Investigation methods and application cases of thallium-related pollution sources in mining enterprises

Fang Wang*, Xiaohui Chen, Liangliang Wu

BGRIMM Technology Group, Beijing, China

*Corresponding author e-mail: wangfang920@126.com

Abstract. Based on data collection, field investigation, sampling and monitoring, statistical analysis of data, an innovative method combining field investigation and monitoring data was proposed. Taking a typical copper mining enterprise as an example, this method is applied to investigate the thallium-related pollution sources in the enterprise, and according to the problems found in the investigation, it is summarized and analyzed that the potential pollution risks such as the storage and transfer of raw materials and waste residues, the unorganized discharge of dust and environmental management should be paid more attention to. The regulation plan and control measures are put forward, which can provide experience for similar copper mining enterprises to carry out thallium-related pollution sources investigation.

Keywords: Mining enterprises, thallium pollution sources, copper mines.

Thallium is a highly dispersed rare metal element that is widely used in chemical, electronics, medicine, aerospace, high energy physics and superconducting materials. Thallium and its compounds are toxic, and long-term exposure or one-time large exposure can have serious effects on human health, such as cancer, nervous system damage, metabolic disorders, etc. Since thallium content is very low in the natural environment, thallium pollution and poisoning in the natural environment are rare. Thallium mainly comes from mining, metal smelting, industrial production and other processes, and has a long environmental cycle and toxic enrichment time (20-30 years).

At present, domestic researches mainly focus on thallium pollution in lead, zinc and iron and steel smelting enterprises [1-4], and there are few researches related to thallium pollution in mines. Thallium can also cause environmental pollution in ore processing and smelting or industrial production. Weathering leaching of thallium-bearing ores can cause thallium to enter water and soil [5]. Thallium can be discharged into the environment through waste gas, waste water, waste residue and other ways, and can also be enriched and spread in organisms through the food chain. The thallium in wastewater can be removed by chemical precipitation, ion exchange, adsorption and other methods to reduce the concentration of thallium discharge. Thallium emission in exhaust gas can be reduced by using bag type dust collector, wet dust collector and other methods to remove thallium. Solidification or stabilization of waste residues containing thallium can reduce the pollution of thallium to the environment. The thallium in the environment can be absorbed, transformed and degraded by biological methods such as plants and microorganisms to reduce the degree of pollution. Therefore, it is of great significance to study the investigation methods and prevention measures of thallium pollution in mining enterprises to reduce thallium pollution from the source.

1. Thallium pollution source investigation method

The method of on-site investigation and supplementary monitoring was used to conduct thallium-related investigation from raw materials and intermediate transportation, production links, material storage and other processes. According to the production process of enterprises and the pollution ways of soil environment and water environment, the focus was on the possible thallium-contaminated sites: mining industrial sites, concentrators, waste dumps, acid reservoirs, tailings ponds, waste water treatment stations. At the same time, thallium-related raw materials, products, solid waste and waste water are monitored. The risk points of thallium pollution were determined through monitoring and analysis. In addition, the historical monitoring data of thallium in wastewater, waste gas and soil of enterprises in recent years were analyzed, and according to the monitoring

results, the effectiveness of control measures was analyzed, and reasonable and feasible improvement and adjustment suggestions were put forward in view of existing problems.

1) Site traceability

The purpose of site traceability is to understand the relevant information of mine production and environmental management, including the operation and management of pollution prevention facilities and equipment, solid waste management, and environmental emergency materials reserve.

Traceability includes:

(1) Control of raw materials According to the collected data and field research, analyze and investigate all raw materials in the factory, including the floor area of the raw materials warehouse, the types of stored raw materials, the storage stock, and whether the construction standards meet the standard requirements, collect the analysis and laboratory ledger of the raw materials purchased by the enterprise for each batch, analyze whether to conduct testing, and prevent and control pollution from the source.

(2) Material transfer

According to the collected data and on-site investigation, analyze and investigate all the temporary temporary storage sites (warehouses) of solid waste in the factory area of the enterprise, including the area of the temporary storage sites (warehouses), the stored solid waste, the storage capacity and the final destination. Whether the temporary temporary storage site (warehouse) meets the relevant requirements of the General Industrial Solid Waste Storage and Landfill Pollution Control Standard (GB 18599-2020) or the Hazardous Waste Storage Pollution Control Standard (GB 18597-2023).

(3) Production process

According to the collected data and field investigation, analyze and investigate the link of pollution risk in the production process adopted by the enterprise.

(4) pollution control facilities

According to the collected data, field investigation, sampling, testing and analysis, investigate whether the pollution control measures such as waste gas and wastewater of enterprises can be effectively disposed of, and whether the emission concentration of pollutants after treatment can meet the corresponding standard requirements. At the same time, trace the direction of the wastewater of the source enterprise, the initial rainwater collection and treatment and disposal, and determine whether it meets the requirements of the relevant norms and discharge standards.

2) Supplementary monitoring

Supplemental monitoring of thallium-related raw materials, products and wastes is carried out at the following points:

(1) Raw materials, main by-products and solid waste: raw ore, waste rock, tailings, concentrate.

(2) Waste water: collection pool water under the tailings dam, drainage from the tailings reservoir spillway, acid waste water from the waste dump, sewage treatment station drainage, circulating water of the upper sump, initial rainwater and rainwater drain.

The risk points of thallium pollution were determined through monitoring and analysis.

3) Propose corrective measures

For the existing thallium-related sources, ensure that pollutants are effectively collected, treated and discharged according to standards, reduce the risk of heavy metal pollution, propose technical feasibility and economic rationality rectification plans or suggestions, and determine the rectification time point.

At the same time, the development of the later supervision plan, to ensure that the project control measures continue to play a role.

The schematic diagram of the technical route is shown in Figure 1.

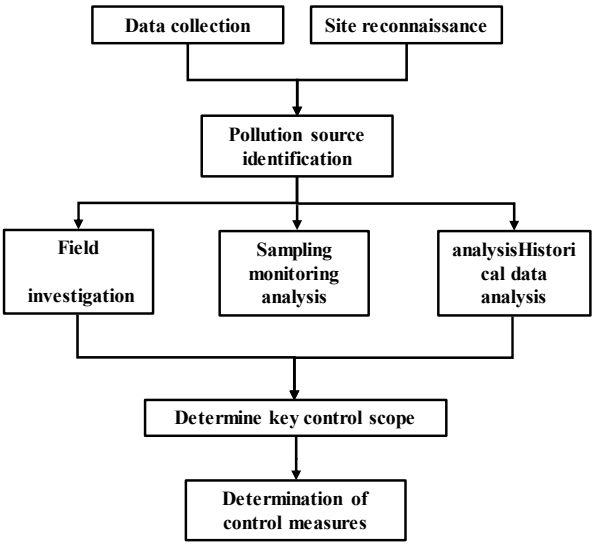

Figure 1 Technology roadmap

2. Case Overview

The investigation enterprise is a typical copper mining enterprise, and the mining area is mainly composed of open-pit stope, waste rock yard, tailings pond, concentrator, mining industrial site, etc. The process of mineral processing is to carry out fine separation of copper ore, and remove impurities in copper ore through flotation, reverse flotation, desulfurization, copper removal and other technological steps to obtain copper concentrate that meets the smelting requirements. The main pollution sources and pollution control measures are as follows:

1) Distribution of waste gas pollution sources

The waste gas mainly includes the dust produced by the perforation, blasting, shoveling, transportation, and unloading truck of the waste soil and stone in the open pit. The dust produced by the feed, crushing and screening division of the raw ore bin in the concentrator; Dust from waste rock yard and tailings pond; Tailings filling slurry preparation station dust, etc.

Among them, water and dust suppression facilities are used in drilling, blasting and transportation, wet dynamic dust collector is used in raw ore silo and lime milk preparation workshop, and pulse flat bag dust collector is equipped in crushing station and filling station of concentrator.

2) Distribution of waste water pollution sources

There are waste rock waste water, concentrator waste water, tailings reservoir overflow water and so on.

Among them, the waste water of the concentrator is recycled and not discharged. The overflow water of the tailings pond will enter the tailings pond after collection, and will not be discharged. The leached water of the waste rock field is acidic water, which is treated by the sewage treatment station and discharged according to the standard.

3) Distribution of solid waste

It is mainly mining waste rock, mineral processing tailings, waste water treatment sludge, dust and mud produced by the purification of dusty waste gas in the processing plant, waste oil and so on.

Among them, mining waste rocks are stacked in waste rock yard; Part of the tailing sand is filled and part of it is stored in the tailing reservoir. Wastewater treatment sludge into the tailings reservoir; The dust and mud produced by the purification of dusty waste gas in the concentrator is returned to the processing process. Waste oil is hazardous waste and shall be disposed of by qualified units.

3. Monitoring and evaluation of thallium-related nodes

According to the analysis of each pollution-producing node, identification of pollution sources and on-site investigation, it is determined that the main thallium pollution risk points are in stopes, waste

dumps, concentrators, tailings ponds, wastewater treatment stations, etc. The objects of monitoring are solid samples and water samples, and the solid samples include raw ore, crushed dust, concentrate, tailings, waste rock, water treatment sludge, etc. Water samples include ground washing water, reuse water, dust removal water, tailings clarified water, acid waste water, tailings reservoir leachate, total outlet drainage, etc.

The thallium test results of solid samples are shown in Table 1. The test results show that the copper content in the inspected copper mine is low, belonging to the copper ore with low thallium content. The thallium content in the raw ore is 0.9 mg/kg, and thallium is gradually enriched in the concentrate during the beneficiation process, and the thallium content in the concentrate is 1.6 mg/kg.

Table 1 Results of thallium solid samples

Name	Thallium (mg/kg)
Waste rock	1.3
Tailing	0.9
Concentrate	1.6
Dust collection	0.9
Raw ore	0.9
Water treatment sludge	0.6

The thallium detection results of water samples are shown in Table 2. It can be seen that the thallium detection values of the total wastewater discharge outlet are 0.16μg/L, which is far lower than the limit value of 5μg/L required by the local standard of Jiangxi Province for the Discharge of Thallium Pollutants in Industrial Wastewater (DB361149-2019). However, the thallium detection values of other wastewater, backwater and industrial water in the mining area are far less than the limit value of 5μg/L. The thallium concentration in the wastewater was low and had no obvious effect on the environment.

Table 2 Test results of water samples involving thallium

Name	Thallium (μg/L)
Select plant ground washing water	0.14
Return water in front of the plant	0.23
Dust removal water	0.06
Tailings clarification water	0.03
Total waste water outlet	0.16
Acidic wastewater	0.26
Tailing reservoir surface water	0.35
Tailing reservoir leachate	0.12

3 Thallium pollution source investigation and rectification measures

Combined with the data collection, on-site investigation of thallium pollution hazards and monitoring and analysis results of thallium-related nodes, the key links of thallium pollution hazards are determined as follows:

Table 3 Summary of potential thallium pollution

Number	Site	Site situation	Thallium pollution potential	site monitoring data analysis	control suggestions
1	Concentrate bin	1, the concentrate bin is open	There is potential thallium	No thallium was detected in zinc concentrate, while	Measures should be taken to

		structure, wind weather is easy to occur unorganized dust dispersion. 2, the concentrate transport process is scattered.	pollution, concentrate silo should be constructed with closed structure, and the control of unorganized discharge during transportation should be strengthened.	the thallium content in lead concentrate was 1.6mg/kg. The background value of thallium in topsoil is greater than the national requirement of 0.620±0.216mg/kg. It is easy for mine dust to pollute the soil through the atmosphere.	prevent the escape of concentrate transportation, and measures such as sealing and covering should be increased to reduce the hidden danger of soil pollution of mine dust.
2	Return water collection tank in front of the plant	1. Cement seepage prevention in the tank body. 2. There is a small amount of acidic water spilling next to the wastewater pool.	There are hidden dangers of thallium pollution, and the acid water spills easily cause soil thallium pollution, such as entering the storm drain easily cause thallium pollution of surface water.	The concentration of thallium in the backwater collection tank (mixed wastewater of the plant) in front of the sampling and monitoring plant is 0.08μg/L, which is far less than the limit value of the local standard of Jiangxi Province "Thallium Pollutant Discharge Standard of Industrial Wastewater" (DB361149-2019).	Strengthen daily management, prevent leakage.
3	Factory floor and workshop floor	1, lead and zinc production workshop to lead and zinc concentrate warehouse factory road is not hardened. 2, lead and zinc production workshop to lead and zinc concentrate warehouse	There is potential thallium contamination. The concentrate scattered during transportation is easy to enter the soil and cause soil pollution.	No thallium was detected in the sulfur concentrate, and the thallium content in the copper concentrate was 1.9mg/kg. No thallium was detected in zinc concentrate, while the thallium content in lead concentrate was 1.6mg/kg. The background value of thallium in	Measures should be taken to prevent leakage and escape of concentrate transportation, and measures such as sealing and covering should be increased to reduce the hidden danger

		factory road there is concentrate scattered.		topsoil is greater than the national requirement of 0.620±0.216mg/kg. Slag into the soil is easy to cause pollution.	of soil pollution of slag. Contaminated soil should be cleaned up and repaired in time.
4	Tailing reservoir leachate collection tank	1. Cement is used to prevent seepage in the tank body. 2, leachate pump back to the tailings reservoir, not discharged. 3, pumping station water pipe accident discharge.	It is necessary to strengthen the routine inspection and maintenance of pipelines to prevent the accidental discharge of leachate.	The concentration of thallium in tailing reservoir leachate was 0.12μg/L, which was far lower than the limit of the local standard of Jiangxi Province "Thallium Pollutant Discharge Standard of Industrial Wastewater" (DB361149-2019).	Strengthen daily management, prevent leakage.
5	Environmental Emergency Plans	The company has included thallium in environmental emergency plans, but has not yet filed with the regulatory authorities.	There is potential thallium contamination.	/	Thallium content should be included in environmental emergency plans and filed with regulatory authorities.
6	Self-monitoring plan	The company has not included thallium in the self-monitoring plan for groundwater and surface water.	There is potential thallium contamination.	/	Thallium should be included in self-monitoring plans for groundwater and surface water.

In view of the above thallium pollution hazards, enterprises mainly have the following kinds of thallium pollution hazards:

(1) Establish a soil environmental management system, put forward clear requirements for production activities that are easy to cause soil pollution hazards, implement and improve the inspection system in the plant, and eliminate pollution hazards in a timely manner.

(2) Strengthen the control of unorganized dust emission in mining areas, reduce the escape and dispersion of thallium-containing waste, and eliminate the hidden danger of thallium pollution.

(3) In view of the leakage caused by the damage of the ground, pool body and pump, production supervision and management should be strengthened to ensure that the operators comply with the operating procedures, implement the inspection system, find hidden dangers and rectify them in time.

(4) The self-monitoring system of groundwater and surface water in mining areas should be implemented, emergency plans related to thallium should be improved, the quality of regional groundwater and surface water should be grasped in real time, and corresponding countermeasures and emergency treatment measures should be proposed for mining areas accordingly.

4. Conclusion

The method proposed in this study is a method to identify the whole process of thallium-related pollution sources in enterprises in a short period of time by using data collection, field investigation and monitoring data combined with field sampling and analysis. It can be effectively applied to the investigation of thallium-related pollution sources in mining enterprises, and prevent and control thallium pollution from the source.

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