The Efficacy of Ca-Mg-(OH)2 Nanocomposite on the Removal of Manganese from Mine Effluent Contaminated River Water

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Introduction

Water is a very important and indispensable component of earthly life forms. It plays a crucial role in nurturing living organisms, however, pollution has been the premier issue of concern. The pollution of water resources has increased due to rapid mining development amongst others. The ever-growing contamination of surface water by effluent emanating from mining activities has been an issue of prime concern to national and international scientific communities and there is a dire need for remediation techniques. Of paramount concern is the introduction of manganese to the receiving environments. Most effluent from commercial, domestic and mining sources are being discharged into water courses and they comprise elevated levels of manganese hence impairing the integrity of the receiving ecosystem to foster life. Specifically, manganese pose a threat to humans, animals and aquatic plants on exposure hence there is a need to develop prudent and pragmatic ways to curtail its impacts. Manganese has the potential to impart colour to waterbodies, gives water a metallic taste, and it has been (eco)-toxicologically determined to cause hallucinations, forgetfulness, and nerve damage, amongst others. Furthermore, manganese has been associated with a nervous system disease with symptoms like Parkinson's disease. As such, there is an urgent need to contain, manage and remove this contaminant prior to consumption. In response to that, several technologies have been developed for the removal of manganese from aqueous environments and they either use physical, chemical, biological methods or a combination of those techniques i.e., hybrid or integrated. Herein, the removal of manganese from the river water contaminated by mine effluent using Ca-Mg-$(OH)_2$ nanocomposite has been reported.

Materials and methods

Raw water samples were collected from the mine water contaminated river in South Africa. Feedstock were procured from lab consumables, Merck, and other laboratory resources suppliers. The nanocomposite was prepared by utilizing mechanochemical synthesis method, at 1:1wt% mass ratio of MgO and CaO to fabricate Ca-Mg-$(OH)_2$ nanocomposite. Batch experimental procedures were used to achieve the objectives of this study, specifically contact time (minutes), feedstock dosage (grams), and mixing speed (rpm). The fate of manganese was determined using state-of-the-art analytical instruments and techniques. PHREEQC geochemical model complemented the results.

Results and discussion

Results on the chemical composition of river water and the product water treated using CaO, MgO, and Ca-Mg-$(OH)_2$ nanocomposite are shown in **Table 1**.

Table 1: Results on the chemical composition of river water and the product water treated using CaO, MgO, and Ca-Mg-$(OH)_2$ nanocomposite

Parameter	SANS Limit	Raw water	Alkalinity generating agents		
			MgO	CaO	Ca-Mg-(OH)$_2$
Manganese (mg/L)	≤0.400	0.382	0.09	0.08	0.05
pH	≤9,7	7.55	8.19	7.60	7.81
Turbidity	≤1	8.21	3.85	0.72	1.17
% Mn removal	-	0	76	79	87
% Turbidity	-	0	53	91	86
Time	-	0	30	30	30
Dosage	-	0	0.5	0.5	0.5
Mixing speed	-	0	250	250	250

Results revealed that 30 minutes of mixing time, 0.5 g of dosage in 500 mL of aqueous solution, and 250 rpm of mixing speed were the optimum conditions for the removal of manganese from aqueous solution. Specifically, CaO is excellent in turbidity removal while MgO is superior in manganese removal and their nanocomposite, i.e., Ca-Mg-(OH)$_2$ balanced the attributes of individual materials and performances thereto. Thenceforth, due to the Ca-Mg-(OH)$_2$ having both properties of MgO and CaO, the material effectively removed manganese, and it demonstrated superiority in performance as compared to individual material. This confirms that this material could synergistically be used to treat Mn-enriched river water. PHREEQC confirmed Mn as divalent and its removal as various species.

Conclusions and recommendations

The nanocomposite demonstrated superior performance as compared to individual materials. PHREEQC geochemical model confirmed that manganese existed as Mn^{2+} and it was removed as manganite, rhodochrosite, and pyrochrosite. As such, findings from this confirmed the performance of Ca-Mg-(OH)$_2$ nanocomposite in the treatment of surface water contaminated by manganese from catchment mining activities. This will go a long way in curtailing the impacts of manganese and mining activities on drinking water and further afield.

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