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Particle Size Distribution of Copper Mine Tailings from Lohan Ranau Sabah and its Relationship with Heavy Metal Content

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ABSTRAK

Analisis saiz partikel telah dilakukan terhadap tahi lombong tembaga dari Lohan, Ranau Sabah. Sebanyak 99.64% daripada partikel tahi lombong tersebut didapati bersaiz < 1000 μm sementara 52.23%, 15.72% dan 4.87% masing-masing bersaiz < 125 μm, < 62.5 μm dan < 38 μm. Kepekatan logam berat yang terekstrak dengan 0.5M HCl dalam turutan ialah Mn > Cu > Ni > Zn > Co Cd dan lebih tinggi pada partikel-partikel yang halus.

ABSTRACT

Particle size analyses were carried out on copper mine tailings from Lohan, Ranau Sabah. About 99.64% of the tailing particles were < 1000 μm in size while 52.23%, 15.72% and 4.87% were < 125 μm, < 62.5 μm and < 38 μm respectively. The amount of heavy metal extracted by 0.5 HCl was in the order Mn > Cu > Ni > Zn > Co > Cd and is relatively higher in the finer tailing particles.

INTRODUCTION

Malaysia's only copper mine, the Mamut Copper Mine, is situated in Ranau, Sabah, at a height of about 1,500 metres above sea level. The mine has been in operation since 1975, and about 5 million tones of ore are extracted annually. Most of the minerals extracted are sulphide minerals, including chalcopyrite (Nagano *et al.*, 1977).

Tailing slurries from the mine are discharged through 15 kilometres of drop tank plumbing system into a square-shaped tailings pond which is located in the Lohan Valley about 900 metres from the mine. The slurries contain about 50% solids and are separated at the pond from the liquid portion using cyclone pumps. The separated solids are used as embankment material to contain the liquid portion prior to final discharge into the nearby rivers.

The mine tailings deposited into the pond are basically rock fragments resulting from the various stages of mineral ore processing at the mine. Owing to their origin, they contain a wide variety of heavy metals in various proportions. It has been shown that the heavy metals such as Cu, Zn, Ni and Co in the tailings were mainly present as sulphide minerals with the exchangeable plus soluble fractions being very low (Marcus, 1985). The present study was carried out to determine the distribution of mine tailing particles according to particle sizes, and the relationship between heavy metal content with particle sizes.

MATERIALS AND METHODS

Tailing samples were taken from three different sites along the top embankment of the Mamut Copper Mine tailings pond. The samples were air-dried and then fractionated into selected particle size fractions (< 1000 μm, < 125 μm, < 62.5 μm and < 38 μm) using the appropriate sieves attached to a mechanical shaker. The percentage weight of each fraction was determined and the four fractions were analysed separately for extractable Mn, Cu, Ni, Zn, Co and Cd. The heavy metals were extracted for 12 hours at room temperature using 0.5M HCl and later determined by atomic absorption spectrophotometry (Perkin-Elmer model 2380).

The pH of the $< 1000\ \mu m$ fraction was measured in 1:2 suspension in distilled water while its organic matter content was determined through loss on ignition.

RESULTS AND DISCUSSION

The particle size distribution of the tailings are as shown in Table 1. It can be seen that the tailings consisted mainly of particles of $< 1000\ \mu m$ in size. On average, 99.64% of the tailings particles were in the $< 1000\ \mu m$ size fraction, while 52.23%, 15.72% and 4.87% were in the $< 125\ \mu m$, $< 62.5\ \mu m$ and $< 38\ \mu m$ size fractions respectively. The weight percentage decreased as particle size decreased, but the relationship was parabolic in nature as shown in *Figure 1*. The size distribution of the tailing particles was expected to be governed by the various processes used at the mine site during the separation of the metals from their ores.

The extractable heavy metal contents of each particle size fraction are as shown in Table 2. The amount of extractable metal was in the order Mn > Cu > Ni > Zn > Co > Cd. The extracted amount did not give the total amount but it was expected to include the more soluble forms of the metals. Marcus (1985) showed that heavy metals in the tailings existed in various

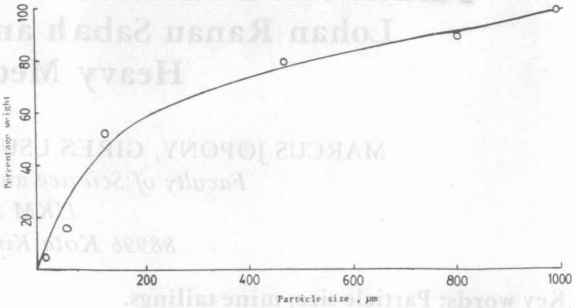

Fig. 1: Relationship between particle sizes and percentage weight of tailings

chemical forms, of which the mineral form was less soluble.

The amount of each metal extracted was higher in the finer fractions of the tailings. The smaller particles would definitely have greater total surface area and thus provide more extractable amount of the metals. Similar correlations between metal concentrations and particle size have been shown for riverine sediments (Wilber and Hunter, 1979; Forstner, 1982) and for soils (Le Riche and Wier, 1963; Fleming and Ryan, 1964).

The $< 1000\ \mu m$ fraction of the tailings would include the finer fractions. Therefore the finer fractions contributed to the overall extractable metal contents of the coarser fraction. Based on the assumption that the proportions of the respective finer fractions in the $< 1000\ \mu m$

TABLE 1
pH, organic matter content and percentage of tailing in each particle size fraction of the copper mine tailing

Sampling site	pH	% Organic matter	Percentage of tailings in each fraction			
			$< 1000\ \mu m$	< 125 m	$< 62.5\ \mu m$	$< 38\ \mu m$
I	7.1	0.31	99.41	45.62	15.66	5.20
II	5.2	0.68	99.80	53.54	16.31	4.26
III	6.0	0.62	99.72	57.83	15.18	5.14
Mean	6.1	0.54	99.64	52.23	15.72	4.87

TABLE 2
Amount of HCl extractable heavy metals in each particle size fraction of the copper mine tailings

Metal	Sampling site	Concentration in each fraction, μgg^{-1}			
		<1000 μm	<125 μm	<62.5 μm	< 38 μm
Mn	I	360.13	433.29	449.13	482.06
	II	200.83	257.08	304.83	358.75
	III	273.75	303.38	304.00	368.44
	Mean	278.24	331.25	352.65	403.08
Cu	I	34.88	50.33	81.63	103.69
	II	88.75	123.25	172.63	231.88
	III	49.17	66.04	102.58	120.06
	Mean	57.60	79.87	118.95	151.88
Ni	I	65.91	90.00	133.79	173.06
	II	38.21	51.00	70.25	94.50
	III	35.04	41.96	62.71	87.13
	Mean	46.39	60.99	88.92	118.23
Zn	I	21.79	27.17	38.71	52.50
	II	28.00	33.04	45.04	63.31
	III	26.42	30.71	40.46	58.59
	Mean	25.40	30.31	41.40	58.17
Co	I	6.25	6.83	9.33	12.00
	II	4.75	5.58	7.71	10.13
	III	5.00	5.71	7.42	10.25
	Mean	5.33	6.04	8.15	10.79
Cd	I	0.83	1.00	1.08	1.31
	II	0.54	0.63	0.92	1.25
	III	0.54	0.71	1.00	1.19
	Mean	0.64	0.78	1.00	1.25

TABLE 3
Contribution of the finer fractions of the tailings of the extractable amount of each heavy metal in the < 1000 μm fraction

Metal	Contribution (%)			
	>125 μm	< 125 μm	< 62.5 μm	< 38 μm
Mn	38.05	61.95	19.92	7.03
Cu	27.84	72.16	32.46	12.79
Ni	31.58	68.42	30.13	12.36
Zn	37.90	62.10	25.62	11.10
Co	41.03	58.97	24.03	9.82
Cd	36.58	63.52	24.56	9.47

fraction were not significantly different compared to their proportions in the whole tailings, the individual contribution of the finer fractions to the extractable metal contents of the < 1000 μm fraction are as shown in Table 3. The < 125 μm tailing fraction collectively contribute > 50% to the extractable amount of each metal in the < 1000 μm fraction.

CONCLUSION

The copper tailings were a mixture of particles of sizes mainly < 1000 μm in diameter and the extractable heavy metal contents were higher in the finer particles. These characteristics need to be considered in future studies if they are to be related with environmental pollution, such as dust pollution, presumed to be caused by the tailing dam.

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