Soil algae and cyanobacteria on gold mine tailings material: Comments on Seiderer et al. (2017)

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Seiderer et al. recently described[1] efforts to grow algae and cyanobacteria on gold mine tailings. They noted:

> *The presence of acids and the high salt content of gold tailings material are likely synergistic in causing biotoxicity as low pH generally increases the bioavailability of metals. As a result, most gold mine* [tailings] *are devoid of vegetation and have a stressed heterotrophic microbial community.*

They reported the pyrites content as <5%.

It is known that, under the conditions on tailings dams, pyrites oxidise and generate acid. This process is dynamic; it starts when the soil pH is less than about 5 and continues until most of the pyrite in the upper few metres has oxidised. Thus their suggested process is most unlikely to prove sustainable. The ongoing production of acidity would have destroyed the colonies first established.

In the early years of the Vegetation Unit established by the Chamber of Mines, attempts were made to vegetate slimes dams soon after placement. In spite of intensive liming, soil acidity would increase. Experiments showed a direct correlation between the amount of residual pyrite in the tailings and the quantity of lime required to ensure sustained vegetative cover. As long as there was more than about 0.2% m/m pyrites in the material, acid was generated and the growth of vegetation negatively affected.

An additional phenomenon was a rise in acidity during the dry season. This rise was traced to evaporation and concentration of the acidity in the near surface moisture. There were strikingly different depth profiles of acidity at the end of summer and the end of winter.

The root cause was the arrival of *Thiobacillus.* For about a year after placement, the tailings were essentially sterile, and slightly alkaline. As things like the residual cyanide were oxidised, the pH started to drop, and at a soil pH of about 5 the thiobacilli became very active. Then the pH dropped rapidly, and remained low. Few other microbial species were present while the thiobacilli were active.

Thiobacillus required oxygen. In sand dumps, diffusional processes and permeability to oxygen-saturated rain meant that oxidation took place throughout the depth of the tailings. But in the slimes, which comprise the majority of the tailings, the fine size (<75 μm) slowed both diffusion and penetration by rain, and oxidation proceeded very slowly more than about 50 cm below surface. The mechanism by which oxygen found its way into the depth of the slimes was finally identified as the expansion and contraction of the gas trapped inside the tailings as the barometric pressure varied. Gas emerging from the slimes when a low-pressure system passed over the tailings could be as low as 3% oxygen.

The arrival of the thiobacilli was associated with an increase in the fixed nitrogen content of the soil. At that stage, it was not known that the thiobacilli were nitrogen-fixers. The Porton microbiological unit in the UK proved that nitrogen fixation was indeed taking place.[2]

These findings enabled procedures to be developed to ensure sustainable growth on tailings. The Vegetation Unit would not attempt to grass tailings until most of the pyrite had been oxidised by the bacteria. A small amount of lime would be added, and the site would then be sprayed continually with water for several weeks to drive the residual acid deep into the slimes. Only then would planting begin – and the young plants had to be shielded against wind-blown slime. Hundreds of hectares were grassed in this way. There were a few patches of failure, which were traced to wind-blown damage of plants; the rest were sustained for 20 or more years, as other species took over.

This work was unfortunately never published in South Africa. It transpired that the same bacterial processes were solubilising uranium, which could be recovered cheaply by mining the tailings. At the time, uranium was a strategic resource, and the information was considered confidential. Some years later, the results were presented at a Canadian conference[3]. It is likely that Seiderer et al. would not have had access to this information.

References

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