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Distribution and health risk assessment of some organic and inorganic substances in a petroleum facility in central Mexico

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ABSTRACT

An oil distribution and storage station was subjected to an Environmental Auditory and results showed soil contamination in part of the surface. An assessment of the site was required in order to fulfill a complete characterization of the contaminants present in soil and groundwater, as well as to establish the probable sources of contamination. Besides, a health risk assessment was performed to set remediation goals. The aim of this work is to show how the entire characterization and risk assessment process performed in this storage station from central Mexico, regarding to subsoil and groundwater. Thirty sample points were examined. Total petroleum hydrocarbons concentrations in soil were in a very low range (20–268 mg/kg). Ethylbenzene, methyl tert-butyl ether, tert-amyl methyl ether, and lead were identified in one sampling point. Iron and zinc were found in all soil samples. There was no correlation between total petroleum hydrocarbons and any of the metals or between both metals. Only two out of four monitoring wells showed total petroleum hydrocarbons levels (1.4 and 66 mg/L, respectively). Regarding lead, all four monitored wells showed lead concentrations (0.043–0.15 mg/L). Results suggested that metal concentrations were not associated to petroleum contamination, but to iron scrap deposits placed over the soil; nevertheless more data is needed to make a clear conclusion. Health risk assessment showed that none of the evaluated contaminants represented a risk either for the on-site or the off-site receptors, since the hazardous quotients estimated did not exceed the acceptable values.

1. Introduction

The oil distribution and storage station (ODSS) under study is located in central Mexico, in the state of Puebla. The region on which it is built is known as the *Eje neovolcanico* province, considered a huge mass of volcanic rocks, accumulated due to successive volcanic episodes (INEGI, 1997). This region is characterized by the predominance of relatively young (upper tertiary and quaternary) volcanic structures of diverse types and textures such as basaltic flows, tuffs and ashes generated successively by many volcanoes during the Cenozoic period. The soil consists of alluvial deposits and volcanic tuff (Pestana et al., 2002), and was classified as silty sand soil (total porosity of 0.46, bulk density of 1.7 g/cm^3, and hydraulic conductivity of 1.0 E−05 cm/s).

The region belongs to the *Rio Atoyac-San Martín Texmelucan* sub-basin at the *Rio Atoyac* basin, included in the *Rio Balsas* (RH18) hydrological region (INEGI, 1997). The water streams nearest to the zone are *El Conde, Atoyac, El Santuario,* and *Ojocotlan-Xaltonatl.* The region has a sub-humid temperate climate, with the raining season in the summer. The annual average temperature is 12.0 °C. The coldest month in the year is January. The hottest month is May with a monthly average temperature of 18.0 °C. Total annual precipitation is about 700 mm, in the driest year and 1500 mm in the wettest year. Dominant winds in the region have a south-east direction with a frequency of 21.6% and average speed of 2.27 m/s (INEGI, 1997).

The studied ODSS facility was used for the storage and delivery of petroleum products, mainly gasoline, propane gas, and diesel. The facility covered a surface of about 600 m × 450 m, constituted mainly by office buildings, workshops, filling devices, storage tanks, one laboratory, and a wastewater treatment plant. Fig. 1 depicts a general map of the ODSS. This facility was subjected to an Environmental Auditory and results showed soil contamination, mainly at the east and south-east part of the facility. Due to confidentiality reasons detailed information about the exact location of the studied ODSS and the name of the company that performed the Environmental Auditory cannot be revealed. The contamination was associated to the disposal of residual sludges from the storage tanks into the soil. For this reason, the Instituto de Ingeniería, UNAM (Institute of Engineering, Autonomous National University

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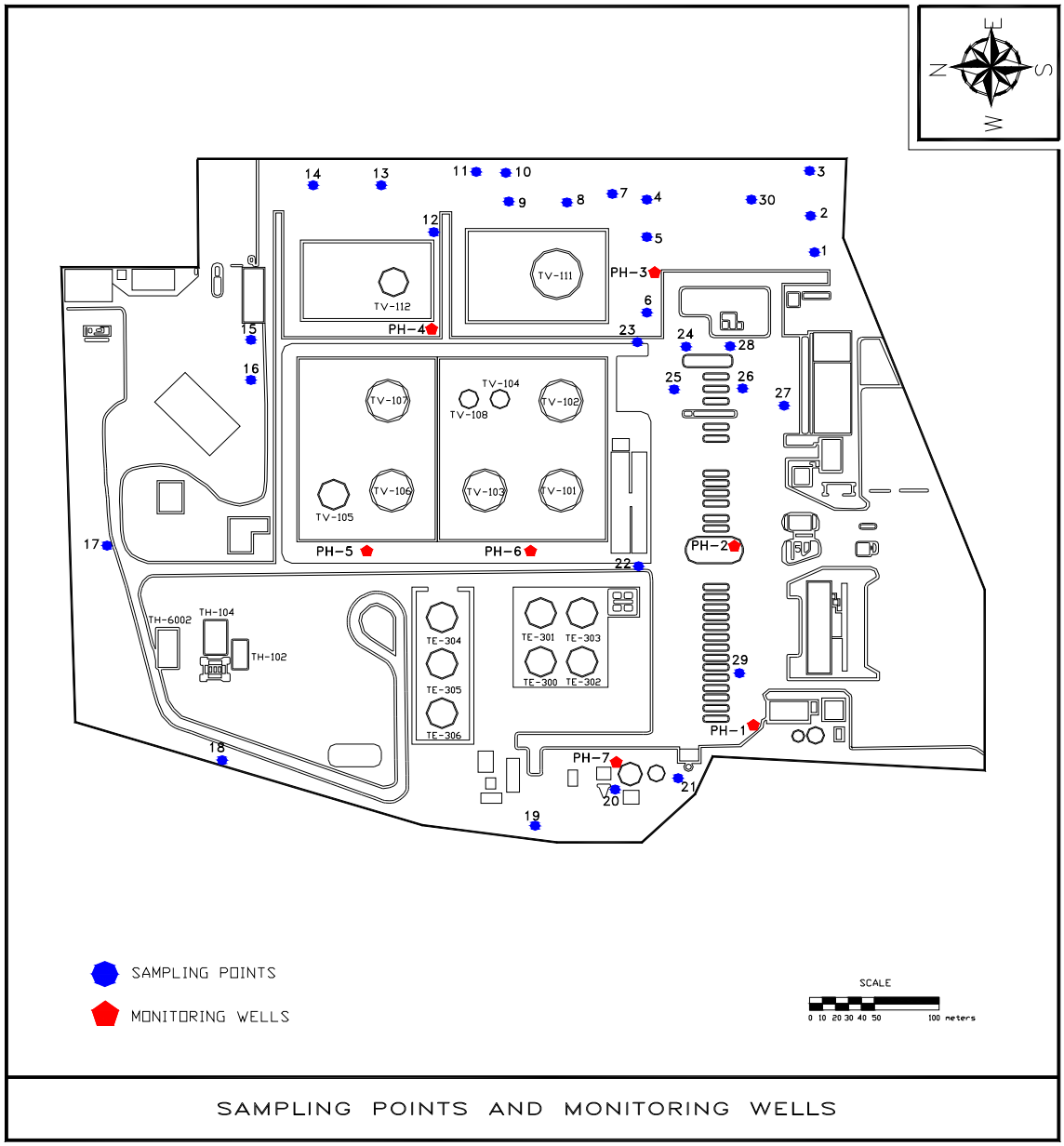

Fig. 1. Soil sampling points and monitoring wells at the studied ODSS.

of Mexico) was requested to perform a complete analysis consisting in subsoil and groundwater characterization and a health risk assessment, as well as to determine the required remediation levels.

Our research group has performed this kind of studies in other ODSS and refineries (Iturbe et al., 2003a, 2003b, 2006a, 2006b) along the country, where the soil presented high concentrations of TPH (>2000 mg/kg), and silty-sand textures. In the present case TPH concentrations were low (<300 mg/kg) but a health risk assessment was required by the Mexican environmental authority in order to prevent any damage to the population exposed. This was required because at the time this project was performed (1999), in Mexico there were no standards to establish soil cleaning levels, there were just the Interim Criteria for Polluted Soil Restoration (PROFEPA, 1998), published by the Mexican Federal Bureau of Environmental Protection (Procuraduría Federal de Protección al Ambiente, PROFEPA), but they were not compulsory, and health risk assessments were an alternative tool to establish soil cleaning levels.

The aim of this work is to show the entire characterization process carried out in an ODSS in Central Mexico, regarding subsoil and groundwater, including the measurement of explosivity levels. Besides, results from a health risk assessment (HRA) procedure are showed in order to determine the risks of the population exposed to some of the contaminants present in both media. Remediation levels proposed for this site are also presented.

2. Materials and methods

2.1. Soil and groundwater sampling procedure

Soil samples were collected from 30 sampling points distributed in the ODSS area (see Fig. 1), at different depths (0–4.5 m). Based on the results obtained from the Environmental Auditory performed previously a targeted soil sampling pattern was used. Most of the sampling points were located in the zones where the Environmental Auditory reported the presence of TPHs (east and