EMERGENCY MONITORING OF TAILINGS LEAKAGE BASED ON GEE PLATFORM

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ABSTRACT: The utilization of mineral resources plays a vital role in supporting and promoting economic development and social progress. As a necessary facility for the development and utilization of mineral resources, the tailings pond also brings a series of safety and environmental problems. The accident caused by the tailings pond will bring great environmental and property losses to its surrounding areas, which is next to the harm of the nuclear radiation or nuclear explosion. Based on the data of Sentinel II and Landsat images provided by GEE (full name of Google Earth Engine) platform, this paper carries out the emergency monitoring of the tailings pond leakage accident that occurred in the Luming Mining Company in Yichun, Heilongjiang province on March 28, 2020. In this paper, the specific changes of the tailings sand throughout the accident is confirmed, the spread of pollution in the Yijimi River near the tailings pond and changes in the length of the river is monitored, and the impact of the accident on the surrounding vegetation and villages is determined.

1. INTRODUCTION

Mineral resources are an important material basis for the survival of human society, but the development of mining industry will inevitably produce tailings ponds. There are more than 10,000 tailings ponds of various sizes in our country. Once the tailings ponds break or leak, they will cause great harm to the surrounding and downstream environment [1].

GEE (full name Google Earth Engine) cloud platform is a platform provided by Google for online visual calculation, analysis and processing of a large number of global-scale earth science data. Specifically, the GEE cloud platform integrates a large number of remote sensing image data and geospatial data sets. At the same time, the GEE cloud platform also has a strong global scale analysis capability, which makes it very convenient for scientists, researchers and developers to monitor changes, map trends and quantify surface differences [2]. At present, a great deal of scientific research has been done on the application of GEE cloud platform. Han-sen et al. [3] used GEE cloud platform and Earth observation satellite data to map the global forest range and its changes from 2000 to 2012 with 30M spatial resolution. With the rapid urbanization in the world today, Huang et al. [4] applied GEE cloud platform and Landsat-5, 7 and 8 image sets to obtain the changes of major land cover types in Beijing in the past 30 years. Lobell et al. [5] used GEE cloud platform, Landsat data and grid weather data to estimate the yield of small-sized agriculture.

In this paper, aiming at the tailings leakage accident of Yichun 3.28 Luming Literature Mining Industry, GEE platform was used to monitor the research area, which quickly and accurately captured the pollution, determined the impact of the accident on the river channel and the surrounding forest farms, and completed the monitoring and analysis of the accident.

2. OVERVIEW, BACKGROUND AND DATA SOURCES OF THE RESEARCH AREA

2.1 Overview Of The Research Area

Yichun City is located in the northeast of Heilongjiang Province. It borders Harbin in the south, Heihe and Suihua in the west, with a total population of 1.276 million. There are 377 mineral sites of various types, including 4 large, 28 medium and 345 small deposits and mineralization points.

2.2 Research Background

On March 28, overflow well No.4 of molybdenum mine tailings pond of Yichun Luming Mining Limited Company, resulting in an increase in water discharge accompanied by tailings. After the incident, sewage flowed about 3 kilometers and entered Yijimi River. The occurrence of this accident directly affected the drinking water source in Tieli City and was a very serious accident. Based on the above situation, this paper will carry out dynamic monitoring of the accident.

2.3 Data Source

2.3.1 Satellite Image Data: Sentinel 2 image provided by GEE platform is the main data used for dynamic monitoring of accidents in this paper. Based on GEE programming, Sentinel 2 images with cloud cover below 8% from 2019-03-01 to 2019-07-29 and 2020-03-01 to 2020-07-29 were screened and used as satellite image data for this study.

2.3.2 Vector Data: Vector data is the vector data of Hulan River Basin provided by the National Earth System Science Data Center, including: Hulan River Basin 1: 250,000 water system data set and Hulan River Basin 1: 250,000 boundary data set.

3. RESEARCH METHODS

3.1 GEE-based NDVI Computing

The normalized vegetation index was used to judge the impact of the accident on the surrounding forest farms. Normalized difference vegetation index (NDVI) is widely used in large-scale vegetation dynamics research because it can effectively reflect vegetation parameters such as vegetation coverage, growth status, biomass and net primary productivity [6-7]. Using infrared and near infrared band data, the normalized vegetation index is calculated according to the following formula (1):

$$NDVI = (NIR - RED) / (NIR + RED) \quad (1)$$

Based on Sentinel 2 data provided by GEE platform, this study calculates NDVI changes of forest farms around tailings ponds for a long time, and compares different years to determine the impact of accidents on forest farms.

3.2 GEE-based NDTI Computing

Based on GEE platform, the normalized difference index (NDTI) proposed by Yu Moli [8] is used to judge the change of tailings water content. The correlation coefficient between NDTI and water content is 0.85. The calculation of NDTI in the study area can reflect the water content of tailings in the study area, and then determine the change of tailings pond during the accident. The NDTI formula is:

$$NDTI = (Ri-Rj) / (Ri+Rj) \qquad (2)$$

Where: Ri and Rj respectively represent the reflectivity of the i-th band and the j-th band, and correspond to the reflectivity of B11 and B12 bands in Sentinel 2 image.

4. RESEARCH RESULTE AND ANALYSIS

4.1 Results of GEE Contamination Dynamics Monitoring

After the 3.28 tailings leakage accident in Yichun, the leaked pollutants entered the Yijimi River and spread downstream along the river course. To clarify the impact of the pollution, the river course through which the pollution flows must first be determined. In this study, Sentinel 2 image with cloud cover less than 8% was selected on GEE platform to dynamically monitor several pollution interception points after the accident. Figures 1-2 below show the images of two key interception points :

Image beside Xingfu reservoir on March 29, 2020 | Image beside Xingfu reservoir on April 5, 2020 | Image beside Xingfu reservoir on April 10, 2020

Figure 1：Images of Yijimi river near Xingfu reservoir before and after the accident

Image of Lanxi old bridge on March 29, 2020 | Image of Lanxi old bridge on April 5, 2020 | Image of Lanxi old bridge on April 10, 2020

Figure 2：Image of Yijimi river near Lanxi old bridge before and after the accident

In the remote sensing images of the two key interception points, it can be clearly seen that the gray pollutants never appeared in the Ejimi River, then flowed downstream and were finally intercepted at Lanxi Old Bridge. Through the observation of remote sensing images of key interception points, it is finally determined that the end point of pollution is at the interception point of Lanxi Old Bridge. The polluted rivers and districts and counties in this accident are shown in Figure 3:

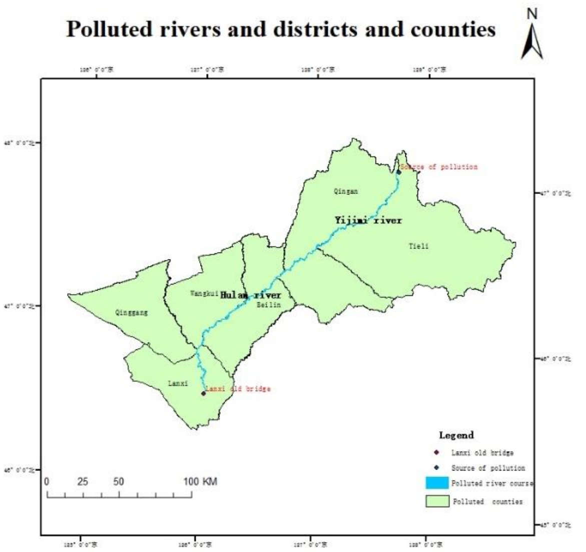

Figure 3：Polluted rivers and districts and counties

4.2 NDVI Calculation Results

There are several large forest farms around the tailings pond where the dam break accident occurred, and the surrounding forest farms are the first to be affected by the tailings pond leakage accident. In order to determine the impact of dam break accident on surrounding forest farms, based on Sentinel 2 images provided by GEE from 2020-03-28 to 2020-07-29, the NDVI changes of the two forest farms closest to the tailings pond are calculated and compared with the NDVI of the same period last year. The results are shown in Figure 5 and 6:

Figure 4：Vector of forest farm around tailings pond

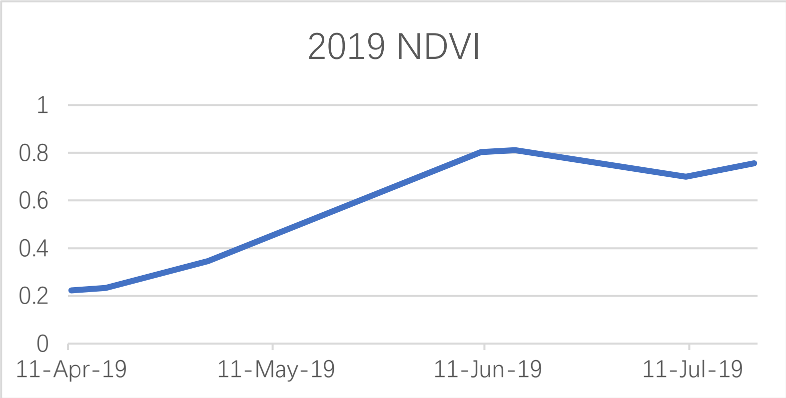

Figure 5：NDVI changes of forest farms around tailings pond in 2019

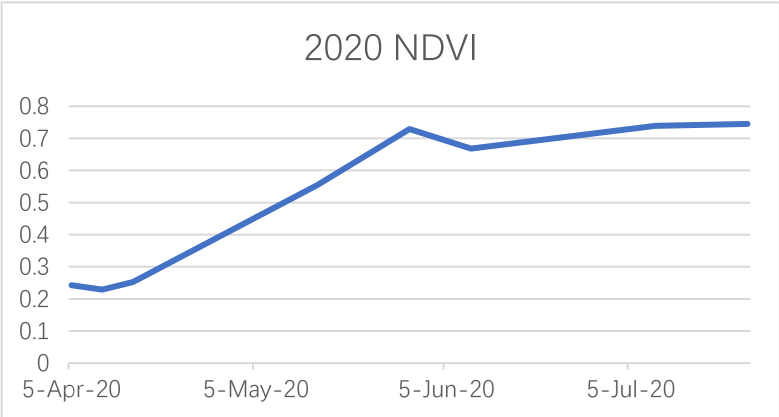

Figure 6：NDVI changes of forest farms around tailings pond in 2020

Comparing the average NDVI curves of forest farms around the tailings pond in 2019 and 2020, it can be seen that the NDVI curves of the two years have not changed significantly, which indicates that the accident has not had a significant impact on vegetation at present.

4.3 NDTI Calculation Results

Import 2019-03-01 to 2019-07-29 in GEE respectively; From March 1, 2020 to July 29, 2020, Sentinel 2 images of the research area are taken as the research area, and the average NDTI of the research area is calculated. The results are shown in Figure 8 and Figure 9:

Figure 7: Vector of tailings sand

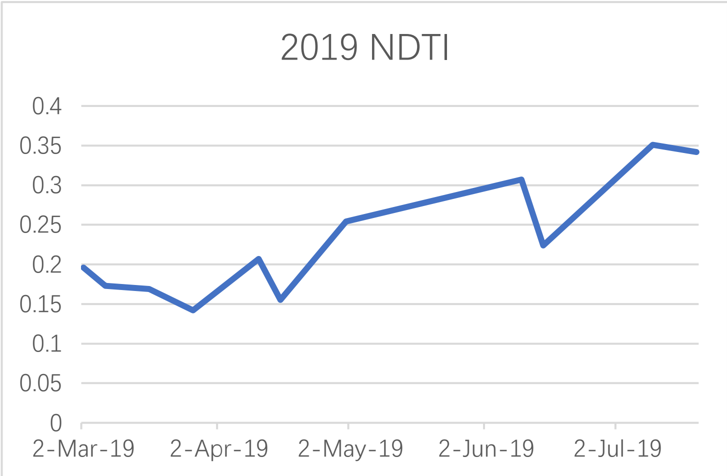

Figure 8: NDTI in the study area from March 1, 2019 to July 1, 2019

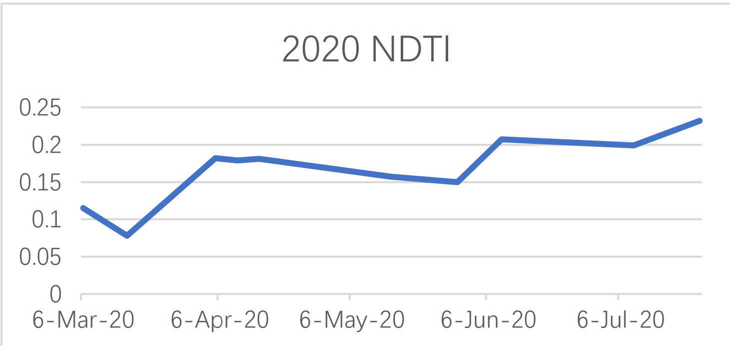

Figure 9: NDTI in the study area from March 1, 2020 to July 1, 2020

Comparing the NDTI curves of the same period of two years, it can be seen that the overall NDTI of the study area in 2020 is lower than that in 2019, which indicates that the water content of tailings decreased after the accident. The decrease in water content of tailings indicates that remedial measures such as pumping water have been taken after the accident, and the production of the mining area may not have resumed due to the responsibility for the personal and property safety of residents around and downstream of the mining area.

5. CONCLUSION

The leakage accident of tailings pond seriously threatens the surrounding economy, ecology and population safety. After the tailings pond leakage accident occurs, the rapid discovery and location of the accident can provide important location reference information for timely emergency disposal and arrangement of follow-up remote sensing observation, and can also provide objective and effective data support for evaluating disaster losses and reasonably deploying rescue forces. GEE platform has the characteristics of large-scale, periodic and comprehensive observation, and is an effective means for emergency monitoring of tailings pond leakage.

Based on GEE platform, combined with the sentry images it provides, the emergency monitoring of tailings pond leakage event was carried out by using various indexes, the location of pollution was determined, the river channel through which the pollution flowed was defined, the origin of pollution and the change of river channel were continuously monitored for a long time, the possible impact of the accident and the subsequent treatment were analyzed, and good results were obtained in the emergency monitoring.

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