ARC '18

مؤتمر مؤسسة قطر
السنوي للبحوث

QATAR FOUNDATION
ANNUAL RESEARCH CONFERENCE

البحث والتطوير: التركيز على
الأولويات، وإحداث الأثر

R&D: FOCUSING ON PRIORITIES,
DELIVERING IMPACT

20-19 مـــارس
19-20 MARCH

مؤسسة قطر
Qatar Foundation
لإطلاق قدرات الإنسان.
Unlocking human potential.

Energy and Environment - Poster Display

http://doi.org/10.5339/qfarc.2018.EEPD709

Groundwater pollution by petroleumderived contaminants in coastal semiarid environment

Riyadh Al-Raoush*, Stephane Ngueleu, Fereidoun Rezanezhad, Philippe Van Cappellen

Department of Civil and Architectural Engineering, Qatar University, P.O Box 2713, Doha, Qatar
* riyadh@qu.edu.qa

A common source of contamination of soil and groundwater in arid and (semi)-arid coastal regions are accidental spills of petroleum products, such as crude oil, gasoline, and diesel fuel. Groundwater pollution by petroleum hydrocarbons is a serious pollution problem that poses hazards to water resources and living organisms including humans. After release to the sub surface, hydrocarbons move downward through the aerobic vadose zone under the force of gravity. Eventually, they reach the groundwater table, where oil overlay promotes the development of anaerobic conditions. The oil phase that occurs as floating product on the water table and as residuum on soil grains provides a continued source supplying hydrocarbons to the groundwater. Accumulations of residual hydrocarbons at or near the water table may undergo smearing due to variations in water table elevation driven by, for example, seasonal changes in recharge and discharge or by tidal forcing in coastal environments. In subsurface environments contaminated by petroleum products, the geochemical conditions near the water table, in particular, the oxygen availability, moisture content, salinity, pH, nutrient concentrations and temperature, are important determinants of biogeochemical processes. Among these variables, the interplay of moisture content, oxygen availability and temperature are critical for understanding the biodegradation of petroleum hydrocarbons in arid and (semi)-arid coastal soil environments. In addition, the fate and transport of hydrocarbons in groundwater also depend on the redox conditions, soil mineralogy and microbial community structure, as well as the availability of suitable electron acceptors and nutrients. We hypothesize that the transition zone between the vadose zone and the groundwater system represents

دار جامعة حمد بن خليفة للنشر
HAMAD BIN KHALIFA UNIVERSITY PRESS

Cite this article as: Al-Raoush R et al. (2018). Groundwater pollution by petroleumderived contaminants in coastal semiarid environment. Qatar Foundation Annual Research Conference Proceedings 2018: EEPD709 http://doi.org/10.5339/qfarc.2018.EEPD709.

a hot spot for the degradation of petroleum hydrocarbons. This transition zone, however, is a dynamic biogeochemical environment, whose functioning is closely linked to the amplitude and frequency of water table fluctuations. We propose to determine the role of water table fluctuations on the coupled hydrological and biogeochemical processes that affect the degradation and partitioning of petroleum hydrocarbons, under conditions relevant to aquifers. Coastal areas in this regard can function as zones of contaminant mass transfers between aquifers and surface water bodies, but also as excellent spots of in situ bioremediation of contaminated soil and groundwater thanks to coupled hydrological and biogeochemical processes. The main objectives of this project are to: 1) quantify the level of sorption and biodegradation of multi-component hydrocarbons in soil and groundwater; 2) quantify the rates of hydrocarbon biodegradation under oscillating aerobic and sulfate reducing conditions in groundwater contaminated with petroleum hydrocarbons; 3) determine the oxygen dynamics in the vadose zone and groundwater affected by hydrocarbon dispersion under variable water table fluctuation regimes; 4) assess the rates and mechanisms of biogeochemical reactions regulating groundwater nutrient turnover during hydrocarbon spill and its movement under conditions of groundwater table fluctuations; and 5) develop a reactive transport model for groundwater pollution by petroleum hydrocarbons. In this project, we combine the acquisition of integrated physical, chemical and microbial data using uniquely designed process-oriented experimental approaches. The results of this project will significantly add to the quantitative knowledge on the effects of water table fluctuations on the release and degradation of petroleum-derived hydrocarbon contaminants in soil environments that experience both arid conditions and tidally-driven water table fluctuations. The expected results of the research will inform groundwater management and protection in arid and (semi)-arid coastal environments.   To quantify the level of sorption and biodegradation of petroleum hydrocarbons in subsurface soils and groundwater (Objective 1), we conducted a series of controlled-laboratory batch experiments under variable salinity, temperature and water chemistry conditions. The soil samples were collected from the eastern coast of Qatar which is close to the North Gas and Al-Shaheen Oil Fields. The initial physical characterization of soil samples showed sand classification with the texture class of sabkhas soil. The results of soil-phase chemical characterization suggested that the dominant minerals of the soil are calcite, dolomite and gypsum and the concentrations of chloride and sodium were found to be high with a chloride-to-sodium ratio of ~1.6.We used volatile benzene and naphthalene hydrocarbons to determine the sorption and biodegradation rates. The results of sorption experiments showed that naphthalene was adsorbed to the soil more than benzene where the initial aqueous concentrations of benzene and naphthalene were reduced at equilibrium due to sorption by approximately 10% and 75%, respectively. This difference was attributed to the organic carbon-water partitioning coefficient which is higher for naphthalene. We developed a sorption kinetics model to define the sorption isotherm of benzene and naphthalene hydrocarbons for the specific coastal soil collected from Qatar site. The model assumes the two sites sorption to the soil, one site in local equilibrium and the other site on first-order kinetic sorption, and the best fits were found for the Langmuir sorption isotherm type for the used hydrocarbons and soil in this project. In this presentation, we present the results of sorption and biodegradation batch experiments as well as the design of a unique dynamic soil column experiment to understand the dynamic responses of the fate, transport and degradation of hydrocarbons and the soil biogeochemical processes to the relatively abrupt changes in hydrogeochemical and climatic conditions.