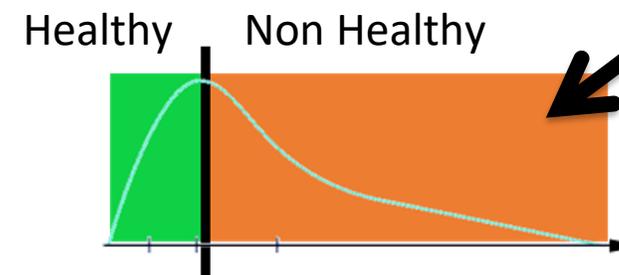
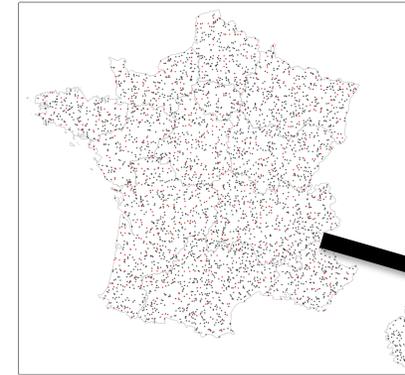


➤ **Navigating the Soil Monitoring Law: Practical Tools & Concepts for Soil Health Assessment regarding Contamination – What do we have – what do we need?**

Antonio Bispo, INRAE, Orleans

➤ Soil Health Monitoring – 3 main steps

- Setting a monitoring framework (based on existing networks)
 - Soil units (land use x soil type)
 - Soil districts (administrative)
 - # sampling points based on stratified random sampling to reach a maximum error percentage (or coefficient of variation) of 5%
- Sampling (0-30 cm) and characterizing soils
 - Trace elements
 - List of selected soil contaminants (e.g. pesticides, PFAs, microplastics...)
- Assessing Soil Health
 - National criteria
 - No Criteria



Monitoring Systems of Agricultural Soils Across Europe Regarding the Upcoming European Soil Monitoring Law

Floise Mason, Sophie Cornu, Dominique Arrouays, Maria Fantappiè, Arwyn Jones, Sophia Götzinger, Heide Spiegel, Katrien Oorts, Caroline Chartin, Luboš Borůvka, Evelin Pihlap, [Eisa Putki](#), Jaakko Heikkinen, Line Boulonne, Christopher Poeplau, Marc Marx, Elisa Tagliareri, Jalina Vinci, Lauris Leitans, Kestutis Armolaitis, Fenny van Egmond, Jozsef Kobza, Johanna Wetterlind, Thomas Drobnik, Juliane Hirte, József Hefler, Božena Smreczak, Lucas Carvalho Gomes, Mogens Humlekrog Greve, Antonio Bispo
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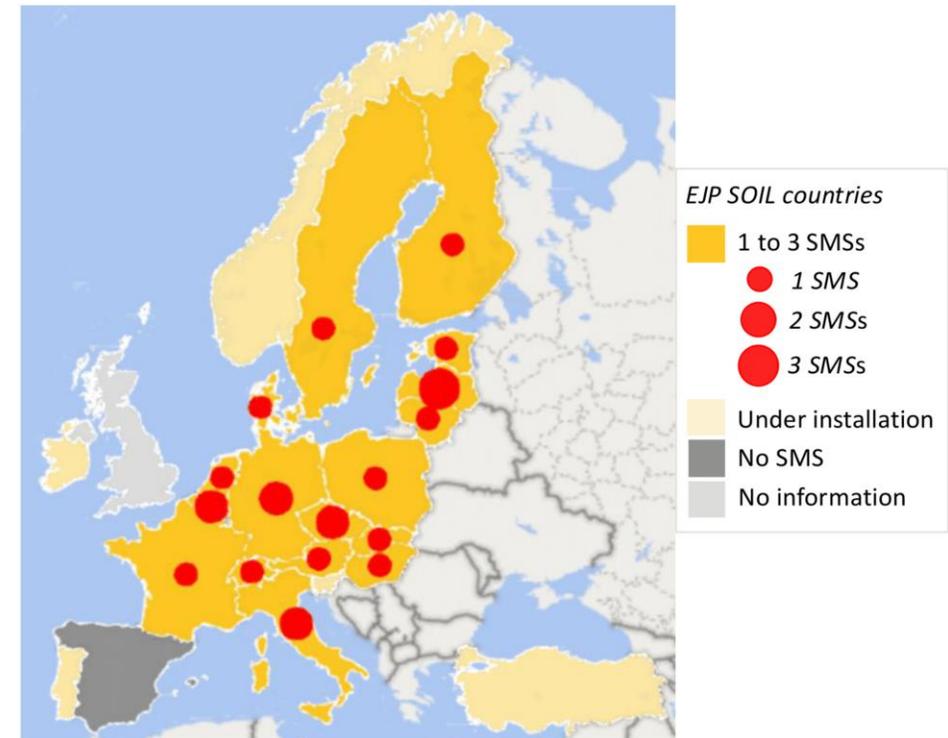
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➤ Setting a monitoring framework

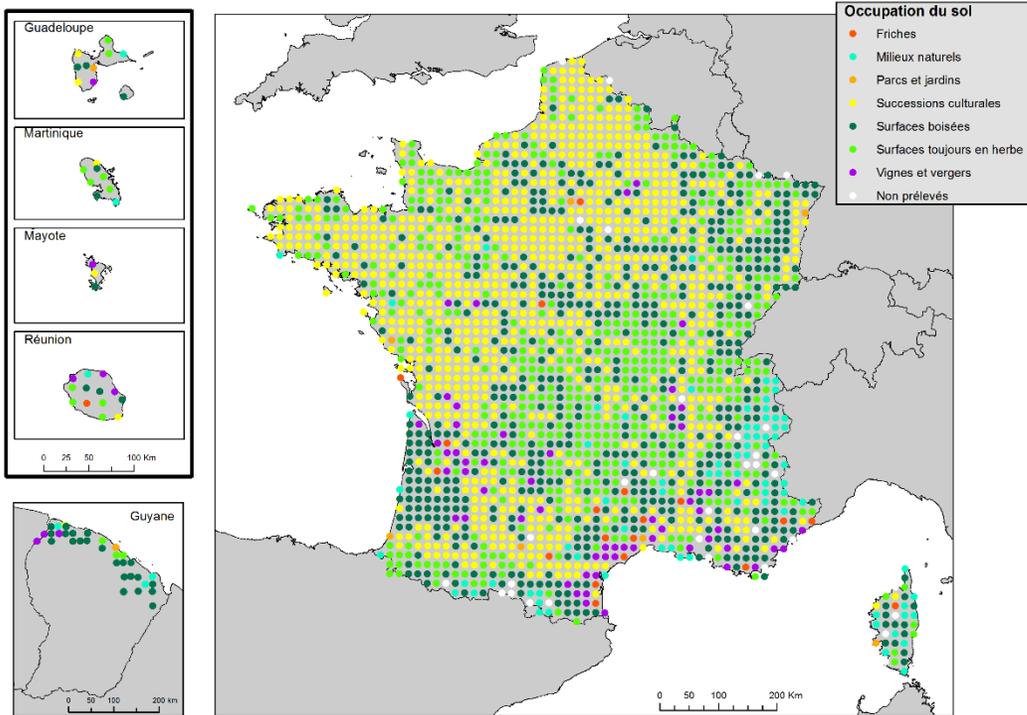
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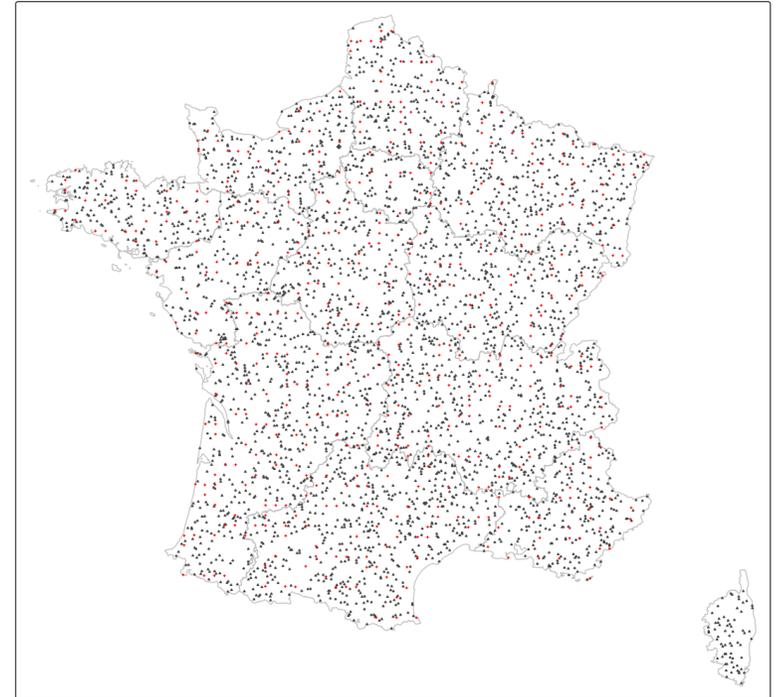
MSs will have to adapt their existing monitoring systems (the sampling strategy)



➤ Example for France: can we combine a grid with a stratified design?



- Existing network
- LUCAS Soil
- New sampling sites



- Designed to report at national scale
- 2,240 sites, based on a 16 km x 16 km grid
- Representing all land-uses and soil types
- 1st campaign (2000-2015), 2nd campaign (2016-2030)

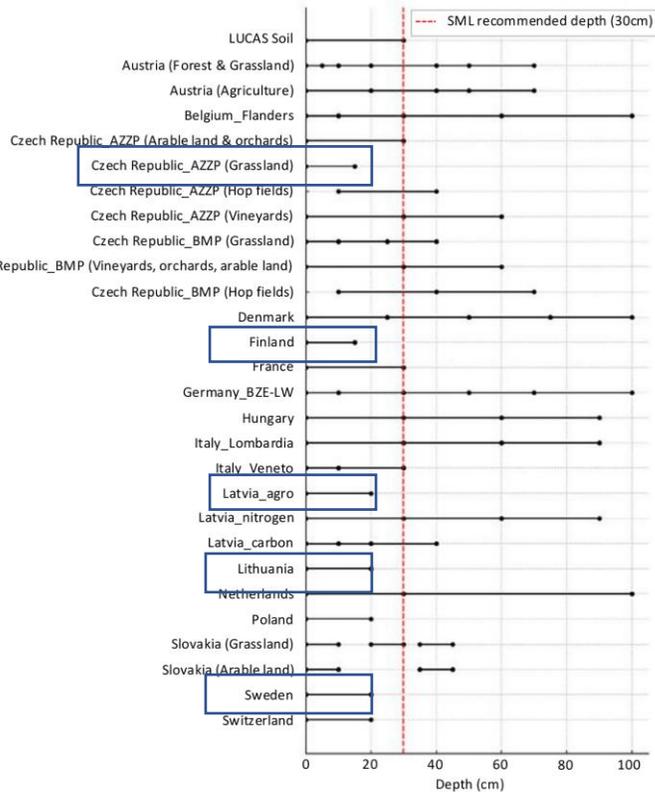
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➤ Sampling (0-30 cm) and characterizing

Sampling



| Soil properties monitored | Number of SMSs measuring each parameter | Frequency of measurements |
|---|--|---------------------------|
| pH | Water: 13, KCl: 8, CaCl ₂ : 9 | Moderately |
| Particle size distribution | 20 | Widely |
| Effective cation exchange capacity (ECEC) | 16 | Widely |
| Electrical conductivity | 9 | Moderately |
| Bulk density | Topsoil: 15, Subsoil: 16 | Widely |
| Soil water holding capacity | 2 | Rarely |
| Saturated hydraulic conductivity (Ksat) | 2 | Rarely |
| Organic carbon | 24 | Widely |
| Carbonate content | 16 | Widely |
| Soil organisms | 8 | Moderately |
| Heavy metals | 15 | Widely |
| Organic contaminants | 6 | Moderately |
| Total nitrogen content | 16 | Widely |
| Extractable phosphorus | 18 | Widely |

List of parameters

Methods

TABLE 3 | Overview of methodologies used to measure soil properties widely monitored across the SMSs, along their alignment with ISO-recommended methods outlined in the SML. SMSs are categorized by ISO-recommended, comparable, or alternative methods, with parentheses indicating the number of SMSs per category.

| Properties monitored | ISO recommended methods | SMSs using | | |
|----------------------------|-------------------------|---|---------------------------------------|--|
| | | The recommended ISO methods | Comparable methods | Alternative methods |
| Particle size distribution | 11277 | BE ³ , DE ¹ , DE ² , DK, EE, EU, SE | IT ² | AT, BE ¹ , CH, CZ ² , FI, FR, HU, IT ¹ , LT, NL, PL, SK |
| ECEC | 11260 | DE ¹ , EU, SE | AT, CH, IT ² | BE ³ , CZ ¹ , CZ ² , DE ² , FR, HU, IT ¹ , NL, PL, SK |
| Bulk density (Topsoil) | 11272 | BE ¹ , BE ² , DE ¹ , DE ² , DK, EE, FR, IT ² , LT, LV ³ | EU | AT, CH, HU, NL |
| Bulk density (Subsoil) | 11272 | BE ¹ , BE ² , DE ¹ , DE ² , DK, FR, IT ² , LT, LV ³ | EU | AT, CH, CZ ² , HU, NL, SK |
| Organic carbon | 10694 | BE ¹ , BE ² , BE ³ , CH, DE ¹ , DK, EE, EU, FR, LT, LV ³ , NL, SE | IT ² | AT, CZ ¹ , CZ ² , DE ² , FI, HU, IT ¹ , LV ¹ , PL, SK |
| Carbonate content | 10693 | BE ³ , CH, EU, DE ² , FR, NL, SK | IT ² | AT, BE ² , CZ ¹ , DE ¹ , DK, HU, PL, SE |
| Heavy metals | 54321 ^a | AT, BE ³ , IT ² | | CH, CZ ² , DE ² , EE, EU, FI, FR, HU, IT ¹ , PL, SE, SK |
| Total nitrogen content | 11261/13878 | BE ¹ , BE ³ , CH, DK, EU, FR, IT ² , SE | AT, DE ¹ , DE ² | CZ ² , FI, HU, IT ¹ , NL |
| Extractable phosphorus | 11263 ^b | EU, FR, IT ² | | AT, BE ³ , CH, CZ ¹ , CZ ² , DE ² , EE, FI, IT ¹ , LT, LV ¹ , NL, PL, SE, SK |

Abbreviations: AT, Austria; BE¹, Belgium_Flanders; BE², Belgium_Wallonia; BE³, Belgium_requa; CH, Switzerland; CZ¹, Czech Republic_AZZP; CZ², Czech Republic_BMP; DE¹, Germany_BZE-LW; DE², Germany_BD; DK, Denmark; EE, Estonia; EU, LUCAS Soil; FI, Finland; FR, France; HU, Hungary; IT¹, Italy_Lombardia; IT², Italy_Veneto; LT, Lithuania; LV¹, Latvia_agro; LV², Latvia_nitrogen; LV³, Latvia_carbon; NL, Netherlands; PL, Poland; SE, Sweden; SK, Slovakia.
^aHeavy metals (As, Sb, Cd, Co, Cr (total), Cu, Hg, Pb, Ni, Tl, V, and Zn) should be measured using ISO 54321 digestion (with Aqua Regia), with optional analysis of bioavailable fractions using ISO 17586 (dilute nitric acid).
^bISO 11263 is the preferred method; nevertheless, other methods can be used as an alternative.



> At a glance

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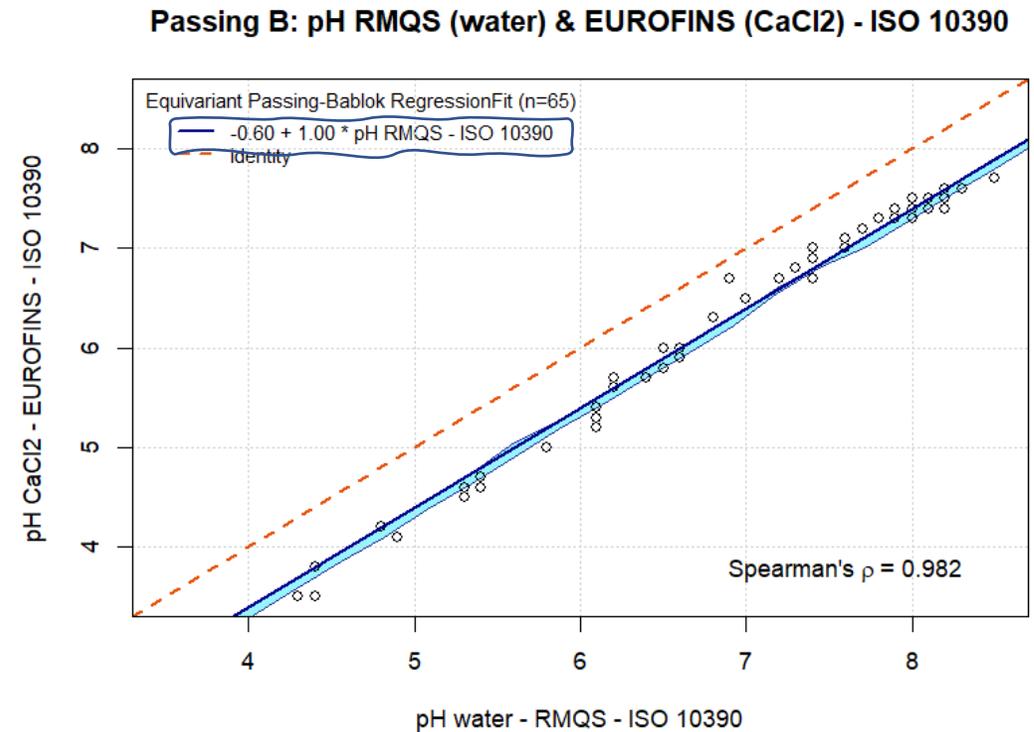
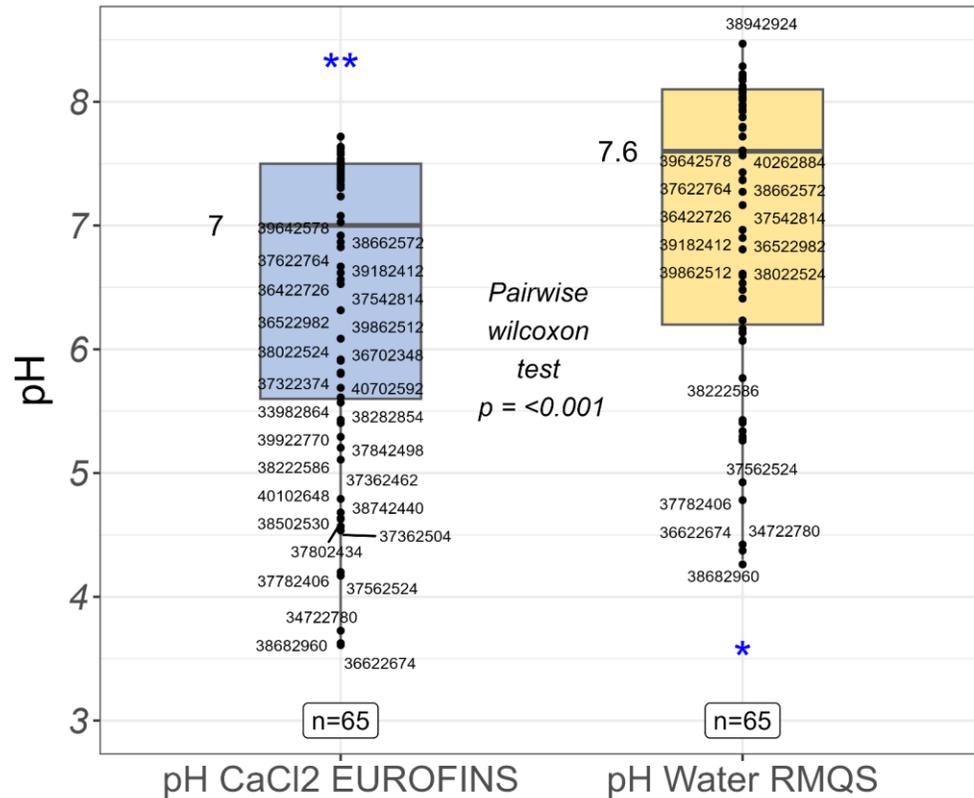
| | | Austria | Belgium_Flanders | Belgium_Wallonia | Belgium_requa | Czech_agro | Czech_BMP | Denmark | Estonia | Finland | France | Germany_BZE-LW | Germany_BD | Hungary | Italy_Lombardia | Italy_Veneto | Latvia_agro | Latvia_nitrogen | Latvia_carbon | Lithuania | Netherlands | Poland | Slovakia | Sweden | Switzerland | LUCAS Soil | |
|----------------------------------|-------------------------------|---------|------------------|------------------|---------------|------------|-----------|---------|---------|---------|--------|----------------|------------|---------|-----------------|--------------|-------------|-----------------|---------------|-----------|-------------|--------|----------|--------|-------------|------------|-------|
| Sampling strategies | Stratified | Red | Green | Green | Grey | Green | Red | Red | Green | Green | Red | Red | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | |
| | Sampling depths ≥ 30 cm | Green | Green | Orange | Grey | Yellow | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| | Composite / Number of samples | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| | Geolocation | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| | Interval ≤ 6 years | Red | Red | Red | Grey | Green | Green | Red | Red | Red | Red | Red | Red | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| | Soil management data | Red | Green | Green | Green | Red | Red | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| Parameters monitored and methods | Soil type recording | Red | Red | Yellow | Grey | Yellow | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | |
| | pH (Water) | Yellow | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | pH (KCl) | Red | Green | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | pH (CaCl2) | Yellow | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Particle size distribution | Orange | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | ECEC | Yellow | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Electrical conductivity | Orange | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Bulk density (topsoil) | Orange | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| | Bulk density (subsoil) | Orange | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| | Water retention capacity | Orange | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Ksat | Orange | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Organic carbon | Orange | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green |
| | Carbonate content | Orange | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Soil organisms | Orange | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Heavy metals | Green | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| | Organic contaminants | Yellow | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red |
| Total nitrogen content | Yellow | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | |
| Extractable phosphorus | Yellow | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | Red | |
| Accessibility | Aggregated data accessibility | Orange | Green | Green | Green | Orange | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | Green | |

From green (full compliance with SML) to red (not compliant at all)

MSs will have to adapt and/or develop transfer functions for sampling and analysis!

➤ Transfer functions

‘Transfer function’ means a **mathematical rule** that enables the value of a measurement performed using a methodology different from a reference methodology to be converted into the value that would be obtained by performing the soil measurement using the reference methodology



> Conclusions

• We have

- Existing monitoring systems in MSs
- Strong skills for sampling soil
- Experience in analysing trace elements and 'old' organic contaminants as PAHs, PCBs
- Few threshold values (mainly for trace elements)

• What we need

- Adapt the existings systems to comply with SML (e.g. combine grid systems with stratified ones, develop transfer functions)
- Identify new relevant contaminants to be monitored (e.g. microplastics, PFAs, pesticides)
- Develop and standardise proper protocols for sampling/preparation/analyse new contaminants
- Develop threshold values based on common rules



The journey is just beginning!
We'll need your expertise on contaminated land