China chemical safety case study: Metals pollution in Liuyang, Hunan Province

In the frame of the EU-funded project: Strengthening the capacity of pollution victims and civil society organizations to increase chemical safety in China (China Chemical Safety Project)

IPEN and Green Beagle
August 2014

Introduction

Hunan Province is a major metals producer and smelter operations have resulted in rice contaminated with high levels of cadmium.[1] This case study focuses on metals pollution from a factory near Liuyang city in Hunan Province which links a small village to the global electronics industry.[2] The case study illustrates how violations of siting, illegal operations, and a botched cleanup have resulted in a complicated pollution problem that caused harm to the community and will be costly to resolve. The case study also illustrates the broader issue of metals pollution in China. According to the Ministry of Agriculture, farming on land almost the size of Belgium has been stopped due to metals contamination and approximately 12 million tonnes of grain are polluted by metals every year in China.[3]

Zhentou residents Wan Lizhi and her son, Ouyang Yuwangs, show the medicine he must take due to cadmium pollution. Photo by Simon Song[4]

A mayor proposes a "zero emissions" development project

In 2004, the Changsha Xianghe Chemical Factory began operations with a license to produce zinc sulfate in Shuangqiao Village of Zhentou Township. The mayor proposed the project since the company would make zinc sulfate animal feed additive and that there would be "zero emissions" and absolutely no pollution. [5] At first, the residents welcomed the plant as an economic boost to the village and an alternative to farming. No one seemed to mind that the location of the plant was on top of a hill, 50 meters from the Xiang River, and that it did not include any buffer zone of safety – a violation of Chinese regulatory standards. In addition, no one realized that cadmium is a common byproduct of refining zinc from ores.[6]

Flat panel displays and a small township

In 2004, the Xianghe factory also branched out into production of indium in violation of its original Environmental Impact Assessment and licensing agreement. Indium is present in zinc ore stocks and is a key metal used in production of semiconductors and liquid crystal displays for flat panel televisions and computer screens. In this way, a small township in Hunan Province became linked to the global consumer market for electronics.

The pollution begins

The company discharged untreated waste containing cadmium, indium, and other toxic metals, poisoning drinking water and agricultural soil.[7] The nearby river serves as the village drinking water source and the water intake is less than 1000 meters away.[8] Workers reportedly worked without any protection from metal dust.[9] However, a former worker told the South China Morning Post that EPB inspectors always alerted plant management before inspections.[10] Due to the lack of awareness and the absence of any notification by the company, some villagers used tailings from the plant operation to fertilize their farmland. This spread the pollution further. Villagers began to report dizziness, fatigue, difficulty in breathing and sore joints.[11]

By 2007, pollution from the Xianghe plant became an obvious problem and the Environmental Protection Bureau (EPB) began testing the area for levels of metals. An environmental official admitted that the nearby Xiang River was heavily polluted with toxic metals.[12] The Liuyang River flows past this area and heads downstream to Liuyang city where it serves as the drinking water source for more than 1.3 million people. Caijing magazine reported that in the preceding years hundreds of metal extraction plants had set up operations due to corruption in certification processes and discharged wastes directly into the river, contaminating the drinking water supply and vegetables grown along the river with cadmium, lead, and mercury.[13]

All fruits and vegetables are polluted with cadmium in the village
Photo by Lu Guang/Greenpeace[14]

Metals contamination in people provokes outrage

In May and June of 2009, two residents of the village died and an autopsy confirmed that cadmium levels “seriously exceeded” legal levels.[15] [16] One-third of the workers in the plant had elevated cadmium levels.[17] Provincial environmental authorities tested 2,888 villagers and found cadmium exceeding legal levels in 509 of them.[18] Thirty-three high risk residents with elevated levels lived between 500 – 1200 meters from the Xianghe plant – and 25 were hospitalized. The findings provoked community outrage and 1000 villagers protested in the streets calling for the closure of the plant. [19] [20] The pollution also devastated the village’s livelihood since food could not be grown on the contaminated farmland.[21] In July 2009, residents had to switch to food and water trucked in from outside the community due to contamination concerns.[22] In the same year, testing revealed that children in the community suffered from lead poisoning.[23]

Residents protest cadmium pollution in Zhentou Township in 2009[24]

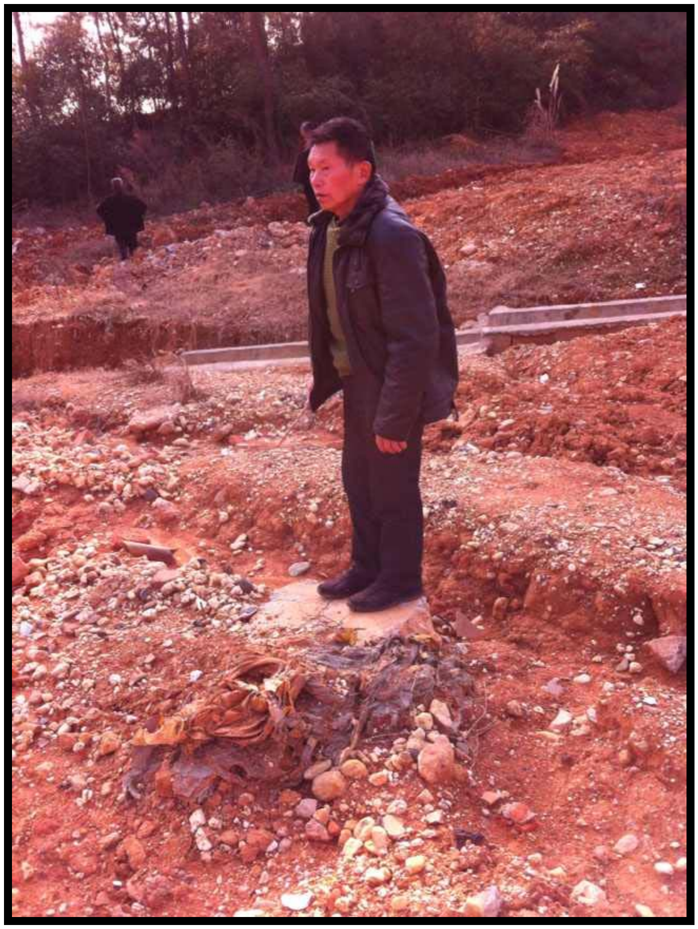
In 2009, government officials closed the Changsha Xianghe Chemical Factory. Authorities detained the legal representative of Xianghe, the president of the company and his deputy. Later, Luo Xiangping (factory owner and president) and Huang Heping (chief manager of the factory) were sentenced to three years in prison, three years probation, and fined ¥100,000 (~€12,250). Tang Wenlong (chief technical officer) and two other executives (Luo Guoliang and Du Kuoming) were not charged, sentenced, or fined. Overall, the sentences shocked the villagers who did not think the punishment matched the crime.

A botched cleanup disperses the pollution

In 2009, authorities closed the Changsha Xianghe Chemical Factory and destroyed the buildings. The EPB contracted with a joint venture company formed between a local and Hong Kong company to clean up the site for a price of ¥16 million. The intended plan involved immobilizing the contaminated soil to prevent further pollution of the river and community. The company kept the planned technique a secret and did not permit villagers to observe the cleanup. However, villagers snuck into the area anyway and became alarmed at the complete mess they observed with large amount of construction debris and loose soil that did not appear immobilized.

After the rain flushed contaminated mud and soil into the village, the local government gave money to the villagers to build a cement ditch to try to stop the flow of polluted soil and water since the polluted facility was built on a hill. The government also gave the community money to build a 10 meter high wall to try to prevent pollution from running off into the Liuyang River.

Unfortunately, they realized later that rainwater carrying cadmium and other toxic metals seeped flowed under the wall into the river. This raised further concerns since the Liuyang River flows downstream to become the drinking water for Liuyang City, population 1.3 million.



Community residents stand on contaminated construction waste
washed from the cadmium pollution site by a flood Photo by Project personnel.

Characterizing the cleanup and pollution

In August 2013, Project personnel became involved in the case. During the entire cleanup period, villagers were not sure what areas were polluted so Project personnel prioritized testing and information releases to help characterize pollution in and around the plant after the first attempt at cleanup. The results became an important part of next steps on the case.

Table 1 shows data on levels of metals in the community and on the site measured using a portable XRF analyzer. The data illustrates a several important points:

- Despite claims of "cleanup" the site remains seriously contaminated at levels that violate Chinese soil quality standards.
- The degree of pollution is so serious that even digging down into the soil produces levels of metals that violate Chinese law
- Though the focus has been on zinc and cadmium, Project testing alerted authorities and the community that arsenic pollution is also a serious problem

- Though many samples have lead levels below the 500 ppm standard, this regulatory level is quite weak and not protective. Unfortunately, the lead poisoning of children in the community illustrates this.
- Overall the data demonstrates a failed cleanup with hazardous levels of arsenic, cadmium, lead and sometimes mercury available in loose soil that that is easily transported into the community and river when it rains.

Table 1. Levels of metals at the “cleaned up” Xianghe chemical plant
(levels in bold are within the sensitivity of the device and violate Chinese regulatory limits)

Location	Cd (ppm)	Hg (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)
Regulatory limit in China	1.0	1.5	500	500	40
Workshop 1 原车间位置	**56**	5	38	**3404**	22
Workshop 1 原车间位置	**26**	7	103	**911**	**44**
Former water pool 原废水池位置	**87**	ND	37	**19200**	5
2 cm below former water pool 下挖 2 厘米	**34**	6	19	**4451**	5
6 cm below former water pool 再下挖 4 厘米	**20**	4	16	**2880**	ND
Inside ditch separating plant from village 导水渠内沉积土	6	4	110	371	**54**
5 cm below inside ditch 下挖 5 厘米	8	5	109	366	**49**
Workshop 2 原车间位置	ND	4	21	115	**224**
Ditch outside former workshop 原车间外水沟位置	6	7	75	258	**809**
5 cm below ditch outside former workshop 下挖 5 厘米	14	ND	350	436	**1077**
150 cm below ditch outside former workshop 向下游再移 150 厘米	8	2	88	**763**	**63**
1 m below ditch outside former workshop 向下游再移动 1 米	2	5	56	262	**881**
Workshop 3 原车间位置	**27**	8	45	**1126**	**46**
20 cm below Workshop 3 下挖 20 厘米	**42**	8	24	**853**	30
Workshop 4 原车间位置	**34**	5	38	**760**	**41**

Location	Cd (ppm)	Hg (ppm)	Pb (ppm)	Zn (ppm)	As (ppm)
Regulatory limit in China	1.0	1.5	500	500	40
20 cm below Workshop 4 下挖 20 厘米	**37**	4	42	**731**	33
Workshop 5 硫酸锌车间	**27**	7	44	**849**	26
Path beside Workshop 5 路边（硬土	**15**	6	24	**781**	27
Warehouse 氧化锌原料仓库	**29**	10	150	**1568**	37
Warehouse 氧化锌原料仓库	**22**	**22**	**1031**	**1470**	**1411**
Cleanup project sampled here and said it was clean 原工程监测取样点	**77**	7	43	**1125**	39
10 cm below Cleanup project sampled here and said it was clean 下挖 10 厘米	**48**	6	41	**1231**	50
20 cm below Cleanup project sampled here and said it was clean 下挖 20 厘米	**74**	4	32	**1264**	41
Village near cleanup 洗袋池西南原工程取样点	**72**	6	310	**2396**	38
Near wall trying to block flow into river 坝底渗出溪边土	**33**	ND	43	**1070**	22
In front of wall (flood carried) 坝前冲积面近坝侧	**53**	7	426	**1139**	**105**

Abbreviations: Cd, cadmium; Hg, mercury; Pb, lead; Zn, zinc; As, arsenic; ppm, parts per million or mg/kg; ND, not detected

In discussions with local government officials, Project personnel recommended a second cleanup based on the sampling data. In autumn of 2013, the local government authorities agreed and privately recognized that the first cleanup effort was a complete failure so they authorized the local company to try to immobilize the polluted soil and perform a second cleanup.

Health impacts

The pollution produced by the Xianghe plant and improper cleanup has taken a severe health toll on the residents – and the village has joined the rising number of China's "cancer villages". As reported in the South China Morning Post, a Shuangquiao villager Luo Jinzhi said, "Our throats, joints and kidneys hurt so much. Those severe illnesses - hydrohepatosis, phthisis and the different types of cancer - no longer sound strange to us. We don't know who will be the next to add on the list of the sick or dead."[25] Project discussions with villagers confirm that they are keeping their own records of deaths to confirm causes of death – many of them from cancer.

The health impacts reported by villagers are consistent with the toxicity of the relevant metals. Table 2 shows that arsenic, cadmium, indium, lead, mercury, and zinc have a variety of harmful effects. The severity of the pollution, proximity of the community, and the length of time without actual resolution of the problem has compounded the impact.

Table 2. Some impacts of metals

Metal	Impacts
Arsenic	Inorganic arsenic is a known human carcinogen with links to lung, skin, and bladder cancers.[26] Studies of human exposure show increased incidence of lung, liver, and heart diseases, lung cancer, and infant mortality.[27] Arsenic exposure in humans is also associated with diabetes.[28] Low to moderate exposures in humans are associated with skin lesions, high blood pressure, and neurological dysfunction.[29] Arsenic exposure is correlated with lower IQ in children.[30]
Cadmium	Cadmium is a known human carcinogen and associated with cancers of the breast, kidney, lung, pancreas, prostate and urinary bladder.[31] The State of California recognizes cadmium as a reproductive toxicant.[32] [33] Cadmium is taken up by various crops including potatoes, root crops, leafy vegetables, and fruits. Other toxic endpoints include lung damage, renal dysfunction, hepatic injury, bone deficiencies, and hypertension.[34]
Indium	In animal studies, indium causes embryonic or fetal malformations and inhalation of indium causes lung damage in workers.[35] [36]
Lead	Lead is a well-known neurotoxicant with no safe level of exposure.[37] The harms from childhood lead exposure are irreversible and persist into adolescence and adulthood.[38] Lead has sensory, motor, cognitive and behavioral impacts, including learning disabilities; attention deficits; disorders in a child's coordination, visual, spatial and language skills, and anemia.[39]
Mercury	Mercury is a well-known neurotoxicant which damages the kidneys and many body systems including the nervous, cardiovascular, respiratory, gastrointestinal, hematologic, immune, and reproductive systems.[40] The developing nervous system is especially vulnerable to damage from mercury and exposure can lead to loss of IQ, abnormal muscle tone, and losses in motor function, attention, and visual – spatial performance.[41]
Zinc	Zinc is an essential trace element for human nutrition. Few well designed studies have characterized the toxicity of zinc. However, high doses of zinc can be harmful. Inhaling large amounts of zinc as dust or as fumes from welding is associated with metal fume fever – a disease that is usually reversible.[42] Other effects associated with long-term excessive zinc intake include anemia, leucopenia, lymphadenopathy, esophagitis, gastritis, hypertension, and depletion of copper and iron.[43] On skin contact, zinc can cause blistering and permanent scarring and it is also a strong eye irritant. [44]

Conclusion

The Liuyuang case study provides opportunities for improvements in several areas:

Vigilance about fulfilling Environmental Impact Assessment (EIA) planning

One of the sad features of this case study is that the company violated its EIA almost from the beginning of its operation and started producing indium with tragic consequences. In addition, the siting of the plant violated Chinese law from the beginning and any serious review of the EIA would have prohibited construction and operation of the plant due to this violation. These problems appear to be common in China. If there is no vigilance about a company fulfilling its EIA, then the assessment process and the manufacturing permit become meaningless exercises in paper work without relevance to actual practice that safeguards human health and the environment.

Enforcement of waste management laws

Rigorous enforcement of Chinese law would have identified this problem much sooner rather than letting it continue for nine years. One relevant law is the Solid Waste Law, which requires that hazardous waste must be shipped to qualified disposing facilities and strictly monitored by the Environmental Protection Bureau for the whole disposal process. Going forward, rigorous enforcement of dumping laws should lead to criminal prosecution. As mentioned above, in June 2013, the Supreme Court of China updated China's criminal code to include environmental crimes involving illegally dumping two tons or more hazardous waste. Enforcement of this new law will be important to help provide justice for communities and a deterrent for cases like this one.

Information disclosure

Public right to know is a key principle of chemical safety but the community was blocked from knowing about the initial cleanup and no information was provided about high levels of toxic metals polluting both the land and water. Public access to plant emissions including wastes should be regularly provided via an accessible, free, pollutant release and transfer registry. Another key aspect to information disclosure is the Environmental Impact Assessment (EIA) report of the Xianghe facility. According to Chinese law, this report should be freely available to the public, but no one from the community has the report.

Effective remediation

In this case, contracts were provided to companies that did not actually perform adequate cleanup. This made a bad problem much worse and resulted in dispersing the original pollution much further. Sampling at the site after the "cleanup" showed it was still highly contaminated. Effective remediation requires careful evaluation of the site, professional methods for removal, sampling to insure cleanliness of the remaining soil, and sound management of the wastes.

Liability and compensation

Liability and compensation is a key principle of chemical safety.[45] In 2010, the Governing Council of the United Nations Environment Programme (UNEP) developed guidelines for national legislation on liability and compensation.[46] China participated in the meeting and its consensus decision to endorse the guidelines. The decision acknowledges Rio Principle 13 and seeks to operationalize Rio Principle 16, the polluter pays principle. Company responsibilities include strict liability for damages either by commission or negligence. The Guidelines grant both individuals and public authorities the right to claim compensation including for damage to property and economic loss. According to Chinese Civil Law, for environmental pollution cases if the plaintiff can prove the existence of polluting activities and damage to property and health, then the defendant should take the responsibility to disapprove the causal relationship between the pollution and damage. In this case, the ¥100,000 fines did not come close to the economic and human damage inflicted on the community by company practices – both in production and cleanup.

Media reports

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About the China Chemical Safety Project

This is an EU-funded project of IPEN with partner Green Beagle that aims to strengthen the capacity of civil society organizations and communities impacted by pollution to increase chemical safety in China. The Project (also known as the China Chemical Safety Project) is being implemented in China over two years with total EU funding of €344,580 and EU contribution of 77.84% of the total cost.

The Project includes:

- Improving capacities of impacted communities and civil society organizations for involvement in policy making
- Training on public participation in environmental impact assessment
- Generating new publicly available data about pollution and impacted communities that contribute to increased implementation of local and national chemical safety policies
- Raising awareness on emissions-related pollution

European Union

Strengthening the capacity of pollution victims and civil society organizations to increase chemical safety in China (China Chemical Safety Project) is funded by the European Union. The contents of this report are the sole responsibility of the IPEN and Green Beagle and can in no way be taken to reflect the views of the European Union.

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In addition, IPEN would like to acknowledge that this document was produced with financial contributions from the Swedish International Development Cooperation Agency through the Swedish Society for Nature Conservation (SSNC), along with other donors. The views herein shall not necessarily be taken to reflect the official opinion of any of these donors, including SSNC or its donors.

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