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Sensitivity Study of Soil Volatile Contaminants Extraction by Controlled Hot Air Injection

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Extended Abstract

Soil vapor extraction (SVE) is an established method for soil decontaminating from toxic substances. It has both, environmental and economical merits [1]. The current study is particularly focused on soil contaminated by volatile fluids. In general, SVE operations are conducted with air at ambient temperatures, sometimes assisted by thermal soil warming. Thermal enhancements of soil vapour extraction (TESVE) processes are usually conducted by electrical soil heating techniques, with or without added steam injection [2]. The current study explores the merit of using exclusively hot air as an alternative to the common practices of TESVE operations. To demonstrate the merit of the hot air TESVE technique, a sandy soil containing contaminated water is studied. The effectiveness of SVE processes is measured by the contaminant mass-removal rate and the removal-capacity limit. In principle, hot air promotes a higher vapour-removal rate and carries a more exhaustive soil-remediation capacity. The study is focused on a representative cylindrical homogeneous moist domain, which is exposed to a radial hot-air flow originating from a central well. Analyses are conducted numerically and analytically to reveal the effectiveness of timely controlled hot air injection methods on various injected air thermodynamic conditions. The governing equations are based on the Darcy law for an expanding compressible flow [3]. The equations were solved to determine the time required for complete soil remediation. The study shows that the injected air heating can be turned off after a specific time while maintaining the full advantage of the hot air technique. This is accomplished by internal soil heat regeneration, which saves air-heating energy by eliminating wasteful soil residual stored heat. Sensitivity analyses were conducted to unveil the dependence of the required soil decontamination time on the injected air temperature and humidity. For the case studied, it is shown that extreme diurnal humidity variations can affect the soil remediation rate by 10%, with a higher sensitivity at lower injected air temperatures. Alternatively, raising the injected temperature by 10^{o}C reduces the remediation time by roughly 10%. However, as the injected temperature is further raised, the corresponding reduced remediation time progressively diminishes. Associated energy and cost evaluations reveal that the reduced time necessary for soil remediation is the dominant cost-saving factor that indeed yields the sound benefits of the hot air injection method.

References

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