

Removal of lead ions from aqueous solution using sphagnum moss peat as adsorbent

YS Ho¹, DAJ Wase¹ and CF Forster^{2*}

¹ School of Chemical Engineering, Birmingham University, Edgbaston, Birmingham B15 2TT

² School of Civil Engineering, Birmingham University, Edgbaston, Birmingham B15 2TT

Abstract

The use of sphagnum moss peat for the removal of lead from aqueous solution has been studied in batch experiments. Investigations include the effect of pH and temperature, and kinetics of adsorption. The adsorption equilibria data were found to follow Langmuir models. It was found that the efficiency of lead removal using sphagnum moss peat as adsorbent depended very little either on the reaction temperatures (10 to 40°C) or on the initial pH values (4.0 to 6.0). Kinetic data suggested that the adsorption process was endothermic and pore diffusion was not the only rate-determining step.

Introduction

Lead is a toxic element which is conservative and which has cumulative characteristics. As such, it is classified by the EC Directive on Dangerous Substances as a List II material (Council of European Communities, 1976). The majority of lead discharges to the environment come from atmospheric and particulate sources. However, there are a range of industries which generate waste waters containing significant concentrations of lead; for example, the lead-acid battery industry (Broom et al., 1994; Squires, 1992), smelting (Hallowell et al., 1973; Carter and Scheiner, 1991), printed wiring board manufacturing (Strilko, 1992) and paper mills (Sharif Fazeli et al., 1991). Mine drainage can also give rise to inputs of lead to the aquatic environment (Larsen et al., 1973; Beelman, 1993). Excessive amounts of lead in the human body can cause hypertension and brain damage. It is, therefore, essential that there are technologies for controlling the concentrations of lead in aqueous emissions.

The technologies which have been used range from the use of granular activated carbon (Reed and Arunachalam, 1994; Reed and Berg, 1993) to chemical treatments (Carter and Scheiner, 1991) and cross-flow filtration (Broom et al., 1994). However, these are processes which are more applicable to developed countries and there is a need to examine technologies which can be used in developing countries. One approach is to use alternative adsorbents. These are low-cost, often naturally occurring, products which have good adsorbent properties. A range of products have been examined previously. These include clays (Farrah et al., 1980), pine bark (Teles de Vasconcelos and Gonzalez Beca, 1994) and penicillium biomass (Niu et al., 1993). Good results have also been reported for peat (McLellan and Rock, 1988). This paper reports the results of a further study into the removal of lead from aqueous solutions by sorption onto sphagnum moss peat in which the effects of contact time, temperature and pH were examined.

Materials and methods

Materials and analytical methods

Sphagnum moss peat, which is commercially available in Britain and Ireland, was dried in an oven for 24 h at 105°C and then screened through a 14 mesh sieve (1.18 mm aperture; B.S. 410/43) to remove any large non-peat solids.

Analytical grade reagents were used in all cases. A stock lead(II) solution (1 000 mg/l) was prepared in distilled water using lead nitrate. All working solutions were prepared by diluting this stock solution with distilled water.

The concentration of lead(II) was determined by acetylene-air atomic absorption spectrophotometry (Instrumentation Laboratory aa/ae spectrophotometer 751) using a single element hollow cathode lamp.

Experimental procedures

Batch sorption experiments were carried out at the desired temperature (10, 20, 30 and 40°C) on a rotary shaker at 100 r/min using capped 250 ml conical flasks.

In the adsorption isotherm tests, peat (0.40 g) was thoroughly mixed with aqueous solutions of lead (100 ml). The initial pH adjustments were carried out either by sulphuric acid or sodium hydroxide solution and recorded as pH_{in}. Three different values of pH_{in} were used; 4.0, 5.0 and 6.0; with initial lead(II) concentrations (C₀) ranging from 10 mg/l to 120 mg/l. After shaking the flasks for 4 h, the reaction mixtures were filtered through filter paper (Whatman No. 1) and the filtrates analysed for pH (recorded as pH_{fin}), and the concentration of lead(II) (Gaid et al., 1994).

In the sorption kinetic experiments, peat (1.2 g) was thoroughly mixed with 350 ml lead(II) solution (100 mg/l). The peat suspensions were shaken for 3 h at the desired temperature (10, 20, 30 and 40°C) using capped 500 ml conical flasks and 2 ml samples were collected and filtered through a 0.45 µm membrane filter every 3 min for the first 15 min, every 5 min for the next 15 min, every 10 min for next half hour every 15 min for the next hour and then at 30 min intervals for the final hour. The filtrates were analysed using atomic absorption spectrophotometry.

* To whom all correspondence should be addressed.
(0121) 414 5049; fax (121) 414 3675

Received 9 March 1995; accepted in revised form 5 February 1996.