Paper Number: 1844

A methodology to assess the movement of hydrocarbons in the subsurface and the remediation thereof

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Petroleum serves as a great source of energy however, with such principle importance; it poses a problem as a global contaminant. Hydrocarbon contamination is a huge threat to groundwater as it contains toxic substances that are insoluble in water referred to as the free phase. These toxins are carcinogenic and mutagenic, and have a major impact on human health and ecosystem stability [1]. When spilled, hydrocarbons will move downward through the unsaturated zone under the influence of gravity and capillary forces, trapping small amounts in the pore spaces. Some of the components within the free phase can dissolve and move as a plume of contaminated water by diffusion and advection within the groundwater [2]. There is a long term effect on ecosystems as the insoluble free phase mass slowly decays and released toxic material into the aquifer making it more difficult to model and control. Petroleum hydrocarbon behaviour in the subsurface is additionally complicated by the presence of multiple chloride and cyclic organic compounds, each with different properties. The net result is that some hydrocarbon fractions are transported faster than others and a contamination plume of varying intensity may spread over a large area [2].

The ultimate aim of this study was to develop a methodology to assess the movement and remediation of hydrocarbons in the subsurface with the use of a numerical model, to improve the management of areas contaminated by hydrocarbons. This includes the migration and delineation of the free phase and dissolved plume. Additionally, it was necessary to simulate a number of remediation options to elevate the risk associated with the contaminant. According to the Manual for site assessment at DNAPL (dense non aqueous phase liquids) contaminated sites in South Africa, MODFLOW and UTCHEM can be used as a facilitator in managing and containing hydrocarbon contamination [3]. The software package UTCHEM was therefore used to model the migration of all hydrocarbon phases and surfactant enhanced remediation, while MODFLOW was used to validate the accuracy of the numerical, multiphase model. The methodology was demonstrated by means of a case study of the Island View site located within the Durban harbour.

After simulating the movement and remediation of tetrachloroethene (PCE), benzene, toluene, ethylbenzene, and xylene, results reflect the complexity of the problem. UTCHEM could not accurately model the migration as the generation of a working model was too simple in comparison to the conceptual model used in MODFLOW. The proposed methodology includes the delineation of the free phase using Geophysical instruments, the modelling of the dissolved contaminated plume using

MODFLOW, and the remediation of the free and dissolved phase using a simplified UTCHEM model if and when necessary in order to isolate the best option for a specific site.

References:

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