CEC and Kd Determination in Landfill Performance Evaluation: A review of methodologies and preparation of standard materials for laboratory analysis

LandSim is a probabilistic quantitative risk assessment model issued by the Environment Agency for use by regulatory staff in landfill performance evaluation. LandSim takes into account factors such as liner and leachate-removal system and design, and the geological and hydrogeological regimes beneath and around the site in question. Among the input values required for the model is the cation exchange capacity (CEC) of geological materials around the landfill and the partition coefficient (K_d) of key solutes in leachates. CEC can be defined as the sum of exchangeable cations that a mineral, rock or soil can adsorb at a specific pH. K_d represents overall sorption of a particular species in leachate, irrespective of process. Both CEC and K_d are critical parameters in modelling the ability over time of the geosphere to retard the migration from landfill sites of leachates in groundwater.

Site-specific values for CEC and K_d have in the past often not been obtained because of the time and expense involved, and because of the absence of appropriate reference standards for calibrating methods. The LandSim manual provides default values for these parameters based on those published in the open literature for typical lithologies.

The principal aims of this study were to recommend standard methods for determining CEC and K_d in geological materials, to produce reference standards for calibrating these methods, and to extend the list of suggested default values currently available in LandSim. The intention is to encourage the adoption within UK laboratories of standard methods for determining CEC and K_d, and to maximize inter-laboratory consistency.

The report is in two parts. Section 1 is a review of methods for determining CEC and K_d, which concludes with recommendations for validation experiments to evaluate and compare methods short-listed for adoption as 'standards' for providing input to LandSim. The CEC methods are: the $BaCl_2$ ('compulsive displacement') method; the $SrCl_2$ (single displacement and summation) method; and the methylene blue (sorption of an inorganic dye) method. Although these methods differ considerably in detail, each offers a combination of relative simplicity, adequate precision and practical advantages over other methods.

Section 2 outlines the results of the validation experiments. CEC and K_d have been determined on six 'reference' materials: Sherwood Sandstone, Mercia Mudstone, Gault Clay, Lower Oxford Clay,

Lower Chalk and Lincolnshire Limestone. Each of these is an important UK lithology, and the site of existing or possible future landfill development. X-ray diffraction (XRD) analysis has been used to identify mineral constituents and provide a basis for interpretation of CEC results.

This R&D report has application not only in respect of landfill assessment and the tool, LandSim, but also in assessing the fate and transport of contaminants in the sub-surface arising from soil contamination. In this respect it has direct application to the assessment of land contamination and its simulation through tools such as ConSim.

This R&D Technical Summary relates to information from R&D Project P1-254 contained in the following output:

R&D Technical Report P340 'CEC and Kd Determination in Landfill Performance Evaluation: A review of methodologies and preparation of standard materials for laboratory analysis'

R&D Project Record P1/254/01 'CEC and Kd Determination in Landfill Performance Evaluation: A review of methodologies and preparation of standard materials for laboratory analysis'

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Project Manager: Philippe de Henaut (NGWCLC)
Project Contractor: British Geological Survey

Copies of R&D Technical Report P340 and Project Record P1/254/01 are available internally from the Regional Libraries and externally from WRc plc (Tel:01793 865138; Fax: 01793 514562).

Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol
BS32 4UD

Tel: 01454 624400
Fax: 01454 624409