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Hydrogeochemical modeling as a tool for the environmental management of mine water polluted river catchments: An application to the Odiel River network (Huelva, Spain)

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The impact of mine waters is currently one of the most severe environmental problems in the water environment. The Odiel River catchment is a clear worldwide example of a river network intensely affected by acid mine drainage, transporting large pollutant loads towards the Ría de Huelva estuary, and ultimately the Atlantic Ocean [1]. The release of acidity and metals, and the longevity of the process, represent a major source of pollution which treatment or possible solutions have been the subject of research in recent years. Prior to the adoption of restoration measures in the region, involving a large economic investment, it was proposed to build a hydrogeochemical model that represents the current situation of the pollution, and serves as a management tool for the Odiel River network. In this sense, its design allows to simulate remediation actions and evaluate their impact on the water quality. The model is based on a set of mixtures modeled with PHREEQC code [2] as analogs to the numerous river confluences. The "MIX" command was used, which enables the mixing two or more aqueous solutions at different mixing ratios. Each ratio theoretically assumes how much each member contributes to the final mixture. Each member is defined as a solution with the command "SOLUTION_SPREAD" including the physicochemical parameters and element concentrations, obtained experimentally and in the field. Coupling the "EQUILIBRIUM_PHASES" command includes the equilibrium reactions with Fe and Al mineral phases and the atmosphere. Consequently, each modeled and equilibrated mixture will be mixed again downstream in new confluences until a global modeling of the catchment is achieved. In this way, the model makes it possible to estimate changes in the physicochemical parameters, the evolution of metal concentrations, and variations in the saturation rates of the mineral phases (precipitation, dissolution or equilibrium). This kind of model is a useful tool for simulating reductions in the pollutant loads of sources predicting how real restoration actions will affect the water quality conditions along the Odiel River catchment. The proposed approach could be applied to other real case scenarios where mine waters originate from various sources, mainly different mines, within a complex river network, establishing itself as an environmental tool for the management of mine water-polluted catchments.

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[1] Nieto, J. M., Sarmiento, A. M., Canovas, C. R., Olias, M., & Ayora, C. (2013). Acid mine drainage in the Iberian Pyrite Belt: 1. Hydrochemical characteristics and pollutant load of the Tinto and Odiel rivers. *Environmental Science and Pollution Research*, 20, 7509-7519.

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