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Optimization of Soil Vapor Extraction by Hot Air Injection in Respect of Wells Spacing and Depth

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Extended Abstract

Soil vapor extraction (SVE) is an established technique for removal of volatile toxic materials from contaminated soils. The method is environmentally and economically effective. There are several methods of performing SVE operations, among which are thermally enhanced soil vapour extraction methods (TESVE). Both, electrical soil heating and steam injection are examples of established TESVE methods. The current research study explores design aspects that could yield effective TESVE through hot air injection, which is a subject that deserve considerably more attention. The analyses are performed numerically to unveil the thermodynamic conditions that develop around multiple air injection wells. Conclusions that were discovered in previous analyses of single wells were applied in the current investigation, among which is the incorporation of in-situ heat regeneration technique, which is implemented by terminating the inlet air heating at a certain stage and letting the stored heat in the soil (accumulated during this stage) to heat up the ambient air injected subsequently. This practice effectively saves unnecessary heating energy. The study addresses the design parameters that govern the soil remediation process. Though the study is conducted for a sandy soil contaminated by propanol, the conclusions are of general nature. Calculations reveal that increasing the spacing between wells is generally advantageous, however, with possible limitations by various constraints. Examination of the air propagating from a well outward shows that the average air cleanup capacity is higher in longer air trajectories within the soil. For example, the time necessary to complete remediation of a 4 meters air path is smaller than twice the time necessary for a 2 meters path (savings of 13.6% of the average time consumed per unit path length). This finding stems from the fact that air released after 2 meters waists unused remediation capacity. If not released after 2 meters and left to initiate the decontamination of the next 2 meters, those next two meters would be easier to remediate thereafter. Concurrently, the averaged pumping energy consumed for moving the air through the pore matrix is smaller per unit path length in longer air trajectories (savings of some 30%). It is a direct consequence of the corresponding reduced remediation time. Furthermore, spacing apart the wells slightly reduces the pumping pressure required to maintain a given air mass flow rate owing to diminished influence of opposing air flow directions between adjacent wells. Though spacing the wells far apart is more efficient per unit of soil volume, it comes on the expense of the time required to decontaminate the total soil volume. Preheating the injected air can reduce the total remediation time by roughly 6% for every 10^{o}C temperature increase, however, this would necessitate larger pumping energy to overcome the effect of increased air specific volume. Beside time constraints, spacing the wells far apart could be limited by the depth of the local water table. Wells that cannot be drilled deep enough must be drilled closer to each other so that the expanding air flow toward the soil surface would cover the entire contaminated zone.