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Simulating Experiments Approaching the Impact on Groundwater from the Filling-in Underground in Coal Mine with Gangue

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In order to discuss the possibility of the filling-in the underground caves with gangue with a large scale, and based on Pingdingshan coal mine area, a case study is carried on to approach the impact on the groundwater from coal solid wastes after the filling-in. Materials used in the experiments are collected from the gangue hill of the 12th mine of the Pingdingshan Coal mine Group. The experiments are mainly designed to stimulate the stripping characteristics or laws of the component of gangue when it is submerged in coal mine groundwater under the hydrostatic condition. Indices detected in the experiments include pH, F⁻ and heavy metal elements include Cd²⁺, Cr⁶⁺, Zn²⁺, Mn²⁺, Pb²⁺, Cu²⁺. The results indicate that the main influence on the ground water comes from pH and F⁻, whilst the other indices coincide the national standard.

Keywords : Gangue, Leaching, Coal mine ground water; Impact on environment

1 INTRODUCTION

During the process of coal mining, large amounts of solid wastes are produced, most of which are gangue. The amount of gangue is very large, at present, it is estimated that the amount is about 15 to 25 percent of raw coal. For the total synthesis utilization amount is less than 45%. Most of these coal wastes are piled naturally, and form gangues with large numbers that occupy vast area of soil. Under the interaction of physical, chemical and biological process such as wind, rain and self-burning for rather a long time, the component of these coal wastes will transfer into atmosphere, water and soil, cause geochemistry abnormality in coal mining area, and lead to environmental pollution and ecological destroy. At the same time, a great deal of subsidence area need to be renovated urgently, and also with the development of environment protection, the policy to manage the

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discharge of solid coal wastes will be stricter and stricter, for instance, the toll is 5 yuan per ton coal wastes now. Therefore, it is very important to search for techniques which can utilize large amount of gangue; the technique will dispose coal wastes, solve the problem of coal mining under buildings, under water bodies or railroads, and improve the ecological environment all at the same time. The utilization of large amount of gangue to fill in the caves underground can solve this problem effectively, but it may lead to serious groundwater pollution and should pay great attention on it^(1~8).

In order to relax the pressure from the charge of the discharge of the coal solid wastes, to solve the environmental pollution problem of gangue hills and to get back the utilization value of the soil and to improve the ecological environment in coal mine area, this paper design and carry through experiments to simulate the mechanism and characteristics of the groundwater when it is being polluted after the filling in the coal mine underground with large amount of gangue, for

example, in 12[#] coal mine of Pingdingshan coal mine group company.

2 BACKGROUND OF THE STUDIED AREA

2.1 Production and discharge of coal solid wastes

In 2002, the output of raw coal of Pingdingshan coal mine group attains 2300×10^4 tons. At present, there are 29 gangues hills in this area. The cumulated amount of gangues accounts to 3211.85×10^4 tons, and occupy as more as $45.5499 \times 10^4 \text{m}^2$ soils. And the amount of gangues is still increasing continuously at a speed of 360×10^4 tons per year. Furthermore, up to now, no safety engineering projects have been carried on to keep the gangue hills from infiltrate, fly dust and self-ignite. Therefore, there exist many hidden-troubles such as collapse, self-ignite and burst. The production and discharge of coal wastes of No.12 coal mine is given in Table 1.

Table 1 The emission and utilization of gangue in 12th mine

height (m)	area (m ²)	production (10 ⁴ t/a)	Utilization amount (10 ⁴ t/a)	Store up amount (10 ⁴ t)
40	12000	17.50	7.00	167.0

2.2 Chemical composition of the gangue

The chemical composition ($W_i\%$) of the gangue in the No.12 coal mine are shown in Table 2.

Table 2 The chemical composition of the gangue (%)

CaO	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂
1.25~	55.09~	15.79~	4.61~	0.84~
3.40	58.31	18.31	5.49	0.92
MgO	SO ₃	P ₂ O ₅	K ₂ O	Na ₂ O
0.81~	0.28~0.84	0.044~	2.50~	0.80~
1.07		0.055	3.38	0.95

As listed in Tab.2, the three main compositions are SiO₂, Al₂O₃ and Fe₂O₃. A social survey on community response to railway.

3 THE EXPERIMENTS

The underground filling room in NO.12 coal mine situated below the phreatic surface level in this located area. So, after fill in the underground room, the gangue will firstly be eluviated by the roof water. Then, it will be submerged in mine water for rather a long time, and during this period, some components such as heavy mental elements is gradually stripping out and transfer and transform in groundwater. The simulating experiments of the mechanism about the impact on groundwater environment were done as following.

3.1 Materials

The material selected come from the gangue hill of the NO.12 coal mine. The lixiviation medium selected in the experiments is de-ionized water and coal mine

water from NO.12 coal mine.

The sampling process: according to the equidistant five-spot sampling method rule, at the each depth of 0.5m, 3m, 5m from surface and at each different position – top, middle and bottom of the hill, we take 3kg gangues on each point. And then crushing, completely mixing and splitting until the total amount is about 30kg, then drying for about 24 hours at the temperature of 105°C. Then put it into bottle, and so, the representative samples are prepared. The samples are given serial numbers according to their particle diameter as following: sample A (completely mixed), sample B (3~25mm), sample C (0~25mm) and sample D (0~3mm).

3.2 Experiments

1kg sample from each sample described above was taken and dried at $105 \pm 5^\circ\text{C}$, then placed in the polyethylene bottles (25L). De-ionized water or mine water was added separately in each bottles and the ratio of solid/liquid was kept at 1/10. Then the samples were mixed round completely at every 6 hours with the time and temperature being noted. The frequency of each sampling and monitoring is once in 24 hours. About 1 hour before each tests, the samples was mixed round completely. After the solution becomes clear, enough amount of liquid was fetched and filtered with quantitative filter paper (film of 0.45 μm). The filtrate was used to measure different kind of ingredient. The tested indices and methods are given in Table 3.

Table 3 Analytical methods and items

Items	The method or instruments	Detection limit (mg/L)
Cd ²⁺ , Zn ²⁺ , Mn ²⁺ , Pb ²⁺ , Cu ²⁺	Atomic absorption	0.001
Cr ⁶⁺	DPC spectrophotometry	0.004
F ⁻	F ⁻ selective electrode	0.05
Total hardness	EDTA Chelatometry	—
pH	Glass electrode method	—
Electrical conductivity	Conductivity apparatus	—

4 RESULTS

4.1 The experiments with de-ionized water under hydrostatic condition

The results of stripping experiment in de-ionized water under hydrostatic condition were shown in Fig.1 to Fig.7; from the figures, it is concludes as following.

4.1.1 F⁻, electrical conductivity and pH value

(1) The value of pH varies from 8.4 to 9.4, presenting alkalinity. With the leaching time lasting, the pH value of sample A and C gradually increase from 8.4 to 9 remaining to be alkaline; the pH value of sample B and D kept at the level 9 basically. These value are all exceed the ground water-quality standard (GB/T14848-9) and hygienic standard for drinking

water (GB5749—85).

(2) With the leaching time lasting, the value of electrical conductivity increased gradually.

(3) The concentration of F^- varied from 0 mg/l to 1 mg/l and measure up to ground water-quality standard. Only one group of data of sample D has a little of deviation at the third measuring. After then, the value maintains 1.0mg/l. The concentration of F^- of other samples all gradually approach to 1.0mg/l.

4.1.2 The heavy metal ion

(1) The change tendency of Zn^{2+} is not obvious. It shows from the curve: With the time lasting, the value of Zn^{2+} is less than 0.1mg/l on the whole.

(2) The concentration of Mn^{2+} , are all below 0.1mg/l. The values of sample D wave disorderly, with a tendency to approach 0.1mg/l.

(3) Cd^{2+} 、 Cr^{6+} are all non-detected.

(4) The values of Pb^{2+} vary from 0 to 0.25mg/l. Among these values, those of sample D fluctuate on initial stage. But on the whole, the variations of these four samples are all less than 0.05mg/l. The concentration range of Cu^{2+} is among 0 to 0.05mg/l. The change tendency of Cu^{2+} is not obviously on the curve during the whole soaking period, it only shows the concentration of Cu^{2+} is accord with that of the standard.

4.2 The experiments with mine water

4.2.1 Ca^{2+} 、 Mg^{2+} and total hardness

As showed in Fig.8 to Fig.10:

(1) Along with the lasting of leaching time, the change of total hardness becomes distinctive with a tendency to approach 3mg/l to 4mg/l. That is to say, with the lasting of leaching time, the data of hardness change less than less.

(2) With the lasting of leaching time, the concentration of Ca^{2+} come to be stable and is among 1 mg/l to 2mg/l.

(3) With the lasting of leaching time, the concentration of Mg^{2+} of sample A, sample B and sample C approach gradually to 1.5 mg/l. While the data of sample D tend to reduce.

4.2.2 pH value, F^- and electronic conductivity

(1) As is shown in the Fig.11, in the mine water, with the lasting of leaching time, the values of pH of four samples all approach to 7.8 on the whole.

(2) The electronic conductivity of some of one or two samples is a little larger than normal at the initial periods, but in general all the data has a tendency to approach to 200 μ s/cm (Shown in Table.4).

(3) With the lasting of leaching time, some data of the concentration of F^- appear to be non-detected, but most of which approach to 1.0mg/l and shows stabilization.

4.2.3 The heavy metal ion

As given in table 4:

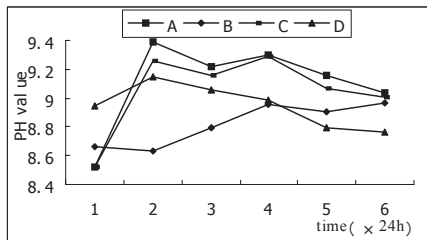


Fig.1 The leaching curve of pH values with de-ionized water

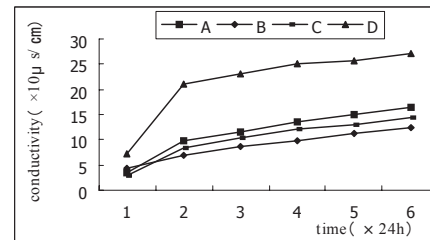


Fig.2 The leaching curve of electronic conductivity with de-ionized water

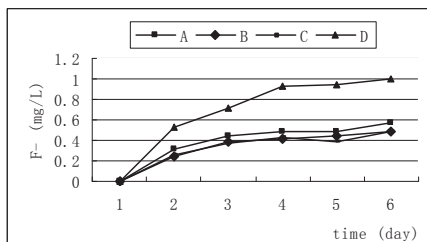


Fig.3 The leaching curve of F^- with de-ionized water

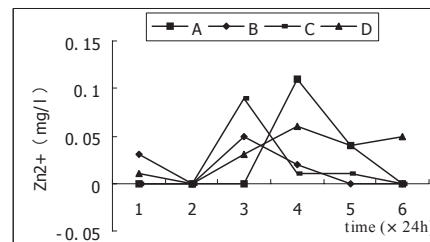


Fig.4 The leaching curve of Zn^{2+} with de-ionized water

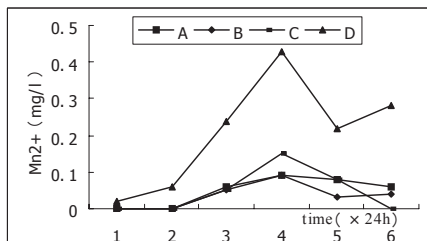


Fig.5 The leaching curve of Mn^{2+} with de-ionized water

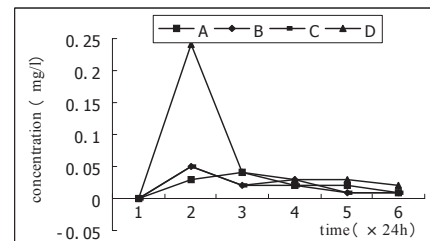


Fig.6 The leaching curve of Pb^{2+} with de-ionized water

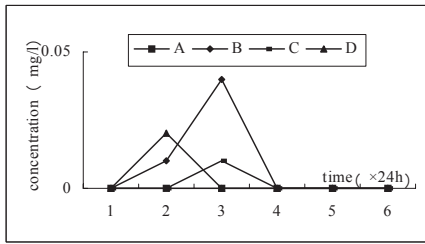


Fig.7 The leaching curve of Cu^{2+} with de-ionized water

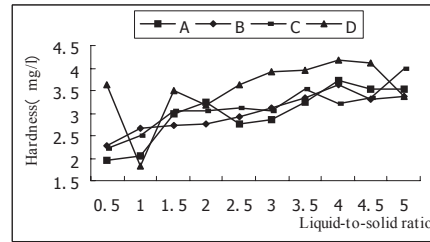


Fig.8 The leaching curve of total hardness with mine water

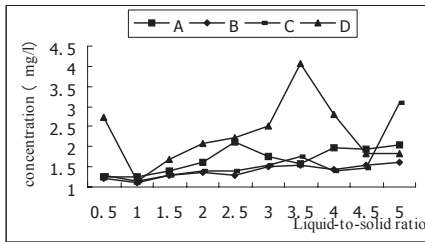


Fig.9 The leaching curve of Ca^{2+} with mine water

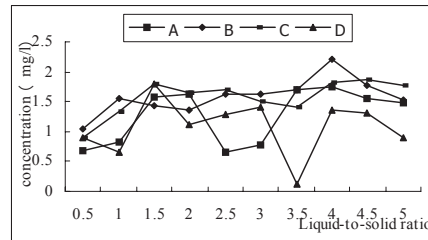


Fig.10 The leaching curve of Mg^{2+} with mine water

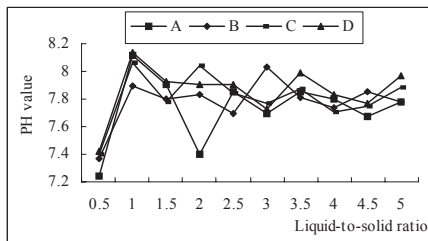


Fig.11 The leaching curve of PH value with mine water

(1) The concentration of Cd^{2+} , Cr^{6+} , Zn^{2+} , Cu^{2+} are all non-detected at the beginning of the experiments. And with the lasting of leaching time, some can be detected occasionally, and the maximal value is not exceeding 0.2mg/l. It shows the leaching characteristic is not changed.

(2) Mn^{2+} can be leach out easily, for at the beginning of the experiments, the curve lift to the highest spot, and with the lasting of leaching time, the concentration become less than 0.2mg/l and gradually approach to 0.

(3) Along with the lasting of leaching time, the concentration of Pb^{2+} is almost not changed.

5 CONCLUSIONS

The following main conclusions were reached in the present study.

1. The value of pH is a little more exceed that of the standard, it is alkaline. This has a great effect on the quality of groundwater and is fit neither for the growth of crops nor for daily drinking. The pH value for drinking water is among 6.5 to 8.5 and that for industrial water is required among 7.0 to 8.5 to keep metallic equipments and pipes from erosion.

2. With the experiments going on, the value of

the electronic conductivity exceed above that of the standard, it indicates that the concentration of total ions or salt content is higher than normal.

3. Compared with that of the national standard, the quantity of F^- is near to the super scale level, so more controlling methods is needed.

4. All of the heavy metal ion, such as Cd^{2+} , Cr^{6+} , Zn^{2+} , Mn^{2+} , Pb^{2+} and Cu^{2+} , are accord with the requirement of the standard or even non-detected. Thus some of the indices should be adjusted in later experiments.

5. Considering that Ca^{2+} and Mg^{2+} are the most important matters that lead to hard water, the test of total hardness is added in the experiments. And the result shows that both the total hardness and the concentration of Ca^{2+} and Mg^{2+} are all not exceed the standard, this shows that filling-in the underground rooms has little effect on the hardness of groundwater.

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