

New Method & Instrumentation for the *In Situ* Soil Contamination Survey

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Abstract: The new soil vapor survey method, based on the combination of total PID and selective IR analysers reveals vital information about a subsurface pollution. The integrated system is able to compensate for the influence of the following disturbing factors: presence of natural methane, soil permeability, natural subsurface barriers, type of contaminant, age of a contaminant, zoning, surface contamination, soil moisture and soil temperature. Simultaneous measurement of total soil gas/vapor concentration (PID) together with IR selective analyses for methane, carbon dioxide, and petroleum hydrocarbons, complemented by oxygen, soil temperature and pressure data brings *in situ* correlation graphs that give completed information about subsurface location and/or migration of the contaminant plume. Correlation among individual measured values and the interpretation of the simultaneous *in situ* data are explained and discussed in this contribution.

Gas from the pore space in soil and rock formations is commonly known as soil vapor. The composition of this phase, in particular the presence and concentration of organic compounds, reveals vital information about pollution of the subsurface environment. Organic compounds constitute a group of contaminants which impact severely on groundwater resources. The presence and distribution of such pollutants can be detected by an established technique known as a Soil Vapor Analysis ("SVA") or Soil Vapor Survey ("SVS").

The following types of contaminants are addressed:

- Liquid organic materials including hydrocarbons (mainly petroleum products) and chlorinated hydrocarbons (industrial solvents, metal-cutting oils etc.).
- Organic vapors from landfills and gas leaks.

HC pollution of the environment is due mainly to two groups of compounds, namely petroleum HC's and halogenated HC's. Petroleum substance have a density less than that of water, and their volatility and solubility in water generally decrease with an increase in the number of carbon atoms in a molecule. On the other hand, the halogenated HC's, of which chlorinated compounds are the most important, have a density greater than that of water. They are characterized by considerable variation in their volatility and solubility in water.

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Since petroleum products are involved in the majority of pollution cases (except possibly in industrial areas) this group receives priority in this overview. The behavior, or fate, of a pollutant is strongly influenced by incident, site and product-specific factors.

MAIN FACTORS AFFECTING *IN SITU* SV MEASUREMENTS

a) Presence of Methane of natural origin: The fact that methane occurs in different concentrations everywhere in the sub-soil environment may cause misinterpretation of all total-based-*in situ* measurements.

b) Soil permeability - may dramatically influence the measured value of any concentration of the free SV phase due to differences in the value of absolute inner surface of variously permeable soils with varying capability of dissolving the liquid contaminant which also produces differences in the emission of the vapor phase.

c) Natural subsurface barriers such as an impermeable clay lens, a subsurface layer of frozen soil, or a sealed fracture, etc., and also artificial materials such polyethylene sheeting or a concrete slab may disturb or truncate the distribution pattern of the vapor phase. Moreover, abnormally high concentrations of soil vapor, which are not directly related to the spatial position of a source, may exist at the edges of such barriers.

e) Age of a contaminant: All petroleum products experience some degree of natural biodegradation process in the subsurface environment. Lighter HC are more readily degraded than the heavier compounds. After a lapse of time the spectral composition of contaminants will dramatically change; moreover, some contaminants may become morphologized (i.e., composed of non-toxic aromatic compounds which are out of the basic hydrocarbon spectrum).

i) Soil temperature: For a given amount of contaminant in the soil, the vapor density and vapor diffusion will increase significantly with increasing temperature. Although fluctuations in soil temperatures are generally seasonal, they may show daily variations which are however, restricted to the top one to two meters of the soil cover.

IN SITU FIELD SURVEY

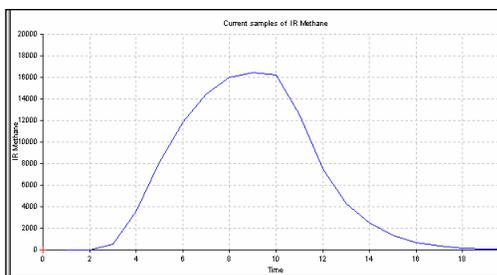
RS DYNAMICS developed a special instrument, Ecoprobe 5, which provides a solution for most of the above-mentioned complicated conditions and offers a true *in situ* method for a reliable soil-contamination survey. Ecoprobe 5 comprises two autonomous analyzers, PID and four channel IR, in one container. This combination provides interpretation for a variety of contamination survey tasks.

PID analyzer measures total concentration of volatile organic compounds and other toxic gases including chlorinated hydrocarbons and **selectively excludes methane from the total sum.**

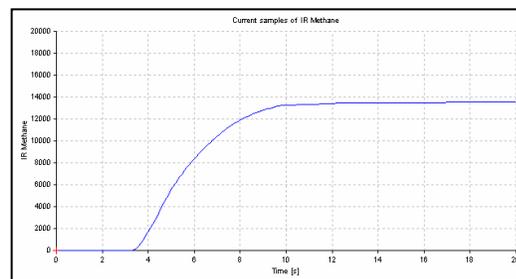
IR analyzer consists of three independent channels (plus one reference channel), which simultaneously measure the following parameters: SV concentration of the most common group of petroleum products, methane and CO₂.

Ecoprobe 5 shows the course of measurement graphs from PID and IR analyzers on the screen during the measurement. This parameter reveals surprising differences of the ability of permeable and poorly permeable soils to donate soil vapor for *in situ* SVS.

Typical example of soil permeability influence: For the test: prepare a given quantity of clay and the same quantity of very permeable soil like sand or forest surface soil. Mix an identical quantity of liquid contaminant into both soil samples. Ecoprobe 5 measurements of SV concentration in both samples will show differences in the shape of the measurement graphs. Previously used time-integrated SVS methods applied special absorbents into which analyzed soil vapor was absorbed during a relatively long time-interval and the resulting laboratory values showed the **average** concentration of the contaminant. The average value of contaminant concentration obtained from the clay sample differed from the contaminant concentration in sand sample by 2 or 3 decimal orders which caused misinterpretation and false evaluation of the Soil Vapor Survey Method.



Poorly permeable soil - clay



Permeable soil - sand

Simultaneous time-integrated measurement of total soil gas / vapor concentration (PID) together with IR selective analyses for methane, carbon dioxide, and petroleum hydrocarbons gives vital information about real contamination of subsurface environment, free of influence of above factors. In addition, the measurement is complemented by oxygen, soil temperature and pressure data. This combination of measurements is especially suited for solid waste disposal studies and for indications of bioremediation progress.

CONCLUSION – advantages of the new method:

- Fast *in situ* location of contaminant sources and contaminant migration trajectories. The analysis takes less than one minute at a particular station!;
- Contamination measurement not influenced by natural Methane;
- True selective methane, CO₂, petroleum HC's and oxygen reading;
- Measurements compensated for soil porosity/permeability influence;
- Ultra-high sensitivity of both, IR and PID units allows to indicate the smallest concentrations; and
- PID unit internal calibration for more than 200 components enables quantitative reading.