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Heavy Metal Concentrations in Tin Mine Effluents in Kepayang River, Perak, Malaysia

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ABSTRACT: *A preliminary study on physico-chemical properties and heavy metal concentrations, i.e., aluminium (Al), arsenic (As), barium (Ba), cadmium (Cd), cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), selenium (Se) and zinc (Zn), was conducted at the nearest point of tin mine effluents in Kepayang River, Perak, Malaysia. Composite samples of surface water and sediments were analysed using inductively coupled plasma mass spectrometry (ICP-MS) and data were compared with the Malaysia's Ministry of Health (MOH) and the Canadian Council of Ministers of the Environment (CCME) guidelines. The concentrations of As and Fe in both water and sediment were found to have exceeded the MOH and CCME guidelines. The output from this study can present as a background report on metal concentrations of tin mine effluents, which will be useful for future monitoring works.*

Keywords: Heavy metals, sediment, tin mine effluent, water, metal concentrations

1. INTRODUCTION

Tin mining is one of the oldest industries in Malaysia. The exploitation of tin ores due to demand has led to uncontrolled mining activities. These activities have caused serious environmental problems such as deterioration of mining land and river water quality. Previous studies in Malaysia showed mining as a major source of heavy metal contaminations in the water.[1,2] Rahman Hydraulic Tin (RHT) Sdn. Bhd. is known to be the largest tin mining company in Malaysia that has been operating in the upper stream area of Kepayang River, Perak, Malaysia since 1907

and is still active.[3] However, over the last few years, lower water quality has been reported downstream, which has caused a decline in the volume of fishes catched in the connected Rui River.[4]

Elevated levels of heavy metals due to mining have been reported to pollute the natural aquatic environments in Malaysia.[5,6] Most of the studies on tin mines in Malaysia only focused on ex-mining areas, and very rarely cover active mines.[1,2] Therefore, this preliminary study attempts to provide data on the metal contents in mine effluents from RHT that has been released into the Kepayang River, so that appropriate action or research can be taken to monitor any hazardous effects on the water and biodiversity downstream.

2. EXPERIMENTAL

RHT is located at the upper stream of Kepayang River (5° 38' 5.79" N 101° 1' 40.79" E) in Klian Intan, Perak, in the northern part of Peninsular Malaysia. Kepayang River is one of the small tributaries of Rui River, which transports any waste or pollutants from the RHT mine into the main Perak River. Composite samples of surface water and sediments were collected in May 2016 at the last point of RHT's settling pond (2400 m^2) (5° 36' 11.2" N 101° 2' 50.5" E), where the mine waste is being treated with limestone, before released into the Kepayang River. The water sample was stored in an acid-washed polyethylene bottle and acidified with concentrated HNO_3 to a pH < 2. Meanwhile, the sediment sample was collected using a plastic scoop and stored in an acid-washed polyethylene bag. Both samples were then transported to the laboratory at 4°C until analysis.

The in-situ water quality parameters such as pH, temperature, electrical conductivity (EC), salinity, dissolved oxygen (DO) and turbidity were measured on site using Thermo Orion pH portable, Thermo Orion conductivity portable, YSI 52 DO meter and Hach 2100P Turbidimeter, respectively. For metal analysis, the water samples were filtered through a 0.45 µm cellulose acetate membrane filter and analysed for total dissolved metals of aluminum (Al), arsenic (As), barium (Ba), cadmium (Cd), cobalt (Co), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), selenium (Se) and zinc (Zn), using inductively coupled plasma mass spectrometry (ICP-MS, Perkin Elmer, ELAN DRC-e).

The pH of sediments was measured according to McLean.[7] The sediment EC was measured following Eigenberg et al.[8] For metals, the sediment samples were oven-dried at 60°C for 48–72 h, then meshed and sieved (63 µm). About 1 g of the dried sediment was digested in a 10 ml solution of a mixture of HNO_3 and $HClO_4$ in the

ratio of 4:1 (v/v) into a block digester at a low temperature (40°C) for 1 h and then at 140°C for 3 h.[9] The digested sample was then diluted to 100 ml with Milli-Q (Millipore, United States) water and filtered through a 0.45 μm cellulose acetate membrane filter before being measured using ICP-MS.

Reagents used in the present study were of analytical grade. All apparatus and glassware were soaked in 10% HNO_3 for at least 24 h and rinsed with distilled water. Triplicate samples were tested for each composite sample. Statistical analysis was conducted using MS Excel 2010 software. Data on both water and sediment were compared to guidelines from the Ministry of Health (MOH) Malaysia for raw and drinking water, and Canadian Council of Ministers of the Environment (CCME) for industrial soil and aquatic life sediment, respectively.

3. RESULTS AND DISCUSSION

Based on the results (Table 1), the pH of both water and sediment were within the range values of the MOH and CCME guidelines. Previous studies showed that water draining from mining activities are usually in acidic condition.[10] However, in this present study, the pH values of both water and sediment were nearly neutral which may be due to the limestone treatment applied to the settling pond upstream on the same day of sampling. According to Edokpayi et al., mining activities can also attribute to the high levels of EC, and levels greater than 700 $\mu S\ cm^{-1}$ may cause negative impacts on aquatic organisms.[11] Therefore, the EC of water in the present study was considered high with a value of 945 $\mu S\ cm^{-1}$.

This study also found that Fe, Mn, As, Al and Ni concentrations have exceeded the recommended MOH guidelines with mean concentrations of 5.679 mg l^{-1}, 4.673 mg l^{-1}, 0.288 mg l^{-1}, 2.750 mg l^{-1} and 0.106 mg l^{-1}, respectively. Meanwhile, in the sediment sample, the mean concentrations of Fe, As, Cu and Pb were found to have exceeded the recommended CCME guidelines with mean values of 14526.73 mg kg^{-1}, 1038.10 mg kg^{-1}, 94.48 mg kg^{-1} and 149.34 mg kg^{-1}, respectively. Overall, the tin mine effluent was responsible for the elevated concentration of As and Fe in both water and sediment of the Kepayang River. This result is supported by Johnson and Hallbergalthough who reported that elevated concentrations of metals such as Al, As, Fe and Mn are related to acid mine drainage from mining activities.[10]

Table 1: Mean concentrations of physico-chemical properties and heavy metals in surface water (mg l^{-1}) and sediment (mg kg^{-1}, dry weight) of tin mine effluent at Kepayang River.

	Water	Sediment	Raw water standards[a]	Drinking water standards[a]	Industrial soil[b]	Predicted effect level[b]
pH	7.13	6.50	5.50–9.00	6.50–9.00	6.00–8.00	–
EC (µS cm^{-1})	945	301	–	–	4000	–
Salinity (ppt)	0.50	0.10	–	–	–	–
Temperature (°C)	32.33	–	–	–	–	–
Turbidity (NTU)	65.47	–	1000.00	5.00	–	–
DO (mg l^{-1})	6.99	–	–	–	–	–
Al	2.750	4844.290	–	0.200	–	–
As	0.288	1038.100	0.010	0.010	12.000	17.000
Ba	0.111	223.410	–	–	2000.000	–
Cd	0.001	0.480	0.003	0.003	22.000	3.530
Co	0.089	20.340	–	–	–	–
Cr	*	7.40	0.05	0.05	87.000	90.00
Cu	0.102	94.480	1.000	1.000	91.000	197.000
Fe	5.679	14526.730	1.000	0.300	300.000	–
Mn	4.673	289.340	0.200	0.100	–	–
Ni	0.106	19.910	–	0.020	89.000	36.000
Pb	0.001	149.340	0.050	0.010	600.000	91.300
Se	0.001	1.440	0.010	0.010	–	–
Zn	0.057	39.780	3.000	3.000	360.000	315.000

*[a]MOH, 2010; [b]CCME, 2015; – not specified; * below detection limit*

4. CONCLUSION

This study has revealed that As and Fe are the major metal contaminants in the Kepayang River, Perak, Malaysia coming from a tin mine company located in the upper stream of the river. Therefore, future monitoring works and treatment should be taken by the mining company and government in order to protect the environment.

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