Study on Environmental Risk Assessment and Control Countermeasures of Tailings pond in a Mountainous Area of North China

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Abstract. The safety and environmental accidents of the tailings pond are likely to cause pollution of surrounding soil and water bodies, and endanger the safety of life and production of surrounding residents. In this study, the analytic hierarchy process (ahp) was used to score environmental sensitivity and control mechanism reliability of tailings ponds. The environmental risk rating model was used to characterize the environmental risk rating of tailings pond. The risk level characterization and evaluation results show that the four tailings ponds were general risks to downstream residents and the environment. Suggestions on environmental risk control of the upstream tailings pond were put forward.

1. Introduction
The increasing number of non-ferrous metals, iron ore and other mining activities in China has led to an increase in the number of tailings ponds. Although the management of tailings ponds has become stricter in recent years, the difficulty of approval of tailings ponds has gradually increased. However, there are still certain safety and environmental risks in the tailings ponds. The main characteristic pollution factor is heavy metals. There are tailings ponds in all major river basins in China, and about 9% of them have water sources downstream.

The tailings pond mainly includes dam body, anti-seepage layer, drainage facilities, backwater and sewage treatment facilities, etc. The dam body and anti-seepage layer can effectively prevent the tailings from infiltrating and running downstream, and the backwater and sewage treatment facilities can be enhanced. The natural precipitation of tailings wastewater plays a purification role [1-2]. However, the safety and environmental issues such as whether the tailings pond can operate safely and whether the tailings pond pollutants exceed the standard are more affected by human factors, such as safety and environmental protection issues caused by improper daily management of enterprises [3-5].

57 environmental accidents occurred in tailings ponds in my country, of which nearly 85% of the incidents caused pollution of the downstream soil and surface water environment, endangering the lives and production safety of surrounding residents from 2006 to 2015 [6-7]. In March of 2020, the tailing pond of Heilongjiang Yichun Luming Mining Co., Ltd. leaked because the tilting of No. 4 overflow well caused a leakage of 2.53 million cubic meters of tailings sand water, which caused the tailings sand water to flow into Yijimi River after 3km. The downstream river causes environmental pollution. Therefore, it is particularly important to carry out environmental risk assessment of tailings ponds with the downstream water bodies as the protection core, delineate the environmental risk levels of tailings ponds, and propose effective management and control measures at different levels.
2. Environmental risk assessment method of the tailings pond

Carry out the tailing pond risk rating evaluation and assessment in the research area in accordance with the “Technical guideline for environmental risk assessment of tailings pond” (HJ 740-2015). The first-level indicators of evaluation include environmental hazards, surrounding environmental sensitivity, and reliability of control mechanisms. The environmental risk is divided into three levels of major, large and general according to the scores of the first-level indicators which the matrix is divided.

Among them, the indicator of environmental hazard (H) totals 100 points, which are scored and summed according to the three indicators of type, nature and scale. The type indicators account for 48 points, mainly from minerals, solid waste and tailings (or tailings water) composition evaluation. The nature indicators account for 28 points, mainly from the perspective of characteristic pollutant index concentration. The scale indicators account for 24 points, mainly from the status quo Courage to evaluate. When the tailings dam environmental hazard score (DH) is not higher than 30 points, it is H3 level; when it is between 30-60 points, it is H2 level; and when it is greater than 60 points, it is H1 level.

The surrounding environment sensitivity (S) totals 100 points, which is obtained by scoring and summing up the three indicators related to the cross-border situation downstream of the tailings pond, the surrounding environment risk receptor situation, and the surrounding environment function category situation. The indicators related to the cross-border situation in the downstream account for 24 points, mainly from evaluations involving the types of cross-border and distances involved. The indicators for surrounding environmental risk receptors account for 54 points. The indicators for the surrounding environmental function category account for 22 points, mainly from water, soil and evaluation of the atmosphere. When the environmental hazard score (Ds) of the tailings pond is not higher than 30 points, it is S3 level; when it is between 30-60 points, it is S2 level; and when it is greater than 60 points, it is S1 level.

The control mechanism reliability (R) totals 100 points, according to the basic conditions (15 points), natural conditions (9 points), production safety conditions (15 points), environmental protection conditions (50 points) and historical events (11 points). Five indicators are scored and summed up.

When the tailings pond environmental hazard score (DR) is not higher than 30 points, it is R3; when it is between 30-60 points, it is R2; and when it is greater than 60, it is R1.

3. Environmental risk assessment of tailings ponds in the study area

3.1. the generality of in the research area

A mountainous area in North China was selected as the research area. Due to the large number of tailings ponds in the area, and the proximity of the downstream to the water source, there was a large potential risk of safety and environmental risks. The study area was about 30km² with four tailings ponds, and the investigation content was the location of tailings ponds (relative to the downstream water body), grade, safety, type and other information.

3.2. Investigation of tailings ponds in the study area

Field investigations were conducted on the four tailings ponds on site, and the results are shown in Table 1.

| Serial number | Tailings ponds | Grade | Location | Safety | category       |
|---------------|----------------|-------|----------|--------|---------------|
| 1             | 1#Tailings pond | fourth grade | northwest side | normal tailings pond | wet discharge |
| 2             | 2#Tailings pond | fifth grade | northwest side | normal tailings pond | dry drainage  |
| 3             | 3#Tailings pond | fourth grade | northeast side | normal tailings pond | wet discharge |
3.3. Environmental risk score of tailings ponds

The tailings ponds within the study area were scored and calculated according to the "Technical Guidelines for Environmental Risk Assessment of Tailings Reservoirs (Trial)" (HJ 740-2015), and the calculation results of the environmental risk indicators of the tailings ponds were given in Table 2.

Table 2. The calculation results for environmental risk index of four tailings ponds

| Serial number | Tailings ponds | H  | S  | R  |
|---------------|----------------|----|----|----|
| 1             | 1#Tailings pond | 12 | 63 | 6.5|
| 2             | 2#Tailings pond | 0  | 63 | 6.5|
| 3             | 3#Tailings pond | 12 | 66 | 6.5|
| 4             | 4#Tailings pond | 12 | 63 | 6.5|

Relevant evaluation indexes are divided into various tailings ponds. The specific results were shown in Table 3.

Table 3. The grade classification result for evaluation index of four tailings ponds

| Serial number | Tailings ponds | H  | S  | R  |
|---------------|----------------|----|----|----|
| 1             | 1#Tailings pond | H3 | S1 | R3 |
| 2             | 2#Tailings pond | H3 | S1 | R3 |
| 3             | 3#Tailings pond | H3 | S1 | R3 |
| 4             | 4#Tailings pond | H3 | S1 | R3 |

3.4. Risk evaluation results

After dividing the environmental risk levels of each tailings pond, the specific results were shown in Table 4.

Table 4. The grade classification result for environmental risk of four tailings ponds

| Serial number | Tailings ponds | General risk | Greater risk | Significant risk |
|---------------|----------------|--------------|--------------|-----------------|
| 1             | 1#Tailings pond | √            | ——           | ——              |
| 2             | 2#Tailings pond | √            | ——           | ——              |
| 3             | 3#Tailings pond | √            | ——           | ——              |
| 4             | 4#Tailings pond | √            | ——           | ——              |

According to the division results, the four tailings ponds were general risk to downstream residents and the environment.

4. Conclusions and recommendations

The tailings pond contains some heavy metal elements and some residues of beneficiation reagents. Once an unexpected accident occurs, it will easily cause different degrees of pollution of the surrounding soil, surface water and groundwater, which poses a serious threat to the production and life of the surrounding residents [8-12]. The downstream tailings pond involves environmental safety of surrounding residents, soil, surface water and groundwater. Therefore, it is particularly important to carry out environmental risk assessment of the upstream tailings pond. The evaluation results show that the four tailings ponds in the study area are of low risk and are far from the downstream residents of the tailings pond. Therefore, they all belong to the general risk level and do not belong to the key supervision tailings ponds. Regarding the environmental risks of tailings ponds in the region, the following suggestions are made:
1) The enterprise should formulate a tailings pond tracking and monitoring mechanism to identify sensitive protection targets in the surroundings, lay out environmental quality tracking and monitoring sections, monitor the characteristic pollution factors of the tailings pond. The monitoring frequency is determined according to the actual situation on site. Establish a pollution source monitoring port, monitoring platform and environmental monitoring account that meet the requirements;

2) Regularly maintain the tailings ponds drainage facilities, sewage treatment facilities and emergency facilities, strengthen the publicity, training and education of emergency knowledge, regularly organize emergency drills to ensure that emergency facilities are complete and emergency materials are available;

3) Actively carry out investigation and treatment of environmental safety hidden dangers in tailings ponds, compile tailings ponds environmental safety hidden troubles investigation table and hidden danger treatment plan table.

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References
[1] Wang Shuquan, Yu Xiao, Zhang Chenbo. Study on development trend and prevention and control measures of pollution sources in tailings pond [J]. Mineral Exploration, 2019, 10 (11): 2746-2752.
[2] Ma Jianqin. Study on pollution prevention and emergency management capability assessment system of tailings pond [D]. Southwest University of Science and Technology, 2018.
[3] Wang Shi, Shi Yong, Wang Wanyin. Comprehensive Safety Evaluation of Tailings Reservoir Based on Fuzzy Multivariate Contact Model [J]. Gold Science and Technology, 2019, 27 (06): 903-911.
[4] Liu Jia, Wang Yabian, Xue Liyang, et al. Study on Standardization Model of Environmental Risk Prevention and Control of Tailings Reservoir [J]. Guangdong Chemical Industry, 2019, 46 (17): 119-121.
[5] Jia Qian. Several suggestions for the construction of the emergency management system for the entire process of environmental accidents in tailings ponds [C]. Disaster and Emergency Toxicology Committee of the Chinese Society of Toxicology. Abstract of a national academic exchange paper. Chinese Society of Toxicology Professional Committee on Disaster and Emergency Toxicology: Chinese Society of Toxicology, 2016: 219.
[6] Jia Qian, Liu Binbin, Yu Fang, et al. Statistics Analysis and Management Suggestion for the Emergent Environmental Accident of Tailing Pond in China [J]. Safety and Environmental Engineering, 2015, 22 (02): 92-96 + 101.
[7] Tan Xiangjie. The "3.28" accident sounded the tailings alarm again [N]. China Gold Daily, 2020-04-03 (002).
[8] Tao Chen, Zi-Ang Yan, Damao Xu, et al. Current situation and forecast of environmental risks of a typical lead-zinc sulfide tailings impoundment based on its geochemical characteristics [J]. Elsevier BV, 2020.
[9] Holtra Anna, Zamorska-Wojdyła Dorota. The pollution indices of trace elements in soils and plants close to the copper and zinc smelting works in Poland's Lower Silesia. [J]. Pubmed, 2020.
[10] Mingjiang Zhang, Minjie Sun, Jianlei Wang, et al. Geographical distribution and risk assessment of heavy metals: a case study of mine tailings pond [J]. Taylor & Francis, 2020, 36 (1).
[11] Hou Qiuli, Xing Yuxin, Gan Ke, et al. Soil environment analysis and heavy metal pollution assessment of typical gold mine tailings ponds around Miyun Reservoir [J]. Energy Environmental Protection, 2019, 33 (06): 55-59.

[12] A case study on environmental risk assessment of tailings pond Nonferrous Metals(Mining Section).