INTEGRATED METHODS IN COST EFFECTIVE AQUIFER REMEDIATION: 3 FIELD EXPERIENCES

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SUMMARY

Groundwater impacted by petroleum products was successfully treated using an integration of two or more methods in 3 field cases. The principle of operation involved groundwater oxygenation (by means of Air Sparging) and a simultaneous increase in groundwater velocity (Pump & Treat).

Water table depression (Pump & Treat, slurping) and subsequent ventilation (Bioventing) of the previously saturated subsoil also proved to be an effective combination.

In these 3 cases TPH concentrations in soil were reduced from 600÷9000 mg/Kg to 5÷50 mg/Kg.

TPH concentrations in groundwater were reduced from 6000÷60000 µg/l to 5÷90 µg/l.

KEYWORDS: aquifer remediation, integrated methods, Pump and Treat, Air Sparging, Bioventing.

INTRODUCTION

Aquifer remediation is often problematic: target reductions in pollution concentrations and in treatment time are not easily met through standard methods such as Pump&Treat or Air Sparging/Biosparging.

However, in many cases an integrated application of different technologies provides more effective results both in terms of remediation and cost; in this paper we present three field experiences that advocate this "integrated approach".

SITE CONDITIONS

Case Study 1 (PD) refers to a loss of gasoline from an UST polluting an area of 500 m^2 to a depth of 4 meters (Figure 1a) with separated and dissolved phases; sandy aquifer with 70 mg/Kg BTEX, and 600 mg/Kg TPH present.

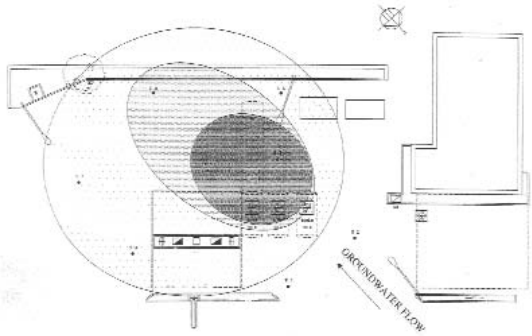

Fig. 1 a
Site 1

Case Study 2 (VR) is a service station where a loss of gasoline reached the ground water with separated and dissolved phases; the water table is 20 m in depth in sandy gravel (Fig. 1b) containing 3900 mg/Kg BTEX and 9600 mg/Kg TPH.

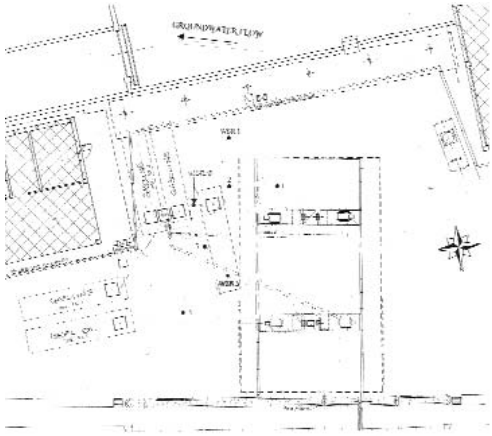

Fig. 1 b
Site 2

Case Study 3 (AT) is an area where an old petroleum product terminal had released large quantities of diesel into the vadose zone and groundwater. Previous to this the water table had already been impacted by gasoline and fuel oil. The saturated medium is sandy (100 mg/Kg BTEX and 3000 mg/Kg TPH) and the piezometric level is 7 m b.g. (Fig. 1c).

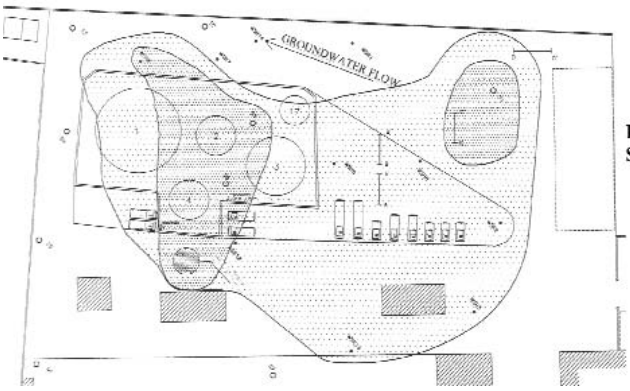

Fig. 1 c
Site 3

INTEGRATED REMEDIATION METHODS

In all three cases a combination of two or more treatments was applied with the aim of simultaneously oxygenating groundwater and increasing groundwater velocity, and as a result accelerating oxygen transfer across the saturated porous medium.

The water table depression and subsequent ventilation of the subsoil where previously the capillary fringe was present also proved to be an effective combination treatment. An increase in groundwater velocity and a reduction in water table level were both obtained by a Pump & Treat process while biostimulation was induced by Air Sparging and Bioventing.

In Site 1 Pump & Treat consisted of a pumping well that initially recovered the separated phase floating on the water table; then oxygen transfer was performed by an Air Sparging network, while well pumping was kept in operation. Dissolved oxygen measurements were taken to confirm and study the effectiveness of this integrated approach.

In Site 2 Pump & Treat was used to collect the free phase floating on the water table and to depress the piezometric level in the plume area. Then Bioventing treatment was applied to the vadose zone including the part previously saturated by the capillary fringe. Respirometric tests and groundwater analysis following the natural piezometric excursion were carried out to verify and study the effect of groundwater manipulation on remediation. Soil boring was also performed to complete the operation.

Site 3 was engineered with a combination of various treatments. Pump&Treat consisted of 4 pumping wells in order to obtain oil recovery and to create a hydraulic barrier; oil recovery was accelerated by means of a slurping network system; treatment in the water table was integrated with Air Sparging in order to increase oxygen transport velocity across the impacted saturated soil. Then Bioventing was applied to the vadose zone. Oil recovery rate, dissolved oxygen and VOC were monitored along with respirometric tests in order to measure the extent and benefit of this integrated approach.

RESULTS

All cases showed a considerable success in the removal of hydrocarbons from the subsoil, through free phase recovery, volatilization and biodegradation. See Fig. 2a, 2b and 2c.

TPH removals vs. time

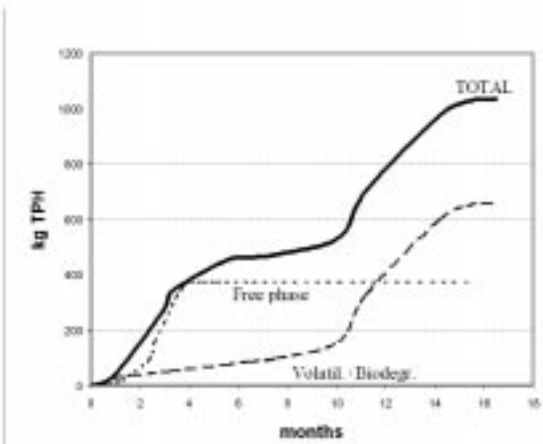

Fig. 2 a
Site 1

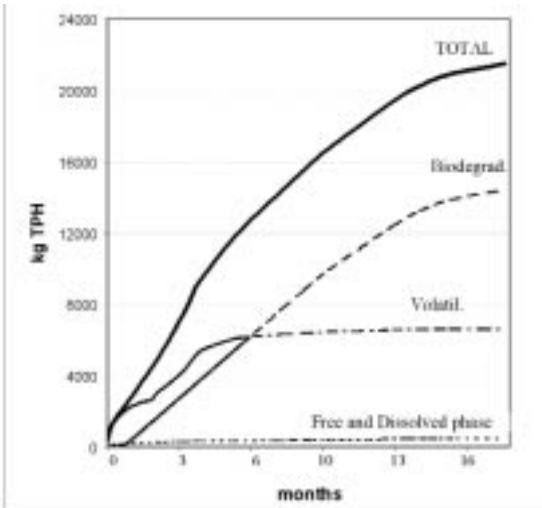

Fig. 2 b
Site 2

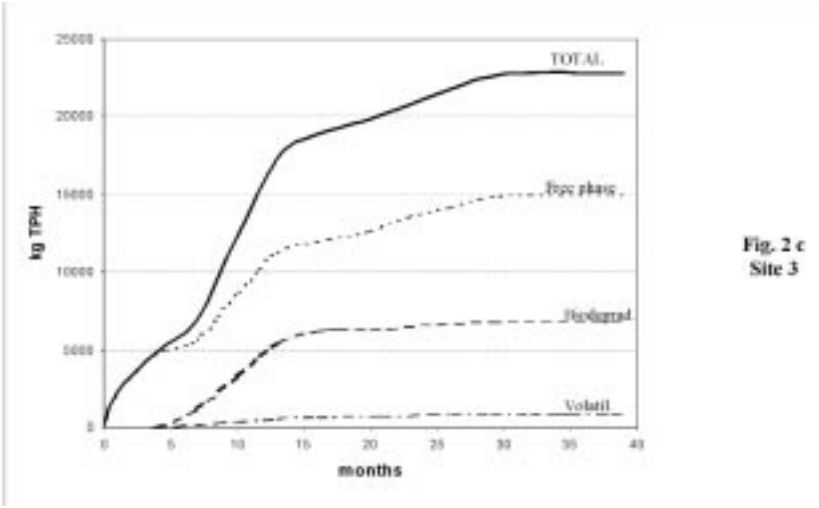

Fig. 2 c
Site 3

In terms of soil and groundwater quality, the following histograms (Fig 3a, 3b) show the results for the three sites:

SOIL and GROUNDWATER before and after treatment

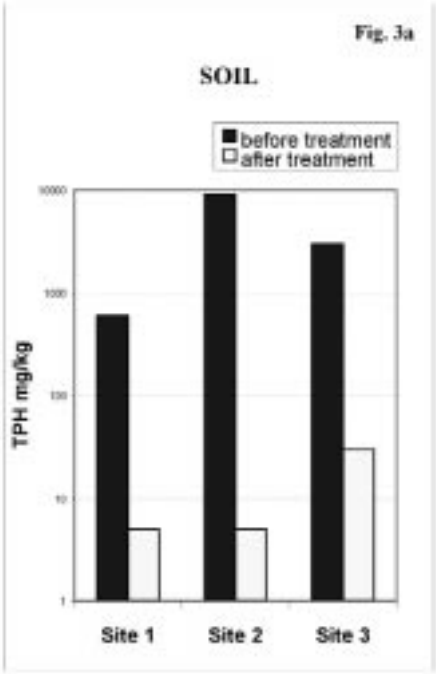

Fig. 3a

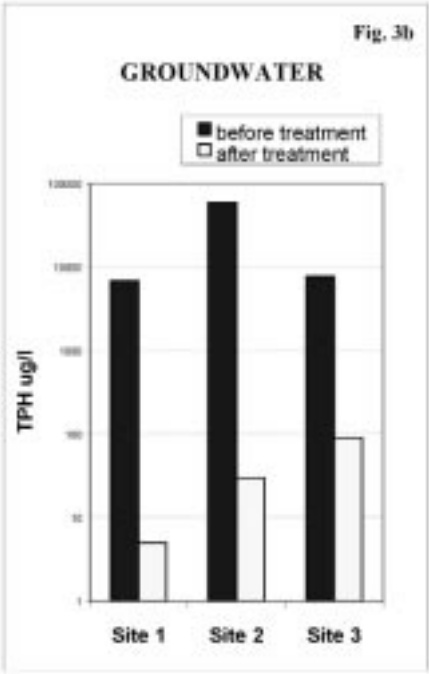

Fig. 3b

ADVANTAGES and PROSPECTS for the FUTURE

The main advantages of applying integrated methods for the remediation of hydrocarbon contaminated aquifers, compared with a singular standard application, can be summarized as follows:

- a more vigorous and varied treatment of the aquifer overcomes the problems created by site anysotropy and a paucity of knowledge from the initial pollution assessment

- more overall cost effective remediation is obtained, offsetting high initial investment.