Silica and Maghemite Nanoparticles for the Remediation of Acid Mine Drainage-Contaminated Waters and Nanoparticle Modification of Metal Uptake by a Freshwater Alga - *Scenedesmus sp*.

ABSTRACT

Aims: The adsorptive removal of Cu, Mn, Hg and U by silica and maghemite nanoparticles (NPs) under acid mine drainage (AMD) conditions was investigated with the aim of assessing the applicability of NPs for remediation of AMD-contaminated water. The effect of NPs on metal uptake by algae, an increasingly popular remediation alternative, was also investigated.

Methods: NP and algal metal removal were quantified by batch experiments using commercially prepared, bare and amine-functionalised silica-carbon hybrid NPs characterised for size, surface area, porosity, crystallinity, elemental composition and hydrodynamic size. Metal uptake by algae was quantified in the presence and absence of NPs.

Results: Silica and maghemite NPs can be used for the adsorptive removal of Cu, Mn, Hg and U from AMD-contaminated surface and ground water. NP metal uptake was rapid and equilibria were attained within 5 minutes with silica and maghemite NPs, and within 45 minutes with amine-functionalised hybrid NPs. Adsorption efficiencies for Cu, Mn, Hg and U at pH 3 were 52, 56, 56 and 49%, respectively with silica and 56, 52, 75 and 50%, respectively, with maghemite NPs. Metal removal was enhanced by >10% in solutions containing ferric, manganese or sulphate ions, although Cu removal was inhibited in solutions with a >1 Mn:Cu ratio. Despite the presence of high affinity amine groups in hybrid NPs, Cu removal was only 52% due to the low surface area of the adsorbent. The comparative study with Hg, however, showed that surface area was not the only determinant of adsorption efficiency: maghemite NPs with a specific surface area ~15 times less than silica adsorbed 21% more Hg.

Metal removal by *Scenedesmus sp*. was enhanced by 12-27% in solutions containing NPs due to the greater sorption surface areas. NPs also modified metal partitioning in algal cells: intracellular concentrations were lower and extracellular concentrations higher in solutions containing NPs relative to controls (no NPs).

Conclusion: Silica and maghemite NPs can be applied for the adsorptive removal of Cu, Mn, Hg and U from AMD-contaminated water and to improve the efficiency of phycoremediation by *Scenedesmus sp*. These findings also point to the possibility of retardation of metals by NPs during their transportation from tailings and contaminated sites. Their partitioning to NPs and the strength of the interactions thereof can determine the prevalence of the metals in solution or in the solid phase.