

The Characteristics of Heavy Metals of the Groundwater in the Gangue-Filled Reclamation Area

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Abstract—In order to study the characteristics of heavy metals of the groundwater in the gangue-filled reclamation area, the heavy metals were investigated at Ju-Ji Coal mine with high groundwater level. The samples of the groundwater were gathered in the gangue-filled reclamation area at different time, studying the characteristics of heavy metals of the groundwater. The results were as follows: the heavy metal content of the Cd, Hg, As and Pb increased with the increase of reclamation time. The heavy metal content of groundwater associated with the reclamation time in linear time.

Keywords—Groundwater; Heavy Metals; Reclamation Time; Gangue-Filled Reclamation

I. INTRODUCTION

The coal gangue is the directly discharged solid waste of coal mining and processing, which accounts for 10% -20% of the emissions of coal production [1]. As the filling coal gangue material of coal mining subsidence, not only to restore the use of the mechanisms subsidence, but also to solves the problems of coal gangue occupied land and damage the ecology. The coal gangue contains a variety of heavy metals, and heavy metals Cd, As, Hg and Pb toxicity, it is difficult degradation by biological effects. The coal gangue under the long-term influence of groundwater, natural rainfall and other conditions, which could easily lead to the release of heavy metals and affect the heavy metal content of groundwater, and then enter the body to threaten to the human health by the way of the food chain. Groundwater of reclamation is an important part of the ecological environment rehabilitation. The study on the features of the time evolution of the coal gangue affecting the heavy metal's content in the reclamation of groundwater, which has important significance for the safe use of the groundwater in the reclaimed area.

Currently, the study on the pollution of the heavy metals in the waters of coal mining subsidence drew relatively significant concern of many experts and scholars. There are many researches on the heavy pollution of the waters in coal mining subsidence [2-6]. While there are a little researches on the pollution and the time evolution

characteristics of the groundwater of the coal gangue of filling reclaimed area in the coal mining area.

This article chooses the reclaimed area in the Juji's coal mining area as the object of study, which is in high phreatic level of the plains region. On the basis of filed investigation and laboratory analysis, we study on the features of the time evolution of the coal gangue affecting the heavy metal's content in the reclamation of groundwater.

II. MATERIALS AND METHODS

A. Overview of the Study Area

The coal mining of Juji is in the city of Yongcheng, which is located in the high groundwater level of plain area. The coal mining of Juji takes reclamation technique in the process of reclamation, which is striping topsoil and filling coal gangue and then covering soil with 60cm on the coal gangue in subsidence area. At the same time, we lay two monitoring wells in reclamation area to monitor the contamination of the groundwater's heavy metals. Before reclamation, the area is the basic farmland which has no heavy metal contamination. The elevation of underground water level in the reclamation area is below the waste rock filling layer.

B. Sample Collection and Processing

The sample point is the two monitoring wells in the reclamation area. And selecting the nearby household well as a control sample, without the mining subsidence affected. When sampling monitoring wells, each sampling copy comes from the two wells and marking the A and B according to the sequence of tests. The sampling time is from December 20, 2012 to December 20, 2014. And taking once every six months for a total of five samples. In the first sampling, sample the household well water as the control sample. The samples will be sent to the lab for analysis. We took the samples of coal gangue from the reclamation land which is nearby the two monitoring wells and the sample of soil from the nearby individual well on June 20, 2012. And then send the samples for analysis in the lab.

C. Testing Methods and Data Processing

The method of testing Cd, Pb is atomic absorption spectrophotometry. The method of testing As and Hg is inductively coupled plasma method.

The statistical analysis of the data is using by the SPSS19.0 and the Microsoft Excel 2013 statistical software.

III. RESULTS AND ANALYSIS

A. Heavy Metal Content of Groundwater Reclamation Area

After determination, the heavy metal content of groundwater of reclamation area and control groundwater of individual well is shown by tab.1 and tab.2. The heavy metal content in the soil nearby individual well and in the coal gangue of reclamation land is shown in the tab.3.

Tab.1 Heavy Metal Content of Different Time in Groundwater of

Reclamation Time(a)	Reclamation Area ($\mu\text{g} \cdot \text{L}^{-1}$)							
	Cd		Hg		As		Pb	
	A	B	A	B	A	B	A	B
0.5	0.519	0.5	0.2	0.3	6.3	6.5	8.9	8.8
1.0	0.521	36	96	13	3	2	9	3
		48	97	17	7	6	2	9
1.5	0.517	0.5	0.2	0.3	6.4	6.6	9.2	9.1
		25	99	21	6	8	3	1
2.0	0.526	0.5	0.2	0.3	6.5	6.7	9.2	9.2
		46	96	24	2	5	1	3
2.5	0.531	0.5	0.3	0.3	6.5	6.8	9.3	9.2
		50	03	27	8	2	3	9

P.s.: the Monitoring A and Monitoring B are Represented by A and B.

Tab.2 Heavy Metal Content in Control Groundwater of Individual Well

Chemical Element	Cd	Hg	As	Pb
Content	0.131	0.089	5.82	6.15

Tab.3 Heavy Metal Content in the Soil Nearby Individual Well and in the Coal Gangue of Reclamation Land (mg/kg)

Sample	Cd	Hg	As	Pb
Soil of Farmland	0.29	0.031	9.3	23.4
Coal Gangue A	2.63	0.092	10.6	37.8
Coal Gangue B	2.85	0.098	10.1	35.3

According to the data in the tab.1, 2 and 3, we found the results. The content of Cd, Hg, As and Pb in the soil of the farmland is less than the content of Cd, Hg, As and Pb in the coal gangue. The heavy metal content of different time in groundwater of reclamation area is more than the heavy metal content in control groundwater of individual well. Contrast with the quality standard values of soil environment, we could find: the heavy metal content in the soil nearby individual well belongs to the primary standard; the content of Hg and As in the coal gangue of A and B belong to the primary standard; while, the content of Cd and Pb belongs to the secondary standard; the Cd content of the coal gangue is much more than the Cd content in the secondary standard of the soil. Thus, it could have the potential risks of pollution on the surrounding ecological environment.

B. The Change Characteristics of the Heavy Metal Content and the Correlation with the Reclamation Time

(1) The change characteristics of the heavy metal Cd content of the groundwater and the correlation with the reclamation in the reclamation area.

Figure 1 is the change trend of the Cd content in groundwater of the monitoring wells of A and B. According to the table 1 and figure 1, we found: the Cd content in groundwater is in the process of rising in the reclamation of 2.5 years. The Cd content of the monitoring well A is more than the Cd content of the monitoring well B. The Cd content in the groundwater of the reclamation area is obviously higher than the heavy metal content in control groundwater of individual well. The Cd content of the coal gangue which is filling material is higher than the Cd content of the content of control soil. The Cd content in groundwater is in the process of rising in the reclamation of 2.5 years, while the water could be used for various purposes in accordance with the national groundwater quality standard. The water doesn't have the potential risks.

Through the reclamation time and Cd content in groundwater by regression analysis, we could find that the reclamation time associated with the Cd content of groundwater in linear time, the content of Cd increases with the increase of reclamation time. The correlation between the Cd content of monitoring well B and the reclamation time is smaller than the Cd content of monitoring well A and the reclamation time. The Cd content of the groundwater in monitoring wells A and B have the basically same change trend.

Fig.1 Changes of Cd Content in Different Monitoring Wells and the Correlation with the Reclamation Time

(2) The change characteristics of the heavy metal Hg content of the groundwater and the correlation with the reclamation in the reclamation area

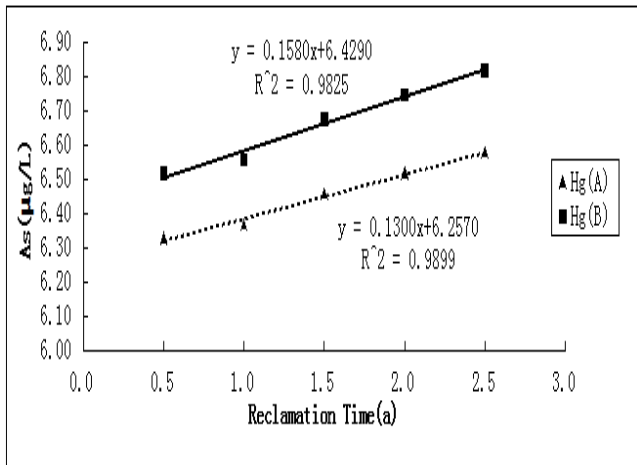


Figure 2 is the change trend of the Hg content in groundwater of the monitoring wells of A and B. According to Table 1 and Figure 2, we found: the Hg content in groundwater is in the process of rising in the reclamation of 2.5 years. The Hg content of the monitoring well B is more than the Hg content of the monitoring well A. The Hg content in the groundwater of the reclamation area is obviously higher than the heavy metal content in control groundwater of individual well. Therefore, the coal gangue Hg content has no effect on the improvement of the Hg content in groundwater. The Hg content of the coal gangue is higher than that in the control soil. It may be one of the influence factors which increase the Hg content of the groundwater. The Hg content in groundwater is in the process of rising in the reclamation of 2.5 years, while the water could be used for various purposes in accordance with the national groundwater quality standard. The water doesn't have the potential risks.

Through the reclamation time and Hg content in groundwater by regression analysis, we could find that the reclamation time associated with the Hg content of groundwater in linear time, the content of Hg increases with the increase of reclamation time. The correlation between the Hg content of monitoring well A and the reclamation time is smaller than that between the Hg content of monitoring well B and the reclamation time. The Hg content of monitoring well B and the reclamation time has the significant correlation. The Hg content of the groundwater in monitoring wells A and B have the basically same change trend.

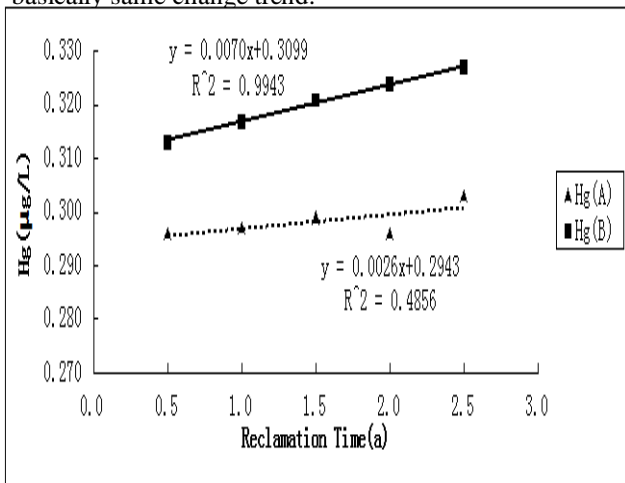


Fig.2 Changes of Hg Content in Different Monitoring Wells and the Correlation with the Reclamation Time

(3) The change characteristics of the heavy metal As content of the groundwater and the correlation with the reclamation in the reclamation area

Figure 3 is the change trend of the As content in groundwater of the monitoring wells of A and B. According to the table 1 and figure 3, we found: the As content in groundwater is in the process of rising in the reclamation of 2.5 years. The As content of the monitoring well B is more than the As content of the monitoring well A. The As content in the groundwater of the reclamation area is obviously less than the heavy metal content in control groundwater of individual well. Therefore, the coal gangue As content has an effect on the improvement of the As content in groundwater. The As content of the coal gangue is higher than that in the control soil. It may be one of the influence factors which increase the As content of the groundwater. The As content in groundwater is in the process of rising in the reclamation of 2.5 years, while the water could be used for various purposes in accordance with the national groundwater quality standard. The water don't have the potential risks.

Through the reclamation time and As content in groundwater by regression analysis, we could find that the reclamation time associated with the As content of groundwater in linear time, the content of As increases with the increase of reclamation time. The As content of monitoring wells A and B and the reclamation time have the significant correlation. The As content of the groundwater in monitoring wells A and B have the basically same change trend.

Fig.3 Changes of As Content in Different Monitoring Wells and the Correlation with the Reclamation Time

(4) The change characteristics of the heavy metal Pb content of the groundwater and the correlation with the reclamation in the reclamation area

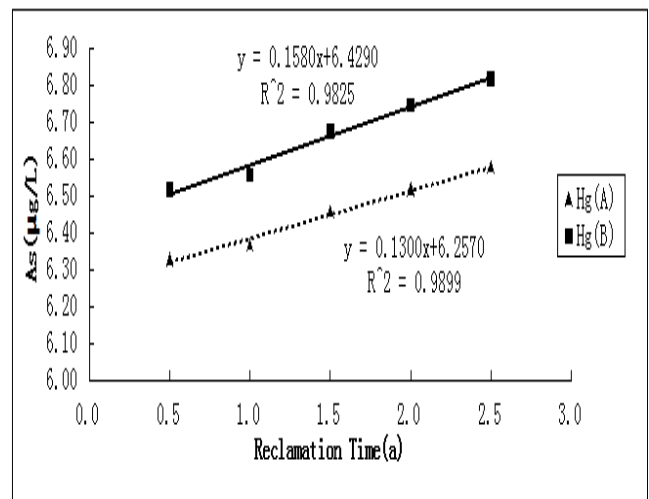


Figure 4 is the change trend of the Pb content in groundwater of the monitoring wells of A and B. According to Table 1 and Figure 4, we found: the Pb content in groundwater is in the process of rising in the reclamation of 2.5 years. The Pb content of the monitoring well B is less than the Pb content of the monitoring well A.

The Pb content in the groundwater of the reclamation area is obviously higher than the heavy metal content in control groundwater of individual well. Therefore, the Pb content of the coal gangue has an effect on the improvement of the Pb content in groundwater. The Pb content of the coal gangue is higher than that in the control soil. It may be one of the influence factors which increase the Pb content of the groundwater. The Pb content in groundwater is in the process of rising in the reclamation of 2.5 years, while the water could be used for various purposes in accordance with the national groundwater quality standard. The water doesn't have the potential risks.

Through the reclamation time and Pb content in groundwater by regression analysis, we could find that the reclamation time associated with the Pb content of groundwater in linear time, the content of Pb increases with the increase of reclamation time. The Pb content of monitoring wells A and B and the reclamation time have the significant correlation. The Pb content of the groundwater in monitoring wells A and B have the basically same change trend.

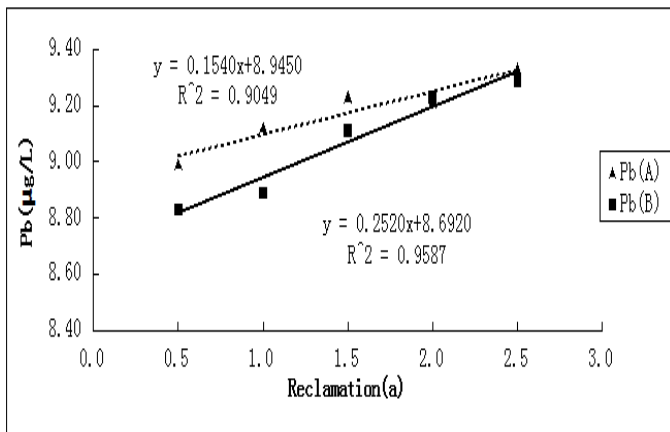


Fig.4 Changes of Pb Content in Different Monitoring Wells and the Correlation with the Reclamation Time Conclusions

(1)The heavy metal content of the Cd, Hg, As and Pb increased with the increase of reclamation time, and they are all higher than the heavy metal content in control groundwater of individual well. The heavy metal content in the soil nearby individual well is less than that in the coal gangue of reclamation land.

(2)The heavy metal content of groundwater associated with the reclamation time in linear time. The correlation between the Cd content in groundwater and the reclamation time is not significant. The correlation between the Hg content in groundwater and the reclamation time was not significant in the monitoring well A, but that in the monitoring well B is significant.

The correlation between the As content in groundwater and the reclamation time is very significant. The correlation between the Pb content in groundwater and the reclamation time is very significant.

(3)The heavy metal content in groundwater is in the process of rising in the reclamation time, while the water could be used for various purposes in accordance with the national groundwater quality standard. The water doesn't have the potential risks.

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