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Heavy Metal Pollution in Surface Water of Linglong Gold Mining Area, China

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Abstract

The concentrations and distribution patterns of lead, mercury, zinc, copper, chromium, arsenic, cadmium in surface water of Linglong deposit area were discussed. The result shows that the surface water of Linglong mining area is seriously polluted by mercury, zinc and cadmium, which of the concentration are higher than the Ⅲ class of National Surface Water Quality Standard, and moderately polluted by chromium and arsenic, which of the concentration conforms to the Ⅲ class national surface water quality standard, and light polluted by lead and copper, which of the concentration conforms to the Ⅱ class national surface water quality standard. The concentration of heavy metals in the gold deposit areas depends upon the distance from the pollution source and scalar transport in rivulet flows, decreases along the flow direction. The concentration and distribution of heavy metal pollutants in surface water are dominated by the geochemical situation and the pollution source, but seriously affected by mining leachate and chemical wastewater discharge.

Key words: surface water, heavy metal pollution, Linglong Gold Mining Area

1. Introduction

In recent years, heavy metal pollution problem becomes increasingly serious with the development of industry. Wastewater from non-ferrous metal ore mining and smelting, electroplating and other industrial production process, is an important pollution source of heavy metal[1]. The heavy metal pollution has the characteristic of the high toxicity, and difficult to degrade, and its migration brings about a broader range of hazards. The research indicated that mining and the smelting activities caused great destruction to the

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water environment. The heavy metals are difficult to clear away from the natural environment, or even form a secondary pollution[2].

The Linglong gold deposit area is located at northeast of Zhaoyuan City, Shandong Province, China. Linglong Gold Group was established in 1962, total gold production in 2007 reached 103.73 million gram. Following the gold production scale unceasingly expanded, the capacity of production increases year by year, and long-year mining that produces a great deal of tailing and mining waste slag which are piled up everywhere. Heavy metals containing in these solid waste released into the aquatic environment through weathering, altering, decomposing, leaching. Therefore, the concentrations and distribution patterns of lead, mercury, zinc, copper, chromium, arsenic, cadmium from the surface water of Linglong gold mining area were analyzed. So as to correctly evaluate the heavy metal pollution of surface water in the region and provide the scientific basis for environment management.

2. Materials and Methods

Using 1:5 million topographic map as field work hand chart to pre-arrange the sampling points. Picked five water samples in the north of the mine and nine water samples in the south both along the stream, particularly water of the point LS10 is from an deep undergroundwater well. The concentrations of lead, zinc, copper and cadmium were analyzed by using plasma mass spectrometry, and the content of mercury and arsenic were analyzed by the atomic fluorescence spectrometry, and the content of hexavalent chromium was analyzed by diphenylcarbazide spectrophotometry.

3. Results and Discussion

3.1 The concentration of heavy metals in surface water

There are statistical results of concentration of seven elements(Pb、Hg、Zn、Cu、Cr、As、Cd) in surface waters of Linglong gold deposit area (table 1). It can be seen in the table, the concentrations of metals in surface water are high and have a wide variation in study area.

The most of sample points have contents of Pb between Ⅱ and Ⅲ class of national surface water quality standards (GB3828-2002), except for the points L11 and L14 exceeds class Ⅲ standard, that the average concentration of Pb exceeds 1.39 times of class Ⅲ. The concentration of Hg of every water samples surpasses class Ⅲ, which is extremely high in the point L2, and the average concentration of Hg in the basin is 60 times of class Ⅴ. The average concentration of Zn exceeds class Ⅲ, which is highest in point L2 that is 3.7 times of class Ⅴ. The concentration of Cu is extremely high in point L2 and in point L14 and L14 are 1 or 2 times of class Ⅴ, while the rest of points are between class Ⅰ and Ⅱ of the surface water quality standard. The highest concentration of Cr showed in point L11 which is 1.5 times of class Ⅴ, and the rest are conformed to class Ⅲ of surface water quality standard. The concentration of As in most samples are conformed to class Ⅲ, except for in point L14, its concentration exceed Ⅲ class standard. The Cd concentration is 1 - 8 times of class Ⅳ standard, but the average concentration of Cd is 3 times of class Ⅴ of surface water quality standard.

Table 1 Statistical Analysis of heavy metals in surface water(μg/L)

element	Pb	Hg	Zn	Cu	Cr	As	Cd
Highest content	433.9	827.2	3720	14605	75.06	187.05	194.5
Lowest content	1.83	0.101	59.905	38.55	0.635	0.214	1.459
Average content	69.63	60.93	1011.33	1641.98	11.33	14.55	30.01

Obviously, there is serious heavy metal pollution in basin surface water of Linglong gold deposit area. The gold mining and smelting have an heavy impact on surface water and even leading to combined pollution of heavy metals, including Hg, Zn, Cd serious pollution, Cr and As moderate pollution, Pb and Cu less pollution.

3.2 Spatial variation of heavy metals in surface water in study area

The spatial distribution of heavy metals along the stream showed in Figure 2. It shows the different on both sides of Linglong gold mine bounding. From the Gold Mine to North, there are high concentration of heavy metals in sampling point L06 because of that affected by the metallurgical plant sewage. Along the stream, the concentration of Hg, Cu, Cd is increased, on the contrast Pb, Zn, Cr, As decreased or changed slowly. In south watershed, the concentrations of Hg, Zn, Cd decreased with distance from the mines along the flow direction, meanwhile As increased.

There chemical plants near sampling point L11 that sewage directly discharge into the stream. In water current before sampling point L11, concentration of Pb and Cr are relatively low, and change little. But in sampling point L11, concentration of Pb and Cr dramatic increase, which are 30 times of the value in the water before flowing through L11. Obviously, it proved that the chemical plant sewage disposal made a great contribution to the concentration of Pb and the Cr. After passing through the point L11, the concentrations drop back to the level before flowing through L11.

Sampling point L12 has water inflow from a large reservoir so that all elements in water samples are relatively low, which is the minimum value in the south of watershed. All detected elements are increase downward the stream after passing through L12 because of sewage discharging from chemical plants, leading to that contents of heavy metal are higher than the value in south of watershed.

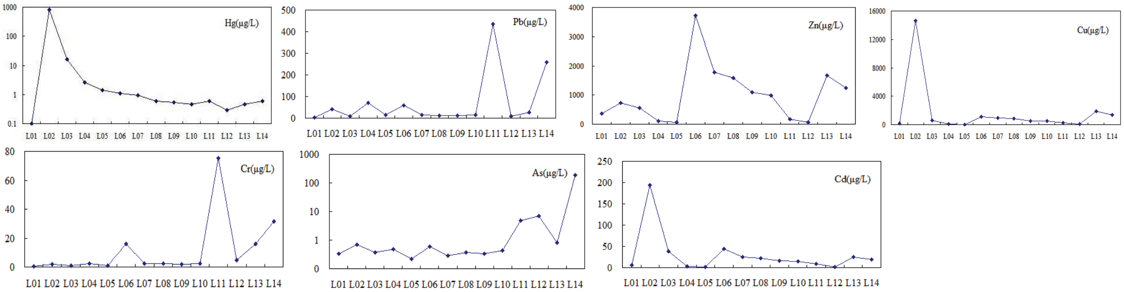

Fig. 1 Spatial distribution of heavy metals in Linglong gold deposit area

There is high concentration of heavy metals in the points where sewage discharge into stream from mines and chemical plants in Linglong gold deposit area, and the concentration decreased rapidly along with the distance far from the pollution sources. It indicated that the migration of heavy metal is very weak in surface water in the study area. The metallic ions of Cu、Hg、As、Pb、Zn and Cd, which associated with gold, are easily react with CN^-, and form heavy metals cyanide in water, and also form the corresponding metal complex compound when has the cyanide excessive[3]. The heavy metal complexes migrated with water leaching has been the most significant cause for heavy metal migration. The heavy metal cyanide usually sank into water substitute for insoluble.

3.3 The correlation analysis of heavy metals

The correlation coefficients of heavy metals in surface water of Linglong gold deposit areas are listed in Table 2. The results indicated that Pb-Cr, Hg-Cu, Hg-Cd, Cu-Cd had a significance correlation that the correlation coefficients were 0.960, 0.986, 0.966, 0.980 in the level of P=0.01, respectively. The remaining elements are less correlative. It can be draw out that the heavy metals in surface water of study area are obviously influenced by the geochemical properties and sources of heavy metals. In Linglong mine, the ore, tailings and waste rock contains large amounts of pyrite and other metal sulfides, which exposed to the surface because of mining activities, and which released large amounts of toxic and harmful heavy metal ions into the surface water through the action of oxidation, leaching and erosion. In addition, there are a massive of different scale of smelting plant, concentration plant, chemical plants and stone processing plant, as the important source of pollution, spread all over the study area. The industrial wastewater with high concentration of heavy metals discharged into surface water caused a variety of compound pollution.

Table 2 The correlation coefficients of heavy metals in surface water

elements	Pb	Hg	Zn	Cu	Cr	As	Cd
Pb	1						
Hg	-0.069	1					
Zn	-0.129	-0.088	1				
Cu	-0.59	0.989	0.016	1			
Cr	0.960	-0.135	-0.025	-0.113	1		
As	0.457	-0.082	0.056	-0.024	0.030	1	
Cd	-0097	0.966	0.129	0.980	-0.140	-0.072	1

4. Conclusions

The data indicated that most of heavy metals concentrations are higher than the Ⅲ or Ⅳ class of the national surface water quality standards. Along the flow direction, with the farther away from sources of pollution, the concentrations of heavy metals decreased. In addition to a large number of tailings, the sewage discharged from chemical plants are also an important sources of heavy metals pollution.

There are significance correlations between Pb-Cr, Hg-Cu, Hg-Cd, and Cu-Cd, and that the correlation coefficients were 0.960, 0.986, 0.966, 0.980 in the level of P=0.01 respectively. It proved that the elements content in surface water are obviously influenced by the geochemical properties and sources of heavy metals.

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