DISTRIBUTION AND SCOPE ANALYSIS OF SOIL AND WATER POLLUTION CONTAMINANT AT ABANDONED METALLIFEROUS MINES USING GIS

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ABSTRACT ... Among many sources of soil and water pollution, former mining regions also play an important role in distribution and scope of pollution. In response, KMRC has made an investigation into the status mine hazard at the abandoned metalliferous mine area in Korea. In this study, we analyzed distribution of mine hazards at abandoned metalliferous mines using GIS. We considered the distribution of mine hazards and its magnitude for each abandoned mine and displayed the mine hazard index (MHI) using GIS. We divided the MHI value for each mine into 5 classes, and displayed the first class as smallest point symbol and the last class as biggest point symbol. The biggest symbol shows the most serious status of mine hazards. This GIS function was included in the AMGIS system KMRS are running, and it would be helpful to make decision of reclamation priority at abandoned metalliferous mine area.

KEY WORDS: soil and water pollution, distribution of mine hazards, abandoned metalliferous mine, GIS, reclamation

1. INTRODUCTION

There are many sources of soil and water pollution, and former mining regions also play an important role in distribution and scope of pollution. Recently mine hazards caused by water and soil pollution at abandoned metalliferous mines became serious social problems.

In response, the Ministry of Environment (2005) has surveyed actual condition and ill effect of 158 abandoned metalliferous mines in Korea, and Jung et al.(2004) have studied the environmental assessment of heavy metals from various abandoned metalliferous mine in Korea.

In this trend Korea Mine Reclamation Corp (KMRC), the government invested firms, was established by the Ministry of Commerce, Industry and Energy in June, 2006. The former organization began in 1995 as CIPB (Coal Industry Promotion Board) to rehabilitate the mine hazard by abandoned underground coal mine. But, as the beginning of new organization, the scope of business becomes to be extended including the hazards at abandoned metalliferous mines.

KMRC has made an investigation into the abandoned metalliferous mines in Korea and as a result, published a report, "A Survey of Mining Hazards in the Abandoned Metal Mines". The contents of the report are; 1) list of abandoned metalliferous mines and their X, Y coordinate value, 2) not-closed mine head of abandoned mine, 3) measured water qualities of acid mine drainage (AMD) (Fig. 1.), 4) state of ground subsidence occurrences, 5) abandoned residential districts and facilities, 6) mine debris, 7) tailing. Especially, AMD, mine debris and tailing have serious effect on soil and water pollution at mining regions.

KMRC has been developing a client-server based GIS system named "Abandoned Mine GIS" (AMGIS) and utilizing it to manage abandoned mine areas, support decision-making policy for rehabilitation in abandoned mine areas and provide basic geological data for regional construction works.

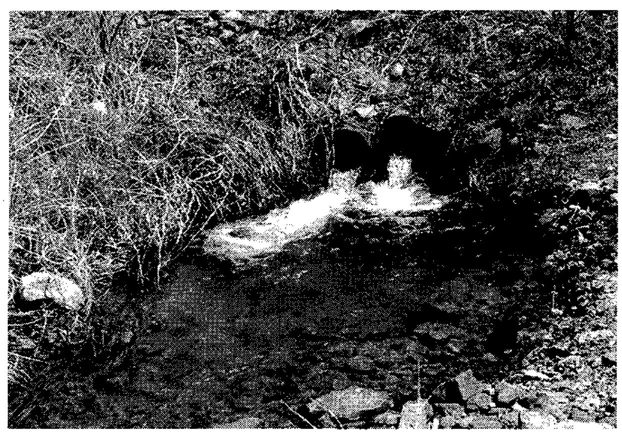

Figure 1. Water pollution due to the acid mine drainage (AMD)

In this study, we displayed the distribution of all abandoned metalliferous mines in Korea as a point layer and analyzed mine hazards in the former mining regions on the AMGIS. We adopted some actual conditions of abandoned mines and inputted them to AMGIS for the end users to map and analyze the status and magnitude of abandoned mines and mine hazards in real time. It will be helpful for the staffs of KMRC to more easily decide the priority of the reclamation project at abandoned metalliferous mine area.

2. DATABASE

2.1 Report analysis

"A Survey of Mining Hazards in the Abandoned Metal Mines" reported the basic information of surveyed 1,022 abandoned metalliferous mines with GPS value at the mine position. It has also six kinds of conditions related to mine hazard such as not-closed mine head of mine, water qualities, ground subsidence occurrence, abandoned facilities, mine debris, tailing.

관리번호 No.	광산명	광종	휴/폐	소재지 도,시	소재지 시,군,구	소재지 읍,면,동	위도 도	위도 분	위도 초	경도 도	경도 분	경도 초
859	금곡,금가,가금,상검	철	폐광	충북	충주	이류	36	57	3.5	127	46	35.5
860	대교	철	폐광	충북	충주	연수	36	59	23.2	127	56	8.2
861	대민	금	폐광	충북	중원	노은						
862	대소	금	폐광	충북	충주	주덕	36	56	56.7	127	46	21.7
863	대황	연	폐광	충북	충주	상모	36	50	15.3	128	2	12.2
864	돈산	중석 휘수연 모리브덴	폐광	충북	충주	앙성	37	4	53.7	127	47	20.2
865	류상	동	폐광	충북	중원	살미	36	53	4.7	128	3	2.1
866	만정,만적	철	폐광	충북	충주	이류	36	56	45.2	127	52	34.3
867	만철	철	폐광	충북	충주	이류	36	56	57.1	127	50	52.2
868	목계	철	폐광	충북	중원	엄정	37	8	16.6	127	54	42.7
869	병역일신	금	폐광	충북	중원	노은	37	3	35.5	127	43	36.8
870	보영	철	폐광	충북	괴산	불정	36	53	10.1	127	51	9.4
871	삼덕	모리브덴	폐광	충북	충주	상모	36	49	43.3	127	59	21
872	삼산	철	폐광	충북	충주	이류	36	56	58.6	127	50	51.3
873	상건	철	폐광	충북	중원	주덕						
874	소산,정금	금	폐광	충북	충주	앙성	37	5	3.2	127	46	45.4

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Figure 2. Basic information of all surveyed mines

Basic information of the mines are the name of mine, mined metal at that time of working, closing or quitting, the address of mine location, and the coordinate value surveyed by GPS (longitude, latitude) of mine position (Fig. 2).

The quantitative analysis of mine hazard in abandoned metalliferous mine area have not been reported or studied as yet. But mine hazards and environment pollutions in the former mining region become serious social problems, so the analysis and estimation of mine hazards is needed for the decision making of rehabilitation policies at abandoned mine area. This report suggested the principles and guidelines in order to analyze the seriousness of mine hazards quantitatively (CIPB, 2005).

In this report, the actual conditions of mine hazards for the surveyed 1,082 abandoned metalliferous mines are analyzed quantitatively, and then the results are classified as three classes such as "urgent" or "A" which means the decontamination is needed urgently, "needed" or "B" which means the decontamination is needed but not urgently, and "traces" or "C", which means the mine has the trace area of pollution.

To display the mine hazards on the AMGIS, six types of mine hazards were divided into three classes, respectively, according to the conditions to belong to each class (Table 1). For example, a not-closed minehead of abandoned mine belongs to the class "urgent" or "A" if the mine has a shaft, and belongs to the class "needed" or "B" if the mine has an inclined shaft or heading.

Table 1. mine hazard class analysis

type of mine hazards \ class	A urgent	B needed	C traces
not-closed minehead of abandoned mine	a shaft	an inclined shaft, heading	
acid mine drainage	prescribed by law		
	more than 34.7L/m (50t/d)	less than 34.7L/m (50t/d)	
ground subsidence occurrence	vertical over 3m depth		traces
abandoned facilities	large lodge or 10 buildings	medium lodge or 5 buildings	1 building or rail or small structure
mine debris	prescribed by law		
	heap amount > $50,000m^3$	heap amount < $50,000m^3$ > $5,000m^3$	heap amount < $5,000m^3$
tailing	prescribed by law		
	heap amount > $10,000m^3$	heap amount < $10,000m^3$ > $1,000m^3$	heap amount < $1,000m^3$

2.2 Mine Hazard Index (MHI)

To determine the reclamation priority of mine hazards for the analyzed abandoned metalliferous mines, we need standards of estimating the seriousness of the hazard.

Among the six types of mine hazards, not-closed minehead of abandoned mine, AMD, mine debris and tailing were thought to be more dangerous than others, so they were assigned 20 relative weight value in the report. The ground subsidence occurrence was assigned 15 and the magnitude of abandoned facilities was assigned 5 weight value according to the relative seriousness they were thought to have. The three classes representing the seriousness of mine hazards, "A", "B" and "C" above, were changed into representative value from 1 to 0.1, where the value of 0.1 means there was a trace of mine hazard.

The value of seriousness was multiplied by weight value, and then Mine Hazard Index was created for the classes of each type of mine hazard (Table 2). The sum of all the MHI of each mine hazard which has occurred in an abandoned mine would be the MHI of that mine. So, the higher the MHI value, the more serious the mine hazard. MHI of the abandoned metalliferous mines will be the basis for the staffs of KMRC to decide the priority of the reclamation project.

Table 2. Mine Hazard Index (MHI)

type of mine hazards	weight (a)	classification	Seriousness (b)	MHI $\Sigma(a \cdot b)$
not-closed minehead of abandoned mine	20	heading	1	20
		an inclined shaft	0.4	8
acid mine drainage	20	over 50t/day	1	20
		less 50t/day	0.8	16
ground subsidence occurrence	15	vertical over 3m depth	1	15
		trace	0.1	1.5
abandoned facilities	15	large lodge or 10 buildings	1	5
		medium lodge or 5 buildings	0.8	4
		1 building or rail or small structure	0.1	0.5
mine debris	20	heap amount > $50{,}000m^3$	1	20
		heap amount < $50{,}000m^3$ > $5{,}000m^3$	0.8	16
		heap amount < $5{,}000m^3$	0.1	2
tailing	20	heap amount > $10{,}000m^3$	1	20
		heap amount < $10{,}000m^3$ > $1{,}000m^3$	0.8	16
		heap amount < $1{,}000m^3$	0.1	2

3. DISPLAYING MHI USING GIS

3.1 GIS Data Processing

To display the MHI of each mine using GIS, first, we built up the spatial database of abandoned metalliferous mines which has coordinate value measured by GPS. In the report, about 90% of mines among the surveyed have coordinate value. Using these data in the report, we constructed the spatial database as a point layer, and the related basic information about the mines in the report are input as the attribute data of the layer. The projection was Bessel 1841 and the Projected Coordinate System was Korean 1985 Korea Central Belt. The spatial database was stored in ArcSDE, spatial database engine.

The status of mine hazards and the MHI value for each abandoned mine were constructed as attribute database, and were stored as Oracle RDBMS table. This attribute database was linked with the spatial database using the common code.

Figure 2 shows the inputted GISDB tables and fields. The spatial database table included the fields of mine id, mine class, mine name, and mine address. The fields of mine hazard type, magnitude of mine hazards and mine hazard index made up the attribute database table.

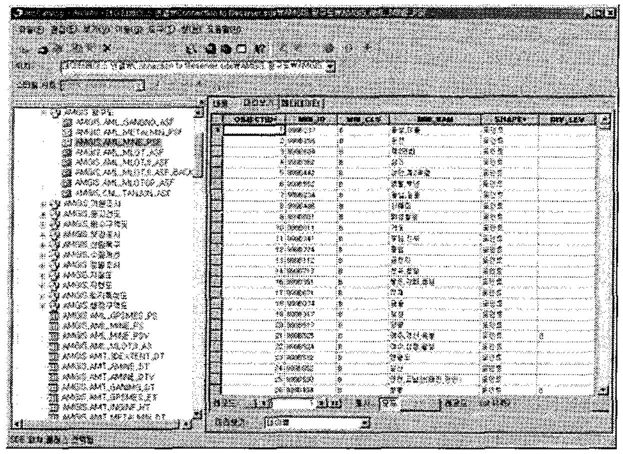

Figure 2. Constructed GIS database

3.2 GIS Data Presentation

We made a GIS functional application in the AMGIS system running at KMRC. The MHI value of each mine was joined with the mine point layer as one database. The database was divided into 5 classes by the MHI value; the first class is 0~7, the second 8~13, the third 14~17, the fourth 18~20 and the last 21~24, respectively.

We displayed the first class as smallest point symbol and the last class as biggest point symbol. So, the biggest symbol represents the most serious status of mine hazards and that mine area needs a reclamation work urgently. This GIS function was constructed on the national scale for the abandoned metalliferous mines. Figure 3 shows the result of GIS presentation of MHI for each abandoned metalliferous mine.

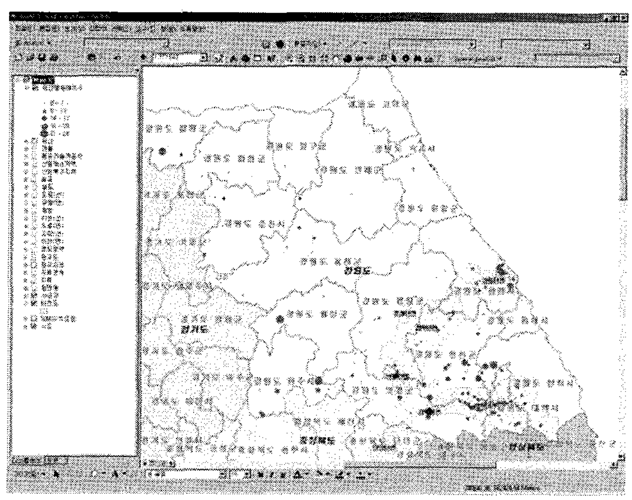

Figure 3. The resultant map of MHI on AMGIS

4. CONCLUSION

In this study, we displayed the seriousness of mine hazards for each abandoned metalliferous mine on the national scale using GIS. With this function, AMGIS of KMRC can support decision making for the reclamation projects in the former mining regions, and this function of

GIS can be applicable not only to abandoned metalliferous mine area but also to all the former mining regions including coal mines and non-metallic mines.

In the future, quantitative distribution and scope analysis of soil and water pollution contaminant at abandoned mines using GIS would be possible, if accurate database will be constructed.

AMGIS are planning to be developed on the web based environment for all the abandoned mines in Korea, so staffs at branch offices of KMRC will be able to share the mine hazard information and make full use of it with the GIS functions.

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