ABSTRACT
PREDICTION OF LANDFALL CLAY LINER THICKNESS FROM MODELED AND EXPERIMENTAL BREAKTHROUGH CURVES OF LEAD (II)

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The biggest environmental problem faced by Metro Manila at the close of the 20th century, was the lack of disposal sites for its garbage brought about by the refusal of Local Government Units to locate new landfill sites in their locality. With the passage of RA 9003, or the Ecological Solid Waste Management Act of 2000, the disposal of solid wastes in open dumpsites has been prohibited and only sanitary landfills are allowed. This law requires the provision for landfill barriers that will prevent the contamination of ground water. The landfill barrier shall consist of "a system of clay layers and/or geosynthethic membranes used to contain leachate and reduce or prevent contaminant flow to groundwater". A logical way of doing this is to design landfill barriers based on the conditions of the prevailing environment particularly the underlying soil. A good barrier should not only prevent leachate from percolating towards the water table but also act as adsorption barriers, capable of attenuating the movement of toxic contaminants. Regulations for most leachate barriers for municipal solid waste landfills (MSWLF) worldwide are generally based on prescriptive design standards. The most common prescriptive design standards require 1.5 - 2.5 mm HDPE geomembrane over a 0.6 – 1 m clay liner with a hydraulic conductivity of 10-9 ms-1 and a service life or contaminating lifespan of 30 years. The clay liner thickness specified by prescriptive standards for sanitary landfills may provide a surface that may not be fully used up as adsorption sites to attenuate the contaminants present in a leachate. This is because during the adsorption process, one side of the concentration front in the clay bed moves faster than the other side, which leaves some areas of the clay as unused areas or areas where adsorption of contaminants does not occur. Using the method called the Length of Unused Bed (LUB) Length of Equilibrium Section (LES) Flow-through Column Method, breakthrough curves were obtained for San Mateo Landfill Clay columns of 1 and 3 cm thickness, pH of 5.2 and 8.8 and for Pb concentrations of 0.04 and 0.4 mg/L. The results show that 30 – 60% of the total clay surface area is used. An effective clay liner thickness can be computed to compensate for this unused area. The computed soil thickness increase is 20% for a pH of 5.2 and 40% for a pH of 8.8. By specifying an effective increase in thickness of 40%, the soil sample with a pH of 5.2 will have used up all adsorption areas and will have a longer breakthrough time. A solute transport model that describes the adsorption of a leachate contaminant like lead in the clay liner barrier of landfills using mass transfer equations for film and intraparticle diffusion is developed. The model is useful in cases where breakthrough curve spreading cannot be explained by dispersion only. To evaluate its validity, the model was applied to several data sets from column experiments. The validity was also tested by a comparison with an analytical solution for the limiting case of predominating dispersion as given by the Adsorption, Dispersion, Sorption Equation (ADSE). Furthermore, a sensitivity analysis was performed to illustrate the influence of different parameters (pH, soil column thickness, contaminant lead concentration, fluid velocity and clay content)) on the shape of the calculated breakthrough curves and the value of the breakthrough point. The results show that the model can closely simulate the experimental results by introducing a correction factor for intraparticle diffusivity ranging from 0.02 to 0.08. The parameter that showed the highest impact on the shape of the BTC and the value of the breakthrough time is the leachate pH.