# Geochemical behaviors of Cu and Co in the sludge deposit at Zambian Copperbelt: Implication for metal recovery and sludge reuse options

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Huge volume of sludge containing Cu and Co has been generated by lime treatment on site and deposited in designated places such as ponds and impoundments at Zambian Copperbelt. However, during periods of heavy rainfall and dry blowing winds, Cu and Co concentrations above the regulated standard limit have been reported into some nearby surrounding environments. To better understand stability of metals in the sludge deposit, we collected sludge samples from drainage and ponds and analyzed mineralogically and geochemically by X-ray diffractometry (XRD), SEM and TEM observation, sequential extraction with geochemical thermodynamic and surface complexation modeling (SCM). Batch sorption experiments were also conducted in single and binary system using 0.01M and 0.05M electrolytes in pH range from 4 to 9.

From the results of sequential extraction and electron microscope observation, most of Cu and Co exists in the fractions of acid extractable and associated with amorphous ferric compound. The lime treatment on the site has been conducted to adjust pH between 6.5 and 7.0. By this treatment, the formation of amorphous ferric compound is available due to ferrous to ferric oxidation and precipitation of ferric hydroxide. Adsorptions of Cu and Co onto the ferric hydroxide are accomplished in pH between 6.5 and 7.0 from the results of SCM. However, due to limited volume of amorphous ferric compound, Cu and Co still exist in the fractions of exchangeable and acid extractable. From XRD, SEM and TEM observation and the results of geochemical thermodynamic modeling, no Cu- and Co- carbonate precipitation were observed. Therefore, the fractions are presumably attributed from adsorption to other mineral components in the sludge. From XRD, the sludge is composed by quartz, feldspar, mica and kaolinite. Among the component minerals, according to surface area contributing adsorption, biotite and kaolinite may play a host of Cu- and Co-adsorption. Due to lack of reliable data, batch sorption experiments were also conducted in single and binary system using 0.01M and 0.05M electrolytes in pH range from 4 to 9 to establish SCM in Cu- and Co-binary system. Based on the results of this study, Cu and Co are stable in the sludge by adsorption if the pH of sludge pond solution is keeping between 6.5 to 7.0. At pH less than 5.5, most of Co and 40% of Cu would be leached out. Therefore, to avoid the leaching, pH of the pond solution should be kept between 6.5 and 7.0. On the contrary, the most of Cu and Co can easily be recoverable from sludge at pH less than 3.5. The residual sludge can be reused for other application such as sand aggregates for some civil construction because the metals are already removed from the sludge by week acid.

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