Soil decontamination of POPs by thermal desorption, applying of thermal desorption for soil decontamination process.

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Thermal desorption is NOT incineration process

Thermal desorption is a way to treat soils contaminated with organic wastes. By heating these soils to temperature 350-800 degrees C°, contaminants will vaporise and separate from the soil. The vaporised gases are collected and treated in cyclone, oxidiser and bag-house and finally washed by gas scrubber. Vaporised contaminants are destroyed in oxidiser in high temperature 850-1100 degrees C° (with a gas retention >2 sec).
SAVATERRA Oy – Samples of References desorption,

<table>
<thead>
<tr>
<th>Year</th>
<th>Ref.</th>
<th>Description</th>
<th>Compound</th>
<th>Concentration</th>
<th>Amount (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>1</td>
<td>Receptory site operated by ST</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt;</td>
<td>0.7-3%</td>
<td>20000</td>
</tr>
<tr>
<td>2002</td>
<td>2</td>
<td>Receptory site operated by ST</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt;</td>
<td>3%</td>
<td>5000</td>
</tr>
<tr>
<td>2002</td>
<td>3</td>
<td>Maarienhav oil harbour</td>
<td>VAC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt;</td>
<td>5%</td>
<td>20000</td>
</tr>
<tr>
<td>2003-2004</td>
<td>4</td>
<td>Puistolanniem oil harbour</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt;</td>
<td>0.3%+1%</td>
<td>100000</td>
</tr>
<tr>
<td>2003-2004</td>
<td>5</td>
<td>Puistolanniem oil harbour</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt;</td>
<td>0.3%+1%</td>
<td>30000</td>
</tr>
<tr>
<td>2004-2005</td>
<td>6</td>
<td>Refinery waste site</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH</td>
<td>7-20%</td>
<td>175000</td>
</tr>
<tr>
<td>2005</td>
<td>7</td>
<td>Impregnation site</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH</td>
<td>0.8-3% + 0.2-0.5%</td>
<td>18000</td>
</tr>
<tr>
<td>2003-2008</td>
<td>8</td>
<td>Receptory site operated by ST</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH+PCB</td>
<td>&gt;2% + &gt;0.5% +0.1-0.2%</td>
<td>100000</td>
</tr>
<tr>
<td>2003-2008</td>
<td>9</td>
<td>Receptory site operated by ST</td>
<td>C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH</td>
<td>&gt;3% + &gt;0.5%</td>
<td>150000</td>
</tr>
<tr>
<td>2003-2008</td>
<td>10</td>
<td>Receptory site operated by ST</td>
<td>C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH - PCDD/F - metals, pesticides, TNT</td>
<td>0.1-5%+0.1-0.5%</td>
<td>250000</td>
</tr>
<tr>
<td>2009</td>
<td>11</td>
<td>Oil drilling mud</td>
<td>C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH</td>
<td>22%</td>
<td>3000</td>
</tr>
<tr>
<td>2010</td>
<td>12</td>
<td>Pulpmill site</td>
<td>C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH+terpentine+black liquor</td>
<td>0.05-4%</td>
<td>55000</td>
</tr>
<tr>
<td>2012</td>
<td>14</td>
<td>Impregnation site</td>
<td>VOC+C&lt;sub&gt;10&lt;/sub&gt;-C&lt;sub&gt;40&lt;/sub&gt; + PAH</td>
<td>0.8-3% + 5%</td>
<td>60000</td>
</tr>
<tr>
<td>2012</td>
<td>15</td>
<td>Impregnation site</td>
<td>CP+PCDD/F</td>
<td>1.5-2000μg/kg</td>
<td>15000</td>
</tr>
<tr>
<td>2014</td>
<td>16</td>
<td>Impregnation site</td>
<td>CP+PCDD/F</td>
<td>1.5-150μg/kg</td>
<td>12000</td>
</tr>
<tr>
<td>2014</td>
<td>17</td>
<td>Mustard gas</td>
<td>military compounds</td>
<td>not public</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td>1013200</td>
</tr>
</tbody>
</table>
In all Savaterra’s environmental permits authorities have given following regulations:

- all treated samples must be analysed by outside independent accredited laboratory
- emission (air) must be made similar way

Savaterra’s owns 6 environmental permits:

- 3x Finland, Norwegian, Sweden, France
Contaminated soils = specific waste
It is mixture of soil and contaminant
Mixture is already hazardous waste
50 mg of contaminant in 1 kg is relation
0.005% of contaminant = Hazardous Element and
99.995% of soil = inert material
Is very noneffective to utilize 99.99\% of inert soil like hazardous waste. Effective and safe way is to utilize only contaminant and clean soil use for earth works.
SAVATERRA Oy - temperature of desorption, oxidation, content of contaminant in after and before treatment:

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Temperature of desorption/boiling point</th>
<th>Temperature of oxidation</th>
<th>Content of contaminant in soil in input - before</th>
<th>Content of contaminant in soil in output - after</th>
</tr>
</thead>
<tbody>
<tr>
<td>SemiVOC</td>
<td>200-300°C</td>
<td>850°C</td>
<td>&lt;80.000mg/kg</td>
<td>0,02-10mg/kg</td>
</tr>
<tr>
<td>PAH</td>
<td>&gt;400°C</td>
<td>850°C</td>
<td>&lt;20-30mg/kg</td>
<td>&lt;5mg/kg</td>
</tr>
<tr>
<td>PCB</td>
<td>&gt;500°C</td>
<td>&gt;1000°C</td>
<td>&lt;10.000mg/kg</td>
<td>&lt;0,5mg/kg</td>
</tr>
<tr>
<td>Pesticides and herbicides</td>
<td>200-300°C</td>
<td>850°C</td>
<td>&lt;10.000mg/kg</td>
<td>Less than detection limit</td>
</tr>
<tr>
<td>VOC</td>
<td>200-300°C</td>
<td>850°C</td>
<td>&lt;80.000mg/kg</td>
<td>0,02-10mg/kg</td>
</tr>
<tr>
<td>Total hydrocarbons TOC</td>
<td>200-400°C</td>
<td>850°C</td>
<td>&lt;80.000mg/kg</td>
<td>&lt;50mg/kg</td>
</tr>
<tr>
<td>Chlorophenols (CP)</td>
<td>&gt;400°C</td>
<td>850°C</td>
<td>&lt;10.000mg/kg</td>
<td>&lt;5mg/kg</td>
</tr>
<tr>
<td>PCDD/Fs</td>
<td>&gt;600°C</td>
<td>&gt;1000°C</td>
<td>&lt;1.000mg/kg*</td>
<td>&lt;0,00005mg/kg</td>
</tr>
<tr>
<td>Cyanid's (CN)</td>
<td>&gt;400°C</td>
<td>850°C</td>
<td>&lt;40.000mg/kg</td>
<td>&lt;10mg/kg</td>
</tr>
<tr>
<td>Metals of 12 groups of elements (e.g. Mercury Hg) (volatile metals)</td>
<td>&gt;400°C</td>
<td>850°C</td>
<td>&lt;10.000mg/kg</td>
<td>0,005mg/kg</td>
</tr>
<tr>
<td>Heavy metals</td>
<td>&gt;400°C</td>
<td>850°C</td>
<td>&lt;10.000mg/kg</td>
<td>Insoluble Salt</td>
</tr>
</tbody>
</table>
SAVATERRA Oy — why to use our system

Reasons for application thermal desorption for contaminated soils?

1) High capacity (40-80t/h) allows reasonable time schedules in bigger projects

2) Post treatment monitoring is minimal

3) Versatility of the method allows high variation of the contamination level and compounds in the input material

4) The method is quite insensitive of the moisture and soil type of the input material

5) The space requirement is low (40m*60m)

6) Comparison of the total costs to other treatment methods, make thermal treatment very attractive alternative

7) Emission control and mass balance are easy to make

8) On-site treatment removes truck rally to landfills and also the use virgin materials as treated material can be used as backfill material.
In our decontamination process we destroy contaminant and produce clean soil.

Cleaned mixture is SOIL - NOT ASH is classified like waste without hazardous properties

Our process is NOT INCINERATION process

FINALLY WE PRODUCE CLEAN SOIL ONLY
EUROPEAN PATENT APPLICATION

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Application number: 12199796.9


Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

Designated Extension States:
BA ME

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Direct contact high temperature thermal desorption
SAVATERRA Oy – thermal desorption layout

1. FEED HOPPER
2. CHARGING CONVEYOR
3. DESORBER DRUM
4. CYCLONE
5. OXIDIZER
6. HEAT EXCHANGER
7. BAGHOUSE
8. SOIL CONDITIONER
9. SCREW CONVEYORS
10. CONTROL CABIN
11. GENERATOR
12. TRANSFORMER
13. WORKING SITE CENTRAL
14. SCRUBBER
15. FUEL TANK
16. HEAVY OIL HEATER
17. WATER TANK
SAVATERRA Oy - 1. Feed hopper - The wheel loader unloads the contaminated soils to feed hopper where material larger than 150 mm in diameter are removed. Larger material will be crushed and recycled into the feed or delivered to landfill. The capacity is adjusted in feed hopper according the concentration and quality of contaminant. If contaminated soil is very wet or has a lot contamination, it may need to be mixed with less contaminated or workable soil for treatment in desorption unit. Metal material will be removed by magnetic after feed hopper.
SAVATERRA Oy - 3. Desorption unit - The desorption unit is used to heat contaminated soil to a high enough temperature and for a long enough time to dry it and vaporise the contaminants from soil. The unit is a rotary desorber which has a rotating cylindrical metal drum. The rotation speed and the angle of the drum will adjust treatment rate (tons/hour). Temperature in the drum can be adjusted in the range of 350-800°C depending on the contaminant. Typical retention time of the material in the desorption drum is approx. 20 minutes. The desorber has direct flame in the oven. This means that the material has direct contact to flame. The material can heat up to 1000°C. Oven will always have under-pressure.
SAVATERRA Oy - 4. Cyclone - As the soil is heated, the contaminants will vaporize and become a part of gas stream of air which is caused by blowers. Gas flow from desorber is guided by under-pressure to cyclone where most of the particulate matter will be removed.
SAVATERRA Oy - 5. Afterburner - After cyclone, vaporized contaminants will be burned in an afterburner (oxidiser). Temperature 850-1100 degrees °C destroys the contaminants in to CO₂.

6. Heat exchanger - The flue gas is cooled to 180°C before entering the bag house.
SAVATERRA Oy - 7. Bag house takes away most of particles. Activated carbon can be utilised in the bag house to remove Hg from the flue gases.
SAVATERRA Oy - 7. Bag house takes away most of particles. Activated carbon can be utilised in the bag house to remove Hg from the flue gases.
**SAVATERRA Oy - 14. Gas scrubber** is connected to process if sulphur (SO\textsubscript{x}) concentration in soil or fuel is exceptional high level. SO\textsubscript{x} will react with water and sodium hydroxide as follows:

\[
\text{SO}_2 + 2 \text{NaOH} \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O}
\]

Scrubber also helps to remove last particles. Water of the scrubber will be treated in water treatment process and re-used in dust binging of soil. Gas washing unit will also take some nitric oxides:

- \(2 \text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_2 + \text{HNO}_3\)
- \(3 \text{HNO}_2 \rightarrow \text{HNO}_3 + 2 \text{NO} + \text{H}_2\text{O}\)
- \(4 \text{NO} + 3 \text{O}_2 + 2 \text{H}_2\text{O} \rightarrow 4 \text{HNO}_3\)
- \(4 \text{NO}_2 + 2 \text{H}_2\text{O} + \text{O}_2 \rightarrow 4 \text{HNO}_3\)

In the gas washer nitric acid will form:

\[
\text{HNO}_3 + \text{NaOH} \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}
\]
SAVATERRA Oy — Emission measurements

The Gasmet CEMS II FTIR measuring system is designed for continuous emissions monitoring measurements (CEMS). Typical application includes H₂O, CO₂, CO, N₂O, NO, NO₂, SO₂, HCl, HF, NH₃, CH₄, CO, CO₂, monitoring from Waste Incinerator or Large Combustion Plants. Measured components and calibration ranges can be changed according to application.

The Gasmet CEMS II is an ideal tool for measuring trace concentrations of pollutants in wet, corrosive gas streams. All parts of the Gasmet CEMS II are heated up to 180°C. It can be used for unlined gases and the sample gases do not need drying beforehand.

The Gasmet CEMS II consists of Gasmet FTIR Gas Analyzer, Gasmet industrial computer, Gasmet sampling system. As an option the system can be equipped with Gasmet TDL or ZO₂ oxygen analyzer and/or with total hydrocarbon analyzer (TID). All parts of the system are 19” rack mounted and are installed on the pull-out shelves. The Gasmet CEMS II includes all power connections and temperature controllers for heated lines and heated sample probe. The operation of the system is fully automatic and controlled by the Gasmet software. Additionally all functions of CEMS II can be controlled manually.

Comprehensive IO functions make possible to connect CEMS II into all kind of automation or reporting systems. Measuring data and alarms can be transferred from Gasmet CEMS II to other systems with analog or digital format. Gasmet CEMS II is also equipped with analog / digital inputs for external data (other analyzers or process).

Gasmet CEMS II provides different alarm functions such as System alarm, Service request, Maintenance on progress (can be set also manually). Concentration alarm, and Result valid. Combination for each alarm can be set on Cabinet. If any of the critical alarm is activated, instrument alarm starts to flow automatically into the system to prevent condensation.

Standard CEMS II is equipped with two open gas valve to allow automated aspirator checks as required by the new legislation.

Gasmet CEMS II is air conditioned with a compressor-cooling unit on top of the cabinet. Cabinet includes necessary to the Gasmet CEMS II is also supported by full remote control.

The Gasmet CEMS II FTIR has a very low cost of ownership; the equipment is extremely well designed, and requires very little maintenance. The system also has a number of in-built fail-safe devices to protect the instrument from potential damage.

**DUSTHUNTER SP100**
Scattered Light Particulate Monitor

Continuous Measurement of Dust with Low to Medium Concentrations

**Intended Purpose**
The DUSTHUNTER SP100 monitor provides continuous measurement of particulates in industrial plants for process control and FS-11 compliance.

**Models**
The DUSTHUNTER SP100 (probe version) is available with the following probe lengths:
- 17.13 in (435 mm)
- 28.94 in (735 mm)
- 40.75 in (1,035 mm)
- 52.36 in (1,335 mm)

This makes the DUSTHUNTER SP100 ideal for a wide range of applications.

The DUSTHUNTER SP100 consists of the following components:
- DH-SP sender/receiver unit
- Flange with tube
- MCU control unit (with/without purge air supply)
- External purge air unit (option)
- Connection cable
- Purge air hose for MCU-P control unit with integrated purge air supply

**General parameters**

- Measuring principle: FTIR (Fourier Transform InfraRed)
- Performance: Simultaneous analysis of up to 50 gas components
- Operating temperature: 20 ± 20°C, non-condensing
- Storage temperature: -20 → 50°C
- Response time, T₉₀: < 180 s, 20 m heated line
- Gas cell temperature: 180°C
- Sample gas: Non-condensing, particle free
- Flow rate: ~ 4 liter per minute
- Sample gas pressure: Ambient
- Installation place: Dust-free and clean ambient air, without external vibrations
<table>
<thead>
<tr>
<th>Compound</th>
<th>Measured concentration</th>
<th>Allowed concentration by 2003/76/EY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total parties (TP)</td>
<td>10 mg/m³</td>
<td>10 mg/m³</td>
</tr>
<tr>
<td>Total organic Carbon (TOC)</td>
<td>&lt;1 mg/m³</td>
<td>10 mg/m³</td>
</tr>
<tr>
<td>Hydrochloric Acid (HCl)</td>
<td>&lt;1 mg/m³</td>
<td>10 mg/m³</td>
</tr>
<tr>
<td>Hydrofluoric Acid (HF)</td>
<td>&lt;1 mg/m³</td>
<td>1 mg/m³</td>
</tr>
<tr>
<td>Sulphur Dioxide (SO₂)</td>
<td>43 mg/m³</td>
<td>50 mg/m³</td>
</tr>
<tr>
<td>Nitrogen Oxides (NOₓ)</td>
<td>143 mg/m³</td>
<td>200 mg/m³</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>2 mg/m³</td>
<td>50 mg/m³</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>7.5%</td>
<td>Not Defined</td>
</tr>
<tr>
<td>Metals: Cd+Tl</td>
<td>0.00001 mg/m³</td>
<td>0.05 mg/m³</td>
</tr>
<tr>
<td>Metals: Hg</td>
<td>0.001 mg/m³</td>
<td>0.05 mg/m³</td>
</tr>
<tr>
<td>Metals: Sb+A +Pb+Cr+Co+Cu+Mn+Ni+V</td>
<td>0.022 mg/m³</td>
<td>0.5 mg/m³</td>
</tr>
<tr>
<td>Dioxins/ furans (I-TEQ)</td>
<td>0.00007 ng/m³</td>
<td>0.1 ng/m³</td>
</tr>
</tbody>
</table>
SAVATERRA Oy company from Arctic Circle
Thank you for your attention