# Manganese and cobalt redox cycling in laterites; biogeochemical and bioprocessing implications

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Cobalt is a critical metal and essential for modern technology yet its supply is limited. Around 48% of the world's annual cobalt production is from the processing of nickel laterites. This study investigated the biogeochemical cycling of cobalt in laterites, and whether microbial metal reduction could be stimulated as a new bioprocessing technique to help recover cobalt sustainably from Ni-laterites.

Sediment microcosms were set up with laterites from Turkey, the Philippines, Kazakhstan and Brazil, and metal-reducing conditions were stimulated by adding acetate or glucose. Biostimulation with glucose led to Co, Ni and Mn being released to the aqueous phase, but this did not occur with acetate. Sequential extractions showed that with both organic substrates the proportion of easily recoverable Co (that is in the aqueous phase or extractable using 0.11M acetic acid) increased from <1% to up to 64%, and this closely mirrored the behaviour of Mn. X-ray absorption spectroscopy showed that at the start of the experiment Co was predominantly present as Co(III), Fe was present as the Fe(III) bearing mineral goethite, and Ni was present as Ni(II) substituted into the goethite crystal lattice. At the end of the experiment Co had been reduced to Co(II), while Fe and Ni speciation did not change. Profiling the microbial community composition by 16S rRNA sequencing showed that sequences closely related to known Mn(IV)/Fe(III) reducing bacteria were present in all laterites, and biostimulation with organic substrates stimulated their growth.

Overall our results demonstrate that the environmental behaviour of Co in laterites is likely to be controlled by Mn biogeochemical cycling by microorganisms. We propose a new two-step bioprocessing strategy to recover Co from laterites, whereby metal-reducing conditions are stimulated by treatment with an organic substrate, then Co is recovered by rinsing with acetic acid. Organic substrates are eco-friendly and potentially can be sourced from waste carbon.