8.7 Decontamination of Volatile Organics in Groundwater

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Cost effective, readily available, decontamination procedures for organically polluted groundwater emanating from waste disposal sites have been evaluated at the Gloucester Landfill near Ottawa, Canada. Peat moss, charcoal, and sawdust were mixed or layered with medium sand to a depth of 3 m in 7 x 3 meter pits excavated in the vadose zone. An additional pit was completely filled with sand to serve as a control. The pits were instrumented with multilevel samplers and initially flooded with uncontaminated groundwater. Subsequently each pit was flooded with approximately 100,000 L of contaminated groundwater. GC results indicate that all three decontaminants have the potential to be cost effective media for improving the quality of organically contaminated leachate.

8.8 Hydrogeologic analysis of long-term solute migration in thick clayey Quaternary deposits

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A detailed field and laboratory investigation was conducted on thick clayey deposits of glacial origin in the clay plains of southern Ontario, northern Ontario, the St. Lawrence Lowlands and northern Wisconsin. A total of 9 sites were instrumented with a network of 15 to 20 piezometers. Core samples were taken from each site for stratigraphic logging, hydraulic testing and mineralogic analysis. Groundwater samples were analyzed for major ions, dissolved gasses and environmental isotopes (^{3}H, ^{18}O, ^{2}H, $^{37}Cl/^{35}Cl$, ^{3}He, ^{4}He, ^{14}C, ^{13}C). The results of the field investigation show that in general groundwater flow occurs in two domains; a shallow domain and a deeper domain. The shallow domain ranges from 5 to 6 m below the surface and corresponds to the zone influenced by surficial weathering and fracturing and may possess significant horizontal components of groundwater flow. The deeper domain corresponds to the zone of unweathered clay and is characterized by the predominance of downward vertical groundwater flow. In the deeper domain calculated values of average linear groundwater velocities are on the order of 0.05 to 0.25 cm/a. The results of the isotope and dissolved gas analyses indicate that the shallow groundwaters are characteristic of modern-day precipitation whereas the deeper groundwaters are characteristic of waters that originated under much colder climatic conditions which is in very

good agreement with the ^{14}C ages that range from 8,000 to 12,000 years B.P. Laboratory breakthrough column experiments on clayey samples from the study sites show that the transport porosity (the effective porosity for solute transport) is on the order of 0.4 to 0.5 which is of the same magnitude as the total porosity. Mathematical simulations of naturally occurring solute profiles (^{18}O, ^{2}H, Cl) made with 1-D analytical solutions and using values of average linear groundwater velocities calculated from field data and laboratory determined values of effective diffusion coefficients in the range of 3.0 to 8.0 x $10^{-6} cm^2/s$ yielded profiles that were in good agreement with observed data. The results of the mathematical simulations were used to demonstrate that the migration of conservative solutes in thick clayey deposits was dominated by the process of diffusion and that the distribution and flux of these solutes can be adequately simulated over large time scales with models based on classical mass transport theory. This study also demonstrates that environmental isotope analyses in conjunction with standard hydrogeological methods is a valuable tool in the evaluation of the long-term waste containment potential of thick clayey deposits.

8.9 Contaminant Migration through Clay

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The design of a landfill facility situated in an area considered hydrogeologically unsuitable for such use requires the installation of a relatively impermeable liner, such as clay, to provide a final barrier between the landfill leachate and the underlying more permeable strata. The design of such a clay liner should be based on consideration of actual field measurements of pollutant migration through clay, in addition to numerical predictions and laboratory studies. Since investigation of an in situ clay liner could seriously disturb its integrity and may promote contamination of the underlying strata, landfills situated on natural clay deposits are more suitable for study.

This paper presents pore fluid cation (sodium, calcium, magnesium and potassium) and chloride migration profiles obtained from several investigations of a 14-year old domestic landfill in Sarnia, Ontario, located on a deep clay deposit. These are supplemented by profiles of the exchangeable cations adsorbed on the clay. Preliminary results for heavy metal and dissolved organic carbon migration from the landfill are also presented.

The profiles indicate that migration through the clay has been dominated by diffusion and that after 14 years of leachate production at the site, both cations and chloride have migrated approximately 1.5 m from the soil/refuse interface. Diffusion coefficients were obtained using an analytical solution to the one-dimensional

dispersion-convection equation, and may be used in the prediction of migration through clay liners. Heavy metal migration appears to be confined to the upper 2 cm of the soil directly beneath the soil/refuse interface, and dissolved organic carbon migration may have occurred to a distance of 60 cm. The distribution of exchange cations on the clay minerals may provide information on retardation of certain alkali and metallic cations.

8.10 Etude sur site expérimental de la migration en terrain semi-perméable d'effluents issus de boues industrielles

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Dans le cadre d'un programme national de recherches sur la mise en décharge de déchets industriels, le B.R.G.M. (departements de l'Eau et Environnement), a réalisé en 1979 et 1980 et poursuivi en 1981, une étude sur site expérimental pour déterminer les risques de pollution liés à la mise en décharge controlée de types de boues qui posent des problèmes soit d'élimination en raison du volume produit et de la toxicité des composants, soit en raison des pollutions qu'elles occasionnent sur certains dépôts sauvages.

Sur un site sableux non saturé, ont été installés deux ensembles de stockage comprenant chacun quatre cuves de stockage d'environ 16 m^3, entourant une fosse centrale d'observation. Les huit cuves sans fond reposent sur le sol et contiennent chacune une boue différente:

- une boue urbaine digérée anaérobie,
- une boue de dégraisseur de station d'épuration,
- une boue cuivreuse,
- une boue de fabrication de colles et gélatines,
- une boue de neutralisation d'effluents de décapage,
- une boue de cassage d'huiles de coupe (procédé Emulseri),
- une boue de rectification à l'huile,
- des goudrons acides.

L'infiltration des effluents dans le terrain sous les cuves est suivie de la surface à 4 m de profondeur, par les moyens d'investigation habituels du milieu non saturé que sont les tensiomètres, les bougies de prélèvement d'eau et les mesures d'humidité neutronique.

Le suivi de l'évolution des effluents et de leur migration dans le terrain, sur une période d'environ deux ans, a permis de distinguer différents comportements des boues, tant au point de vue hydrodynamique que du point de vue de la composition chimique des effluents.

Le calcul des flux de polluant sous chaque cuve a permis d'évaluer les risques sur l'environnement de la mise en décharge de ces diverses boues et d'extrapoler leur comportement à plus long terme, résultats qui devraient servir à préciser ou réviser la règlementation actuelle