GEOMICROBIOLOGY OF AN UN-REMEDIATED AND A REMEDIATED PORPHYRY TAILINGS DEPOSIT, BAHIA DE ITE PERU

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The Bahía de Ite is a bay located in the Atacama Desert about 1000 km south of Lima, Southern Peru. From 1960 to 1997, about 785 million metric tons of tailings from the 2 porphyry copper mines, Cuajone and Toquepala were deposited at this bay. After deposition ceased in 1997, the remediation was initiated by Southern Peru Copper Corporation (SPCC) with the installation of a wetland cover on the oxidizing tailings, using the alkaline water from the Locumba River and transplantation of the flora, which developed locally. Since then, nearly the complete surface (about 80%) of the tailings deposit was covered with this wetland, except the central delta area and the areas along the shoreline (Fig. 1). Currently, the Bahía de Ite represents the biggest wetland at the Peruvian Coast.

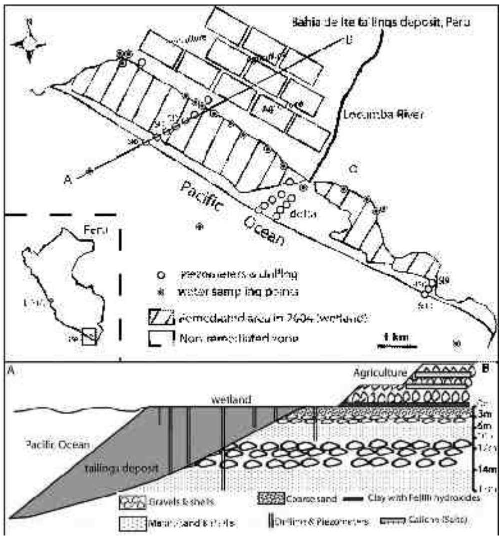

Fig. 1: Overview of the Bahía de Ite marine shore tailings deposit, Peru with the location of the sampling point. The scale in the lower profile is strongly exaggerated for better visibility.

In order to understand the biogeochemical processes resulting from the construction of a wetland on the oxidizing tailings, a 3 years investigation was performed at this porphyry copper tailings deposit. The measurements were done in both remediated and non remediated tailings from October 2004 to October 2007. The non remediated tailings had a low-pH oxidation zone (pH 3 – 4) where the dominant process was an oxidative dissolution of sulfide (Dold and Fontbote, 2001), carried out mainly by *Leptospirillum spp*, *Acidithiobacillus spp* and *Sulfobacillus spp* (Fig. 2; Diaby et al 2007). This led to generation of AMD containing average (n=8) 684 mg/L Cu, 504 mg/L Al, 355 mg/L Fe, 211 mg/L Mn, 48 mg/L Zn, and 2.5 mg/L Ni. Due to the arid climate strong accumulation of efflorescent salts (10 – 20 cm thick) was noted at the surface due to capillary upwards transport of metal cations (Dold, 2006). Below the oxidation zone, was the neutrophilic primary zone characterized by both SO_4^{2-} and Fe reductions induced respectively by SRB and FeRB such as *Geobacter* spp (Fig 2). As in the primary zone of the oxidizing tailings the same processes induced by SRB and FeRB was found below the wetland in the remediated tailings. The activity of SRB might play a role on metal removal processes (Johnson and Hallberg, 2005).

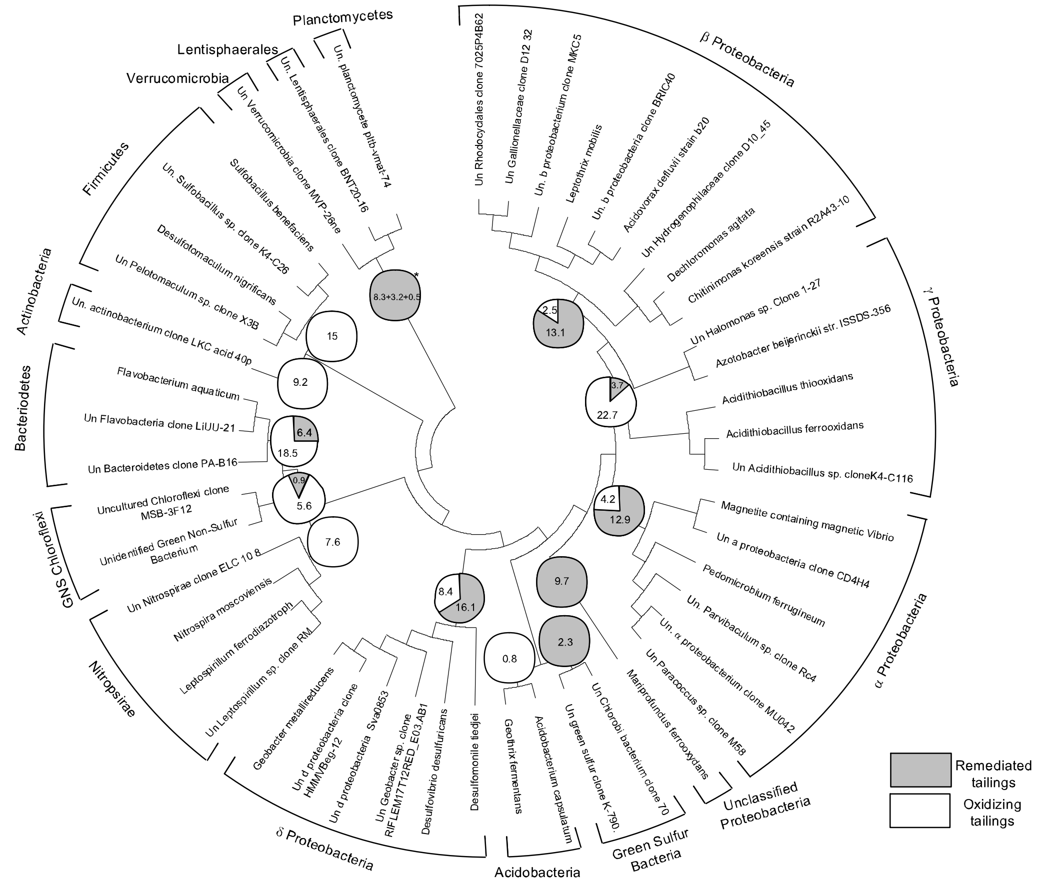

Figure 2: Bacterial phylogenic tree based on 16S rRNA clone from Ite bay. Tree was constructed by Neighbor-Joining method. The distances were computed using the Maximum Composite Likelihood method. All positions containing gaps were eliminated from the dataset (Complete deletion option). Phylogenetic analyses were conducted in MEGA4 (Tamura et al 2007). The numbers inside the circles are the percentages of each phylum detected in the oxidizing and the remediated tailings.*8.3 + 3.2 + 0.5 is the sum of percentages of respectively Verrucomicrobia, Lentisphaerales and Planctomycetes.

The implementation of a wetland above oxidizing tailings created reducing condition and release of iron (II) which promoted development of lithoautoprophic neutrophilic iron oxidizing bacteria such as *Mariprofundus ferroxidans, Galionella spp, Leptotrix mobilis*. Other ubiquitous bacteria related to fresh water and marine environment such as the phyla *Proteobacteria, Verrucomicrobia, Lentisphaerales, Green Sulfur Bacteria and Planctomycetales* were also detected in the wetland. In this wetland (i.e. remediated tailings) the heavy metals showed very low concentrations (mainly below the detection limit) due to the near neutral pH and reducing conditions (~150 mV) established excepted for iron and manganese.

The implementation of the wetland promoted neutralization of the AMD, geochemical condition for SRB growth and metal removal from solution. The monitoring over 3 years showed a strong stability of the remediation process, suggesting that the remediation approach is effective and would be stable as long as it will be saturated.

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