INNOVATIVE SITE INVESTIGATION TOOL FOR NAPL CONTAMINATED AREAS IN BRAZIL

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Key words
LNAPL, petroleum hydrocarbons, radon, site investigation

INTRODUCTION

Production, storage, and handling of fuel have led to serious contamination of soil and groundwater in many countries worldwide. Main causes are leaking storage tanks, drip losses, or accidents.

Over the years large scale contamination did also occur in Brazil, mainly caused by the petroleum industry. Due to the related harmful impact of the released chemicals on the environment there is an urgent need to investigate and to remedy the concerned sites in the near future. Urban sprawl increases the economic necessity to redevelop abandoned industrial areas in a way that allows their future use as industrial or residential areas. Additionally, in areas that suffer subsurface contamination the supply of process water and/or potable water may become problematic due to low quality of the available groundwater resources.

Generally fast and low-cost techniques for contamination identification and evaluation help to assist on-going processes of site investigation, site assessment and eventually of site remediation. In this paper the principle and the advantages of an innovative technique suitable for subsurface NAPL contamination assessment will be presented.

For risk assessment as well as for planning and conducting remediation measures it is necessary to locate the contamination source zone and the plume of dissolved contaminants. Also the mass of contaminants in the subsurface has to be quantified. Fuels are known as LNAPL (= light non aqueous phase liquids), i.e. they show a density lower than water. Hence, free product floats on the water when reaching the groundwater level after an accidental spill. With a fluctuating water table due to the seasonable variation a smear zone develops in the aquifer.

It is possible to detect liquid organic phases by mapping the BTEX concentration in the soil gas of the unsaturated zone. However, this approach is only promising if these VOC are constituents of the NAPL. In the case of contamination by diesel, jet fuel or heavy mineral oil this method will hardly work. Another possibility is conventional drilling with soil sampling accompanied by installing groundwater observation wells and monitoring of the thickness of the floating organic phase. Disadvantages of this approach are that it is time consuming and expensive. Thus, in most cases limited information is available about the shape of source zone and resulting plume as well as about the amount of the free product in the subsurface.

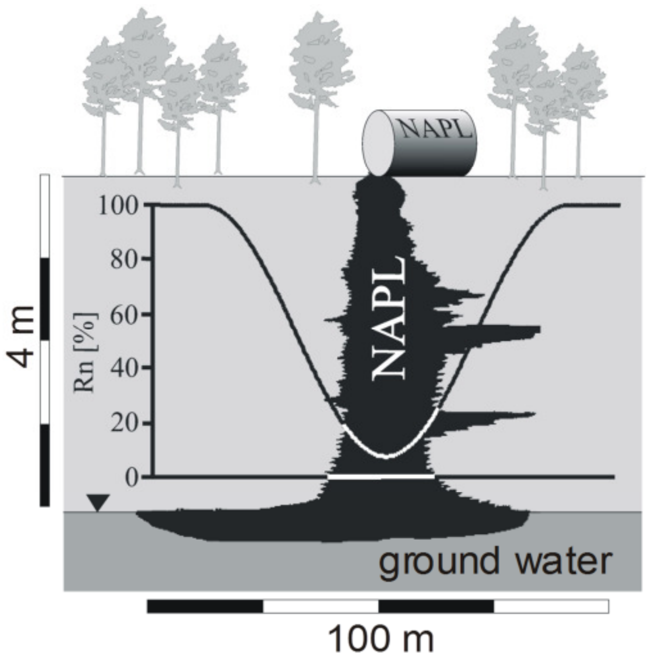

Figure 1: Schematic sketch of the principle of radon distribution in the close vicinity of a site contaminated with LNAPL

The radioactive noble gas radon (^{222}Rn) is a naturally occurring component of the soil gas. It can be detected fast and easily applying sensitive mobile radon detectors. Furthermore, it shows a very high solubility in non-polar organic liquids. NAPL/air partition coefficients are in a range of about 10 to 12, NAPL/water partition coefficients range between about 40 and 50 [Schubert et al. (2002)]. Consequently, radon that is naturally available in the subsurface will accumulate in the organic phase and its concentration in groundwater and soil gas will be reduced considerably compared to areas without any NAPL contamination present. Figure 1 schematically shows the effect. When mapping the radon concentration on a suitable sampling grid at the suspected industrial site it is possible to locate indirectly the source zone.

RESULTS

An abandoned airfield was used as test site to demonstrate the potential of the radon-method for detecting LNAPL contamination in the subsurface [Schubert et al. (2002)]. The geological setting was characterised by a homogeneous sandy soil; the groundwater level was identified at approximately 4 m below surface level. Freely floating phase (kerosene) was explored beforehand with a thickness of 0.1 m - 0.5 m. Old kerosene tanks are assumed to be the main source of the contamination.

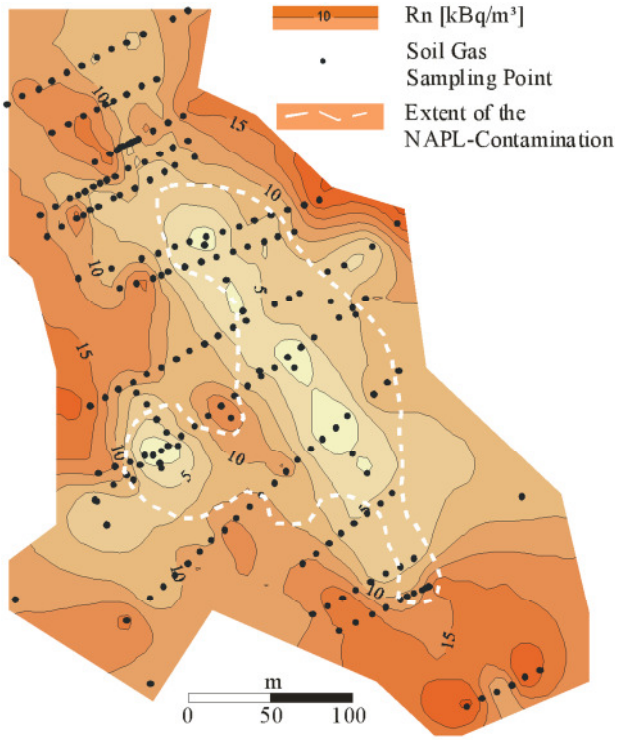

Figure 2: Distribution of Radon in the soil gas at a former airfield with a NAPL contamination.

Soil gas samples were taken at approx. 200 different locations covering the area and the ^{222}Rn concentrations were measured. The depth of sampling was 0.9 m below surface level to exclude any influence of changing meteorological conditions. The concentration of ^{222}Rn was measured as counts of radioactivity per volume soil gas (Bq/m^3). Figure 2 illustrates the results of the radon survey on the airfield. Radon concentrations higher than about 10 kBq/m^3 were found in the uncontaminated vicinity of the site; significantly lower concentrations (≤ 5 kBq/m^3) were detected at several areas in the centre of the site. These low radon concentrations indicate the presence of NAPL. The achieved results are in a good agreement with data from conventional investigation of the site carried out before.

The radon method was also applied on several other sites in Europe with satisfying results [Grossmann et al. (2007), Höhener and Surbeck (2004), Schubert et al. (2005, 2007a, 2007b)]. First investigations were performed at a refinery and a storage tank in Brazil in 2009 [Quintão et al. (2009)].

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