LIFE+ project Vopak ExperO3

Newsletter nr. 5 – August 2015

Abstract

At the Vopak Terminal ACS a soil and groundwater contamination with chlorinated aliphatic hydrocarbons, BTEX and petroleum hydrocarbons is present. The contamination is being treated by means of in situ remediation using In-Situ Chemical Oxidation (ISCO) since April 2013. The first phase of the in situ remediation, regarding the former drum storage area, was successfully completed in November 2013. The second phase, focusing on the source area around the former excavation zone, is on-going since then. Due to emission issues, the remediation works were temporarily halted begin 2014. Field emission tests were carried out and, based on the results, optimal injection regimes that eliminate emissions were defined. Also, the liquid tight concrete cover was restored. The injections have been resumed in June 2014. At the same time, the treatment of the plume area in the midway was initiated. Beginning 2015, less than 9 months after the injections have started, the remediation targets were reached in certain areas of the midway. Injections in these areas have been stopped. Since March 2015 injections in the small source area in the tank farm are started. Since January 2016 the injections in the small source area, where the remediation targets are nearly reached, were stopped so that last phase of the remediation, the injections in the big source area in the tank farm, could be started up.
The remediation is now ongoing in and around the former excavation zone, in a part of the midway (close to the tank farm) and in the big source area of the tank farm.

Project description

Given the different physical and chemical characteristics of the contaminants in the soil and groundwater at the Vopak terminal ACS, remediation using traditional techniques would result in a time-consuming and expensive process. ISCO therefore offers a promising alternative for the simultaneous remediation of a cocktail of organic contaminants. With this technique, an oxidant is injected in the subsoil, causing oxidation of the contaminants into harmless products. Perozone, a mixture of hydrogen peroxide and ozone, is capable of oxidizing all types of organic contaminants.

Since the presence of strong oxidants causes major issues with regard to health and safety on explosion sensitive (EX-rated) sites, the development of an extensive health and safety plan and continuous monitoring of health and safety parameters during the remediation activities are of prime importance for the project.

This LIFE project focuses on a cost efficient, energy efficient and environmental advantageous innovative remediation technology that can be the solution for in situ remediation of complex contaminations in industrial and high risk areas where it is usually difficult and expensive to remediate using traditional techniques.

Remediation progress

The initial remediation concept comprises a combination of excavation, ISCO and multi-phase extraction (MPE), as shown in the map.

Since the start of the in situ remediation works, some changes have been made to the original concept. As the MPE was shut down due to environmental permit issues, the contamination is now being treated by only ISCO combined with soil vapour extraction (SVE).

Currently, the remediation targets are reached in the former drum storage and in parts of the midway. The remediation is ongoing in the area in and around the excavation zone (where concentrations have already drastically reduced), in the area of the midway close to the tank farm and in the small source area and big source area in the tank farm.

The remediation status of these zones is visualized in figure 1.

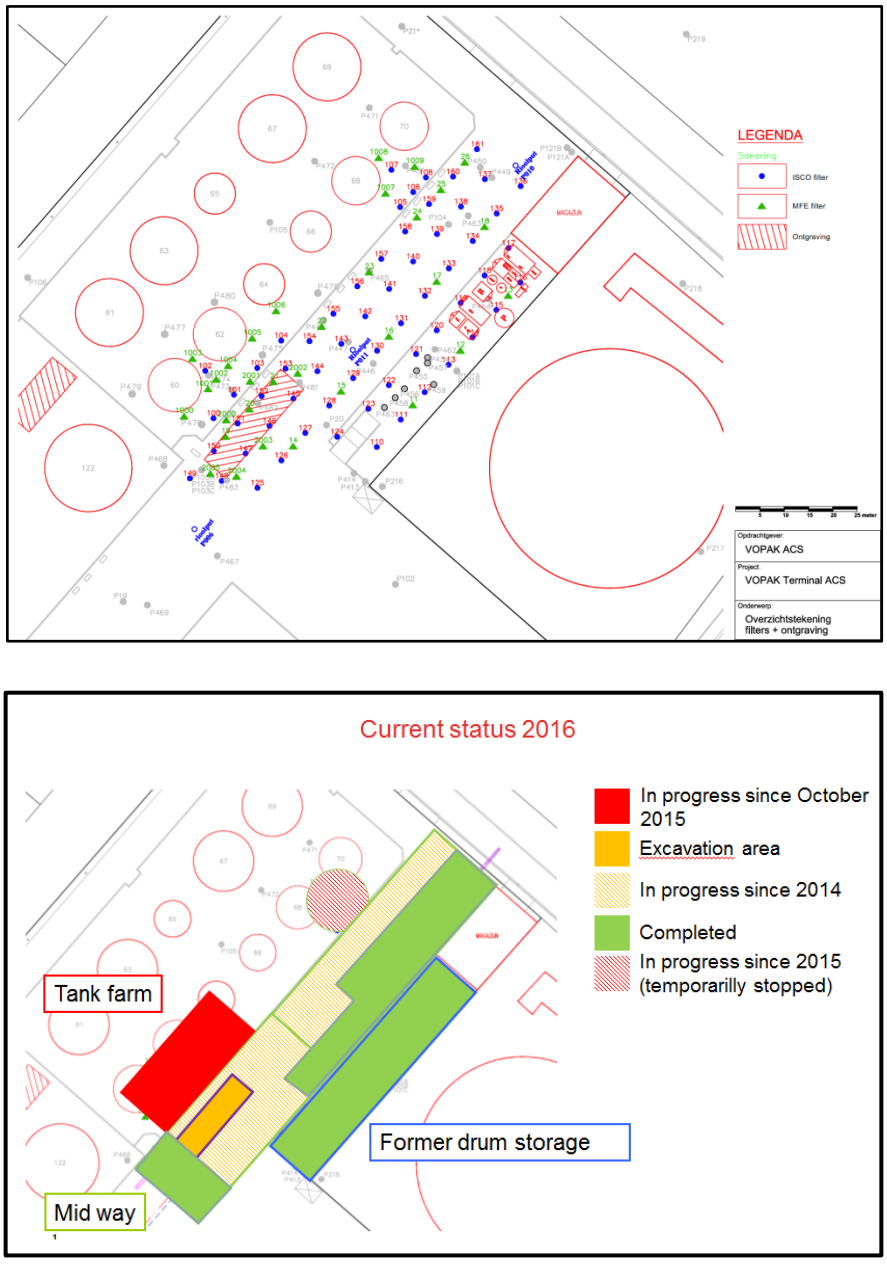


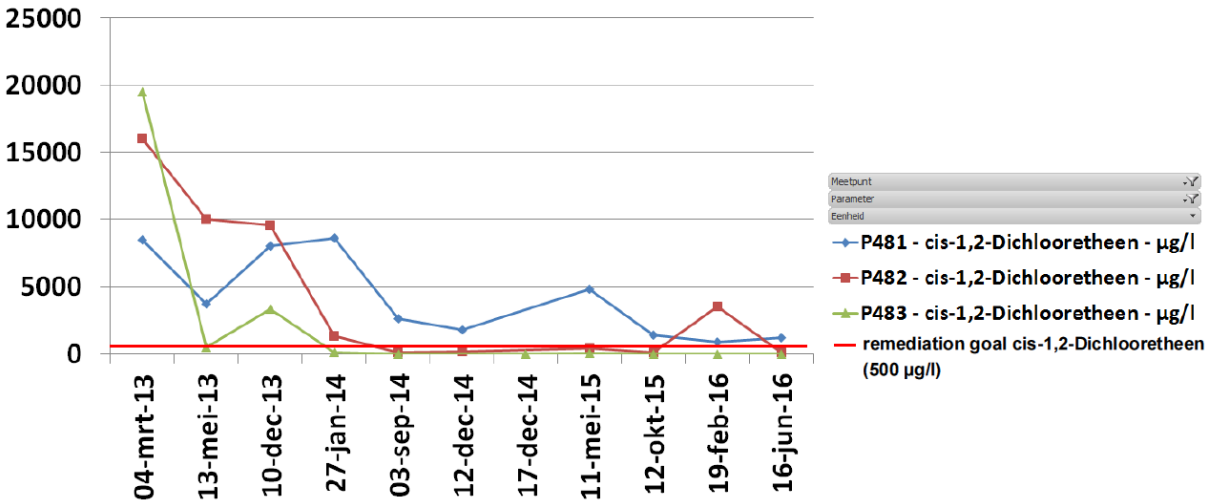
Figure 1. Remediation concept and overview of the remediation progress.

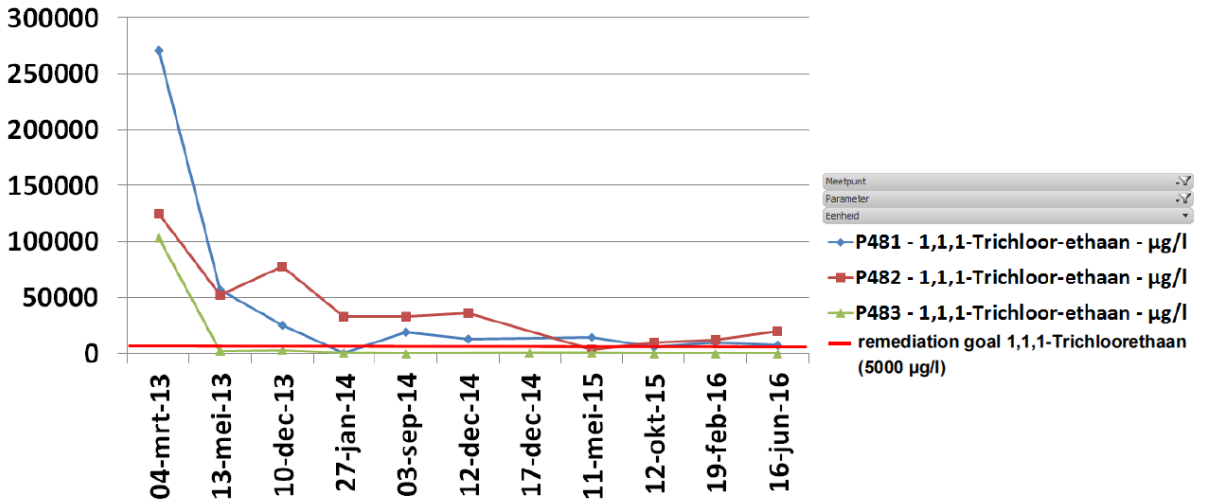
Source area “excavation zone”

The in-situ remediation using ISCO combined with SVE (soil vapour extraction) in the source area near the excavation zone was started in November 2013. In the beginning only ozone was injected instead of perozone, in order to test the effectiveness of ozone as a sole oxidant in source areas with a high contamination load. As the concentrations started to decrease injections of perozone were started.

Monitoring results

The evolution since 2013 of groundwater concentrations of the most important contaminants is illustrated in the charts below. The red lines indicate the remediation goals as defined in the remedial action plan. Each graph shows the evolution of one contaminant for the three monitoring wells in and around the excavation zone.





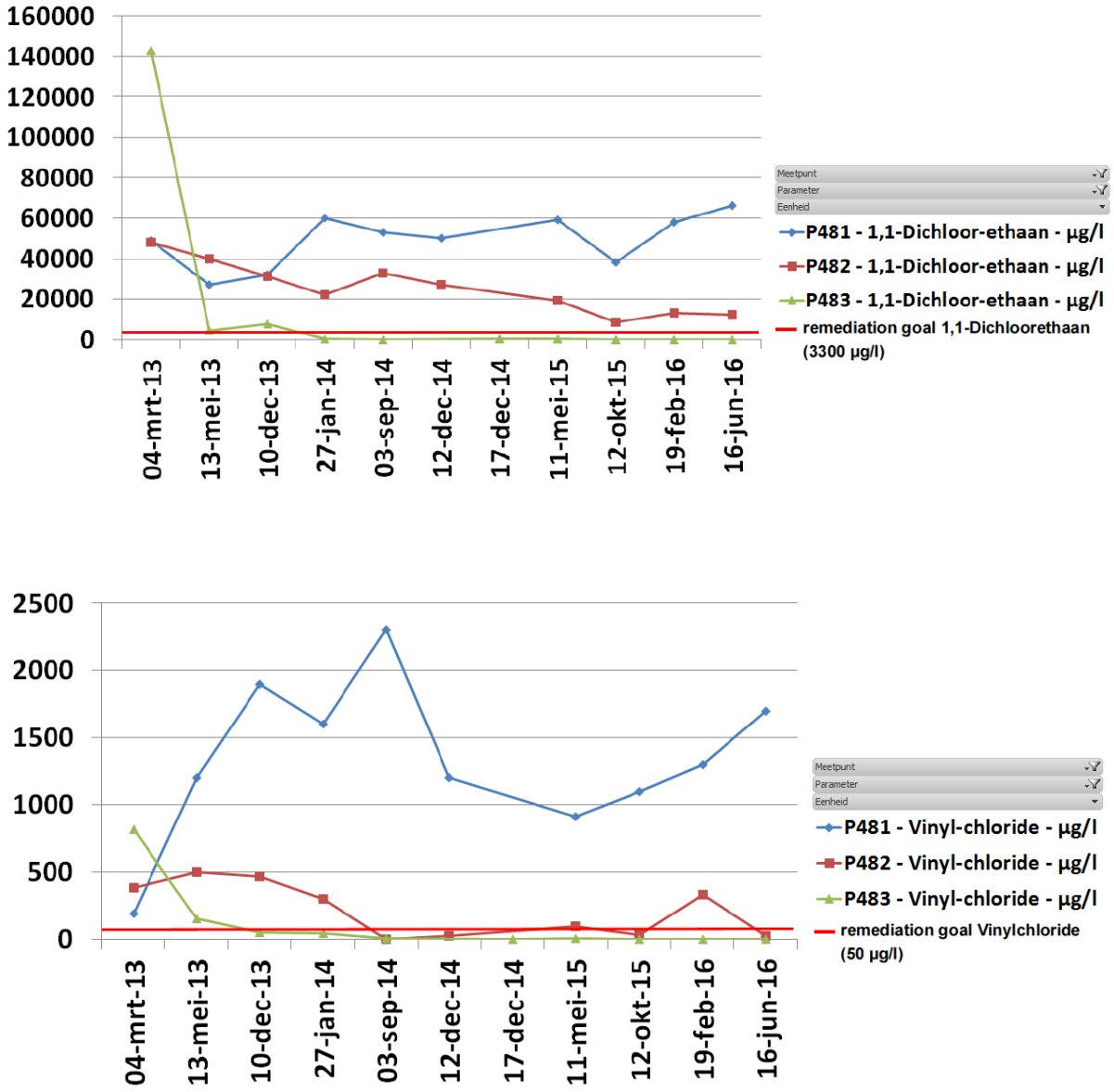


Figure 2. Charts showing the evolution of groundwater concentrations in the monitoring wells during the in situ remediation in the source area around the excavation zone.

Since the start of the remediation beginning 2013, the results can be considered spectacular. An initial strong decrease after the excavation was noticed in the 3 monitoring wells. After a more or less stable period between end 2013 and end 2014 a further decline is obtained for most of the parameters in wells 481 and 482. Only the chloro-ethanes still stay more or less stable. In P482 the remediation targets for all contaminants, except 1,1-DCA and 1,1,1-TCA, are reached. The contaminant concentrations in the groundwater around P481 are still high for 1,1-DCA and VC. The remediation goals for 1,2-DCE and 1,1,1-TCA are nearly reached. Generally the contamination in P481 has decreased with about 90% compared to the initial concentrations of beginning 2013. It was expected that the concentrations would stabilize at a certain (high) concentration as long as a high mass is present in the soil (as pure product). At a certain moment, when the mass load and hence the dissolution rate will be reduced enough, the groundwater concentrations will decrease (more strongly). Results of the last campaigns show an increase of the contamination concentration in the groundwater of well P481 and P482. These concentration increases are related to the increase of the ground water level through which contaminants of the vadose zone are dissolving in the groundwater. The contaminant increases are observed at the non-excavated former sources (zones at which contaminants migrated through the vadose zone into the groundwater). Wells P481 and P482 are located the edge of the excavated source zone.

The third well (P483) shows a spectacular improvement shortly after the excavation. A few months after the ozone injections started the remediation target values were reached. Based on the results of the monitoring events of September and December 2014, the perozone injections around the area of P483 are stopped. The groundwater monitoring of June 2016 confirmed that the concentrations remain stable and that all remediation target values are met, even after Perozone injections were stopped.

Emissions

After the renewal of the concrete floor no more emissions towards the atmosphere have been noticed.

Plume area midway

The remediation target values have been reached in the monitoring wells near the former drum storage area (P446, P449 and P463A). Based on the results of the monitoring events of September and December 2014, the perozone injections in the Midway along the former drum storage are stopped (see Figure 1).
The low groundwater concentrations measured in the monitoring well P463 in May 2015 confirm that the remediation target is reached in the area around this well and no relevant rebound occurs after Perozone injections were stopped.

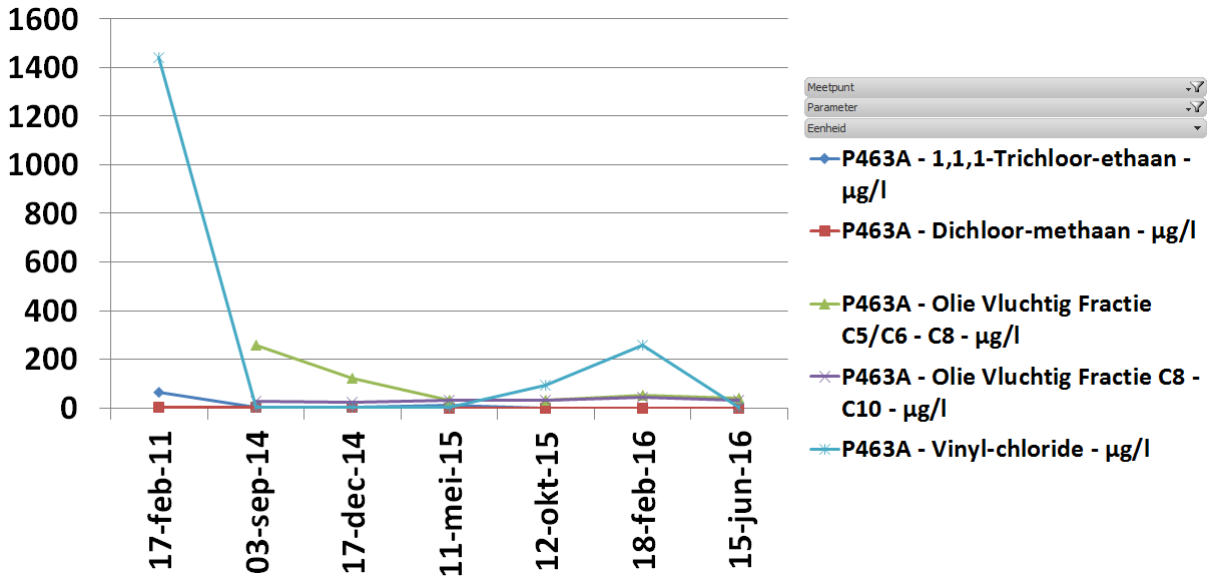


Figure 3. Chart showing the evolution of groundwater concentrations in monitoring well P463A during the in situ remediation (plume area midway).

In the monitoring wells along the tank farm (P447, P448, P450 and P465) the remediation target values were reached for almost all contaminants except for volatile TPH in most wells and chloro-ethanes in P448 and P465. After fluctuating concentrations ,1,1 dichloro-ethane in P448, met in June 2016 the remediation goal for the first time. Further evolution needs to be checked in the next monitoring events but the results for P448 are very encouraging. In the groundwater of P465located in het former source zone, 1,1-dichloroethane continue showing an concentration increase due increasing groundwater levels during these monitoring campaigns. Contaminations of the vadose zone are dissolving under these conditions contributing to concentration fluctuations.

P450 has not been sampled in 2016 because the remediation targets were reached in September 2014.

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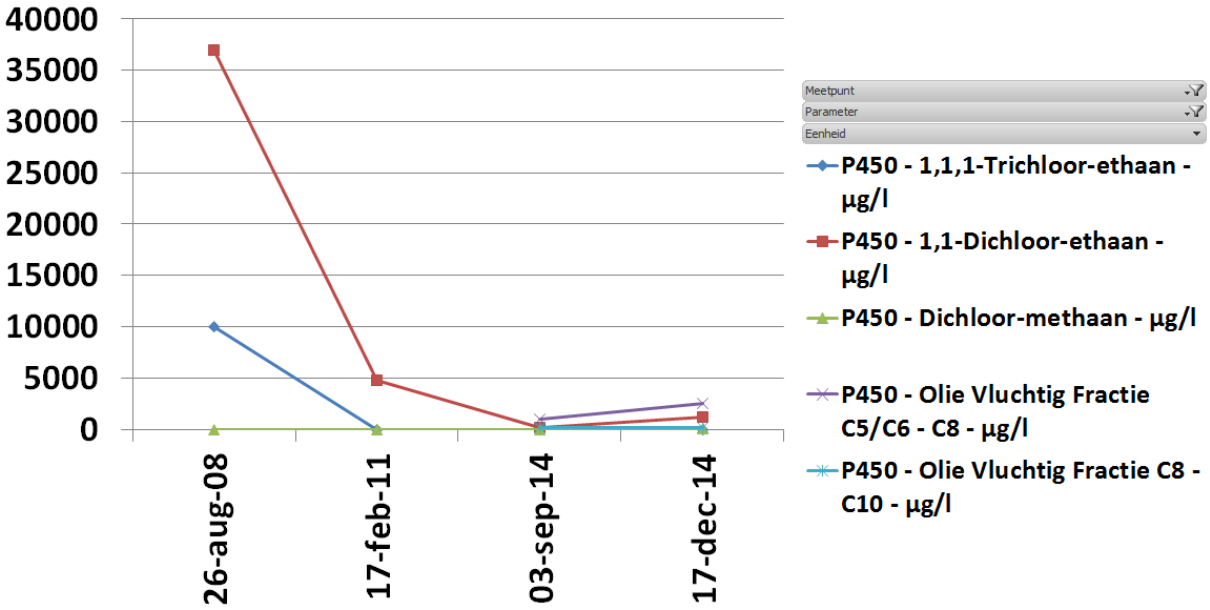
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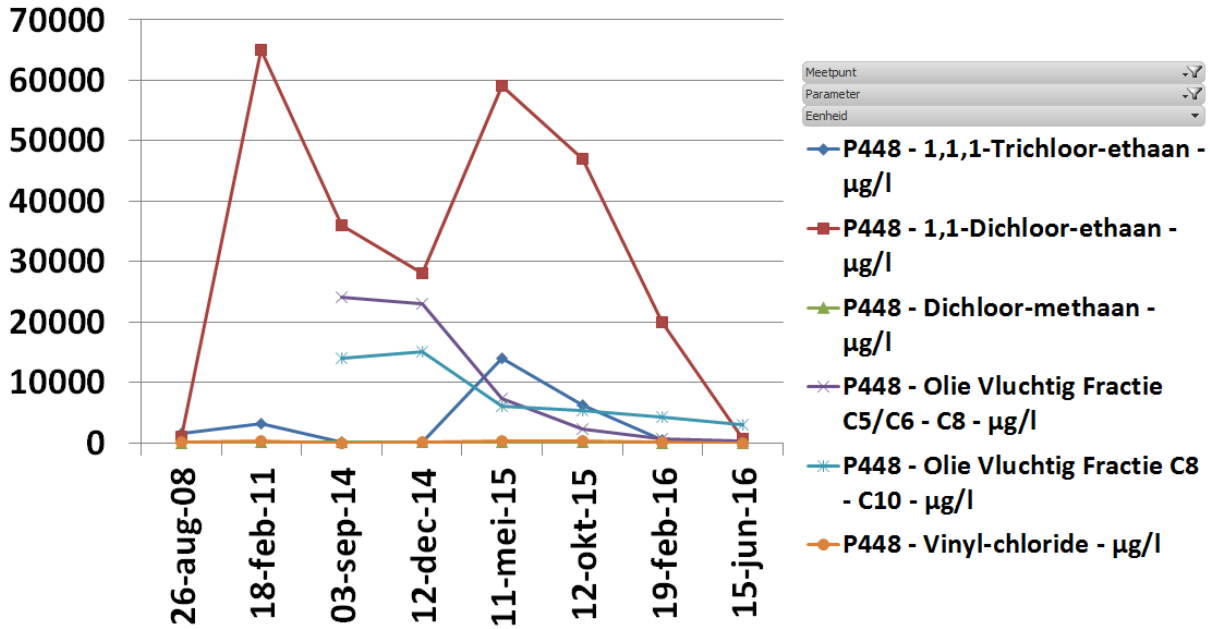
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P448 - Dichloor-methaan - µg/l
P448 - Olie Vluchtig Fractie C5/C6 - C8 - µg/l
P448 - Olie Vluchtig Fractie C8 - C10 - µg/l
P448 - Vinyl-chloride - µg/l

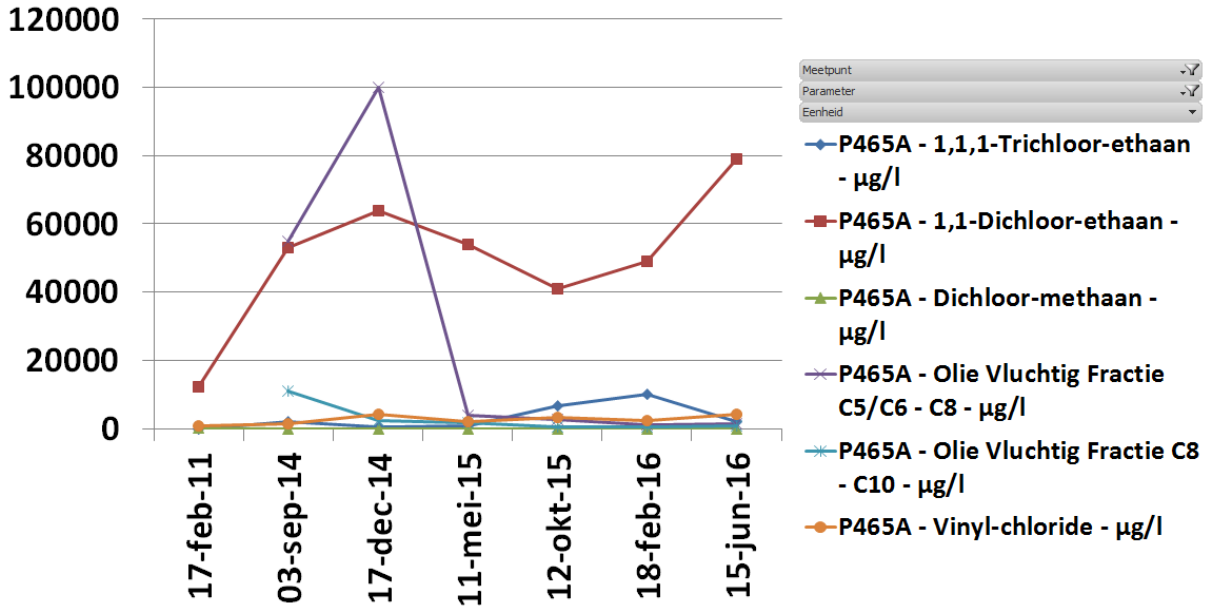

Figure 4. Charts showing the evolution of groundwater concentrations in the monitoring wells during the in situ remediation in the plume area midway.

Emissions

Since February 2015 no more emissions towards the atmosphere have been noticed.

Small source area in the tank farm

The in-situ remediation using ISCO combined with SVE (soil vapour extraction) in the small source area in the tank farm was started in March 2015. One of the main risks in the tank farm is the corrosion of the tank floor due to ozone emissions. The tank farm itself is liquid tight but the storage tanks are built on a foundation of stabilized sand and hence the tank floors may come in contact with ozone. Two soil vapor monitoring wells (484 and 485) are installed just next to the two storage tanks that are situated in the injection influence radius. Possible ozone emissions should be captured by the vertical soil vapor extraction wells/MFE-filters (1007-1009) situated around the injections wells (see figure). The efficacy of this system is continuously monitored by two soil vapor monitoring wells.

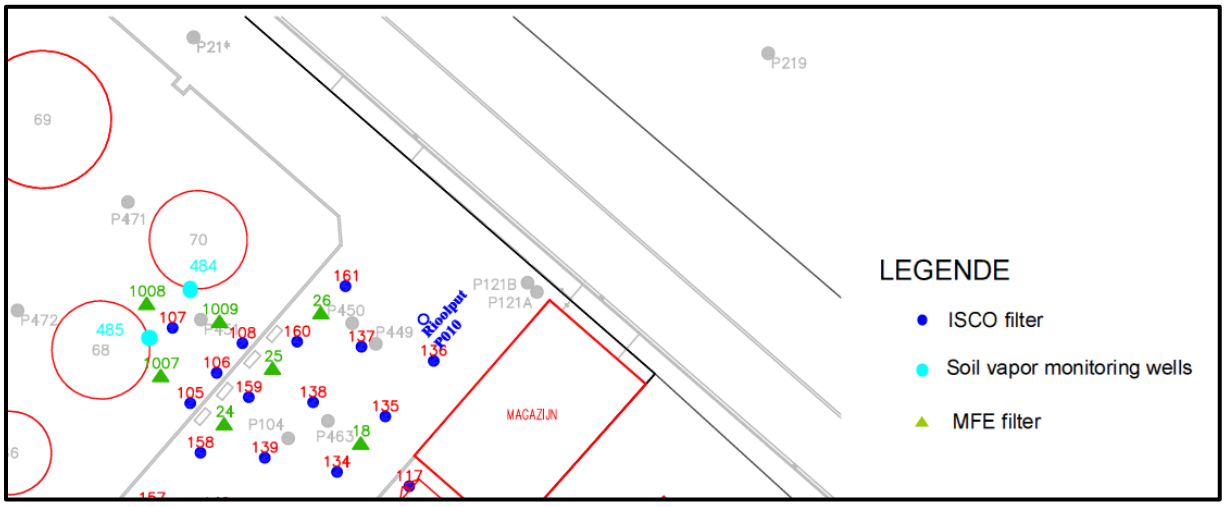

Figure 5. Indication of the positions of the soil vapor monitoring wells in the tank farm.

After only 2 months of injections in the small source area of the tank farm (P451) the concentration of volatile total petroleum hydrocarbons had decreased already remarkably.
Except for 1,2-DCE all the remediation goals were reached in December 2015. The last phase of the remediation (big source area in the tankfarm) has started in January 2016. Because of capacity reasons the injections in the small source were in January. Since then 1,2-DCE remains more or less stable..

Both PCE and TCE decreased within the start of the injection. However these concentrations demonstrate a rebound since February 2016. Further remediation is necessary and evolution of the concentrations needs to be checked in the next monitoring events.

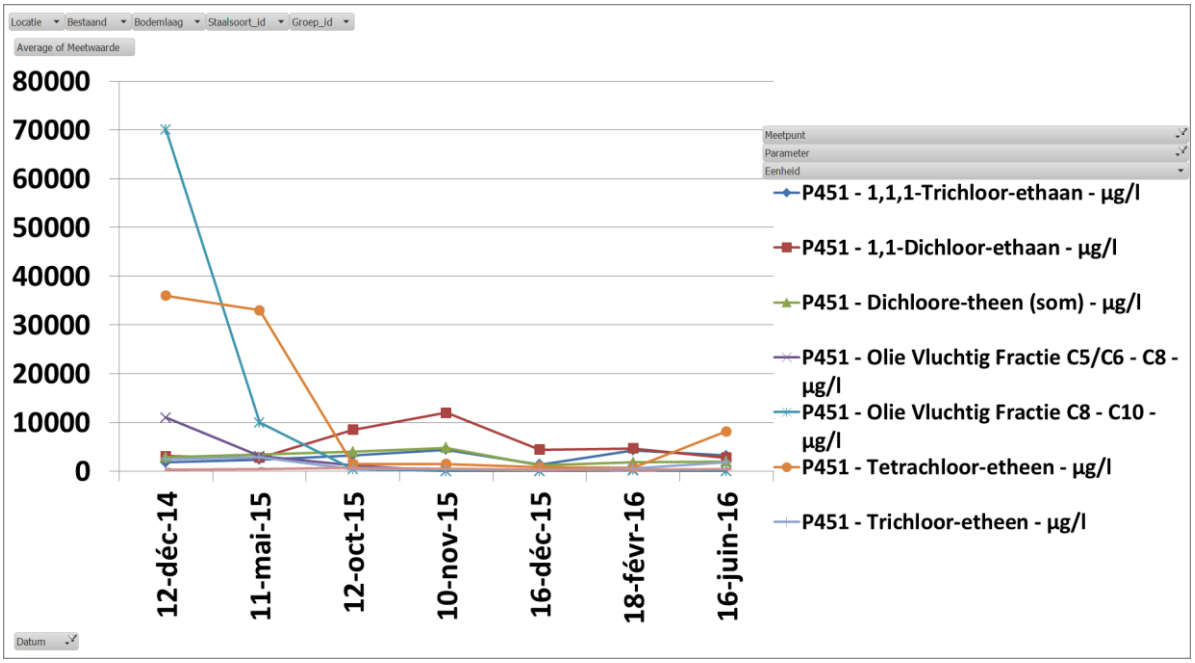

Figure 6. Charts showing the evolution of groundwater concentrations in the monitoring wells during the in situ remediation in the small source area in the tank farm.

Emissions

No emissions towards the atmosphere or soil vapour close to the tanks have been noticed.

Big source area in the tank farm

Preparation

Mid 2015 phase 4, the remediation by ISCO of the big source area in the tank farm, has been prepared. One of the main risks in the tank farm is the corrosion of the tank floor due to ozone emissions. The tank farm itself is liquid tight but the storage tanks are built on a foundation of stabilized sand and hence the tank floors may come in contact with ozone.

Four soil vapor monitoring wells have been installed in the tank farm. The 4 wells are installed just next to the 4 storage tanks (60, 62 and 64) that are situated in the injection influence radius. Possible ozone emissions should be captured by the vertical soil vapor extraction wells/MFE-filters (1000-1006) situated around the injections wells (see figure). The efficacy of this system will be monitored by the four soil vapor monitoring wells (486, 487, 488, 489). If ozone concentrations or increased oxygen concentrations are detected in the vapor monitoring wells, the injections will be stopped immediately and additional actions have to be implemented to prevent contact of ozone with the tank floors.

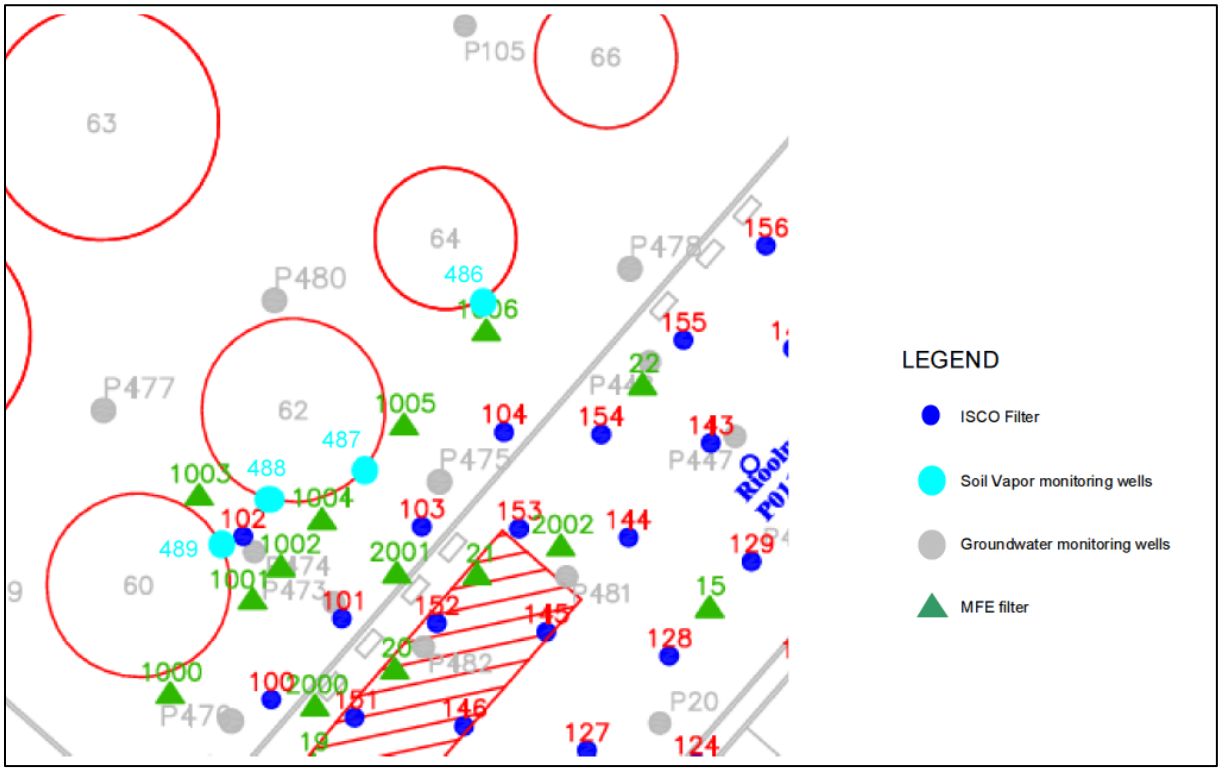

Figure 7. Indication of the positions of the soil vapor monitoring wells in the tank farm.

Start up

The remediation of the big source area in the tank farm started in January 2016. A similar step by step method as for the small area was used to start up de the remediation and no emissions were detected.

Monitoring results

Exceedance of remediation goals are only observed in wells P473 and P475. After one month of injections in the big source area of the tank farm the concentration of volatile total petroleum hydrocarbons and also the chloro-ethanes has decreased remarkably in these wells. After six months these concentrations remained more or less stable above the remediation goals.

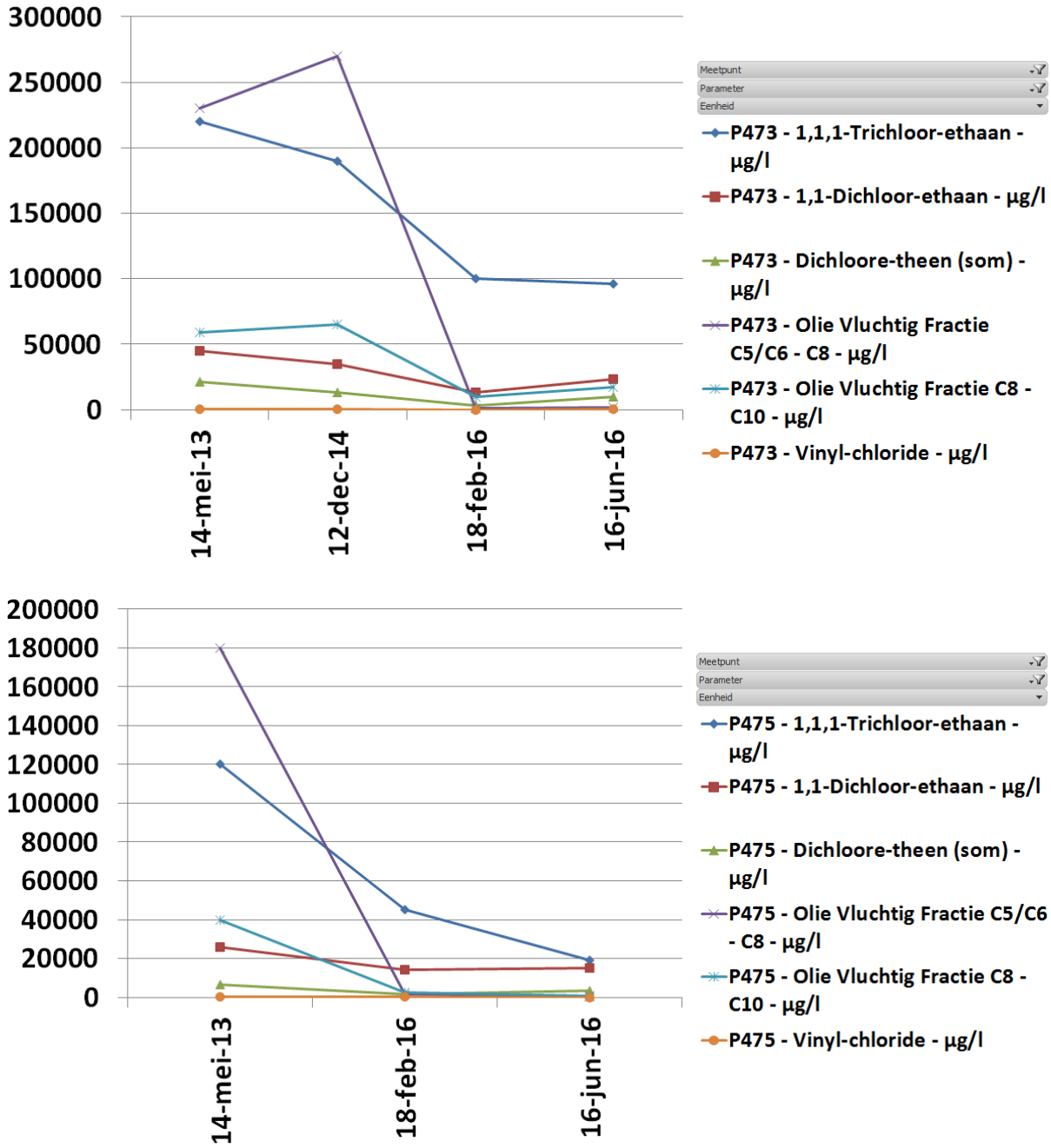

Figure 8. Charts showing the evolution of groundwater concentrations in the monitoring wells during the in situ remediation in the big source area in the tank farm.

Emissions

No emissions towards the atmosphere or soil vapour close to the tanks have been noticed.

Next steps

The injections in the excavation zone around P481 and 482, in the Midway along the tank farm and in the big source area in the tank farm will be continued. As soon as capacity becomes available the injections in the small source area need to be restarted. The duration of the injections in the high mass zones will be longer than initially estimated due to the H&S limits of the vapour emissions. However, both further optimization of the injection regime should be considered depending upon the results in the near future without causing emissions in order to accelerate the remediation.

The next monitoring event is scheduled for October 2016.

More information

More information can be found on the project website www.vopak-experO3.be.