INSURE

Innovative Sustainable Remediation

SITE PROGRESS REPORT 2 (1/2018)

UHEL

EUROPEAN UNION
European Regional Development Fund

Interreg
Central Baltic

Site Janakkala, Finland (UHEL)

Preliminary studies and activities on the site were performed during project Tankki in 2013-2014 by superintendent Ramboll Finland Oy, and the contractor responsible for treatments, Nordic Envicon Oy. The study site is located on a residential area on the premises of a single household (Fig 1.1.). The leaking was due to a hole or holes in the private heating oil tank dug in the ground, approximately 1 m from the north corner of the house, left intact, and suggested to remain so by the landowner. The removal is ruled out because of the vulnerable location near the house and connected sub-surface structures. The contamination on the area is heterogeneously distributed with concentrations from 2,5-3 meters, near the bottom of the tank, varying between <50 mg-3300 mg /kg. The soil is clayey and highly impermeable, Because of this, and because it was suspected that the soil under the tank was coarser and had high concentrations, the sampling and water injections were decided to be performed through small holes in the tank itself. For this five holes (4 cm ø) were drilled (Fig 1.2.). Higher concentrations were indeed found in the preliminary sampling. Because of the soil mobilization the original sampling holes could be used repeatedly for subsequent samplings.

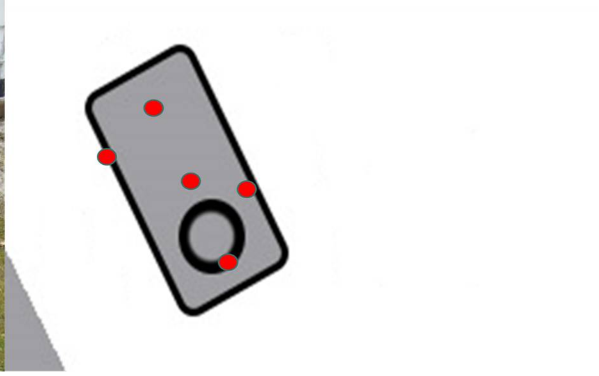

Fig 1.1. The site after the chemical oxidation treatment

Fig 1.2. Drawing of the tank with the sampling spots in red, only the results from the three spots on the bottom axis have been used for the surveys since the other two are higher up the ceiling where the oil hydrocarbon concentrations are negligible by comparison

In 2016 the soil was treated with chemical oxidation based on Fenton’s reagent as described in site progress report 1. The hydrogen peroxide injection was performed twice with a two week interval, with sampling performed immediately before each reagent injection. Since both hydrogen peroxide and the released oxygen can be toxic in higher concentrations, steps were then taken to restore the original microbial activity. This was attempted by introducing a soil transplant from a successful biostimulation treatment, carrying bacteria capable of digesting diesel oil hydrocarbons. Oxygen was introduced as calcium peroxide and nitrogen as an agricultural nitrate-ammonium mixture fertilizer, Suomen salpietari. The soil was sampled after 2,5 months and then after 4 and finally 10 months. New nitrogen was added after 2,5 months. According to the final sampling it was concluded that biostimulation was likely effective but should be continued in a modified form. From that point onwards, freshly patented meat industry waste product bone meal was used as a slow release source for not only nitrogen, but also for phosphorus, potassium and calcium. During the biostimulation steps, all additives were filled into the tank after which the landowner added fresh water on a frequent basis, so that moisture, oxygen and fertilizer would enter the contaminated zone with sufficient periods of aerobic conditions in between the additions. Since positive response has mostly been observed in the upper layer of the soil (0-10 cm) the option of surface activity enhancing products has been considered. The change of fertilizer could be done within the existing research plan approved by the Centre for Economic Development, Transport and the Environment, whereas the use of surfactants would probably call for a modification.

The total reduction after 10 months of biostimulation was 94% from the original level, whereas during the last six months the efficiency was lower than expected (Table 1.1.). The current treatment is set to continue until May 2018.

Table 1.1. Oil hydrocarbon levels at different stages of the in situ actions.

	average c(C10-C40) (mg/kg dw)	total reduction
original level	25000	
1st chemical treatment	7000	72 %
2nd chemical treatment	9000	64 %
biostimulation 2,5 months	6000	76 %
biostimulation 4 months	2500	90 %
biostimulation 10 months	1600	94 %

Site Motala, Sweden (UHEL & POP)

The water samples previously received from Motala, were previously treated by POP for DNA isolation. The isolated DNA was PCR amplified in 2017, but due to problems with proof reading PCR enzymes, the preparation for sequencing took a long time. The PCR products were finally send for sequencing in late 2017. The results will be available after the bioinformatics analysis that will start in January 2018.

Sampling, drilling and installations for the UHEL's biostimulation treatment for the oil hydrocabon contaminated site (Fig 2.1.) were made by Sweco in June 2017, commissioned by Hanna Wåhlen from SGU who was also present. Therese Hjälm and Therese Erlandsson represented the municipality of Motala and Martin Romantschuk represented the University of Helsinki. The electrician present was Larsson from Veteranpoolen. Anders Andersson, the owner, was present most of the time, and he did the digging.

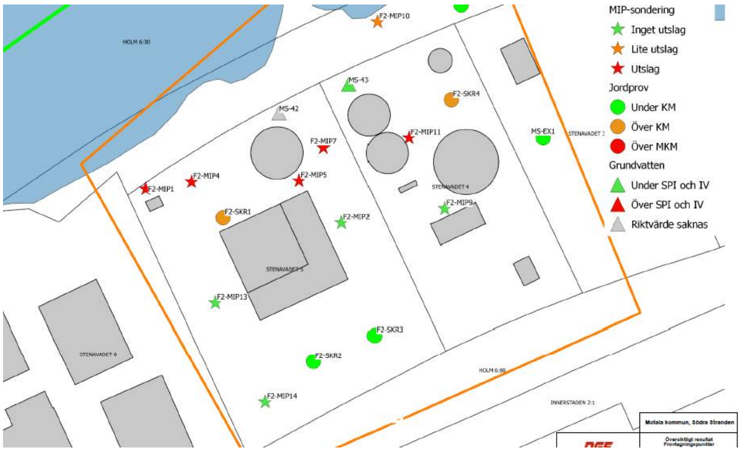

Fig 2.1. The oil hydrocarbon contaminated site södra stranden

Ground water tubes were inserted in two rows in parallel to the lake shore, 6 m apart from each other. Four ground water tubes were inserted with 2m intervals to make a 6 m row of tubes. The tubes were inserted down to depth of 5.5 m, while 0.5 m of the tubes were sticking out of the ground. From 2-2.5 m downwards (from the top of the ground) the tubes were perforated. When measured, the ground water level was ca 2.7 m below ground, which is lower than normal by more than 50 cm. Stainless steel rods, two meters each, with treads were connected with bolts to form 6 m rods that were inserted into the ground water tubes. In most cases the rods stood up 2 - 4 cm above the ground water tube edge, but in some cases stones were inserted into the tubes, which brought the steel rods 5 – 20 cm higher, which made it easier to attach the electric cords. Nevertheless, the steel rods in the tubes were standing in water from ca 2.7 – 5.5 m below ground.

When drilling the holes for the ground water tubes, the ground was found to be sandy but also partly quite dense (silt, mixed with clay). Samples were occasionally difficult to withdraw. When inserting ground water tubes, some of the holes were found to cave in, filling the hole, but eventually all tubes were inserted. Samples of the ground water were taken from three of the ground water tube holes, and from three additional holes within the treatment area, one of which was a previously identified hot spot.

Two reference holes were drilled outside the treatment area, ca. 30 m from it, but with a record of also containing oil contamination. Samples were collected from 2.5 m downwards with 50 cm intervals from giving 6 samples from each sampled hole. In some of the holes the wet sand clearly smelled of oil, while the next hole could be totally free from smell. Samples were also collected for a later analysis of water volume in the saturated part of the soil, that is, the “void” of the soil.

A ditch was dug along the anode row, with the center ca 1 m from the row. To avoid caving in, the ditch was dug in a steep V shape, first with a broad scoop, later with a narrow scoop.

When water started to flow into the ditch (depth almost 3 m) a total of eight buckets of CaO_2 and twenty buckets of meat bone meal was spread into the ditch, after which the ditch was filled up.

The anode (+) electric cord was attached to the row of electrodes further from the lake shore, and the cathode (-) cord was attached to the row closer to the lake shore (Fig 2.2.). This arrangement was based on the assumption that the main direction of ground water flow would be towards the lake.

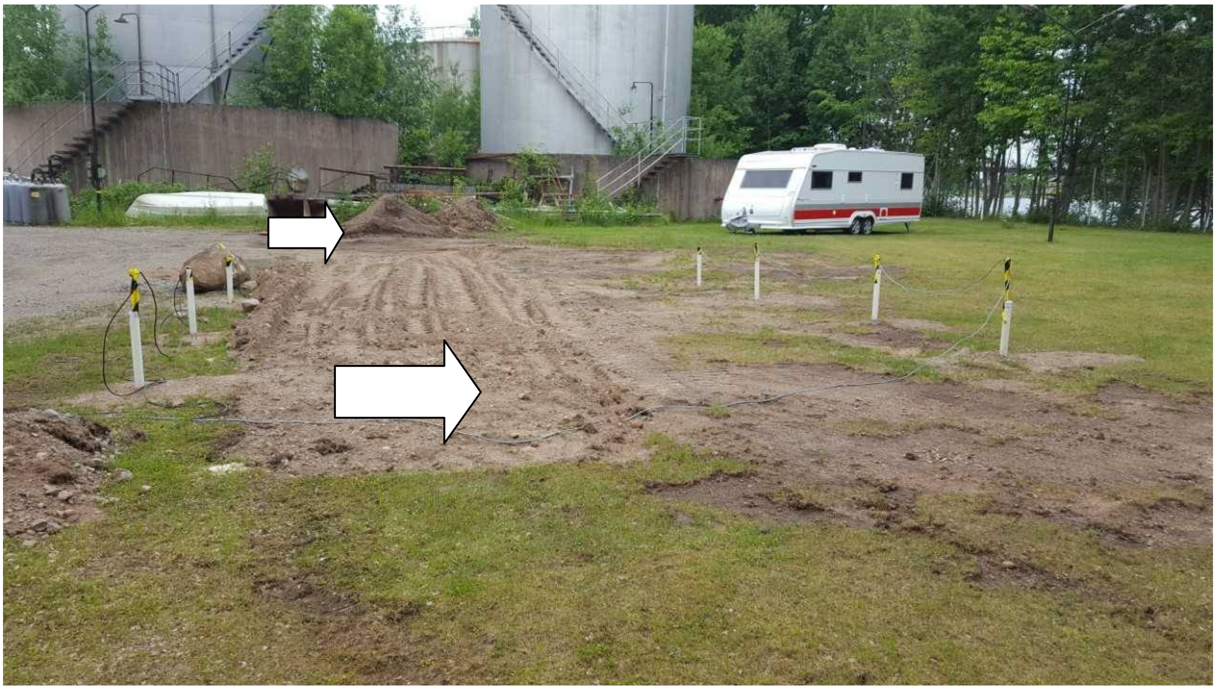

Fig 2.2. the study area with the direction of the electric field shown in white arrows

The electric cords were pushed through an old oil outlet in the "upstream" oil cistern, (emptied and used for storage), that is now the place for the transformer. The DC cords were connected to the transformer just inside the wall near the oil cistern oil outlet. A new 50 m cord (16A capacity, 2.5 cm cross section, 5 cords) was directly connected to the transformer incoming (AC 380V) end, and the other end was pushed through another oil outlet in the opposite end of the oil cistern, then to be connected with a 32 A plug to the outlet on the outside wall of the next storage building. The voltage switch was turned to the smallest (100V) position. The current was measured separately to each of the electrodes and the result was recorded in photos. The electricity was connected at ca. 16.00 on June 8th 2017. The general situation was from then on monitored by A. Andersson, and T. Hjälm.

The site was visited by Martin Romantscuh and Harri Talvenmäki of UHEL in 8th of September 2017. Erika Ejnarsson and Magnus Magnusson from Sweco with members of Motala commune and site owner Andersson were also present. Sweco performed sampling.

Currents were measured from both anodes and cathodes before and after the voltage was switched from 100 V to 150 V. Also temperature and oxygen measurement were measured from the anode side as well as from a control spot outside the treated zone. Anode electrodes were found to have corroded as suspected, and new pieces were added to reach the original electrode height. Samples were taken to Lahti by members of UHEL, and later analyzed by staff of UHEL Aqua Lab, mainly for nitrogen concentrations. It was found that the nitrogen concentration in the water phase showed correspondence with the biostimulation effort, whereas concentrations in the soil samples were below LOQ-levels making the soil samples therefore unfit for surveying the situation.

Similar follow-up visit was done in December 2017 Martin Romantschuk. Voltage was now switched to 200 V. Waters samples were brought to Lahti for nitrogen analysis, and soil samples were delivered to Populus Group Oy for biological analysis. DNA isolation will be done in the beginning of 2018 from the soil samples for identifying the microbial communities during remediation.

All results received so far were studied by UHEL in December 2017 (Fig 2.3.). It was concluded that while no significant changes in the oil concentrations could be observed, slight mobilizing effect on oil hydrocarbons towards the surface was possible. As high concentrations of oxygen have been detected only in the anode pores, and since nitrogen had already been detected in sufficient doses also outside the source, it was suspected that oxygen was the primary limiting factor, and therefore further steps would require use of oxygen releasing compounds such as hydoren peroxide or calcium peroxide.

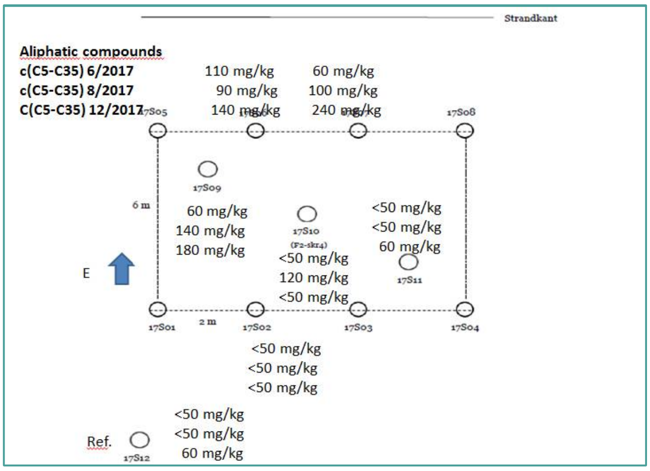

Fig 2.3. Electrode and samplings spots with average oil hydrocarbon concentrations in the soil at different sampling dates

Site Valmiera, Latvia (UHEL)

A preliminary activity plan was provided by UHEL and agreed on by Populus group Oy and passed on to Valmiera in November 2017. The plan consists of approximate location for the treatment pilot spot, requirements for the electro-kinetic setup including power transmission, connection, transformer and cable requirements, installation and sampling protocol, additive injection and maintenance work to be performed by the local personnel, schedule for future samplings and security protocol. Discussions concerning the final plan between UHEL, Valmiera and Pēteris Birzgalis from the chosen contractor, SIA Vides Konsultāciju Birojs have been on-going during the winter months. Most of the planned on site activities are planned to take place in connection with the next two project meetings, both of them in Latvia, near the site.

Site Vidzeme, Latvia (Vidzeme)

Former project site Krustmaļi was investigated in February-March 2017 and the tested parameters and the results have been presented in the site investigation report. The final conclusions were as follow:

-Contamination with heavy metals was not found.

-In four samples insignificant concentrations of pesticides were found, but not even remotely near the level at which, in accordance with the law, remediation is needed.

- A similar concentration of atrazine was found in one of the groundwater samples in the northern part of the territory, however taking into account the geological characteristics of the area, this contamination was considered to be extremely local, weak in intensity and with relatively small risks involved.

-The groundwater indicative values in the tested samples are mostly normal, but almost all groundwater samples include high concentration of nitrogen and its compounds, which is most likely connected to previous loading of the territory – storing of fertilizers and the intensity of agricultural work carried out in the neighboring territories.

-According to the results, the quality of the site is considered to be satisfactory. The detected pollution is negligible and does not cause danger to the environment, nor can it be considered to endanger animal or human health.

-The results of the research are considered to be in line with the detailed study stage and there is no economic justification for any additional research in the area. Performing a remediation work is not considered to be beneficial as it was found that the pollution is relatively weak in intensity and local, in turn the nitrogen content of groundwater will decrease naturally

-The specialists of SIA "Vides Konsultāciju Birojs" (experts, who did the investigation) recommend to change the status of the territory - from “Potentially contaminated” to

“Potentially not contaminated” site, thus eliminating existing and exploratory economic activities encumbrances.

An alternative site has been suggested for pilot tests but a final acceptation from the site owner hasn’t yet been provided.

Site Villähde/Nastola, Finland (UHEL)

Preliminary studies and activities on the site were performed during project Tankki in 2013-2014 by superintendent Ramboll Finland Oy, and the contractor responsible for treatments, Nordic Envicon Oy. The contamination is due to a filling accident in 2001, near spot marked in figure 5.1. The area was treated in 2016 as described in status report 1/ 2017. The situation before and after 4,5 months of active treatment are shown in fig 5.2..

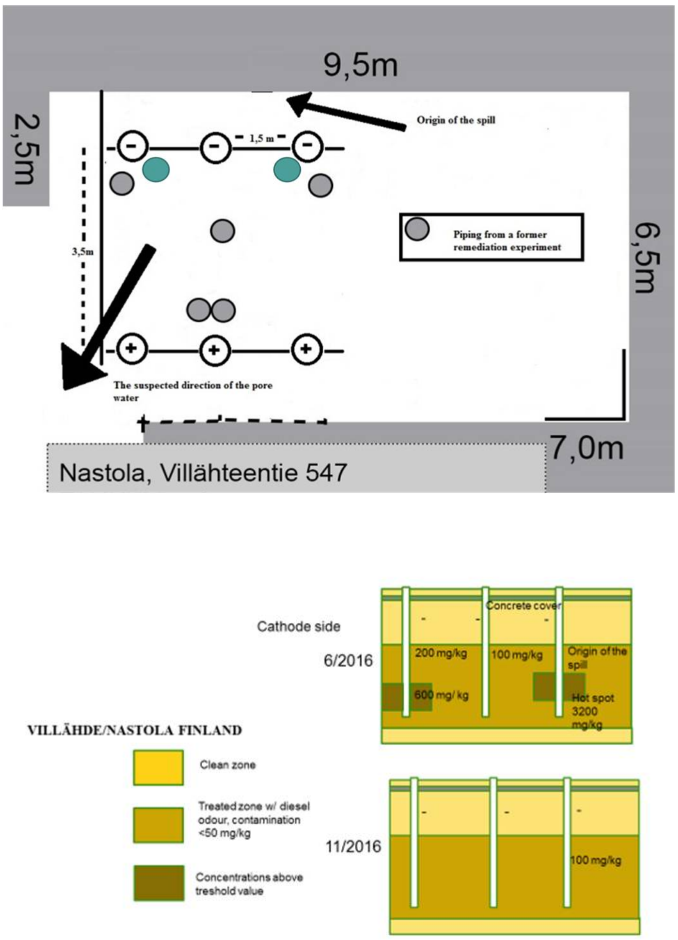

Fig 5.1. & 5.2. The study area, and a cross-section portrait of the cathode (-) side before and after treatment

The final investigations on the area were performed by an independent party, consultant Vahanen Oy, who could apply both the investigations and the risk assessment for a price under the tender threshold, since the personnel were involved with the original site investigations around project Tankki in 2013, then done by Ramboll Oy, who had a thorough knowledge of the case. The investigations were performed as three drillings VAH1-VAH3, with VAL 1 within, and the other two southeast from the treatment zone (Fig 5.3). Organoleptic survey of approximately 1m length soil columns from depths 8-14 m was performed prior to standard analysis. Groundwater was investigated from two groundwater wells: VAH 1 to west from the premises and VAH 2 south from the treated zone. No traces of oil hydrocarbons were found on the site on concentrations above or near the threshold value, and it was concluded that no further actions are needed, either on the study site or the zone suspected to have been impacted by the spill.

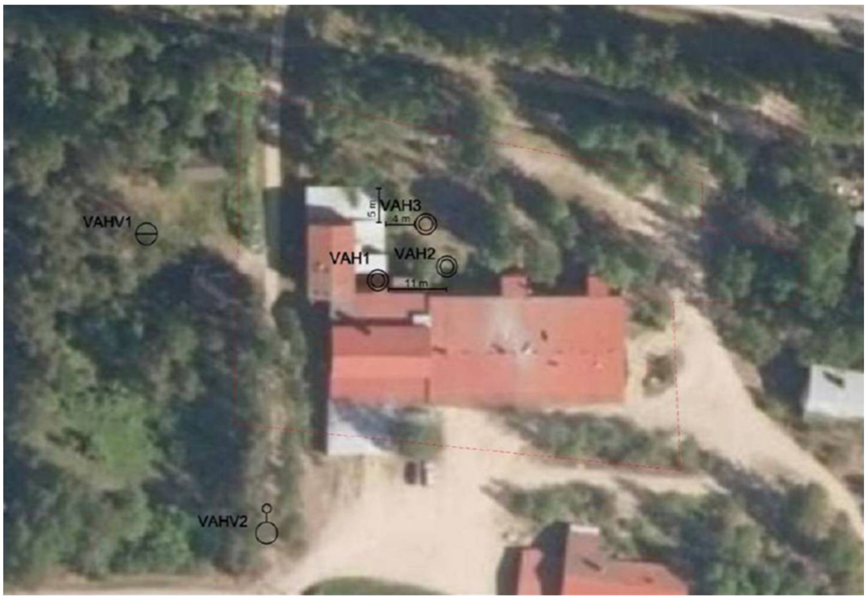

Fig 5.3. The site investigations done by consultant Vahanen Oy with the sampling spots marked

Site Virrat, Finland (POP)

The Kiertotie 18 industrial site, situated in a lake district in Pirkanmaa, has been contaminated with oil hydrocarbons and with heavy metals. The property is privately owned, and the remediation plan was agreed upon by the local environmental authority, Pirkanmaa Ely-keskus (Pirely) 2016. Pirely is taking part in financing of the remediation. Phytoremediation was chosen as the most suitable remediation method. The contractor is the Natural Resources Institute Finland, LUKE.

In 2017 two spots on the site were still found to have very high concentrations of hydrocarbons and heavy metals respectively, and they had to be removed by excavation before starting of the planting.

Fig 6.1. Oil and Hb-contaminated hot spots removed by digging before starting the planting

The soil at the Kiertotie 18 site is very stony and compacted, and drillings had to be done prior to the planting of hybrid aspen plants in 2017.

Fig. 6.2. a-b. Drilling holes for planting at the Kiertotie 18 industrial site in Virrat

Hybrid aspen and European aspen seedlings were chosen for the phytoremediation. Altogether 1200 aspen seedlings in 17 planting blocks were planted during 2017.

Fig. 6.3. a-b. Hybrid aspen and European aspen seedlings (*Populus tremula* and *tremuloides*)

First sampling of the site was done in summer 2017 according to the experimental design to get the soil status at the start of the phytoremediation.

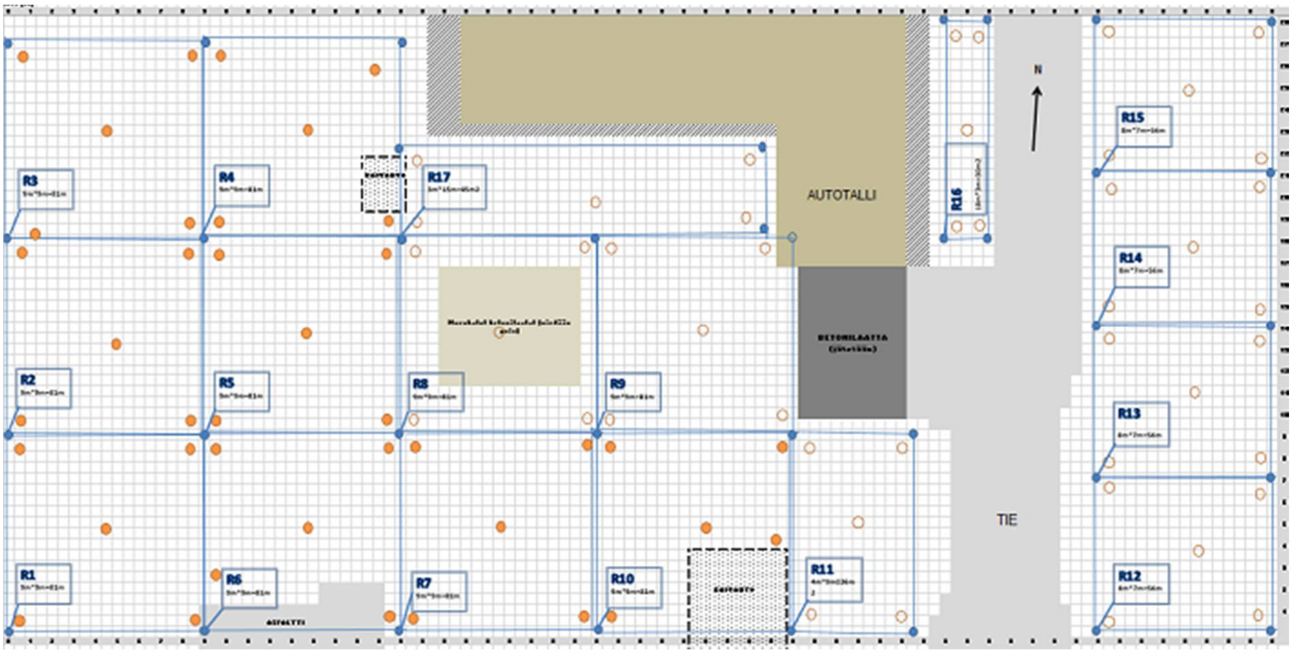

Fig. 6.4. The experimental design

The DNA from the samples was isolated and PCR amplified for identification of bacteria and archaea in the contaminated soil. The DNA samples have been sequenced in late 2017 and the bioinformatic analysis will start in 2018 to figure out the microbial communities (bacteria and archaea) in soil.

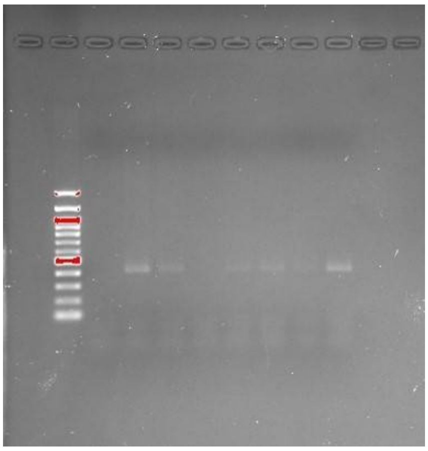

Fig.6.5. Agarose gel. DNA ladder to the left. PCR amplified DNA (from soil) bands on the right

The Virrat pilot site was photographed using DJI Phantom 4 remotely piloted aircraft system (RPAS) in October 2017. The pictures will be used for making GIS maps of the phytoremediation.

Fig 6.6. DJI Phantom 4 RPAS equipped with IPad for remote control using specially designed computer program for photographing a preselected area with the mini aircraft