Graphene Oxide for Removal of Heavy Metals from Tunnel Wash Water

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Abstract

The potential of graphene-based materials like graphene oxide (GO) and reduced graphene oxide (rGO) as efficient adsorbents for contaminants such as radionuclides, cationic/anionic dyes and heavy metals has been studied in the recent years with encouraging results (Yang, 2010), (Zhao, 2011), (Ramesha, 2011), (Romanchuk, 2013). In the present work we evaluate GO as scavenger for heavy metals from tunnel wash water. Norway has approximately 800 km of tunnel construction along its territory (Torp, 2013); these tunnels are subjected to regular maintenance that includes washing episodes. Tunnel wash water can contain particulate material, soap, polycyclic aromatic hydrocarbons (PAH), oil components and heavy metals such as zinc (Zn), lead (Pb), copper (Cu) and cadmium (Cd) among others (Meland, 2012).

In order to test the performance of GO as an adsorbent for heavy metals present in tunnel wash water, three experimental series were conducted. Series 1 and 2 were done in tunnel wash water from a half-wash episode in December 2015 at the Nordby tunnel in Akershus province in Norway. The water sample was characterized and results showed measurable concentrations of Zn (650 µg/L), Cu (60 µg/L), Pb (8.3 µg/L), PAH and oil components. Series 3 was done in deionized water containing 5 ppm of Zn, Cu, Pb and Cd. Samples from the three series were treated with GO (0.6 g/L) and an inorganic flocculant* developed by our company in order to enhance separation. Graphene oxide was prepared by modified Hummers method (Hummers, 1958). The precipitate was separated by centrifugation and the supernatant was analysed by inductively coupled plasma mass spectrometry for elemental analysis. Results in terms of relative adsorption efficiency are shown in Table 1.

Table 1 Results of experimental series 1,2 and 3; pH value and relative adsorption efficiency are shown.

Series	pH	Heavy Metal and Relative Adsorption Efficiency (%)
1	7	Cu (71.7%), Zn (94.3%), Pb (> 75.9%)[1]
2	7.9	Cu (88.4%), Zn (94.2%), Pb (> 75.9%)[1]
3	7.9	Cu (99.9%), Zn (99.3%), Pb (99.9%), Cd (99.9%)

Efficiencies for Cu and Zn in series 1 and 2 are high, however values for Zn are higher than the ones for Cu, suggesting that mechanisms such as cation competition and concentration effects may influence the adsorption of these metals onto GO when present in a multicomponent system. Results from series 3 show very high adsorption efficiency for all the heavy metals tested, suggesting that the presence of PAH and oil components in series 1 and 2, may negatively affect the adsorption of Zn and Cu and potentially other heavy metals onto GO. The pH value in all series is near neutral value, this suggest that the removal of these metals may not be attributed to formation of precipitating species. These results represent a step forward to understanding the potential of GO in the water treatment field, where management of rest-cations and large pH adjustments are still challenges to overcome.

*Note: *Flocculant is pending approval for a patent.*

[1] Concentration values for Pb (not shown) after treatment were under the LOQ (2.0 µg/l), thus it is possible to say that the adsorption efficiency for Pb is at least 75.9% in both series 1 and 2.

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