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Establishing the Hydrological Conditions Beneath an Unlined Municipal Landfill and an Engineered Landfill Site in Malaysia Using Numerical Groundwater Flow Models – Case Studies

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As part of the measures to initiate effective remedial program once aberrations are detected, numerical groundwater flow model is the effective tool to understand the hydrological conditions beneath the subsurface. An unlined ex-landfill site in Kuala Lumpur (Site A) and an operating engineered landfill site in the coastal area of Pahang (Site B) were investigated. Visual MODFLOW (VMOD) flex models was used to establish the groundwater flow system at the two-landfill site. MODFLOW 2005 engine code was used to construct the groundwater flow models while the flow path of particles was modelled using MODPATH. The groundwater flow model for Site A was calibrated and modelled as a three (3) layer steady-state VMOD flex model while Site B was set up as a (6) layer transient groundwater flow model. The steady state groundwater models for Site A was simulated for a model time scale of 30 years while the transient's groundwater model for Site B was simulated for Five (5) different modelling time scale up to 30 years. The steady - state VMOD flex model revealed that the hydraulic gradient in Site A is mainly from the north-west around the landfill area and groundwater flow is discharging in the north-east and south-east in the river and ponds located within the landfill site. The entire VMODFLOW flex transient simulations for Site B generally indicate that the hydraulic gradient originates from the northern boundary of the site and the general trend of groundwater flow is in the north-southeast directions towards the eastern boundary of the project site and discharging to the South China Sea which is located at 3km east of the site. In addition, the pond at Site A is discharging directly to the aquifer at Layer 2 (silty SAND). While at Site B, the retention pond is hydraulically connected to the Layer 2 (sandy clayey SILT) and equally providing seepages to the Layer 3 (shallow silty SAND aquifer). MODPATH demonstrate that the major groundwater flow (or movement) in Site A is in the Layer 2, (Silty SAND formation) which is the main aquifer at the site and where most of the groundwater is located. In contrast, at Site B the major groundwater flow is in the shallow silty SAND aquifer (Layer 3) rather than the deeper aquifer (layer 5) at the site where the greatest potentials for groundwater could be located. The VMOD flex models' simulations signify that the pathways in which contaminates will follow is largely dependent on the directions of groundwater flow at the site. It is recommended that the aquifer, ponds and river at the sites should be protected from surface contaminations because the impact of groundwater contamination will be direct on the aquifer at Layer 2 (silty SAND layer) at Site A, while the effect is expected to be minor at the aquifer at Layer 3 (shallow silty SAND aquifer) at Site B due to confining- unconfining sandy CLAY layers. This paper showed that the numerical groundwater flow modelling for analyzing and solving groundwater problems is a useful tool for evaluating the hydrological conditions in the groundwater regime at the two landfill sites.

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