Geochemical modeling of chromium oxidation and treatment of polluted waters by RO/NF membrane processes

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Geoenic Cr(VI) contamination is a worldwide environmental issue which mainly occurs in areas where ophiolitic rocks crop out. In these areas Cr (VI) can reach high concentrations into groundwaters becoming highly dangerous for human health. Indeed Cr(VI) is recognized as highly toxic element with high mobility and bioavailability [1]. Due to these features, starting from July 2017, Italian government has lowered the Cr(VI) limit value for drinking water to 10 µg/L. To improve the living standards in contaminated areas, it is needed (i) to understand the release and fate of contaminant during the water-rock interaction and (ii) to develop efficient remediation systems for natural polluted waters. In this regard, a complementary study on genesis and treatment of a Cr-rich groundwater coming from Italian ophiolitic aquifers was conducted. Reaction path modelling is a proven geochemical tool to understand the release of Cr and its oxidation from Cr(III) to Cr(VI) during the water-rock interaction. The generally accepted hypothesis of scientific community is that geogenic Cr(III) oxidation is driven by the reduction of trivalent and tetravalent manganese (Mn(III); Mn (IV)) [2] whereas in this work the role of trivalent Fe hosted in serpentine minerals was re-evaluated. Unlike Mn, Fe is the main oxidant present in suitable amount in these rocks. Literature data confirmed the presence of Fe(III) into serpentine minerals hence reaction path modelling was performed varying the Fe (III)/Fe(tot) ratio ranging from 0.60 to 1.00. The theoretical paths, reproduce the analytical concentrations of relevant solutes, including Cr(VI), in the Mg-HCO\textsubscript{3} water type hosted in the ophiolitic aquifers of Italy [3]. With increasing of Fe(III)/Fe(tot) ratio in serpentine minerals, high Cr(VI) concentration hold into solution until high alkalinity values. In addition, the spring with the highest Cr(VI) content (75 µg/L) was treated to lower its concentration below the threshold values. In this work membrane technologies were used as innovative method considering their many benefits, like the improvement of product quality without using chemicals [4]. A laboratory-scale set-up was used to carry out both Nanofiltration (NF) and Reverse Osmosis (RO) experiments. The experiments were conducted on different commercial membranes: one NF membrane module named DK (polyamide) and two RO membrane modules named AD (polyamide) and CD (cellulose).Tests were performed varying the operating pressures, and high Cr(VI) rejections (around 95%) were reached for all tested membranes, leading to a water containing Cr(VI) in concentrations below the threshold limits. The high flux, obtained already at lower operating pressures (27 L/m\textsuperscript{2}h-10bar), combined with high
selectivity towards Cr(VI) makes NF a favorable remediation option. The results obtained in this work are in line with the few data available in the literature for natural contaminated waters and there are quite promising for future scientific developments and application.

References