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A novel technology for neutralizing acidity and attenuating toxic chemical species from acid mine drainage using cryptocrystalline magnesite tailings

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ABSTRACT:

The present study was developed with the aim of beneficiating two waste materials by converting them into a resource. Magnesite tailings, which is the by-product of magnesite mining, was used to remediate acid mine drainage (AMD) which is the by-product of gold mining. This will go a long way in minimizing the use of virgin resources and thus fostering the process of sustainable development. AMD was reacted with magnesite tailings at an optimum equilibration time of 30 min and 1 g of magnesite tailings dosage. Contact of AMD with magnesite tailings led to an increase in pH ($\text{pH} > 10$) and a drastic reduction in inorganic contaminants ($>99\%$), except for sulphate that achieved $>80\%$ for sulphate removal efficiency. Kinetic studies showed that adsorption of chemical species by magnesite tailings fitted well to pseudo-second-order adsorption kinetics hence confirming chemisorption. Pore diffusion was also determined to be one of the principal mechanisms acting as a major rate governing step. PHREEQC, in C language geochemical modelling predicted that Fe removed as $\text{Fe}(\text{OH})_3$, goethite (FeOOH), and jarosite ($\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$), Al as basaluminite ($\text{Al}_4(\text{SO}_4)(\text{OH})_{10}\cdot 5(\text{H}_2\text{O})$), boehmite ($\text{AlO}(\text{OH})$), jurbanite ($\text{AlSO}_4(\text{OH})\cdot 5\text{H}_2\text{O}$), and $\text{Al}(\text{OH})_3$ as gibbsite and diaspore. Al and Fe also precipitated as iron (oxy)-hydroxides and aluminium (oxy)-hydroxides. Mn precipitated as rhodochrosite (MnCO_3) and manganite (MnOOH). Ca was removed as gypsum ($\text{CaSO}_4\cdot 2\text{H}_2\text{O}$) and dolomite ($\text{CaMg}(\text{CO}_3)_2$). Sulphate was removed as gypsum and Fe, Al hydroxyl sulphate minerals. Mg was removed as brucite ($\text{Mg}(\text{OH})_2$) and dolomite ($\text{CaMg}(\text{CO}_3)_2$). This would explain the reduction in the chemical species contents in the treated water. Based on the above, it was concluded that magnesite tailings can neutralize and attenuate elevated concentrations of chemical species in AMD to within prescribed legal frameworks for water use in agricultural and industrial sectors in South Africa.