Soil quality assessment – screening and monitoring tools at different scales

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TASK 4

Screening and monitoring tools at different scales
Presently, there is no common European system for soil monitoring. In consequence there is large diversity of existing national and regional monitoring systems. This results in a diversity of monitoring organisation schemes, range of parameters determined, frequency of sampling, and methods of analysis.
Actual state of soil monitoring in Europe

In many countries two different systems for agricultural and forest soils exist. Some progress was achieved in monitoring of forest soils. Statutory soil monitoring is actually carried out in a number of EEA member countries but it is rarely suitable for the purposes of soil protection.
The following urgent research needs were identified by SOWA:

- Unification of measurement techniques and integration of various approaches adopted by individual countries to enable comparisons.

- Applying the predictive analysis for future risk assessment on a European level.

- Studying prolonged effects of toxic substances on different soil ecosystems and the effect of the sudden or slow loss of the buffer capacity of soils due to the accumulation of heavy metals, organic compounds, and other pollutants ("ecological time bomb").
The following urgent research needs were identified by SOWA

- Definition of a preliminary list of mandatory parameters and indicators chosen for diffuse contamination.
- Developing and applying techniques for monitoring radio-nuclides and soil solution chemistry
- Undertake the intra-site geo-statistical data processing, especially for some easy detectable key soil parameters (e.g. particle size distribution, cation exchange capacity, pH, EC, soil organic carbon, magnetic susceptibility) that could result in an improvement of the sampling design to detect actual changes within the soil as opposed to spatial variation (to make monitoring more sensitive to early changes)
The following research needs were identified by SOWA

- Developing the fast and cost-effective on-site screening and monitoring techniques which will serve as an early warning system.
The Water Frame Directive and the Soil Thematic Strategy determine the most urgent needs for assessing and monitoring quality and quality changes of the water-soil-sediment-air system. As many as possible environmental compounds have to be tested and monitored. The list of pollutants is still increasing. Taking into consideration both, economical costs of quality and sensitivity development with increasing demand for their quantity, then it is necessary to apply relatively inexpensive field techniques for environmental site assessment and pollution detection.
16 x 16 km cell size
21,760 cells
(ICP Forest)
Preliminary cost calculation for acquisition of the basic site description parameters in Monitoring Level I (According to EUROSTAT)

Total per site – 10 000 €
(including 4 000 € of laboratory cost for the basic contaminants)

Total: 21 760 x 10 000 = 217 600 000 €!
Laboratory: 21 760 x 4 000 = 87 040 000 €!
Increasing of cost-efficiency by reducing the number of chemical analysis (level I)

Trace elements actually monitored in Poland
Cd, Cr, Cu, Ni, Pb, Zn

Trace elements recommended for European Soil Monitoring
As, Cd, Cr, Cu, Hg, Mo, Mn, Ni, Pb, P, Se, S, V, Zn
Soil contamination levels in 50 monitoring points in Silesian District (Poland)
To reduce the cost of monitoring system the most important research needs in the future can be focused on:
Applying the cost effective and fast geophysical screening methods (e.g. field magnetometry)

Methodology is based on using magnetic iron oxides of anthropogenic origin as a tracers for some trace elements. Anthropogenic magnetic particles are components of many industrial and urban dusts emitted to the atmosphere and deposited on the soil surface, which can be easily detected by measurement of topsoil magnetic susceptibility. The industrial and urban deposition is also the main source of chemical contamination in many areas.
Applying bacterial sensors

More common using of biosensors for soil organic and inorganic pollution control.

For example the bioluminescence techniques for Cd, Zn, Cr, Hg detection
WECSA Soil Access System

PST1 resin capsule useful mainly for detection:

K, S, P, NO₃, NH₄, Ca, Mg, Na, Mn, Fe, Zn, Cu, Pb, Hg
Providing a new soil assessment system (e.g. technologies based on resin capsule "adsorbers")

WECSA Soil Access System

A UNIBEST ENV resin capsule adsorbs organics that are in the soil from both the liquid and vapor phases
Portable Heavy metal analysers

Development of techniques for Portable Heavy Metal Analysers

Validation the portable techniques and application of the ISO quality regulation to them
Developing of uniform techniques for detection of emerging contaminants
<table>
<thead>
<tr>
<th>Compound class</th>
<th>Examples</th>
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<tbody>
<tr>
<td>Pharmaceuticals Veterinary and human antibiotics</td>
<td>Trimethoprim, erytromycine, lincomycin, sulfamethaxozole</td>
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<tr>
<td>Analgesics, anti-inflammatory drugs</td>
<td>Codein, ibuprofene, acetaminophen, acetylsalicylic acid, diclofenac, fenoprofen</td>
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<tr>
<td>Psychiatric drugs</td>
<td>Diazepam</td>
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<tr>
<td>Lipid regulators</td>
<td>Bezafibrate, clofibrate acid, fenofibric acid</td>
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<tr>
<td>β-blockers</td>
<td>Metoprolol, propanolol, timolol</td>
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<tr>
<td>X-ray contrasts</td>
<td>Iopromide, iopamidol, diatrizoate</td>
</tr>
<tr>
<td>Steroids and hormones</td>
<td>Estradiol, estrone, estriol, diethylstilbestrol</td>
</tr>
<tr>
<td>Personal care products</td>
<td>Nitro, polycyclic and macrocyclic musks, benzophenone, methylbenzylidene camphor N,N-diethyltoluamide</td>
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<tr>
<td>Fragrances</td>
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<td>Sun-screen agents</td>
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<td>Insect repellents</td>
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<tr>
<td>Antiseptics</td>
<td>Triclosan, Chlorophene</td>
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<tr>
<td>Surfactants and surfactant metabolites</td>
<td>Alkylphenol ethoxylates, 4-nonylphnol, 4-octylphenol, alkylphenol carboxylates</td>
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<td>Flame retardants</td>
<td></td>
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<tr>
<td>Industrial additives and agents</td>
<td>Chelating agents (EDTA), aromatic sulfonates,</td>
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<tr>
<td>Gasoline additives</td>
<td>Dialkyl ethers, Methyl-β-butyl ether (MTBE)</td>
</tr>
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The innovative techniques could be considered in 4 groups according to their place in stepwise procedure for screening, monitoring, and testing:

- **Remote sensing for large scale overview and monitoring changes**
- **Proxy methods for regional scale overview and selection of sampling points**
- **On site sensors for fast estimation of pollution (quality and quantity)**
- **Sampling and analysis for individual pollutants**
Screening and monitoring tools at different scales

Most relevant scientific questions

- How can we identify and quantify adverse effects and trends? (e.g. by time or spatial integration or measurements of proxies)?
- What are suitable proxies to quantify pollution and indicators for soil quality and functioning?
- What controls the appropriate design for data acquisition at different scales?
- Which analytical techniques are needed for cost-effective screening and monitoring of known and emerging compounds? How can these techniques be validated (field and lab)?
- Which environmental tracers could be used for a better understanding of the soil system?