0
Chen Jenlin	Dec. 31, 1975	90.0	60.0	
	Jan. 23, 1976	44.0		30.0
Ho Enzai	Dec. 31, 1975	96.0	51.5	
	Jan. 23, 1976	70.0		50.0

Table 2 (continued)

Name	Date of blood and urine sampling	Blood mercury, ppb	
		Total mercury	Methyl mercury
Pan Yunxian	Jan. 4, 1976	340	249
	Jan. 12, 1976	270	199
	Jan. 19, 1976	220	174
Chang Wanzai	Jan. 4, 1976	280	244
	Jan. 12, 1976	210	207
	Jan. 19, 1976	190	171
Chang Shizai	Jan. 4, 1976	180	144
	Jan. 12, 1976	150	122
	Jan. 19, 1976	140	65
Chen Jenlin	Jan. 4, 1976	300	141
	Jan. 12, 1976	130	94
	Jan. 19, 1976	130	89
Ho Enzai	Jan. 4, 1976	260	169
	Jan. 12, 1976	230	136
	Jan. 19, 1976	160	115

Name	Urine total mercury, ppb	Main clinical symptoms		
		Obstruction to sensory ending	Reduction of centripetal visual field	Nervous hearing disorder
Pan Yunxian	6.6			
	8.4	−	−	+
	8.4			
Chang Wanzai	14.4			
	12.0	+	−	+
	10.4			
Chang Shizai	20.4			
	22.5	+	+	+
	24.0			
Chen Jenlin	26.0			
	25.5	+	−	+
	24.0			
Ho Enzai	15.2			
	14.5	−	−	−
	10.2			

After 1977, by the control of pollution source and water separating system, about 90% of mercury pollution was eliminated. The quality of canal water had been improved. Mercury level of water that nears to discharge exit was about 1 −3 ppb, other positions decreased to less than 1 ppb. Mercury level in fish body had been decreased year by year. Area of serious polluted sediment had reduced and narrowed. But there is still about 40 tons mercury in the sediment. The mercury in sediment is the main eliminating object (Table 2).

According to a estimation, during 1976 to 1982, about 20 tons mercury was transported from Ji Canal into Bohai Sea (average amount was 2.8 tons/year), included 17 tons that is carried by mud and sand, and 2.9 tons that is carried by water. According to simulated calculation by computer, when mercury level in sediment is 100 ppm, mercury transporting from canal to sea will be about 2 tons / year, and 20 −30 years of time is necessary to decreasing the mercury level to 25 ppm (Pan, 1982; Lin, 1984b). The area which sediment is polluted seriously is only 500 −700 m along the river. Now the pollution source is shut down basically, and monitoring work on water quality is strengthened, it is expected that the mercury pollution will decrease step by step, and the water quality will recover as well.

REFERENCES

Lin Yuhuan, Chinese Journal of Environmental Science, 1984a, 5(4): 9
Lin Yuhuan, Chinese Journal of Environmental Science, 1984b, 5(5): 25
Pan Yunzhou, China Environmental Sciences, 1982, 2(2): 49
Tang Yijian, Comment on Environmental Studies in China, 1984, 5(2): 1
Wang Shuhai and Wang Renhua, China Environmental Sciences, 1983, 3(4): 18
Wang Shuhai, Chinese Journal of Environmental Science, 1986, 7(2): 73
Zhang Shen, Acta Scientiae Circumstantiae, 1981, 1(4): 349