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A case study of the key factors and mechanism associated with mining site pollution control based on an E-platform management system

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ABSTRACT

An E-platform framework method of mine site pollution control was proposed and tested with big-data of survey system, technology system, and expert decision system. The survey system was used to detect multiple factors and control indexes of the mining area. Key controlling factor and ecological risk index of pressure sensitive model was used to evaluate the pollution determining factors. The ecological footprint was applied to evaluate sustainable development capability. The technical system serves the entire organization and production. An alarming alert is activated when the combination pressure sensitive index is above the threshold value. The expert decision system provides legal basis and decision-making services. It can establish the relationship between metabolism and secondary market for recycling of resources. The resources will be re-allocated by turning on the physical, chemical, biological defensive methods correspondingly. Three sub-platform systems promote the virtuous cycle of multi-level market and the improvement of resource integration capability. The whole mining site was integrated at a new risk rank level for pollution control by big-data of E-platform framework. All progress and sub-systems links will be imported into the big-database of E-framework friendly. The real-time data can be shared by executable interface. The data structures, interfaces between subsystems, independence and systematic are well integrated.

1. Introduction

Research for mining site pollution control intends to set up an all around technology combining the code, scientific standard and practical experience with expert decision system. The system method available includes the probabilistic sensitivity analysis (Hamed, 1999), evaluation of ecological security in Tongling city (Wang and Zhou, 2012), the legal systems of soil pollution prevention and control in China mining (Liang, 2010), the key mining area pollution and the potential ecological risk evaluation in Dahuofang upstream (Liu, 2013) etc.

The key features of big-data are large capacity, variety, high speed and high value, which have broad application in the E-period. The "big-data forum" of Chinese international mining conference were hold by a number of research institutes and central enterprises launched the "China Mining Big-data Alliance" on September 22, 2016, and set up the "first global mining block chain specialized committee" in the alliance. It committed to common development of Chinese global mining by the internet, big-data and block chain. This is clearly a booming new field of research. For Big-data research institutions, the big-data is the need for a new model to deal with the ability to have a stronger decision-making, insight into the ability to find and optimize the process to adapt to the massive, high growth and diversification of information assets in ecosystem.

Based on the survey systems, technology systems, legal and decision-making systems, an E-platform of mine soil pollution are proposing to build up by the method of big-data (cloud data). Even though the Chinese mines have large monitoring data associated with them, the management experience and the market demand have not been conveniently linked and interfaced. The establishment of E-platform by Big-data and integrate information for building up the large amount of data of mines are needed.

As a case study, Tongling mine has been carrying out reformation for more than ten years since 2005. It has resulted in better pollution control, which can be served as a reference for the industry. The E-platform framework was built up based on a case study and an understanding of the cloud database for pollution prevention and management. Research on mining pollution concludes the key areas of foci

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including water-soil pollution and bioremediation, and metal contamination.

Soil pollution was investigated using sequential extraction on homogenized soil samples (Anmachalam et al., 1996), mine lands contaminated by heavy metals in Guangxi, China (Li et a1., 2013b) and aerobic microbial activity in fresh and aged bottom ashes from municipal solid waste incineration (Bayard et al., 2009). Water related cases include bioremediation of metal contamination in the Plankenburg River (Jackson et al., 2009), use of immobilized microorganisms for bioremediation of acidic mine wastewater (Macaskie et al., 1996), and soil chromium bioremediation synergic activity of actinobacteria and plants (Polti et al., 2011).

Technology for environmental remediation (Nirola et al., 2016) can removal of heavy metals from industrial wastewater by free and immobilized cells of *Aspergillus niger* (Tsekova et al., 2010), indigenous microorganisms as potential bioremediators for environments contaminated with heavy metals (Colin et al., 2012), biological rehabilitation of polluted groundwater in mining area (Yu et a1., 2005). Bioremediation can also deal with acidic mine effluents (Johnson, 1995, 1996), and Cd and Zn phytoextraction potential by the hyperaccumulators *Thlaspi eaeruleseens* and *Arabidopsis halleri* in the field (McGrath et a1., 2006). Others are available on accumulation of heavy metals by four solanceae plants in mining contaminated soil (Deng et al., 2011), use of sulphate reducing bacteria to assist the removal of heavy metals from acidic mine drainage (Adam and Edyvean, 1996), effects of biochar application on growth and typical metal accumulation of rape in mining contaminated soil (Hou et al., 2014), bioprocess for fast production of enriched biocompost from municipal solid wastes (Helen et al., 2015), bioremediation of mercury and the bacterial *mer* genes involved (Hirak and Surajit, 2012), phylogenetic and genome analyses of antimony-oxidizing bacteria isolated from antimony mined soil (Li et al., 2013a). Obviously, the fragmentation of technology and data requires a better systematic integration for all of them.

2. Materials and methods

2.1. Big-data system of mining pollution prevention

The E-platform collects the real-time cloud data and results of pollution prevention to optimize the industrial configuration, which can realize the sharing of resources and synergetic development. Base on these two points, it refers from legal norms to mining progress and pre-process and post-process as a longitude disposing approach. The attribution of mining management in mining area is named "the idea of using mine to govern mining". The system integrates resources and turns on the physical, chemical, biological defensive treatment measurements. The "precaution, monitor, trimming, govern" of three-dimensional defense mechanism could be built up. The whole feature of framework is taking precaution as main actions, monitoring on a time based manner, dynamic trimming with whole-progress govern. A Big-data systems of pollution govern in Tongling is shown in Fig. S1.

2.1.1. Surveying system and function

The surveying system and function was to evaluate the potential influence of waste on the physico-chemical properties of the area. The mine surveying system is lead by the data interface and the platform can be authorized and shared by multi-parties. The accumulation and discharge of wastewater, waste-air and mining wastes were collected and processed together with monitoring data to form the big-data of the system. All data will be as the foundation of the operation of the whole big-data system. Based on the big-data collected, the ecological damage index of various subsystem can be evaluated real-time; a reasonable classification treatment or recycling system could be made then.

2.1.2. Three-levels waste monitor system

Three-levels waste monitor system includes the main pollution mixing of waste water and underground water from the monitoring mining area. After monitoring, processing, isolating and refolding the chemical reaction and forces for the heavy metal elements into the irrigation water and domestic water, the key indexes of quantity and concentration can control the whole system in real time. The basic status and transmission pathways of polluting heavy mental in soil and underwater are shown in Table 1.

Table 1
The basic status and ways of polluting heavy mental soil and underwater.

Heavy metal	Nature mineral	Artificial pollution source	Form of pollutants
Cd	Cadmium sulfide (CdS)	Selecting and smelting of Non-ferrous metal	$CdCO_3$, CdS,Cd $(OH)_3$
		Production of chemicals and battery production	$CdSO_4$, CdB_2, $CdCl_2$
		Electroplating industry	$Cd(CH_3COO)_2$
Cr	Chromite ($FeOCr_2O_3$)	Chromium compound production	Cro_3, $Crcl_3$, Na_2CrO_4
	Picrochromite ($Mg.FeCr_2O_4$)	Acid mordant dyeing	K_2Cro_4, $ZnCrO_4$, Ca_2CrO_4
	Alumchromite	Chromium metal smelting	Ag_2Cro_4, $PbCrO_4$
Zn	Zincite (ZnO)	Selecting and smelting of Non-ferrous metal	$ZnBr_2$, ZnI_2,Zn $(NO_3)_2$
	Smithsonite ($ZnCO_3$)	Paint rubber processing	$ZnSO_4$, ZnS, ZnF_2
	Franklinite ($ZnFe_2O_4$)	Zinc chloride production	$ZnMnO_4$
Pb	Cerusite ($PbCO_3$)	Electromachining sludge	$Pb(CH_3COO)_2$, $PbBr_2$
	Galena (PbS)	Spent battery	$Pb(OH)_2$, $PbSO_4$
	Dechenite ($PbCrO_4$)	Scrap lead storage battery	Pb_2ClO_4
Cu	Chalcopyrite ($CuFeS_2$)	Selecting and smelting of Non-ferrous metal	$CuBr_2$, $Cu(OH)_2$, $CuSO_4$
	Zigueline (Cu_2O)	Plastic electroplating	$CuCO_3$, $Cu(NO_3)_2$
	Malachite ($Cu_2(OH)_2CO_3$)		$Cu(CH_3COO)_2$

2.2. Mine assessment system and function

The information and data of mine assessment system are gotten mainly from the three-level waste monitor system. The function of mine assessment system is leading-in the monitoring field data and compared with the standard and code database real-time. It will evaluate the ecological pollution situation of mining area with pointed comprehensive factors and give the file record all the time. If the level is higher than the standard, the system will drive safety alerting. Multi-factor comprehensive evaluation method, potential ecological risk assessment index method, the grey system theory method, Nemerow index method, improved Nemerow index method and index weight method etc could be integrated for algorithm system convenient, which will evaluate ecological pressure situation real-time. All algorithms provide the basis data for model, which include ecological security evaluation, pollution factor evaluation and the evaluation index systems for urban development.

For some mining area, based on the ecological environment pressure comprehensive factor, resource constraints comprehensive factor and environment influence comprehensive factor, the system will evaluate the security and stability of ecological environment real-time. Some evaluating method is used to compute system integrated and normalized membership degree (Wang and Zhou, 2012), the pressure index and response index of system behavior is based on the system eigenvalues of the normalized membership.

$$H'_{ip} = (H_{ip} - 2)/(4 - 2) = (H_{ip} - 2)/2 \quad (i = 1,2, \cdots,10; p = 1,2,3) \qquad [1]$$

To build the calculating model: