

# Characterize the Hydrocarbon Contamination in Shallow Groundwater and Soil Using GIS System in Zukait area, Oman

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### Abstract

The preliminary study describes the groundwater and soil contamination by hydrocarbon in Zukait, Oman. The hydrocarbon contamination had been documented long time ago for almost more than 20 years. The contamination incidents had been detected either through floating free oil on the top of the shallow groundwater or on the soil.

Groundwater for Oman is considered very precious resources more than 94 % of it is used for different purposes mainly for drinking and irrigation. Therefore, his Majesty Sultan Qaboos and the government took many vital steps to develop and conserve these valuable resources.

Contamination by hydrocarbon is a very serious problem in Oman. Hydrocarbons are organic compounds and some kinds are soluble in water and exist as dissolved form and as insoluble nonaqueous phase, which can migrate through the subsurface. The hydrocarbon contamination has been created by releases of oil products from an oil pipeline.

Ministry of Water Resources (MWR) had done great efforts in the past to capture the free oil and eliminate the contamination. Nevertheless, the contamination after these years is still obviously existing and moving as a separate free object on the top of the water level, dissolved in groundwater and adsorbed to the soil material and aquifer matrix.

There are important health effects related to drinking water contaminated by hydrocarbon. Certain carcinogenic effects have been associated with benzene, which has been defined by EPA as class A carcinogen. The maximum contamination level goals for benzene in drinking water is set by WHO and EPA as zero. The Omani standard for drinking water recently added the BTEX compounds. Chlorinated the contaminated water

for disinfecting the water (standard procedure in Oman) could cause chlorinated hydrocarbon, which is also harmful for human health.

In Zukait area the contamination is still exist in a very bad manner. The contamination took place in the 1970s through a leakage from the PDO pipeline. The contamination has deteriorated the quality of groundwater and very large area of soil in the vicinity of the pipeline. The hydrocarbon contamination of the soil is very clearly seen in the effected area. Other area the contaminated soil can be discovered at depth less than 5 cm. The distribution of the contamination in the soil shows that interference had been played a role in relocating the contaminated hydrocarbon from specific site to another.

The crude oil as NAPL is still floating in the top of the water table of a shallow well. The fluctuation of the water table plays a negative role in spreading the contamination in different direction. It also effected the vadose zone above the oil table. A high concentration of the total hydrocarbon up to 4,500,000  $\mu\text{g/l}$  had been recorded in some of the wells, which is located close to the PDO pipeline.

The aquifer material consists of alluvium, which is highly permeable and effect the velocity of groundwater. The continuous exploitation of the groundwater in the vicinity area facilitates the distribution of the hydrocarbon contamination in groundwater to larger areas.

Although the groundwater is evidently contaminated by hydrocarbon in Zukait, some polluted wells are still functioning and used for various purposes and especially for irrigation, which could pose a great threat to the human health and environment.

Despite the long period of contact time between hydrocarbon and aquifer the natural attenuation due to various processes such as advection, adsorption, biological degradation, dispersion, and volatilization did not effectively reduce contaminant toxicity, mobility, or volume of hydrocarbon to levels that are protective of human health.

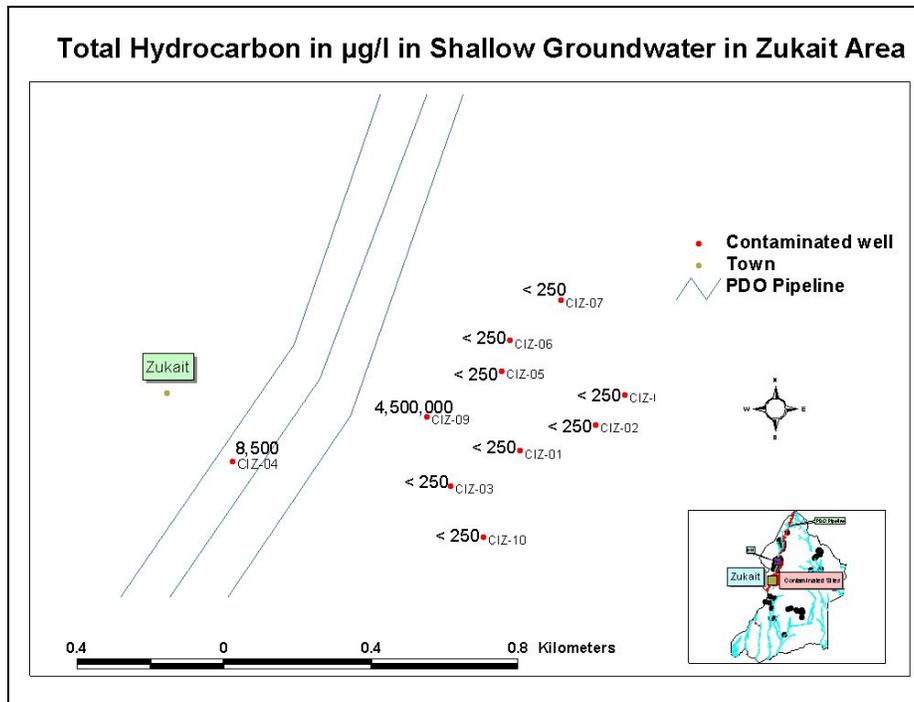
The contaminants become part of the shallow groundwater flow system in Zukait and others and continue posing a threat to the precious water resources. The free hydrocarbon body will continue dissolve in groundwater for a long period unless some action will be taken to remove it or stop it from spreading.

## Introduction

Groundwater resources in Oman are considered very precious. It is used practically as a main source for various purposes, domestic, agricultural, industrial, commercial and most important as a main source for drinking. The public water suppliers are obligated to furnish water to their consumer that meet the Omani drinking-water standard. Groundwater contamination is one of the major problems facing the country and of great concern for the Ministries dealing with water and environment

The hydrocarbon contamination to the groundwater subject to this study was originated from the leakage of the crude oil pipeline, UST, landfills and injection wells. Many locations in different areas have been contaminated by enormous amount of oil contamination.

Contamination of shallow groundwater and soil in Zukait area that had been occurred long times ago, unfortunately still exists for the time being in very bad manner. The contamination had recorded in the area in mid 1970s and early 1980s in the hundug wells. The reason for the oil contamination is a leaking from the PDO pipeline, which is running in Wilayat Izki (Fig.6). The leakage had caused a big damage to the soil and shallow groundwater.



*Fig.6 shows the location of the contaminated groundwater wells in Zukait area.*

## Soil Contamination:

The hydrocarbon contamination of the soil is very clear and extremely huge along the area of the PDO pipeline. The extent of the saturated hydrocarbon in the soil in one of the contaminated sites is very clearly seen in the picture No.1. A clear boundary shows the

saturated part of the soil (red color) with the unsaturated part. Couple of hundred meters from the contaminated soil zone, the upper part of the soil looks very clean and there is absolutely no sign of contamination. Nevertheless, if you dig only 5-cm hole in the ground you will observe that the soil is supersaturated with hydrocarbon (Picture No.2). The distribution pattern of the contaminated hydrocarbon in the soil is worth to be studied. It looks like that hydrocarbon movement through the vadose zone proceeds not only by advection and diffusion, but also due to a man-interference.



*Picture No.1 Saturated Soil Zone close to the subsurface PDO pipeline.*

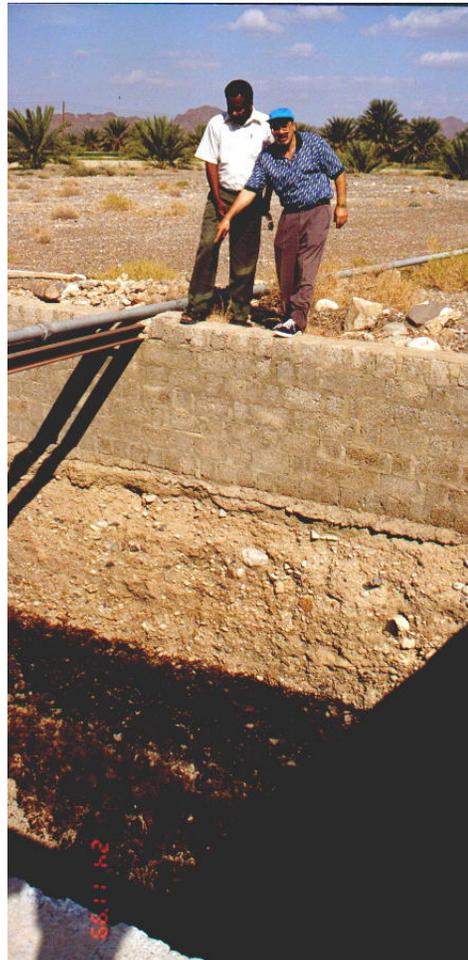


*Picture No. 2 shows the saturated soil at 5-cm depth some hundred meters from the contaminated site.*

### **Groundwater Contamination**

The shallow groundwater wells within one kilometer from the leaked pipeline had been also affected seriously. Picture 3 shows the free crude oil is floating on the top of the

water table of one of the wells located less than half kilometers from the PDO pipeline. The picture demonstrates how the floating free oil in the contaminated well has been complicated the situation due to the rise and fall of the water table. As the water table rises, the layer of the floating oil also rises and the residual oil is left in the vadose zone above the oil table as it falls.



***Picture 3 shows the residual oil in the vadose above the oil table in the well.***

Figure 6 demonstrates the concentration of the total hydrocarbon in the shallow wells located near the PDO pipeline. The highest concentration is 4,500,000  $\mu\text{g/l}$  and recorded for the C12-9 well located around 300 m from the PDO pipeline.

Even if the contamination in the site is obviously clear, the groundwater and soil is still used for irrigation and agriculture (Picture 4). The photograph shows that the groundwater well is currently functioning and its contaminated water by hydrocarbon is used for irrigation. The precipitated hydrocarbon is clearly seen in the settling channel that receives water from the pipe attached to the orifice of the well. The environmental awareness is an important step to educate the people about the negative health effect of using contaminated water and soil. Nevertheless, an immediate and strong action should

be taken from the authority to close the contaminated wells and prevent using them for any purpose.



*Picture 4 shows one of the contaminated wells is in use for agriculture in Zukait area*

The alluvium materials form the principal and most potential aquifer in the study area. The water level is very shallow, less than 3 meters and lying next to a small wadi. Such hydrogeological setting allows the contaminated groundwater to travel long distance.