Recommended indicators to assess soil health: proposal from EJP SOIL

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The story behind…

- WP6 in charge of Deliverable D6.5 "*Guidelines for accounting and monitoring agricultural soil carbon, fertility and degradation changes at different scales*"
- Several meetings to decide how to organize the work, how to engage several EJP SOIL partners in this deliverable
- Identification of main chapters and lead authors
- 1st draft delivered in October 2023, revised by JRC
- New version delivered in April 2024

Main objectives

- **Review and recommend** ways of measuring, reporting and accounting **changes** in carbon, fertility and degradation
- Review **based on existing documents** (e.g. EEA report)**, projects** (e.g.EJP SOIL SIREN, SERENA, MINOTAUR)**, SML proposal, EUSO Dashboard**...
- **Identify** possible **indicators** and **respective interpretation** values if available and, if not, will **suggest/propose** ways of developing such values.
- **Consider costs and practical use** of the indicators (e.g. time for sampling, depths..)

List of indicators and respective links with fertility and degradation

Parameter (chapter)	Fertile state	Degraded state	Remarks
SOC (4.2)	Good SOC content	SOC decline, GHG emissions	
Soil nutrients (4.3)	Sufficient nutrients, balanced	Nutrient decline and unbalance	
CEC/ECEC and exchangeable bases (4.4)	Good CEC/ECEC	Sodification	
pH (4.5)	Good pH	Acidification	
Electrical conductivity (4.6)	Good EC	Soil salinity	
AWC (4.7)	Good AWC	Soil aridity	
Soil Biodiversity (4.8)	Good soil biodiversity	Decline in soil biodiversity	
Soil structure (4.9)	Good soil structure	Soil compaction and degradation of soil structure	
Contamination (4.10)		Contamination	No corresponding fertile state
Sealing (4.11)		Sealing	No corresponding fertile state
Soil erosion (4.12)		Soil erosion	No corresponding fertile state

Outline of the chapters for the 2 versions

D6.5 V October 2023

1. **Measurement and monitoring with traditional methods** (field/lab): a brief overview of how the specific parameter discussed in the chapter is traditionally measured
2. **Measurement and monitoring with PS/RS**: a brief exploration of how Remote Sensing and Proximal sensing could be used to monitor the parameter
3. **Existing thresholds and target values**: Thresholds and target values are important topics in the light of e.g. the development of the Soil Monitoring Law, as these are used to distinguish between healthy and degraded state and to monitor the progress of (policy) aims regarding soil health
4. **Modelling**: For some soil threats, modelling is the most used or most suitable way of monitoring and mapping
5. **Effects of scale (time/space)**: scale issues are important as it becomes more and more clear scale can influence the way in which processes operate, and besides that different monitoring methods might be needed for different scales. This may have an impact on mapping too.
6. **Degradation processes**: All chapters deal with fertile state (if this exists, see Table 4.1.1.) as well as with degraded state. This section discusses the relevant degradation processes for the parameter
7. **Recommendations**: summarizing the chapter, and providing recommendations for monitoring of the parameter that is discussed

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1. **Why measure?:** Introduction explaining the importance of measuring and monitoring the parameter that is discussed. This relates amongst others to point 6 from the list above.
2. **How to measure?:** Explanation of how measuring/monitoring can be done, thus covering points 1,2,4 and 5 from the list above
3. **Do we have thresholds?:** Covering topic 3 from the list above
4. **Recommendations:** covering topic 7 from the list above

Strong reduction of the content *(2-3 p max for each chapter)*

Initial chapters kept as annexes

Improved the readiness of the deliverable

Several concluding tables (e.g. for SOC)

Indicator(s)	Threshold/ limit value(s)	Frequency	Period to sample/measure (season, crop cycle, status of the soil)	Type of sampling	Top soil only?	Measurements methods	Estimated costs/sample (sampling not included)
SOC/Clay (-SML) Not in EUSO dashboard. Not recommended by EJP	To be adapted to agro-pedo-climatic conditions. The reference to grasslands in SML may be misleading or too ambitious.	**5 y** (+SML) even if changes will only be detected after 10 y or more	Avoid recent OC incorporation to soil	Several cores within a plot. (+ SML)	Yes (+SML)	Dry combustion: ISO 10694:1995. Particle-size analysis: ISO 13320:2009. (+SML)	10 to 30€ sample if SOC only 50 to 80€ if SOC with clay content and/or bulk density
SOC/SOCexp (-SML) Not in EUSO dashboard	To be adapted to pedo-climatic conditions		Avoid recent OC incorporation to soil	Several cores within a plot.	No. (-SML)	Dry combustion: ISO 10694:1995. Particle-size analysis: ISO 13320:2009. + regression or statistics at the scale of pedo-climatic conditions	
SOC/SOCmax (-SML) Proposed by the EUSO dashboard	To be adapted to pedo-climatic conditions		Avoid recent OC incorporation to soil	Several cores within a plot.	No. (-SML)	Dry combustion: ISO 10694:1995. Particle-size analysis: ISO 13320:2009. + statistics at the scale of pedo-climatic conditions	
SOC content (+SML)	No decrease.		Avoid recent OC incorporation to soil	Several cores within a plot. Fixed depths or horizon-based depths down to 1 m.	No (-SML)	Dry combustion: ISO 10694:1995. Agreement with SML. Particle-size analysis: ISO 13320:2009 may be necessary to fix target/threshold values.	
SOC Stock (+SML)	No decrease. Objective of increase to adapt to pedo-climatic conditions		Avoid recent OC incorporation to soil; avoid recent tillage	several undisturbed cores. Fixed depths or horizon based depths down to 1 m	No (-SML)	Dry combustion: ISO 10694:1995. Dry Bulk density: ISO 11272: 2017 + coarse fragments	

EJP SOIL Indicators vs SML

	Agreement	Changes suggested
SOC	• SOC Content • SOC Stock	• Delete: SOC/clay • Add: SOC/SOCexp and SOC/SOCmax
Soil nutrients	Total N, Extractable P	Add : P stocks (not only available P) and C/N ratio (N potential delivery)
CEC		CEC and ESP to be added
pH	pH in Water	
Electrical conductivity	Electr. Conductivity	
Available water capacity		Infiltration rate, permeability along the soil profile and/or the soil porosity
Soil biodiversity	Biodiversity (since last version of SML)	Biodiversity (functional and structural indicators)
Soil structure	Bulk density	
Soil contamination	Trace elements and selected organics	
Soil sealing	Soil sealing	
Soil erosion	Soil loss rate	

Other changes suggested

- **Frequency** (5 to 6 years between each campaign proposed by the SML)**:**
  - Too short to expect any significant change (if no drastic change to the management as LUC)
  - Not all contaminants need to be measured every 5 years
- **Sampling**
  - topsoil and subsoil
  - at field or basin scale depending on the soil indicator
- **Definition of proper sampling periods:**
  - Soil biodiversity in spring or autumn
  - Not just after a management intervention (e.g. pesticide application, tillage); need contact with owner to avoid this…
- **Estimation of the costs: 1,000 to 2,500 € per location**

Next steps

- **Publish the deliverable online (when validated)**

- **Work on a review/position paper with all contributors?**

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EJP SOIL Indicators vs SML

Agreement

1. Organic carbon:
   - SOC Content
   - SOC Stock
2. Nutrients: Total N, Extractable P
3. pH in Water
4. Electr. Conductivity
5. Biodiversity (since last version of SML)
6. Trace elements and selected organics
7. Bulk density
8. Soil sealing
9. Soil loss rate

Changes suggested

- Organic carbon:
  - Delete: SOC/clay
  - Add: SOC/SOCexp, SOC/SOCmax
- Nutrients: add P stocks (not only available P)
- CEC and ESP to be added
- Infiltration rate, permeability along the soil profile and/or the soil porosity
- Biodiversity (functional and structural indicators)

Concluding tables - 2 (e.g. for SOC)

Soil parameters	Soil Quality Indicator	Frequency	Depth and scale	Costs
SOC	SOC/SOCexp	Can be measured every 5 y since not that expensive but changes will only be detected after 10 y or more	Topsoil and subsoil	10 to 30 € for measuring SOC 50 to 80 € for measuring SOC stocks (including bulk density)
	SOC/SOCmax			
	Delta SOC content			
	Delta SOC Stock			