MERCURY POLLUTION FROM SMALL GOLD MINES IN CHINA

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Abstract. Small scale gold mining activity in some mountainous areas of China has caused a series of Hg pollution problems. Preliminary study indicated that impacts of Hg pollution on the surrounding environment, air, water and soil are dramatic, and human contamination requires attention.

1. Introduction

Gold mining activity in a developing country such as China plays an important role in economic progress. The production of gold in China increases annually at almost 10% in recent years. In 1995 China produced 105 tons of gold, about one-third of which was from small-scale mines. Those small scale gold mines were located in China's mountainous areas, and their distribution is shown in Figure 1.

Figure 1. The distribution of small scale gold mines in China

The distribution of gold mines from the north to the south part of China demonstrates the regional difference in mineral types. These are: alluvial ore, rock ore, and co-existing ore. The alluvial gold mineral is mainly exploited by individuals, and about half of rock gold mineral and co-existing gold mineral were mined by individuals and collective units (comparing with those by national units). Where individuals and collective units were

short of funds, equipment and techniques, they usually exploited small gold mines with simple tools and extracted gold with Hg amalgamation. Typically, there are two types of gold extraction processes of Hg amalgamation as shown in Figure 2.

a. Hg amalgamation plus flotation, 50T/d

b. Hg amalgamation, 10T/d

Figure 2. Process of small scale gold mining

Hg pollution from small gold mining activities seemed to be serious in China but little data existed. The investigation on the use of Hg in gold mining and its environmental problems in China was initiated by SCOPE CHINA/CAST in 1993-1994. Small scale gold mining in many mountainous areas, such as Jilin, Hebei, Henan, Shandong, Shanxi, Hunan, Jiangxi, Sichuan, Hainan Province was popular in earlier 90s', and caused Hg pollution. The concentration of Hg in field air, water, tailings, and human bodies exceeded tens times background. Dexing County, Jiangxi Province was taken as one site to show such problem.

2. Case study

Dexing County of Jiangxi Province is one of the sites located in south China which is abundant in non-ferrous mineral resources mixed with Au ores. It had around 200 small scale gold mines using Hg amalgamation to extract gold in 1990-1995 as shown in Figure 3. As there were no special workplaces, individuals and collective units usually extracted gold in their living houses, and caused Hg pollution to the surrounding environment of the villages and impacts on the villagers.

Figure 3. Small scale gold mining in Dexing County, Jiangxi Province, China

A general survey was undertaken in two villages named Shangluo and Zhangjiaban in Dexing County. Samples were taken from 4 families near Jishui River (Figure 4). The villagers transported gold ore from mines to their houses, then used their houses as workrooms to extract gold. The layout of the typical houses in one of the families was shown in Figure 5.

Air samples were collected by GS-« 2 » Type Sampler with gold wire, 1.5 m above the ground at 0.5L/min, 60 minutes for each sample (NEPA, 1989). Hg was determined by YYG-3 cold atomic fluorometer using Argon as carrier for Hg vapor. Four samples were collected per day for each location. River water, well water, waste water and tailings (discharged) samples were collected with plastic bottles soaked by diluted HNO_3 , digested by $\text{HNO}_3\text{H}_2\text{SO}_4\text{KMnO}_4$, and tested the content of Hg content by YYG-3 cold atomic fluorometer.

Figure 4. The Location of the Villages in Dexing County

To investigate the impacts of Hg pollution on human health, urine samples were taken from 185 villagers who contacted Hg directly. 131 adult men, 21 adult women, 33 children under 16 years old were included. Hg content in urine was analyzed.

1---Workroom 2---Copper Plate Workshop 3---Bedroom
4---Sitting room 5---Kitchen

Figure 5. The scheme of workplace near riverbank

3. Results and discussion

3.1 CONCENTRATION OF Hg IN AIR

Table 1 shows the concentration of Hg in air from workroom, kitchen, bedroom, sitting room, copper plate workshop. The background value of atmospheric Hg is $10\text{--}20\text{ ng.m}^{-3}$. According to China's national standards, the content of Hg in air from living areas is less than 0.0003 mg.m^{-3} , the upper limit of Hg concentration in air from workplace is 0.01 mg.m^{-3} . The average content of Hg in air from these small scale gold mines' workplace exceeded the upper limit by 80-300 fold. Even in the kitchen, bedroom, sitting room, the content of Hg in the air also exceeded the permissible value by 8-30 times.

TABLE 1
Concentration of Hg in air from different workplaces

Sample site	Workroom (mg.m^{-3})	Kitchen (mg.m^{-3})	Bedroom (mg.m^{-3})	Sitting room (mg.m^{-3})	Copper plate workshop (mg.m^{-3})
Wang's House	2.8432	0.0024	0.0068	0.0038	0.9481
Su'House	1.9456	0.0026	0.0089	0.0044	0.7982
Zhang'House	3.0465	0.0054	0.0141	0.0089	1.2577
Li'House	2.5341	0.0048	0.0099	0.0045	0.9960
Average	2.6000	0.0038	0.0099	0.0054	1.0000

3.2 CONCENTRATION OF HG IN GOLD EXTRACTING WASTES

The concentration of Hg in gold extracting wastes monitored in disposal sites is shown in Table 2. According to China's standards, the discharging standard value of total Hg in wastewater is less than 0.05mg.L^{-1} . From the data obtained, the concentration of Hg in wastewater from small gold mines was $0.5\text{--}1.0\text{ mg.L}^{-1}$, about 10-20 times of permission value, and the wastewater was discharged to environment without any treatment. The total content of Hg in solid tailings was terribly high, up to $100\text{--}300\text{ mg.kg}^{-1}$. The tailings were heaped beside the villages, near the river. Apparently, the Hg in the tailings went to the soil, air, and water eventually.

TABLE 2
Concentration of Hg in gold extracting wastes

Sample site	Tailing water (mg.L^{-1})	Air above Tailings (mg.m^{-3})	Solid tailings (mg.kg^{-1})	Waste water (mg.L^{-1})
Wang's House	0.0035	0.0112	160.75	0.6442
Su'House	0.0021	0.0107	107.66	0.5104
Zhang'House	0.0065	0.0228	302.28	1.0355
Li'House	0.0039	0.0153	184.81	0.6697
Average	0.0040	0.0150	188.88	0.7150

3.3 CONCENTRATION OF Hg IN THE SURROUNDING ENVIRONMENT

The concentration of Hg in the surrounding environment is shown in Table 3. The water at discharged river mouth was highly polluted, and the concentration of Hg exceeded its

background value by 10 to 3000 fold. The Hg content of soil near the workshop was found to be 1100 mg.kg⁻¹, larger by 1000 fold than the background value (Shuijing Wang, 1995).

TABLE 3
Concentration of Hg in surroundings

Sample	Drainage (mg.L ⁻¹)	Well water (mg.L ⁻¹)	Discharged mouth (mg.L ⁻¹)	Background water (mg.L ⁻¹)
1	0.01164	0.0012	0.2905	<0.0001
2	0.01051	0.0010	0.3014	
3	0.01087	0.0010	0.3008	
Average	0.01101	0.0011	0.2976	

3.4 ROUGH ESTIMATION OF Hg IN SMALL SCALE GOLD MINES IN 1992-95

There are 200 sets of extraction and roll mill in Dexing County during 1992-95. Primary ore treated for one set amounted to 4 tons per day, and 1 kg Hg for each ton of ore was needed, thus:

$$4 \times 2 = 8 \text{ kg Hg.day}^{-1}$$

$$200 \times 8 = 1600 \text{ kg Hg.day}^{-1}$$

About 10-20 % of total Hg was lost. Thus, in Dexing County during operation, every day about 160-320 kg of Hg went into the environment. Of the lost Hg, it was estimated that 2% transformed into Hg vapor, 80% was discharged to dumps, and the remainder into soil and waste water.

3.5 PRELIMINARY EPIDEMIOLOGICAL STUDY

The concentration of Hg in urine samples is shown in Table 4. The normal value of concentration of Hg in human urine is less than 20 ug.L⁻¹ (Weiming Gan, 1995). Most of the tested values were higher than normal value, the highest concentration of Hg in urine was 50 fold higher. The youngest boy was only two years old.

TABLE 4
Hg in urine of 185 villagers*

Kinds of persons	Total number	Number of persons whose urine Hg larger than 20 ug.L ⁻¹	Range of urine Hg (ug.L ⁻¹)	Average urine Hg (ug.L ⁻¹)	Percentage of abnormal urine Hg
Adult men	131	125	3.6 to 289.9	66.49	95%
Adult women	21	17	4.0 to 417.9	64.09	81%
Girls under 16 years old	19	14	4.7 to 194.5	38.13	71%
Boys under 16 years old	14	12	8.3 to 539.6	86.96	86%
Total	185	168	3.6 to 539.6	65.73	91%

* Abnormal is greater than 20 ug.L⁻¹

4. Conclusions

The preliminary assessment of Hg in small scale gold mining at Dexing has indicated the serious status of Hg pollution in China. It affected human health to a great extent. Further study is urgently needed.

Since September 1996, most of the small scale gold mining activities were strictly prohibited by China's national environmental legislation. Recent investigation in late 1996 indicated all those small mines in Dexing County were shut off. There will be changes concerning Hg pollution status in China. A new study on the assessment of Hg pollution in small gold mining areas is to begin in 1997-1998

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