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General survey of metal pollution in Dawu River at Dexing Copper Mine

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Abstract—For the investigation of Dexing Copper Mine, the principal characteristics of its aquatic system were studied. Sampling over the area was carried out. The results of general survey for Dawu River are described in this paper.

Keywords: metal pollution; Dexing Copper Mine; acid mine drainage.

Dawu River is running through the region of Dexing Copper Mine (Fig. 1). It is 14 km long, possessing the flow as 0.5–2.0 m^3/s and the current velocity as 0.3–1.5 m/s. Its sources are the mountain springs. Their water quality background is listed as Table 1. After receiving three kinds of polluted water flows one after another, the chemical condition of aquatic system has been much complicated. The initial pollution sources are seepages from the mineral deposits. They are clear but acidified to a pH about 2.8 (Table 2). The main pollution sources are the acid mine drainages from waste stone dump. They contain a large amount of iron,

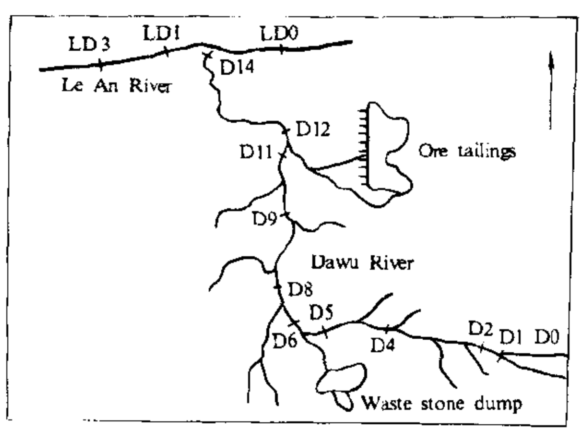

Fig. 1 Dawu River in Dexing Copper Mine

sulfur and various metal species and gain brown colour with pH about 2.4 (Table 3). Another pollution source is the alkaline wastewater from the ore floatation plant. It appears as concentrated suspension of ore tailings and has a pH above 12 (Table 4). The statistical flows of Dawu River and discharging wastewater are listed in Table 5. The amount of wastewater flows as much as 10% of that of the river flow is discharging into the river successively at different points from the upper to the lower stream, causing the river heavily polluted as an escape canal.

Table 1 Water quality background of Dawu River, ppm

Species	Range	Species	Range
pH	7.02–7.72	Ca +Mg	0.5–0.7 meq / L
TFe	0.095–0.185	HCO_3^-	0.5–0.8 meq / L
Cu	0.037–0.072	SO_4^{2-}	0.32–1.52
Pb	< 0.06	S	< 0.02
Zn	0.02–0.1	DO	4–6
Cd	< 0.005	BOD_5	0.5–2.2
Co	< 0.03		
Be	< 0.0002		

Table 2 Water quality of seepage from deposit, ppm
(1987, 11)

Species	Range	Species	Range
pH	2.80	Ca	9.00
TFe	1.66	Mg	3.00
Mn	0.28	Na	1.23
Al	3.85	K	28.86
Cu	0.14	S	18.98
Pb	0.00	Co	0.06
Cd	0.01	Sr	0.05
Zn	0.15	Ba	0.05

Table 3 Chemical composition of acid mine drainage in general, ppm
(1987, 12–1988, 12)

Species	Range	Species	Range
pH	2.24–2.60	Ca	180–375
TFe	2130–2420	Mg	352–576
Fe(II)	120–270	Na +K	32.17–147.32
Mn	30–60	SO_4^{2-}	4400–5022
Al	650–870	S	3025–4580
Cu	80–120	P	20.4–154
Zn	2.5–4.2	F	10–20
Cd	0.2–0.4		

Table 4 Alkaline wastewater from ore floatation plant, ppm (1987, 11)

Species	Range	Species	Range
pH	12.23	Ca	454.30
Fe	24.73	Mg	31.30
Mn	1.76	Na	33.83
Al	20.31	K	183.93
Cu	3.75	S	173.30
Pb	1.24	Co	0.55
Cd	0.09	Ni	0.02
Sr	0.64	Ba	0.98

Table 5 Flows of Dawu River and the wastewaters, m^3 / a (1985–1987)

	pH	1985	1986	1987
Dawu River total	3.6–4.8	56 299 886	85 830 643	79 887 696
Acid drainage	2.2–2.4	2 386 195	2 418 58	2 432 607
Alkaline waste	11–12	——	3 176 736	3 522 861

In different seasons 1987–1989, a large number of water and sediment samples were collected for many times along the river at about 20 sites distributed as Fig. 1. The chemical components such as Fe, Al, Mn, Cu, Cd, Pb, Zn, Ca, Mg, Na, K and S were determined by ICP and XRF respectively. The anions such as F^-, Cl^-, NO_3^- and SO_4^{2-} were determined by IC. The ferrous iron was determined colorimetrically with phenanthroline. An example of chemical composition of the polluted sediments is shown in Table 6. The changing concentration of main pollutants and pH values along the Dawu River are listed in Tables 7–9.

Table 6 Chemical composition of the polluted sediments, ppm (1987, 11)

Species	After joining		Species	After joining	
	Acid water	Alkaline water		Acid water	Alkaline water
pH	2.72	4.72	Ca	1663.4	16762
Fe	64200	38400	Mg	4982.5	15335
Mn	93.66	741.56	Na	2153.5	1167.7
Al	97700	101700	K	3322.7	41154
Cu	459.36	2598.5	S	1064.4	1986.8
Pb	33.00	11.95	P	1131.0	816.87
Zn	27.89	54.27	Sr	41.4	32.97
Ni	6.86	104.76	Ba	546.5	563.1
Co	14.76	23.90	Cr	95.35	80.84

Data listed in Table 7 were collected during the dry season in Nov.1987. On the upper stream, the river was first polluted by seepage from deposits. The total contents of iron and sulfur were as high as hundreds ppm. Their oxidation and hydrolysis reactions acidified the water to pH 2.2–2.4. Then precipitation started and concentration decreased but the content of copper

Table 7 The main pollutants in Dawu River, ppm
(1987, 11)

	No.	pH	Fe	S	Cu
Source water	S0	7.10	2.18	10.23	0.19
			(0.2–0.5)	(1.0–5.0)	(0.02–0.10)
Acidified leakage water	D0	2.80	1.66	18.98	0.14
Polluted step by step	D1–1	2.30	58.95	84.23	0.27
along the river	D1–2	2.20	582.50	594.58	2.69
	D2	2.42	530.83	427.00	2.24
Precipitation started	D4	2.84	116.55	358.58	16.15
Before receiving	D5	2.87	159.75	394.50	19.59
acid drainage water			(51.48)	(306.00)	(15.16)
Acid water from waste stone dump	6–13	2.40	2208.00	4122.50	118.45
After receiving acid drainage water	D6	2.72	444.7	757.13	26.41
Precipitation and sedi-	D8	2.80	341.88	825.00	27.48
mentation became evident	D9	2.75	307.50	597.50	14.25
	D10	2.82	225.15	579.09	19.55
			(129.10)	(316.20)	(12.30)
Befor receiving alkaline wastewater	D11	2.96	86.88	346.25	11.87
Alkaline wastewater	11–1	12.23	24.73	173.30	3.75
from ores flotation plant	11–2	12.23	7.04	54.08	0.53
After receiving alkaline wastewater	D12	4.72	22.75	165.90	5.11
			(6.29)	(144.50)	(3.72)
Before join into Le An	D14	5.28	21.03	173.47	4.27
River			(3.98)	(125.50)	(1.71)
Le An River, before	LD0	7.88	1.44	0.99	0.02
receiving Dawu River			(0.10)	(0.63)	(0.00)
After receiving, 500m	LD1	7.36	3.98	125.50	1.71
			(0.02)	(8.31)	(0.01)
1000m	LD3	7.44	1.08	8.69	0.08
			(0.35)	(7.63)	(0.03)

* The data in parentheses are samples filtrated through 0.45 μ membrane

Table 8 The main pollutants in Dawu River at rainy season, ppm (1988,5)

Sites	No.	pH	TFe	Fe(II)	Mn	Al	Cu	Zn	S	SO_4^{2-}
Upper Stream	D4	2.83	182.10	36.05	4.68	61.59	19.04	1.20	320.5	668
Before joining acid water	D5	2.81	224.50	——	5.33	59.60	19.47	1.63	364.9	813
Acid water	614	2.57	2130	270.2	32.83	642.5	80.25	4.10	4680	5120
After joining acid water	D6	2.76	462.6	66.2	6.77	102.8	72.52	0.75	549.3	1215
Precipitation is evident	D9	2.83	206.2	44.3	3.64	55.14	12.05	1.26	283.4	694
Before joining alkal. water	D11	3.03	147.3	32.7	3.64	55.33	10.38	0.39	272.4	437
After joining alkal. water	D12	4.28	84.2	10.3	2.02	27.11	5.29	0.30	136.9	364
Before joining into Le An Acid side	D14	4.02	54.7	25.5	3.92	53.36	9.72	0.45	251.1	413
Alkal. side		4.60	23.9	3.24	3.02	41.66	9.79	0.98	140.7	
Le An River 500m	LD1	3.97	32.03	4.12	0.90	31.54	2.27	0.64	48.5	147
1000m	LD3	4.50	21.97	1.78	0.76	13.32	1.83	0.62	36.6	43

kept as 10–20 ppm. After receiving the acid drainage water all the pollutants highly increased their concentration and the river became brown. Afterwards, the precipitation and sedimentation began to be more evident. A great amount of metals and sulfur was accumulated in the bed sediments. After receiving the alkaline wastewater, the pH increased to above 4.7. In addition, the pollutants were also adsorbed on the surface of discharged ore tailing particulates and transported along the river and settled onto the bed. The concentrations of pollutants at lower reaches decreased continuously. Approaching the mouth to Le An River, their contents were already not so high, especially the dissolved species. After mixing and diluting in the Le An River the concentration of metals appeared to be lower even than the permissible limit level.

However, the effect of seasonal variations was significant. In rainy season, owing to the increased rate and speedy velocity of the acid mine water flow, it could not mix fully with the alkaline water and the two currents were running somewhat separately. A polluted zone of acid water with high flow rate was observed during rainy season in 1987. Its pH was 3.6 and the concentrations of Fe and Cu were 228.4 and 11.8 ppm respectively, much higher than that beyond this zone. The acid water current flowed even directly into the Le An River affecting its water quality for much longer distance. The concentrations of main pollutants along the river at rainy season are shown in Table 8.

Table 9 The main pollutants in Dawu River after cutting the acid drainage at dry season, ppm (1988,11)

Sites	No.	pH	TFe	Fe(II)	Mn	Al	Cu	Zn	S	SO_4^{2-}
Upper Stream	D4	2.89	54.51	9.62	10.98	94.21	14.78	0.97	513.3	905
Before siting acid water	D5	2.82	60.85	7.84	10.32	88.96	14.00	0.94	469.4	776
Acid water	614	2.46	1580	214.2	62.3	829.5	82.9	3.36	3824	4560
Without joining acid water	D9	2.74	26.2	7.42	9.17	71.21	8.89	0.60	346.5	1220
Precipitation is evident	D10	3.36	9.47	3.26	6.42	52.21	6.87	0.60	251.5	540
Before joining alkal. water	D11	3.47	13.27	3.02	6.86	7.00	1.15	0.60	97.6	209
After joining alkal. water	D12	11.62	1.37	0.04	1.86	1.74	0.18	—	43.4	115
Before joining into Le An River		9.68	2.17	—	0.27	2.30	0.24	—	58.4	142
Le An River	D14									
500m	LD1	8.87	1.19	—	0.16	1.28	0.12	—	15.08	47
1000m	LD3	8.42	0.14	—	0.02	0.41	0.03	—	14.86	43

The environmental protection of Dexing Copper Mine has adopted some measures to improve the conditions. They constructed recently a pipeline to collect and transport the acid drainage water to a treatment plant for neutralizing it by alkaline wastewater and precipitating the iron and sulfur compounds in basins.

The concentrations of pollutants after cutting the acid drainage at dry season are listed in Table 9. At the lower reach of Dawu River the alkaline waste tailing flow with its high pH value and particulates became to be the main pollution source. The pH at the joint point was increased to about 9.0 and the turbidity made by ore tailings presented much higher. In addition, when the ore floatation work was interrupted by power cut the overflow of wastewater polluted the river even more seriously.

On the basis of field survey the studies on physico-chemical processes and water quality model can be accomplished in turn.

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