Sub-soil contamination due to oil spills in zones surrounding oil pipeline-pump stations and oil pipeline right-of-ways in Southwest-Mexico

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Abstract Oil spills due to oil pipelines is a very frequent problem in Mexico. Petroleos Mexicanos (PEMEX), very concerned with the environmental agenda, has been developing inspection and correction plans for zones around oil pipelines pumping stations and pipeline right-of-way. These stations are located at regular intervals of kilometres along the pipelines. In this study, two sections of an oil pipeline and two pipeline pumping stations zones are characterized in terms of the presence of Total Petroleum Hydrocarbons (TPHs) and Polycyclic Aromatic Hydrocarbons (PAHs). The study comprehends sampling of the areas, delimitation of contamination in the vertical and horizontal extension, analysis of the sampled soils regarding TPHs content and, in some cases, the 16 PAHs considered as priority by USEPA, calculation of areas and volumes contaminated (according to Mexican legislation, specifically NOM-EM-138-ECOL-2002) and, finally, a proposal for the best remediation techniques suitable for the contamination levels and the localization of contaminants.

Keywords PAHs · Pipelines · Pumping stations · Soil contamination · TPHs

Introduction

Oil and oil-products transport is a crucial operation for their production-transformation-distribution cycle. There are several ways to transport petroleum hydrocarbons, including tank-cars, ships, trains, and ducts, among others. Pipelines are metallic pipes that connect oil production zones with refinery facilities or refineries with oil storage and distribution stations separated by long distances. Pipelines can even connect installations from one country to another with any of the previous purposes. Mexico has a large pipeline system. The main products transported by means of this net are crude (oilducts), gas (gas-ducts), petrochemical products, fuel-oil (fuel oil-pipelines), and even different products together, such as diesel, gasoline, and gas (polyducts). In 2000, Mexico had a pipeline net of about 28,450 km of pipelines with mean diameters between 16 and 29 in. (Instituto Mexicano del Transporte 2000). For that year, 20% of the pipelines were devoted to oil transport, while 35.6% were used for gas transportation. Most of the pipelines (39.8%) transported more than one product (polyducts) and only 3.7% of the pipelines were built to transport petrochemical products.

It has been reported that more than 30% of the oil pipelines in Mexico have been in operation for more
than 30 years. Oil ducts’ lifetime has been calculated in 25–30 years (La Jornada 2001). This is a big problem for PEMEX, the national-industry in charge of exploration, production, transformation, storage, and distribution of oil and oil-derivatives. There are three main causes for oil spills in oil and oil-products pipeline systems: (1) The bad physical state of pipelines due to their age. (2) Problems in maintenance operations. (3) Clandestine poaching, mainly of refined oil-products (i.e., gasolines). Unfortunately, in Latin America and Mexico this is a common practice. More than 80% of oil spills near oil pipelines are due to this infamous practice. PEMEX, very concerned with the environmental agenda, has been developing inspection and correction plans for zones around oil pipelines pumping stations and pipeline right-of-ways. These stations are located at regular intervals of some kilometres along the ducts’ extension. There are big pumping stations where installations comprise several operation facilities, offices, sometimes storage tanks or ditches, treatment plants, etc. The main problems are encountered in zones far away from cities and frequently used roads, since those pumping stations are more exposed to vandalism and clandestine poaching of gasoline and other fuels.

The aim of this investigation is to show the characterization carried out in a zone around oil-duct pumping stations located in southwestern Mexico, near an important refinery located at Salina Cruz, Oaxaca. The specific places to evaluate soil contamination were: (1) km 0+800, km 1+900, km 4+590, km 6+020, km 8+800, km 9+500, km 11+499. (2) Zones located south from diesel-storage tanks, and south from the storage ditch of the Medias Aguas pumping station. (3) A zone used for residues treatment, located in the northwest of the Loma Larga pumping station and south from the storage ditch. (4) The area corresponding to Petapa, km 27+200 of the 16-in. multiproduct pipeline (closed line). All these sites were selected because the preliminary observation of the facilities revealed the presence or risk of hydrocarbon spills.

The study comprehends sampling of the areas, delimitation of contamination in the vertical and horizontal extension, analysis of the sampled soils regarding TPH and, in some cases, the 16 PAHs considered as priority by USEPA, calculation of areas and volumes contaminated (according to Mexican legislation, specifically NOM-EM-138-ECOL-2002) and, finally, a proposal for the best remediation techniques suitable for the contamination levels and the localization of contaminants. This study was performed at the end of 2004, this is the reason for using the 2002-legislation regarding environmental issues.

There are few publications available on literature regarding monitoring petroleum contaminated sites. Rifai et al. (2000) made an excellent review regarding characterization and remediation considerations in monitoring hazardous waste sites, while other authors have made excellent contributions, i.e., Adeniyi and Afolabi (2002), Al-Sarawi et al. (1998), Barakat et al. (2001), Rong (2001), Shriadah (1999), to mention some.

In previous works, our group has carried out site characterizations at petroleum facilities, including refineries, oil storage and distribution stations, and marine ports (Iturbe et al. 1998, 2003a, b, 2004c, 2005, 2006a, b, c). These studies included soil and groundwater characterizations, health risk analysis, determination of the contaminated areas and volumes, calculations of cleanup levels, and suggestions on remediation techniques suitable for some of the contaminated sites, among other activities. This is a first investigation related with oil duct ways and pumping stations. Three aspects should be taken into account when characterizing oil duct ways and pumping stations (1) Oil pipelines and pumping stations are a conjunction of sites, interconnected with the pipeline itself, and can be separated by tens and hundreds of kilometres, (2) Some pipeline pumping stations are big installations including auxiliary facilities, but most of them are very small sites in the middle of nowhere, (3) Although some sections of the pipelines and some pumping stations coincide with small and big cities, large amounts of pipeline sections and pumping stations are located in the countryside, in arid regions with no industrial, agricultural, or housing developments.

Materials and methods

Sampling of sites was carried out following the suggestions of an Environmental Audit performed at the site by PROFEPA. It was decided to sample 11 points at Salina Cruz pipeline right-of-ways, five points at Loma Larga pumping station, five points at Medias Aguas pumping station, and two points in the area of Petapa, km 27+200 of the 16-in. polyduct. Sampling was performed at different depths, from 0.8 to 3 m. Sampling